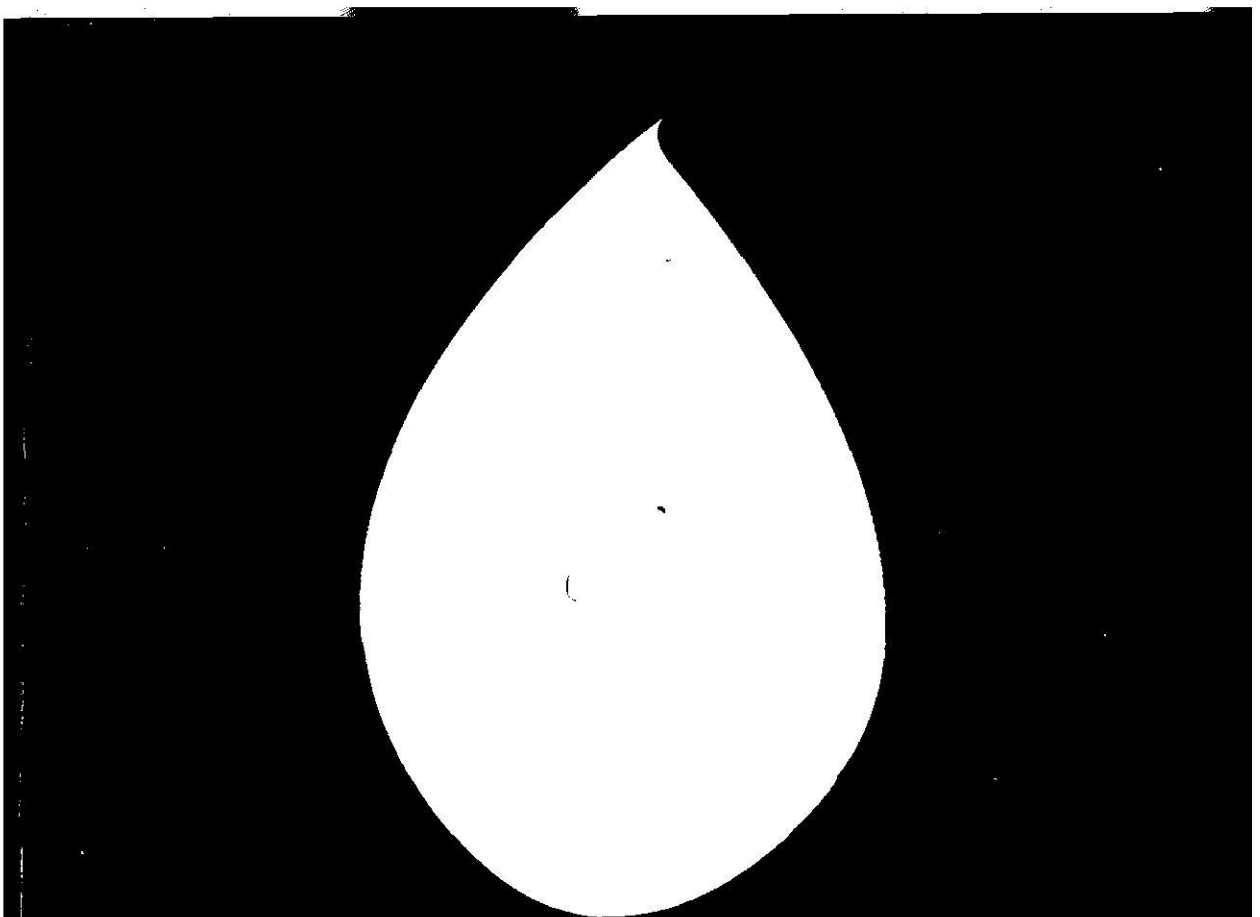
Journal of Oilseeds Research

Volume 16 No. 2 December 1999 ISSN 0970-2776



Indian Society of Oilseeds Research

DIRECTORATE OF OILSEEDS RESEARCH
RAJENDRANAGAR HYDERABAD - 500 030 INDIA

Journal of Oilseeds Research is published half yearly by the Indian Society of Oilseeds Research

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JOURNAL OF OILSEEDS RESEARCH

Voume 16 | December, 1999 | Number 2

CONTENTS

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J. Oilseeds Res. 16(2) 1999 : 183-195
ISSN 0970-2776

SCREENING TECHNIQUES FOR EVALUATION OF DOUBLE LOW CHARACTERISTICS IN OILSEED BRASSICAS

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ABSTRACT

Oilseed Brassicas are the third most important oilseed crop of the world and the second most important edible oilseed crop of India. Prior to 1970, rapeseed mustard breeding efforts were mainly directed towards increase in seed and oil yield. During recent years, due to the growing awareness about the nutritional quality of the oil and meal, the emphasis has shifted towards breeding for quality traits in rapeseed mustard. The Indian rapeseed mustard cultivars have high amounts of nutritionally undesired components, erucic acid and glucosinolates. Since both erucic acid and glucosinolates are governed by multiple recessive genes, a large number of segregating plant populations are required to be screened for selection of double low plants. The lack of cost effective, efficient and precise analytical methods may restrict the breeding efforts towards development of double low ('OO' or 'Canola' quality) cultivars. In view of this, various analytical methods for analysis of erucic acid and glucosinolates are discussed in this review article.

Keywords : Brassica, Rapeseed mustard, nutritional quality, double low, erucic acid, glucosinolate.

The oleiferous brassicas account for about 30% of the total oilseeds being produced in India. Having achieved a substantial increase in yield during past decade, the emphasis is being laid upon improvement in the nutritional quality for sustained production. The presence of two nutritionally undesired components in the rapeseed-mustard varieties grown in India, i.e., high amounts of erucic acid (40-50%) in the seed oil and high glucosinolates (80-160 m moles/g) in the oil free meal, restrict the utilization and expansion of Indian rapeseed mustard oil and cake at the global level. The diet rich in high erucic acid has shown to be associated with fibrotic changes in myocardium (Gopalan *et al.*, 1974, Sauer and Kramer, 1983) and glucosinolates are considered harmful for consumption for feed purposes (Bille *et al.* 1983, Bell, 1984).

'Canola' (commonly known as double low or 'OO') is a trade name designating rapeseed-mustard having less than 2% erucic acid in the seed oil and less than 30 m moles glucosinolate/g of the deoiled cake (Downey 1990) and is considered ideal for food and feed purposes. In India, efforts were initiated about two decades ago for the introduction/development of canola quality cultivars suitable for Indian agroclimatic conditions. As a result some O/OO lines have been identified (Malode *et al.* 1995; Agnihotri *et al.* 1995, Agnihotri and Kaushik 1998, 1999, Kaushik and Agnihotri 1996) but they need to be improved for their agronomic attributes.

The breeding for low erucic acid and low glucosinolate becomes difficult due to the non-availability of desirable donor sources as well as the complicated genetic factors. The erucic acid content is reported to be under the control of two genes with additive effects (Harvey and Downey 1964, Kondra and Stefansson 1965, Siebel and Pauls 1989). Each seed from the same plant contains different genetic background resulting in seed to seed variation in the levels of erucic acid. Glucosinolates are controlled by maternal genotype and are governed by at least three partially

Received for publication in October, 1998.

recessive genes (Kondra and Stefansson 1970, Uzunova *et al.* 1995). Since both erucic acid and glucosinolates are inherited independently, a large number of segregating plant populations need to be screened, and the lack of precise and efficient screening techniques for erucic acid and glucosinolate may become the bottleneck for quality breeding programmes.

In addition to the reduction in erucic acid and glucosinolate, several other parameters are important for the improvement in quality such as oil content, crude fibre, protein content, minerals and amino acids. The concept of 'double low' is recently being replaced by the concept of 'triple low', whereby emphasis is being made on developing varieties having low erucic acid, low glucosinolate and yellow seed coat colour. This is because the yellow seed coat colour has been shown to have low fibre and high oil content. In addition, certain minor constituents of importance comprise phytic acid, sinapine, phenolic compounds etc., however, the breeding programme generally include these compounds as a part of the monitoring only. Considering the national priority towards development of double low varieties suitable to grow under Indian agroclimatic conditions, the present paper describes the screening techniques for these two quality parameters.

1. SCREENING TECHNIQUES FOR ESTIMATIN OF ERUCIC ACID

The fatty acids are the triacylglycerols found abundntly in specialized plant tissues. The most bundant fatty acids in the plant oils and fats are unbranched, even numbered, monocarboxylic acids in which all carbon atoms are either saturated (e.g. palmitic, stearic acids) or unsaturated to varying degrees (e.g. oleic, linoleic, linolenic, erucic acids). The methods employed for the estimation of fatty acids can broadly be classified into two different types; the chromatographic and non-chromatographic methods.

Non-chromatographic methods for the estimation of erucic acid

In general the solubility of fats in organic solvents decreases with increasing chain length and vice versa (Rao *et al.* 1955, Arnold *et al.* 1963). The Gas-Liquid Chromatography (GLC) analysis of commercial seed samples (Craig 1961) and of low erucic acid seeds (Downey and Craig 1964) estabilished an inverse relationship between erucic acid and oleic acid content. Taking this characteristic into account McGregor (1977) described a non-chromatographic method for determination of erucic acid depending on the solubility of oil in absolute ethanol or a mixture of methanol and n-propanol (1.7:2; v/v). The time required for a warm alcoholic solution of the oil to turn opaque on cooling was related to the erucic acid content. This method was used for quality control in the commercial seed samples, but it is not suitable for quality breeding due to low sensitivity.

The Near Infrared Reflectance Spectroscopy (NIRS) is a rapid and non-destructive technique that allows the analysis of intact Brassica seeds for several constitutents at the same time (Biston et al. 1988). The possibility of determining oleic acid content in zero erucic acid rapeseed lines by the use of NIRS was demonstrated by Reinhardt and Robbelen (1991). Recently, Velasco et al. (1995a,b) have analysed erucic acid content of traditional rapeseed and *B. carinata* through NIRS. However, the procedure requires a large number of seed samples covering entire range for proper calibration of the expensive equipment. Once caliberated, it can be utilized for initial screening of seeds to identify the low plant types, that can be further evaluated by a suitable chromatographic procedure for accurate quantification.

Chromatographic methods for the estimation of erucic acid

The early methods for the erucic acid estimation involved co-precipitation of the erucic acid

with the saturated fatty acids as lead or magnesium salts, followed by the separation of free acids by fractional crystalization in ethanol (Stiepel 1926, Kaufmann and fiedler 1938; cited in McGregor 1980). Thin Layer Chromatography (TLC) was described by Stahl (1969) for analysis of lipids. These methods were time consuming and lacked senstivity. Thies (1971) utilized paper chromatography as quick screening method for the selection of seeds having less than 3% erucic acid, where a quantitative evaluation of the erucic acid content was not necessary. The separation of fatty acids, within a distance of 7 cm on the chromatography paper, in 95% acetic acid as the mobile phase, was achieved after three hours only. The grey-green spots found on the developed chromatograms remained stable upto one year. However, the method can be used only as a initial qualitative screening method.

Subsequently the gas chromatography (GC) methods were introduced for separation and quantitative determination of methyl esters of individual fatty acids (Craig and Murty 1958, 1959; Conacher and Chada 1974). McGregor introduced gas chromatography determination of linolenic acid (1974) and erucic acid (1977). However, it is more efficient to screen for individaul fatty acids, such as linoleic, linolenic and erucic acid simultaneously by gas chromatography. The GC methods have been improved over the years for sample prepartation and automation (Appelqvist 1968). Downey and Harvey (1963), in a major breakthrough for selection and breeding for low erucic acid, described a method for fatty acids determination through half seed technique. This was further facilitated by exuding the oil with the tip of a warm soldering iron (McGregor 1974, Stringam and McGregor 1980).

Sample preparation for GC requires oil extraction and esterification of fatty acids. Downey and Craig (1964) have described the use of methanolic hydrochloric acid for achieving esterification. Further workers have utilized sodium methoxide for the purpose (Hougen and Bodo 1973, Stringam and McGregor 1980). These procedures required the extraction of oil prior to eseterification. A one step transesterification using acetylchloride in methanol-benezene (4:1,v/v) was described by Lepage and Roy (1986). Banerjee et al. (1992) demonstrated the use of microwave heating to reduce the reaction time. Kaushik and Agnihotri (1997) have further improved the method of Lepage and Roy for fatty acid analysis, by the use of microwave heating in place of conventional heating, thus substantially reducing the reaction time for esterification from 1 hour to 2min.

Different liquid phases can be employed for the gas chromatography. The non-polar liquid phases, such as SE-30 and UCN-98 are preferred for the separation of long chain fatty acids due to their low volatilities. Polar liquid phases, such as diethylene glycol succinate (DEGS) and butane diol succinate (BDS), have higher volatility resulting in short column length. These should be used only when separation for both chain length and degree of unsaturation is required to obtain a complete fatty acid analysis. For both types of analysis chromatography is facilitated by use of low volatile GP3% SP-2310/2%SP-2300 for rapeseed analysis (McGregor 1980). In the method described by Kaushik and Agnihotri (1997), rapid separation was achieved on stainless steel GC column packed with a mixture of 2% SP 2300 and 3% SP 2310 on chromosorb 'W'. The complete elution is achieved within 7 min on a 1.8m column and in 15 min by a 3 m column. In view of the reduced reaction time and economical cost of column, the method is suitable for routine analysis of fatty acids for the quality improvement programme.

II. SCREENING TECHNIQUES FOR ESTIMATION OF GLUCOSINOLATES (S)

The glucosinolates belong to a family of sulphur containing secondary metabolites, derived from amino acids and are found in all parts of plants of *Brassica* species. More than 90 glucosinolates

have already been identified (Benette *et al.* 1996) and the known glucosinolates can be classified into three main classes: aliphatic/alkenyl glucosinolates derived fromL-Methionine, aromatic glucosinolates derived fromL-Phenylalanine/L-Tyrosine and the indolyl glucosinolates derived from L-Tryptophan (Sorenson 1991). The various analytical methods employed for the isolation,separation, identification and quantification of glucosinolate can be broadly divided into two different types, the methods for total glucosinolate determination and the methods for determination of individaul glucosinolates.

Methods for total glucosinolate determination

The traditional methods for total glucosinolate determination are based on the measurement of degradation products arising out of the hydrolysis of glucosinolate and include spectrophotometric/colorimetric analysis of reaction productsformed between thymol-sulphuric acid and intact/desulpho-glucosinolates, or determination of glucose liberated by myrosinase catalyzed hydrolysis. The total glucosinolate can also be directly determined in seed samples by NIR spectroscopy (Biston *et al.* 1988) and x-ray fluorescence (Schnug and Haneklaus, 1988) or x-ray reflectance (Tholen *et al.* 1993). These methods save the sample preparation time. However, they do not fulfill the requirements for simple, reliable and economical method to differentiate varieties with very low glucosinolate content (Bjerg *et al.* 1987). Test tape and ELISA methods can be employed for initial screening of glucosinolate in large number of segregating plant populations in breeding programmes.

Spectrophotometric methods based on measurement of degradation products:

Some of the initial methods are argentimetric method involving steam distillation and titration of the volatile isothiocyanates (Wetter 1955) combined with UV spectroscopy of the oxazolidinethiones (Wetter 1957), gas chromatography of the volatile isothiocyanates combined with UV spectroscopy of the oxazolidine-thiones (Youngs and Wetter 1967). UV spectroscopy of thiourea derivatives of the isothiocyanates (Appelqvist and Josefsson 1967; Daxenbichler *et al.* 1970; Wetter and Youngs 1976). Out of these the thiourea-UV method of Wetter and Youngs gained maximum popularity due to reproducibility of results (Mc Gregor 1980).

Following this Thies (1983) described a spectrophotometric method for total glucosinolate estimation based on the property of palladium to form colored complexes with glucosinolates. Later Kolovrat-O (1988) described a modified palladium test, using $PdCl_2$+ NaCl in place of Na_2PdCl_4 as the reactive agent. However, palladium based methods did not gain much popularity due to a simpler and cheaper (Thymol) method offered in lieu of this, for total glucosinolate estimation.

Thymol method

Subsequently, a method for determination of total glucosinolate content using thymol reagent was reported by Brzezinski and Mendelewski 1984. However, many laboratories reported technical difficulty regarding use of concentrated sulphuric acid, and high degrees of variation in replicate analyses. Thus, Truscott and Shen (1987) modified the thymol method of glucosinolate estimation. The procedure reported in a final value of 0.23% thymol in the incubation tube as against 0.11% thymol reported earlier, eliminating the under-estimation of glucosinolate content in the rapeseed with high levels of glucosinolates. The method was further modified by Tholen et al (1989) and is useful for screening a large number of samples.

Methods based on measurement of myrosinase-catalysed hydrolysis products:

Lein (1970) described two methods for measuring the glucosinolate content in raw extracts of *B.napus* seeds without defatting the

seeds prior to analysis. These methods are based on the measurement of glucose released as a result of hydrolysis of glucosinolates by the enzyme myrosinase. The liberated glucose was quantitatively measured by the enzyme-system (hexokinase+ATP/glucose-6-phosphotydel dehydrogenase+NADP,) the 'Glucose-UV-Test' or by the glucoseoxidase /peroxidase system, the 'Glukotest'. The 'Glukotest' was found to be very efficient allowing analysis of 200 plants/day against 50 plants/day by the 'Glucose-UV-Test'. The Glucose-UV-Test was found to be highly senstive whereby only one cotyledon or a single seed of *B.napus* could be measured with ± 1% accuracy. Bjorkman (1972) used glucose oxidase, peroxidase and the chromogen 0-dianiside for colorimetric determination of glucosinolates in purified rapeseed-extracts.

Quick screening methods for large plant populations

Test Tape Method

In order to meet the requirements of a commercial glucosinolate assay, a rapid, simple and specific test-paper technique was developed by Comer (1956) for semi quantitative glucose determination. Lein (1970) demonstrated the use of glucose test paper to determine the approximate glucosinolate level in rapeseed. Van Etten *et al* (1974) while estimating the crude extracts observed the presence of substances that hampered the colour development. They could overcome this problem by separating the inhibiting substances from glucose through capillary action while using the test papers. Based on these observations, McGregor and Downey (1975) reported a modified test tape method for identification of low glucosinolate rapeseed. The glucose released from hydrolysis of the glucosinolates by the endogenous myrosinase in aqueous seed extracts was measured after removal of interfering substances with charcoal. This enhanced the sensitivity and reproducibility of the of the glucose test paper technique and permitted the estimation of glucosinolate in approximately 5 min. only, thus rendering it suitable for commercial screening.

ELISA method

Enzyme-linked immunoabsorbent assays (ELISAs) are quite suitable for the analysis of the glucosinolate content in large number of samples. Hassan *et al.* (1988) reported an ELISA assay for determination of alkenyl glucosinolates, which was not specific for quantitative determination of sinigrin. Recently, Doorn *et al.* (1998) have reported estimation of the Sinigrin and progoitrin glucosinolates by specific antibody ELISA assays in Brussels sprouts and stipulate that it may be possible to apply this technique to seed samples.

Methods of determination of individual glucosinolates

The traditional methods based on measurement of degradation products arising out of glucosinolate hydrolysis lack precision and quantification of various components and thus are not suitable for analysing unknown samples for compositional requirement. Keeping this in view, chromatographic methods were developed for quantitative analysis of glucosinolates, which include GC and High Performance Liquid Chromatography (HPLC) of glucosinolate degradation products, GLC of pertrimethyl silylated desulphoglucosinolates, and HPLC of intact or desulphoglucosinolates.

GLC method for glucosinolate determination

The GLC technique is in extensive use for the analysis of hydrolysis products of glucosinolatess following treatment using myrosinase enzyme or as their trimethyl silyl desulpho derivatives. Underhill and Kirkland (1971) analysed the glucosinolates of defatted rapeseed meal as their trimethyl silyl derivatives by GLC. Persson (1974) and Thies (1974, 1976, 1977,

1978, 1979, 1980) further improved the original method by introducting ion-exchange chromatography to remove impurities. In the original method the intact glucosinolates were silylated directly without desulphation resulting in poor derivatization and sensitivity. Thies (1980) intorduced on-column desulphation to improve the subsequent derivatization. The method requires relatively tedious and longer sample preparation time and is expensive as compared to the colorimetric methods, but this disadvantage is overcome by the fact that it provides glucosinolate composition.

The determination of the indole glucosinolate, however, remained unsatisfactory by these methods. Heaney and Fenwick (1980,1982) demonstrated the use of high temperature for derivatization, separation and detection of all of the major glucosinolates in rapeseed, including the two indoles, glucobrassicin (3-indolylmethyl glucosinolate) and neoglucobrassicin (1-methoxy-3-indolylmethyl glucosinolate). Truscott *et al.* (1982, 1983) identified 4-hydroxy-glucobrassicin (4-hydroxy-3-indolylmethyl glucosinolate) as the major indole glucosinolate *in rapeseed*. Studies conducted by Sosulski and Dabrowski (1984) demonstrated a two fold difference in the detector response of 4-hydroxyglucobrassicin which is very sensitive to high temperature, oxygen and heavy metals (Thies, 1985), than that calculated by TMS method thus indicating poor recovery.

Brzezinski *et al* (1986) carried out a comparative study on glucosinolate determination by thymol and GLC methods and found that the results obtained with thymol method were always higher than with GLC, and attributed this to indolyl glucosinolates. Slominski and Campbell (1987) showed that substantial loss of indoles occurred during the heat inactivation of myrosinase enzyme. Also the volume of water used to elute the desulphoglucosinolates from the DEAE sephadex column had pronounced effect on indole glucosinolates. In order to avoid decomposition of indole glucosinolates during the heat inactivation of myrosinase, they recommend a standard procedure invovling 15 min dry heat treatment followed by 3 min wet heat treatment.

HPLC method for glucosinolate determination

The HPLC method was first described by Turscott et al. (1983) and later several workers used this technique for quantitative determination of individual glucosinolates (Spinks *et al.* 1984, Sang and Truscott, 1984, McGregor 1985; Palmer *et al.* 1987). Heaney *et al* (1986) described anHPLC method based on analysis of desulphoglucosinolates, after glucosinolates extration using hot methanol and incubation with sulphatase enzyme. Buchner and Thies (1987) reported on the optimisation of the HPLC method of dsesulphoglucosinolates analysis with special reference to the indolyl glucosinolates. Lichter *et al.* (1988) designed an automated HPLC system that allowed a large number of samples to be determined in a much shorter time as compared to the earlier described HPLC methods. Iqbal *et al.* (1995) have further modified the method of desulphated glucosinolates (Kraling *et al.* 1990) by reducing the extraction volume, doubling the injection volume and making some adjustments in the internal standard's dilution resulting in better resolution of individual glucosinolates.

Separation of desulphoglucosinolates by HPLC is highly specific, can be applied to both seed or vegetative samples and most of the major known glucosinolates can be determined from one chromatogram. However, it requires time consuming enzymatic desulphatation step and some glucosinolates escape detection (Bjerg and Sorenson 1986). These limitations can be overcome by a HPLC based procedure for the analysis of intact glucosinolates (Moller *et al.* 1985). However, separation of intact glucosinolates by ion pairing reagents require elevated column temperature and expensive ion pairing chemicals (Lichter *et al.* 1988). Considering these disadvantages, ion-suppression chromatography can be employed for

the separation of intact glucosinolates through the use of specific salt solution in the aqueous mobile phase. A method using aqueous ammonium acetate-acetonitrile mixture as mobile phase was reported by Bjorkqvist and Hase (1988). It required defatting of the seeds, followed by extraction and precipitation of proteins with 0.03 M barium acetate and lead acetate. Kaushik and Agnihotri (1999) have further improved the method involving single step extraction in boiling water after dry heat inactivation of myrosinase and separation of individual glucosinolates using ammonium sulphate as specific salt in the mobile phase. All major glucosinolates could be eluted within 10 min. run tme and the method can be effectively utilized for routine glucosinolate analysis.

One of the most important criteria for analysis of glucosinolates is the availability of a pure reference compound to be utilized as internal check for calibration. Calibration is commonly performed with the commercial available sinigrin or benzoyl glucosinolate. Since particular glucosinolate predominates in particular species, rapeseed meals with different and known contents of glucosinolates are utilized for caluclation of relative response factors. The individual glucosinolates are quantified by integration of their peak areas taking into account the specific response factors as determined by Buchner (Iqbal et al. 1995, lichter et al. 1988, Thies 1976).

CONCLUSIONS

In order to find out the relative suitability of various methods employed for the quality analysis, collaborative studies involving rapeseed breeders and chemists, were undertaken in 1974 and 1978, followed by a Symposium on Analytical Chemistry of Rapeseed and its Products at Winnipeg, Manitoba, organised by Canola Councilof Canada (McGregor, 1980). In India, a seminar on Interlaboratory Harmonization of Analytical Methods was held in1984 under the Indo-Swedish Collaborative Research Program on Rapeseed/Mustard Impovement and Oil and Protein Utilization. The discussions were held on various techniques for quality parameters and standard methods were described including Soxhlet method for oil content, macro/micro Kjeldahl method for protein content and GLC method for fatty acid profile. However, the analysis of glucosinolates was not considered during the deliberations.

The non-chromatographic methods used for estimation of fatty acids, specially erucic acid, were time consuming and lacked sensitivity (McGregor 1977). Although the GLC methods require expensive equipment and are technically demanding, they are precise and accurate, hence more suitable to the research needs for quality improvement in rapeseed mustard. The complete fatty acids profile can be resolved from the same chromatogram, and simultaneous selections can be made for specific fatty acid contents such as low erucic and linolenic acids, high oleic and linoleic acids. Prolonged treatment of lipids in an acid or alkali environment during sample preparation was found to cause isomerization of fatty acids, and the shorter reaction times were recommended as it not only saves time, but also involves less risk of side reactions (Appelqvist 1968). The recently described methods involving a single step extraction procedure (Lepage and Roy 1986), use of microwave heating in place of conventional heating (Banerjee *et al.* 1992) and its further improvement (Kaushik and Agnihotri 1997) have made good progress in this direction. These methods are more precise as they do not require the time consuming oil extraction procedure, thus reducing the risks of artifacts. In addition, the latter has increased efficiency in terms of reduced reaction time for sample prepartation as well as separation of fatty acids on the column, enhancing the chromatograph capacity and can be easily employed for quick, quantitative estimation of fatty acids. Therefore, the paper chromatography can be employed for the initial screening to select potential low erucic acid

plants, followed by quantitative estimat ion by the above described methods of GLC.

For glucosinolate analysis, the traditional methods based on the estimation of degradation products, are generally not accepted becaue the experiments concluded that some type of glucosinolates escaped detection in these tests (Nielsen *et al.* 1979). Further, these procedures are not considered to be accurate since the enzymatic hydrolysis may not reach completion and may proceed by different routes (Olsen and Sorensen 1980). The spectrophotometric UV determination of thiourea derivatives and oxazolidine-2-thiones, as well as determination of glucose, sulphate and thiocyanate can be used as fast screening methods but they only give the total glucosinolate content and may not fulfill the requirements of quality breeding necessitating the analysis of individual glucosinolates. Even for initial screening, the Test-tape method (McGregor and Downey 1975) is more efficient, accurate and economical than any of these methods.

The quantitative determination of different types of glucosinolates, can be achieved by GC or HPLC of glucosinolate degradation products, GC of trimethylsilyl desulphoglucosinolate, and HPLC of intact or desulphoglucosinolates. After reviewing the available methods (Mc Gregor 1980), the repeatability for the thiourea UV method was found to be better than that of TMS and reproducibilities were found to be similar. The thiourea-UV method does not provide information about the glucosinolate composition. However, it can be used for a batch type operation and has a higher output than the TMS method. McGregor (1986) compared the thymol method with TMS-GC method for glucosinolate analysis and observed that the simplicity, lower cost and comparable precision indicate that thymol analysis is a suitable alternative to gas chromatography of TMS derivatives where compositional information is not essential. Therefore either of these methods can be used with sufficient simplicity and precision depending upon the requirement for total glucosinolate or glucosinolate compositional estimation.

Although GLC was found adequate for glucosinolate analysis as compared to the earlier described methods and remained the most commonly used method for quantification of glucosinolates for many years, there are some problems regarding estimation of indole-glucosinolates by this method, especially the 4-OH-glucobrassicin (Thies 1985). The GLC of per-trimethylsilylated desulphoglucosinolates (TMS) also has limitations because it is not possible to convert all of the important glucosinolates into volatile derivatives (Christensen *et al.* 1982). This limiation of the TMS-GC method for the analysis of indole glucosinolate, can be resolved by reversed phase HPLC of desulpho or intact glucosinolates.

The reversed phase HPLC of intact or desul phoglucosinolate can be used with gradient technique with a high resolution, but require relatively expensive instrumentation (Moller *et al.* 1985). Brzezinski *et al.* (1986) compared the thymol method with HPLC and found a good compatibility between the two. The desulphotechnique has the highest specificity but some glucosinolates may escape detection and it also requires time consuming and costly desulphatation step. On the other hand, the HPLC of intact glucosinolate requires a counter ion and thereby elevated column temperature (Bjerg and Sorensen 1987). However, it is certainly advantageous because it does not require the time consuming and expensive enzymatic treatment, and all known glucosinolates can be determined on one chromatogram. Recently described method by Kaushik and Agnihotri (1999), involving dry heat inactivation of myrosinase in seeds, and a single step extraction of glucosinolates in boiling water, followed by ion suppression HPLC separation of intact glucosinolates by ammonium sulphate offers an economical, simple and efficient alternate for quantitative estimation of individual glucosinolates.

In order to make quick advances in the plant breeding programmes, a large number of seed samples have to be analysed within a given time frame. Therefore, an ideal method of analysis should be acccurate and precise, as well as simple, rapid and economical. Since any single method may not fulfill all of these requirements, a two method system is recommended for the fatty acids and glucosinolate analysis (McGregor *et al.* 1983) for quality breeding. The quick screening methods like Test tape of ELISA test could be profitably utilized for the inital screening of the large segregating plant populations to select the potential low glucosinolate plants. Of these two methods, the former is considered to be more economical. The thiourea-UV test or thymol method could then be applied for more accurate estimation of the total glucosinolate content where the glucosinolate composition is not of primary concern. Among these the latter was found to be more accurate, simple and cost effective. However, for quantitative estimation, the HPLC of intact glucosinolate certainly has advantage over the TMS-GC method in terms of being more efficient, precise and economical. Similarly, paper chromatography can be applied for quick screening of low erucic acid plants, followed by quantitative estimation of fatty acids profile by GLC. Although initial investments are required, in the plant breeding experiments where the fatty acids and glucosinolate profile is not known, and the analysis of individual fatty acids and glucosinolate is mandatory by GC/HPLC, the ultimate success will depend on the judicious application and blend of appropriate qualitative/quantitative techniques for selection of desired genotype having good quality and yielding capability for sustained production.

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J. Oilseeds Res. 16(2) 1999 : 196-202
ISSN 0970-2776

COMBINING ABILITY AND HETEROSIS FOR SEED YIELD AND IT'S RELATED TRAITS IN INDIAN MUSTARD (*Brassica juncea* (L.)Czern & coss.)

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ABSTRACT

Combining ability analysis through a diallel set without reciprocals involving nine genotypes of Indian mustard (*Brassica juncea* (L.) Czern & coss.) for twelve characters in two environments revealed the importance of both additive and non-additive gene action for all the traits studied. Varieties RH781 and Cream Pool in stress environment (E1) and PHR1, RC781, T59, Pusa Bold and Cream Pool in normal environment (E2) were identified as good general combiners for seed yield as well as oil yield. Where as hybrid Cream Pool x RH781 in stress environment and RH781 x RC 781 in normal environment were superior on the basis of per se performance and SCA effects. These two crosses have potential for commercial exploitation of heterosis both for seed yield and oil yield.

Key Words : Brassica juncea, Indian mustard, Combining ability, Heterosis, Quantitative traits.

INTRODUCTION

Indian mustard (*Brassica juncea* (L.) Czern & coss.) is an important oilseed crop which has received attention of geneticists and breeders for its genetic improvement as it has exhibited greater production potential under varying environments. Knowledge about combining ability of parents is a prerequisite in any Plant breeding programme aimed at either varietal improvement or exploitation of heterosis. The present investigation was, therefore, undertaken to estimate combining ability and heterosis for seed yield and its related traits.

MATERIALS AND METHODS

Nine varieties of Indian mustard viz., Culture, PHR1, RC 781, RH781, RH791, RH755, T59, Pusa Bold and Cream Pool were crossed in all possible combinations excluding reciprocals. The resulting 36 hybrids and 9 parents were evaluated in RBD with three replications in two environments during *rabi*, 1993-94. The environments were generated by different irrigation levels and fertilizer doses (Table-1).

Table : 1 Details of the two environments

Source	E1(Stress)	E2(Normal)
I. Irrigation	Only One (At flowering stage when wilting started)	Three (At Pre-bloom ,flowring & pod filling stage)
II.Fertilizer doses (Kg/ha)		
i. Basal	40N+30P_2O_5+ 20 K_2O	40N+60P_2O_5+ 40K_2O
ii.Top dressing (with 1st Irrigation)	---	40N

Each entry was grown in a single 3m long row spaced at 30 cm apart with the intra row distance of 10cm. The crop was raised using recommended technology. Observations were recorded on 10 randomly selected competitive plants for twelve quantitative characters. Combining ability analysis was done for individual environment (2) and over the environments (3) using method 2, model 1 (4). Heterosis was estimated over the Mid parent (MP)(1) and best variety among the parents for individual character.

Received for publication in July, 1998.

Table : 2 Analysis of variance for combining ability over environments for different characters in Indian Mustard

Source of variation	d.f.	Mean sum of squares											
		Days to flowering	*Days to* maturity	*Plant* height (m)	*Primary* branches/ plant	*Siliquae* per plant	*Siliquae* length (cm)	Seeds per siliqua	Test weight (g)	Seed density (g/ml)	Harvest index (%)	Seed Yield per plant (g)	Oil Yield per plant (g)
GCA	8	46.147**	62.231**	0.052**	1.539**	6084.938**	0.157**	1.762**	0.186**	0.0002**	232.480**	9.795**	2.436**
SCA	36	75.807++**	74.46**	0.039**	1.275**	7630.371**	0.239++**	2.841**	0.168**	0.0003**	123.599**	14.611**	2.041**
Environments	1	312.375**	174.577**	0.234**	7.473**	29448.662**	22.407**	108.667**	1.304**	0.0098*	190.199**	340.693**	63.521**
GCAxEnvironments	8	12.397*	55.056**	0.019*	1.944**	14065.950**	0.157**	1.620**	0.091**	0.0002**	189.729**	7.701**	1.287**
SCAxEnvironments	36	18.360**	68.177**	0.032**	0.850**	8360.39**	0.104**	2.149**	0.203**	0.0003**	154.852**	18.191**	2.646**
Error	176	5.996	4.781	0.009	0.210	312.996	0.054	0.061	0.011	0.0002	1.638	0.531	0.073
σ^2GCA : σ^2SCA		1:86.06	1:60.04	1:34.12	1:39.67	1:62.75	1:90.13	1:80.83	1:44.14	0:0.154	1:26.15	1:75.22	1:41.23
σ^2(GCAXE) : σ^2(SCAXE)		1:88.17	1:62.41	1:101.75	1:18.26	1:28.96	1:24.10	1:66.29	1:119.41	----	1:40.32	1:121.92	1:104.87

*, ** Significant against error at 5% and 1% level, respectively

+,++ Significant against respective environmental interaction at 5% and 1% level, respectively

-Indicate negative variance due to dominace effect

RESULTS AND DISCUSSION

Pooled analysis of variance for combining ability (Table-2) revealed that mean squares due to GCA and SCA were highly significant for all the characters indicating the importance of both additive and non-additive gene effects in their inheritance. However, σ^2 GCA/ σ^2 SCA was less than unity for all the traits which indicated relatively greater role of non-additive genes. Both σ^2 GCA and σ^2 SCA showed significant interaction with environments for all the traits except σ^2 GCA for seed density. Further, the magnitude of mean squares due to σ^2 SCA X environment was higher than σ^2 GCA X environment which suggested that non-additive components were relatively more unstable. These results are in confirmation with the finding of (5,6). Mean squares due to σ^2 GCA was significant for days to flowering only. While Mean squares due to σ^2 SCA were significant for days to flowering and siliqua length when tested against their respective environmental interaction component. Therefore, for these characters the results were discussed under E1, E2 and on pooled basis also.

On the basis of GCA effects, RH781 and Cream Pool under E1, and PHR1, RC 781, T59, Pusa Bold and Cream Pool under E2 were good general combiners for seed yield and oil yield per plant. Out of these cultivars, RH781, PHR1, and Cream Pool were good general combiners for some important yield contributing traits also. Variety Culture emerged as the most desirable general combiner for earliness in E1. Cream Pool for seed yield, oil yield and number of seeds per siliqua; RH781 for harvest index, test weight and number of seeds per siliqua; RH791 for harvest index; T 59 for oil yield per plant and RC781 for number of siliqua per plant were good general combiners over both the environments (Table-3). Since the GCA effects are attributed to fixable components i.e. additive and additive x additive gene effects, the above mentioned parents can be used in hybridization programme for the improvement of respective traits through transgressive segregants (4,7).

SCA effects are attributed to dominance and its interactions. Based on per se performance and SCA effects nine crosses in E1 and ten crosses in E2 were considered as desirable for seed yield and oil yield (Table-4&5). Most of these crosses involved atleast one good general combiner par-

Table : 3 Superior general combiners for different characters in Indian mustard

Characters	E1	E2	Pooled
Days to flower	Culture, RC781, RH755 &T59	-	Culture, RC781 &T59
Days to maturity	Culture	RH791 &RH755	-
Plant height	RH781	-	-
No. of primary branches/plant	Culture &PHR1	RH791, Pusa Bold & Cream Pool	-
No. of siliqua/plant	RC781, RH781 & Cream Pool	PHR1, RC781,T59 & Pusa Bold	-
Siliqua length	Cream Pool	RH781	RH781, & Cream Pool
No. of seeds/siliqua	RH781, T59, Pusa Bold & Cream Pool	PHR1, RH781 & Cream Pool	-
Test Weight	Culture, RH781 & Pusa Bold	PHR1, RH781 & Cream Pool	-
Harvest Index	RH781, RH791 & Pusa Bold	Culture, PHR1, RC781, RH781, RH791 &Cream Pool	-
Seed yield/plant	Culture, RH781 & Cream Pool	PHR1,RC781, T59, Pusa Bold & Cream Pool	
Oil Yield/plant	RH781, T59 & Cream Pool	PHR1,RC781, T59, Pusa Bold & Cream Pool	

Table :4 Crosses showing significant positive SCA effects for seed yield and other traits in Indian Mustard

Crosses		Days to flowering	Days to maturity	Plant height (m)	Primary branches/ plant	Siliquae per plant	Siliqua length (cm)	Seeds/ siliqua	Test weight (g)	Seed density (g/ml)	Harvest index (%)	Seed Yield/ plant (g)	Oil Yield/ plant (g)
E I													
T59xCulture		--	--	--	--	76.44	--	--	0.62	--	6.30	5.03	2.09
		(60.33)	(117.67)	(1.01)	(6.33)	(389.00)	(3.33)	(11.07)	(3.51)	(0.535)	(39.20)	(16.33)	(6.52)
Pusa boldxCulture		--	-7.05	--	--	--	--	--	0.46	0.025	9.32	1.47	0.60
		(69.33)	(109.33)	(0.95)	(6.83)	(343.33)	(3.64)	(10.30)	(3.56)	(0.556)	(47.52)	(12.80)	(4.83)
RH781xRC781		--	--	--	0.94	123.35	0.62	--	--	--	--	4.50	1.40
		(60.00)	(123.33)	(1.29)	(6.43)	(558.00)	(4.11)	(10.00)	(2.89)	(0.515)	(20.57)	(17.20)	(5.83)
RH791xRC781		--	--	--	--	147.17	--	--	0.65	0.029	3.04	8.22	3.11
		(59.67)	129.33)	(1.11)	(5.07)	(533.00)	(3.40)	(10.40)	(3.34)	(0.560)	(34.50)	(18.90)	(6.91)
T59xRH781		--	-5.69	0.48	1.65	182.81	--	2.81	--	--	20.16	4.59	1.96
		(63.00)	(114.33)	(1.64)	(7.47)	(582.33)	3.76)	(14.03)	(2.14)	(0.523)	(61.62)	(16.87)	(6.63)
Cream poolxRH781		--	--	--	--	107.02	--	1.86	0.72	--	11.22	8.43	2.94
		(74.00)	(129.27)	(0.79)	(5.40)	(560.00)	(4.12)	(13.50)	(3.61)	(0.546)	(53.27)	(22.40)	(7.83)
Cream poolxRH791		--	-3.69	0.41	--	108.84	--	--	0.60	--	2.91	5.25	1.87
		(73.67)	(113.67)	(1.46)	(6.00)	(513.00)	(3.82)	(11.10)	(3.29)	(0.530)	(40.77)	(17.20)	(6.14)
Cream poolX RH755		--	--	--	--	--	0.92	5.90	--	--	--	4.49	1.55
		(61.67)	(115.33)	(0.85)	(6.50)	(299.00)	(4.71)	(17.40)	(2.85)	(0.550)	(24.57)	(15.70)	(5.50)
Pusa Bold xT59		--	--	--	--	57.53	--	1.44	0.69	--	--	6.43	2.39
		(63.67)	(118.00)	(1.09)	(6.53)	(379.67)	(4.08)	(12.77)	(3.47)	(0.548)	(26.63)	(16.97)	(6.74)
SCA range		07.64 to 10.66	-9.21 to 12.40	-0.09 to 0.48	-1.97 to 1.65	-200.74 to 182.81	-0.80 to 0.92	-2.99 to 5.90	-0.80 to 0.72	-0.027 to 0.034	-20.31 to 28.25	-4.99 to 8.43	-1.92 to 3.11
Range for per se performance	Parents	56.00 to 75.67	104.33 to 115.33	0.85 to1.47	4.83 to10.17	314.00 to 463.33	3.06 to 4.04	9.33 to13.43	2.10 to 3.61	0.493 0.548	16.87 to40.88	3.47 to6.07	9.67 to 17.17
	Hybrids	55.33 to 74.33	109.00 to133.00	0.79 to 1.64	4.73 to 7.47	175.00 to 582.00	2.77 to 4.71	8.10 to 17.40	2.14 to 3.61	0.508 to 0.574	13.47 to 61.62	1.83 to 7.83	4.53 to 22.40

Values in parenthesis indicate per-se performance

Table : 5 Crosses showing significant positive SCA effects for seed yield and other traits in Indian Mustard

Crosses	Days to flowering	Days to maturity	Plant height (m)	Primary branches/ plant	Siliquae per plant	Siliqua length (cm)	Seeds/ siliqua	Test weight (g)	Seed density (g/ml)	Harvest index (%)	Seed Yield/ plant (g)	Oil Yield/ plant (g)
E2												
RH791xCulture	-8.47	--	--	--	128.28	--	--	0.65	--	--	7.04	2.74
	(58.00)	(107.67)	(1.11)	(7.50)	(504.00)	(4.42)	(12.40)	(3.61)	(0.571)	(32.30)	(20.53)	**(7.67)**
RC781xPHR1	--	--	--	--	94.04	--	0.65	--	--	15.29	5.18	2.11
	(70.33)	(124.67)	(1.24)	(7.10)	(525.00)	(4.98)	(14.20)	(3.11)	(0.557)	(54.37)	(21.70)	(8.25)
T59xPHR1	--	-9.15	--	--	**52.83**	**0.60**	**2.19**	--	--	21.93	5.46	2.35
	(75.33)	(107.00)	(1.23)	(7.50)	(480.67)	(4.97)	(14.93)	**(3.47)**	(0.562)	(57.17)	(21.77)	(9.03)
Cream PoolxPHR1	--	--	--	**0.88**	--	--	**0.48**	0.35	--	--	1.82	0.70
	(76.67)	(118.00)	(1.16)	(8.20)	(364.67)	**(4.79)**	(14.47)	(3.66)	**(0.568)**	(27.31)	(18.53)	(6.98)
RH781xRC781	-7.08	--	--	1.64	96.62	0.51	2.36	0.36	--	--	**8.02**	**2.80**
	(60.00)	(127.33)	(1.21)	(7.83)	(462.33)	(5.49)	(16.00)	(3.39)	**(0.552)**	(32.95)	**(22.80)**	**(8.15)**
Pusa BoldxRC781	--	**4.61**	--	--	100.77	--	0.71	--	--	16.73	4.94	2.12
	(72.33)	**(122.33)**	(1.39)	(8.17)	**(554.00)**	**(3.68)**	(13.87)	**(2.88)**	(0.540)	(18.93)	(21.60)	(8.58)
T59xRH755	--	**-4.82**	--	--	155.68	--	--	0.60	--	--	6.84	3.02
	(61.67)	**(107.00)**	(1.26)	(7.17)	(558.33)	**(4.16)**	**(11.40)**	(3.66)	(0.561)	(20.49)	(21.63)	(9.11)
Pussa Bold xRH755	--	-6.42	--	--	48.22	--	1.09	--	--	--	3.87	1.29
	(64.33)	(107.67)	(0.98)	(6.50)	(458.33)	(4.60)	(13.80)	(3.05)	(0.550)	(19.03)	(19.07)	(7.18)
Pusa Bold xT59	--	--	--	--	62.56	--	1.71	--	--	--	4.64	1.63
	(64.33)	**(128.00)**	(0.96)	**(8.00)**	**(512.67)**	**(4.65)**	(14.07)	**(3.16)**	(0.556)	(16.07)	(21.10)	**(8.63)**
Cream Pool xT59	--	--	--	--	80.65	--	--	--	--	--	**3.11**	**1.53**
	(66.33)	**(127.67)**	**(0.90)**	**(7.67)**	(500.00)	**(4.80)**	(13.10)	(3.11)	**(0.560)**	**(17.23)**	**(19.57)**	**(8.32)**
SCA range	-9.72 to 12.47	**-10.97** to 13.42	-0.09 to 0.28	-2.10 to 1.64	-140.93 to 155.68	-0.94 to 0.63	-2.23 to 2.36	-0.63 to 0.65	-0.042 to 0.027	-18.25 to 23.29	-7.03 to 8.02	-2.65 to 3.02
Range for per se performance Parents	56.00 to 75.67	105.33 to 129.333	1.03 to1.74	5.23 to10.00	363.00 to 495.00	3.65 to 5.15	10.13 to14.53	2.82 to 3.79	0.509 0.587	18.50 to43.60	4.80 to6.44	11.30 to 17.37
Hybrids	57.67 to80.33	105.00 to132.00	0.77 to 1.45	4.00 to 8.20	181.67 to 558.33	3.68 to 5.49	10.87 to 16.00	2.20 to 3.66	0.518 to 0.585	16.07 to 63.30	3.04 to 9.11	8.04 to 22.80

Values in parenthesis indicate per-se performance

ent. The cross Cream Pool x RH781 exhibited highest per se performance (22.40 gm) and SCA effects (8.43) in E1 for seed yield. The SCA effects of this cross was in desirable direction for yield contributing traits also. Further, this cross exhibited 129.27 and 96.24 per cent superiority over Varuna in terms of seed yield and oil yield, respectively. The highest per se performance (22.80 gm) and SCA effect (8.02) was exhibited by cross RH781xRC781 under E2 for seed yield. This cross was followed by T59xPHR1, RC781xPHR1, T59xRH755 and Pusa Bold xRC781. These crosses exhibited 101.76 & 69.79, 92.65 & 88.12, 92.03 & 71.87, 91.41 & 89.79 and 91.15 & 78.75 percentage superiority over Varuna for seed yield and oil yield per plant, respectively. All these crosses have also potential for some direct components of seed yield (Table-6).

Potential heterotic crosses involving atleast one parent of good general combining ability with non-significant SCA effects were identified for handling of segregating generations for getting transgressive segregants (8). No such cross could be identified for seed yield and oil yield. However, for some other characters few crosses could be identified as promising like T59xRH755 for days to flowering in E1, and RH781 x Culture and PHR1xCulture in E2 for harvest index. Besides this, heterotic crosses with significant SCA effect can also give transgressive segregants provided the GCA effects of parents are of greater magnitude (9). Based on this criteria, cross RH791xRH781 for harvest index in E1 and Cream PoolxRH781 for harvest index and Cream PoolxPHR1 for number of seeds per siliqua in E2 were found promising (Table-7).

On the basis of heterosis and combining ability effects, the selection of parents can be done for hybridization. Like-wise crosses can also be selected both for handling of segregating generations with an aim to obtain transgressive segregants or for commercial exploitation of heterosis. The crosses Cream Pool xRH781 under E1, and T59xPHR 1, RC 781 x PHR1, T59xRH 755 and Pusa Bold xRc 781 under E2 were identified as potential for commercial exploitation of heterosis both for yield and oil yield per plant. In these cross combinations, development of male sterile in one parent and its complete fertility restoration by other parent would make feasibility of commercial exploitation of heterosis.

Simultaneously, under E1, the parents like culture, RC781, T59, Pusa Bold and Cream Pool may be used for initiating a cyclic improvement programme. This is suggested as these parents were good general combiners for seed yield and oil yield. Like wise under favourable environment the same approaches can be used using the parents like PHR1, RC 781, T59, Pusa Bold and Cream Pool.

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Table :6 Significant standard heterosis for seed yield and other traits in Indian Mustard

S.N.	Crosses	Siliquae/plant	Seeds/Siliqua	Harvest index (%)	Oil Yield/Plant	Seed Yield/Plant
	E1					
1.	Cream Pool x RH781	20.86 (78.34)	–	30.32 (29.41)	28.98 (96.24)	30.49 (129.27)
	E2					
2.	RH781 x RC781	–	10.09 (57.94)	–	26.54 (69.79)	31.29 (101.76)
3.	T59 x PHR1	–	–	31.13 (37.32)	40.20 (88.12)	25.37 (92.65)
4.	RC781 x PHR1	–	–	24.69 (30.60)	28.09 (71.87)	24.95 (92.03)
5.	T59 x RH755	12.79 (45.02)	–	–	41.39 (89.79)	24.57 (91.41)
6.	Pusa Bold x RC781	11.92 (43.89)	–	–	33.11 (78.75)	24.38 (91.15)
7.	Pusa Bold x T59	–	–	–	33.89 (79.79)	21.50 (86.72)
8.	RH791 x Culture	–	–	–	19.04 (59.79)	18.23 (81.68)
9.	Cream Pool x T59	–	–	–	29.18 (73.33)	12.67 (73.18)

Table :7 Heterotic crosses with their combining ability effects for different characters in Indian Mustard

Character	Crosses	gi	gj	Sij
E1				
Days to flowering	T59 (H) x RH755 (L)	-2.20	-1.10	-2.85
Harvest index	RH791 (M) x RH781 (H)	4.59	8.79	6.38**
E2				
Harvest index	RH781 (H) x Culture (H)	2.63	2.73	-2.92
	PHR1 (M) x RH781 (H)	1.70	2.73	-2.95
	Cream Pool (L) xRH781 (H)	0.86	2.63	3.35**
No. of seeds/siliqua	Cream Pool (H) x PHR1 (L)	0.53	0.37	0.48*

*, ** indicates significance at 5% and 1% level, respectively.

J. Oilseeds Res. 16(2) 1999 : 203-209
ISSN 0970-2776

GENETICS OF RESISTANCE TO RENIFORM NEMATODE IN CASTOR (*Ricinus communis* L).

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ABSTRACT

Evaluation of nine crosses for reaction to reniform nematode (*Rotylenchulus reniformis)* was carried out in pots and analysed using scaling test, six parameter model and three parameter model. High magnitude of additive and non-additive gene effects in the expression of resistance to reniform nematode in hybrid combination SPS 43-3x48-1 with higher mean and significant heterosis (-41.42%) and heterobeltiosis (-40.98%) in desirable negative direction suggested that the isolation of homozygous recombinants having desirable level of resistance to reniform nematode from advance segregation generations would be feasible. Low magnitude of narrow sense heritability observed for resistance to reniform nematode in almost all crosses revealed the importance of non-additive gene action in the expression of this trait.

Key Words : Nematode resistance, gene effects, heterosis, Castor

INTRODUCTION

Castor is an important oilseed crop prone to several biotic and abiotic factors affecting it's successful and profitable cultivation in our country. Plant parasitic nematodes are one of them. Reniform nematode *(Rotylenchulus reniformis* Linford and Oliveira, 1940) was first reported on Castor by Seshadri and Sivakumar (1963) in India and is a key nematode dreadly affecting Castor crop. The information on genetics of resistanc to reniform nematode is not available though the crop has great commercial value. Therefore, the present investigagion was undertaken for the estimation of genetic parameters for resistance to reniform nematode.

MATERIALS AND METHODS

A pot study was conducted at Department of Nematology, B.A. College of Agriculture, G.A.U., Anand Campus, Anand during January to April, 1996 involving nine crosses viz., SPS 43-3X 48-1, 48-1 X ARUNA, 48-1X TMV5, SPS 43-3 X SKI 49, VP 1 X ARUNA, VP 1 X TMV5, ARUNA X SKI 49, TMV5 X SKI 12 & SKI 12 X SKI 49, each having six generations (P1, P2, F1, F2, B1 & B2) in complete randomized block design with three replications in net house.

Parents were selected on the basis of their reaction to reniform nematode *(Rotylenchulus reniformis)* as follows:

Sr. No.	Genotype	Mean number of females of reniform *nematode/plant*	Reaction
1.	48-1	7.00	R
2.	SPS 43-3	4.00	R
3.	ARUNA	14.00	MR
4.	VP-1	13.00	MR
5.	TMV 5	25.00	S
6.	SKI 12	27.00	S
7.	SKI 49	39.00	HS

Scale :

0 - HR (Highly Resistant)
1 to 10 - R (Resistant)
11 to 20 -MR (Moderately resistant)
21 to 30 -S (Susceptible)
> 30 - HS (Highly susceptible)

Standard practices established for extraction, inoculation and screening for reniform

Received for publication in September, 1998.

nematode at this department were followed during the investigation. In six generations of each of the nine crosses, number of female reniform nematodes was counted per plant. Five plants each in P1, P2 and F1, ten plants each in B1 and B2 and 20 plants each in F2 population in all nine crosses were sampled for counting number of female reniform nematodes 12 days after inoculation of seedling at two leaf stage. Analysis was done using scaling test (Hayman and Mather, 1955), six parameter model suggested by Hayman (1958) and three parameter model suggested by Jinks and Joens (1958).

RESULTS AND DISCUSSION

The analysis of variance revealed significant differences among different generations in all crosses (Table 1) for resistance to reniform nematode except cross V and IX (VP 1 X ARUNA AND SKI 12 X SKI 49)

The estimates of scaling tests (Table 3) were significant for Crosses I, II, III, IV, VII and VIII indicating the presence of non-allelic interaction for this trait. However, CrossVI showed non-significant scaling test suggesting involvement of only intra-allelic interaction for the expression of resistance to reniform nematode.

The partitioning of genetic components of variance summerised in Table 3 revealed that in Cross I, all the gene effects were found significant for the expression of this trait. However, only dominance and additive X additive gene effects were of greater magnitude in the desirable negative direction. Barring additive, all other gene effects were significant in cross II in which dominance and additive X additive gene effects were higher in magnitude with desirable negative effects.

In Cross II, dominance X dominance and additive X dominance components of interallelic interaction were significant. All the gene effects Viz. additive, dominance and epistatic were highly significant in Cross IV, where dominance and additive X additive components exhibited desirable negative effects in that order. The opposite direction of dominance and dominance X dominance components revealed predominance of non-additive gene action indicating the presence of duplicate type of epistasis. In cross VI only additive gene effect was found significant with desirable negative effect of lower mangnitude. In case of cross VII all the gene effects except additive X dominance interaction effect were found significant wherein additive X additive, dominance and additive gene effects were negative and of higher magnitude in that order. However, the opposite signs of dominance and dominance X dominance indicated that the interactions were on balance and mainly of duplicate epistasis in nature. In cross VIII only

Table 1 : Analysis of variance of six generations for resistance to reniform nematode in nine crosses of Castor.

Source	df	Crosses								
		I	II	III	IV	V	VI	VII	VIII	IX
Replication	2	2.662	0.082	0.164	4.425	0.218	1.677	5.292	0.007	0.051
Generation	5	96.530**	16.799**	34.285**	119.348**	2.558	13.248**	25.169**	3.004**	1.621
Error	10									

* and ** indicate significance at 5 and 1 % levels of significance, respectively.

Table 2 : Mean values of number of reniform female nematodes/plant for six generations in nine crosses of castor

Crosses	Generations*						S.Em.±	C.D. (0.05)	C.V. %
	P1 (5)	P2 (5)	F1 (5)	F2 (20)	B1 (10)	B2 (10)			
I	5.93	6.02	3.50	10.97	4.78	6.01	0.13	0.39	3.50
II	5.87	12.53	8.73	11.38	8.30	8.95	0.62	1.98	11.70
III	8.97	18.43	11.60	12.75	9.80	10.98	1.14	3.60	16.38
IV	9.10	27.73	17.20	16.63	12.32	16.52	0.53	1.65	4.99
V	14.27	12.90	12.83	13.94	14.83	14.97	0.58	NS	7.25
VI	13.57	19.53	16.80	17.33	16.22	18.77	0.78	2.45	7.91
VII	15.27	22.63	18.97	22.90	18.27	20.64	1.06	3.34	9.27
VIII	21.97	23.73	22.27	23.10	21.77	24.22	0.41	1.29	3.10
IX	20.73	21.93	20.57	22.13	21.70	22.30	0.69	NS	5.52

* Number in ( ) indicates mean value of the plants.

additive X dominance and additive components were significant with desirable negative effect.

Significant dominance and additive X additive effects of relatively higher magnitude in desirable negative direction were observed in crosses I, II, VII and IV. However, significant additive effects in negative direction were noted in crosses I, IV, VI, VII andVIII but were of very low magnitude.

Plant parasitic nematodes are real threat to successful and profitable cultivation of castor crop. The significant involvement of dominant and additive X additive gene effects in the expression of resistance to reniform nematode in Cross I, II, IV and VII suggested that hybrid vigour or cyclic method of breeding (i.e. recurrent selection) can profitably be used for improvement of this character. Duplicate epistasis coupled with significant negative (additive X additive) effects in these crosses (i.e. I, II, IV and VII) further indicated the possibility of obtaining genotypes with higher level of resistance in advance segregating generations. The involvement of additive gene effects in cross I, IV, VII and VIII in desirable negative direction revealed that the isolation of homozygous recombinants having desirable level of resistance from the segregating populations of these crosses would be feasible and thus hybridization followed by selection would be an appropriate breeding method for the improvement of this trait.

Heterosis and Inbreeding depression

For this character, parent having less number of females of reniform nematode on infection was considered to be a better parent (Table 4).

Relative heterosis ranged from - 41.42% (Cross-I) to 1.51% (Cross-VI). Highly significant negative heterosis was observed in Cross-I (-

Table 3 : Estimates of scaling tests and gene effects for number of reniform female nematodes/plant in castor.

Crosses	Scaling tests				Gene effects								
					Six parameter model						Three parameter model		
	A	B	C	D	m	d	h	i	j	l	m	d	h
I	0.12	2.51**	24.92**	11.14**	10.97**	-1.24**	-24.76**	-22.29**	-2.39**	19.66**	-	-	-
II	2.00	-3.37**	9.64**	5.50**	11.38**	-0.65	-11.47**	-11.01**	5.37**	12.37**	-	-	-
III	-0.97	-8.07**	0.41	4.72	12.75**	-1.18	-11.55	-9.45	7.10**	18.48*	-	-	-
IV	-1.67	-11.90**	-4.73	4.42**	16.63**	-4.20**	-10.06**	-8.84**	10.23**	22.41**	-	-	-
VI	2.07	1.20	2.61	-0.33	-	-	-	-	-	-	15.89**	-2.98**	4.84
VII	2.30	-0.31	15.77**	6.89**	22.90**	-2.38**	-13.76**	-13.77**	2.61	11.78**	-	-	-
VIII	-0.70	2.43*	2.18	0.22	23.10**	-2.45**	-1.03	-0.45	-3.13*	-1.29	-	-	-

* and ** indicates significance at 5 and 1 % levels of significance, respectively.

Table 4 : Estimates of heterosis (M.P.%), heterobeltiosis (B.P.%) inbreeding depression, heritability and genetic advance as percent of mean for resistance to reniform nematode in nine crosses of castor

	Crosses	Heterosis (%)		Inbreeding depression	Heritability(%)		Genetic advance
		Mid Parent	Better Parent	(%)	Broad sense	Narrow sense	(% of mean)
I	SPS 43-3x48-1	-41.42**	-40.98**	-68.09**	99.27	1.99	1.75
II	48-1 X ARUNA	-5.11	48.72**	-30.36**	81.51	8.51	4.81
III	48-1 X TMV 5	-15.33	29.32	-9.91	72.07	7.29	4.11
IV	SPS 43-3 X SKI 49	-6.59	89.01**	3.31	97.95	0.69	0.49
V	VP 1 X ARUNA	-5.56**	-0.54	-8.65	33.34	52.82	14.88
VI	VP 1 X TMV 5	1.51	23.80**	-3.15	67.73	10.11	2.99
VII	ARUNA X SKI 49	0.11	23.23*	-10.70*	68.36	6.41	2.27
VIII	TMV 5 X SKI 12	-2.54	1.37	-3.73	62.48	22.38	2.33
IX	SKI 12 X SKI 49	3.56	-0.77	-6.81	4.58	12.53	1.83

* and ** indicates significance at 5 and 1 % levels of significance respectively

41.42%) and Cross V (-5.56%). Thus, out of nine crosses, only two crosses viz., CrossI and Cross V showed desirable heterosis for resistance to reniform nematode in castor. The estimates of heterobeltiosis for the trait ranged from -40.98% (Cross I) to 89.01% (Cross IV). It was found that Cross I (-40.98%) exhibited highly significant negative heterobeltiosis, whereas Cross II (48.72%), Cross V (89.01%), Cross VI (23.80%) and Cross VII (23.23%) showed significant positive heterobeltiosis. Thus, out of nine crosses, only Cross I showed desirable heterobeltiosis for resistance to reniform nematode in F1.

The cross combination, SPS 43-3 X 48-1 (Cross I) depicted the highest magnitude of highly significant negative relative heterosis (-41.42%) and heterobeltiosis (-40.98%) with the minimum number (3.50) of females of reniform nematode/ plant followed by Cross 48-1 X Aruna (Cross II) with -5.11% relative heterosis and 48.72% heterobeltiosis and 8.73 mean number of females of reniform nematode/plant. The nematode infects the plant at all stages (i.e. from germination to maturity) which makes difficult to control it through plant protection. Therefore, breeding nematode resistant variety/hybrid is most economical and feasible for yield sustainability. To develop resistant hybrids the information on inheritance of resistance to reniform nematode is of paramount importance.

The magnitude of inbreeding depression varied from -68.09% (Cross I) to 3.31% (Cross IV). Crosses viz., I (-68.09%), II (-30.36%) and VII (-20.70%) revealed significant negative inbreeding depression, indicating the higher level of infestation of reniform nematodes in F2 population as compared to F1. The inbreeding depression was found to be positive in Cross III (3.31%). Which was non-significant.

Heritability and Genetic Advance

The heritability estimates in broad sense ranged from 4.58% (Cross IX) to 99.27% (Cross I), whereas the narrow sense heritability ranged from 0.69% (Cross IV) to 52.82% (Cross V). It was observed that Cross V and IX exhibited high narrow sense heritability than their respective broad heritability values (Table 4). This may be due to interactions of environment with gene complex. Cross V expressed moderate broad sense and high narrow sense heritability alongwith high genetic advance which indicated better opportunity for selecting relatively resistant genotypes in segregating populations. The estimates of genetic advance as per cent of mean varied from 0.49% (Cross IV) to 14.88% (Cross V). Crosses I, II, III, IV, VI and VII exhibited low narrow sense heritability indicating the predominance of non additive gene action. Cross VIII expressed high broad sense and moderate narrow sense heritabilty alongwith moderate genetic advance which indicated better opportunity for selecting relatively resistant genotypes in advanced generations. Crosses II, III, VI and VII expressed high broad sense heritability and low narrow sense heritability coupled with moderate to high genetic advance which indicates that some, but not significant imporvement in the resistance to reniform nematode could be achieved through selection in segregating generations. Very high broad sense heritability and very low narrow sense heritability coupled with low genetic advance in Cross I and Cross IV indicated very little possibility of improving this character by straight selection.

Among the various crosses (involving diverse parents) attempted for resistance to reniform nematodes, hybrid combination viz. SPS 43-3 X 48-1 with higher mean, significant predominat involvement of nonadditive gene effects, highest magnitude of heterosis and heterobeltiosis in desired negetive direction and low narrow sense heritability suggested that the isolation of homozygous recombinants having desirable level of resistance from advance segregating generations would be feasible.

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J. Oilseeds Res. 16(2) 1999 : 210-212
ISSN 0970-2776

REACTION OF DIVERSE CMS SOURCES, TESTERS AND THEIR HYBRIDS TO DOWNY MILDEW CAUSED BY *Plasmopara halstedii* IN SUNFLOWER *(Helianthus annuus* L.)*

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ABSTRACT

Thirty six sunflower hybrids synthesized in the background of three diverse sources of cytoplasmic male sterility (CMS) viz., *Helianthus petiolaris* (CMS-F), *Helianthus petiolaris* ssp. fallax (CMS-PF) and *Helianthus annuus* ssp. lenticularis (CMS-I) along with their respective male (12) and female parents (3) were screened in disease sick plots under field condition to study their reaction to downy mildew caused by *Plasmopara halstedii.* Among the three sources CMS-F recorded 86 per cent susceptibility, while CMS-PF and CMS-I exhibited complete resistance. The disease reaction among restorers varied from highly resistant (0-incidence) to complete susceptibility (100% incidence). The hybrids of the cytoplasmic background of CMS-F exhibited susceptibility from 30.33 to 100 per cent, while that of the hybrids of CMS-I revealed 0.00 to 60.00 per cent susceptibility. On the contrary, all hybrids in the background of CMS-PF were free of downy mildew. Overall results indicated that the female parents seems to have greater influence in determining the level of resistance of the hybrid to downy mildew.

Key Words : Cytoplasmic male sterility, Diversification, Downy mildew, *Helianthus*, *Plasmopara halstedii*

INTRODUCTION

Downy mildew of Sunflower being a destructive seed, soil and air borne disease is of considerable economic importance in the recent years. In India, the disease which was first noticed in Marathwada region of Maharashtra in 1984 has spread to many newer areas in the neighbouring states of Andhra Pradesh and Karnataka in recent years. The severity of disease causing yield loss up to 50 per cent or even more has threatened the sunflower cultivation in the country and has thrown fresh challenges to the breeders (Viranyi, 1992)

Several studies have been made to identify resistant sources in the cultivated species of *Helianthus*. Mayee and Patil (1987) and Patil and Mayee (1988) reported sources of resistance in cultivars, hybrids, restorers and CMS lines of sunflower. However, limited attempts have been made till now to study the influence of cytoplasmic background on disease reaction. Nevertheless, many reports stress the need for CMS diversification for superior economic traits and also as a means for checking vulnerability of hybrids to diseases (Fleming, 1972; Gracen and Grogan, 1974; Kumar *et al.*, 1983; Kruleva *et al.*, 1988; Davidenko *et al.*, 1988; Mangat and Virk, 1993 and Gill, 1993)

In the present investigation, an attempt was made to assess the differential reaction of sunflower hybrids having different cytosterile backgrounds viz., *Helianthus petiolaris* (CMS-F), *Helianthus petiolaris* ssp. fallax (CMS-PF) and *Helianthus annuus* ssp. lenticularis (CMS-I) to downy mildew incited by *Plasmopara halstedii.*

MATERIALS AND METHODS

The three diverse cytoplasmic male sterile (CMS) sources viz., *Helianthus petiolaris*

* Part of the Ph.D. thesis submitted to the University of Agricultural Sciences, Bangalore by the first author.

Recived for publication in September, 1998.

(Leclercq, 1969), *Helianthus petiolaris* ssp. fallax (Serieys, 1987) and *Helianthus annuus* ssp. lenticularis (Heiser, 1982) designated as CMS-F, CMS-PF and CMS-I, respectively, their corresponding pollen fertile counterparts and twelve testers viz. Morden, Acc. Nos. 218, 398, 400, 401, 402, 438, 652, 666, 693, 781 and 1091 which are susceptible to downy mildew were used in the present investigation.

A total of 36 hybrids (H1 to H36) of different cytoplasmic backgrounds as given in Table1 were developed by crossing three diverse CMS sources (CMS-F, CMS-PF and CMS-I) to a common set of 12 testers (Morden, Acc. Nos. 218, 398, 400, 401, 402, 438, 652, 666, 693, 781 and 1091) under field conditions. The parents and the hybrids were tested for reaction to downy mildew at the downy mildew research center, Oil seeds Research Station, Latur, Maharashtra and the reaction to downy mildew was expressed in percentage.

RESULTS AND DISCUSSION

The reaction of CMS sources, testers and their hybrids to downy mildew in disease sick plots under field conditions is presented in Table -1.

Reaction of Parents

Among the three cytoplasmic male sterile lines CMS-F showed susceptibility to an extent of 86.00 per cent while, CMS-PF and CMS-I exhibited complete resistance (0-incidence) in disease sick plots. The twelve male parents involved in the study showed varying reaction ranging from highly resistant (0-incidence) in Acc. Nos. 218,438,693 and 781 to complete susceptibility (100% incidence) in Acc. No. 398.

Reaction of hybrids

Disease incidence of the hybrids having CMS-F cytoplasmic background varied from 30.33 (H2) to 100 per cent (H4, H5,H7, H8 and H10) with an overall mean of 83.52 per cent. In contrary, hybrids of CMS-PF were free of downy mildew disease. Among the Hyrbids of CMSI, H28 and H32 exhibited 37.5 and 60 per cent infection, respectively while, the other hybrids showed complete resistance (0-incidence).

The cytoplasmic sources involved in the study showed differential reaction to downy mildew. These results are similar to the findings of Gracen and Grogan (1974) who recorded differential reaction of three diverse maize cytoplasm to *Helminthosporium maydis and Phyllosticta maydis*. The female parents seem to have greater influence in deciding the level of resistance in the hybrids as the level of resistance observed in hybrids was comparable to their respective female parents. Nevertheless, it is difficult to say with precision that the resistance conferred to the hybrids was solely due to cytoplasmic differences and not due to differences in the nuclear factors present in the different CMS sources. This question can be answered only when alloplasmic lines are developed and the resultant hybrids are tested for downy mildew reaction. However, to confirm the possible role of female parents in deciding the extent of susceptibility/resistance in the hybrids needs further investigation.

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Table1 : Incidence of downy mildew in diverse CMS sources, testers and their hybrids of sunflower

S.No.	Parents/Hybrids	Incidence (%)
A. Parents		
(i)	**Females(CMS Sources)**	
1	CMS-F	86.00
2.	CMS-PF	0.00
3.	CMS-I	0.00
(ii)	**Males (Testers)**	
1.	Morden	57.14
2.	Acc. No. 218	0.00
3.	Acc. No. 398	100.00
4.	Acc. No. 400	20.00
5.	Acc. No. 401	40.00
6.	Acc. No. 409	60.00
7.	Acc. No. 438	0.00
8.	Acc. No. 652	2.67
9.	Acc. No. 666	88.88
10.	Acc. No. 693	0.00
11.	Acc. No. 781	0.00
12.	Acc. No. 1091	20.00
B	**Hybrids**	
1.	CMS-F x Morden	90.00
2.	CMS-F x 218	30.33
3.	CMS-F x 398	90.00
4.	CMS-F x 400	100.00
5.	CMS-F x 401	100.00
6.	CMS-F x 409	70.00
7.	CMS-F x 438	100.00
8.	CMS-F x 652	100.00
9.	CMS-F x 666	88.88
10.	CMS-F x 693	100.00
11.	CMS-F x 781	50.00
12.	CMS-F x 1091	80.00
13.	CMS-PF x Modern	0.00
14.	CMS-PF x 218	0.00
15.	CMS-PF x 398	0.00
16.	CMS-PF x 400	0.00
17.	CMS-PF x 401	0.00
18.	CMS-PF x 409	0.00
19.	CMS-PF x 438	0.00
20.	CMS-PF x 652	0.00
21.	CMS-PF x 666	0.00
22.	CMS-PF x 693	0.00
23.	CMS-PF x 781	0.00
24.	CMS-PF x 1091	0.00
25.	CMS-I x Modern	0.00
26.	CMS-I x 218	0.00
27.	CMS-I x 398	0.00
28.	CMS-I x 400	37.50
29.	CMS-I x 401	0.00
30.	CMS-I x 409	0.00
31.	CMS-I x 438	0.00
32.	CMS-I x 652	60.00
33.	CMS-I x 666	0.00
34.	CMS-I x 693	0.00
35.	CMS-I x 781	0.00
36.	CMS-I x 1091	0.00

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J. Oilseeds Res. 16(2) 1999 : 213-215
ISSN 0970-2776

PARAMETERS OF GENETIC VARIABILITY AND CORRELATION STUDIES IN LINSEED (*Linum usitatissimum* L.)

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ABSTRACT

Higher genetic variation was observed for all the characters studied except for plant height, though the differences were highly significant among the genotypes for all the characters including plant height as well. High heritability coupled with high genetic advance values were observed for number of capsules per plant, primary and secondary branches. Grain yield exhibited positve and significant correlation coefficient values with all the characters except plant height.

Key Words: Linseed, heritability, genetic advance, correlations.

INTRODUCTION

India has largest area in the world under linseed crop which has several commercial uses for oil and fibres. However, the grain yield is very low (260 kg/ha) as compared to Canada (1080 kg/ha) being the highest. The exploitation of genetic variability is important for further genetic upgradation in this crop as genetic variation is the base for effective plant improvement programme. The estimates of heritabilty and correlation coefficients among the component characters provide a base of the extent of genetic gain per cycle through selection. The present study was carried out with a view to finding out the parameters of genetic variability for yield and its components in linseed.

MATERIALS AND METHODS

The experimental material, consisting of eighteen elite genotypes of linseed, was grown in Randomized Block Design with three replications during *Rabi* 1995-96 at PAU, Regional Research Station Gurdaspur. Each genotype was grown in a single row of three meter length, spaced 22 cm apart with plant to plant spacing of 5 cm. Data were recorded on five competitive plants of each entry for grain yield (g), plant height (cm), number of primary and secondary branches, capsules per plant and dry matter yield (g). The mean values were used to estimate the various statistical/genetic parameters following Kempthorne, (1957).

RESULTS AND DISCUSSION

The analysis of variance presented table 1. showing highly significant variety mean squares for all the characters revealed that the genotypes were considerably variable.

Genetic variability

All the characters exhibited wide range of variability (Table 2) except plant height. Smaller differences between the PCV and GCV indicated that the variability was primarily due to genotypic differences. Therefore, selection based on phenotypic differences is expected to be effective. The heritability estimates obtained were high for number of capsules, primary and secondary branches. High heritabilty coupled with high genetic advance observed for these characters revealed the importance of additive gene effects vis-a-vis better scope for improvement through selection. High heritability estimates associated with high genetic advance were also reported for yield, number of capsules and branches per plant by Kumar and Singh, (1969).

Received for publication in September, 1998

Table1 : Analysis of variance for various economic characters

Sources of Variation	d.f.	Mean Squares					
		Yield	Pri. Br.	Sec.Br.	Pl.ht.	Cap./pl.	Dry Matter
Replications	2	7.18	0.57	4.09	11.43	2066.01	3.28
Varieties	17	17.19**	6.29**	229.76**	96.22**	6597.14**	106.04**
Error	34	3.67	0.67	25.95	11.52	354.47	25.98

**, Significant at p = 0.01

Table2 : Genetic variability parameters

Character	GCV (%)	PCV (%)	Heritability (%)	Genetic advance as % of mean	Mean	Range
Grain yield	27.28	36.81	55.00	36.65	7.77	3.73-15.20
Primary branches	31.64	36.72	73.62	47.11	4.33	2.40-7.20
Secondary branches	32.23	37.90	72.36	48.25	25.57	14.70-45.60
Plant height	8.24	9.78	71.02	12.21	64.45	54.90-77.50
Capsules /plant	28.97	31.33	85.44	47.12	157.50	89.90-249.60
Dry matter	22.19	31.16	50.66	27.42	23.30	16.00-36.00

Correlations

The estimates of correlation coefficients presented in table 3. indicated that grain yield had positive and highly significant association with all the characters except plant height. The genotypic correlation coefficients were invariably higher than phenotypic correlation coefficient for all the characters. Patil *et al.* (1980) and Chandra, (1978) also reported the positive association of seed yield with capsules number. Plant height showed non-significant but positive association with grain yield and secondary branches whereas, Doucet, (1978) observed a strong positive association between yield and stem length.

The genetic variability and for that matter biometrical informations available have not been fully exploited in linseed improvement. The proper use of this knowledge is needed to tailor the architecture of new genotypes. The future breeding strategy should envisage the exploitation of genetic variability vis-a-vis better genetic stocks become available for use in genetic improvement of linseed.

Table3 : Estimates of phenotypic (P) and genotypic (G) correlation coefficients

Character		Grain yield (g)	Primary branches	Secondary branches	Plant height (cm)	Capsules /plant	Dry matter (g)
Grain yield	P	-	0.729**	0.746**	0.195	0.506**	0.805**
	G		0.864**	0.871**	0.197	0.571**	0.913**
Primary branches	P		-	0.856**	0.340*	0.627**	0.778**
	G			0.900**	0.360*	0.670**	0.884**
Secondary branches	P			-	0.313	0.565**	0.608**
	G				0.314	0.594**	0.638**
Plant height	P				-	0.337*	0.455**
	G					0.369*	0.493**
Capsules /plant	P					-	0.646**
	G						0.739**
Dry matter	P						-
	G						

*, Significant at p = 0.05

**, Significant at p = 0.01

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J. Oilseeds Res. 16(2) 1999 : 216-218
ISSN 0970-2776

STUDY OF GENETIC DIVERGENCE IN GROUNDNUT OVER LOCATIONS

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ABSTRACT

Twenty eight genotypes of groundnut were grouped into five clusters at both locations, viz., Midnapur and Purulia. Genotypes grouped together were of diverse origin for both the locations. Cluster composition and intercluster genetic divergence varied with change in location. The first two cononical roots accounted for about 55% and 70% of the total variability for Midnapur and Purulia, respectively. Pod yield/plant, harvest index and 100 seed weight were major contributors of total genetic divergence for both the locations. Genotypes of cluster I and PI 314817 were most stable diverse genotypes.

Keywords : Genetic divergence, groundnut, stability.

INTRODUCTION

The study of genetic diversity through the application of multivariate analysis by means of D^2 statistics and canonical analysis, is considered to be a useful approach for quantifying the degree of divergence between biological populations at genotypic level. Information on the genotypes contributing high degree of genetic divergence and its relation to stability over the environments is helpful in breeding programmes. Hence, the study aims to identify stable and diverse genotypes which can be effectively used in groundnut improvement programme.

MATERIALS AND METHODS

A total of thirteen spanish bunch (SB), five virginia bunch (VB), six virginia runner (VR) and four valencia (VL) groundnut genotypes were used for the study. The crop was grown in randomized block design with three replications during second week of July, 1993 at Midnapur and Purulia districts of West Bengal. Plot size was 5 x 5 m2 with spacing of 30 cm between rows and 10 cm within rows. A basal dose of NPK at the rate of 20:40:20 was given during land preparation. Irrigation was given as and when required. Observations were recorded on ten random plants excluding border rows for plant height, pod number per plant, shell weight per plant, 100 seed weight, biological yield, harvest index, pod yield per plant and seed yield per plant. The genetic diversity was estimated by Mahalanobis'D^2 statistic. The original variable (X's) which were inter correlated were transformed into a set of uncorrelated variables (Y's, linear function of X's) by Pivotal condensation method (Rao, 1952). The varieties were grouped into clusters. D^2 being treated as the square of generalized distance according to the method described by Tocher (Rao, 1952). The principle component analysis (Canonical analysis) was done to confirm the result of D^2 analysis.

RESULTS AND DISCUSSION

D^2 analysis

On the basis of D^2 values all the 28 genotypes were grouped into five clusters at both the locations. Cluster I comprised 23 genotypes, cluster II had two genotypes and cluster III, IV and V had one genotype each at both the locations (Table 1 and 2). In cluster I, twelve and thirteen genotypes were of Indian origin at Midnapur and Purulia, respectively. Rest were from USA, Africa, Brazil, Peru, Senegal, China and USSR in both the locations. Similarly, in cluster II at Purulia, two genotypes

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Recieved for publication in October, 1998.

Table 1. Distribution of groundnut genotypes in different cluster obtained by multivariate analysis and their place of acclimatization at Midnapur

Cluster No.	No. of genotypes	Genotypes	Origin
I	23	CS-13, ICGV 86015, Selection 230, TMV2(7731) Pant GS 23, FDRS 6, NRCG 3362 NRCG 2148, ICGV 87121, ICGV 86055, Gunajato	India
		NCAC 2326, EC 21989, Starr	USA
		NFG 79, NCAC 749	USA
		Ah 20, Ah 7171	Africa
		NCAC 17143	Brazil
		Code No.2	Peru
		64-2	China
		Zuled	USSR
II	01	Bhutani-9, GAUG 10	India
III	01	NRCG 2845	Senegal
IV	01	C-163	India
V	01	PI 314817	Peru

were from USA and Peru, where as genotypes from Cluster III and IV were of Indian Origin. The above cluster pattern indicates that genetic diversity among the genotypes was not always related with their place of acclimatization which supported the earlier observation of Golakia and Makne (1992) in groundnut. However, majority of the genotypes of Indian origin tended to be grouped together. This indicates that geographic distribution had at least some influence for clustering of populations but may not be considered as adequate index for genetic diversity. Human selection might have been a potent factor to cause genetic diversity. Significantly genotypes Bhutani-9 and GAUG-10 of Indian origin were shifted to cluster II at Midnapur location which were in cluster I at Purulia location. NCAC 2326 of USA origin belonging to cluster I at Midnapur location was found to be constituent member of cluster V at Purulia location. Similarly, NRCG 2845 of cluster III at Midnapur also. This demonstrates the change of cluster composition due to the change of location. Environment thus, influences the cluster composition. This can further be amplified when genetic distance between clusters obtained at two locations were compared. At Midnapur, minimum genetic divergence was recorded between cluster II and III while at Purulia it was between cluster I and IV (Table 3). Maximum intercluster genetic divergence also varied with the change of location. At Midnapur maximum genetic divergence was observed between III and IV i.e., between NRCG 2845 (Senegal) and C 163 (India). While, at Purulia it was between cluster II and V i.e., between EC 21989 (USA), PI 314817 (Peru) and NCAC 2326 (USA). This again confirms that environment plays a major role in shifting a genotype from one cluster to another as observed by Das and Dasgupta (1984) in blackgram, Biswas and Das (1985) in lentil and Hazra (1991) in cowpea.

Canonical Analysis

Of the total variance, 33.06 and 39.52 were accounted by h_1 and 22.90 and 30.69 were by h_2 at

Table 2. Distribution of groundnut genotypes in different cluster obtained by multivariate analysis and their place of acclimatization at Purulia

Cluster No.	No. of genotypes	Genotypes	Origin
I	23	ICGV 86015, CS-13, Bhutani-9 Selection 230, Pant GS 23 FDRS 6, GAUG 10, C-163 ICGV 86055, Gunajato NRCG 3362	India
		NCAC 749, NFG 79, Starr	USA
		Ah 20, Ah 7171	Africa
		64-2	China
		Code No.2	Peru
		NCAC 17143	Brazil
		NRCG 2845	Senegal
		Zuled	USSR
II	02	EC 21989	USA
		PI 314817	Peru
III	01	TMV2 (7731)	India
IV	01	TMV2(7705)	India
V	01	NCAC 2326	Peru

Table 3.Average intra and inter cluster D^2 values in twenty eight genotypes of groundnut

Clusters	I	II	III	IV	V
Midnapur					
I	110.75208.05	343.75	499.32	292.91	
II	91.67	145.14	537.77	172.38	
III		0	1053.89	358.82	
IV			0	399.52	
V				0	
Purulia					
I	252.94493.50	407.13	353.02	546.91	
II	262.71	439.05	633.26	1077.42	
III		0	487.18	933.24	
IV			0	518.02	
V				0	

Midnapur and Purulia location, respectively. The first two canonical roots accounted for about 55% and 70% of the total variability for Midnapur and Purulia, respectively (Table - 4). It was found that clusters were distinctly delineataed to their respective positions confirming D^2 analysis. The canonical analysis revealed the importance of pod number in the first vector for both the locations, while the second vector showed the importance of pod yield at Midnapur. Harvest index at Purulia and pod number as well as 100 seed weight for both the locations. There was therefore, considerable concordance between the findings in two environments regarding the importance of pod yield, harvest index and 100 seed weight as major contributors of total genetic divergence.

Stable diverse genotypes

The D^2 analysis presented above indicates the sensitivity of cluster composition and intercluster distance due to environmental variation. Hence it is important and desirable to identify stable diverse genotypes which would cluster in same group in different environments consistently. In the present study a single genotype PI 314817 displayed high order of genetic distance consistently and never grouped into cluster I.

Table 4. Canonical analysis of twenty eight genotypes in two environments

Characters	Z_1		Z_2	
	Midnapur	Purulia	Midnapur	Purulia
Plant Height	0.0451	0.4101	-0.0089	-0.0785
Pod No.	0.9061	0.5885	0.2751	0.2238
Shell weight	-0.0038	-0.6376	0.0059	0.4235
100 seed weight	-0.3219	0.0860	0.4023	0.5187
B.Y.	0.2015	-0.2583	0.1075	-0.5107
H.I.	0.0792	-0.5164	0.1991	0.6782
Pod yield	-0.1304	0.0215	0.8226	0.1584
Seed yield	-0.0967	-0.0853	0.1856	-0.4585

Variation accounted by (E_1) = 33.06, (E_1) =22.90

(E_2)-39.52 (E_2)=30.69

Crossing between genotypes of cluster I and the genotype PI 314817 would throw desirable segregants for general or specific adaptation along with high mean performances of seed yield and of its component characters as suggested by Bhatt (1970) in wheat.

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J. Oilseeds Res. 16(2) 1999 : 219-226
ISSN 0970-2776

STUDIES ON PHYSIOLOGICAL AND BIOCHEMICAL ASPECTS OF SEED QUALITY IN NATURAL AGED SEEDS OF INDIAN MUSTARD (*Brassica juncea* L.)

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ABSTRACT

Eight seed lots of Indian mustard comprising two promising varieties viz., RH 30 and RH 8113 of *Brassica juncea* (L.) Czern & Coss. were subjected for various physiological and biochemical tests namely; standard germination, speed of germination, seedling vigour, electrical conductivity of seed leachates, respiration rate, protein content, peroxidase enzymes, total soluble carbohydrates, speed of emergence and grain yield. It was observed that seed quality and vigour of all the seed lots declined considerably after two years. However, this decline was more rapid in three and four year old seed in both the varieties. Standard germination, speed of germination, seedling vigour, respiration rate, protein content, peroxidase enzymes, speed of emergence and grain yield decreased significantly as the age of the seed increased. Electrical conductivity and total soluble carbohydrates increased significantly with increase in the age of seed. The standard germination, speed of germination, seedling vigour index, respiration rate, protein content, peroxidase enzymes, speed of emergence and seed yield had showed positive and significant correlation among themselves. The total soluble carbohydrates and electrical conductivity test were negatively and significantly correlated with all other parameters.

Key words :Physioloical, biochemical quality, age, seeds, mustard

INTRODUCTION

A seed is living system and like all living systems, it is subjected to degenerative processes which culminative in death (Delouche, 1963; Abdul-Baki and Anderson, 1972). Rapid deterioration of stored seeds is a serious problem in the tropical and subtropical countries where high temperature and high relative humidity greatly accelerate the seed ageing phenomenon. Vigour tests are normally designed to measure certain aspects of seed deterioration. The viability of carry-over seed lots deteriorates rapidly and it is important to sow the viable seeds. Although seed viability is not only a function of seed storage but a variety of factors to which the parent plant is exposed during seed formation can also profoundly affect subsequent viability of seeds. Physiological and biochemical changes occur in seeds during storage depending upon the storage condition (Roos, 1980). Since the pre-storage history of seed lots differs, their physiological conditions, hence suitability for storage also differs markedly. There is a inverse relationship between seed vigour and seed deterioration. The deteriorative process is greatly increased by exposing them to very adverse levels of temperature and relative humidity (Delouche and Baskin, 1973). Information on the physiological and biochemical basis of seed viability is fragmentary. Hence, the present investigation was made to ascertain the effect of seed deterioration by natural ageing on the physiological and biochemical parameters of seed quality in different lots of mustard (*Brassica juncea* (L.) Czern & Coss.

MATERIALS AND METHODS

Eight seed lots of two varieties viz., RH 30 & RH 8113 of *Brassica juncea* (L.) Czern & Coss. were created by storing the seed from one to four years under ambient conditions. All the seed lots were subjected to standard germination, speed of

Recieved for publication in October, 1998.

germination, seedling vigour, electrical conductivity, respiration rate, total protein, peroxidase enzymes, total soluble carbohydrates, speed of emergence and grain yield.

Standard germination tests. Three replicates of 100 seeds per lot were placed on the top of the filter papers (T.P.) in 18 cm diameter petri plates containing 15 cm of water. The petri plates were kept in germinator at 20°C. The final count of normal seedlings was recorded on 8th day according to the rules of International Seed Testing Association (ISTA, 1985) and normal seedlings were expressed as percent germination.

Speed of germination. Seeds of all the lots with three replications of 100 seeds each were placed for germination as described for the standard germination tests. After the start of germination, germinated seeds were counted daily until the test was complete. The speed of germination index was calculated as described by Maguire (1962) as follows:

$$X = \frac{\text{No.of seeds germinated}}{\text{Da y s to first count}} + \cdots + \frac{\text{No.of seeds germinated}}{\text{Days to final count}}$$

Seedling vigour index. Seedling vigour index was calculated with the help of data recorded on germination percentage and seedling growth according to International Seed Testing Association (ISTA, 1985) by the formula given below.

Seedling vigour index = Seedling length (cm) x Germination percentage

Electrical conductivity. One hundred seeds in three replications were placed in 250 ml. flasks and then 50 ml. of deionised water was added. The flasks were placed in an incubator at a constant temperature of 20°C for 24 hours after which the contents of the flasks were gently stirred. The electrical conductivity of seed leachates was measured by conductivity meter. The conductivity was measured and expressed as μ mhos per cm per seed.

Respiration rate: A Gilson Differential Respirometer measured oxygen uptake. In order to find out the optimum stage of seedlings, respiration rate was measured daily startimg from one day old seedlings to five day old seedlings. The respiration rate was observed to be maximum in three days old seedlings. So for all subsequent samplings three days old seedlings were used. Ten normal seedlings taken at random were placed in the main compartment of reaction flasks having one ml. distilled water and 0.1 ml. of 20 per cent KOH in center well. A rolled filter paper strip of equal dimension was also placed in central well to increase the surface area for absorption of CO_2. The reaction flasks were placed in a 25°C water bath and were shaken at 78 oscillations/min for 30 minutes. Readings were taken three times at an interval of 30 minutes after equilibrating the system for 30 minutes. Respiration rate is reported as micro liters of oxygen absorbed per seedling per hour (μlO_2/seedling/hour) at standard temperature and pressure.

Total proteins. Total protein content was estimated by the method of Lowry *et al.* (1951) using Folin-Cio-Calteau reagent. The amount of protein was calculated from a standard curve prepared with gradient concentration of bovin serum albumin (Sigma Chemical CO. USA).

Peroxidase enzyme. Peroxidase activity was measured by the method of Shannon *et al.* (1966) following the oxidation of O-dianisidine in the presence of hydrogen peroxide. To 0.05 ml of enzyme extract was added 2ml of acetate buffer (pH 4.5) and 0.1 ml of O-dianisidine solution. To this was added 0.1 ml of 0.2M hydrogen peroxide to start the reaction. The reading was taken at 470 nm after every 15 seconds for one minute and enzyme unit was expressed as:

The amount of enzyme required to bring about a change in absorbance of 0.01 per minute (unit/g Fr.wt/minute).

Total soluble carbohydrates. Total soluble carbohydrates were estimated by the method of Yemm and Willis (1954). Extraction of soluble carbohydrates was done according to Bernett and Naylar (1966). Seed extract measuring 0.1 ml was taken in a test tube and evaporated to dryness. After cooling, the residue was dissolved in 1.0 ml of distilled water and kept in refrigerator for 2-3 hour. Then, 4.0 ml of anthrone reagent was added and the tubes were kept in the boiling water bath for 10 minutes. Bluish green colour so developed was read at a wave length of 620 nm against a reagent blank. Standard curve was prepared using graded concentration of glucose and the calculations were made from the standard curve.

Grain yield. (q/ha.). All the siliquae of the plant at maturity were threshed and seeds were weighed after air drying and the grain yield was expressed as q/ha.

RESULTS AND DISCUSSION

The results indicated that one and two years old seeds of both the varieties were observed to record germination percent above Minimum Seed Certification Standard level and it ranged from 86.67 to 98.0% with an average of 70.38% (Table-1). After 2 years, the germination percentage declined significantly and ranged from 18.33% to 76.67%. The effect of natural ageing was more pronounced in cultivar RH 30 than in cultivar RH 8113 in later stages indicating that the latter maintained its superiority over RH 30 in later stages, so it could be rated as a good storer. The standard germination has been shown to be positively and significantly correlated with all parameters except electrical conductivity and total soluble carbohydrates (Table-2).

The speed of germination index values ranged from 6.11 to 36.68 with an average of 22.50 (Table-1). As the age of the seed increased, the quality of the seed deteriorated. The germination speed slowed down significantly with increase in the age of the seed. The speed of germination values for seed lots 1,2,5 and 6 were of high magnitude and ranged from 23.83 to 36.68 whereas for seed lots 3,4,7 and 8, these values ranged from 6.11 to 24.50. The vigorous seeds have been shown to germinate rapidly The cultivar RH 8113 retained fastest speed (6.60) over RH 30 (6.11) in 4-year old seeds. The speed of germination was found to be positively and significantly correlated with all the parameters except electrical conductivity and total soluble carbohydrates (Table-2). The present results are in accordance with those of Saxena et al. (1987), Palanisamy and Karivaratharaju (1991) and Narwal (1995).

Seedling vigour index was calculated by standard germination (%) multiplied by seedling length (cm). It ranged from 61.77 to 1172.73 with average of 688.78. As the ageing period increased, the seedling vigour declined significantly in all the varieties. The seedling vigour index values for lots 1,2,5 and 6 were of higher magnitude (849.37 to 1172.73) whereas for seed lots 3,4,7 and 8 these values ranged from 61.77 to 682.36 (Table-1). Results also showed that the cultivar RH 8113 was more vigorous as compared to RH 30 in later stages. Seedling vigour index was positively and significantly correlated with all the traits expect electrical conductivity and total soluble carbohydrates (Table-2). The present results are in accordance with those of Saxena et al. (1987), Palanisamy and Karivaratharaju (1991) and Narwal (1995).

The conductivity values of seed leachates ranged from 10.20 to 31.56 μ mhos/cm/seed with an average of 18.70 μ mhos/cm/seed (Table-1). The seed lots differed significantly in conductivity, the amount of electrolytes which leach from the seeds. Poor membrance structure and leaky cells are usually associated with deteriorating and low vigour seeds. It is interesting to observe that as the age of the seed increased, conductivity also increased. The highest membranae integrity was

Table 1. Mean Values of different physiological and biochemical aspects of seed quality as influenced by natural ageing of Indian mustard cultivars

Cultivars	Natural ageing period (years)	Germination (%)	Speed of germination	Seedling vigour index	Electrical conductivity (μ mhos/cm/seed)	Respiration rate(μ $_1O_2$/seedling /h.)	Protein content (mg/g)	Peroxidase enzyme (unit/g fr. Wt./min.)	Total solube carbohydrates (mg/g)	Speed of emergence	Seed yield (q/ha.)
RH 30	1(1)*	98.00	36.68	1172.73	15.60	17.00	25.70	2150.00	31.73	34.57	29.22
	2(2)*	89.67	32.12	912.67	20.57	15.00	25.67	1976.67	33.00	31.47	22.56
	3(3)*	74.33	24.50	622.14	22.67	7.80	17.43	1166.67	39.67	23.47	13.48
	4(4)*	18.33	6.11	61.77	31.56	1.40	9.03	226.67	58.03	4.76	1.78
RH 8113	1(5)*	94.67	31.30	1098.17	10.20	18.60	20.77	1930.00	23.93	28.96	21.82
	2(6)*	86.67	23.83	849.37	15.50	16.00	20.47	1960.00	25.80	23.67	14.95
	3(7)*	76.67	18.87	682.36	16.50	10.00	16.40	1116.67	32.67	18.65	6.79
	4(8)*	25.67	6.60	111.00	16.97	3.20	9.65	306.67	55.40	5.98	1.25
	Mean	70.38	22.50	688.78	18.70	11.12	18.14	1088.11	37.53	21.44	13.98
CD (0.05)											
Variety(V)		1.12	1.05	17.53	0.30	0.54	0.42	27.89	0.40	0.65	0.79
Lot (L)		1.12	1.05	17.53	0.30	0.54	0.42	27.89	0.40	0.65	0.79
VxL		2.23	2.09	35.07	0.59	1.09	0.84	55.78	0.80	1.30	1.57

( )* Figures in parenthesis indicate the assigned lot number.

observed in RH 8113 as compared to RH 30 in all the lots. The extent of leakage from low vigour seeds also causes secondary effects. Nutrients exuded from seeds during germination stimulate micro-organism activity and secondary infection. The permeability of membranes has been observed to increase upon seed storage which is expressed by increased loss of electrolytes, sugars, amino acids and phenols in the leachates during imbibition (*Ghosh et al, 1981; Deswal and Sheoran,* 1993). Palamisamy and Karivaratharaju (1991) also observed increased leaching of electrolytes in tomato seeds with increased period of storage. The present results are in agreement with the work done by Diojode (1987) and Narwal (1995). The E.C showed negative correlation with all the parameters except total soluble carbohydrates (Table-2).

The respiration rate ranged from 1.40 to 18.60 $\mu l\, O_2$ per seedling per hour. The respiration rate values for seed lots 1,2,5 and 6 were of higher magnitude (15.00 to 18.60), whereas for seed lots 3,4,7 and 8, these values ranged from 1.40 to 10.00 (Table-1). The results also showed that RH 8113 exhibited high respiration rate as compared to RH 30 in all the lots. Respiration rate showed a significant positive correlation with all the parameters except electrical conductivity and total soluble carbohydrates (Table-2). Carver and Matthews (1975) also observed positive correlation between O_2 uptake and field emergence in pea seed lots averaged over nine sowing dates. Low rate of O_2 uptake, i.e. decreased respiration during deterioration has been reported by Woodstock (1969) and Mitra *et al.* (1974).

The protein content (mg/g) ranged from 9.03 to 25.70 with an average of 18.14 mg/g. The variety RH 30 recorded high protein content as compared to RH 8113, however it slightly decreased during 4 year of storage. The protein content had been shown to be high in vigorous seed and lower in the seed of low vigour. As the ageing period increased, the protein content decreased. For the seed lots viz; lot 1,2,5 and 6, the protein content ranged from 20.47 to 25.70mg/g whereas the protein content for seed lots 3,4,7 and 8 ranged from 9.03 to 17.43 mg/g. The protein content also showed a positive and significant correlation with all the traits except electrical conductivity and total soluble carbohydrates (Table-2).

The peroxidase activity was maximum in all the varieties in one year old seeds. After that all the varieties expressed continuous and gradual reduction in peroxidase activity in all the seed lots during ambient storage. As the ageing period increased the enzyme activity decreased. The peroxidase enzyme ranged from 226.67 to 2150.00 with an average of 1088.11 units/g Fr.wt/minute. Peroxidase enzyme showed positive and significant correlation with all the parameters except total soluble carbohydrates and electrical conductivity (table-2).

The total soluble carbohydraates ranged from 23.93 to 58.03 with an average of 37.57 mg/g. Total soluble carbohydrates were significantly high in RH 30 as compared to RH 8113 in all the seed lots. Total soluble carbohydrates exhibited significant and negative correlation with all the parameters except electrical conductivity (Table-2). Abdul-Baki and Anderson (1970) reported natural ageing to differ in loss of sugars, so it appears that the method has to be standardised carefully for seed of each crop. Kumari (1994) reported that total soluble sugars showed a general increase upon storage in onion.

Under field conditions, the speed of emergence was calculated as seedling emergence rate index. The speed of emergence values ranged from 4.76 to 34.57 with an average of 21.44. As the age of the seed increased, the quality of the seed deteriorated and thus the speed of emergence reduced significantly. The speed of emergence

Table 2 : Correlation coefficient (r) among different physiological and biochemical parameters of different seed lots of Indian mustard

Sr. No	Parameters	1	2	3	4	5	6	7	8	9	10
1.	Germination (%)	1.00	0.97**	0.97**	-0.80**	0.92**	0.76**	0.93**	-0.92**	0.98**	0.86**
2.	Speed of germination		1.00	0.96**	-0.72**	0.91**	0.76**	0.92**	-0.90**	0.99**	0.90**
3.	Seedling vigour index			1.00	-0.74**	-0.97**	0.87**	0.96**	-0.88**	0.96**	0.93**
4.	Electrical conductivity (μ mhos/cm/seed)				1.00	-0.78**	-0.52*	-0.69**	0.73**	-0.72**	-0.60*
5.	Respiration rate ($\mu_l O2$/seedling/h.)					1.00	0.86**	0.97**	-0.88**	0.91**	0.91**
6.	Protein content (mg/g)						1.00	0.88**	-0.61*	0.78**	0.91**
7.	Peroxidase enzymes *(units/g.Fr. Wt./min.)*							1.00	-0.87**	0.93*	0.93**
8.	Total soluble carbohydrates (mg/g)								1.00	-0.90**	-0.73*
9.	Speed of emergence									1.00	0.90**
10.	Seed yield (q/ha)										1.00

*Significant at 5.0 percent; ** Significant at 1.00 percent

values for seed lots 1,2,5 and 6 were of higher magnitude (34.57 to 23.67) whereas for the seed lots 3,4,7 and 8, these values were low and ranged from 4.76 to 23.47 (Table-1). Similar observations were also reported by Khattra *et al.* (1988) in soybean and Ram *et al.,* (1991) in pigeonpea. The speed of emergence showed significant and positive correlation with all the parameters except electrical conductivity and total soluble carbohydrates (Table-2).

The seed yield ranged from 1.25 to 29.22 q/ha. (Table-1). The variety RH 30 recorded significantly higher yield in all the lots as compared to RH 8113. Maximum seed yield was recorded with one year old seeds whereas it declined with the age of the seeds. The seed yield was significantly and positively correlated with all the parameters except electrical conductivity and total soluble carbohydrates (Table-2).

These results suggest that the seed vigour tests are more sensitive indices of seed quality than the standard germination test. Further, as seed deterioration was advanced by natural ageing in mustard seeds, the following physiological/biochemical changes were observed:

- The germination potential, speed of germination, seedling vigour, speed of emergence and seed yield declined.
- The electrical conductivity of seed leachates and total soluble carbohydrates increased.
- The enzyme activity e.g. peroxidase enzyme decreased.
- The respiration rate and protein content were reduced.
- The mustard seed should not be stored after two years under ambient conditions.

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J. Oilseeds Res. 16(2) 1999: 227-229
ISSN 0970-2776

TRANSFER OF DOUBLE LOW CHARACTERISTICS IN EARLY MATURING *Brassica napus*

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ABSTRACT

The work reports transfer of low erucic acid and low glucosinolate characteristics from exotic sources (B.napus var. Regent and Cyclone) in the early maturing lines of B.napus suitable for Indian growing conditions, through interspecific hybridization and half seed analysis. The fatty acids and glucosinolates were analysed by improved methods of Gas Liquid Chromatogrpahy(GLC) and High Performance Liquid Chromatography (HPLC). The newly developed double low strains TERI (OO)R 985 and TERI(OO)R986 have zero erucic acid in the seed oil and low glucosinolate (12-15 μ m/g) in the oil free meal. In addition, the former is dwarf and early maturing (125 days), a desired characteristic for growing under rainfed conditions.

Key words: Rapeseed, *B.napus*, nutritional quality, erucic acid, glucosinolates, double low.

INTRODUCTION

The rapeseed oil contains the lowest level of saturated fatty acids (6%) as compared to any other vegetable oil. It also contains adequate amounts of the two essential fatty acids; linoleic and linolenic. The oil free meal is a good source of proteins, well balanced amino acids and minerals. However, the adverse effects of erucic acid and glucosinolate on birds and animals (Gopalan *et al.* 1974; Kumar and Tsunoda 1980; Bille *et al.* 1983; Bell 1984), has resulted in the research efforts for breeding rapeseed mustard with low levels of these two nutritionally undesired components (Scarth 1995). The traditional rapeseed mustard cultivars grown in India have high erucic acid (40-50%) in the seed oil and high glucosinolates (80-160 μ m/g) in the oil free meal, restricting the global utilisation of Indian rapeseed mustard oil and cake. Efforts to introduce exotic 'Canola' quality (double low; having <2% erucic acid in the seed oil and <30 μ m glucosinolate/g oil free meal; Downey 1990) rapeseed cultivars in India did not meet with success due to non-adaptability of these nutritionally superior exotic cultivars to Indian agroclimatic conditions.

MATERIALS AND METHODS

The early maturing *B.napus* lines TBN-1 and TBN-5, derived from advanced generation backcross progeny of (*B.napus* x Raphanobrassica) x *B.napus* (Agnihotri *et al.* 1990) and selected for zero erucic acid through half seed technique (Agnihotri *et al.* 1995) were used as female parent. The exotic double low *B.napus* var. Regent and Cyclone were used as pollen donors for the transfer of double low characteristics.

The plants were grown to maturity and the F_1 seeds were harvested. The F_2 single plants were grown in experimental plots at TERI field station, Gual Pahari, Gurgaon, following the standard agronomic practices. The plants were bagged, and selfed and open pollinated (OP) F_3 seeds were collected from a large number of individual plants.

The F_3 OP seeds were analyzed for their glucosinolate content by an improved HPLC method (Kaushik and Agnihotri 1999). The selfed seeds of the plants, showing less than 30μm glucosinolate/g oil free meal, were utilized to raise single plant progenies. During the next three subsequent generations the single plant progenies

Received for publication in October, 1998.

were grown, and selfed and OP seeds were harvested from the individual plants. The glucosinolate content was analyzed in each generation to select plants having glucosinolate less than 30 µm/g oil free meal. Simultaneously the plants were selected for early maturity in each generation.

The F6 selfed seeds of the plants having less than 30µm glucosinolate/g oil free meal, were analyzed for their fatty acids content. The fatty acids composition was determined by an improved GLC method (Kaushik and Agnihotri, 1997). The plants having less than 2% erucic acid in the seed oil and less than 30µm aliphatic glucosinolate/g oil free meal were identified for further progeny advancement. The F7 single plant progenies of the double low plants were grown in the field during *rabi* 1997-98 for collection of selfed and OP seeds, and agronomical data were recorded.

RESULTS AND DISCUSSION

The glucosinolate content of the F3 seeds in the crosses *B.napus* line TBN-1 x *B.napus* var. Regent and *B.napus* line TBN-5 x *B.napus* var.Cyclone ranged from 16-120 and 11-40 µm/g oil free meal, respectively. From the plants analyzed, fifteen plants derived from crosses TBN-1 x Regent and eight plants derived from crosses TBN-5 x Cyclone were identified having less than 30 µm glucosinolate/g oil free meal. While some of the plant progenies segregated for glucosinolate content, others showed stable glucosinolate content. The plants synthesized less than 30 µm glucosinolate/g oil free meal in the subsequent generations (F4 to F6). In general, the plants derived from TBN-1 x Regent were early in maturity (120-130 days) as compared to those derived from crosses TBN-5 x Cyclone (125 to 145 days). The quality and agronomical characteristics (based on average of ten randomly selected plants) of the selected low erucic acid and low glucosinolate strains TERI(OO)R985 and TERI(OO)R986, derived from crosses TBN-1 x Regent and TBN-5 x Cyclone, respectively, are given in Table-1. These double low strains are 15 to 28 days early in maturity, they have more number of pods/plant and slightly higher seed weight as compared to the var.GSL-1. The selected lines have low erucic acid (<2%) and low glucosinolate (12-15µm) as compared to about 36% erucic acid and 77µm glucosinolate/g oil free meal in the *B.napus* national check var.GSL-1. In addition they have much higher oleic acid (48-57%) as against only about 25% in GLS-1. Therefore, the oil from these double low strains will have a better shelf life.

ACKNOWLEDGEMENTS

The financial assistance from NOVOD Board, Gurgaow is acknowledged. We are grateful to Dr.R.K. Downey, Emeritus Scientist, Agriculture and Agri-Food Canada Research Station, Saskatoon, Canada for gift of the double low pollen donors.

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Table 1 : The agronomical and quality characteristics of newly developed double low *B. napus* strains

Characteristics	Teri (OO)R985	Teri (OO)R986	GSL-1 (NC)
Agronomical			
Plant height (cm)	121	174	176
Primary branches/plant	6	10	8
Secondary branches/plant	4	5	4
Length from base to first branching (cm)	7	41	75
Siliquae/plant	218	291	155
Siliquae on main branch	28	47	34
Siliqua length (cm)	6.3	6.6	6.6
Seeds/siliqua	22	23	20
1000 seed weight (g)	2.76	3.13	2.25
Seed colour/size	Dark brown/ Medium	Dark brown/ Medium	Light brown/ Small
Seed yield/plant (g)	13.1	15.2	8.7
Days to maturity	125	143	153
Quality			
Oleic acid (%)	48.0	57.2	21.6
Linoleic acid (%)	32.7	22.3	14.8
Linolenic acid (%)	12.9	10.5	20.5
Erucic acid (%)	0.0	0.0	36.7
Glucosinolate (μm/g oil free meal)	15.3	12.2	77.2

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J. Oilseeds Res. 16(2) 1999 : 230-233
ISSN 0970-2776

GENETIC DIVERGENCE IN MUTANT CULTURES OF GROUNDNUT (*Arachis hypogaea* L.)

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ABSTRACT

Twenty one mutant cultures of groundnut (of M7 generation) along with parent AK 12-24 and checks Chico and Kuber were evaluated for genetic divergence on the basis of 13 characters. Both were taken to compare the variability induced by mutagenesis in other part of study. The cultures were grouped into 16 Clusters. Cluster I was the largest with 5 mutant cultures. The divergence was only due to genetic distance because cultures were derived from the same parent AK 12-24 by mutagenic treatments. Crossing between cultures in cluster VI and XVI would probably bring about desirable genotypes because of higher intercluster distance between these two clusters.

Key words : Groundnut, genetic divergence, mutant cultures

INTRODUCTION

Mutation creates genetic variability and provide the breeders the required opportunity to exploit probably the whole potential range of germplasm. The crosses between groups with the maximum genetic divergence would be more responsive to improvement, since they are likely to produce desirable recombinations in their progenies. Such estimates of divergence would also help choose parents for hybridization in order to exploit heterosis or to select desirable segregants. The present investigation aims at determining the genetic divergence in mutant cultures of groundnut.

MATERIALS AND METHODS

Twenty one mutant cultures (M7 generation) of groundnut cultivar AK 12-24 were derived by treatment with either solo gama rays/colchicine/ EMS or combined mutagenesis under oilseeds Improvement Project of Tirhut College of Agriculture, Dholi, RAU, Bihar. These mutant cultures along with the parent AK 12-24 and the two checks, Kuber and Chico were sown in RCB design with three replications in *kharif* 1996 at the research farm of Tirhut College of Agriculture, Dholi. Plot size was 5.1x0.9 sq.m. each plot consisting of three rows. The row-to-row and plant-to-plant distances were maintained at 30 cm and 15 cm, respectively. Standard production techniques were adopted to raise a good crop under optimum management during the entire crop period. Data were recorded on thirteen quantitative characters mentioned in Table 3. Mahalanobis D^2-statistics (1928) were used to know the genetic distance among culures. The clusters were formed on the basis of minimum generalised distance using Tocher's method as described by Rao (1952).

RESULTS AND DISCUSSION

The analysis of variance revealed significant differences among the cultures for all the characters under study. Based on Mahalanobis/D^2 statistics, mutant culture of groundnut along with parent and checks were grouped into sixteen clusters (Table 1). Cluster I, the largest one consisted of five cultures, cluster II with three cultures, cluster III and IV each with two cultures while cluster V to XVI consisted of single mutant culture. Parent AK 12-24 and checks Kuber and Chico, taken for comparison, differed in most of the characters under study and thus fallen under separate clusters. The

Rceived for publication in October, 1998

Table 2 : Average intra (diagonal) and inter-cluster distances (D/D^2) values of mutant cultures of groundnut

Cluster	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI
I	6.42	18.53	9.59	9.68	13.65	17.03	14.30	10.57	12.42	23.91	8.17	16.37	9.47	13.11	16.06	50.85
II		6.36	13.64	22.34	13.72	32.57	9.81	20.26	23.82	26.07	17.21	18.66	13.42	17.17	25.53	41.91
III			6.63	12.31	10.43	22.64	9.83	10.97	15.65	25.35	9.00	13.17	8.77	15.20	18.58	47.69
IV				8.08	13.64	14.17	19.08	16.42	11.77	30.04	13.68	13.18	12.56	18.15	18.71	55.14
V					0	24.05	15.54	14.20	19.94	31.31	16.45	11.40	11.55	18.41	20.96	51.54
VI						0	28.49	20.56	16.11	32.48	20.75	24.71	21.06	23.08	16.89	61.12
VII							0	13.74	18.88	19.87	9.82	18.68	9.68	12.81	21.75	41.42
VIII								0	16.81	30.85	12.28	13.50	15.37	21.48	17.53	54.82
IX									0	26.30	13.31	17.46	14.91	16.52	21.08	49.78
X										0	19.20	35.51	21.42	14.83	28.67	39.04
XI											0	17.97	8.75	11.92	17.38	47.23
XII												0	15.97	23.69	23.95	54.54
XIII													0	9.42	18.75	47.23
XIV														0	20.75	42.99
XV															0	55.05
XVI																0

Table 3: Cluster means for thirteen quantitative characters in mutant cultures of groundnut.

Characters \ Cluster	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI
Days to 50% flowering	25.00	24.44	24.83	25.33	24.66	26.66	25.66	25.33	22.66	26.33	26.00	25.66	26.00	24.66	25.00	21.00
Length of main axis	42.10	43.01	47.93	35.29	48.26	39.73	43.46	51.20	19.46	41.86	42.33	27.86	37.13	35.66	43.93	21.53
Number of primary branches per plant	5.31	5.04	4.93	5.40	5.33	5.06	5.60	5.26	7.26	4.93	5.33	6.46	4.60	5.46	5.20	4.13
Days to maturity	105.26	104.88	104.5	105.5	105.0	106.66	106.0	104.66	101.0	106.6	106.66	106.0	107.33	105.0	105.0	83.66
Number of pods per plant	23.10	18.44	19.90	22.80	20.20	19.26	20.66	21.80	28.98	15.20	18.20	20.20	19.00	22.66	21.13	17.06
Number of kernels per pod	1.90	1.93	2.00	2.03	2.24	2.32	1.68	2.14	1.77	1.59	1.92	2.19	1.92	1.63	2.06	1.30
Shelling percentage	66.53	72.74	71.61	68.95	71.96	60.73	72.28	72.17	66.04	58.04	67.39	76.09	68.82	62.58	66.20	66.30
Kernel test weight	26.56	23.50	23.58	24.91	25.16	28.00	25.33	28.66	29.00	23.00	26.66	28.16	26.00	24.16	27.16	17.33
Harvest index	9.40	7.41	9.67	8.33	6.87	9.95	8.78	10.99	10.75	9.07	10.70	9.96	8.12	7.10	8.61	7.10
Podyield /plant	18.05	13.28	16.43	19.23	15.93	21.73	15.40	17.66	20.20	16.33	16.86	16.53	16.73	17.40	18.26	13.20
Kernel yield per plant	12.05	9.67	11.58	13.24	11.46	13.26	11.13	12.82	13.25	9.36	11.37	12.58	11.52	10.89	12.09	8.75
Kernel oil content	50.75	50.32	50.77	50.22	50.60	51.53	50.43	51.50	50.76	51.23	51.36	50.66	51.16	51.00	51.13	51.66
Oilyield per plant	6.11	4.86	5.93	6.68	5.80	6.88	5.61	6.60	6.72	4.79	5.84	6 68	5.89	5.54	6.18	4.52

result indicated that there was a wide range of variation amongst the mutant cultures for almost all characters. It is expected that treatment with different dose and combination of mutagens had created wide range of genetic differences in the materials.

Highest inter-cluster distance (61.12) was observed between cluster VI and XVI (Table 2). The force of differentiation appeared different at inter and intra-cluster levels, which is supported by the findings of Sandhu and Sangha (1974). It is suggested that maximum exploitation of heterosis will result by crossing between cluster VI and XVI. Clustering pattern in the present study indicated that only the genetic differences induced by various mutagens rather than other factors are responsible to genetic divergence, because the mutant cultures of M7 generation (i.e, fixed population) were derived from the same parent AK 12-24 by mutagenic treatments. Only genotypic differences caused by mutagenesis are responsible for genetic divergence instead of other factors like geographical etc.

Table 1 : Clustering pattern of mutant cultures of groundnut (*Arachis hypogaea* L.)

Cluster No.	Number of cultures	Mutant cultures
I	5	DGM 22/22, DGM 30/25, DGM 64/61, DGM 71/65, DGM 90/78
II	3	DGM 5/4, DGM 30/96, DGM 67/62
III	2	DGM 89/77, Kuber (check)
IV	2	DGM 18/12, DGM, 127/125
V	1	DGM 42/39
VI	1	DGM 83/69
VII	1	DGM 9/5
VIII	1	DGM 52/34
IX	1	DGM 85/71
X	1	DGM 33/28
XI	1	DGM 29/34
XII	1	DGM 54/48
XIII	1	DGM 39/34
XIV	1	DGM 63/60
XV	1	AK 12-24 (Parent)
XVI	1	*Chico (check)*

It is evident from Table 3 that the mutant cultures placed in cluster VI possessed highest pod yield and oil yield per plant, however cultures in cluster II had lower economic value. Also, the mutant cultures placed in above two clusters had considerable inter-cluster distance (32.57). Therefore, crossing between DGM 83/69 and either DGM 5/4 or DGM 30/96 or DGM 67/62 would probably bring about desirable genotype which will be higher for both the economic yields, i.e., pod yield and oil yield. Nadaf et al. (1986) suggested that pod yield was the potential source of divergence at inter-cluster level.

DGM 85/71 (cluster IX) was observed to be early in flowering and maturity but had comparatively low yield. Although the inter-cluster distance between cluster IX and VI was not high, the crossing between DGM 85/71 and DGM 83/69 may result in a genotype having early maturity with higher pod and oil yield.

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J. Oilseeds Res. 16(2) 1999 : 234-240
ISSN 0970-2776

COMPARISON OF MACRO MUTATION FREQUENCY IN HOMOZYGOUS AND HETEROZYGOUS GENOTYPES OF GROUNDNUT BY GAMMARAYS

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ABSTRACT

Seeds of six parents and nine crosses in groundnut were subjected to 20 krad of gamma rays. The second generation (F2, M2 and F2M2) progenies were scored for the frequencies of morphological variants. F2M2 generation had the highest frequency of morophological variations followed by M2 generation. Efficiency of irradiation on both heterozygous and homozygous gentoype in producing variations was thus broughtout. Morphological variants with erect type, dwarf plant type, imparipinnate leaflets, bifurcated leaflets, bold pods and variegated testa colour of economic value were identified.

Key words : Groundnut, morphological variant, Dwarf, imparipinnate, bifurcated leaflets, variegated testa, Induced mutation.

INTRODUCTION

Mutations are a source of useful variants either directly or with recombination. In this respect mutations induced by gamma rays in groundnut are of significance. Variants affecting almost every feature of the plant have been observed by irradiating with gammarays (Patil and Chandramouli, 1979). The present study was undertaken to compare the frequency of morphological variants in homozygous and heterozygous genotypes in second generation after irradiation.

MATERIALS AND METHODS

Crosses were effected using three virginia bunch lines viz., VB 26, VB 54 and VB 83 as pollen parents and three spanish bunch lines viz. VRI 2, VRI 3 and Co2 as ovule parents (Table 1). Totally nine cross combinations were effected adopting the variants obtained in the study having imparipinnate leaflets of normal size without any accessory leflets. About 25 per cent of the leaves were imparipinnate.

The spectrum of pod variants were bold and elongated pods. The bold sized pods have a mean length of 3.20 cm and a breadth of 2.40 cm. The elongated pods were having increased length and decreased girth (4.20x1.00 cm) as compared to control (2.30x1.30 cm). The pod deviant plants had all pods of the same type. The variation in colours of testa recorded were red and veriegated type.

Chlorophyll

The frequency of variants effecting chlorophyll ranged from 0.80 (VRI 3) to 5.40 per cent (VB 83) in M2 generation. In F2 generation the frequencies ranged from 0.50 to 0.90 per cent. However, in four crosses there were no chlorophyll deviants. In F2M2 generation, while the cross Co 2 x VB 26 recorded lowest frequency of 2.60, the crosses VRI 2x VB 83 and VRI 3 xVB 83

Received for publication in October, 1998

Table 1 : Sources and important characteristics of groundnut genotypes.

S.No.	Genotype	Source	Origin	BotanicalClassification, habit and growth	Important Characteristics
1.	Co2	Department of oil seeds, School of Genetics, TNAU, Coimbatore	EMS mutant from 'POL-1'	*Arachis hypogaea* sub sp. *fastigiata* var. *Vulgaris spanish* bunch habit	Bold pods, high yield, duration 105 days
2.	VRI 2	Regional Research Station, Vridhachalam	JL24xCO2	*Arachis hypogaea* sub sp. *fastigiata* var. *Vulgaris* spanish bunch habit	Bold pods, high yield, duration 105 days
3.	VRI 3	Regional Research Station, Vridhachalam	J11xKobou-33-1	*Arachis hypogaea* sub sp. *fastigiata* var. *vulgaris* spanish bunch habit	High yield, with short duration of 90 days
4.	VB 26	ICRISAT, Hyderabad	Inter specific hybrid derivative of (*A.correntina* x *A.batizocoi*)^{2}x *A.hypogaea*	Interspecific derivative, Virginia bunch habit	Small pods, high yield, medium durationof 125days
5.	VB 54	ICRISAT, Hyderabad	(*A.batizocoi*)^{2}x *A.hypogaea*	Interspecific derivative, Virginia bunch habit	Small pods high yield, medium duration of 125 days
6.	VB 83	ICRISAT, Hyderabad	(*A.correntina* x *A.chacoense*)^{2}x *A.hypogaea*	Interspecific derivative, Virginia bunch habit	Small pods, high yield, medium duration of 125 days

recoreded maximum of 5.80 per cent. While comparing the three different segregating generations, the F2 recorded the least and the F2M2 had highest chlorophyll deviants. The spectrum of chlorophyll deviants recorded are albino, Xantha, viridis and chlorina.

Growth habit

Plants with alteration in growth habit were observed in all the three generations and the frequency varied from 1.10 (Co 2) to 2.90 per cent (VB 83) in M2, 0.40 (Co 2xVB 83) to 0.90 per cent (VRI x VB 83) in F2 and 0.50 (Co2 x VB 54) to 1.90 per cent (VRI 3 x VB 26) and VRI 3 xVB 83) in F2M2. while all the parents and crosses had growth habit variations in M2 and F2M2, respectively, five crosses in F2 did not throw deviants for growth habit. The growth habit variants included erect and spreading type. The erect type of variants were mostly obtained from M2 generation of VB 83 which was actually a semi spreading one. It is interesting to note that an erect type plant with 110 days duration was obtained from semi spreading type, with longer duration of 125 days. Such short duration erectoid types might be of economic importance. Such erect types can accomodate more number of population per unit area thereby increasing the pod yield over unit area with lesser duration. Another important deviation obtained was spreading types. Spreading type variants were isolated from F2M2 of the cross VRI 3 x VB 26 and F2 of VRI 3xVB 26. The spreading nature of technique was advocated by Norden (1973). Seeds of all the six parents and crossed seeds of nine combinations were subjected to 20 Kard of gamma rays.

The materials were sown on the day of irradiation in the experimental fields of Centre for Plant Breeding and Genetics, Coimbatore during *Kharif* 1994. All the available plants at harvest in first generation viz., M1, F1 and F1M1 were forwarded to second generation as plant to row basis during *Kharif* 1995. A total of 12 plants in a row of 3.6m length were raised for each available single plant of first generation. The second generation progenies were scored for the frequencies of morphological deviants involving chlorophyll, growth habit, plant type, leaf characters, pod attributes, kernel size, shape and testa colour.

RESULTS AND DISCUSSION

The M2, F2 and F2M2 populations were studied for deviations in morphological characters invoving vegetative and reproductive parts. The frequencies of different variants are presented in Table 2.

The types of variations oberved were chlorophyll variants, growth habit variants like erect type from spreading habit and dwarf plant type, leaf variants like bifurcated leaflets, imparipinnately compound leaf, and pod variants like bold pods, elongated pods.

The spectrum of chlorophyll variants recorded were albino, Xantha, viridis and chlorina. The growth habit variants included erect and spreading type. An erect type variant was isolated from semi spreading type. The spreading type variants were isolated from the cross of Spanish bunch X Virginia bunch. In dwarf plant type, the plants were looking like a clump of a plant, with condensed nodes and tiny leaflets.

The variations observed in leaf were bifurcated leaflets, imparipinnately compound leaves. A variant of bifurcated leaf lets having high proportion of leaf lets with bifurcated leaflets was observed, but the other leaflets were normal. The imparipinate leaf deviants were mainly due to etiolated primary branches variying in length from 55.2 to 58.3 cm as against 22.7 to 33.1 cm in semispreading types. It is interesting to note spreading types in the segregating population of the crosses involving bunch X semi spreading genotypes.

Table 2 : Frequency percent of morphological variants in second generation in groundnut

Generation	Chlorophyll					Growth habit			Plant type
	Albino	Xantha	*Viridis*	*Chlorina*	Total	Erect	Spreading	Total	Dwarf types
M_2									
CO2	0.8	0.50	0.30	0.50	2.10	-	1.10	1.10	0.20
VRI 2	1.0	0.40	0.40	1.00	2.80	-	1.40	1.40	1.40
VRI 3	0.60	-	0.10	0.10	0.80	-	2.10	2.10	0.40
VB 26	0.70	0.90	0.60	0.80	3.00	1.30	-	1.30	0.70
VB 54	0.90	0.70	0.80	0.70	3.10	1.80	-	1.80	1.30
VB 83	1.70	0.80	0.80	2.10	5.40	2.90	-	2.90	1.00
F_2									
Co2XVB 26	0.50	-	-	-	0.50	-	-	-	-
Co2 XVB 54	0.50	-	-	-	0.50	-	-	-	-
Co2XVB 83	-	-	-	-	-	-	0.40	0.40	-
VRI2XVB 26	-	-	-	-	-	-	0.50	0.50	-
VRI2XVB54	0.60	-	-	0.30	0.90	-	-	-	-
VRI2XVB 83	-	-	-	-	-	-	0.90	0.90	-
VRI3XVB 54	0.30	-	-	0.20	0.50	-	-	-	-
VRI3XVB 83	-	-	-	-	-	-	0.50	0.50	-
F_2M_2									
Co2XVB 26	0.90	0.40	0.60	0.70	2.60	-	1.70	1.70	0.40
Co2XVB 54	1.00	0.50	0.80	0.90	3.20	-	0.50	0.50	0.50
Co2XVB 83	1.20	0.80	0.60	1.60	4.20	-	1.40	1.40	0.90
VRI2XVB 26	1.10	0.70	0.70	1.70	4.20	-	0.80	0.80	0.80
VRI2XVB 54	1.40	0.90	0.20	2.30	4.80	-	0.60	0.60	0.60
VRI3XVB 83	2.90	0.50	0.60	1.80	5.80	-	1.40	1.40	1.00
VRI3XVB 26	0.90	0.40	0.60	0.80	2.70	-	1.90	1.90	1.20
VRI3XVB 54	1.30	0.60	0.50	0.90	3.30	-	1.30	1 30	0.40
VRI3XVB 83	2.00	0.90	1.10	1.80	5.80	-	1.90	1.90	0.80

Table2 Continued-----

Plant type

Only in two segregating generations viz., M2 and F2M2, the dwarf plant types were observed. The frequency raned from 0.40 (VRI 3) to 1.40 per cent (VRI 2) in M2 and 0.40 (Co 2xVB 26 and VRI 3 x VB 54) to 1.20 per cent (VRI3xVB 26) in F2M2. The height of these plants ranged from 6.5 to 7.8 cm as against normal height of 25.0 to 35.0cm recorded by the parents. These dwarf plants were looking like a small clump of a plant, nodes congested and lef lets tiny. They mostly had single seeded pods. Patil and Mouli (1975) reported dwarf mutants in groundnut with a distinct phenotype with smaller leaflets in the present study.

Leaf

In M2 generation the deviation in leaf characteristics ranged from 0.40 (VRI 3) to 1.80 per cent (VB 54). In F2M2 generation, the frequency of leaf variations ranged from 0.40 (VRI 3 x VB 26) to 2.40 per cent (VRI 2 x VB 54). In F2 there was no variation for leaf characteristics. While comparing M2, F2M2 recorded more of deviation. The leaf variations observed were bifurcated leaflets and imparipinnate compound leaf. The leaf mutants were mostly isolated from M2 of VB 54 and F2M2 of VRI 2x VB 54 and Co 2 x VB 83. The imparipinnate leaf mutants obtained in the study were having imparipinnate leaflets of normal size with out any accessory leaf lets as reported by Patil *et al.* (1984) and Deshmukh *et.al.*, (1991). A variant of bifurcated leaf lets having high proportion of leaf lets with bifurcation was observed. Patil *et al.*, (1984) isolated a bifurcated mutant in the progeny of a cross in groundnut. The leaf mutant identified in the present study may be utilised as genetic marker for further study.

Pod

In M2 generation, the genotype VRI 3 had a minimum frequency per cent of 0.40 pod deviations and the genotype VB 54 had maximum frequency of 1.80 per cent in M2 generation. In F2, the cross VRI 2xVB 54 had a minimum of 0.50 and the cross Co2 xVB 26 had a maximum of 1.10 per cent frequency. In F2 M2, a minimum deviation frequency of 0.40 per cent was recorded by Co 2 x VB 26,VRI 2 x VB 26, VRI 3xVB 26 and VRI 3 x VB 26 and VRI 3 x VB 83 and a maximum frequency of 2.40 was recorded by VRI 2xVB 54. The spectrum of pod deviations are bold and elongated pods. These mutants were mostly isolated from F2M2 of VRI 3xVB 54 and VRI2 xVB 26. The bold sized pods had a mean length of 3.20 cm and a breadth of 2.40 cm as against 2.30 cm length and 1.30 cm breadth in control. It had a range of 2.82 to 3.31 cm in length and 1.95 to 2.47 cm in breadth. There was no variation in pod shape. The seeds from these bold pods were also bold with increased kernel weight. These deviants offer much scope for improvement of kernel yield. The long pods were characterised by elongated pods having increased length and decreaed girth (4.20 x1.00 cm) as compared to control (2.30 x1.30 cm). Similar elongated pods were also reported by Patil (1966) and bold pods were reported by Manoharan and Thangavelu (1990)

Testa colour

The deviation for testa colour ranged from 0,30 (VB 26) to 0.90 per cent (VB 54) among the parents in M2 generation. In F2 generation none of the crosses showed colour varation. All the nine crosses in F2M2 showed variations for testa colour ranging from 0.40 (CO 2xVB 26, VRI 3 xVB 26 and VRI 3xVB 83) to 5.40 per cent (VRI2xVB 54). The different colours of testa recorded like red, rose and variegated types were mostly isolated from F2M2 of VRI 2x VB 54. Mutants with red, rose, variegated testa were already reported by Patil and Mouli (1979) and Ramanathan (1983).

Among different populations studied,

Table 2 Contd... : **Frequency percent of morphological variants in second generation in groundnut**

Generation	Leaf			Pod			Testa colour		
	Bifurcated	Imparipinnately	Total	Bold	Elongated	Total	Red	Variegated	Total
M_2									
CO2	0.20	0 90	1.10	-	0.50	0.50	0.50	-	0.50
VRI 2	0.10	0 40	0.50	-	0.90	0.90	0.50	-	0.50
VRI 3	0.10	0.30	0.40	-	0.40	0.40	0.80	-	0.80
VB 26	0.20	0.80	1.00	0.20	0.50	0.70	0.30	-	0.30
VB 54	0.30	1.50	1.80	1.20	0.60	1.80	0.10	0.80	0.90
VB 83	-	1.00	1.00	-	0.50	0.50	0.50	-	0.50
F_2									
Co2XVB 26	-	-	-	-	1.10	1.10	-	-	-
Co2 XVB 54	-	-	-	0.40	0.60	1.00	-	-	-
Co2XVB 83	-	-	-	-	0.70	0.70	-	-	-
VRI2XVB 26	-	-	-	-	-	-	-	-	-
VRI2XVB 54	-	-	-	0.50	-	0.50	-	-	-
VRI2XVB 83	-	-	-	-	-	-	-	-	-
VRI3XVB 54	-	-	-	1.00	-	1.00	-	-	-
VRI3XVB 83	-	-	-	-	-	-	-	-	-
F_2M_2									
Co2XVB 26	0.30	1.00	1.30	-	0.40	0.40	-	0.40	0.40
Co2XVB 54	0.20	0.90	1.10	-	1.10	1.10	-	0.50	0.50
Co2XVB 83	0.40	1.90	2.30	0.20	0.70	0.90	0.20	0.70	0.90
VRI2XVB 26	0.30	1.40	1.70	0.10	0.30	0.40	0.10	0.70	0.80
VRI2XVB 54	0.40	2.00	2.40	0.40	2 00	2.40	0.90	4.50	5.40
VRI3XVB 83	0.10	0.40	0.50	0.20	0.80	1.00	0.10	0.40	0.50
VRI3XVB 26	-	0.40	0.40	0.20	0.20	0.40	0.10	0.30	0.40
VRI3XVB 54	0.30	1.80	2.10	0.20	0 60	0.80	0.20	0.60	0.80
VRI3XVB 83	0.10	1.10	1.20	-	0.40	0.40	-	0.40	0.40

F2M2 had more macro mutation frequency, followed by M2 generation, thus bringing out the efficiency of irradiation in both heterozgous and homozgous genotypes in producting major deviations. Morphological deviants with erect type, dwarf plant type, imparipinnate leaflets, bifurcated leaflets, bold pods, elongated pods and variegated testa colour are of economic value.

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J. Oilseeds Res. 16(2) 1999 : 241-244
ISSN 0970-2776

PHENOTYPIC STABILITY FOR SEED YIELD IN NIGER (*Guizotia abyssinica Cass)*

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ABSTRACT

Eight niger genotypes were evaluated at seven locations during *Kharif*, 1997-98, with respect to seed yield. Significant genotype x environment interaction was observed. On partitioning, linear component was observed to be large in magnitude, indicating that the prediction is possible over locations. Accordingly, the genotypes viz., JNS-7, GA-10, BNS-9, SNS-8 and No.71 were observed to be well adapted over environments for seed yield. Mean performance was positively and significantly associated with regression coefficient and coefficient of determination, indicating that the genotypes with high mean performance were in general, better responsive to favourable environments. A positive and significant correlation between regression coefficient and coefficient of determination was also observed, thus, indicating that the stability parameters were governed by independent genotypic system in niger.

Key words: GxE interaction, stability, seed yield, niger.

INTRODUCTION

Niger (*Guizotia abyssinica* Cass) is a highly cross pollinated crop with self-incompatibility mechanism and hence heterozygosity confers adaptability to niger genotypes. However, there is no certainty of consistant performance of such genotypes across diverse environments. Hence, under such a situation, identification of genotypes stable in seed yield is necessary. With this view, present investigaion was carried out.

MATERIALS AND METHODS

Eight genotypes of niger were evaluated at seven locations in the country viz., Semiliguda (Orissa), Udaipur (Rajasthan), kanke (Bihar), Jagadalpur and Chhindwara (MP), Igatpuri (Maharashtra) and Raichur (Karnataka) for seed yield stability during *kharif* 1997-98 under rainfed conditions. They were grown in randomized block design with three replications. The plot size was 3.6mx5m with 12 rows. The spacing adopted was 30x10cm. The seed yield data were recorded and subjected to stability analysis. The model of Eberhart and Russel (1996) as modified by Ram *et al.* (1970) was adopted for computing the stability parameters. The coefficient of determination was calculated for each genotype as suggested by Bilbro and Ray (1976).

RESULTS AND DISCUSSION

Pooled analysis of variance showed that the mean differences between genotypes and environments were highly significant, indicating considerable variability among genotypes and environments (Table-1). The significance of mean square due to GxE interaction for seed yield indicated that the genotypes interacted strongly with environments. Similar results have also been reported by Joshi and Patil (1982) Verulkar and Upadhyay (1989), Upadhyay (1993) and Kumar *et al.* (1993).

The environmental additive effects at different locations expressed as deviation from grand mean indicated that Semiliguda in Orissa state (2.75) had the favourable season (mean seed yield of 7.11 q/ha) followed by Chhindwara (1.35) in M.P. with a mean yield of 5.71q/ha. However,

Received for publication in November, 1998.

the season at Igatpuri was found to be the poorest (-1.42) with a mean yield of 2.94q/ha followed by Jagdalpur (-1.38) with a mean yield of 2.98q/ha.

Table 1 : ANOVA for stability in niger

	d.f	Mean sum of square
Genotypes	7	0.311**
Environments	6	23.179**
G X E	42	0.293**
Environment + (G X E)	48	0.067**
Environment linear	1	0.0008*
G X E linear	7	0.360**
Pooled deviation	40	0.0001
Pooled error	98	0.0018

*, ** Significant at 5 and 1% level, respectively.

Different measures of stability have been used by various workers. Earlier, Finlay and Wilkinson (1963) considered linear regression slope as a measure of stability. Eberhart and Russel (1966) emphasized the need of considering both linear and nonlinear components of GxE interaction in judging the stability of a genotype. However, in the present study, the regression coefficient (bi) as a measure of adaptability and coefficient of determination (r^2) as a measure of stability are considered (Bilbro and Ray, 1976). The stability is assessed by considering three parameters viz., phenotypic index (Pi), regression coefficient (bi) and coefficient of determination (r^2). The phenotypic index which reflects the mean performance of varieties over locations was positive in five out of eight genotypes studied. The highest phenotypic index was recorded by the genotype JNS-7 followed by No.71 and GA-10.

The regression coefficients differed significantly from each other for six genotypes indicating their better adaptability to all environments; thus, reflecting almost a linear response to environmental change. The genotype JNS-7 was observed to be better adapted to all environments.

Simple correlation coefficients among three stability parameters was calculated and are presented in Table-2. The results revealed that the mean performance was positively and significantly asociated with regression coefficient and coefficient of determination, indicating the genotypes with high mean performance were in general better responsive to favourable environment. A positive and significant correlation between regression coefficient and coefficient of determination was also observed indicating that the stability parameters were governed by different gene or genes in combination in niger.

It is imperative at present to develop and identify varieties suitable for rainfed condition with vagaries of monsoon. Thus, the varieties performing well over environments were JNS-7, GA-10, BNS-9, SNS-8 and No.71. Certain genotypes perform better at one location than another, hence emphasis is needed for developing gentoypes adapted to specific environment rather than for adaption over wide range of environments in future breeding programmes. Nevertheless, there is a need to develop stable genotypes across wide range of environments.

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Table 2 : Seed yield over locations and estimates of stability parameters in Niger

Cultivar	Seed yield (q/ha)								Pi	bi	r^2
	Semiliguda	Udaipur	Kanke	Jagdalpur	Igatpuri	Raichur	Chhindwara	Mean			
BNS-9	7.55	4.30	4.89	2.72	3.43	2.80	5.02	4.39	0.03	0.95*	0.99*
SNS-8	7.77	3.67	4.44	2.75	3.28	4.27	4.53	4.39	0.03	0.96*	0.97*
Payur-1	6.44	2.64	4.44	3.39	2.63	3.67	4.42	3.95	-0.41	0.60	0.81*
JNS-7	7.11	2.96	5.33	2.80	3.07	3.80	7.33	4.63	0.27	1.15*	0.99*
JNS-8	6.67	2.96	4.89	3.05	2.49	2.67	7.56	4.33	-0.03	1.54*	0.78*
No.71	6.67	3.47	5.00	3.33	2.61	4.40	5.77	4.46	0.10	0.81*	0.98*
GA-10	7.55	2.80	6.00	3.01	3.28	2.33	6.16	4.45	0.09	0.99*	0.92*
IGP-76	7.11	4.00	6.00	2.81	2.75	2.73	4.89	4.33	-0.03	0.56	0.62
Mean	7.11	3.35	5.12	2.98	2.94	3.33	5.71	4.36	-	-	-
Environmental index	2.75	-1.02	0.76	-1.38	-1.42	-1.04	1.35				
Correlations											
X : bi=0.79*		X : r^2 = 0.84*									

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J. Oilseeds Res. 16(2) 1999 : 245-249
ISSN 0970-2776

INTEGRATED WEED MANAGEMENT IN KHARIF SESAME (*Sesamum indicum* L.)

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ABSTRACT

Field experiments were carried out during *Kharif* seasons from 1994 to 97at five locations to findout the effective and economical wayof weed control in sesame on different soil types. The pooled results indicated that on Inceptisol at Tikamgarh, weed free check (3 hand weedings) recorded the highest seed yield. On Vertisol at Amreli and Aridisol at Mandore, highest seed yield was obtained with hand weedings (20 and 30 DAS) But on Vertisol at Jalgaon, two hoeings and hand weedings (20 and 30 DAS) resulted in highest yield. On Alfisol at Vridhachalam, Alachlor granules 2 kg a.i./ha+ one hand weeding (30 DAS) recorded the highest yield. *Considering* the economics, one hand weeding (20 DAs) at Vridhachalam, two hand weedings (20 and 30 DAS) at Amreli and Mandore, three hand weedings (20, 30 and 45 DAS) at Tikamgarh and two hoeings and hand weedings (20 and 30 DAS) at Jalgaon are recommended for effective weed management during *Kharif* season.

Key words : Weed management, soiltype, sesame.

INTRODUCTION

Sesame faces serious weed competition due to slow initial growth of crop (Gaur and Tomar, 1978)). During *Kharif* season, high temperature and frequent rainfall favours growth of weeds resulting in yield losses ranging from 16 to 68% (Varaprasad and Shastri, 1993). During the critical period for weed competition i.e. 15-30 days after sowing (Kondap and Rao, 1978), it is difficult to adopt conventional methods of weed control due to unfavourable soil or weather conditions and tender nature of crop. As this period concides with peak demand for labour , it becomes difficult to get labour for hand weeding. There are many reports of advantages of using herbicides in sesame (Rao and Rao, 1985, Bansode and Shelke, 1991, Padmaja *et al.* 1993, Kanan and Wahab, 1995, Balasubramaniyan and Dharmalingam, 1997). However, it may be advantageous to go for integration of different methods of weed management to economise resource use and to reduce environmental pollution. Present studies were, therefore, carried out to find efficient method of integrated managementof weeds in sesame during *Kharif* season in different soil types.

MATERIALS AND METHODS

The experiment was carried out under the All India Coordinated Sesame Improvement Project at five locations viz; Tikamgarh (Madhya Pradesh), Amreli (Gujrat), Jalgaon (Maharashtra), Mandore (Rajasthan) and Vridhachalam (Tamil Nadu) during *Kharif* seasons from 1995 to 1997 except at Vridhachalam where the study was conducted during 1994 and 1995. The soil types were Inceptisol at Tikamgarh, Vertisol at Amreli and Jalgaon, Aridisol at Mandore and Alfisol at Vridhachalam. The soil texture was sandy at Tikamgarh, clay at Amreli and Jalgaon and sandy loam at Mandore and Vridhachalam. The soils had pH of 7.5, 7.7, 7.8 7.3 and 7.2 and organic carbon of 0.25, 0.54, 0.62, 0.23 and 0.44 at the five locations, respectively.

The treatments comprised hand weeding, hoeing, herbicides and combination of hand weeding and herbicides along with unweeded and weed

Received for publication in September, 1998.

free checks (Table 2). The treatments were laidout in randomised block design with three replications. The crop was sown during first fortnight of July with a spacing of 30x10cm. Recommended fertilizers were applied at the time of planting. All the herbicides were applied as pre-emergence spray or granule application just after sowing but before germination. Spraying was done by high volume sprayer with flat fan nozzle. Data on diferent weed species, weed dry weight at harvest and seed yield were recorded. From these, weed index was workedout. The economic viability of different reatments was determined by using market rates of inputs and output. Data are pooled over the years and pooled means are presented.

RESULTS AND DISCUSSION

Weed Flora

The number of weed species recorded were 12,13,7,12 and 13 at Tikamgarh, Amreli, Jalgaon, Mandore and Vridhachalam, respectively. Out of these, *Cyperus iria* L. among sedges, *Cynodon dactylon* (L). Pers and *Echinochloa crusgalli* among grasses and *Euphorbia hirta* among broad leaved weeds were observed at all the locations. Highest incidence of sedges was observed at Vriddhachalam.

Weed dry weight and weed index

There was marked reduction in dry weight of weeds by different weed control treatments (Table 1). Hand weeding at 30 DAS was more effective than at 20 DAS in reducing the dry weight of weeds at all the centres except at Amreli. At Jalgaon, there was further reduction in the dry weight of weeds when two hand weedings were given at 20 and 30DAS. Hoeing as well as hoeing and hand weeding were very effective in reducing the dry weight of weeds. Among herbicides, pendimethalin 1 kg a.i./ha at Tikamgarh and Jalgaon (0.5 kg a.i./ha), Alachlor liquid 1.5 kg a.i/ha at Amreli, Metolachlor 2 kg a.i./ha at Mandore and Alachlor granules 2 kg a.i./ha at Vriddhachalam were more effective than others in reducing the dry weight of weeds. Combination of these herbicides along with one hand weding 30 DAS further reduced the dry weight of weeds. Weed index followed the trend similar to dry weight of weeds at all the locations.

Seed Yield

There were significant differences in seed yield of sesame among weed control treatments at all the locations (Table 2). On Inceptisol at Tikamgarh, weed freecheck recorded singificantly the highest yield (380.kg/ha). Hand weeding (20 and 30 DAS) recorded highest seed yield followed by Alachlor liquid 1.5 kg a.i./ha+HW 30 DAS. At Amreli on Vertisol, hand weeding twice (1230 kg/ha) recorded the highest yield closely followed by Alachlor liquid 1.5 kg a.i./ha+HW 30 DAS(1110 kg/ha) and both these treatments recorded significantly higher yield than all other treatments. At Jalgaon on Vertisol, hoeing and hand weeding twice at 20 and 30 DAS (1239 kg/ha) recorded the highest yield followed by two hand weedings (1098 kg/ha) and hoeing twice (1076kg /ha.) Among herbicides, Pendimethalin @ 0.5 kg a.i./ha+HW 30 DAS recorded the highest yield (937 kg/ha). On Aridisol at Mandore, two hand weedings recorded the highest yield (710 kg/ha) which was at par with Alachlor G 2 kg a.i./ha+H.W. 30 DAS(713 kg/ha) and Alachlor L 1.5 kg a.i//ha + HW 30 DAS (670 kg/ha) but significantly higher than the yields obtained with other treatments. On Alfisol at Vridhachalam, Alachlor G 2 kg a.i./ha+HW 30 DAS recorded significantly highest yield (821 kg/ha), which was more than that recorded with weed free check (660 kg/ha) where three hand weedings were done. Effective weed control in sesame by Alachlor was also reported by many workers (Bansode and Shelke, 1991 and Kanan and Wahab, 1995). Many workers have also observed that just hand weeding is enough for effective weed control in sesame (Balasubramaniyan and Dharmalingam, 1997).

Table 1 :Effect of weed control treatments on dry weight of weeds and weed index at different locations.

Treatment	*Dry weight of weeds at harvest (kg/ha)*					Weed Index (%)				
	Tikam-garh	Amreli	Jalgaon	Mandore	Vridha-chalam*	Tikam-garh	Amreli	Jalgaon	Mandore	Vridha-chalam*
1. Unweeded Check	2630	3931	887	3330	1650	81.6	72.7	64.4	59.3	43.0
2. HW (20 DAS)	1160	1502	508	1170	900	44.2	28.1	39.6	31.5	9.7
3. HW (30 DAS)	840	1575	458	880	750	37.1	31.0	27.9	28.7	14.2
4. HW (20 & 30 DAS)	740	1293	239	790	650	19.7	-	11.4	-	5.2
5. Hoeing (20 DAS)	-	-	293	-	-	-	-	40.3	-	-
6. Hoeing (30 DAS)	-	-	395	-	-	-	-	38.5	-	-
7. Hoeing (20 & 30 DAS)	-	-	339	-	-	-	-	13.1	-	-
8. Hoeing & HW(20 & 30 DAS)	-	-	122	-	-	-	-	-	-	-
9. Alachlor L (1.5kg ai/ha)	1060	2166	635	1310	890	32.9	28.9	46.1	32.2	20.2
10. Alachlor G (2.0 kg ai/ha)	1270	2819	-	1440	800	50.8	35.8	-	29.6	16.7
11. Pendimethalin (0.5 or 1.0 kg ai/ha)	700	3132	559	1900	1020	47.1	45.8	39.5	40.6	19.7
12. Metolachlor (1.0 or 1.25 or 2.0 kg ai/ha)	1380	3232	597	1100	880	57.3	42.3	40.0	39.4	22.3
13. Fluchloralin (1.0 kg ai/ha)	-	-	-	-	1010	-	-	-	-	-
14. Alachlor G(1.5kg ai/ha + HW (30 DAS)	800	1452	398	710	350	24.2	9.7	42.8	5.6	27.6
15. Alachlor G(2.0 kg ai/ha+ HW (30 DAS)	840	2151	-	730	440	31.3	39.8	-	-	-
16. Pendimethalin (0.05 or 1.0 kg ai/ha)+ HW (30 DAS)	610	2297	239	750	830	32.6	31.3	24.3	23.5	12.1
17. Metolachlor (1.0 or 1.25 or 2.0 kg ai/ha)+HW (30 DAS)	820	2923	347	730	630	44.4	28.3	28.6	22.1	13.0
18. Fluchloralin (1.0 kg ai/ha)+ HW (30 DAS)	-	-	-	-	790	-	-	-	-	16.7
19. Weed free (3 HW at 20,30 & 45 DAS)	310	-	-	-	230	-	-	-	-	-

L : Liquid, G: Granules, HW: Handweeding, DAS: Days after sowing, a.i. : Active ingredient

* *Two Years pooled data, 1994 and 1995*

** Pendimethalin (I) @ 0.5 kg/ha - Jalgaon, Mandore

(II) @ 1.0 kg/ha-Tikamagarh, Amreli and Jalgaon

*** Metolachlor (I) 1.0 kg ai/ha- Tikamgarh, (II), 1.25 kg ai/ha Vridhachalam

(III) 2.0 kg ai/ha-Amreli, Jalgaon and Mandore.

Table 2 : Effect of weed control treatments on seed yield of sesame at different locations (pooled data 1995 to 97)

Treatment	Seed yield (kg/ha)				
	Tikamgarh	Amreli	Jalgaon	Mandore	Vridhachalam
T1	70	336	441	289	376
T2	212	884	781	486	596
T3	239	849	893	506	566
T4	305	1230	1098	710	626
T5	-	-	739	-	-
T6	-	-	762	-	-
T7	-	-	1076	-	-
T8	-	-	1239	-	-
T9	255	875	668	481	527
T10	187	789	-	500	550
T11	201	667	749	422	530
T12	162	746	746	430	513
T13	-	-	-	-	478
T14	288	1110	708	670	588
T15	261	742	-	713	821
T16	256	845	937	543	580
T17	211	882	884	553	574
T18	-	-	-	-	550
T19	-	-	-	-	660

Table 3 : Effect of weed control treatments on benefit - cost - ratio of sesame at different locations *(pooled data 1995 to 97)*

Treatment	Benefit cost ratio				
	Tikamgarh	Amreli	Jalgaon	Mandore	Vridhachalam
T1	0.43	1.21	3.17	1.83	1.30
T2	1.05	2.60	4.91	2.43	1.78
T3	1.18	2.43	5.57	2.53	1.65
T4	1.29	3.36	6.26	3.07	1.59
T5	-	-	4.84	-	-
T6	-	-	4.88	-	-
T7	-	-	6.22	-	-
T8	-	-	6.04	-	-
T9	1.04	2.42	3.95	2.42	1.64
T10	0.86	1.85	-	2.11	1.56
T11	0.60	1.84	4.38	1.86	1.40
T12	0.82	2.37	4.27	2.38	1.54
T13	-	-	-	-	1.38
T14	1.06	2.97	3.78	2.80	1.58
T15	1.02	2.21	-	2.20	1.56
T16	0.70	2.15	4.40	2.00	1.43
T17	0.93	2.12	4.59	2.79	1.50
T18	-	-	-	-	1.39
T19	1.39	-	-	-	1.62

Economics

Highest benefit-cost-ratio was obtained with two hand weedings (20 and 30 DAS) at Tikamgarh, Amreli and Mandore, Two hoeings and hand weeding (20 and 30 DAS) at Jalgaon and just one hand weeding at 20 DAS at Vriddhachalam. Benefit cost-ratios from chemical weed control were not comparable with that obtained from hand weeding or hoeing treatment (Table 3).

The results clearly indicated that in sesame just one or two hand weedings or hoeing and hand weeding can easily take care of weeds during *Kharif* season in all the soil types. Weed control through herbicides or through the combination of herbicides with cultural practices is not economical as compared to just hand weeding or hoeing.

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J. Oilseeds Res. 16(2) 1999 : 250-252
ISSN 0970-2776

EFFECT OF SOIL SOLARIZATION ON CERTAIN SOIL PROPERTIES, GROWTH AND YIELD OF GROUNDNUT

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ABSTRACT

Solar heating of soils by polyethylene sheets during the hot season results in increased soil temperatures and the killing of certain pathogens. Solarization increases the temperatures by 9-11°C in the upper soil layer. Field experiments showed enhanced plant growth in solar heated soils, even in the absence of known pathogens. The solarized soils showed increased concentrations of nitrate nitrogen and available phosphorus. Groundnut plants grown under solarized soils showed enhanced plant growth in comparison with non-solarized control.

Key words : Soil solarization, soil properties, groundnut.

INTRODUCTION

Soil solarization is a method of hydrothermal disinfestation accomplished by covering the moist soil with polyethylene sheet during summer. In addition to reducing the number of fungi, nematodes, insects and weed seeds, soil solarization often results in increased plant growth response (IGR), even when no major plant pathogens or pests can be isolated from oil or plant roots (Chen and Katan, 1980; Stapleton and Devay, 1984). Among the mechanisms proposed for the observed IGR are elimination of minor pathogens and parasites including biological control and soluble mineral nutrients (Chen and Katan, 1980). Changes in concentrations of available soil mineral nutrients are often observed following soil disinfestation. Hence,an investigation was carried out to know the effect of soil solarization on mineral nutrients release and on plant growth.

MATERIALS AND METHODS

A field experiment was conducted at the Main Research Station, Hebbal, University of Agricultural Sciences, Bangalore during 1995-96 and 1996-97. There were 8 treatments, each replicated thrice. The treatments included covering with transparent polyethylene (TP) of 0.05mm for 15, 30 and 45 days, TP of 0.075mm for 15, 30 and 45 days and black polyethylene(BP) for 45 days besides a non-solarized control. Before spreading polyethylene sheet, irrigation was done to increase the thermal conductivity. Maximum soil temperatures during the treatment were monitored. Immediately following removal of the polyethylene film, soil samples were taken from 15 cm depth at random with a screw augar from each replication and composited. The composite samples were frozen in polyethylene bags until the content of soil nutrients were determined. Groundnut was then sown and observations were recorded at regular intervals. The soil nitrate nitrogen extracted by 0.2 percent Ca (OH)2 was colorimetrically determined by chromotropic acid method (CTA) as suggested by Sims and Jackson (1971). The available phosphorus was estimated by molybdate stannous chloride method. The intensity of blue colour was read on spectrophotometer at 660 nm (Jackson, 1973).

RESULTS AND DISCUSSION

Effect on soil chemical and biological properties

Results of the chemical analysis showed that the content of soil nitrate nitrogen and available phosphorus were significantly differing among the treatments (Table 1). Covering soil with transpar-

Received for publication in July, 1998

ent polyethylene of 0.075mm for 45 days recorded significantly higher nitrate nitrogen (25.25 kg'ha) which was on par with TP of 0.050mm for 45 days (24.54 kg/ha). These treatments recorded 7.86 kg more soil nitrate nitrogen content than control. The pronounced increase in nitrate nitrogen in the solarized soils might have resulted from the decomposition of the soil organic matter. Similar observations were made by Chen and Katan (1980). Similarly, the available phosphorus content was significantly higher under TP of 0.050 mm for 45 days (36.75 kg/ha) than control (32.00 kg/ha). Stapleton et al. (1985) observed that soil phosphorus increased in solarized soil by about 2-12 kg per ha.

The data on the effect of treatments on the microbial population revealed the variations in the fungal and bacterial populations. Among the various treatments, covering with TP of 0.050 mm for 45 days and TP of 0.075 mm for 45 days caused significant reductions (53.8 and 50.9 %, respectively) in fungal population. Cartia (1987) also reported decrease in fungal population by 53 per cent due to solarization. Bacterial population was more in case of TP of 0.075mm for 45 days and TP of 0.050 mm for 45 days but these were on par with control. But the bacterial population was significantly reduced in TP of 0.050 mm for 15 days, TP of 0.075 mm for 15 days and in BP of 0.125mm for 45 days. The reduction in the bacterial population in these treatments might be due to less spore formation. The population of actinomycetes was unaffected due to various treatments.

Effect on growth and yield of groundnut

Solarization of soils for longer durations recorded significantly higher plant height and number of branches compared to control (Table-2). Lesser plant height and number of branches in control might be due to the competition between weeds and the crop for resources. Similar observations were reported in groundnut by Biradar (1996). Average number of nodules and nodule dry weight per plant of groundnut at 45 days did not show significant differences among the treatments. At 75 days covering TP of 0.075 mm for 45 days

Table 1 : Effect of soil solarization on soil properties (pooled data of two years)

Treatment	Soil Nutrient Content (kg/ha)		Population/g of soil		
	Nitrate nitrogen	Available phosphorus	Fungi 10^4	Bacteria 10^4	Actinomycetes 10^5
TP 0.050 mm for 15 days	19.00	33.00	7.6	12.3	6.6
TP 0.050 mm for 30 days	21.60	35.28	7.2	13.2	6.7
TP 0.050 mm for 45 days	24.54	36.75	5.2	13.7	6.0
TP 0.075 mm for 15 days	20.64	32.74	7.7	12.5	6.7
TP 0.075 mm for 30 days	21.57	35.00	7.1	13.0	6.4
TP 0.075 mm for 45 days	25.25	34.25	5.3	13.9	6.1
BP 0.125 mm for 45 days	20.00	33.65	7.6	12.2	6.3
Control	17.00	32.00	8.0	13.3	7.0
SEm ±	0.75	0.97	0.10	0.19	0.35
CD (0.05)	2.20	2.90	0.30	0.57	NS

TP = Transparent polyethylene; BP - Black polyethylene; NS = Not significant.

Table 2 : Effect of soil solarization on growth and yield of groundnut (pooled data of two years)

Treatment	Plant height (Cm) at 90 DAS	No. of branches at 90 DAS	Nodule number per plant at		Nodule dry weight (g/plant) at		Pod yield (kg/ha)	Haulm yield (kg/ha)
			45 DAS	75 DAS	45 DAS	75 DAS		
TP 0.050 mm for 15 days	33.5	4.48	83.51	109.16	0.093	0.115	10.55	15.58
TP 0.050 mm for 30 days	34.9	5.16	93.04	111.42	0.093	0.113	14.87	20.60
TP 0.050 mm for 45 days	38.3	6.00	100.29	119.00	0.107	0.130	20.64	28.64
TP 0.075 mm for 15 days	33.6	4.89	56.77	107.15	0.090	0.108	10.00	17.66
TP 0.075 mm for 30 days	33.7	5.02	89.31	114.56	0.095	0.117	13.26	19.07
TP 0.075 mm for 45 days	38.0	5.72	96.86	124.65	0.100	0.123	19.60	26.92
BP 0.125 mm for 45 days	35.8	4.67	90.86	109.67	0.092	0.107	10.58	19.42
Control	33.5	3.92	75.45	96.25	0.070	0.097	4.68	9.88
SEm ±	1.02	0.18	5.50	4.15	0.044	0.004	0.64	0.60
CD (0.05)	2.95	0.53	NS	11.92	NS	0.013	1.76	1.74

resulted in maximum number of root nodules (124.65/plant) and nodule dry weight (0.130 g/plant) which were on par with TP of 0.075 mm for 45 days but differed significantly from control. The improvement in nodule growth and nodule weight might be due to improved growth response under solarization of soil compared to control. Covering with transparent polyethylene of 0.050 mm and 0.075 mm recorded significantly higher pod yields (20.64 and 19.60 q/ha respectively) over control (4.68 q/ha). Black polyethylene and shorter durations (15 days) of solarization did not differ significantly. The significantly higher pod yield recorded by the most effective treatments mentioned above is attributed to better utilization of growth resources under solarized treatments. These observations are in line with the findings of Habeeburrahman and Hosmani (1996).

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J. Oilseeds Res. 16(2) 1999 : 253-256
ISSN 0970-2776

EFFECT OF IRRIGATION SCHEDULING ON PERFORMANCE OF GROUNDNUT

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ABSTRACT

A field experiment was conducted during 1992-93 and 1993-94 *rabi* season to optimize irrigation scheduling for groundnut grown under variable water supplies. In 1992-93, scheduling of irrigation at 0.6 or 0.8 Eta/Etm at any stage of crop growth followed by no water deficit (Eta=Etm) at two other stages - flowering and pod development and maturity (moderate water stress) resulted in significantly higher pod yield than the crop irrigated at 0.8 or 0.6 of Eta/Etm throughout crop growth period. On the other hand, in 1993-94, the crop irrigated at 0.6 Eta/Etm at vegetative stage or 0.8 at flowering and no stress at other two stages and the crop irrigated with out any stress at any of the crop growth stages resulted in significantly higher pod yield than the crop irrigated with Eta/Etm of 0.6 or 0.8 through out crop growth. The crop irrigated with 0.8 Eta/Etm throughout crop growth though resulted in lower pod yield, but WUE (6.49 kg.mm water) was higher as compared to other irrigation schedules.

Keywords : Irrigation, yield, groundnut.

INTRODUCTION

Groundnut is grown in large areas under irrigation during winter in the Sri Ram Sagar Project command area of Andhra Pradesh. In low rainfall years, due to low water storage, the area of irrigated crops under this Project's command area decreases considerably. The recommended practice is to irrigate the crop before the soil moisture reaches a level where crop yields are adversely affected. Irrigation water management of this type is applicable when land and water supply is unlimited (Singh *et al*, 1976). Under water scarcity conditions, the aim must be to get optimum crop yield with maximum water use efficiency. With this objective, an experiment using methodology suggested by Doorenbos and Kassam (1979) was conducted for two seasons on groundnut to quantify the effect of soil moisture deficit and to suggest appropriate water management practices to minimize yield losses under conditions of water deficits.

MATERIALS AND METHODS

Field experiments were conducted during dry season (Oct-Apr) of 1992-93 and 1993-94 at ANGR Agricultural University, Regional Agricultural Research Station, Jagtial situated at an altitude of 243.4 m above MSL on 78.56° E longitude and 18.49° N latitude. The weekly mean maximum temperature for the crop period (Oct-Mar) of 1992-93 and 1993-94 ranged between 28.3 and 41.4°C. The mean weekly daily evaporation ranged between 2.5 and 9.4 mm per day with a wind velocity of 1.2 to 6.0 km/hr during the crop growth period. A total of 67.2 mm rainfall was received in three rainy days in the first 2 weeks after sowing in 1992-93.

The soil of the experimental site was red sandy loam with pH7.4,organic carbon 6.3 kg ha^{-1}, available nitrogen 267 kg ha^{-1}, available$P_2 0_5$ 8.64 ha^{-1} and available $K_2 0$ 394 ha^{-1}. The experiment was laid out in randomized block design with 9 treatments (Table 1) replicated three times.

The crop was sown on Nov 13, 1992 and Oct 18, 1993 at a spacing of 30cmx7.5cm. The variety under test was JL24. The crop was fertilized with 30 kg N/ha. 60kg/ha $P_2 0_5$ and 40 kg/ha $K_2 O$. Gypsum @500 kg/ha was applied in bands

Received for publication in July, 1998.

at 30 Days after germination (DAG). Entire P_2O_5 and K_2O along with 2/3 N was applied at sowing and remaining 1/3 N at 30 DAS.

The single value constants on dry weight basis were: field capacity 12.4%, wilting coefficient 5.3%, bulk density 1.35 g/cm3 and available moisture was 96mm, in 100 cm depth of soil profile. The treatments were based on Doorenbos and Kassam (1979) as indicated in Table 1 were imposed by allowing moisture deficit at different crop growth stages.

Two common irrigations of 50 mm each were given at sowing and 8 DAS. The measured quantity of water was applied through surface irrigation to each plot with the help of "V" notch. The quantity of water applied at each irrigation was added and the total water applied under each treatment was computed.

The field water use efficiency (FWUE) expressed as ratio between pod yield to the quantity of water applied was estimated.

RESULTS AND DISCUSSION

Pod yield

Pooled analysis of pod yield indicated that there was significant difference among different irrigation treatments. In 1992-93, the crop irrigated at Eta/Etm ratio of 1.0 throughout crop growth resutled in significantly higher pod yield than that of crop receiving irrigation with stress at any one of the growth stages (Table 1). The crop irrigated with 0.6 or 0.8 Eta/Etm ratio at any of the crop growth stages - vegetative, flowering or pod development and maturity and no stress at other two stages resulted in significantly higher pod yield as compared to the crop irrigated with 0.6 or 0.8 Eta/Etm ratio through out crop growth. On the other hand, in 1993-94, the crop irrigated at 0.6 Eta/Etm ratio at vegetative stage or 0.8 at flowering and no stress at any of the growth stages resulted in significantly higher pod yield compared to that irrigated with Eta/Etm ratio of 0.6 or 0.8 through out crop growth. In the latter two treatments,the severe moisture stress during growth period might have adversly affected the process of remobilisation of photosynthates and reduced the pod yield significantly. The crop irrigated at Eta/Etm of0.8 at vegetative stage. 0.8 at pod development and maturity, and 0.6 at flowering and no stress at other two stages and the crop irrigated with Eta/Etm of 0.8 through out crop growth resulted in similar pod yield. It has been reported that the pod yield was greater with no stress through out the crop growth period (Parmar *et al.* 1989) and the pod yield was lower when stress was imposed during flowering stage followed by pod development stage (Golakiya and Patel, 1992). The moisture stress during 10-40 DAS is beneficial in increasing the pod yield due to synchronous pod development. The pod initiation and pod development stages were reported to be more critical stages requiring irrigation (Ramachandrappa *et al.* 1992). Drastic reduction in pod yield in the crop scheduled with irrigation of 0.6 Eta/Etm at pod devlopment and maturity in 1993-94 might be due to poor mobilization of assimilates from leaf to stem.

Water supplied

Greater quantity of water was given to the crop where irrigation was scheduled at Eta/Etm =1.0 through out the crop growth (Table 1). This was followed by the crop received irrigation at 0.8 Eta/Etm at vegetative stage (T4) and Eta/Etm =1.0 at other stages. The lowest water was applied to the crop irrigated at Eta/Etm=0.6 through out the crop growth (196 mm) followed by 0.8 through out the crop growth (232 mm). The water given at 0.6 Eta/Etm at vegetative (338 mm) at flowering (329 mm) or pod development and maturity (324 mm) and Eta/Etm = 1.0 at other stages was almost similar. The water applied in 0.8 of Eta/Etm at different stages (T4, T5 and T6) ranged between 354 mm to 418 mm.

The relation between pod yield and water applied was estimated through regression analysis (Fig 1). The best fit curve was found to be quadratic.

Table 1 : Effect of scheduling of irrigation on pod yield and WUE of groundnut

Treatments	Eta/Etm ratio considered			No.of irrigations		Water applied (mm)			Pod yield, (kg/ha)			Mean WUE (kg pods/mm of water)
				1992-93	1993-94	1992-93	1993-94	pooled	1992-93	1993-94	Mean	
	Vegeta-tive (8-35 DAS)	Flower-ing (35-70DAS)	Pod dev-elopment and maturity (70-125DAS)									
T1	*1.0*	*1.0*	*1.0*	*9*	*11*	*490*	*421*	*455*	*2425*	*1785*	*2120*	**4.66**
T2	*0.6*	0.6	0.6	4	4	193	199	196	1114	1002	1058	**5.40**
T3	0.8	0.8	0.8	5	6	252	212	232	1553	1456	1505	**6.49**
T4	0.8	1.0	1.0	8	9	430	406	418	1951	1648	1799	**4.31**
T5	1.0	0.8	1.0	7	9	369	338	354	2000	1860	1930	**5.45**
T6	1.0	1.0	0.8	7	9	371	398	385	1918	1598	1758	**4.57**
T7	0.6	1.0	1.0	7	8	372	304	338	2114	2000	2057	**6.09**
T8	1.0	0.6	1.0	7	8	371	288	329	2081	1754	1918	**5.83**
T9	1.0	1.0	0.6	7	9	365	282	324	1975	1247	1611	**4.97**
SEm ±									104	78	120	
CD (0.05)									313	238	390	

Eta = Actual evapotranspiration,Etm = Maximum evapotranspiration,WUE = Water Use Efficiency

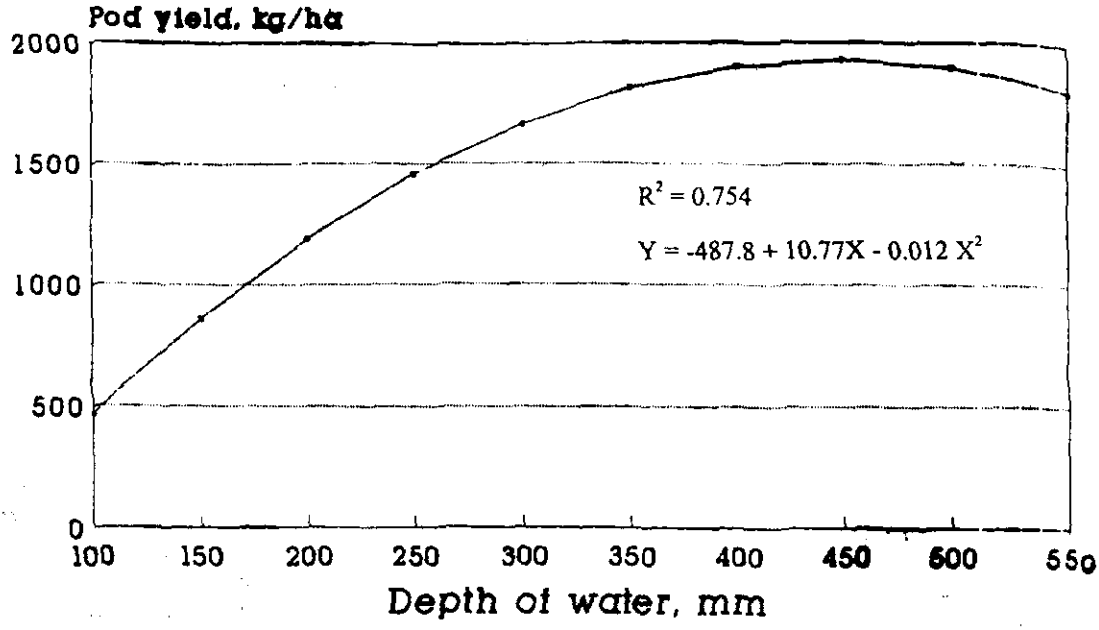

Fig.1 : Effect of depth of water on pod yield of goundnut

Water Use Efficiency (WUE)

The water use efficiency was higher in the crop receiving irrigation at 0.8 of Eta/Etm throughout the crop growth period followed by the crop receiving irrigation at 0.6 of Eta/Etm at vegetative stage (6.09) and flowering stage (5.83) at Eta/Etm =1.0 at other two crop growth stages. The WUE was similar in the crop receiving irrigation at 0.6 of Eta/Etm all through crop growth period or 0.8 at flowering stage and 1.0 at other two stages. The water use efficiency was lower when Eta/Etm =0.8 was given at vegetative (T4) or pod development and maturity (T6) and Eta/Etm=1.0 at other stages.

Under Sri Ram Sagar Project Commond area of Andhra Pradesh, scheduling irrigation at Eta/Etm during flowering and pod development and maturity and 0.6 during vegetative stage was ideal for groundnut. In times of deficit water supply, scheduling irrigation at Eta/Etm=0.6 or 0.8 at flowering and Eta/Etm=1.0 at vegetative and pod development and maturity stages result in higher yield.

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J. Oilseeds Res. 16(2) 1999 : 257-262
ISSN 0970-2776

SOIL TEST BASED FERTILIZER RECOMMENDATION FOR GROUNDNUT GROWN IN RICE FALLOWS (INCEPTISOLS) OF JAGTIAL IN ANDHRA PRADESH.

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ABSTRACT

Soil test crop response correlation studies have been condcted with groundnut (Girnar-1) grown in rice fallows of inceptisols of Jagtial during *rabi* 1991-92. Significant correlations were found between pod yield and soil available nutrients (N and P) and fertilizer nutrients (N and P) but not soil and fertilizer potassium. Multiple regression models for predicting pod yield through soil fertilizer nutrients and their interaction have been calibrated. The models were found to have a high and significant predictability value. Fertilizer adjustment equations based on the targetted yield concept (Ramamoorthy et al, 1967) have been developed. Using the fertilizer adjustment equations, a ready reckoner of fertilizers at varying soil test values for attaining groundnut yield targets of 25 and 30q/ha have been worked out. The results have been verified by conducting field verification trials in the farmers fields of Nizamabad and Kurnool districts. The trials have indicated that soil test crop response recommendation of fertilizers has given a higher benefit-cost ratio compared to farmers practice and general recommendation of N, P and K fertilizer doses.

Key words : Groundnut, Rice fallows, Fertilizer adjustment equations, Soil test crop response correlation, Field verification trials.

INTRODUCTION

Groundnut is a principal oil seed crop of Andhra Pradesh with an area of 18.83 lakh hectares in *kharif* and 3.83 lakh hectares in *rabi* with a total production of 26.25 lakh tonnes per year (DSE, 1996). The average production of groundnut during *kharif* and *rabi* seasons was 1128 and 1486 kg/ha, respectively. The groundnut yields during rabi season are low which may be due to imbalanced fertilization and lower level of crop management. So there is a great scope to increase the productivity from 2000 to 2500 kg/ha by exploiting full potential of groundnut by better management practices and balanced nutrition. With liberalisation of economy, the cost of fertilizers has gone up and the prices may further increase in future thus resulting in a reduction in the benefit-cost ratio to the farmers. In real sense, balanced fertilization should be based on soil test values rather than fertilizers applied to the crops. By adopting balanced fertilization through soil testing, fertilizer doses can be varied based on soil fertility and can increase the overall productivity of the crop. So far little work has been done in this direction in Andhra Pradesh. However, the work in other states has shown encouraging results. Rani Perumal *et al.,* (1988) reported that the nutrient requirement (kg/q), percent nutrient contribution from soil and fertilizers were 6.86, 1.24 and 2.73; 42.8, 73.1 and 9.3; 149.3, 26.3 and 30.3 for nitrogen, phosphorus and potassium, respectively.

Reddy *et al.*, (1994) have found that the N, P and K nutrient requirement (kg/q), percent contribution from soil and fertilizers were 6.23, 4.28 and 3.00; 65, 137 and 8.1; 160,51 and 86 respectively for *summer* groundnut grown in black soils of Rahuri. Similarly, the estimates were 4.77, 0.47 and 1.70; 24.6, 75.2 and 7.5; 190.9, 9.1 and 29.3 for nitrogen, phosphorous and potassium, respectively for *kharif* groundnut grown in black soils of Rahuri. Hence, with the objective of de-

Received for publication in August, 1998

veloping soil test based fertilizer doses the present study was planned in Rice fallows of northern Telangana Zone in Andhra Pradesh.

MATERIALS AND METHODS

The experiment on groundnut (Girnar-1) was conducted in rice fallow at Regional Agricultural Research Station, Jagtial during *rabi* 1991-92. Four fertility gradients designated as oX, 1/2X, 1 X and 2 X of *kharif* rice experimental plot was retained. Each gradient was divided into 30 plots and a set of 27 treated and 3 control plots were superimposed to the plots. The fertilizer treatments comprised three levels each of nitrogen (15,30 and 45 kg/ha), phosphorus (0, 45 and 90kg/ha) and potassium (0,30 and 60kg/ha). The design adopted was a mixed factorial Randomised Block Design. The crop was sown on 22nd January, 1991 and harvested on 10th May, 1991.

Soil samples were collected from each subplot before incorporation of fertilizers and were analysed for organic carbon (Walkley and Black, 1934), available nitrogen by alkaline permanganate method (Subbiah and Asija, 1956), available phosphorus by Olsen's method (Olsen *et al.* 1954) and available potassium by ammonium acetate extractant as described by Jackson (1973).

The pod and haulm samples collected at harvest were analysed for nitrogen, phosphorus and potassium contents. Total uptake of nutrients was calculated using pod yield and haulm yield data. Basic data and fertilizer adjustment equations for tragetted yield were evaluated by using pod yield data, total uptake of nutrients, soil test values and applied fetilizer doses as given by Ramamoorthy et al (1967)

Using the pod yield, soil, fertilizer and plant uptake data, estimates of correlation were determined. Prediction models of pod yield through soil and fertilizer nutrients and their interactions can be calibrated for predicting pod yield. Estimates of nutrient requirement (kg/q), percent contribution from soil and fertilizers are determined for calibrating soil test based fertilizer adjustment equations. The equations are used for determining soil test based optimal fertilizer doses for attaining different groundnut pod yield targets in Andhra Pradesh.

RESULTS AND DISCUSSION

The data clearly indicated the existence of fertility gradient in the experimental plots as there was a wide variability in soil test values and organic carbon (%) (Table 1). The ranges were 0.30 to

Table 1 : Range and mean of soil test values and pod yield in treated and control plots

Variable	Range	Mean	Standard deviation	Coefficient of Variation (%)
Soil test values				
Organic carbon (%)	0.30-0.61	0.47	0.23	49.8
Alkaline permanganate nitrogen (kg/ha)	165-276	202	140	69.3
Olsen's P (kg/ha)	6-28	15	10	66.7
Ammonium acetate K (kg/ha)	215-457	327	80	24.8
Pod yield (kg/ha)				
Treated plots	1525-4120	3047	1015	32.1
Control Plots	1500-2100	1821	900	49.5

0.61 for organic carbon (%), 165 to 276kg/ha for available soil nitrogen, 6 to 28 kg/ha for available soil phosphorus and 215 to 457 for available soil potassium. The pod yields of treated and control plots were found to range between 1525 and 4120, 1500 and 2100 with a mean of 3047 and 1821kg/ha, respectively. The data are used for further statistical treatment to derive soil test based fertilizer adjustment equations.

Estimates of correlation among different variables

Estimates of correlation have been derived between pod yield, uptake, soil and fertilizer nitrogen, phosphorus and potassium nutrients. Pod yield was found to have a significant correlation with $KMnO_4$-N (0.45**), Olsen's P (0.66), fertilizer nitrogen (0.80**) and fertilizer phosphorus (0.75**) but not with Ammonium acetate potassium (0.10) and fertilizer potassium (0.12). The plant uptake of nutrients were significantly correlated with pod yield which were 0.72** for nitrogen, 0.68** for phosphorus and 0.52** for potassium. Uptake of N and P had significant correlation with the other variables like organic carbon (%), $KMnO_4$-N, Olsen's P, fertilizer N and fertilizer P but not with Ammonium acetate K and fertilizer potassium. While uptake of K had significant correlation with ammonium acetate K (0.22*), it did not have any significant relation with fertilizer potassium (Table 2).

Multiple regression equations of groundnut pod yield

The multiple regression equations of pod yield with soil and fertilizer N, P and K variables and their interactions have been calibrated and are presented below:

1. $Y=868-0.36\ SN+123.98^{**}SP-3.45\ SK-2.01FN+0.38\ FN^2+26.59^{**}\ FP-0.11FP^2-9.30FK-0.09\ FK^2+0.01\ FNSN-0.44\ FPSP+0.06\ FKSK$

($KMnO_4$-N, Olsen's P, Amm.ace-K) $R^2=0.73^{**}$

2. $Y=1396-0.27SN+107.4^{**}SP-1.48SK+6.70\ FN+0.27FN^2+19.29^{**}FP-0.11^{*}FP^2+9.06FK-0.08\ FK^2$

($KMnO_4$-N, Olsen's P, Amm.ace-K) $R^2=0.72^{**}$

3. $Y=2181+49.18^{*}FN-0.43\ FN^2+19.77^{**}FP-0.11FP^2+3.03\ FK+0.002\ FK^2$ $R^2=0.47^{**}$

The above equations are useful for predicting pod yield significantly. Soil P and fertilizer P were found to be important as they were highly significant for pod yield production.

Table 2 :Relationship between yield, uptake, soil and fertilizer nutrients in groundnut at Jagtial

	Uptake variables			Soil Variables				Fertilizer variables		
	UN	UP	UK	OC	KM	OL	AM	FN	FP	FK
GY	0.72**	0.68**	0.52**	0.22*	0.45**	0.66**	0.10	0.80**	0.75**	0.12
UN		0.88**	0.80**	0.26**	0.42**	0.55**	0.12	0.92**	0.63**	0.06
UP			0.73**	0.22*	0.61**	0.67**	0.09	0.77**	0.69**	0.10
UK				0.32**	0.38**	0.48**	0.22*	0.56*	0.52**	0.15

*and ** are significant at 5 and 1% level of significance,GY = Grain yield, UN, UP and UK = Uptake N, P and K nutrients, OC = Organic carbon (%), KM = Alkaline permanganate nitrogen, OL = Olsen's P, AM = Ammonium acetate K, FN, FP and FK = Fertiliser N, P and K nutrients.

Soil test calibrations for targetted yield

Using the data of pod yield, uptake of nutrients and soil test values and applied fertilizer nutrients, the estimates of nutrient requirement (kg/q), percent contribution from soil and fertilizer nitrogen, phosphorus and potassium have been determined. Fertilizer adjustment equations for targetted yield of groundnut have been calibrated from basic data (Table 3). The nutrient requirement (kg/q) of nitrogen, phosphorus and potassium were 5.28, 1.58 and 2.64 ,respectively. The percent nutrient contribution from soil and fertilizer nutrients were 34.7, 102.3 and 11.7; 389.2, 44 and 165 for nitrogen, phosphorus and potassium, respectively. These results of nutrient requirement are in close confirmity with the result of Rani Perumal et al (1988) who reported the nitrogen, phosphorus and potassium requirement (kg/q) as 6.86, 1.24 and 2.73, respectively. The percent contribution of nutrients from soil and fertilizers are following the same trend of results reported by Rani Perumal *et al.* (1988) and Reddy *et al.* (1994).

Using fertilizer adjustment equations for targetted yield, a ready reckoner of fertilizer doses at varying soil test values for specific yield target has been developed. It is observed that fertilizer doses are decreasing with increasing soil test values for attaining a given yield target. The quantity of nitrogen fertilizer to be applied for production of 25 and 30q/ha were found to be 25 and 32; 6 and 14 kg N/ha at a soil test value of 100 and 300 kg/ha respectively. Fertilizer P requirement at 5 kg soil available P was 63 and 80 kg/ha for production of 25 and 30 q/ha respectively. However, the P requirement reached 'zero' level when the available phosphorus was 15 and 20 kg/ha for production of 25 and 30 q/ha respectively. Fertilizer K requirement at 100 kg K/ha soil available potassium was 31 and 39 kg/ha for production of 25 and 30 q/ha respectively and its requirement reached 'zero' level at 450 and 525 kg available soil potassium. Fertilizer nitrogen, phosphorus and potassium requirement for production of 25 and 30 q /ha at average soil test values viz., 200 kg N, 15 kg P and 327 kg K/ha of the experiement were 16, 10, 11;23, 28, 19 kg/ha respectively. The above results clearly show that the fertilizer requirement varies with soil test values for the same level of production. Hence, balanced fertilization through soil testing will become essential for groundnut (Table 4).

Verification of fertilizer adjustment equations in the farmers fields

The fertilizer adjustment equations developed for rice fallow groundnut in inceptisols of Jagtial have been tested for pod yield targets of 25 and 30 q/ha in the farmers fields of Nizamabad district (sandy loam soils) and Kurnool district (medium black

Table 3 :Basic data and fertilizer adjustment equations for targetted yield of groundnut (Girnar-1) in rice fallows of Jagtial

	Basic data			Fertilizer adjustment Equations	Response yardstick (kg/kg)
Nutrient	NR (kg/q)	CS(%)	CF(%)		
N	5.28	34.7	389.2	FN=1.36T-0.09 SN	15.52
P	1.58	102.3	44.0	FP_2O_5=3.60T-5.32SP	
K	2.64	11.7	165.9	FK_2O-1.59T-0.09SK	

NR = nutrient required in kg per quintal of pod production, CS = percent nutrient contributed from soil, CF = percent nutrient contributed from fertilizer, T = yield target (q/ha), SN, SP and SK = soil available nitrogen, phosphorus and potassium in kg/ha, FN, FP_2O_5 and FK_2O = Fertilizer nitrogen, phosphorus and potassium required in kg/ha.

Table 4 : Ready reckoner of fertilizer doses at varying soil test values for attaining specific yield targets of groundnut grown in rice fallows.

Soil available nutrients (kg/ha)			Fertilizer nutrients required (kg/ha) for yield target of 25q/ha			30q/ha		
N	P	K	N	P_2O_5	K_2O	N	P_2O_5	K_2O
100	5	100	25	63	31	32	81	39
125	10	150	23	37	26	30	55	34
150	15	200	21	10	22	27	28	30
175	20	250	18	0	17	25	2	25
200	25	300	16		13	23	0	21
225	30	350	14		8	21		16
250	35	400	12		4	18		12
275	40	450	9		0	16		7
300	45	500	7			14		2

Table 5 : Field verification trials in sandy loam soils of Nizamabad and medium black soils of Kurnool district

Location	Soil test values (kg/ha)			Treatments	Fertilizer doses (kg/ha)			Yield (q/ha)	Achiev-ement(%)	BC Ratio
	N	P	K		N	P_2O_5	K_2O			
Nizamabad										
Srinagar Road	227	76	290	FP	58	29	36	2550	-	24.7
C.Janaki Ramaiah				GRD	30	50	40	2740	-	23.2
				STCR (25q/ha)	14	0	14	2700	108	154.0
				STCR (30q/ha)	21	0	22	2780	93	104.0
Rudrur	**227**	**69**	**260**	FP	58	29	36	2500	-	24.2
M.Rama-mohan Rao				GRD	30	50	40	2720	-	23.0
				STCR (25q/ha)	14	0	16	2750	110	147.0
				STCR (30q/ha)	21	0	24	2725	91	97.0
Kurnool										
Yemmiganur	186	30	399	FP	125	115	44	2500	-	9.5
V.K.Adivanna				GRD	30	50	40	2100	-	18.9
				STCR (**25q/ha**)	17	0	4	2450	98	194.0
				STCR (**30q/ha**)	24	0	12	2600	87	122.0
Nandavaram										
A.Thimma Reddy	299	8	344	FP	85	50	30	2000	-	14.5
				GRD	30	50	40	2280	-	20.5
				STCR (25q/ha)	7	47	10	2470	98.8	33.0
				STCR (30q/ha)	16	65	17	2750	91.7	22.8

FP = Farmer's practice, GRD = General recommended dose, STCR = Soil test crop response dose, BC = Benefit -Cost

soils) for their validity and adoption by Soil Testing Laboratories. Both the yield targets (25 and 30 q/ha) tested were found to be achievable in all the places tested within ± variation (Table 5). Highest benefit-cost ratio was obtained with the fertilization based on fertilizer adjustment equations developed under soil test crop response methodology compared to general recommended dose and farmers practice. Hence, the Soil Testing Laboratory of Nizamabad and Kurnool districts can utilise the fertilizer adjustment equations for recommending fertilizer schedule based on soil test values for rice fallow groundnut grown in these two districts in both light and black soils.

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J. Oilseeds Res. 16(2) 1999 : 263-266
ISSN 0970-2776

EFFECT OF PIGEONPEA-BASED INTERCROPPING ON THE DRY MATTER ACCUMULATION IN PLANT PARTS OF SOYBEAN*

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ABSTRACT

A field experiment was conducted at Agricultural Research Station, Gulbarga, Karnataka on vertisols during *Kharif* seasons of 1992-93 and 1993-94 to study the influence of cropping systems and row proportions in pigeonpea based intercropping systems on dry matter production and its accumulation in different plant parts of soybean viz., stem, leaves, petioles and reproductive parts. Intercropping with pigeonpea significantly influenced the dry matter production of soybean at 50 DAS and at harvest. The sole crop of soybean, 50 DAS produced significantly higher dry matter (14.77 g plant^{-1}) compared with intercropped soybean (12.39 g plant^{-1}). Similar trend was observed at harvest also. The intercropped soybean under 2:4 and 1:2 (12.69 g plant^{-1}) row proportions of pigeonpea and soybean produced significantly higher dry matter at harvest when compared to 2:1 row proportion (9.93 g plant^{-1}).

Keywords : Dry matter production, Row proportion, Cropping systems, Soybean.

INTRODUCTION

Soybean is one of the oilseed crops of economic importance in Indian Agriculture. Its cultivation is restricted to states like Madhya Pradesh, Uttar Pradesh, Maharashtra, Gujarat and Karnataka. Being a short statured and early maturing crop it suits well in intercropping system. In Karnataka, it is cultivated mostly in the districts of Belgaum, Dharwad and Shimoga. However, its cultivation can extend to Gulbarga district as intercrop with Pigeonpea which is grown on a large scale. Rao and Mishra (1989) reported that growing two legumes together helped in increasing productivity as well as achieving higher LER. Soybean was found to be a profitable intercrop with pigeonpea (Tomar *et al.* 1984; Ramdas and Tirumurugan, 1993). Hence, the present investigation was carried out at the Agricultural Research Station, Gulbarga, to assess the effect of pigeonpea-based intercropping on the dry matter accumulation in plant parts of soybean.

MATERIALS AND METHODS

The field experiment was conducted during *Kharif* seasons of 1992-93 and 1993-94 at the Agricultural Research Station, Gulbarga. The soil was vertisol. The soil pH was 8.3 with 0.54 per cent organic carbon, 25 kg ha-1 of available phosphorus and 350 kg ha-1 of available potassium. There were 10 treatments comprising eight row proportions of pigeonpea and soybean (1:1,1:2, 1:3, 1:4,2:1,2:2,2:3 and 2:4) with two sole crops of pigeonpea and soybean. The experiment was laid out in a Randomized Block Design with three replications. The gross plot size was 4.8 m x 5.4 m and the net plot size varied under different row proportions. The varieties used were Maruti (ICPL -8863) and Monetta of pigeonpea and soybean, respectively. The population of pigeonpea was maintained at 100 per cent of its sole optimum (55,555 plants/ha) in all the treatments by adjusting the intra row space. While, the population of soybean varied under 2:1 (33%), 1:1 and 2:2

* Part of the Ph.D. thesis submitted by senior author to the University of Agricultural Sciences, Dharwad, Karnataka.

Received for publication in September, 1998

(50%), 2:3 (60%), 1:2 and 2:4 (66%), 1:3 (75%) and 1:4 (80%) row proportions of pigeonpea and soybean. The intra row space of 10 cm was maintained for soybean in all the intercropping treatments. Sole crop of pigeonpea was sown at a spacing of 90 cm x 20 cm and sole soybean was sown at a spacing of 30 cm x 10 cm. The recommended dose of fertilizer for pigeonpea (25:50 N:P kg ha-1) and soybean (25:37.5:25:12.5 N:P:K:Zn kg ha-1) were applied as basal dose. In case of intercropping treatments the fertilizers were applied in proportionate to the sole optimum population for main crop and intercrop separately. Five plants at random were uprooted from each plot and the soil was removed. The plant samples were separated into leaves, petioles, stem and reproductive parts and dried separately at 70°C in hot air oven for 72 hours. The completely dried samples were weighed and the dry weight of different plant parts was expressed in grams on per plant basis. The rainfall received during crop growth period was adequate and well distributed. The crops were harvested at their physiological maturity.

RESULTS AND DISCUSSION

Effect of cropping systems

Soybean intercropped with pigeonpea influenced the dry matter production and its accumulation in stem, leaves, petioles and reproductive parts of soybean significantly. The sole crop of soybean at 50 DAS, during 1992, 1993 and in their pooled analysis, produced significantly higher dry matter when compared to the intercropped soybean. Same trend was observed at harvest during 1992, 1993 and in their pooled analysis. In the pooled analysis at the time of harvesting, the dry matter produced by the sole crop of soybean (14.58 g plant^{-1}) was 23 per cent higher than intercropped soybean (11.87 g plant^{-1}) (Table-1). Similar reduction in the dry matter production of intercrops with pigeonpea have been reported by Madhusudan Rao *et al.* (1989). The lower dry matter production in case of intercropped soybean could be attributed mainly to increased total population of soybean and pigeonpea per unit area resulting in increased competition for growth resources, specially the moisture, nutrients and light. The soybean intercropped with pigeonpea influenced the dry matter accumulation in the stem of soybean significantly at 50 DAS and at harvest (Table-1). At the time of harvesting, the dry matter accumulated in the stem of sole soybean (4.43 g plant^{-1}) was 17 per cent higher than intercropped sybean (3.78 g plant^{-1}). Dry matter accumulation in pods followed the similar trend as that of dry matter accumulation in stem of soybean. In the pooled analysis at the time of harvesting, the dry matter accumulated in the pods of sole soybean (10.13 g plant^{-1}) was significantly higher by 25 per cent than intercropped soybean (8.08 g plant^{-1}) (Table-1). The reduction in dry matter accumulation in pods of intercropped soybean was mainly attributed to the lower dry matter production ability. Sole soybean recorded significantly higher dry matter accumulation in leaves and petioles of 5.55 g plant^{-1} and 1.593 g plant^{-1}, respectively at 50 DAS in the pooled analysis and this was 12 and 26 per cent higher, respectively when compared to intercropped soybean (Table-1). The lower dry matter accumulation in leaves of intercropped soybean could be due to lower leaf area when compared to sole soybean. The reduced leaf area of intercropped soybean may be due to limited photosynthetic ability as a result of competition for water and nutrient supply under increased population pressure due to the presence of pigeonpea as an associated crop (Donald, 1963).

Effect of row proportions

Soybean intercropped under different row proportions with pigeonpea influenced the dry matter production of soybean significantly at 50 DAS and at harvest during both the years of experimentation and in their pooled data (Table-1). In the pooled analysis at the time of harvesting, the dry matter produced under 2:4 (12.69 g plant^{-1}) and 1:2 (12.69 g plant^{-1}) row proportions of pigeonpea and soy-

Table 1 : Dry matter production of soybean (g plant^{-1}) as influnced by intercropping with pigeonpea at different row proportions (Pooled mean of 1992 and 1993)

Treatment	Leaves		Petiols		Stem			Pods		Plant		
	30DAS	50DAS	30DAS	50DAS	30DAS	50DAS	Harvest	50DAS	Harvest	30DAS	50DAS	Harvest
Cropping system												
Sole soybean	1.64	5.55	0.172	1.593	0.69	3.50	4.43	4.12	10.13	2.40	14.77	14.58
Intercropped soybean	1.58	4.97	0.170	1.260	0.67	2.86	3.78	3.32	8.08	2.42	12.39	11.87
S.Ed ±	0.03	0.06	0.003	0.075	0.02	0.06	0.04	0.06	0.20	0.02	0.13	0.23
CD (0.05)	0.05	0.12	NS	0.154	NS	0.12	0.08	0.12	0.41	NS	0.27	0.47
Row proportion (RP)												
PP SB												
1 1	1.57	4.76	0.161	1.192	0.67	2.73	3.61	3.00	6.47	2.39	11.58	10.20
1 2	1.58	5.01	0.166	1.233	0.67	2.86	3.87	3.33	8.82	2.41	12.45	12.69
1 3	1.56	4.97	0.166	1.328	0.68	2.92	3.86	3.41	8.76	2.40	12.62	12.63
1 4	1.58	5.18	0.175	1.417	0.66	2.92	3.85	3.63	8.67	2.43	13.13	12.52
2 1	1.59	4.67	0.171	1.097	0.67	2.62	3.52	3.01	6.41	2.43	11.40	9.93
2 2	1.57	4.92	0.172	1.153	0.67	2.81	3.76	3.13	7.94	2.40	11.91	11.70
2 3	1.61	5.02	0.173	1.273	0.68	2.95	3.89	3.43	8.77	2.45	12.68	12.59
2 4	1.61	5.23	0.169	1.363	0.68	3.05	3.87	3.69	8.83	2.46	11.33	12.69
S.Em ±	0.01	0.05	0.002	0.05	0.01	0.04	0.04	0.07	0.16	0.03	0.11	0.22
C D (0.05)	0.03	0.16	0.007	0.15	NS	0.12	0.12	0.21	0.48	NS	0.33	0.64

bean were 28 per cent higher than that under 2:1 row proportion of pigeonpea and soybean (9.93 g plant^{-1}). The lower dry matter production under 2:1 row proportion could be attributed to the fact that pigeonpea plants covered the intercrop because of lesser space between two pairs of pigeonpea. This restricts the development of leaf area and the crop as a whole and thereby producing lower dry matter. Row proportions also significantly influenced the dry matter accumulation in different plant parts of soybean intercropped with pigeonpea. The dry matter accumulated in the leaves of soybean under 2:1 was 11 per cent lower when compared to 2:4 row proportion (5.23 g plant^{-1}) at 50 DAS (Table-1). The reduction in the dry matter accumulation in leaves of soybean could be due to competition for growth resources especially for light was least under 1:4 and 2:4 row proportions, because the pigeonpea plants did not smother soybean because of wider space. While under 2:1 row proportion, the pigeonpea smothered soybean which restricts the leaf area and thereby dry matter accumulation in leaves. Similar trend of increased dry matter accumulation was observed in stem (3.87 g plant^{-1}) and reproductive parts (8.83 g plant^{-1}) of intercropped soybean under 2:4 row proportion of pigeonpea and soybean .

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J. Oilseeds Res. 16(2) 1999 : 267-270
ISSN 0970-2776

RESPONSE OF LINSEED VARIETIES TO IRRIGATION AND FERTILITY LEVELS

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ABSTRACT

An experiment was conducted on linseed (Linum usitatissimum L.) with three levels of irrigation (no irrigation, one irrigation 30 days after sowing (DAS), two irrigations 30+60 DAS), three fertility levels (control, 30:15:10: and 60:30:15 kg NPK/ha) and three varieties (JLS-1, T-397, and JL-23) in a sandy clay loam soil at the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur during winter season of 1989-90 and 1990-91. Two irrigations improved plant growth, yield attributes and seed yield than one. The growth and yield increased due to higher fertility level. Among the varieties JL-23 produced higher seed yield compared with T-397 and JLS-1. It gave higher seed yield at all levels of irrigation and fertility. The highest yield (1029 kg/ha) was obtained in JL-23 at 60:30:15 NPK kg/ha with two irrigations.

Key words: Linseed; irrigation; fertility levels; varieties

INTRODUCTION

The productivity level of linseed in the country as well as Madhya Pradesh has remained low (263 kg/ha) against realizable yield of 1500 kg/ha. This indicated that there is a wide scope to increase overall production of linseed through improvement in productivity level by cultural manipulation. Among the various factors contributing towards the attainment of potential yield of linseed, scheduling of irrigation, fertility level and varieties have considerable practical importance. In view of this, field experiments were conducted for two seasons to study response of linseed varieties to irrigations and fertility levels.

MATERIALS AND METHODS

The experiment was conducted during winter season of 1989-90 and 1990-91 at the Research cum Instructional Farm, Faculty of Agricultural Engineering, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur. The soil was sandy clay loam having 278.21 kg N, 21 kg P_2O_5 and 360 K_2O/ha in available forms. Three levels of irrigation (no irrigation, one irrigation at 30 days after sowing and two irrigations at 30 + 60 days after sowing) as main plots, three levels of fertilizer (O:O:O, 30:15:10 and 60:30:15 NPK kg/ha) in sub plots and three varieties (JLS-1, T-397 and JL-23) in sub-sub plots were tested in split plot design with three replications. The sowing was done @ 30 kg seed/ha in 30 cm rows apart. The NPK were supplied through urea, super phosphate and muriate of potash, respectively at sowing. The seed was sown in dry seedbed. Therefore, one irrigation was provided uniformly to all plots for germination.

RESULTS AND DISCUSSION

Growth attributes

Two irrigations, fertility level of 60:30:15 NPK kg/ha and variety JL-23 recorded tallest plants in both the years. The number of basal branches/ plant at harvest was greatest with one irrigation compared with no irrigation in first year. While, in second year, the number of basal branches was greatest with two irrigations compared with no irrigation. The number of branches was significantly higher with higher fertility level of 60:30:15

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Received for publication in February, 1993.

Table 1 : Growth and yield attributes of linseed in relation to irrigation, fertility levels and varieties

Treatment	Plant height (cm)		No. of Branches/ (plant)		Dry matter yield (g/plant)		No. of Capsules/ plant		Crop Biomass (kg/ha)		Net return
	89-90	90-91	89-90	90-91	89-90	90-91	89-90	90-91	89-90	90-91	(Rs./ha)
Irrigation											
No Irrigation	53.08	58.18	5.60	5.53	2.10	2.10	11.68	17.90	1734	1510	2694
Irrigation at 30 DAS	55.52	59.32	6.07	5.83	3.02	3.11	13.19	21.10	1906	1726	3288
Irrigation at 30,60DAS	56.91	61.25	6.03	6.05	3.18	3.76	15.91	25.92	2216	2082	1116
SE(d)	0.259	0.260	0.10	0.08	0.13	0.10	0.908	0.615	88.85	3.218	-
CD (0.05)	0.718	0.721	0.28	0.23	0.36	0.29	2.250	1.707	216.66	6.319	-
Fertilizer (NPK/ha)											
0-0-0	51.77	52.18	5.61	5.17	2.16	2.06	8.72	13.35	1133	1095	1642
30-15-10	55.08	55.29	5.89	5.82	2.88	2.87	13.60	20.50	1918	1699	3259
60-30-15	55.78	65.60	6.17	6.13	3.86	1.02	18.80	31.33	2171	1558	5227
SE (d)	0.107	0.161	0.07	0.08	0.07	0.13	0.706	0.550	115.29	3.588	-
CD (0.05)	0.891	1.011	0.15	0.17	0.16	0.29	1.538	1.198	251.22	5.531	-
Varieties											
JLS-1	51.65	58.19	5.38	5.71	2.78	2.85	12.59	20.81	1878	1651	3058
T397	55.08	58.83	5.88	5.78	2.95	2.91	13.15	21.32	1956	1728	3318
JL23	55.78	59.71	5.99	5.90	3.17	3.21	11.75	23.03	2022	2006	3758
SE (d)	0.188	0.176	0.07	0.08	0.08	0.13	1.107	0.558	86.61	2.641	-
CD (0.05)	NS	0.965	NS	NS	0.16	0.27	NS	1.128	NS	3.789	-

Table 2 :Influence of irrigation and fertility levels on seed yield (kg/ha) of different varieties of linseed

Irrigation \ Fertilizer	1989-90				1990-91			
Variety	F0	F1	F2	Mean	F0	F1	F2	Mean
I0	109.93	575.75	691.11	558.93	211.90	101.16	605.08	118.0
I1	157.19	622.53	718.79	620.10	289.97	189.80	702.30	197.03
I2	515.14	698.02	911.51	718.21	328.69	552.30	892.99	591.33
V1	135.10	598.61	783.61	605.87	272.68	117.21	680.08	166.66
V2	161.15	633.16	806.91	633.85	291.10	176.81	701.81	189.93
V3	185.12	661.53	823.59	657.85	308.79	522.21	818.15	519.82
Mean	160.75	632.10	811.71	-	290.85	182.09	733.16	-

Variety \ Irrigation	V1	V2	V3	Mean	V1	V2	V3	Mean
I0	538.00	565.65	570.11	558.93	388.88	118.01	117.21	118.01
I1	590.10	625.19	615.92	620.10	173.10	198.51	518.97	197.03
I2	689.52	710.71	751.18	718.21	537.19	553.23	683.27	591.33

Irrigation (I)	28.960	80.390	0.577	1.601
Fertilizer (F)	39.060	85.110	0.909	**1.980**
Varieties (V)	**27.610**	**NS**	0.819	**1.661**
Fertilizer at same level of Irrigation	67.650	**NS**	1.575	**3.133**
Irrigation at same level of Fertilizer	62.370	**NS**	1.109	**3.213**
Variety at same level of Irrigation or Fertilizer	17.820	**NS**	1.118	**2.877**
Irrigation at same level of Variety	18.610	**NS**	1.291	**2.818**
Fertilizer at same level of Variety	55.230	**NS**	1.172	**3.071**

NPK kg/ha compared with other two levels in both years. Varieties did not differ significantly for number of branhes during both years of study. The dry matter production (g/plant) was greatest under two irrigations. Dry matter production was also significantly higher with one irrigation than no irrigation. Significantly higher dry matter production was noted under 60:30:15 NPK kg/ha over 30:15:10 NPK kg/ha and control. Amongst varieties, significantly higher dry weight was recorded in JL-23 as compared to JLS-1.

Yield attributes

The number of capsules/plant was the highest in crop irrigated twice and it was significantly superior to unirrigated conditions as well as those which were irrigated only once. Significantly higher number of capsules was recorded with fertility level of 60:30:15 NPK kg/ha as compared with 30:15:10 NPK kg/ha and control. Variety JL-23 produced the highest number of capsules and it was significantly superior to T-397 and JLS-1 during 1990-91 only. Significantly higher crop biomass was recorded with two irrigations as compared with one and no irrigation. The production of crop biomass was more under 60:30:15 NPK kg/ha than 30:15:10 NPK kg/ha and control. Significantly higher crop biomass was noted in JL-23 as compared to T-397 and JLS-1 (Table-1).

Seed Yield (kg/ha)

Significantly higher seed yield was recorded from the plots irrigated twice (718.24 kg/ha) as compared to the plots irrigated only once (620.40) and unirrigated plots (558.93). Chhida Singh (1973) and Rao (1982) also noted significant increase in seed yield with two irrigations. Significantly higher seed yield (814.71, 733.16) was recorded with 60:30:15 kg NPK/ha as compared to 30:15:10 NPK kg/ha (632.10, 482.09) and control (460.75, 290.85). The increased yield with 60:40:20 NPK kg/ha was also reported by Tomer et al (1985). Among the varieties, JL-23 produced significantly higher seed yield (549.82) as compared to T-397 (489.93) and JLS-1 (466.66) during second year.

The interaction of irrigation x fertility level, irrigation x varieties and fertility x varieties were significant on seed yield during second year. The highest yield was noted with two irrigations and higher fertility levels. Significantly higher seed yield of varietiy JL-23 was recorded with two irrigations and higher fertility of 60:30:15 NPK kg/ha (Table -2).

Economics

Economic analysis of various treatments revealed that two irrigations (30 + 60 days) gave the highest net return (Rs.4146/ha). The higher fertility of 60:30:15 NPK kg/ha proved economical (Rs.5227/ha). Amongst the varieties JL-23 gave the highest net return of Rs.3758/ha. The highest net profit of Rs.7972 and B:C ratio (3.61) was recorded under combination of JL-23 grown with two irrigations and 60:30:15 NPK kg/ha fertilizer.

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J. Oilseeds Res. 16(2) 1999 : 271-275
ISSN 0970-2776

CERTIFIED SEED PRODUCTION OF SAFFLOWER HYBRIDS IN RELATION TO PLANT DENSITY AND NUTRITION IN ALFISOLS UNDER IRRIGATED CONDITIONS.

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ABSTRACT

Field investigations were made at the Directorate of Oilseeds Research, Rajendranagar, Hyderabad, during rabi 1995-96 on DSH-130 and on DSH-129 during 1996-97 and 1998-99 on alfisols to assess the effect of plant densities (45x20cm, 45 x 30 cm and 45 x 40 cm) and fertilizer levels (recommended dose of 40-40-20 NPK/ha, RDF+FYM 5t/ha; 50% RDF +FYM 5t/ha; 150% RDF and 200% RDF) on the certified safflower hybrid seed production in a randomized block design with 3 replications under irrigated situations. It was observed that maximum DSH-129 hybrid seed yield of 1228 kg/ha and 465 kg/ha was obtained in 1996 and 1998, respectively with a spacing of 40 x 30 cm, although the variations between different spacings were not discernible. Likewise spacing did not significantly influence the yield of DSH-130 during 1995-96. Significant interaction between spacing and fertilizer on the yield of pollen parent showed that sowing at 45 x 30 cm in conjunction with application of 200% recommended dose of fertilizer (80-80-40 kg NPK/ha) offered significantly greater yield than the rest in 1996-97. Application of 200% recommended dose of fertilizer resulted in maximum hybrid seed yield, as well as male parent yield of DSH-129 during both the years, though the variations were not significant. The test weight of hybrid seed was not significantly influenced either by plant densities or fertilizer.

Key words : Certified seed, plant density, fertilizer, safflower hybrids.

INTRODUCTION

Safflower *(Carthamus tinctorius* L) is an important oilseed crop of India raised on vertisols during post-rainy season utilizing the conserved residual soil moisture. Currently in India it is raised on an area of 6.84 lakh hectares with a production of 3.96 lakh tonnes and a productivity of 579 kg/ha. To break the yield barriers hybrid programmes based on genetic male sterility system resulted in development of safflower hybrids such as DSH 129, DSH-130, etc. The first safflower hybrid DSH 129 has been released in 1997 for commercial cultivation both under irrigated and residual moisture conditions in India. It exhibited 22% greater seed yield and 30% higher oil yield than the national check Annigeri-I. This hybrid has been evolved based on genetic male sterility system (GMS) controlled by recessive alleles. To popularise this newly released hybrid there is a need to produce certified seed of good quality in sufficient quantities. This in turn calls for a need to generate seed production technology, with particular reference to plant density and optimum fertilizer to maximise seed production. Differential response of commercial safflower to plant density and fertilizer application under irrigated conditions has been reported by various workers (Padmavathi and Raghavaiah 1994, Singh *et al.* 1995, Mane and Jadhav 1994; Mundel *et al.* 1994). Sharma and Verma (1984) obtained no response to spacing and NP fertilizers. Raghavaiah and Anjani (1998) observed synergestic effect of farmyard manure when integrated with inorganic fertilizer under irrigated conditions in alfisols. The present study has therefore been conducted to assess the seed production of safflower hybrids in relation to plant density and nutrition.

Received for publication in May, 1999

MATERIALS AND METHODS

A field investigation has been conducted during rabi 1995-96, 1996-97 and 1998-99 at the research farm of the Directorate of Oilseeds Research, Rajendranagar, Hyderabad, on alfisols under irrigated conditions. The parents of safflower hybrid DSH-129 (MSS9 (O) x A-1) have been sown in 3:1 (female:male) row proportion during 1996-97 and 1998-99, while during 1995-96 hybrid DSH - 130 (MSS 17xA-1) was tested. The treatments consisted of 3 plant densities (45 x 20 cm, 45 x 30 cm and 45 x 40 cm) and five fertility levels (viz., Recommended dose of 40-40-20 kg NPK/ha (RDF), RDF+Farmyard manure (FYM) @ 5t/ha; 50% RDF+FYM @ 5t/ha; 150% RDF and 200% RDF) tested in a factorial randomized block design with 3 replications. The soil of the experimental field was a sandy loam characterised by low nitrogen (0.36% organic carbon) medium available phosphorus (18.2 kg/ha) and high available potassium (300 kg/ha) with a pH of 6.8. The crop was sown on 16th October and harvested on 3rd April, 1996. It was sown on 10th November in 1998. Well decomposed farmyard manure was applied to the soil before sowing and incorporated into the soil as per the treatments. The crop received NPK fertilizer as per treatment in 2 splits i.e., half of the nitrogen and the entire quantity of phosphorus and potassium were applied as basal dose before sowing, while the remaining quantity of nitrogen was top dressed at rosette stage (40 days after sowing) of the crop. The seed yield and yield components were recorded from 5 randomly selected plants from each net plot. The male fertile plants (MF) from the 3 male sterile (MS) parent rows were rouguedout after carefully observing the floral morphology at the time of flowering making sure that only the male sterile plants were leftout in the field. The male sterile plants were characterized by small head size, shortened corolla and low extrusion of stigma without pollen in the anthers. Such rouging operations were carried out several times until the last plant in the male sterile rows flowered. This was done meticulously to see that the male sterile flowers were pollinated only through the pollen from pollen parent (A-1) which is sown adjacent to the 3 male sterile parent rows. Thus each plot comprised 6 male sterile parent rows and 3 pollen parent rows sown in 3:1 ratio. The final plant stands were counted and the yields per hectare were calculated based on the net plot yields. The crop received 6 irrigations each of 50 mm depth during the crop growth period.

RESULTS AND DISCUSSION

Effect of plant density

The results revealed that the different plant densities could not bring about discernible variations in the certified hybrid seed yield of DSH 130 in 1995-96 and DSH 129 safflower during both the years (1996-97 and 1998-99) of experimentation. Sharma and Verma (1984) also did not obtain significant response to spacing. However, maximum hybrid (DSH 129) seed yield of 1228 kg/ha and 465 kg/ha was obtained in 1996 and 1998, respectively with a spacing of 45 x 30 cm. This suggests that safflower crop possesses greater plasticity to adjust to spacing through production of more number of branches, capsules and seed/capsule resulting in greater yield even under low density. The test weight of seed tended to move up with low population densities as compared with high densities. The greater hybrid seed yield obtained in 1996 than in 1998 was due to higher final plant stands in the former than in the latter year (Table 1). The differential behaviour of the hybrids could be due to per-se performance of their male sterile lines and their combining ability with the pollen parent (Anjani, 1997). Availability of pollen and honey bee population at flowering time also can influence the seed production.

The seed yield of male parent was significantly higher with 45 x 30 cm spacing (882 kg/ha) during 1996-97 than that obtained with 45 x

Table 1 : Effect of plant density and fertilizer on certified seed production of Safflower hybrids

Treatment	Final plant stand (000/ha) of male sterile parent of hybrid			Hybrid Seed yield (kg/ha)			Yield of pollen parent (kg/ha)			100 seed Wt (g)
	DSH 130	DSH 129		DSH 130	DSH 129					
	1995-96	1996-97	1998-99	1995-96	1996-97	1998-99	1995-96	1996-97	1998-99	1998-99
Plant density										
S1-45x20 cm (1.11 lakh pl/ha)	28.70	36.07	24.41	357.2	1168.8	440.4	902.6	707.7	878.8	4.74
S2-45x30 cm (0.74 lakh pl/ha)	25.15	39.93	19.93	310.0	1228.7	465.5	915.7	881.9	923.9	4.89
S3-45x40 cm (0.55 lakh pl/ha)	26.59	33.13	17.19	354.4	1092.7	445.8	913.7	906.8	827.6	4.87
SEm ±	1.91	3.49	1.03	38.07	108.6	29.9	26.16	12.64	93.5	0.12
C.D. (0.05)	NS	NS	2.99	NS	NS	NS	NS	36.64	NS	NS
Fertilizer Level										
F1 Recommended dose (40-40-20 kg NPK/ha)	27.72	41.76	20.06	351.4	1271.9	425.7	750.3	767.9	825.5	5.02
F2 RDF+FYM @ 25t/ha	30.06	41.67	21.85	411.0	1290.6	471.7	908.9	781.2	855.0	4.76
F3 50% RDF+FYM @5t/ha	25.25	29.44	19.63	318.0	891.2	418.5	957.7	820.1	832.8	4.90
F4 150%RDF (60-60-30 NPK/ha)	26.05	28.67	21.30	317.2	992.5	490.8	988.8	851.8	913.6	4.63
F5 200% RDF (80-80-40 NPK/ha)	25.00	38.67	19.69	305.0	1370.9	446.3	947.7	939.4	957.1	4.84
SEm ±	2.47	4.51	1.33	49.15	140.2	38.6	33.78	16.32	120.7	0.16
CD (0.05)	NS	NS	NS	NS	NS	NS	97.90	47.26	NS	NS
Plant density X Fertilizer	NS	NS	NS	NS	NS	NS	NS	Sig*	NS	NS

RDF : Recommended dose of fertilizer, NS : not significant

20 cm (707 kg/ha). Similarly during 1998-99 the male parent seed yield was highest with 45 x 30 cm spacing although the variations were not discernible (Table 1). Significant interaction between plant densities and fertilizer on the seed yield of male parent in 1996-97 revealed that sowing at 45 x 30 cm in conjunction with application of 200% recommended dose of fertilizer (80-80-40 NPK/ha) offered substantially higher yield (1077 kg/ha) than the rest of the test treatments signifying the complementary role played by these two production factors (Table 2).

Effect of fertilizer

Application of varied quantities of fertilizer had no discernible influence on the seed yield of DSH 130 in 1995-96 and of DSH 129 safflower hybrid during 1996 and 1998. Sharma and Verma (1984) also reported no response of safflower to NP fertilizer. However, in 1996-97 application of 200% recommended dose of fertilizer provided the highest seed yield (1371 kg/ha) as well as yield from male parent (939 kg/ha) under irrigated conditions. During 1998-99 application of 150% recommended dose of fertilizer (491 kg/ha) offered maximum hybrid seed yield closely followed by RDF+FYM 5t/ha (472 kg/ha). Application of 150% RDF + FYM 5t/ha gave maximum yield of DSH-130 hybrid (411 kg/ha) during 1995-96. Raghavaiah and Anjani (1998) observed synergestic effect of FYM when integrated with inorganic fertilizer in safflower. As in 1996-97, application of 200% recommended dose of fertilizer resulted in the maximum seed yield of pollen parent (957 kg/ha) in 1998-99 (Table-1). Application of 150% RDF gave maximum yield of male parent (A-1) of DSH-130 hybrid in 1995-96 (989 kg/ha) which was on par with other fertilizer treatments and significantly superior to recommended dose of fertilizer (750 kg/ha).

From the above discussion it can be concluded that safflower certified hybrid seed production was not significantly influenced by plant densities indicating the plasticity and compensatory mechanism for loss of population stand. Application of NPK alone (40-40-20 NPK/ha) or in conjunction with farmyard manure beyond the recommended dose did not offer much advantage in

Table 2 : **Interaction effect of plant density and fertilizer on the seed yield (kg/ha) of pollen parent in 1996-97**

Spacing (Plant density)	Fertilizer					
	F1	F2	F3	F4	F5	Mean
S-1 45x20 cm (1,11,000 pl/ha)	677.4	700.4	681.9	711.5	767.0	707.6
S-2 45x30 cm (74,000 pl/ha)	783.1	793.7	848.9	906.9	1077.2	881.9
S-3 45x40 cm (55500 pl/ha)	843.3	849.6	929.6	937.2	974.1	906.8
Mean	767.9	781.5	820.1	851.9	939.4	832.1
SEm ±	28.2					
CD (0.05)	81.8					

F1- Recommended dose of fertilizer (40-40-20 Kg NPK/ha), F2- RDF + FYM @ 5t/ha, F3-50% RDF + FYM @ 5t/ha, F4-150%RDF and F5-200% RDF.

terms of certified seed yield of hybrids DSH-130 and DSH-129. Seeding pollen parent (A-1) at 45 x 30 cm along with 80-80-40 kg NPK/ha produced significantly greater yield than the rest under irrigated conditions in alfisols.

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J. Oilseeds Res. 16(2) 1999 : 276-280
ISSN 0970-2776

STUDIES ON AVAILABLE SULPHUR STATUS AND GROUNDNUT RESPONSE IN COASTAL ALLUVIAL SOILS OF NELLORE DISTRICT (A.P.)

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ABSTRACT

Alluvial soils where groundnut is grown in Nellore district of Andhra Pradesh, were studied for their sulphur status. The total sulphur content of the soils ranged from 104 to 166 ppm with a mean of 130.3 ppm. The studies of the soils under green house conditions revealed that sulphur application significantly increased the drymatter yield and sulphur uptake of groundnut plants at 30 and 60 DAS. Sulphur had a synergistic effect on absorption of N,P and K by goundnut. The available sulphur extracted with 0.15% $CaCl_2$, 1% NaCl and N NH_4OAc pH (7.0) was positively and significantly correlated with drymatter yield and sulphur uptake by groundnut at 60 DAS of the crop growth, indicating that any one of the extractants could be used for predicting the available sulphur status of soils of Nellore district.

Key words: *Sulphur, availability indices, Alluvial soils, Synergistic effect, groundnut.*

INTRODUCTION

Sulphur deficiency in India was observed in various states and ninety out of 400 districts were identified as 'S' deficient to varying degrees and intensity (Tandon 1986 and 1991). With the result it is now classified as "fourth major plant nutrient" next to N, P and K (Vijaya Chandran, 1985). The importance of sulphur nutrition in groundnut has been established. Sulphur is important in promoting nodulation in legumes thereby promoting nitrogen fixation, besides being a constituent of aminoacids like methionine (21% S), cysteine (26% S) and cystine (27% S). With increasing awareness of sulphur deficiency, it becomes necessary to study the different 'S' fractions and available status of S in soils inorder to select a suitable soil test method to determine the content of available sulphur. Little information is available on available S status and response of goundnut to S fertilization in alluvial soils. Hence the present investigation was conducted to study the response of groundnut to 'S' fertilization under green house conditions.

MATERIALS AND METHODS

Ten villages of Nellore district of Andhra Pradesh were selected for the study, where the soils were alluvial and groundnut is being cultivated every year. Surface (0-30cm) composite soil samples were collected from every village. These samples were analysed for different physico-chemical characters following standard methods (Jackson 1967). Triacid mixture (HNO_3+$HCL0_4$+H3 $P0_4$) in 1:1:2 ratio were used for the extraction of total sulphur. The procedure described by Bardsely and Lancaster (1965) was used for the estimation of organic sulphur. Various extractants viz; 0.15% $CaCl_2$ (Williams and Steinbergs, 1959), 1% NaCl (Williams and Steinbergs,1959), N NH_4OAC pH 7.0 (Palaskar and Ghosh, 1982), 0.01 N HCl (Pal and Motiramani, 1971), 0.5 M NaHCO3 pH 8.5 (Kilmer and Nearpass, 1960), 1 N NaOAC pH 7.0 (Williams and Steinbergs, 1959) and KH_2PO_4 500 ppm (Williams and Steinbergs, 1959) solutions were used for the extraction of available sulphur and determined colorimetrically (Vogel, 1961).

Received for publication in September, 1998.

Table 1 : Basic characterization of the soils of Nellore district in Andhra Pradesh

Sl. No.	Location	pH (1:2)	EC dsm-1 1:2	O.C	CEC (me/ 100g)	Available Nutrients N kg ha-1	P kg ha-1	K kg ha-1	Ex.Ca (me/ 100g)	Ex Mg (me 100g)	Total S (ppm)	Organic S (ppm)	Available 'S' (0.15% CaCl2) (ppm)
1	Drasanamala	7.15	0.29	0.26	2.86	213.3	6.4	179.2	**4.85**	**1.00**	126.0	**54.0**	18.0
2.	K.G. Kandriga	7.85	0.07	0.30	4.99	210.1	7.6	156.8	4.75	**1.85**	**154.2**	**76.0**	**10.5**
3.	D. Adivi	7.55	0.11	0.23	4.19	188.2	7.9	134.4	4.75	**1.85**	**120.4**	**52.0**	**11.5**
4.	P.G. Thota	8.10	0.11	0.28	6.64	203.8	8.2	196.0	4.40	**3.60**	**130.5**	**58.0**	**9.0**
5.	Palchuru	7.45	0.18	0.22	11.34	156.8	9.6	112.0	**3.75**	**2.85**	**104.0**	**45.0**	**6.0**
6.	Chavali	7.35	0.18	0.25	4.08	181.9	8.1	145.0	4.15	2.20	110.8	49.6	14.0
7.	Bhimavaram	7.50	0.22	0.34	4.21	141.1	10.2	235.2	5.70	2.65	166.0	85.0	10.0
8.	Naidupet	7.30	0.15	0.26	4.09	169.4	6.9	89.6	3.25	2.25	134.2	60.2	15.0
9.	Menakur	7.50	0.07	0.29	4.35	178.8	9.0	156.8	4.40	3.10	146.0	68.0	14.0
10.	Pellakur	7.35	0.04	0.24	3.98	213.3	3.9	78.4	**3.40**	**2.60**	**110.4**	**49.0**	8.0
	Range	7.15	0.04	0.22	2.86	141.0	3.9	78.4	**3.25**	**1.00**	**104**	**61.2**	**6.0**
		to	to	to	to	to	to	to	to	to	to	to	to
		8.10	0.29	0.34	11.34	213.3	10.2	235.2	5.70	3.60	166	81.0	18.0
	Mean	7.51	0.14	0.27	5.07	185.7	7.8	148.3	4.34	2.39	130.3	70.6	11.6

A green house experiment was conducted with soils from 10 villages as main treatments and four levels of 'S' (0,10,20 and 40 ppm) in three replications with groundnut (var.K-134) as a test crop at College of Agriculture, Tirupati during *rabi* 1993-94.

Earthen pots (30 cm upper diameter and 30 cm depth) were filled with 7 kilograms of soil and randomly arranged in RBD Design with factorial concept. Sulphur was added as (NH4)2 SO4 and K2SO4 in solution form. Five groundnut seeds were sown in each pot and later thinned to two plants. The potted plants were kept weed and pest free. Two and three plants were harvested at 30 and 60 DAS of the crop respectively, processed separately and analysed for S,N,P and K as described by Jackson (1967). Diacid extracts of plants was determined colorimetrically as described by Jackson (1967).

RESULTS AND DISCUSSION

The soils were sand to loamy sand in texture with neutral to moderately alkaline in reaction (Table 1). They were low in available N and P, low to medium in available K and low in organic carbon. Soils are comparatively low in total 'S' content 104 to 166 ppm with a mean of 130.3 ppm as compared to alluvial soils of Krishna delta area of Andhra Pradesh (1,518 to 2,244 ppm as reported by Praveen Kumar, 1981). The total 'S' was positively and significantly correlated with inorganic fractions (r=0.96**). Organic carbon was possitively and significantly correlated with total 'S' (r = 0.96**) organic 'S' (r = 0.97**) and inorganic 'S' (r = 0.64**). Based on available 'S' (0.15%) $CaCl_2$ extractable) Kanwar (1963) rated the soils containing 0-5 ppm as highly deficient; 5-10 ppm deficient, 10-15 ppm satisfactory and 15 ppm and above as good. According to this rating, the soils under study can be classified as 40% deficient, 50% satisfactory and 10% as good in 'S' supplying power.

Response to 'S' fertilizer application at 10,20 and 40 ppm 'S' levels in terms of drymatter yield was observed in five soils and all soils out of 10 soils at 30 and 60 DAS (Table 2). There was an increase in drymatter production to the extent of 24.6% and 4.71% with 40 ppm 'S' application at 30 and 60 DAS respectively. Similar response to 'S' application was earlier reported by Ramanathan and Ramanathan (1982).

Sulphur application at 10,20 and 40 ppm significantly increased the uptake of sulphur by groundnut over that of control at both stages viz; 30 and 60 DAS (Table 2). Significant difference in uptake of sulphur was observed in all soils at both stages of the crop growth. Application of sulphur had synergistic effect on the uptake of N, P and K by groundnut at 30 and 60 DAS.

Simple correlaion and regression analyses carried out between the available sulphur and plant attributes (Table 3) indicate that 0.15% $CaCl_2$, 1% NaCl and N NH_4OAC (pH 7.0) extractable sulphur gave significant positive correlation with drymatter yield (r=0.882**, r=0.66* and r=0.65* respectively) and also 0.15% $CaCl_2$ and 1% NaCl extractable sulphur with 'S' uptake (r=0.84**, r=0.67* respectively) at S_0 level at 60 DAS of the crop.

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Table 2 : Drymatter production and sulphur uptake by groundnut at 30 and 60 (figures in brackets) DAS of the crop.

Sl.	Location	Drymatter (g/pot)					Sulphur uptake (mg/pot)				
		S_0	S_{10}	S_{20}	S_{40}	Mean	S_0	S_{10}	S_{20}	S_{40}	Mean
1.	Drasanamala	1.20(9.72)	1.27(9.72)	1.33(9.80)	1.40(10.10)	1.29(9.83)	2.18(17.59)	2.38(22.16)	2.54(25.87)	3.08(25.86)	2.55(22.87)
2.	K.G. Kandriga	1.33(8.26)	1.87(8.26)	2.06(8.33)	2.00(8.40)	1.81(8.31)	2.53(15.36)	3.59(21.15)	4.04(20.07)	4.60(23.35)	3.69(19.98)
3.	D. Adivi	1.20(7.53)	1.20(7.60)	1.53(7.60)	1.53(7.72)	1.36(7.61)	2.27(14.46)	2.33(17.86)	3.01(19.08)	3.19(25.94)	2.70(29.33)
4.	P.G. Thota	1.33(6.60)	1.27(6.66)	1.67(6.73)	1.80(6.80)	1.51(6.69)	2.64(12.28)	2.65(15.05)	3.59(19.45)	4.14(18.84)	3.26(16.40)
5.	Palchuru	1.73(6.93)	1.67(7.33)	1.80(8.00)	2.00(8.60)	1.79(7.58)	3.61(13.79)	3.62(18.03)	3.96(22.08)	4.54(24.26)	3.93(19.54)
6.	Chavali	1.60(8.73)	1.93(8.80)	2.13(8.87)	2.33(9.03)	1.99(8.85)	3.36(17.02)	4.17(19.71)	4.64(25.37)	5.48(27.36)	4.41(22.37)
7.	Bhimavaram	1.80(8.53)	1.80(8.53)	1.87(8.67)	1.93(8.83)	1.85(8.63)	2.70(15.44)	2.89(19.79)	3.39(22.63)	3.78(28.60)	3.19(21.61)
8.	Naidupet	1.40(8.80)	1.80(8.86)	1.73(8.94)	1.73(9.00)	1.66(8.90)	2.66(16.02)	3.42(23.48)	3.61(23.42)	4.13(28.08)	3.46(22.75)
9.	Menakur	1.33(8.60)	1.33(8.73)	1.40(8.80)	1.47(8.80)	1.38(8.73)	2.68(16.51)	2.79(20.69)	3.02(25.34)	3.43(23.32)	2.98(21.47)
10.	Pellakur	1.27(7.00)	1.40(7.06)	1.40(7.20)	1.47(7.86)	1.38(7.28)	2.39(14.14)	2.74(17.08)	2.79(19.58)	3.21(23.42)	2.78(18.56)
	Range	1.20(6.60)	1.20(6.66)	1.33(7.20)	1.40(6.86)		2.18(12.28)	2.38(15.05)	2.54(19.08)	3.08(18.84)	
		to	to	to	to		to	to	to	to	
		1.80(9.72)	1.93(9.72)	2.13(9.80)	2.33(10.10)		3.61(17.59)	4.17(23.48)	4.64(25.87)	5.48(28.60)	
	Mean	1.42(8.07)	1.55(8.16)	1.69(8.29)	1.77(8.45)		2.70(15.26)	3.06(19.50)	3.46(22.29)	3.96(24.90)	

CD (P=0.05)

1) Soils = 0.28(0.17)
2) Sulphur levels = 0.18(0.11)
3) Soils x Sulphur levels = N.S.(0.34)

CD = (P=0.05)

1) Soils = 0.04(1.37)
2) Sulphur levels = 0.03(0.87)
3) Soils x Sulphur levels = 0.09(2.75)

Table 3: Correlation co-efficients between biological attributes and **available sulphur extracted** with *various extractants in groundnut.*

S.No.	Extractant	30 DAS		60 DAS	
		Drymatter (So)	S uptake (So)	Drymatter (So)	S uptake (So)
1.	0.01 N HCL	0.051	0.260	-0.420	-0.440
2.	0.5 M NaH CO_3 (pH 8.5)	-0.345	-0.008	0.977	0.278
3.	N NH_4OAC (pH 7.0)	-0.557	-0.430	0.650*	0.580
4.	1N Na OAC(pH7.0)	-0.230	-0.030	0.053	0.043
5.	1% NaCl	-0.380	-0.300	0.660*	0.670*
6.	0.15%$CaCl_2$	-0.365	-0.372	0.882**	0.840**
7.	KH_2PO_4 (500 ppm)	-0.370	-0.440	-0.253	-0.205

* Significant at 5 % level,** Significant at **1% level.**

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J. Oilseeds Res. 16(2) 1999 : 281-284
ISSN 0970-2776

RESPONSE OF GROUNDNUT (*Arachis hypogaea*) SEEDS TO DRYING AND STORAGE METHODS

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ABSTRACT

The influence of drying methods, viz., conventional farmers' method (D1), shade drying of pods intact with plants and separation of pods thereafter (D2), stripping of pods after harvest and exposing them to direct sunlight in a single layer (D3), stripping of pods after harvest and shade drying in a single layer (D4), DOR (Directorate of Oilseeds Research) method (D5), coupled with three storage containers, viz., plastic silo (S1), gunny bag (S2) and polythene lined gunny bag containing anhydrous calcium chloride (S3) was studied on seed viability, fungal invasion, moisture and sugar content in seeds of groundnut var. JL-24. With increase in storage period, viability of seeds decreased while fungal flora activity, moisture and sugar content in seeds increased gradually. Pods dried in D1 and D3 lost viability rapidly, while that in D4 and D5 maintained viability for a longer period. S3 and S1 proved to be better storage containers than S2 for seed storage.

Key words: Groundnut, Storage contaners, Post harvest technology, Seed viability

INTRODUCTION

Out of the total production of oilseeds, 70% is stored traditionally by the farmers in India. The losses during storage are to the extent of 10 to 15 per cent. It is, however, possible to reduce the storage loss by 50% if improved post harvest techniques are adopted. In groundnut (*Arachis hypogaea*) harvesting and drying are operations that play a crucial role in determining the seed viability. Although the Directorate of Oilseeds Research has proposed a method for drying the pods to prolong its viability (DOR, 1983), little work has been done to study the impact of drying methods on viability of seed in humid climate of eastern India. Therefore, an attempt was made at the Bidhan Chandra Krishi Viswavidyalaya, West Bengal to develop practicable storage technique to prolong viability of groundnut seeds.

MATERIALS AND METHODS

The experiment was conducted in the University Farm, Kalyani during the *kharif* (rainy) season of 1992 and 1993. The groundnut variety, JL-24 was sown in plots of 8mx6m size with recommended agronomic practices. Immediately after harvest, pods were dried by the following five methods, replicated thrice.

D1 : Small heaps of plants with pod intact, left in thefield (conventional farmers' method);

D2 : Shade drying of pods with pod intact and separation of pods thereafter:

D3 : Stripping of pods after harvest and exposing them to direct sunlight in a single layer;

D4 : Stripping of pods after harvest and shade drying in a single layer;

D5 : Staking of two heaps of plants of one metre diameter in an inverted manner one over the other in the field in such a way that haulms of the upper heap will cover the exposed peripheral pods from direct sunlight. During night time the upper heap was removed and the pods in both the bundles were exposed and again the heaps were brought back to inverted position in the morning (DOR, 1983).

Received for publication in September, 1998

The harvested pods by the above methods were stored as follows:

S1 : 2kg of pods in plastic silo;

S2 : 2kg of pods in gunny bag;

S3 : 2kg of pods in polythene (300 gauge thickness) lined gunny bag with centrally placed plastic container containing 25g anhydrous calcium chloride. The plastic container had perforations on its upper half.

Viability of seeds was determined by dipping seeds in 0.25% solution of 2,3,5 triphenyl tetrazolium chloride after removal of seed coat. This was kept in dark at room temperature (28°C) for 6 hours. Based on staining pattern, the viable and nonviable seeds were categorised (Agarwal and Dadlani, 1992). Total water soluble sugar was determined by the phenosulphuric acid method (Dubois *et al*, 1956) calibrated with glucose. Ten kernels from each treatment were immersed in 25ml distilled water and the leachate was collected after 48 hours for analysis of total water soluble sugar present in the seeds. Moisture content was estimated by oven drying at 105°C for 5 hours to constant weight (Dange *et al.*, 1985). Moist blotter method was followed to enumerate fungi associated with seeds (ISTA, 1985). Statistical analysis was done in factorial randomised block design.

RESULTS AND DISCUSSION

Drying method

Initial seed viability of all drying methods was quite high (98%) and was not reduced much upto three months of storage (Table 1). But afterwards, seeds dried under shade (D4) and DOR method (D5) showed higher seed viability. Pods dried by conventional farmers' method (D1) had the lowest viability (38%) after one year of storage. High seed viability in shade drying of pod in a single layer and DOR method might be due to avoidance of high pod temperature during drying process. The lowest seed viability recorded in conventional farmers' method might be due to non uniform exposure to sun light causing build up of more humidity in lower layer (Nautiyal and Zala, 1991). Moisture and sugar content were lowest in pods in D4 and it was highest in pods dried by D1 method at the end of storage period (Table 1). The poor quality seeds obtained from D1 might be associated with higher efflux of solute through seed membrance. This leakage suggests an increased permeability of cell membrane of seeds and inconsistent with the view that loss of membrane integrity is the first event in the sequence of deteriorative changes leading to loss of viability (Delouche, 1969). Faster rate of moisture loss during drying process might have led to greater damage of seed membrane. Pathological test of the stored seed sample collected from each drying method confirmed maximum growth of fungus in conventional farmers' method and minimum growth of fungus in shade drying of pods in a single layer (Table 2).

Storage container

The highest seed viability was recorded in polythene lined gunny bag containing anhydrous calcium chloride (Table 1) which might have absorbed moisture from the surroundings. Viability of seeds stored in gunny bag decreased gradually with advancement of storage period and became nil after 9 months of storage and this might be due to free passage of air through the gunny bag creating congenial condition for growth of seed microflora. This was in conformity with the findings of Nautiyal et al. (1991). Moisture and sugar content were highest in seeds stored in gunny bag and were lowest in polythene lined gunny bag containing $CaCl_2$ (Table2)

Thus, it may be concluded that in subtropical humid regions, shade drying of pods in a single layer was the best drying method of groundnut

Table 1 : Effect of method of drying and storage containers on seed viability, moisture and sugar content in groundnut (mean data of 2 years)

Treatment	Seed viability (%)				Moisture content (%)				Sugar content (mg/g of seeds)			
Storage period in months	3	6	9	12	3	6	9	12	3	6	9	12
Methods of drying												
D1	91.3 (72.5)	60.3 (50.9)	42.0 (40.4)	30.0 (33.2)	7.8 (2.8)	9.1 (3.10)	10.0 (3.24)	10.8 (3.36)	0.15	0.67	0.82	0.97
D2	95.3 (77.5)	66.3 (54.55)	44.3 (41.7)	33.3 (35.2)	7.9 (2.90)	8.4 (2.98)	9.7 (3.19)	10.6 (3.33)	0.17	0.60	0.72	0.85
D3	95.3 (77.5)	63.7 (52.9)	44.7 (42.0)	36.0 (36.9)	7.7 (7.86)	8.6 3.02)	9.8 (3.21)	10.7 (3.35)	0.17	0.62	0.77	0.90
D4	96.0 (78.5)	69.7 (56.6)	46.0 (42.7)	37.3 (37.6)	7.8 (2.88)	8.3 (2.97)	9.5 (3.16)	10.3 (3.29)	0.15	0.60	0.67	0.77
D5	96.7 (79.5)	67.7 (55.4)	45.3 (42.3)	37.3 (37.6)	7.8 (2.88)	8.7 (3.03)	9.7 (3.19)	10.4 (3.30)	0.15	0.60	0.67	0.82
CD (0.05)	(2.17)	(2.55)	1.06)	(1.55)	NS	(0.017)	(0.014)	(0.017)	NS	0.028	0.033	0.045
Storage containers												
S1	93.6 (75.3)	82.0 (64.9)	65.0 (53.7)	46.4 (42.9)	7.7 (2.86)	8.4 (2.86)	9.4 (3.15)	10.2 (3.27)	0.15	0.45	0.60	0.77
S2	94.8 (76.8)	29.0 (32.6)	0 (0.29)	0 (0.29)	7.9 (2.90)	9.2 (3.11)	10.7 (3.35)	11.8 (3.51)	0.15	0.97	1.05	1.17
S3	96.4 (79.1)	85.6 (68.0)	68.4 (55.8)	58.0 (49.6)	7.7 (2.86)	8.3 (2.97)	9.1 (3.10)	9.7 (3.19)	0.15	0.42	0.54	0.65
CD (0.05)	(1.68)	(1.98)	(0.82)	(1.20)	(0.014)	(0.015)	(0.011)	(0.015)	NS	0.023	0.028	0.038

Seed viability (%) was analysed with transformed arc sine values and moisture content (%) was analysed with transformed square root values. *Treatment details are given in the next.*

Table 2 : Effect of methods of drying and storage containers on fungal invasion (%) of groundnut seeds at 12 months of storage

Methods of drying	Plastic silo				Gunny bag				PG+CaCl2				Mean			
	AN	AF	PS	RS	AN	AF	PS	RS	AN	AF	PS	RS	AN	AF	PS	RS
D1	30	23	20	20	50	33	20	60	23	10	7	7	35	22	16	29
D2	30	20	10	10	40	30	20	50	17	10	7	7	29	20	12	22
D3	30	10	10	20	40	23	10	57	17	7	7	7	29	13	9	28
D4	10	7	10	10	20	20	7	30	7	7	0	0	12	11	6	13
D5	17	7	7	10	23	10	17	25	10	7	3	0	17	8	9	12
Mean	24	13	11	14	35	23	15	44	15	8	5	4				

An : *Aspergillus niger*; AF : *Aspergillus flavus*; PS : *Pencillum* spp.; RS: *Rhizopus* spp.; PG+$CaCl_2$: Polythene lined gunny bag containing $CaCl_2$.

and polythene lined gunny bag containing $CaCl_2$ was the best storage container for groundnut pods for seed purpose.

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J. Oilseeds Res. 16(2) 1999: 285-288
ISSN 0970-2776

PERFORMANCE OF ABYSSINIAN MUSTARD (*Brassica carinata*) UNDER RAINFED CONDITIONS OF JAMMU

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ABSTRACT

An experiment was conducted under rainfed conditions during the winter season of 1995-96 to 1997-98 to study the performance of Abyssinian mustard (*Brassica carinata*) genotypes in respect of yield potential at SKUAST, Dryland Research Sub-Station Bari Brahamna, Jammu. The results indicated that genotypes PC-5, PCC-5 and NPC-2 performed better in respect of growth and out yielded others in seed yield and oil content.

Keywords: Brassica carinata, yield attributes, seed and oil yield.

INTRODUCTION

In India, rapeseed and mustard group is the second most important source of edible oil after groundnut. Considerable efforts are being made by breeders for improving the production in different agro-climatic regions of the country. But the yield obtained from these Indian mustards is low especially under rainfed conditions. But *Brassica carninata* has an edge over the domesticated speies under rainfed conditions. Yield upto 44q/ha under irrigated and 36 q/ha under rainfed trials have been observed in these species (Anand and Rawat, 1984). Besides, high yielding these are also resistant to Alternaria blight, white rust, tolerant to aphid, drought and shattering. Since major area in Jammu division is rainfed, it becomes imperative to study the performance of these genotypes before their recommendation for general cultivation. The experiment was conducted to evaluate the high yielding genotypes of *Brassica carinata* under dry land conditions of Jammu.

MATERIALS AND METHODS

The field investigations were carried out during *rabi* (Winter) season of 1995-96 to 1997-98, at All India Coordinated Research Sub Station for Dryland Agriculture, Dhiansar, Bari Brahamna, (Jammu). Sixteen genotypes of mustard (*Brassica carinata*) were evaluated in randomized block design with three replications. The crop was sown in third week of October during all the three years with a spacing of 45X15cm in a plot size of 5mX2.7m. The soil was sandy loam in texture and low in available N(205 kg/ha). P(20kg/ha) and medium in K (179 kg/ha) having pH of 7.4. Recommended doses of N and P @ 60 and 30 kg/ha, respecitvely were applied to the crop. The total rainfall received during the growing season from October to March in 1995-96, 1996-97 and 1997-98 was 152.5, 189.9 and 327.4mm, respectively. Observations were recorded on five randomly selected plants/replication in each genotype for height, main shoot length, primary and secondary branches, siliquae/plant, pod length, seeds/pod and 1000-seed weight. Seed yield was calculated on net plot basis and oil content and oil yield was determined for each genotype from the sample from each plot replication wise.

RESULTS AND DISCUSSION

Growth and Yield Attributes

The pooled analysis of (Table 1) data revealed that the genotypes differed significantly in respect of yield attributes viz., plant height, main shoot length, primary and secondary branches, siliquae/plant, pod length, number of seeds/pod and days

Received for publication in October, 1998

Table 1 : Growth and Yield attributes of different genotypes of *Brassica carinata* (Mean values of three years)

Genotypes	Plant height (cm)	Main shoot length (cm)	Primary Branches/ Plant	Secondary Branches/ Plant	No. of siliquae/ Plant	Pod length (cm)	Seeds/ siliqua	1000-seed weight(g)	Days to Maturity
PCC-2	171.0	59.6	10.8	14.9	241.2	4.30	14.20	2.90	173
PC-5	187.3	61.3	11.3	15.8	244.2	4.50	16.03	3.20	177
PCC-5	176.6	60.3	11.0	13.7	238.3	4.29	15.66	3.16	170
NPC-2	181.5	57.4	8.9	12.8	237.5	4.33	15.16	3.13	169
PCC-7	172.0	53.3	9.9	12.5	232.7	4.16	13.50	2.86	172
PEC-9221	175.3	48.2	10.7	12.8	236.1	4.25	12.60	2.83	173
NPC-27	177.0	45.0	8.9	12.4	235.2	4.23	12.03	2.93	170
DIR-1522	170.0	51.3	8.5	13.2	236.1	4.22	12.50	2.92	171
HC-9001	174.3	52.6	9.1	13.7	240.4	4.23	14.10	2.96	174
JTC-16	172.3	52.4	8.5	10.8	235.1	4.22	13.52	3.00	172
Car-6A	171.2	53.3	7.7	11.3	234.7	4.20	12.36	2.90	170
PCC-4	173.1	52.6	8.6	13.0	234.9	4.30	12.26	2.96	172
DIR-1502	172.3	53.5	8.2	12.8	233.1	4.06	12.06	2.86	172
DIR-1519	185.6	55.0	8.2	12.6	234.0	4.26	12.20	2.90	171
NPC-5	187.0	55.3	9.0	14.6	238.5	4.13	11.30	2.90	170
DLSC-2	174.3	51.3	8.3	11.2	232.6	4.06	10.53	2.93	168
CD (0.05)	4.02	3.66	1.06	1.48	6.26	0.21	0.62	0.08	2.3

to maturity. Genotype PC-5 attained maximum height (187.3cm) but was statistically at par with DIR-1519 and NPC-5. Longest main shoot being 61.3 cm with more number of primary and secondary branches was also recorded in PC-5 which was at par with PCC-2, PCC-5 and NPC-5. PC-5 had heighest number of siliquae/plant (244.2) and was at par with PCC-2, HC-9001,NPC-2 and PCC-5 with corresponding values of 244.2, 240.4, 238.5 and 238.2 siliquae/plant, respectively. Highest pod lenght (4.50cm), seeds/siliquae (17.03) and 1000 seed weight (3.26g) was also recorded in case of PC-5, but these yield attributes were at par with PCC-2, PCC-5 and NPC-2. All other genotypes recorded comparatively low values of yield attributes. Similar findings have been reported by Rajput *et al.*, (1996).

Seed Yield and Oil Content

The genotypes differed significantly for seed yield during all the three years. During 1995-96 genotype HC-9001 recorded the highest seed yield of 17.68q/ha but was at par with PC-5 (17.07q/ha) which in turn was at par with PCC-5 (16.23q/ha) and was superior to all other genotypes (Table-2). Lowest yield of 9.98q/ha was recorded by NPC-5. The performance of all the genotypes was satisfactory during 1995-96 and 1997-98. But there was overall reduction in seed yield of all the genotypes during 1996-97. The reduction in yield was attributed to prolonged dry spell experienced by the crop due to insufficient moisture in the soil. The highest seed yield (8.53q/ha) was recorded by PC-5 closely followed by PBC-9221 and DIR

Table 2 : Seed Yield and Oil Content of different genotypes of *Brassica carinata*

Varieties	Seed Yield (q/ha)				Seed Oil content (%)	Oil yield (qha)
	1995-96	1996-97	1997-98	Pooled		
PCC-2	14.83	7.89	16.45	13.05	36.6	4.77
PC-5	17.07	8.53	18.87	14.81	38.4	5.68
PCC-5	16.23	7.20	17.96	13.79	37.8	5.21
NPC-2	14.57	6.78	19.61	13.65	37.2	5.07
PCC-7	14.29	7.08	11.12	10.83	36.6	3.96
PEC-9221	13.66	8.50	13.62	11.93	36.8	4.39
NPC-27	14.29	7.18	16.55	12.67	37.2	4.71
DIR-1522	14.77	8.26	10.63	11.22	36.5	4.08
HC-9001	17.68	7.87	14.92	13.49	36.9	4.97
JTC-16	14.07	7.34	11.69	11.03	35.6	3.92
Car-6A	14.02	7.68	12.82	11.50	35.4	4.07
PCC-4	13.70	7.93	13.74	11.79	36.1	4.25
DIR-1502	9.99	7.68	9.94	9.20	35.7	3.28
DIR-1519	14.85	7.71	10.63	11.06	36.2	4.00
NPC-5	9.98	6.32	18.35	11.55	37.5	4.33
DLSC-2	9.99	8.14	11.71	9.95	35.8	3.56
CD (0.05)	1.41	1.03	1.65	1.29	NS	-

1522 with 8.5 and 8.26q/ha, respecitvely. This also indicates the ability of some of the genotypes to combat moisture stress due to their deep root system (Chatterjee and Sen, 1977). During 1997-98 genotype NPC-2 recorded highest seed yield of 19.61q/ha and was at par with PC-5 (18.87q/ha), PCC-5(17.96q/ha) and NPC-5 (18.35q/ha).

The pooled data of three years indicated that the highest seed yield of 14.81 q/ha was recorded in case of PC-5 which was at par with PCC-5 and NPC-2 with seed yield of 13.79 and 13.65q/ha, respectively. The differential performance of all other genotypes in respect of yield was mainly due to their variable siliquae bearing capacity, seeds/siliquae and 1000 seed weight. The findings are in accordance with that of Sharma (1994).

The oil content in different genotypes, though non-significant, was highest in PC-5 (38.4%) closely followed by PCC-5 (37.8%) and NPC-2 (37.2%). Lowest oil content (35.4%) was recorded in case of Car-6A. Similarly highest oil yield of 6.58q/ha was obtained from PC-5 followed by PCC-5 and NPC-2 with 5.21 and 5.07q/ha respecitvely. The findings suggest the scope for adoption of high yielding genotypes of *Brassica carinata*, like PC-5, PCC-5, NPC-2 and HC-9001 under rainfed conditions of Jammu Division.

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J. Oilseeds Res. 16(2) 1999 : 289-294
ISSN 0970-2776

OPTIMUM SOWING TIME FOR GROUNDNUT (*Arachis hypogaea* L.) GENOTYPES DURING POSTMONSOON SEASON IN MARATHWADA

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ABSTRACT

A field experiment was conducted on medium deep vertisol in 1995-96 and 1996-97 at Agricultural College Farm, Parbhani to find optimum sowing time for groundnut genotypes during the postmonsoon season. The experimental design was split plot consisting of four sowing dates i.e. 15 and 30 September and 15 and 30 October assigned to main plots and six genotypes viz. ICGS-11, ICGS-44, LGN-2, SB-XI, JL-24 and TAG-24 put to subplots. Sowing groundnut genotypes on 15 September (37 MW) gave significantly higher pod yield which decreased significantly as sowings were delayed. Early maturing erect Spanish bunch genotype TAG-24 followed by semi spreading Spanish buch gntoypes, ICGS-44 and ICGS-11 recorded significantly higher pod yield than other gnotypes in the postmonsoon season. TAG-24 showed wider adaptability for second fortnight of Septmeber (37-38 MW) and ICGS-11 and ICGS-44 were found second to TAG-24 as evidenced by sowing date x genotype interaction.

Key Words : Genotypes, sowing dates, postmonsoon, adaptability.

INTRODUCTION

In recent years attempts have been made to grow groundnut during postrainy (rabi) environment to ensure stability and higher production with minimum irrigation water by utilizing residual soil moisture and postmonsoon rains. It is claimed that postrainy season is ecologically suitable for potential groundnut production (Reddy *et al.*, 1985 and Chatterjee and Bhattacharya, 1986). Ghadekar (1988) at Nagpur, Thorat *et al.* (1989) at Dapoli, Deshmukh, (1991) and Lodh (1994) at Parbhani have reported that groundnut can be grown successfully during postmonsoon season in Maharashtra. They reported that groundnut crop can be adapted to frost free mild winter season (rabi) due to tropical and hot agroclimatic conditions with the fulfillment of heat unit requirement and non interference of minimum air temperature with physiological processes.

In Marathwada region of Maharashtra the weather conditions prevailed during *rabi* (mid Sept.-mid March) season favourably match with the growth phenophases of groundnut i.e. warm weather (25-32°C) with relativelylonger photoperiod during vegetative phase and cool weather (18-25°C) with short photoperiod (8-9 h) and bright sunshine during reproductive stage which favours pod setting and pod development. Since the productivity of groundnut in the traditional rainy season is low and unstable due to erratic rains and heavy incidence of foliar diseases, the postmonsoon (rabi) season seems to be congenial for potential yield of groundnut with minimum water supply. Therefore, the present study was undertaken to evaluate the effect of different sowing dates on the yield of groundnut genotypes and to optimize the sowing time and select suitable genotypes of groundnut for postmonsoon season.

MATERIALS AND METHODS

Field experiment was conducted during postrainy (rabi) season of 1995-96 and 1996-97 in medium deep black clayey soil (vertisol) on the farm of College of Agriculture, Marathwada Agricultural

Received for publication in October, 1998

University, Parbhani. The experimental design was split plot with three replications. Four sowing dates; 15 and 30 September and 15 and 30 October were assigned to the main plots and six varieties viz., ICGS-11, ICGS-44, LGN-2, SB-XI, JL-24 and TAG-24 were put to sub-plots. The seeds treated with Bavistin @ 2.5 g/kg were sown by dibbling on broad ridge and furrow (BBF) land layout at 30X10cm spacing with two lines on the BBF. Uniform basal dose of 25 kg nitrogen and 60 kg P_2O_5/ha was applied before sowing. In all 5 irrigations were applied in furrow after two lines at an interval of 15-18 days using 50 mm irrigation water per irrigation. The recommended weed and pest control measures were followed. Soil of the experiment was low in available nitrogen, medium in available phosphorus and high in available potash with slightly alkaline in reaction and moderate available water holding capacity (205mm/m). The total rainfall received during experimental period was 95 mm and 466 mm in 1995-96 and 1996-97. The net plot size for yield estimation was 5.40X2.70m^2.

RESULTS AND DISCUSSION

Weather

The weather parameters prevailed during the period of investigation revealed that relatively higher temperature during vegetative growth and comparatively cool weather (17-22^{0}C) coinciding with reproductive stage were favourable for proper growth and yield of groundnut especially for the cop sown on 15 and 30 September. Weather was more favou.able in the second year compared to first year of experimentation.

Sowing dates

The crop sown on 15 September recorded the highest dry pod yield as evidenced by the data of individual season and pooled mean of two seasons (Table 1). The yield decreased significantly with delayed sowing and the lowest dry pod yield was obtained with 30 October sowing. However, the yield differences between 15 and 30 October sowing were not significant during first season. The mean increase in pod yield with 15th September sowing was 16, 93 and 154 per cent compared with 30 September, 15 October and 30 October sowings, respectively. Differences in pod yield of groundnut sown on different sowing dates in postmonsoon season have been reported by Ghadekar (1989), Thorat *et al.* (1989) and Lodh (1994).

The highest pod yield of groundnut sown on 15 September and 30 Septmeber was the result of significant improvement in yield attributes viz. two seeded as well as total pods plant^{-1}, weight of pods plant^{-1}, shelling percentage and test weight (Table 3) due to favourable temperature and photoperiod during vegetative and reproductive growth stages. Higher mean temperature (28-30^{0}C) and relatively longer photoperiod (10-12h) promoted rapid vegetative (expansive) growth and flowering, while relatively lower temperatures (20-25^{0}C) and shorter photoperiod (8-9 h) during reproductive stage (pegging, pod set and pod filling) favoured rapid pod development. Early flowering and longer pod filling period in cool climate with high photosynthetically active radiation (PAR) provides an opportunity for efficient partitioning of dry matter to pods thereby high pod yield (Ketring, 1984; Emery *et al.*, 1981; Campbell and McCloud, 1979 and Bell *et al.*, 1991). The drastic reduction in pod yield in delayed sowing on 15 and 30 October may be due to fall in temperatures during vegetative and early pegging and pod setting stages thereby affecting translocation and partitioning of photosynthates from source to sink vis-a-vis pod development as evidenced by very low harvest index (Table 1). Similar effects of low temperature on pod yield of groundnut have been reported by Sandhu and Hundal (1993).

Sowing groundnut on 30 September in the first season and 15 October in the second recorded

	Pod yield (kg/ha)			Haulm yield (kg/ha)			Harvest index		
	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled
Sowing dates									
15 Sept	**2130**	2784	2457	2577	2918	2747	0.44	0.50	0.47
30 Sept.	**1894**	2325	2110	3434	3949	3691	0.35	0.37	0.36
15 Oct	**1403**	1132	1257	4220	2796	3508	0.25	0.29	0.27
30 Oct	**1318**	614	966	3718	2248	2833	0.28	0.21	0.25
S.E. ±	**29**	18	42	63	69	81	0.006	0.007	0.008
CD (0.05)	**100**	148	123	215	240	280	0.021	0.025	0.029
Genotypes									
ICGS-11	**1678**	2140	1909	3670	3357	3513	0.31	0.34	0.33
ICGS-44	**1822**	1733	1778	3527	2696	3112	0.33	0.36	0.35
LGN-2	**1739**	1341	1540	3373	3127	3250	0.31	0.29	0.30
SB-XI	**1567**	1309	1438	3678	2745	3207	0.29	0.30	0.30
JL-24	**1413**	1224	1318	3996	3610	3803	0.26	0.23	0.25
TAG-24	**1543**	2534	2268	2230	2331	2281	0.45	0.50	0.48
S.E. ±	**35**	41	36	75	108	113	0.006	0.007	0.008
C.D.(0.05)	**101**	117	104	213	308	325	0.018	0.021	0.024
Interaction (DxV)									
S.E. ±	67	82	71	150	216	227	0.01	0.014	0.017
C.D. (0.05)	**191**	233	203	427	616	650	0.03	0.041	0.048
Mean	1680	1713	1700	3412	2978	3195	0.33	0.340	0.340

significantly higher haulm yield than other sowing dates. However, the differences between D2 and D3 were not significant when data are pooled (Table 2 (b)).

Genotypes

Early maturing erect and compact canopy Spanish bunch cultivar TAG-24 recorded significantly higher pod yield over rest of the cultivars. This was followed by ICGS-44 during 1995-96 and ICGS-11 in 1996-97. Both these genotypes proved significantly superior to other genotypes. However, in pooled data ICGS-11 proved better than ICGS-44; Semi-spreading Virginia bunch cultivar, LGN-2 stood at third position with significantly higher yield than JL-24 and SB-XI during 1995-96 and when data is pooled. However, it was at par with these genotypes during 1996-97. Increased yield of TAG-24 followed by ICGS-44, ICGS-11 and LGN-2 has been the result of improvement in yield attributes viz., two seeded as well as total pods plant^{-1} and weight of pods plant^{-1}. This may be due to high partitioning of dry matter to pods as evidenced by significantly higher harvest index in these genotypes (Table 2 (c)). These resuls are in conformity with those of Lodh (1994) and Patil *et al.* (1995).

The variety JL-24 produced significantly higher dry haulm yield than rest of the cultivars except that it was at par with ICGS-11 in both the seasons as well as when data are pooled (Table 2 (b)).

Interaction

The interaction effect between sowing dates and cultivars for dry pod, dry haulm yields and harvest index were significant (Table 2 (a,b,c). Variety TAG-24 gave significantly higher dry pod yield than rest of the varieties under all dates of sowing. The interaction effects also revealed that TAG-24 sown on 30 September recorded the highest pod yield over rest of the treatment combinations. This is mainly attributed to high harvest index of this cultivar (Table 2(c)). This was followed by TAG-24 sown on 15 September and ICGS-11 sown on 15 September and 30 September which were at par and gave significantly higher pod yield than other sowing dates x cultivar combinations. The dry pod yields of ICGS-44 sown on 30 Septmeber, SB-XI and LGN-2 sown on 15 Septmeber were comparable and stood at third position. JL-24 sown on 30 September recorded significantly higher haulm yield over rest of the sowing dates x genotypes combinations except that it was at par with LGN-2 sown on 30 Septmeber, ICGS-11 sown on 30 September and 15 October and JL-24 sown on 15 October. TAG-24 recorded the lowest dry haulm yield under all sowing dates (Table 2 (b)).

On the basis of two seasons study it is concluded that groundnut in postrainy season be sown between 15-20 September (37-38 Met. Week) under Parbhani conditions. Early maturing erect Spanish bunch cultivar TAG-24 flollowed b ICGS-11 and ICGS-44 are most suitable for obtaining high yields during postrainy season. TAG-24 has high adaptability for second fortnight of September followed by ICGS-11 and ICGS-44.

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Table 2 (a) : **Interaction effect of sowing dates x genotypes on dry pod yield (pooled mean 1995-97)**

Treatments	15 Sept.	30 Sept.	15 Oct.	30 Oct.	Mean
ICGS-11	2687	2760	1310	881	1909
ICGS-44	2579	2234	1396	903	1778
LGN-2	2221	1146	1156	1032	1540
SB-XI	2311	1380	1129	933	1438
JL-24	2123	1552	884	707	1319
TAG-24	2816	3027	1772	1340	2239
Mean	2457	2110	1268	966	
Se±	71	C.D. (0.05)	203		

Table 2 (b) : **Interaction effect of sowing dates x genotypes on dry haulm yield (pooled mean 1995-97)**

Treatments	15 Sept.	30 Sept.	15 Oct.	30 Oct.	Mean
ICGS-11	2796	3953	4263	3041	3541
ICGS-44	2737	3364	3465	2882	3112
LGN-2	2944	4227	3088	2739	3250
SB-XI	3225	3681	3014	2930	3208
JL-24	2814	4497	4371	3531	3803
TAG-24	1969	2428	2849	1877	2281
Mean	2748	3692	3508	2803	
Se ±	227	C.D. (0.05)	650		

Table 2 (c) : **Interaction effect of sowing dates x genotypes on harvest index (pooled mean 1995-97)**

Treatments	15 Sept.	30 Sept.	15 Oct.	30 Oct.	Mean
ICGS-11	0.48	0.40	0.24	0.20	0.33
ICGS-44	0.49	0.40	0.30	0.23	0.35
LGN-2	0.44	0.30	0.27	0.26	0.30
SB-XI	0.41	0.27	0.28	0.24	0.30
JL-24	0.43	0.26	0.16	0.15	0.25
TAG-24	0.59	0.65	0.38	0.42	0.48
Mean	0.47	0.36	0.27	0.25	
Se ±		0.017	C.D. (0.05) =	0.048	

Table 3 : Effect of sowing dates and genotypes on yield attributing characters of goundnuts in postmonsoon season (1995-97)

Treatments	Mean number of pods plant^{-1}						Weight of pods (g/plant)		Mean Shelling
	One Seeded		Two seeded		Total pods				
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	(%)
Sowing dates									
15 Sept	4.50	6.52	14.50	19.24	18.55	25.54	13.95	20.93	74.30
30 Sept	4.68	9.72	12.60	17.25	16.30	26.73	12.15	21.46	73.40
15 Oct	5.65	6.32	9.80	8.63	15.56	15.06	10.09	10.30	72.10
30Oct	7.86	3.03	9.30	5.12	17.18	9.93	14.66	5.33	71.10
S.E ±	0.15	0.38	0.17	1.13	0.31	1.52	0.39	1.58	0.39
C.D. (0.05)	0.50	1.31	0.59	3.89	0.90	5.26	1.34	5.48	1.35
Genotypes									
CGS-11	6.46	7.55	11.60	12.00	18.05	19.51	12.34	17.46	72.60
ICGS-44	7.01	7.18	11.55	11.63	18.61	18.96	12.94	16.44	73.00
LGN-2	5.70	6.73	11.20	12.66	16.90	18.53	15.93	14.72	71.10
SB-XI	4.91	5.33	12.70	13.91	17.61	19.85	12.27	10.83	75.10
JL-24	3.38	4.40	9.90	10.31	13.28	14.21	10.33	11.21	71.70
TAG-24-24	5.93	7.20	12.50	14.85	18.40	21.83	12.43	16.36	72.40
S.E. ±	0.28	0.45	0.29	0.69	0.79	0.95	0.30	0.96	0.40
C.D (0.05)	0.60	1.27	0.17	1.95	N.S	2.71	0.86	2.73	1.14
Interaction (DxV)									
S.E. ±	0.42	0.89	0.54	1.27	1.59	1.89	0.60	1.91	0.80
C.D (0.05)	1.21	2.55	1.55	3.92	N.S.	5.41	1.72	5.45	N.S
Mean	5.56	6.39	10.63	12.56	16.88	18.81	12.71	14.50	72.70

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J. Oilseeds Res. 16(2) 1999 : 295-298
ISSN 0970-2776

PERFORMANCE OF CASTOR (*Ricinus Communis* L) HYBRIDS UNDER DIFFERENT LEVELS OF FERTILIZER IN RAINFED CONDITIONS ON ALFISOLS.

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ABSTRACT

Field experiements conducted during kharif 1996-97 through 1998-99 at the Directorate of Oilseeds Research, Rajendranagar, Hyderabad under rainfed conditions on alfisols to findout the influence of fertilizer on castor hybrids revealed that the hybrid DCH 177 out yielded the other test hybrids DCH 178, DCH 30, and GCH 4. This was due to its wilt resistance and substantially higher test weight of seeds. In years of adequate rainfall as occured in 1996-97 the crop responded upto 150% recommended dose of fertilizer (60-60-0NPK/ha). Also the genotypes interacted favourably with fertilizer, where DCH 177 when fertilized with 75% RDF+FYM 5 t/ha offered distinct improvement in seed yield over the rest of the treatments. However, in years of scanty rainfall as in 1997-98 the response to applied fertilizer was not discernible although application of organic manure showed some beneficial effect. Hybrids differed in oil content, while fertilizer application had a disirable effect on oil content.

Key words: Castor hybrids, fertilizer, rainfed conditions.

INTRODUCTION

Under traditional rainfed cropping systems in Semiarid tropical region, castor crop is raised on light textured soils by the resource-poor farmers with low inputs and poor management resulting in diminished yields and returns. Castor cultivation is beset with a number of problems of biotic and abiotic nature such as wilt, botrytis (caused by incessant rains) etc. The castor farmers in the traditional castor belt of Andhra Pradesh find the crop no longer remunerative and as a consequence crop shifts are taking place in favour of rainfed cotton, maize, soybean etc., resulting in decline in castor area. Having sensed the issue, high yielding wilt resistant genotypes suited to rainfed conditons have been developed. This calls for a need to generate information on their response to fertilizer to harness their full yield potential under rainfed conditions of SAT region. Hence the present studies were conducted.

MATERIALS AND METHODS

The current investigation was carried out during 3 consecutive *kharif* seasons of 1996-97 through 1998-99 at the research farm of the Directorate of Oilseeds Research, Rajendranagar, Hyderabad on alfisols to assess the response of five castor hybrids (DCH 32, DCH 177, DCH 178, DCH 30 and GCH 4) to five fertilizer levels (control, recommended dose of fertilizer (40-40-0NPK/ha); 150% RDF, 50% RDF+FYM 10 t/ha, and 75% RDF+FYM 5t/ha) under rainfed condition. During 1998-99 only the hybrids DCH-32, DCH-177 and GCH 4 were included in the study. The treatment combinations were tested in a factorial randomized block design with 3 replications. The soil of the experimental field was sandy loam, having a pH 6.7, low available nitrogen (orgnic carbon 0.3%), medium available phosphorus (16.7 kg/ha) and high available potassium (360 kg/ha). The hybrids were sown at a spacing of 90x40 cm in plots of size 5.4m x 4.5m. The experiment was sown on 8th July, 1996; 25 July 1997 and 8th July, 1998. The crop recieved half the dose of nitrogen and full dose of phosphorus as basal dose at the time of sowing, while the remaining half of N as per treatment was top dressed at 30-40 days after sowing. Nitrogen was applied in the form of urea, while phosphorus was applied as single super phosphate. The crop was raised purely under

Received for publication in June, 1999

rainfed conditions. During 1996-97 the crop experienced a precipitation of 645 mm as against 387 mm during (June-Nov)1997-98 which was considered to be a drought year. Observations on plant stands, different order spike yields, test weight of seed, oil content were made. The oil content in seed was estimated using NMR (Nuclear Magnetic Resonance) equipment.

RESULTS AND DISCUSSION

Performance of Hybrids

Perusal of data presented in Table 1 showed that the castor hybrid DCH 177 (2003 kg/ha) remaining comparable to DCH 178 (1922kg/ha) offered substantially greater yield than the rest of the test hybrids. These hybrids have possessed significantly higher test weight of seeds than their counterparts during 1996-97 which could be the reason for higher yields in DCH 177 and DCH 178.

During 1997-98 the hybrids DCH 177 (491 kg/ha) and DCH 178 (453 kg/ha) remaining comparable to each other out yielded DCH 32 hybrid (254 kg/ha) which in turn was superior to DCH 30 (188 kg/ha) and GCH 4 (205 kg/ha). The higher test weight of seeds in DCH 177 and DCH 178 has contributed to greater yields. The response in terms of yield of the different hybrids was in tune with the final plant stands recorded. The incidence of wilt and root rot due to drought conditions in 1997-98 in DCH 30, GCH 4 and DCH 32 hybrids was observed to be higher than in DCH 177 and DCH 178 resulting in lower plant stands and concomittant diminished seed yields. Weather analysis of 1997-98 showed that the season was characterised by very low rainfall (387.4 mm from June- November 97) received in 24 rainy days in comparison with the corresponding period during 1996-97 (645 mm rain received in 43 rainy days) at Hyderabad. This has resulted in steap fall in productivity levels of castor hybirds raised under rainfed conditions in 1997 in comparison with 1996 and 1998 seasons.

During 1998-99 it was found that the castor hybrids differed significantly in yields where in DCH 177 out yielded (1300 kg/ha) GCH 4 (1040 kg/ha) and DCH 32 (942 kg/ha) which in turn were comparable in their performance. The higher yields in DCH 177 hybrid has been due to its relatively higher wilt resistance than GCH 4 and DCH 32. As reported by Gangadhar Rao *et al.* (1998) the superior performance of certain castor hybrids could be due to higher leaf reflectance and transmission properties leading to quick response of stomata. Differential yield response of castor genotypes under rainfed conditons was also reported by Baby Akula and Bapireddy (1998). Increase in yield gap between hybrid and variety of castor under moisture stress imposed by ill distribution of rainfall was also reported (Rao *et al.*, 1986).

Effect of Fertilizer

During 1996-97 there was linear enhancement in castor yield with increase in fertilizer dose upto 150% recommended dose (1877 kg/ha) over no fertilizer (1379 kg/ha). Substituting 50% of recommended inorganic fertilizer with 10t/ha farmyard manure was on par with 150% RDF in seed yields (1950 kg/ha). Application of 75% of RDF through inorganic form in conjunction with FYM @ 5t/ha provided significantly higher castor yield (2245 kg/ha) than the rest of the fertilizer treatments. There was significant enhancement in the test weight of seed when the crop received fertilizer, which resulted in significant increase in the seed yield of castor (Table 1).

There was a significant interaction between genotype and fertilizer on castor yield, wherein the hybrid DCH 177 fertilized with 75% RDF together with FYM @ 5t/ha offered distinct improvement in seed yield over the rest of the treatment combinations (Table 2). Castor has been reported to respond upto 50-30-0 NPK/ha under rainfed conditions in favourable environment in sole and intercropping with cluster bean (Reddy, 1986, and Reddy and Venkateswarlu, 1989).

During 1997-98 where the crop season was characterised by very low rainfall resulting in soil

Table 1 : Effect of genotypes and fertilizer on the yield, 100 seed weight and oil content of castor under rainfed conditions

Treatment	Final Plant stand ('000/ha)			Total seed yield (kg/ha)			100 seed wt (g)			Oil content (%)
	1996	1997	1998	1996	1997	1998	1996	1997	1998	
Castor Hybrids										
DCH 32	25.8	10.4	18.0	1528	254	942	27.9	25.3	27.53	49.36
DCH 177	25.0	14.7	19.7	2003	491	1300	30.5	30.0	31.27	50.32
DCH 178	23.4	11.6	-	1922	453	-	30.9	30.9	-	51.77
DCH 30	26.7	7.7	-	1809	188	-	28.6	27.5	-	49.41
GCH 4	25.1	6.3	16.0	1792	205	1040	29.1	27.7	31.47	51.21
SEm ±	0.59	0.71	0.58	39.6	17.40	42.8	0.46	0.34	0.45	0.25
C.D. (0.05)	1.67	2.2	1.67	112.7	48.9	123.9	1.32	1.0	1.31	0.71
Fertilizer (kg/ha)										
Control (0-0-0 NPK/ha)	25.7	9.4	17.1	1379	275	1063	28.0	27.8	29.56	49.71
Recommended dose of fertilizer (40-40-0NPK/ha)	24.6	10.8	17.8	1604	293	1099	29.5	27.8	28.89	50.43
150% RDF (60-60-0 NPK/ha)	26.0	10.1	18.6	1877	336	1145	29.4	28.5	31.00	50.65
50% RDF (20-20-0 NPK/ha) + FYM @ 10 t/ha	25.5	10.4	18.7	1950	338	1088	30.3	28.8	31.00	50.60
75% RDF (30-30-0 NPK/ha) + FYM @ 5t/ha	24.4	9.9	17.4	2245	349	1076	29.7	28.6	30.00	**50.63**
SEm ±	0.59	0.71	0.75	39.6	17.40	55.2	0.46	0.34	0.58	**0.25**
C.D. (0.05)	NS	NS	NS	112.7	NS	NS	1.32	**NS**	**NS**	**0.71**
Genotype X Fertilizer	NS	NS	NS	Sig	NS	NS	NS	NS	**NS**	**NS**

Table 2 : Interaction effect of genotype X Fertilizer on castor bean yield (kg/ha) during 1996-97

Genotype	Fertilizer					
	F1	F2	F3	F4	F5	Mean
DCH 32	1154	1388	1397	1647	2056	1528
DCH 177	1511	1609	2106	2118	2673	2003
DCH 178	1383	1713	2116	2071	2327	1922
DCH 30	1282	1673	1952	2033	2108	1810
GCH 4	1564	1639	1817	1879	2063	1792
Mean	1379	1604	1877	1950	2246	1811
SEm ±	88.6					
C.D. (0.05)	252.0					

F1 : Control (0-0-0- NPK/ha); F2 : RDF (40-40-0 NPK/ha); F3 -150% RDF (60-60-0 NPK/ha); F4-50% RDF+FYM 10t/ha; F5: 75% RDF+FYM 5t/ha.

and plant drought, no discernible variations in seed yield were observed due to application of different fertilizer doses. However, there was an increasing trend in seed yield with increase in fertilizer dose. As in the preceding year, application of 75% RDF through inorganic form in conjunction with FYM @ 5t/ha recorded maximum yield of 349 kg/ha under rainfed conditions (Table 1). Conjunctive use of reduced level of inorganic fertilizer and FYM showed a favourable effect on test weight of seed as compared to lower levels of inorganic fertilizer.

During 1998-99 the seed yield tended to increase with increasing level of fertilizer application, though the variations were not discernible. Application of 150% RDF gave maximum yield (1145 kg/ha). Reduced level of inorganic fertilizer in association with FYM showed a favourable influence on test weight of seed in comparison with lower doses of fertilizer (Table 1). Subba Reddy *et al.*, (1999) reported optimum castor yield with 10-30-0 NPK/ha as basal plus 20 kg/ha as top dress.

Oil Content

Among the test hybrids DCH 178 (51.7%) and GCH 4 (51.2%) showed significantly higher oil content in seeds than the rest of the hybrids.

Fertilizer application had a significant influence on oil content (50.6%) than no fertilizer (49.7%), suggesting the importance of nutrition in elevating oil content, seed yield and resultant oil yield (Table 1).

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J. Oilseeds Res. 16(2) 1999: 299-302
ISSN 0970-2776

EFFICACY OF *Bacillus thuringiensis* AGAINST CASTOR SEMILOOPER *Achoea janata* LINN. (LEPIDOPTERA: NOCTUIDAE)

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ABSTRACT

Commercial formulations of *Bacillus thuringiensis* (B.t.) var.*kurstaki* and var. *thuringiensis* were tested against castor semilooper *Achoea janata* - a major pest of castor (*Ricinus communis* Linn.) and a voracious foliage feeder. Feeding cessation was observed in larvae exposed to B.t. sprayed castor leaves. B.t. var. *kurstaki* and var. *thuringiensis* were comparable to the insecticidal check monocrotophos (0.05%). Effective control of the pest (84.31% mortality) was obtained in the field with B.t. var. *kurstaki* (0.5%) even under conditions of high pest density (10-15 larvae/plant). B.t. was safe to the natural larval parasitoid *Microplitis maculipennis*.

Key words: Bacillus thuringiensis, Ricinus communis, Achoea janata.

INTRODUCTION

Castor (*Ricinus communis*), a major industrial oilseed crop grown in the states of Gujarat, Andhra Pradesh, Tamil Nadu, Orissa, Rajasthan and Karnataka, suffers from serious insect pest problems of which semilooper, *Achoea janata* L., is the major yield limiting factor (Senapathi and Das, 1989). Castor semilooper is a voracious feeder causing extensive defoliation and at times of severe incidence also feeds on developing capsules (Rai and Jayaramaiah, 1978). First incidence of semilooper on annual castor occurs in late June and early July and the pest completes three to four overlapping generations in a season (Khan, 1946). In nature the pest is known to be attacked by an egg parasitoid, *Trichogramma chilonis* (Ishii) and two larval parasitoids viz., *Microplitis maculipennis* (Szep) and *Euplectrus* sp. However, the incidence of these natural enemies occurs late in the season when serious damage by the pest has already been done. Use of chemical insecticides adversely affects the natural enemy population and their continued use poses problems such as development of insecticide resistance. Control of semilooper through use of *Achoea janata* baculovirus, though an attractive and safe alternative from the environmental standpoint, is beset with problems like slow speed of kill usually associated with insect viruses. *Bacillus thuringiensis* on the other hand, combines the twin advantages of safety to natural enemies and rapid action. Although B.t. is readily available and registered for numerous lepidopterous pests in many countries (175 B.t. products registered with EPA, US since 1961), in India B.t. products received approval for registration only recently. Todate, tests with B.t. in India have mostly been confined to the laboratory. Hence, there arises a need for field testing the registered B.t. formulations for their efficacy before making recommendations. In this paper, the efficacy of two varieties of *B. thuringiensis* in the laboratory and field tests against *A.janata* is reported.

MATERIALS AND METHODS

The preparations of *Bacillus thuringiensis* var. *kurstaki* and var. *thuringiensis* used in all the tests were water dispersable fine dry wettable powders which were tested against castor semilooper.

Received for publication in December, 1997

Laboratory bioassays

Castor semilooper larvae (instar V) were exposed to castor leaves sprayed with B.t. var. *kurstaki* at three doses - 0.25%, 0.5% and 0.75%. For each treatment, 3 replicates were maintained with 10-15 larvae/replicate. Spray solution was prepared by suspending the commercial preparations in water. Observations on larval weights and mortality were recorded at 24h and 48 h after exposure of larvae to treated leaves.

Field studies

Treatments were imposed on the natural semilooper population. The study was carried out in a split-plot design with genotypes, to study the response of semilooper to B.t. in different canopy types, in main plots and insecticidal treatments in sub-plots (4m x 5m). Three genotypes of castor viz., Aruna, VP-1 and GCH-4 were sown on 15 June 1994. The insecticidal treatments imposed were: i) B.t. var. *kurstaki* (0.5%), ii) B.t. var. *thuringiensis* (0.5%), iii) Monocrotophos spray (0.05%), and iv) Unsprayed control. Three replicates were maintained for each treatment. Two sprays were taken up - first at 45 days after sowing (D.A.S.) and the second at 70 D.A.S. Pre-treatment counts of semilooper larvae at 24 h prior to spray and post-treatment counts at 48 h after spray were recorded. At the time of the first spray, whole plot counts for larvae were taken as the pest incidence was low. For the second spray, larval counts on 5 plants/plot were taken due to a high pest incidence (10-15 larvae/plant). Similarly counts of *M. maculipennis* parasitized semilooper larvae (identified by the pupal cocoon of the parasitoid attached to the abdominal prolegs) were also recorded.

Larval mortality data in the laboratory test was subjected to ANOVA and in the field tests to ANOVA for split-plot design after angular transformation (Arcsin squreroot percentage).

RESULTS AND DISCUSSION

Laboratory studies have shown feeding cessation by larvae at 24 h after the bioassay as reflected by the larval weights (Table 1). Larval mortality after 24 h was low in all the treatments (10-20%). However, significant mortality ($P<0.01$) was observed after 48 h in all the treatments over unsprayed control. Highest cumulative mortality (87%) was recorded in 0.5% B.t. spray. Although a similar mortality was observed in 0.25% B.t. spray, weight gain of the surviving larvae was relatively higher. Based on this observation, the two formulations of B.t were field tested at 0.5% concentration.

Larval mortality after the first spray at 45 DAS was similar (>90%) in the B.t. sprayed and monocrotophos sprayed plots across genotypes but was significantly higher over unsprayed control (Table 2). The decrease in larval population in the control plots can be attributed to the late instar larvae entering into pupation since no dead larvae were recorded.

After the second spray at 70 DAS a significant decrease in semilooper population was recorded in both B.t. var. *kurstaki* and var. *thuringiensis* sprays comparable to that in monocrotophos spray irrespective of the genotypes (Table 2). Variation in larval mortality among the genotypes as well as interaction between the genotypes and treatments at both sprays was non-significant. Parasitisation of semilooper larvae by *M. maculipennis* at 70 DAS was similar in all the treatments across the genotypes indicating the safety of B.t. to the parasitoid.

Efficacy of B.t. as a dust against *A.janata* on castor has been reported by Kulshreshtha *et al.*, 1965. Bioassay against castor semilooper with spore+endotoxin and predissolved endotoxin of different varieties of B.t. showed that B.t. var. *kurstaki* was most pathogenic followed by var.

Table 1 : Laboratory testing of *Bacillus thuringiensis* var *kurstaki* against Vth instar castor semilooper larvae

Treatment	After 24 h		After 48 h	
	Mean wt (mg) /surviving larva [a]	Percentage mortality [b]	Mean wt (mg) /surviving larva [a]	Percentage mortality [bc]
Bt (0.25%)	232.7±21.7(28)	6.6(11.56)	309.7±28.8(6)	76.6 (61.2)
Bt (0.5%)	180.1±27.4(23)	20.6(19.63)	163.3±35.5(4)	86.6 (68.9)
Bt (0.75%)	182.4± 27.4(27)	10.0(13.8)	179.0±32.9(7)	76.6 (61.2)
Untreated	401.1± 62.3 (29)	0(4.05)	574.5±101.6(29)	3.3(8.9)
LSD (P=0.01)		NS		18.04

[a] Values are mean ± SE; Figures in parentheses are number of surviving larvae in each treatment

[b] Figures in parentheses are angular transformed values; Data subjected to analysis of variance.

[c] Cumulative mortality

Table 2 : Field efficacy of B.t. formulations against castor semilooper

	Mean % decrease in larvae at [a]		% increase in parasitization [b]
	45 D.A.S.	*70 D.A.S.*	*70 D. A. S*
Genotypes			
VP-1	67.42(55.26)	63.62(54.66)	35.84(36.37)
Aruna	81.26(71.17)	58.74(49.41)	31.58(28.05)
GCH-4	82.68(71.99)	70.77(59.65)	34.64(32.70)
SEm ±	3.560	3.231	4.654
C.D. (P-0.05)	NS	NS	NS
Treatments			
B.t var. *kurstaki* **(0.5%)**	90.31 (78.73)	84.31(68.99)	21.96(22.65)
B.t.var *thuringiensis* **(0.5%)**	92.02(77.15)	69.63(57.59)	39.70(35.74)
Monocrotophos **(0.05%)**	91.62(76.77)	73.71 (59.91)	40.53 (36.56)
Unsprayed control	34.44(31.92)	33.20(31.80)	33.89(34.54)
SEm±	5.081	5.184	7.182
C.D. (P=0.05)	15.10	15.40	NS

[a] Decrease in semilooper population 48 h after spray over pre-treatment count; Figures in parentheses are angular transformed values (Arcsin percentage)

[b] Increase in parasitisation 48 h after spray over pre-treatment count

galleriae and var. *berliner* (Deshpande and Ramakrishnan, 1982; Deshmukh and Deshpande, 1989). In this study, B.t. var. *kurstaki* and var. *thuringiensis* gave similar mortality comparable to the insecticidal check even at a high pest density.

Formulations of B.t. var. *kurstaki* were the most effective against *Chrysodeixis chalcites* (Esp.) on tomato and *Pthorimaea operculella* (Zeller) on potato in Israel (Mohammed, 1993) and cotton leafworm, *Spodoptera exigua* (Hb.) in Egypt with safety to the associated predators (Broza and Sneh, 1994). Two formulations of B.t. caused complete feeding cessation after 24 h and gave effective control of *Manduca quinquemaculata* (Haw.) on tobacco regardless of the rates appliled and had no detrimental effect on the parasitoid *Cotesia congregata* (Cheng and Hanlon, 1990).

The present study shows: a) Immediate feeding cessation in castor semilooper after ingestion of B.t. in both laboratory and field tests, b) Castor semilooper can be effectively controlled either by B.t.var. *kurstaki* or var. *thuringiensis* at 0.5% irrespective of the genotype or the stage of the larvae, and c) B.t. preparations were found safe to the larval parasitoid, *M. maculipennis*.

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J. Oilseeds Res. 16(2) 1999 : 303-305
ISSN 0970-2776

UTILIZATION OF SUNFLOWER CAKE AND ITS PROTEIN ISOLATE IN SOME INDIAN SNACK ITEMS

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ABSTRACT

Whole seed Sunflower cake, partially dehulled cake, completely dehulled cake flours and their protein isolates were utilised in the preparation of biscuits and other Indian food items like *pakodi* and *chapathi*. Different grades of sunflower cake added at 10% level enhanced the protein content of the snack items from 11-21g/100g (control) to 13-24g/100g. Protein isolate added at 5% level increased the protein content of food items to 14.5-25g from that of control. At 10% level the protein content was around 17.8-28.9g/100g. Taste panel acceptability was 50-90% for the protein biscuits and snack foods as against 100% for the control. There is a good scope for utilisation of sunflower cakes and protein isolates as food ingredients in view of their higher protein content and acceptability.

Key words: Sunflower, Partially dehulled, Dehulled cake, Protein isolate, Snack foods.

INTRODUCTION

The increased production of oilseeds at around 23 m. tonnes has made available more oilcakes which presently stands at about 12 to 15 million tonnes. Through export of 4.3 million tonnes of oilcakes India earned about Rs. 2400 crores of foreign exchange (Mehta, 1997). Inspite of this India is left with 8-12 million tonnes of oilcakes which are mostly being utilised as animal feed. Sunflower is an important oilseed with a production of 15 lakh tonnes seed per annum. The seedcake availability is around 6.6lakh tonnes. The protein content of sunflower cake ranges from 20-40% and in view of the higher cost as well as non availability of animal protein, there is a great scope for utilisation of oilcake proteins for human consumption (Deosthale and Longvah, 1988). In the present study varied grades of sunflower seedcakes and their protein isolates, have been utilised in the preparation of biscuits and indigenous food items like *pakodi* and *chapthi* and their utility and acceptability has been examined.

MATERIALS AND METHODS

Sunflower seeds grown during 95-96 season were collected from the D.O.R. farm, Rajendranagar, Hyderabad. The seeds were stored in gunny bags till analysis. The oil was extracted using Komet oil expeller from whole seeds, partially dehulled and completely dehulled seeds. The oilcakes were collected and powdered using kniftec grinder prior to analysis. The protein content of the whole seed cake flour was 25g/100g, partially dehulled cake was 28g/100g and fully dehulled cake was 30g/100g. (AOCS method N * 6.25). Protein isolates were prepared from sunflower whole seedcake and dehulled seedcake. Seedcake was extracted with 0.5M NaCl (1:5w/v) thrice, (after thorough shaking) the proteins were precipitated using 1 N HCl at P^H 4.5 filtered, washed and freeze-dried at -30° C (Landey, 1970).

The food items namely biscuits, *pakodi* and *chapathi* were prepared according to the procedure of Taradalal *et al.*, (1980). In place of flour (*Maida* for biscuits, Bengal gram flour for *pakodi* and wheat flour for *chapathi*) whole sunflower cake flour, partially dehulled cake and fully dehulledcake were incorporated at 10% and 20%, while the protein isolates were included at 5% and 10% level. The items prepared were subjected to sensory evaluation by a panel consisting of 10

Received for publication in October, 1998

members. The products were evaluated for colour, appearance, flavour, texture and overall acceptability(Mayor Doyal, 1982). A score was given to each attribute on hedonic scale of 5 (5-very good, 4-good, 3-fair, 2-average, 1-poor). Percent acceptability was calculated for each snack item and the results along with protein content are presented in Tables 1 and 2.

RESULTS AND DISCUSSION

Dehulled seedcake when incorporated at 10 and 20% level in the preparation of biscuits, *pakodi* and *chapathi* have been accepted to a level ranging from 72 to 92% with 10% level incorporation being more acceptable (86-92%) (Table 1). The partially dehulled cake acceptability ranged from 60 to 72% with the whole seed cake being least acceptable (50-70%) which might be due to the higher crude fibre content and the unpleasant colour of the food items (Milolcyczak *et. al.*, 1970). The protein content of all the preparations was higher (13-27g/100g) over the control (11-21g/100g). Keeping in view the higher protein content of the snacks, incorporation of the seedcake flour, particullarly dehulled cake, should be encouraged from the nutritional angle as well as the utilisation of oilcakes which are available in plenty at a cheaper price (3Rs/kg).

Similarly, use of protein isolate from whole seed sunflowercake and dehulled seedcake showed 54-85% acceptance levels. Incorporation into biscuits and *chapathi* at 5% and 10% level was found to be acceptable at levels of 76-85%. The acceptance was low at 54-72% when used in *chapathi* making. This could be the attributed to the dark colour of the product. Protein content of the items made with the isolate was higher (14.5-29g/100g) as against 11-21g/100g in the control. It is thus evident that apart from acceptability of the protein isolate snacks, the increased protein content, should enable them for their utilisation in preparation of the food items like biscuit and *pakodi*.

Table 1 : Acceptability and protein content of snacks/food items made with sunflower seed cakes

Sl. No.	Product	Control	Treatment detail					
			Whole seed Cake (%)		Partially Dehulled cake (%)		Dehulled Seed cake (%)	
			10	20	10	20	10	20
1.	**BISCUIT**							
	a. Protein (g/100g)	12.0	14.3	16.8	14.8	17.5	15.0	18.0
	b. O. Accept (%)	100	55	50	66	60	92	82
2.	**PAKODI**							
	a. Protein (g/100g)	21.0	23.2	25.5	23.6	26.4	24.0	27.0
	b. O. Accept (%)	100	70	56	70	64	90	72
3.	**CHAPATI**							
	a. Protein (g/100g)	11.0	13.4	15.7	13.8	16.5	13.9	17.0
	b. O.Accept (%)	100	62	58	72	60	86	72

Note : O. Accep=Over all acceptability

Table 2 : Acceptability and protein content of snack items made with protein isolate of sunflower seed cake

Sl. No	Product	Control	Treatment detail			
			Whole seed cake pt. Isolate		Dehulled seed cake pt. Isolate	
			5%	10%	5%	10%
1.	**BISCUIT**					
a.	Protein (g/100g)	12.0	15.3	18.62	16.0	19.80
b.	O. Accept (%)	100	78	76	85	80
2.	**PAKODI**					
a.	Protein (g/100g)	21.0	24.3	27.8	25.0	28.9
b.	O. Accept (%)	100	80	76	84	82
3.	**CHAPATI**					
a.	Protein (g/100g)	11.0	14.5	17.8	15.0	18.9
b.	O.Accept (%)	100	60	54	72	68

Note : O. Accep=Over all acceptability. Pt=Protein

Increased protein content of the protein isolate food items should offset the increased cost of the protein isolates. Such items may have more utility as weaning foods and for patients during convalescent periods.

ACKNOWLEDGEMENT

We wish to express our sincere thanks to ICAR for providing financial assistance.

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J. Oilseeds Res. 16(2) 1999 : 306-309
ISSN 0970-2776

YIELD, ECONOMICS AND SUSTAINABILITY PARAMETERS IN LINSEED FRONTLINE DEMONSTRATIONS IN KOTA DIVISION

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ABSTRACT

Sixty eight frontline demonstrations were conducted during rabi 1991-92 to 1995-96 in Kota division of Rajasthan on linseed. It was found that cultivation of linseed under high fertility conditions was more profitable as compared to that under rainfed and low fertility conditions. Sustainability parameters like sustainable yield index (SYI) and sustainable value index (SVI) were also greater with improved technology.

Keywords : Yield, economics, sustainability, linseed

INTRODUCTION

Linseed (*Linum Usitatissimum* L.) is usually treated as a poor man's crop due to its low productivity. This is mainly because it is a rainfed crop grown on marginal lands with little or without input except seed. Variations in rainfall, and susceptibility of local material to wilt and powdery mildew discourage the addition of inputs in this crop.

Linseed is grown in Rajasthan in an area of 0.676 lakh ha, producing 0.204 lakh tonnes of seed. State productivity of linseed is 372 Kg/ha as against the national productivity of 298 kg/ha. Initial surveys of Kota division revealed that there was hardly any adoption of technology by the linseed growers perhaps due to the conviction that linseed is only a marginal crop. However, adoption of improved technology such as improved seed, use of fertilizer, minimum irrigation, disease and pest control and a little change in agronomy of the crop would increase the productivity.

Hence, to transfer the technologies to the linseed growers, ICAR has launched a special project on frontline demonstrations with a view to demonstrate the yield potential with improved technology vis-a-vis yield with farmers' practice under real farm situations.

MATERIALS AND METHODS

Kota division receives normal precipitation of 75cm distributed between June and September, with a coefficient of variation of 24.6 percent. Early withdrawal of monsoon adversely affects linseed area and productivity. Soils are heavy black with medium "N" high "P"and medium "K". Major linseed planting is done in second fortnight of October.

Sixty eight frontline demonstrations were conducted during *Rabi* 1991-92 to 1995-96. Demonstrations were laid out in an area of 0.4 ha each for improved and farmers' practice. Out of them 50 demonstrations were on whole package including varieties (Triveni & Kiran), while 18 were under cropping system with high fertility conditions and double purpose varieties (LCK 8528, RL 29-2 and RL 904). Recommended package of practices and need based plant protection measures were followed in raising the crop under improved practices. Improved varieties of TFL were used for sowing. Cropping system demonstrations were sown after soybean. As regards farmers' practice, farmers were allowed to follow their own traditional practices. However, farmers selected for cropping system demonstrations had partially adopted improved technology.

Data recorded on seed yield and net return

Received for publication in October, 1998

Table 1 : Yield, economics and sustainability in Linseed Frontline demonstrations (1991-95) laidout in farmers' fields of Kota Division (Rajasthan)

Particulars	91-92		92-93		93-94		94-95		95-96		Mean	
	I	F	I	F	I	F	I	F	I	F	I	F
Number of Demonstrations	14 (1)	14 (1)	14 (2)	14 (2)	14 (4)	14 (4)	10 (5)	10 (5)	16 (6)	16 (6)	68 (18)	**68 (18)**
Mean seed yield q/ha. (Rainfed)	6.12	3.79	6.92	3.34	6.78	2.79	6.50	2.35	9.84	3.54	7.23	**3.16**
Mean seed yield q/ha. (Irrigated)	17.90	10.00	14.50	9.37	18.31	9.00	14.60	6.00	17.02	8.07	16.47	8.49
Increase in seed yield ove F.P. (%)	**64.54**		116.58		121.49		169.03		139.12		123.11	
Mean net return (Rs./ha)	3831	1920	3777	1220	3882	1339	5005	1320	10665	3329	5432	1826
Marginal B:C ratio	3.680	2.680	3.050	1.590	2.860	2.390	3.100	1.960	2.980	2.100	3.130	2.140
Sustainable Yield Index (SYI)	*0.156*	*0.182*	*0.182*	*0.062*	0.053	-0.038	0.078	0.055	0.282	0.167	0.116	0.059
Sustainable Value Index (SVI)	*0.145*	*-0.029*	*0.112*	*-0.135*	*-0.110*	*-0.183*	0.050	0.054	0.246	0.101	-0.020	-0.081

I : Improved method, F: Farmers' method; Figures in parenthesis indicate the number of demonstrations under high fertility conditions.

Table 2 : Variability in seed yield (Kg/ha) and Net return (Rs./ha) of linseed frontline demonstrations (1991-92 to 1995-96)

Particulars	91-92		92-93		93-94		94-95		95-96		Mean	
	I	F	I	F	I	F	I	F	I	F	I	F
Seed yield range (q/ha)	3.79-17.90	1.90-10.00	2.75-16.25	2.00-11.25	5.12-22.00	1.75-12.50	5.00-20.00	2.00-7.50	5.80-20.00	2.50-10.00	2.75-22.00	1.75-12.50
Mean seed yield	6.12	3.79	6.92	3.34	6.78	2.79	6.50	2.35	9.84	3.54	7.23	3.16
Std. deviation	3.32	1.97	3.03	2.64	5.61	3.27	4.94	1.94	4.19	1.86	4.67	2.42
C.V. %	47.70	46.58	37.91	62.71	55.69	71.55	46.83	46.49	33.47	33.57	49.94	54.94
Net return range (Rs./ha)	2500-16700	580-9500	2416-11743	324-10081	2747-20696	327-11258	2750-21652	1125-6200	4045-22296	999-10600	2416-22296	324-11258
Mean	3831	1920	3777	1220	3882	1339	5005	1320	10665	3329	5432	1826
Std. deviation	3587	2194	2426	2581	6153	3401	6091	1653	5186	2256	5878	2735
C.V. %	75.39	89.11	52.01	120 17	82.30	108.38	63.39	60.24	40.37	51.46	74.26	117.97

I : Improved method, F: Farmers' method;

are subjected to statistical analysis for calculation of standard deviation and coefficient of variation standard procedure (Panse and Sukhatme, 1961). Sustainability indices were worked out using the formula (SYI/SVI)=y-O/Y Max, where Y/V is estimated average yield/net return of practice over year (study period), O is standard deviation and Y max is observed as maximum yield/maximum net return during the study. (Singh *et al*, 1990).

RESULTS AND DISCUSSION

Improved package of practices gave remarkable increase in seed yield ranging from 64.54 to 169.03 percent with a mean of 123.11 per cent over farmers' practice (Table 1). While improved method recorded seed yield ranging from 2.75 q/ha to 22q/ha with a mean of 9.75q/ha against an yield ranging from 1.75 q/ha to 12.50 q/ha with a mean of 4.45 q/ha recorded in farmers' practice. These results are in conformity with results on frontline demonstrations from other AICORPO centers, (Anonymous 1994, 1995 and 1996). Cultivation of linseed under irrigated and high fertility conditions proved to be profitable with a seed yield ranging from 14.50 q/ha to 18.31 q/ha with a mean seed yield of 16.47 q/ha as compared to farmers' practice where it ranged from 6 to 10 q/ha with a mean of 8.49 q/ha. Farmers' practice recorded higher coefficient of variation for seed yield in all the years except in 1991-92 and 1994-95 where the CV was almost equal to improved practices which could perhaps be attributed to early withdrawal of monsoon and high incidence of diseases in local cultivars. (Soma Sekhara *et al*, 1994).

Improved practice gave higher net returns ranging from Rs.2416 to Rs.22296/ha, with a mean value of Rs.7915/ha as compared to farmers' practice which recorded Rs.324 to Rs.11258/ha with a mean value of Rs.2318/ha. The cost effectiveness of growing linseed under high fertility conditions is further confirmed by B:C ratio which ranged from 2.86 to 3.68 with an average of 3.13. Coefficient of variation values obtained for mean economic net return from farmer's practice were of higher magnitude except in 1994-95 where demonstrations under both the situations were equal in number. Higher economic return obtained from improved practice was mainly due to higher yield obtained under high fertility conditions.

Further improved method of cultivation exhibited higher value of sustainability indices (SYI and SVI) for all the years except 1991-92 (SYI) and 1994-95 (SVI). However, overall mean of 5 years for sustainability parameters was also of higher magnitude with improved practice as compared to farmers' practice because of higher standard deviation values obtained with improved method. The standard deviation values varied due to variation in crop response to input depending upon varying situation of cultivation i.e. low fertility and high fertility conditions.

Thus, it is concluded that cultivation of linseed under high fertility conditions was more profitable as compared to cultivation under rainfed and low fertility conditions. Sustainability parameters like SYI and SVI were also higher with improved practice.

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J. Oilseeds Res. 16(2) 1999: 310-313
ISSN 0970-2776

IMPACT OF CONSERVATION PRACTICES ON SOIL MOISTURE AND CROP YIELD IN A WATERSHED - A CASE STUDY

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ABSTRACT

Attempts have been made to understand the effect of moisture conservation measures at terrace and interterrace levels on farmers fields in the watershed area of Kurnool district of A.P., during 1989-90 and 1990-91 which were reported to be below normal rainfall years. It was found that the low cost measures like compartmental bunding and contour cultivation are equally efficient in conserving moisture and in positively influencing yields of groundnut and sorghum crops of the tract

Keywords : Conservation, soilmoisture, groundnut

INTRODUCTION

Rayalaseema comes under the rainfall scarcity region of Andhra Pradesh. Climatically this region falls under arid to semi-arid area with annual rainfall ranging between 400 and 670 mm. Due to vagaries of monsoon, crop yields are very low and unstable. Therefore, the situation necessitates improving the productivity through resource conservation measures.

MATERIALS AND METHODS

A field study was conducted at Chinnatekur watershed 12 km away from Kurnool receiving an average annual rainfall of 654 mm with a fair distribution from June to October (Anonymous, 1987).

The soils are black, red and mixed with fairly good drainage, shallow to moderate in depth (20 to 60cm), with slope varying between 1 and 2 percent, with soil pH between 7.5 and 9.5 and EC between 0.14 and 2.40 m μ hos/cm. Soils are rich in potassium ranging between 560 and 972 kg/ha. Presently, these soils are put to cultivation of crops like groundnut, pearl millet, sunflower, sorghum, pigeonpea etc.

Soil and moisture conservation practices have been recognised as an integral part of agriculture for improving productivity. The techniques practiced are of two types.

Conservation measures

Terrace level graded bunds	Interterrace level
High cost	Low cost
Rough grading	Compartmental bunding
Graded border strips	contour cultivation

Terrace level

Graded bunds of 0.75m² cross section at vertical interval of 1.0 m and having variable gradients of 0.1 to 0.3 per cent with stone checks in the depressions were formed over an area of 305 ha at a cost of Rs.409/ha. (After stabilisation no maintenance is required).

Inter terrace Level

High Cost

i. Rough grading in between bunds was done in 138 ha at a cost of Rs.333.60/ha (only once, no maintenance is required).

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Received for publication in December, 1998

ii. Graded border strips of 40 m long and 10 m width with longitudinal gradient of 0.2% were formed in between the graded bunds in an area of 2.13 ha at a cost of Rs.4538/ha (annual maintenance required).

Low cost

i. Compartmental bunding: These were formed every year before the onset of monsoon with the help of a bullock drawn bund former. The size of the compartments were 6 x 6 m and 4 x 4 m where slopes are 1% and more than 1% respectively. These bunds are disturbed/destroyed at the time of sowing. The main objective of this practice was to improve *insitu* moisture in the profile to help during crop growth period. The cost involved in this case was only Rs.15 /ha (these are formed every year).

ii. Cultivation across the slope: Where cost involved is negligible.

The study was conducted in *Kharif* on groundnut and in *rabi* on sorghum in separate fields of light shallow black soils for two years (*1989-90* and *1990-91*).

The treatments studied in groundnut and sorghum are as follows:

Treatments	Kharif Groundnut	Rabi Sorghum
T1	Graded bund + graded border strips	Graded bund + graded border strips
T2	Graded bund+ rough grading	Graded bund+ compartmental bunding
T3	Graded bund + sowing along the bund	Graded bund + sowing along the bund
T4	Graded bund + sowing along the slope	Unbunded area
T5	Graded bund+ compartmental bunding	
T6	Unbanded area	

The yields were collected through crop cutting studies from plots of 5m x 5m size. The moisture conserved under different treatments and its effect on groundnut pod yield was studied.

RESULTS AND DISCUSSION

The highest groundnut pod yields were recorded in graded border strips (T-1) with 831 and 750 kg/ha followed by 810 and 680 kg/ha in compartmental bunding (T-5) and 760 and 650 kg/ha under rough grading (T-2) during 1989 and 1990, respectively. The per cent increase in yield in graded border strips, compartmental bunding, and land smoothening during 1989 was 32.9, 29.6 and 21.6 respectively over bunded area, while it was 41.5, 28.30 and 32.64 respectively over unbunded plot during 1990. Graded bunding with cultivation across the slope gave 8.52 and 9.09 per cent more groundnut pod yield over graded bunding with along the slope followed by 12.03 and 8.25 cm in compartmental bunding, 11.95 and 7.50 cm under rough grading, 11.22 and 7.39 cm under graded bunding with across the slope, 10.76 and 6.83 cm under graded bunding with along the slope cultivation and 10.60 and 6.83 cm under unbunded plots during 1989 and 1990 respectively. Same trend was noticed at other crop growth stages during both the years. The results conform to the findings of Ali and Prasad (1972) and Barai *et al.*, (1991).

The moisture conserved and its effect on *rabi* sorghum yield under different interrace level measures are presented in Table 2. During 1989-90 highest moisture content at sowing time (15.0 cm), upto 45 cm soil depth was recorded in graded border strips followed by 13.65 cm in compartmental bunding, 12.51 cm in graded bunding and only 12.0 cm in unbunded plots, while in 1990-91 moisture content of 10.20 cm , 9.55 cm and 8.45 cm was recorded at sowing time under compartmental bunding, graded bunding and unbunded plots, respectively. Similar trend was noticed at other crop growth stages. Singh (1965)

Table 1: Soil moisture and groundnut yield as influenced by moisture conservation practices during kharif season

	Moisture content upto 45 cm soil depth (cm)					
	Sowing time	Flowering stage	Pegging stage	Pod development	Harvesting	Groundnut Pod yield (kg/ha)
1989						
T-1	16.72	12.99	12.79	13.02	9.29	831
T-2	13.86	12.09	11.95	12.03	7.05	760
T-3	13.84	11.75	11.22	11.76	6.23	700
T-4	13.10	11.35	10.76	11.53	6.09	645
T-5	13.94	12.10	12.03	12.32	7.68	810
T-6	13.21	10.92	10.60	11.06	5.31	625
Rainfall (mm) = **588.5, Crop growth period = 329.9 mm,** Date of sowing : 10.06.89.						
1990						
T-1	13.90	13.52	9.28	9.44	9.21	750
T-2	11.89	12.28	7.50	7.82	7.82	650
T-3	11.60	12.18	7.39	7.77	7.74	600
T-4	11.29	11.63	6.87	7.17	6.70	550
T-5	12.40	12.75	8.25	8.60	8.45	680
T-6	10.96	11.20	6.83	7.03	6.15	530
Rainfall (mm) - 523.4, Crop growth period - 333.6 mm, Date of sowing : 15.06.90.						

reported that bunded fields conserved more moisture during sowing of *rabi* season crops to the extent of 11.8 per cent as compared to only 10.7 per cent in control plot.

It is evident from Table 2 that increase in sorghum yield was 37.3%, 31.89% and 9.32% under graded border strips, compartmental bunding and graded bunding, respectively over unbunded area during 1989-90. The increase in sorghum yield during 1990-91 due to compartmental bunding and graded bunding was 28.8 and 13.3 per cent, respectively over the yield from unbunded plot (600 kg/ha).

It could be inferred that border strips are superior to all other moisture conservation measures followed by compartmental bunding and graded bunding. These results are in conformity with the findings of Barai *et al.*, (1991). However, due to involvement of high expenditure on the formation of graded border strips and risk involve in their maintenance, it is felt that they are not feasible to the poor Indian farmers. Hence, compartmental bunding is recommended to the Indian farmers as it requires very meagre amount for its formation, apart from being an effective and proven soil moisture conservation practice for sustained productivity.

Table 2: **Soil moisture and rabi sorghum yield as influenced by moisture conservation practices during kharif season**

Sl.No.	Soil moisture content upto 45 cm soil depth (cm)				
	Sowing time	Flowering stage	Grain development	Harvesting time	Sorghum grain yield (kg/ha)
1989-90					
T-1	15.00	10.45	8.81	6.86	1016
T-2	13.65	9.26	7.72	6.15	676
T-3	12.51	8.22	6.60	5.05	809
T-4	12.00	7.65	6.05	4.80	740
Rainfall (mm) = 588.5, Crop growth period = 85.2 mm, Date of sowing : 27.07.89.					
1990-91					
T-1	Crop changed				
T-2	10.20	9.10	6.15	4.64	725
T-3	9.55	7.40	5.31	3.98	680
T-4	8.45	6.88	4.56	3.42	600
Rainfall (mm) - 523.4, Crop growth period - 170.4 mm, Date of sowing : 25.09.1990.					

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J. Oilseeds Res. 16(2) 1999 : 314-316
ISSN 0970-2776

COMBINING ABILITY ANALYSIS IN RAPESEED *(Brassica campestris* L.) USING RECESSIVE GENIC MALE STERILITY

Considerable amount of heterosis for yield and its components in F1 hybrids of rapeseed have been reported by various workers (Das and Rai, 1972; Patnaik and Murty, 1978; Verma *et al.* 1989). It is difficult to exploit heterosis on commercial scale by producing hybrid seeds through hand emasculation and pollination. These reports encourage the development of pollination control systems i.e, male sterility, self-incompatibility or gametocide application. However, the development of such mechanisms is highly complicated and time consuming. Ling and Yan (1983) utilized genic male sterility for hybrid seed production in *Brassica napus*. The genic male sterile lines, MST1 in *toria* (Chauhan *et al.*, 1986) and YSMS 8163 in yellow *Sarson* have been developed at this centre. The present paper reports estimates of general and specific combining ability of these genic male sterile lines for their use in heterosis breeding.

The material for the present experiment was developed by crossing 2 genic male sterile lines viz., MST1 of *toria* and YSMS 8163 of yellow *sarson* with 10 lines of each *toria* and yellow *sarson* in a line x tester mating design. These forty crosses were evaluated alongwith 22 parental lines (2 male steriles + 20 germplasm) in Randomized Complete Block Design with 3 replications. The row to row spacing was kept 30 cm and plant to plant distance of 10 cm was maintained after thinning at 15 days of sowing. Observations were recorded on days to flowering, days to maturity, number of primary branches, number of secondary branches, number of seeds/siliqua, 1000-seed weight (g), seed yield per plant (g) and oil content (%). Combining ability analysis was done using the method of Kempthorne (1957).

The analysis of variance for combining ability revealed that mean squares due to crosses were significant for all the characters. The interactions between males and females were significant for all the characters under study (Table 1).

PT 9001 and BAUTR 1 of *toria* were good general combiners for early flowering and maturity. Yellow *sarson* strains NDYS 8, GPY 892 and NDYS 2 were good general combiners for number of primary branches. BAUTR 1, PT 303, TH 9002 and Torch for number of secondary branches; PT 303 followed by NDYS 1, NDYS 19 and NDYS 4 for 1000-seed weight; NDYS 11, NDYS 19, NDYS 56, NDYS 1 and NDYS 8 for number of seeds/siliqua; yellow toria, NDYS 8, JMT 6902, NDYS 11 and YST 151, for seed yield and JMT 6902, YST 151, NDYS 11 and Bhawani for oil content were good general combiners.

MST 1 was good general combiner for number of primary branches and seeds/siliqua. While YSMS 8163 was found good general combiner for early flowering and maturity, number of secondary branches, 1000-seed weight, seed yield/plant and oil content.

Crosses YSMS 8163 x YST 151, MST1 x GPYS 892, MST 1 x NDYS 11, MST 1 x T 9, YSMS 8163 x NDYS 1, MST 1 x yellow Toria, YSMS 8163 x NDYS 2 and MSY 1 x TH 9002 exhibited high *sca* effects for seed yield/plant and moderately high for days to flowering, days to maturity and number of primary branches. Crosses YSMS 8163 x NDYS 11, MST 1 x NDYS 2, MST 1 x NDYS 19, MST 1 x Bhawani, YSMS 8163 x GPYS 892, YSMS 8163 x yellow Toria, YSMS 8163 x T 9 and MST 1 x Bele showed high *sca* effects for oil content.

Received for publication in October, 1997.

Table 1 : Analysis of variance for combining ability for eight characters in *Brassica campestris*

Source of variation	D.F.	Days to flowering	Days to maturity	No. of primary branches	No. of secondary branches	1000-seed weight (g)	No.of seeds/ Siliqua	Seed yield/ plant (g)	Oil content (%)
Replications	2	0.99	0.43	0.18	3.75	0.16	1.01	0.01	0.89
Crosses	39	47.96**	107.65**	8.80**	229.48**	0.39**	91.90**	3.51**	4.04**
Males (M)	19	42.42	131.18	6.90	199.58	0.45	66.08	2.51	4.62
Female (F)	1	173.38	2.95	30.72	2399.41	0.05	1008.17**	0.55	4.04
M X F	19	46.89**	89.11**	9.54**	145.17**	0.35**	69.50**	4.66**	3.67**
Error	78	1.57	4.32	0.73	1.80	0.04	0.80	0.08	0.19

** Significant at 1% probability level.

Comparison of *sca* effects in relation to gca effects of the respective parental lines indicated that crosses with high *sca* effects involved low x high, high x low and low x low general combiners. Crosses YSMS 8163 x YST 151, MST 1 xT 9 and MST 1 x yelllow Toria with high *sca* effects and high per se performance may give rise to high yielding hybrids by using genic male sterility.

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J. Oilseeds Res. 16(2) 1999 : 317-319
ISSN 0970-2776

SELECTION RESPONSE IN SEED YIELD THROUGH DIRECT AND INDIRECT SELECTION IN SUNFLOWER

Among oilseeds, sunflower is an important crop and its seeds (Achenes) contain 40-42 per cent high quality oil. Achene yield being a complex and low heritable trait; breeding of high yielding genotypes of sunflower is a difficult task. A prior information on the expected genetic gain in achene yield will be helpful in deciding the selection strategy for its genetic improvement. The present paper analyses the direct and indirect genetic gains that could be made in seed yield of sunflower.

Random samples of 32 male parents and 96 female parents were selected from the EC 68414 population of sunflower and mated in NC-1 design (Comstock and Robinson, 1948, 1952) to develop 96 full sib and 32 half-sib families. Field evaluation of the material was done during the spring season (February, 1994). The whole material was divided into eight sets and evaluated in the field design as suggested by Comstock and Robinson (1952). Each set of 12 progenies was assigned to a block and replicated twice within a block. Each replication within a set contained 12 plots. Each plot consisted of a single row of 3.0 metre length accommodating 10 plants. Data on 11 morpho-physiological characters were recorded on four randomly selected plants in each genotype in each replication. Statistical analysis was done according to Comstock and Robinson (1952). Direct and indirect genetic gains were calculated following Falconer and Mackay (1996).

The highest direct genetic gain (40.75%) was observed for biological yield per plant followed by seed yield per plant, number of seeds per head, stem diameter, plant height, head diameter, days to 50 per cent flowering, percentage of filled seeds, number of leaves per plant and days to maturity in a descending order (Table 1). High genetic advance in sunflower had been reported for plant height (Dilruba Begum *et al.*, 1988), seed yield per plant (Singh and Yadav, 1986; Alam *et al.*, 1987 and Dilruba Begum *et al.*, 1988), number of seeds per head and percentage of filled seeds (Reddy and Reddy, 1979). In general, our results agree with these workers. Nevertheless several workers have observed low genetic advance for head diameter and plant height (Muhammed Tariq *et al.*, 1992) and high genetic advance for 100-seed weight (Singh and Yadav, 1986). In the present study, narrow sense heritability (h^2n) and additive genetic correlation were used to estimate direct and indirect genetic responses respectively. These parameters were derived using the genetic components of variance and co-variances estimated through NC-1 design (Kumar *et al.* 1997). Analogous to additive genetic variance ($\sigma^2 A$) which is a variance in breeding value; the additive genetic correlation is based on covariance between breeding values (σA_{xy}) of two characters (X and Y). Evidently, it is the narrow sense heritability and additive genetic correlation which gives the useful estimates of genetic response in direct and indirect selection.

The results indicated that a substantial genetic improvement through direct selection could be expected for most of the characters in EC-68414 population of sunflower. The highest positive expected correlated response in seed yield per plant (34.99%) was observed through selection on days to 50 per cent flowering. Other characters which contributed high correlated response to seed yield per plant were biological yield per plant followed by number of seeds per head, stem diameter, plant height, days to maturity, head diameter, number of leaves per plant and percentage of filled seeds in descending order. Correlated response is the expected change in the magnitude of the character under question as a result of se-

Received for publication in January, 1998

Table 1 : Estimates of direct genetic gain and correlated response (per cent of mean) in 11 morpho-physiological characters through themselves in sunflower population

Character	Correlated response in										
	Days to 50% flowering	Days to maturity	Stem diameter (cm)	Head diameter (cm)	No. of leaves/ plant	Plant height (cm)	Bilogical yield/plant (g)	Seed yield/ plant (g)	Husk content (%)	No. of seeds/ head	%age of filled seeds
Days of 50% flowering	**8.81**	6.03	23.62	21.49	12.32	12.16	47.39	34.99	-0.09	34.20	11.66
Days to maturity	5.46	**3.34**	1024	10.37	12.15	8.77	24.02	19.57	2.54	19.23	8.52
Stem diameter (cm)	6.27	3.04	**18.11**	15.03	6.97	3.46	28.23	**28.58**	-1.22	28.19	7.48
Head diameter (cm)	6.55	3.50	17.32	**12.21**	5.06	2.46	25.53	**19.52**	1.19	31.82	5.80
No. of leaves/ plant	4.01	4.35	8.66	5.36	**5.39**	5.96	21.33	16.20	-3.00	11.52	5.44
Plant height (cm)	5.14	4.08	**5.11**	3.40	7.76	**12.86**	26.94	22.42	0.31	23.74	4.10
Bilogical yield/plant (g)	7.95	4.44	17.22	14.00	10.99	10.70	**40.75**	31.47	2.00	40.38	6.79
Seed yield/ plant (g)	7.95	4.91	19.29	14.52	11.32	12.07	42.68	**32.12**	1.00	38.01	7.53
Husk content (%)	-0.03	1.27	1.97	1.73	-4.19	0.34	5.36	2.01	**2.07**	-7.82	-2.46
No. of seeds/ head	5.58	3.46	17.32	16.99	5.77	9.17	39.30	27.29	**-2.82**	**20.68**	**0.63**
Percentage of filled seeds	4.95	4.00	11.81	8.06	7.13	4.13	17.19	14.06	**-2.32**	**1.64**	**8.71**

Bold figures on diagonal are direct genetic gain.

lection on other related characters. It is a function of additive genetic correlation between the traits, selection intensity of the correlated traits, narrow sense heritability of both the traits and the phenotypic standard deviation of the trait. In mathematical form correlated response in characters $Y(CRy)=i_x h_x h_y r_g \sigma P_y$. Depending upon these parameters, the traits differed in their correlated response.

From the above discussion it appears that seed yield and its components in EC-68414population of sunflower may be genetically improved effectively through indirect selection based on days to 50 per cent flowering. However, the optimum number of days for 50 percent flowering should be ascertained through construction of multiple trait selection indices.

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J. Oilseeds Res. 16(2) 1999 : 320-322
ISSN 0970-2776

ESTIMATES OF GENETIC VARIABILITY IN INTERMATED PROGENIES OF SESAME

Wide variability is the cornerstone of successful varietal improvement programme. To develop improved varieties, most breeders have used the pedigree method of selection following hybridization. Such methods when adopted for autogamous crops, the genes controlling desirable traits are rapidly fixed in homozygous state. The genes controlling different traits are gnerally dispersed in different genotypes having linkages with desirable and undesirable attributes also. Intercrossing of F2 segregants provides chances of finding superior recombinants in F3 or later generations by breaking linkages. The investigation was undertaken to study the extent of variability created through intermating in the F2 generation of sesame.

F2 seeds of the cross combinations TMV 6x CO1 and TMV 3X CO1 and their parents involved were raised during *Kharif,* 1996 at the Oilseeds Breeding Station, Tamilnadu Agricultural University. Two hundred plants were maintained in each cross combination. Forty plants were chosen at random and intermating was done using twenty of them as male parents and the remaining as female parents. The female parents involved in the intermating were also selfed to get F3 progenies. The selfed and intermated progenies were raised in rows of 3 m length with a spacing of 30 x 15cm during the next season in a randomised block design with three replications. Observations were recorded for nine quantitative traits on ten random plants in each of the twenty intermated progenies and selfed progenies. Phenotypic coefficient of variation, genotypic coefficient of variation (Burton, 1952), heritability (Lush, 1940) and genetic advance (Johnson *et al.*, 1955) as percentage of mean were estimated.

The mean and the genetic parameters in F3 and intermated progenies are given in table 1. The comparision of mean of different characters of the F3 and the intermated progenies revealed that intermated progenies exhibited superior mean performance over the selfed (F3) progenies for all the traits in both the cross combinations. Joshi (1979) opined that intermating of F2 population was found to increase population mean in the progenies. This is of immense value to the plant breeder as population means go on decreasing progressively from F2 generation onwards. Superior mean performance of the intermated progenies over the selfed progenies would generally be expected when a major portion of the total genetic variance is additive and additive x additive type (Singh and Dwivedi, 1978). Thus increased mean values of the intermated progenies over selfed progenies in the present study favour the presence of additive gene action. In sesame, many workers (Chandramony and Nayar, 1988; Ibrahim *et al.*, 1983; Dharmalingam and Ramanathan,1993) have observed the predominance of additive gene action for many characters.

Further, the intermated progenies generated higher *GCV* than the selfed progenies in this study. This substantiated the fact that increase in genetic variability not available in F3 generation was released in the intermated progenies as a result of intermating. Gill *et al.* (1973) pointed out that intercrossing in segregating generations generated more variability. Increase in genetic variance is expected in those crosses with a preponderance of repulsion phase linkages. (Gardner, 1963; Singh and Murthy, 1973).

A comparison of heritability estimates between the F2s and intermated progenies revealed that heritability estimates were high in the intermated progenies. The high heritability may

Received for publication in December, 1998

Table 1 : *Mean* and the genetic parameters for F3 and intermated progenies

Characters	Generation	Mean		GCV%		PCV%		Heritability %		GA as % of mean	
		TMV6X CO1	TMV3X CO1	TMV6X CO1	TMV3X CO1	TMV6X CO1	TMV3X CO1	TMV6X CO1	TMV3X CO1	TMV6X CO1	TMV3X CO1
Plant height	F3	81.64cm	86.40cm	7.80	8.59	11.66	11.58	44.78	55.03	10.76	13.13
	IP	87.52	89.12	8.47	11.08	11.70	13.40	52.32	68.42	12.62	18.88
Primary	F3	3.40	3.28	16.78	20.55	29.99	25.69	75.96	64.01	46.93	33.87
branch No.	IP	4.04	3.36	28.58	43.65	31.14	46.17	84.21	89.38	54.02	85.01
Capsule No.	F3	23.44	24.20	26.37	27.45	35.07	33.21	56.54	68.31	40.85	46.73
per plant	IP	33.84	25.72	36.85	41.82	40.18	45.40	84.11	84.97	69.62	79.42
Seed No.	F3	43.56	52.88	11.97	7.73	12.59	8.97	90.34	74.28	23.43	13.72
per capsule	IP	48.12	52.94	14.16	9.91	14.60	10.90	94.11	82.62	28.30	18.55
1000 Seed	F3	2.10g	2.00g	10.38	7.57	16.44	11.91	39.85	40.56	13.50	9.95
weight	IP	2.14g	2.46g	14.20	17.17	18.93	18.72	56.28	84.12	21.94	32.45
Oil content	F3	45.14%	45.52%	7.35	5.44	8.42	6.22	76.13	76.52	13.21	9.80
	IP	48.93%	48.48%	11.64	11.96	12.24	12.29	90.39	94.70	22.79	23.98
TDMP	F3	39.49g	40.72g	24.69	15.00	28.32	18.89	76.01	63.04	44.35	24.53
	IP	40.01g	41.24g	25.01	44.13	28.51	45.56	76.95	93.80	45.19	88.04
Harvest	F3	7.49%	7.92%	34.36	15.25	39.09	21.90	77.25	48.47	62.21	21.87
Index	IP	9.98%	8.10%	37.57	38.47	40.09	41.43	87.82	86.24	75.53	73.60
Single	F3	3.00g	3.14g	41.60	30.39	47.25	32.79	77.53	85.90	75.46	58.02
Plant Yield	IP	3.96g	3.40g	49.38	45.75	54.90	47.14	80.89	94.18	91.49	91.45

IP - Intermated Progenies, TDMP - Total Dry Matter Production.

be attributed to the presence of additive genes. High heritability coupled with high genetic advance was recorded by the intermated progenies for all characters except plant height (in cross 1 and 2), seed number per capsule (cross 2) and 1000 seed weight (cross 1). Those traits with high heritability and high genetic advance have a higher selection value and the variations in them can be attributed to a high degree of additive gene effects.

Due to the superior mean performance, higher *GCV* and heritability coupled with high genetic advance the intermated progenies may be considered suitable for selection of superior plants compared to F3 generation.

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J. Oilseeds Res. 16(2) 1999 : 323-326
ISSN 0970-2776

CORRELATION AND PATH ANALYSIS IN CERTAIN METRIC TRAITS IN SAFFLOWER

Safflower (*Carthamus tinctorius* L.) is mainly grown as a rainfed crop in *rabi* season on residual soil moisture resulting in poor producitvity (400-500 kg/ha.). In order to increase the yield potential of safflower an understanding of relative importance of yield contributing characters and relationship among these traits is important for fast genetic gain. Besides, a knowledge of the direct contribution of different traits to seed yield is useful for formulating selection criteria in breeding programme. Comparative analysis of these parameters under dryland and irrigated conditions is useful for assessing the performance of the selections. Therefore, the present study on correlation and path coefficient analysis of yield in 32 genotypes (30 selections +2 checks) was undertaken.

Thirty diverse selections derived from crosses of male sterile lines with varieties alongwith two checks were used for conducting experiment. The fertile selections were stabilised for different characters. These genotypes were planted in two replications on October 9, 1996 in 3 rows of 3m length, 45 cm apart under rainfed and irrigated conditions. The means were utilised to estimate the correlation coefficient and path analysis (Dewey and Lu, 1959).

The phenotypic and genotypic correlaion coefficients between yield and eight related metric traits as well as correlation among themselves were studied. As there were no major deviations between phenotypic and genotypic correlation coefficients or paths, the results are presented at phenotypic level only (Table 1)

The plant height, number of secondary branches, number of capsules per plant, number of seeds per capsule and test weight possessed significant and positive correlation with seed yield under rainfed as well as irrigated condition except test weight which was positively and significanlty correlated with yield under rainfed condition only. These results are in agreement with earlier findings of Makne *et al.* (1985).

Inter character correlation at phenotypic level showed that days to 50% flowering recorded positive and significant correlation with number of primary branches, number of capsules per plant under irrigated conditions, where as its inter character correlation with days to maturity was significant at both the conditions. The plant height recorded significant and possitive correlation with number of seeds per capsule under both the conditions, where as it has recorded positive correlation with number of capsules under rainfed condition only.

The number of primary branches showed positive and significant correlation under both conditions with number of secondary branches and number of capsules per plant. The number of secondary branches showed significant and positive correlation with number of capsules per plant. Similar findings for these traits were reported by Lakha *et al.* (1989). Thus plant height, number of secondary branches, number of capsules per plant and number seeds could be useful traits as selection criteria for improving seed yield in safflower.

Correlation coefficient do not quantify the relative contribution of the causal effect to the ultimate entity yield. Path coefficient analysis on the other hand permits the separation of direct effect from indirect effect. The present study (Table 2) revealed that plant height, number of secondary branches, number of capsules and number of seeds per capsule are the most important characters because they have the highest positive direct

Received for publication in December, 1998

Table 1.Phenotypic correlation of yield with other yield components in safflower under irrigated and rainfed condition.

Character	Environment	Days to 50% flowering	Days to maturity	Plant height	Number of primary	Number of secondary	Number of capsules/pl.	Number of seeds per/cap.	Test weight	Seed yield/ plant
1.Days to 50%	I	1.000	0.347*	-0.093	0.414*	0.329	0 434*	-0.467**	0.272	-0.112
flowering	R	1.000	0.400*	-0.252	0.233	0.101	0.267	-0.514**	0.118	-0.229
2. Days to	I		1.000	0.213	0.201	0.122	0.130	0.332	0.153	0.087
maturity	R		1.000	0.207	0.105	0.142	0.142	0.084	0.217	0.111
3. *Plant height*	I			*1.000*	*0.064*	*0.297*	*0.383**	0.485**	0.140	0.469**
	R			1.000	0 093	0.271	0.370*	0.319	0.228	0.556**
4. Number of	I				1.000	0.697**	0.713**	-0.153	0.244	0.163
primary branches	R				1.000	0.605**	0.727**	-0.399*	0.216	0.152
5. Number of seco-	I					1.000	0.881**	-0.050	0.212	0.420*
ndary branches	R					1.000	0.814**	-0.134	0.113	0.436**
6. Number of cap-	I						1.000	-0.324	0.191	0.371*
sules per plant	R						1.000	-0.084	0.332	0.400*
7. Number of seeds	I							1.000	-0.059	0.398*
per capsule	R							1.000	-0.023	0.431*
8. Test weight	I								1.000	0.188
	R								1.000	0.356*

* and ** siquificant at 5 and 1 % level, respectively; I-irrigated, R-rainfed.

Table 2. Direct and Indirect effects (Phenotypic) of yield components on yield of safflower under irrigated and rainfed condition.

Character	Environment	Days to 50% flowering	Days to maturity	Plant height	Number of primary branches	Number of secondary branches	Number of capsules/ plant	Number of seeds/ capsule	Test weight	Phenotypic Corr. with Yield
1.Days to 50% flowering	I	-0.032	-0.037	-0.010	-0.050	0.012	0.168	-0.192	0.030	-0.111
	R	-0.023	-0.039	-0.105	-0.023	0.030	0.058	-0.163	0.035	-0.230
2. Days to maturity	I	-0.010	-0.118	0.024	-0.027	0.044	0.020	0.136	0.017	0.087
	R	-0.009	-0.098	0.045	-0.005	0.042	0.036	0.034	0.065	0.110
3. Plant height	I	0 003	0.200	0.115	-0.008	0.108	0.080	0.015	-0.025	0.468
	R	0 005	0.131	0.217	-0.009	0.081	0.080	0.070	-0.020	0.555
4. Number of primary branches	I	-0.013	-0.023	0.227	-0.837	0.501	0.312	-0.063	0.058	0.162
	R	-0.004	-0.006	0.220	-0.801	0.484	0.358	-0.164	0.065	0.152
5. Number of secondary branches	I	-0.010	-0.014	0.034	-0.095	0.365	0.138	-0.020	0.023	0.419
	R	-0.002	-0.013	0.056	-0.091	0.298	0.176	-0.055	0.036	0.435
6. Number of capsules per plant	I	-0.014	-0.015	0.044	-0.098	0.101	0.357	-0.034	0.028	0.370
	R	-0.006	-0.013	0.087	-0.073	0.233	0 247	-0.133	0.057	0.399
7. Number of seeds per capsule	I	0.015	-0.039	0.055	-0.045	0.018	-0.023	0.413	0.003	0.397
	R	0.012	-0.008	0.062	0.004	0.038	-0.070	0.412	-0.017	0.431
8. Test weight	I	-0.018	-0.028	0.016	-0.037	0.076	0.056	0.011	0.111	0.187
	R	-0.030	-0.041	0.048	-0.021	0.033	0.041	0.024	0.301	0.356

Residual factor : I - Irrigated condition = 0.485; R - Rainfed condition = 0.546

effects on seed yield. Patil *et al.* (1990) also reported similar results. The direct selection for characters having higher positive direct effect will enhance the breeding efficiency for good yield in Safflower.

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J. Oilseeds Res. 16(2) 1999 : 327-330
ISSN 0970-2776

EVALUATION OF SUITABLE INTERCROPS FOR INTERCROPPING WITH SESAME (*Sesamum indicum* L.)*

Sesame (*Sesamum indicum* L.) is a major edible oilseed crop with a productivity level of 360 kg per hectare (Anon.1994). The lower productivity of sesame is due to its cultivation on poor and marginal soils. Chandrasekaran *et al.*(1974) and Kondap *et al.* (1985) observed intercropping of legumes with sesame is advantageous and profitable. Sesame being a longer duration, deep rooted crop, fits well in intercropping systems as an inter crop or as base/main crop with compatible intercrops. Sesame grows slow in early stages of growth during which period the more rapidly growing intercrops can dominate and utilise the resources efficiently. Hence, there is a possibility of growing a compatible intercrop in sesame with diversity in growth habit and duration.

A field experiment was conducted during *kharif* 1990 at the Agricultural College Farm, Dharwad to identify suitable crops for intercropping in sesame. The soil of the experimental field was black clay with 7.5 pH, medium in available nitrogen (0.051%), phosphorus (0.002%) and potash (0.025%). The experiment was laidout in randomised block design with four replications and nine treatments. Recommended doses of fertilizers were applied to all treatment combinations on the basis of plant population. The varieties of sesame, groundnut, soybean, greengram and Frenchbean in the experiment were E-8, Dh-3-30, Monetta, Pusabaisaki and selection-9, respectively. All crops were sown on 28th June, 1990. The harvesting was done at 80 DAS in soybean, 103 DAS in sesame and 108 DAS in groundnut. Greengram was harvested in two pickings (61 and 68 DAS) and green pods of Frenchbean in four pickings (35,42,50 and 70 DAS). The yield was computed from the yield of net plot (3.6mx2.7m).

Seed yield of sesame obtained in different treatments differed considerably. Sole cropping of sesame gave significantly higher seed yield (7.7q/ha) than intercropping (6.4q/ha), mainly because of increased plant population per unit area (Table 1). In intercropping, the sesame yield was reduced because of replacement population of component crops. Similar findings were reported by Baskaran (1986). Sesame seed yield was significantly higher when intercropped with greengram (7.0q/ha) and Frenchbean (6.8q/ha) as compared with soybean (6.1q/ha) and groundnut (5.7q/ha). Complementary effect of greegram and Frenchbean on sesame may be attributed to the higher seed yield of sesame. Mahapatra *et al.* (1990) and Chandrasekaran *et al.* (1974) observed complementary effect of pigeonpea on sesame. Groundnut and soybean had depressing effect on the yield of sesame. Higher competitive ability of groundnut (Aron, 1972) and Soybean (Sadaphal *et al.*, 1980) have been observed.

Significantly higher Land Equivalent Ratio (LER) and system productivity Index (SPI) values were observed in intercropping of sesame with greengram (1.27 and 9.8 respectively) and Frenchbean (1.24 and 9.6, respectivley) than with groundnut (1.16 and 9.0, respectively) and soybean (1.07 and 8.3, respectively). Greengram, frenchbean and groundnut with sesame recorded higher Area Time Equivalent Ratios (1.15, 1.12 and 1.12, respectively). than with soybean (1.00). Similar differences in yield advantages were observed on the basis of LER and ATER by Allen and Obura (1983) in intercropping studies of corn with cowpea and soybean and SPI by Odo (1991) in intercropping of cowpea with short and tall sorghum. Willey (1979) opined that the advantages

* Part of the M.Sc. (Agri.) Thesis submitted by the Senior author to the University of Agricultural Sciences, Dharwad.

Received for publication in December, 1998

Table 1 : Seed yield of sesame, yield of intercrops, Land Equivalent Ratio (LER), Area Time Equivalent Ratio (ATER), System Productivity Index (SPI) and sesame equivalent yield as influenced by cropping system

Treatments	Seed yield of sesame (q/ha)	Yield of inter-crops (q/ha)	LER	ATER	SPI	Sesame equivalent yield (q/ha)
Sole sesame (30 x 10cm)	7.7	-	1.00	1.00	7.7	7.7
Sole groundnut (30 x 15 cm)	-	27.3	1.00	1.00	7.7	16.6
Sole soybean (30 x 10 cm)	-	14.2	1.00	1.00	7.7	8.1
Sole greengram (30 x 10 cm)	-	8.6	1.00	1.00	7.7	4.9
Sole frenchbean (30 x 15 cm)	-	55.6 (green pods)	1.00	1.00	7.7	12.9
Sesame + groundnut (3:1)	5.7	11.4	1.16	1.12	9.0	12.6
Sesame + Soybean (3:1)	6.1	4.0	1.07	1.00	8.3	8.4
Sesame + Greengram (3:1)	7.0	3.1	1.27	1.15	9.8	8.8
Sesame + Frenchbean (3:1)	6.8	19.6 (green pods)	1.24	1.12	9.6	11.3
S.E.±	0.21	-	0.03	0.03	0.2	0.4
L.S.D.(0.05)	0.6	-	0.07	0.08	0.3	1.0
Cropping systems						
Sole	7.7	26.4	1.00	1.00	7.7	7.7
Intercropped	6.4	9.5	1.18	1.10	9.2	10.3
S.Ed±	0.24	-	0.02	0.02	0.1	0.3
L.S.D (0.05)	0.5	-	0.04	0.04	0.2	0.7

occur where the difference between component crops is of time factor than of crop type.

Intercropping of sesame provided significantly higher sesame equivalent yield (10.3q/ha) than sole sesame (7.7 q/ha). Among the intercrops, groundnut produced higher sesame equivalent yield due to its higher yield and market price. Higher sesame equivalent yield was observed by Kondap *et al.* (1985) in sesame+ redgram and Gangwar and Kumar (1989) in sesame+blackgram intercropping systems.

Intercropping recorded higher gross and net income (Rs.16,120 and Rs.13,773 per ha, respectively) than sole sesame (Rs.12,361 and Rs.11,193 per ha, respectively) (Table 2). However, higher benefit: cost ratio was with sesame sole cropping (5.59) than intercropping (6.27) because of lower cost of cultivation.

In the present study, sesame+ greengram intercropping performed better on the basis of yield advantages. While Baskaran (1986) obtained higher gross and net income by intercropping sesame with greengram. Sesame+ groundnut gave higher gross and net income (Rs.19,574 and Rs.17,378 per ha, respectively) followed by Sesame+frenchbean (Rs.17,613 and Rs.15,628 per ha, respectively) and sesame + greengram (Rs.13,881 and Rs.12,576 per ha, respectively). Higher net income from sesame+groundnut intercropping system was mainly due to higher economic yield and market price of groundnut. Chandrasekaran *et al* (1974) and Muralibaskaran *et al.* (1991) observed higher gross and net income

Table 2 : Economic analysis of sesame based Intercropping systems

Treatments	Cost of culivation (Rs/ha)	Cross income (Rs/ha)	Net income (Rs/ha)	Benefit: cost ratio
Sole sesame (30 x 10cm)	1,167	12,361	11,193	9.59
Sole groundnut (30 x 15 cm)	3,876	25,130	21,253	5.48
Sole soybean (30 x 10 cm)	2,686	12,605	9,918	3.69
Sole greengram (30 x 10 cm)	1,970	7,723	5,752	2.92
Sole frenchbean (30 x 15 cm)	3,229	19,210	15,980	4.95
Sesame + groundnut (3:1)	2,195	19,574	17,378	7.92
Sesame + Soybean (3:1)	1,527	13,225	11,698	7.66
Sesame + Greengram (3:1)	1,305	13,881	12,576	9.64
Sesame + Frenchbean (3:1)	1,984	17,613	15,628	7.88
Cropping systems				
Sole	1,167	12,361	11,193	9.59
Intercropped	2,346	16,120	13,773	6.27

Economics based on selling rates of Sesame Rs. 1,400; Groundnut Rs. 850; Soybean Rs. 800; Greengram Rs. 800; and Frenchbean (green pods) Rs. 325 per quintal during 1990.

due to groundnut + sesame intercropping system. Among the intercropping treatments, higher benefit: cost ratio was observed with sesame+ greengram (9.64).

Among the intercrops tried with sesame, frenchbean (green pod) and greengram were found to be the best on the basis of yield and yield advantages. If we consider the economic return, groundnut, frenchbean and greengram were profitable intercrops with sesame.

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J. Oilseeds Res. 16(2) 1999 : 331-334
ISSN 0970-2776

IS THE DURATION OF SEED DORMANCY INFLUENCED BY WATER AVAILABILITY DURING REPRODUCTIVE GROWTH PERIOD IN SUNFLOWER?

Plants are exposed to many adverse environmental conditions during their growth and development. Among them, availability of soil water is the most common and vital factor which influences crop performance at all stages of growth. It has been reported in literature that seed dormancy is also affected by moisture stress in some crop species. For instance, in *Avena fatua*, seeds produced on water stressed plants exhibited shorter dormancy period (Sawney and Naylor, 1981; Naylor, 1983) while cotton embryos showed decreased germination when drought was imposed 30-40 days after anthesis (Vigil and Fang, 1990). Decreased soil moisture levels in wild oats has been shown to decrease the duration of dormancy (Sexsmith, 1969). The influence of moisture stress during flowering and seed filling on seed dormancy in sunflower has hardly been studied. It is in this context that a study was conducted with the objective of investigating the effect of moisture stress both during early reproductive stage as well as seed filling stage on the length of seed dormancy in five sunflower genotypes.

The experiment was conducted in the experimental farm of University of Agricultural Sciences, GKVK, Bangalore during 1990. Five sunflower genotypes viz., Morden, KBSH-1, BSH-1, MSFH-1 and EC 68415 were grown in split plot design with three replicatins each. Treatments included control (irrigation at regular intervals), early stress (irrigation withheld between 40 and 70 days after sowing (DAS) and late stress (irrigation withheld between 50 and 80 DAS). All other recommended package of practices were followed. On maturity, capitula were harvested and seeds threshed. Starting from the day of harvest, the germination (expressed as percentage) of the seeds was assessed at 5 day intervals by placing the seeds in petri plates lined with moistened filter paper. The germination test was withdrawn when 90-100% germination was attained. The mean number of days taken for germination was compared among treatments and varieties using ANOVA (for treatments and varieties) and Student's t-test (for treatments.) The frequency distribution of germination percentage (at 5 day intervals) between treatments was compared using Kolmogorov-Smirnov (KS) test (Siegel, 1956). The mean number of days taken for germination was calculated using the formula

$$\text{Mean} = \sum_{i=1}^{w} \frac{(n_i - n_{i-1})M}{n_w}$$

where n_i-number of seeds germinated in i^{th} week

n_{i-1}= number of seeds germinated in $(i-1)^{th}$ week

M= median (in days) of $(i-(i-1)^{th}$ duration

w= total number of weeks over which the germination was monitored

n= total number of seeds germinated at the end of w^{th} week

Moisture stress at early or late reproductive stages was effective in changing the frequency distribution pattern from that of control in Morden, KBSH-1, MSFH-1 and EC 68415, while in BSH-1 frequency distribution remained same in all the treatments. (Table 1). This indicates that number of seeds germinated at each observation day varied between treatments.

Mean days taken for germination varied significantly among genotypes (Table 2). It varied from 23.4 ± 2.14 (Morden in control treatment) to 41.70 ± 2.22 (MSFH-1 under late stress treat-

Received for publication in April, 1997.

Table 1 : Probability values for the differences in mean days taken for germination and for the frequency distribution of germination percentage as affected by moisture stress treatment.

Variety	Treatments compared	Probability Value	
		t value	Dmax value
Morden	C vs S_1	NS	NS
	C vs S_2	p<0.01	p<0.01
	S_1 vs S_2	p<0.01	p<0.01
KBSH-1	C vs S_1	NS	p<0.05
	C vs S_2	NS	NS
	S_1 vs S_2	NS	p<0.05
EC 68415	C vs S_1	p<0.05	p<0.5
	C vs S_2	NS	NS
	S_1 vs S_2	p<0.01	p<0.01
MSFH-1	C vs S_1	NS	NS
	C vs S_2	NS	p<0.01
	S_1 vs S_2	NS	p<0.01
BSH-1	C vs S_1	NS	NS
	C vs S_2	NS	NS
	S_1 vs S_2	NS	NS

C = Control, S1 = Early stress and S2 = Late stress

ment) days. Late stress in Morden and MSFH-1 and early stress in Morden and EC 68415 increased the mean days taken for germination while in other cultivars there was no significant difference between control and stress treatments. In other words, stress treatment postponed the days taken for germination in Morden (under both early and late stress.), EC 68415 (early stress), and MSFH-1 (late stress).

A number of reports indicate the influence of environmental conditions such as temperature (Sexsmith,1969; Heide *et al.* 1976; Sawney and Naylor, 1980; Jakahashi *et al.*,1987), moisture stress (Sawney and Naylor, 1981; Naylor, 1983; Vigil and Fang, 1990) and photoperiodic conditions (Kigel *et al.*, 1979; Jakahashi *et al.*, 1987) on the extent of seed dormancy. For instance, inwheat it has been shown that 15-20 days drying of whole plants during post anthesis period (before natural grain desiccation at 40 days post anthesis) doubled the duration of dormancy which was attributed to the damaging effects of drying (King, 1993). Thus, the conditions under which mother plant is growing during seed development significantly influences seed dormancy. Moisture stress during reproductive period has been shown to decrease the dormancy period in *Avena fatua* (Sawney and Naylor, 1980; Naylor, 1983) while in *Digitaria milanjana*, seeds from low rainfall area (relatively stressed) showed lower dormancy duration (Hacker, 1984 and 1988). Though this suggests species specific effect of moisture stress on seed dormancy,it is important to note that such conflicting results might also arise due to the differences imposed with respect to the degree of stress in other associated parameters such as temperature, light etc.

In the present study moisture stress (early

Table 2: Mean days taken for dormancy release as affected by moisture stress in sunflower.

Variety	Control	Early stress	Late stress	CD value
Morden	23.4 ± 2.14	26.8 ± 2.46	36.8 ± 2.80	3.98
KBSH-1	35.4 ± 1.96	34.9 ± 2.04	34.0 ± 1.32	NS
EC 68415	35.3 ± 2.29	43.1 ± 1.93	32.8 ± 1.97	4.46
BSH-1	24.8 ± 2.37	26.2 ± 2.62	22.2 ± 1.96	NS
MSFH-1	33.4 ± 2.57	35.4 ± 2.85	41.7 ± 2.22	NS
CD Value	3.21	3.64	4.06	

or late stress) increased the duration of dormancy in Morden, MSFH-1 and EC 68415. Interestingly, however, there was significant difference in the frequency distribution of timing of germination between all 3 pairs viz, control vs early stress,control vs late stress and early stress vs late stress for most of the genotypes. The effect of moisture stress in altering the duration of dormancy could be through several ways. Moisture stress might affect the allocation of dormancy inducing chemicals or it might alter the ability of the embryos to overcome the maternally imposed seed dormancy (Krishnamurthy, 1990).

Ravishankar (1990) reported that in sunflower the moisture stress at early reproductive stage increases the kernel to pericarp ratio (due to the reduction in pericarp thickness). It might be expected that under such conditions seeds exhibit lesser dormancy duration (as the concentraion of the dormancy inducing factor per unit weight of the kernel would be less compared to control plants.) However, results of our experiments do not support this prediction. Rather, dormancy release may depend on altered inhibitor-promoter ratio than on the pericarp thickness. The differences in the frequency distribution noticed between treatments may be due to changes in the promoter-inhibitor concentrations. It would be interesting to study this aspect in greater detail.

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J. Oilseeds Res. 16(2) 1999 : 335-336
ISSN 0970-2776

AGRONOMIC PRACTICES FOR YIELD IMPROVEMENT OF KHARIF GROUNDNUT IN WESTERN ORISSA

Cultivation of groundnut during both *kharif* and *rabi*/summer seasons is gaining popularity in Western Orissa, particularly in uplands in *kharif* and canal tail-end areas in *rabi*/summer. However, the groundnut productivity is low during *kharif* as compared to rabi/summer. Excessive vegetative growth during *kharif* is one of the major causes of low productivity. Since studies on agronomic management practices to reduce the vegetative growth and to improve the productivity of *kharif* groundnut is limited, the present study on effect of seven management practices on the yield of groundnut was taken up.

Field experiments were conducted at Regional Research Station, Chiplima, Orissa during *kharif* of 1995 and 1996. The soil of the experimental site was sandy loam in texture, slightly acidic in reaction (pH 6.2) with available N, P and K contents of 240, 16 and 172 kg/ha, respectively. The experiment was carried out in RBD replicated thrice. The treatments comprisied : T_1 = Recommended fertilizer (20:40:40kg/ha N, P_2O_5, K_2O), $T_2 = T_1$+ 20 kg P_2O_5/ha, $T_3 = T_1$+ drum rolling at 55 DAS, $T_4 = T_1$+ topping at 55 DAS, $T_5 = T_1$ + removal of branches leaving 3 branches at 70 DAS, $T_6 = T_1$+ MH spray 250 ppm at 42 DAS and $T_7 = T_1$+CCC spray @ 3000 ppm at 42 DAS.

Groundnut variety 'OG 52-1' (Smruti) was sown in lines at 30 cmx10cm spacing during 1st week of July. Nitrogen, P_2O_5 and K_2O fertilizers were applied as basal in the form of urea, SSP and MOP, respectively. One hand weeding was done at 25 days after sowing.

Pod yield of groundnut with recommended fertilizer dose was 1644 kg/ha (Table 1). Additional application of 20kg P_2O_5/ha increased the pod yield by 13.4 % over recommended dose. This observation was in agreement with the findings of Nayak *et al.*, (1989), Patra *et al.* (1995) and Raghavaiah *et al.* (1995). Drum rolling, topping at 55 days after sowing (DAS) and removal of branches at 70 DAS were not beneficial in improving yield of *kharif* groundnut. These practices, on the other hand, depressed yield by 8.8, 12.0 and 23.7%, respectively. These practices reduced the photosynthetic area and thus adversely affected the pod filling. Spraying MH@250 ppm at 42 DAS increased yield by 14.4%. However, spraying CCC@3000 ppm did not exhibit significant beneficial effect on pod yield.

Similar response was also observed in respect of kernel yield. Higher level of phosphate and spray of MH@250 ppm at 42 DAS increased kernel yield by 13.6 and 13.9% respectively, while drum rolling and topping at 55 DAS and removal of branches at 70 DAS decresead kernel yield by 9.1, 12.4 and 23.6%, respectively. Application of higher level of phosphorus and spray of growth retardant (MH) increased the number of pods per plant and pod weight per plant, but number of kernels per pod and shelling percentage remained unaffected.

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Received for publication in July, 1998

Table 1 : Effect of management practices on yield components and yield of kharif groundnut (pooled data of 1995 and 1996)

Treat. ment	Pods/ Plant	Pod weight/ plant (g)	Kernels/ pod	100 kernel weight (g)	Shelling %	Pod yield (kg/ha)			Kernel yield (kg/ha)		
						1995	1996	Mean	1995	1996	Mean
T1	10.4	9.0	1.82	36.7	70.7	1767	1520	1644	1248	1076	1162
T2	12.7	10.0	1.78	37.3	70.8	1998	1732	1865	1409	1236	1320
T3	9.0	7.5	1.78	**37.1**	**70.3**	**1584**	1417	1500	1114	998	1056
T4	8.9	6.9	1.84	36.2	70.4	1517	1376	1447	1071	966	1018
T5	8.6	7.0	1.79	35.6	70.4	1200	1308	1254	850	916	**888**
T6	12.3	10.2	1.80	36.7	70.5	2004	1756	1880	1409	1240	1324
T7	11.3	9.1	1.78	36.8	70.8	1968	1560	1764	1397	1100	1249
S.Em±	0.27	0.24	0.03	0.67	0.55	69	61	46	44	48	**43**
CD(0.05)	0.80	0.71	NS	NS	NS	204	180	145	130	142	127

J. Oilseeds Res. 16(2) 1999 : 337-339
ISSN 0970-2776

INFLUENCE OF INTEGRATED SUPPLY OF NITROGEN THROUGH ORGANIC AND INORGANIC SOURCES ON GROWTH, NUTRIENT UPTAKE AND YIELD OF SOYBEAN

Low and inconsistent yields of soybean in Andhra Pradesh are attributed to various factors. Among the production factors, nutrient availability has been shown to play vital role in boosting soybean productivity (Mishra *et al.*1990). It is well documented that conjunctive use of organic and inorganic fertilizers boost crop yields and also maintain soil health on a long term basis (Dhar,1962). Hence an experiment was conducted to study the influence of both organic and inorganic fertilizers on growth, yield and nutrient uptake in soybean.

A field experiment was conducted at Agricultural College Farm, Baptla during *rabi* 1995-96. The soil of the experimental site was sandy loam with low available N (188.2 kg/ha), medium available P_2O_5 (23.4kg/ha) and K_2O(453.8 kg/ha) having pH 7.2. There were three organic sources (FYM, biogas slurry and vermicompost) each at three levels (5,10 and 15t/ha) in conjunction with 50 kg N/ha as urea. Besides these 9 treatments, two treatments with 50 and 100 kg N/ha as urea and one without nitrogen were also included. Twelve treatment combinations were laid out in a randomized block design with factorial concept and replicated four items. The seeds were sown at a spacing of 30 x 10cm in a previous year soybean sown field. Organic manuers were applied as basal along with a uniform dose of 60 kg P_2O_5/ ha and 40 kg K_2O/ha as single super phosphate and muriate of potash, respectively. Urea was applied as per treatments in two splits, half as basal and remaining half at 30 DAS. The uptake of NPK was estimated by following standard procedures (Piper, 1966).

With every increase in the rate of application of organic manuers leaf area index and dry matter production increased significantly over its lower level. The higher rate of manure application significantly enhanced the NPK uptake by seed and haulms and seed yield over its lower rate. This is in agreement with findings of Nimje and Jagdish seth (1987) who reported increased uptake of NPK, dry matter and seed yield at higher rates of FYM application. Biogas slurry at 15t/ ha+50Kg N/ha as urea gave significantly higher seed yield with higher uptake of NPK in seed and haulms than other sources at corresponding level. Such increased response to the highest level of organic source plus 50 Kg N as urea is due to low available status of nitrogen in the soil.

Different organic sources did not vary significantly in dry matter, nutrient uptake and seed yield except LAI. Vermicompost at 15t/ha recorded significantly higher LAI than biogas slurry and FYM, while at 10 and 5t/ha levels no such differences between sources were observed.

The interaction between sources and rates of organic manuers was significant with regard to dry matter. The biogas slurry at 5t/ha recorded significantly higher dry matter than FYM and vermicompost. While vermicompost at10t/ha level was superior to other sources and no significant differences in the dry matter due to sources at 15t/ha level were observed.

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Received for publication in July, 1998

Table 1 : LAI, dry matter production, nutrient uptake and seed yield of soybean as affected by organic and inorganic source of nutrient

Treatments	Leaf Area Index (60 DAS)	Dry Matter (g/m2) at harvest	N uptake(kg/ha)		P uptake(kg/ha)		K uptake(kg/ha)		Seed yield (kg/ha)
			Seed	Haulm	Seed	Haulm	Seed	Haulm	
FYM@5t/ha + 50 kg N as urea	1.85	271.9	48.4	10.7	2.8	5.2	2.9	8.6	782
FYM@10t/ha + 50 kg N as urea	2.98	377.4	57.8	15.0	3.7	6.7	3.7	11.0	893
FYM@15t/ha + 50 kg N as urea	3.93	436.3	67.7	22.1	4.6	8.0	5.2	13.5	1019
BGS@5t/ha + 50 kg N as urea	1.98	469.3	51.6	12.5	3.4	6.6	2.7	9.7	805
BGS@10t/ha + 50 kg N as urea	2.88	379.2	65.5	20.3	4.6	8.4	4.6	13.1	1015
BGS@15t/ha + 50 kg N as urea	3.84	437.7	83.7	28.9	5.5	8.8	6.1	15.6	1217
VC@5t/ha + 50 kg N as urea	2.06	318.5	49.4	11.9	3.1	5.2	2.9	9.3	787
VC@10t/ha + 50 kg N as urea	2.99	416.4	58.3	18.5	3.9	6.9	4.4	12.1	906
VC@15t/ha + 50 kg N as urea	4.26	435.6	76.4	24.7	4.8	8.1	6.1	15.1	1143
100kg N/ha as urea	2.99	382.5	60.2	21.6	3.0	5.3	4.2	10.3	904
50kg N/ha as urea	1.41	296.3	20.4	10.4	1.4	2.4	2.0	6.0	494
No nitrogen	0.72	186.8	10.2	6.4	0.9	1.7	1.7	3.0	297
CD (p=0.05)	0.28	63.1	5.4	2.3	0.3	0.6	0.6	0.9	129
Sources of Manures									
Farm Yard Manure (FYM)	2.92	361.9	58.0	15.9	3.7	6.6	3.9	11.0	897
Biogar Slurry (BGS)	2.90	428.7	66.9	18.4	4.5	7.9	4.5	12.8	1013
Verni Compost (VC)	3.12	390.2	61.4	20.3	3.9	6.7	4.5	12.2	945
CD(p=0.05)	0.18	NS	NS	NS	NS	NS	NS	NS	NS
Rates of Manures									
5t + 50kg N/ha as urea	1.96	353.3	49.8	11.7	3.1	5.7	2.8	9.2	792
10t + 50kg N/ha as urea	2.95	391.0	60.5	18.0	4.1	7.3	4.2	12.1	938
15t + 50kg N/ha as urea	4.01	436.6	75.9	25.2	5.0	8.3	5.8	14.7	1127
CD(p=0.05)	0.18	29.2	9.8	5.8	0.7	1.1	0.7	2.2	126
Sorces X Rates CD(p=0.05)	NS	35.2	NS	NS	NS	NS	NS	NS	NS

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J. Oilseeds Res. 16(2) 1999 : 340-342
ISSN 0970-2776

INFLUENCE OF IRRIGATION SCHEDULES ON GROWTH AND YIELD OF SUMMER SESAME

The South-eastern part of Madhya Pradesh "Chhattisgarh region", is richly endowed with abundant rainfall (1250 mm), optimum solar radiation, favourable temperature, relatively well distributed soils ranging from entisols to vertisols and has surplus man power for year round crop production. About 20 percent of the area in Chhattisgarh is irrigated. The irrigation is mainly through canal (8.31 lakh hectares) and is protective in nature. The irrigation water is supplied from September onwards to protect the crop against drought. The irrigated area under tanks, tube wells and wells is 0.89, 0.30 and 0.61 lakh hectares, respectively. In spite of this, the region lags behind in crop productivity. During post monsoon season about 80 percent area is covered under "Relay" or "Utera" system by growing low potential (0.5 to 1.5 q/ha) crops like *Lathyrus* and linseed. Therefore, there is a need to develop suitable agrotechniques for growing summer crop wherever irrigation facilities exist. The review of earlier literature reveals that very meagre work has been done to explore the possibilities of growing successful sesame in summer season. More specifically not much attention has been paid to water management of sesame. The present study was, therefore, carried out in summer 1997, to find out the best schedule of irrigation for sesame at Raipur.

Field experiment was conducted on sandy loam soil in a randomized block design with three replications during summer 1997 at Instructional Farm of Indira Gandhi Agriculture University, Raipur. The treatments consisted of twelve irrigation schedules viz., IW/CPE of 0.3 (2 irrigations at 47 and 71 DAS), 0.5 (4 irrigations at 22, 51, 65 and 78 DAS), 0.7 (6 irrigations at 16, 30, 53, 63, 74 and 82 DAS), 0.3+0.5 (4 irrigations at 47, 61, 75 and 85 DAS), 0.3+0.7 (5 irrigations at47, 57, 67, 76 and 85 DAs), 0.5+0.3 (3 irrigations at 22, 61 and 83 DAS), 0.5+0.7(6 irrigations at 22, 47, 57, 67, 76 and 83 DAS), 0.7+0.3 (3 irrigations at 16, 57 and 79 DAS), 0.7+0.5 (5 irrigations at 16,47,61, 75 and 85 DAS), 3 irrigations (35,48 and 64 DAS), 4 irrigations (20,35,48 and 64 DAS) and 5 irrigations (20,35, 48, 64 and 76 DAS). The two values of IW/CPE together indicate that the Ist value was considered for first irrigation and 2nd value was considered for second and onward irrigations. The field capacity, permanent wilting point and water holding capacity of the soil were 32.3, 7.9 and 24.4 cm, respectively. Sesame variety "TKG-21" with a seedrate of 5 kg/ha was sown on February 26, 1997 with a row spacing of 30 cm. Harvesting was done on May 26, 1997. A rainfall of 89.6mm was received during the crop growth period.

Seed and stalk yields of sesame were significantly affected by different irrigation schedules (Table 1). The highest seed and stalk yields were recorded under 0.5+0.7 IW/CPE ratio (6 irrigations at 22,47, 57, 67, 76 and 83 DAS) being at par with 0.7 IW/CPE rato (6 irrigations applied at 16,30,53,63, 74 and 82 DAS) and 5 irrigations at 20, 35, 48, 64 and 76 DAS. These treatments were significantly superior to other irrigation schedules except 4 irrigations at 20,35, 48 and 64 DAS which was at par with 5 irrigations at 20, 35, 48, 64 and 76 DAS. The average increase in seed yield due to irrigation schedulted at 0.5+0.7, 0.7 IW/CPE ratios and 5 irrigations at 20, 35, 48, 64 and 76 DAS was 84.6, 71.4 and 69.2 per cent, respectively over 0.5+0.3 IW/CPE ratio. Similarly, highest yield contributing characters such as number of capsules/plant, seeds/capsule and thousand seed weight were recorded under 0.5+0.7 IW/CPE ratio but at par with 5 irrigations at 20, 35, 48, 64 and 76 DAS and 0.7 IW/CPE ratio.

Received for publication in July, 1998

Table 1. Effect of irrigation schedules on growth, yield attributes and yield of summer sesame

Irrigation schedule	Number of irrigations	Plant height (cm)	No. of branches/ plant	Dry matter accumu-lation (g/plant)	No.of capsules/ plant	Number of seeds/ capsule	1000-seed weight (g)	seed yield (q/ha)	Stalk yield (q/ha)	Harvest Index (%)
I_1:0.3 IW:CPE ratio	2	76.90	3.06	18.13	44.26	69.34	2.62	11.7	23.7	33.02
I_2 : 0.5 IW:CPE ratio	4	82.92	3.11	20.03	50.60	70.60	2.76	12.6	27.9	**31.18**
I_3 : 0.7 IW:CPE ratio	6	85.98	3.56	24.95	58.33	72.40	3.09	15.6	33.7	**31.60**
I_4:0.3+0.5 IW:CPE ratio	4	79.80	2.80	20.57	48.40	70.33	2.93	12.7	24.5	**34.52**
I_5: 0.3+0.5 IW:CPE ratio	5	80.02	3.06	20.25	54.06	70.67	2.95	13.4	25.0	**34.95**
I_6: 0.5+0.3 IW:CPE ratio	3	82.86	3.10	22.72	41.00	66.67	2.79	9.1	26.3	**25.59**
I_7: 0.5+0.7 IW:CPE ratio	6	84.60	3.65	26.22	59.20	72.60	3.14	16.8	35.7	**32.05**
I_8: 0.7+0.3 IW:CPE ratio	3	82.65	3.16	21.58	42.47	68.60	2.72	10.4	26.6	**28.04**
I_9: 0.7+0.5 IW:CPE ratio	5	83.79	3.00	23.22	47.73	70.00	2.92	13.6	31.1	**30.47**
I_{10}: 3 Irrigations (35,48 & 64 DAS)	3	81.49	3.26	19.82	49.00	70.47	2.87	13.3	26.7	**33.27**
I_{11}: 4 Irrigations (20,35,48 & 64 DAS)	4	83.40	3.23	24.83	56.86	71.06	3.00	14.1	30.8	**31.44**
I_{12}: 5 Irrigations (20,35, 48, 64 & 76 DAS)	5	84.81	3.60	25.84	58.86	72.46	3.07	15.4	**34.1**	31.12
SEm ±		1.02	0.03	0.939	1.17	0.68	0.04	0.547	1.26	**1.44**
CD (P=0.05)		2.98	0.09	2.754	3.42	1.99	0.11	1.600	3.68	4.22

Note : One common irrigation was given just after sowing for proper germination.

Irrigation influenced the growth parameters like plant height, branches and dry matter accumulation. Maximum plant height was recorded in 6 irrigations (0.7 and 0.5+0.7 IW/CPE ratios) but number of irrigations were of least importance than time of application. Plant height in 4 irrigations at 20, 35, 48 and 64 DAS) and 6 irrigations (0.7 and 0.5+0.7 IW/CPE ratios) were found statistically similar. Dry matter accumulation followed the pattern of plant height. Scheduling irrigation at proper time is more important than its frequencey. Vegetative,flowering and capsule formation are the critical stages in sesame (Ghosh and Biswas, 1984 and Majumdar and Roy, 1992). Withholding irrigation at this stage resulted in water stress in the plants which adversely affected physiological and morphological processes (Slatyer, 1970 and Hsiao, 1973).

The results of the present investigation indicated that among irrigation schedules, IW/CPE ratio of 0.5+0.7 (6 irrigations at 22, 47, 57, 67, 76 and 83 DAS) produced maximum yield (16.8q/ha) of sesamum. It is interesting to note that irrigation requirement can be reduced by applying 5 irrigations at 20, 35, 48, 64 and 76 DAS to get optimum yield (15.4 q/ha) and can be further reduced by applying 4 irrigations at 20,35, 48 and 64 DAS to get an attractive yield (14.1 q/ha). This investigation also revealed that water stress should be avoided during vegetative, flowering and capsule formation stages in order to achieve better production of sesamum.

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J. Oilseeds Res. 16(2) 1999 : 343-345
ISSN 0970-2776

EFFECT OF SOURCES AND LEVELS OF SULPHUR ON CHLOROPHYLL, PROTEIN AND OIL OUTPUT IN SOYBEAN (*Glycine max*. L. Merrill)

In plants, sulphur is required for the formation of chlorophyll, amino acids (cysteine, systine and methionine) and glucosides or glucosinolates which are involved in photosynthesis, protein synthesis and oil formation, respectively. Though S is not a constituent of chlorophyll, chlorosis of S-deficient plants has been attributed to impairment of photosynthesis by an indirect effect on protein level and chlorophyll content of chloroplast (Ulrich and Hylton, 1968). Being a constituent of protein, S application helps in its formation in seeds. In general, oil accumulation rapidly starts in developing soybean seeds immediately after completion of protein accumulation (Agarwal and Vyas, 1974). The application of S influences plant growth by enhancing photosynthetic ability and also improves the quality of produce in terms of protein and oil contents in seeds. The carriers used for supplementation of S are likely to show variable impact on improvement of chlorophyll, protein and oil content. Hence a study was undertaken to assess the effect of S levels and carriers on chlorophyll, protein and oil contents in soybean plant and seeds.

A field experiment was carried out on soybean cv JS-335 during rainy season 1995 and 1996 at J.N. Agricultural University, Jabalpur (M.P.) Ten treatments comprised 3 sources of S viz., elemental sulphur (ES), gypsum (GY) and oxalic acid industry waste (OAIW), and 3 levels of S (10, 20 and 40 kg S ha^{-1}) and an absolute control were tested in a randomized block design with 3 replications. The soil was clay loam analysed low in available N (228 kg ha^{-1}), P (7.87 kg ha^{-1}), S (6.82 kg ha^{-1}) and high in available K (381 kg ha^{-1}), with pH 7.1. Sowing was done on July 17 and 13 during 1995 and 1996, respectively by drilling 80 kg seeds ha^{-1} with 30 cm x 10 cm spacing. The crop was uniformly fertilized with 20 kg N, 50 kg P_2O_5 and 20 kg K_2O ha^{-1} at the time of sowing through diammonium phosphate (18% N, 46 % P_2O_5) and muriate of potash (60% K_2O). Chlorophyll "a" and "b" and total chlorophyll contents were estimated at 60 days after sowing (DAS) by acetone extraction procedure (Yoshida *et al.*, 1972) The protein content in seeds was determined by multiplying nitrogen content of seeds with 6.25 (Jackson, 1967) and oil content was estimated by Soxhelet extraction method (AOAC, 1965). Oil yield was worked out by multiplying the oil content of seeds with seed yield.

Elemental Sulphur produced the highest chlorophyll contents (a,b and total) in soybean leaves at 60 DAS which were at par with those with gypsum and these two S-sources proved markedly superior over OAIW (Table 1). The S contents of ES are available to plants immediately after oxidation of S in the soil, while S contained in GY is slowly available and OAIW is organically bound. The variability in S releasing behaviour of these S-sources to plants might have led to variation in chlorophyll contents in soybean leaves. Increasing rates of S application correspondingly increased chlorophyll contents upto 20 kg S ha^{-1}. Being an activator of a number of enzymes involved in photosynthesis and carbohydrate metabolism, S is indirectly involved in chlorophyll synthesis by photo conversion of existing

Received for publication in July, 1998

Table 1. Effect of sources and levels of S on Chlorophyll, protein and oil contents and oil yield in soybean (Mean data for 1995 and 1996)

Treatment	Chlorophyll content(mg g^{-1}) at 60 DAS			Protein(%)	Oil(%)	Oil yield (kg ha^{-1})
	Chlorophyll "a"	Chlorophyll "b"	Chlorophyll "a+b"			
S-Sources						
Elemental Sulphur	1.532	1.135	2.667	34.67	20.19	2.96
Gypsum	1.503	1.106	2.609	34.33	20.12	2.90
Oxalic Acid Industry Waste	1.412	1.051	2.463	34.70	20.06	2.88
S Em ±	0.024	0.015	0.023	0.14	0.18	0.12
C D (P=0.05)	0.067	0.042	0.066	N S	N S	N S
S- level (kg/ha)						
0	1.173	0.851	2.024	33.67	18.17	2.22
10	1.321	1.030	2.351	35.00	20.09	2.72
20	1.571	1.251	2.822	34.39	20.05	2.93
40	1.489	1.074	2.563	34.86	20.46	3.01
S Em±	0.024	0.015	0.023	0.14	0.18	0.12
C D (P=0.05)	0.067	0.042	0.066	N S	N S	N S
Control v/s treated						
S Em±	0.048	0.036	0.067	0.22	0.25	0.16
C D (P=0.05)	0.143	0.107	0.199	0.65	0.72	0.47

DAS - Days after sowing

photochlorophyllide to chlorophyll. Similar positive effect of S on chlorophyll formation in rice (Nanavati et al., 1973) and mustard (Dubey *et al.*, 1992) have been documented.

Sulphur application at 10, 20 and 40 kg S ha^{-1} through ES or GY or OAIW increased protein content in seeds over control (0 kg S ha^{-1}) but differences between different sources as well as levels of S were not significant. These results are in agreement with the findings of Patel *et al.*, (1992) and Lal *et al.* (1993)

Oil content in soybean seeds did not vary due to different S-sources (ES, GY and OAIW). Every incremental dose of S (0.10,20,40 kg ha^{-1})

correspondingy increased oil content upto 40 kg ha^{-1} but differences were not significant beyond 10 kg S ha^{-1}. Singh and Sahu (1986), also recorded increased oil content in oil seeds by increasing S-application as a result of increased glycosides which on hydrolysis increased oil contents. Similar oil content in seeds due to varying S-sources gave an indication that Ca content of GY had no positive effect on oil content in soybean seeds confirming the views of Lal *et al.*, (1993). Oil yield is directly related to seed yield and oil content in seeds. Both seed yield and oil contents were comparable between different S-sources, hence oil yield did not differ due to them.Control plot produced markedly the lowest oil yield which increased by 22.5, 32.0 and 35.5% with 10, 20 and 40 kg S ha^{-1}, respectively.

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J. Oilseeds Res. 16(2) 1999 : 346-347
ISSN 0970-2776

EFFECT OF SPACING, NITROGEN AND PHOSPHORUS ON SUMMER GROUNDNUT

Groundnut *(Arachis hypogaea L.)* is a major oilseed crop grown during *kharif* season in India. Due to vagaries of monsoon and crop shifts in favour of more remunerative crops, the productivity of the crop is decreasing in some areas. Therefore, the area of summer groundnut is increasing continuously because of high productivity. Yield is a function of inter and intra-plant competition and as such there is a considerable scope for increasing the yield by adjusting plant population to an optimum level (Raghavaiah *et al,* 1995). Similarly, there is ample scope, for increasing production through fertilizer application (Roshan Lal and Ganga Saran, 1988). However, the information on plant density and nutrient requirements, especially N and P for summer groundnut is lacking in the rice bowl of Eastern Madhya Pradesh. Therefore, the present investigation was undertaken to study the effect of spacing, nitrogen and phosphorus on summer grondnut.

A field experiment was conducted at Madhya Pradesh Rice Research Institute, Indira Gandhi Krishi Vishwavidyalaya, Baronda Farm (Raipur) during the summer season of 1993. The soilof the experimental field was loam, having pH 7.6 and medium in available N (302 kg/ha) and P (15.7 kg P_2O_5/ha), and high in available K (402.5 kg K_2O/ha). Three spacings (30 cm x 10 cm, 30 cm x 15cm and 30cm x 20 cm) were assigned to main plots and three levels of N (0, 25 and 50 kg/ha) and four levels of P_2O_5 (0,20,40 and 60kg/ha) to sub plots in split plot design with three replications. The gross and net plot size was 3.6 m x 4.2m and 2.7 m x 3.6 m, respectively. The groundnut (SB-11) was sown on 28 January, 1993 giving pre and post-sowing irrigation. Thereafter, irrigations were given at 75mm CPE schedule. The full dose of N and P alongwith 20 kg K_2O/ha were applied as basal at the time of sowing through urea, single super phosphate and muriate of potash, respectively.

A spacing of 30 cm x 15 cm (22.22 plants/m^2) and 30 cm x 10 cm (33.33 plants/m^2) being at par recorded significantly higher dry-pod yield than 30 cm x 20 cm (16.66 plants/m^2) spacing (Table 1). This highlights the importance of maintaining adequate plant stands for realising higher yield. This is in agreement with the findings of Jadhao *et al.* (1992). However, the yield components such as number of pods/plant and 100-kernel weight were found non-significant.

Increase in level of N increased significantly the haulm yield, number of pods and pod weight per plant, although the pod yield and 100-kernel weight did not record similar trend (Table 1). The pod yield responded to N application only up to 25 kg/ha. Hundred kernel weight also followed the trend of pod yield. Similar observations were made by Roshan Lal and Ganga Saran (1988).

Phosphorus had significant effect on groundnut (Table 1). Application of P increased the pod and haulm yield significantly up to 60 kg P_2O_5/ha. Further, the haulm yields obtained with 20 and 40 kg P_2O_5/ha were at par. Yield attributes showed a linear response to P. Increase in pod yield was due to improvement in yield attributes by P application. This is in conformity with the findings of Kaushik and Jain (1991).

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Received for publication in July, 1998

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Table 1: Yield and yield attributes of summer groundnut as affected by spacing, nitrogen and phosphorus nutrition

Treatment	Dry-pod yield (q/ha)	Haulm yield (q/ha)	Pod/plant (No.)	Pod weight/ plant(g)	100 kernel weight(g)
Spacing (cm)					
30x10	28.33	84.51	22.92	15.22	40.24
30x15	29.25	80.88	23.41	15.73	40.43
30x20	22.75	58.37	25.12	17.35	40.91
SEm ±	0.74	1.85	0.81	0.64	0.31
CD (0.05)	2.11	5.40	N S	NS	N S
Nitrogen (kg/ha)					
0	20.72	60.91	21.60	12.86	39.41
25	27.11	82.15	26.71	18.35	40.36
50	28.35	87.52	30.35	20.91	40.56
SEm ±	0.80	1.37	1.10	0.51	0.11
CD (0.05)	2.31	4.10	3.05	1.50	0.30
Phosphorus (P_2O_5 kg/ha)					
0	25.88	76.42	20.34	11.74	39.37
20	28.14	84.11	23.72	16.11	40.11
40	30.75	86.72	26.31	18.57	40.64
60	32.67	90.36	29.53	20.66	40.92
SEm ±	0.64	1.22	0.80	0.52	0.08
CD (0.05)	1.91	3.50	2.42	1.53	0.25

J. Oilseeds Res. 16(2) 1999 : 348-349
ISSN 0970-2776

EFFECT OF ENRICHED FARMYARD MANURE AND TIME OF GYPSUM APPLICATION ON GROWTH AND YIELD OF SOYBEAN(*Glycine max.*)

The low productivity of soybean in India is due to its cultivation on soils of low organic content and improper supply of essential nutrients like Ca andS compared to NPK. Though the bulky organic manures like, Farmyard manure (FYM) is most essential for crop productivity, its scarcity limits application. However, the deficit could be managed through use of enriched farmyard manure. Gypsum application improves pod number and grain filling in soybean, since it contains 29.2 and 18.6 percent of Ca and S, respectively. Reghuwanshi *et al.* (1977)and Kanpal and Chandel (1993) noticed appreciable effect of gypsum in soybean when applied along with NPK. The constant availability of these secondary nutrients at appropriate stages of crop requirement could be assured only when the gypsum was applied in splits rather than the entire dose as basal. Considering these facts the present study was conducted with an objective to find out the effect of enriched FYM and time of gypsum application on yield of soybean.

Field experiments were conducted at Regional Research Station, Vriddhachalam under irrigated condition during winter seasons (November-February) of 1993 and 1994, with soybean cultivar Co.2. The soil type was sandy loam with available soil NPK of 152:12.8:143.6 and 156.4:13.1:130.0 kg ha^{-1}, respectively. The trials were laid out in split-plot design with four replications. In Main plot, Farmyard manure (FYM) @ 12.5 t ha^{-1} as basal (F_1), Enriched FYM @ 750 kg ha^{-1} (750 kg of powdered FYM + 10 kg of P_2O_5 + 45 kg of K_20 mixed and kept for a month and 10kg of 'N' added to this before application) as basal application (F_2) were compared with control (F_3). The recommended NPK for soybean @ 20:80:40 kg ha^{-1} was applied for all the treatments. The treatments in sub-plot constitute the time of gypsum application viz., G1-entire dose as basal (200 kg ha^{-1}). G_2-entire dose top dressed on 30 days after sowing (DAS) and G_3-equal splits as basal and topdress on 30 DAS. While the nitrogen was applied in two splits (basal and topdress on 30 DAS), the full dose of potassium was applied basally. Twentyfive kg of soybean seeds were treated with 1.25 kg of rhizobium before sowing. Two sprays of 2 percent DAP were given on 45 and 60 DAS. The data on plant height and dry matter production at harvest, leaf area index at 60 DAS, 100 grain weight and grain yield at harvest were recorded.

Among the growth components, excluding the plant height the data on Leaf Area Index (LAI) and dry matter production (DMP) showed significant variations (Table 1). Application of enriched FYM (F_2) significantly registered the maximum mean LAI (3.9) and DMP (51.3 q ha^{-1}) which was 11.4 and 23.0 percent increase over control (F_3). Regarding times of gypsum application, equal splits at basal and on 30 DAS (G_3) recorded the maximum mean LAI and DMP with 3.8 and 50.4 q ha^{-1} respectively compared to entire dose as basal (G_1) or top dressed (G_2). In yield components also, the enriched FYM application (F_2) significantly recorded the maximum mean number of pods $plant^{-1}$ of 164.0, number of grains pod^{-1} of 2.3 and 8.4 g of 100 grain weight. Similarly, split application of gypsum (G_3) accounted for the maximum mean values of these yield components. The maximum mean soybean grain yield of 2031 kg ha^{-1} was obtained under enriched FYM application (F_2) which was 32.4 percent higher over control. The beneficial effect of enriched FYM on soil physicochemical and biological activities might have improved the growth and yield components and en-

Received for publication in July, 1998

Table : Effect of different treatments on soybean(Mean of two years)

Treatments	Plant height at harvest (cm)	LAI at 60DAS	DMP at harvest (Q/ha)	No.pods /plant	No.grains /pod	100 grain weight (g)	Grain Yield (kg/ha)	Net income (Rs/ha)	C:B ratio
Farmyard Manure									
F1-FYM	63.6	3.6	50.3	70.4	2.2	8.3	1969	9372	2.46
F2-Enriched FYM	65.4	3.9	51.3	82.0	2.3	8.4	2031	10,131	2.65
F3-Control	63.7	3.5	41.4	56.7	2.2	8.2	1533	6900	2.28
CD(P=0.05)	NS	0.24	8.72	23.7	0.04	0.11	337		
Gypsum application									
G1-Basal	63	3.7	46.9	65.9	2.2	8.0	1857	9492	2.76
G2-Top dress	61.7	3.4	43.8	74.3	2.2	8.3	1690	8156	2.52
G3-Basal &Topdress	68	3.8	50.4	79.5	2.2	8.6	1986	10,470	2.93
CD(P=0.05)	NS	0.19	6.4	13.1	NS	0.08	246		

Price of Soybean Rs 8/kg; FYM Rs 60/t; N Rs.7.3/kg; P Rs.17.6/kg; K Rs.7.8/kg; Gypsum Rs 0.6/kg;Labour Rs 27/day.

hanced the soybean yields. The same treatment gave the maximum net return and C:B ratio of Rs. 10,131 ha^{-1} and 2.65, respectively. The results are in line with the findings of Purkayastha and Menon (1984) and Prabakaran and Ravi (1996). A significant increment in mean grain yield (1986 kg ha^{-1}), net return (10,470 Rs ha^{-1}) and C:B ratio (2.93) were also registered with split application of gypsum (G_3) and it might be due to the ensured availability of Ca and S in accordance with stages of crop requirement, resulting in effective pod development and grain filling.

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J. Oilseeds Res. 16(2) 1999 : 350-353
ISSN 0970-2776

INTEGRATED WEED MANAGEMENT IN SUNFLOWER

Of late sunflower has emerged as one of the important oil seed crops in India. In Karnataka it has even surpassed groundnut with respect to area (1.4 m ha) and currently is the leading oilseed crop with a production of 5.1 lakh tons. But the average productivity (521 kg/ha) is lower than the world average (1173 kg/ha). Weed menace is one of the important limitations for increasing the productivity especially under irrigated conditions. Weed competition in this crop is known to cause reduction in yield to the tune of 26-50% (Kondap *et al*, 1983). To solve this problem, several workers explored the possibility of using herbicide to control weeds (Patel *et al*, 1994, Reddy *et al*, 1993). However, herbicides alone are unable to give complete control of weeds because of their selectivity to contain weeds. Use of herbicides could be more effective if supplemented with cultural methods. Lack of information on this aspect in Tunga Bhadra Project command area where sunflower is the major crop prompted to take the present study to formulate an integrated approach to manage the weeds in irrigated sunflower.

A field experiment was conducted at Regional Research Station, Raichur for three consecutive years from 1994-1996 during *Kharif* season under irrigated condition. The experiment was laid out in randomized block design with 12 treatments.(four herbicides viz., Fluchloralin, Pendimethalin, Metalochlor and Alachlor alone and in combination with one hand weeding and intercultivation at 35 days after sowing were compared with farmers practice and hand weeding alone) replicated thrice. The soil was red sandy having 156, 42 and 394 kg/ha of available N,P_2O_5 and K_2O, respectively. The crop was sown at 60cm x 30cm spacing and fertilized with 60:75:60 kg N, P_2O_5 and K_2O per ha respectively in the form of urea, sigle superphosphate and muriate of potash. The gross and net plot sizes were 4.2m x 4.2m and 3.6m x 4.2m. The dry weight of weeds was recorded at harvest stage of the crop. Weed control efficiency was calculated by standard method. Economics of weed management practices was also worked out.

The predominant weeds associated with the crop were *Trichodesma sp., Oldenlandia spp., Euphorbia sp., Tridax procumbens, Ocimum cannum, Legasca mollis, Tribulus terrestris, Commelina sp., Phyllanthus niruri, Sida sp.* Among monocots *Erograstis sp., Cyperus spp., Paspalum sp., and Dactyloctenium egyptian,* were prominent.

Pooled analysis of data showed that dry weight of weeds recored at harvest was significuntly lower in integrated and local method of weed control as compared to unweeded check and application of herbicides alone (Table 1). The lowest dry weight of weeds (508 kg/ha) was observed when Pendimethalin was applied as pre emergence spray @ 1 l ai/ha with one HW and IC at 35 DAS which is followed by Fluchloralin @ 1 l ai/ha with one HW and IC at 35 DAS (602 kg/ha). Application of herbicieds alone also recorded lower dry weight of weeds when compared to unweeded check and two IC at 25 and 40 DAS. Among herbicides, Pendimethalin @ 1 l ai/ha perforemed better (1499 kg/ha) than Metolochlor (2068 kg/ha), Fluchloralin (2140 kg/ha) and Alachlor (2309 kg/ha). Similar results were reported by Patel *et al* (1994).

Herbicides alone controlled 32 to 36 per cent of weeds. However, when they were integrated with one HW and IC at 35 DAS controlled 74 to 82 per cent which was marginally higher than local method of weed control (32%).

Seed yield of sunflower was significantly influenced by weed control treatments in all the three years (Table 1). In general during 1996 seed yields were very low due to heavy and inces-

Received for publication in July, 1998

Table 1: Seed yield of sunflower and dry weed weight as influenced by various weed control treatments

Treatments	Sunflower yield(kg/ha)				Dry weed weight (kg/ha)				Weed control efficiency (%)			
	1994	1995	1996	Mean	1994	1995	1996	Mean	1994	1995	1996	Mean
Fluchloralin@ 1 l/ha	13.1	7.8	10.2	10.3	3117	1155	1643	2140	38	34	37	36
Pendimethalin@ 1 l/ha	14.1	8.2	10.3	10.4	2129	1215	1153	1499	58	51	55	55
Metalochlor@ 1 l/ha	15.2	7.3	10.3	11.1	2716	1774	1713	2068	46	29	34	36
Alachlor@ 1.5 l/ha	13.9	5.9	9.9	7.9	3518	1774	1694	2329	30	29	35	31
Tr1+1HW+IC at 35 DAS	19.4	8.5	10.8	12.8	231	655	917	602	95	74	65	78
Tr2+1HW+IC at 35 DAS	18.5	9.6	12.4	13.4	308	482	736	508	94	80	73	82
Tr3+1HW+IC at 35 DAS	18.7	8.5	11.4	12.8	386	714	925	669	92	71	64	75
Tr4+1HW+IC at 35 DAS	18.9	7.7	10.4	12.3	555	714	994	755	89	71	62	74
1HW+1Cat 25 DAS	16.6	7.6	9.7	11.3	386	1215	1181	927	92	51	55	66
2IC at 25& 40 DAS	14.0	5.9	8.6	9.5	2704	1871	2014	2188	46	26	23	32
Weed freecheck	18.9	9.3	10.9	12.8	00	00	00	00	100	100	100	100
Unweededcheck	10.6	5.1	7.2	7.6	5031	2507	2615	3385	-	-	-	-
SEm±	1.05	0.55	0.58	0.44	201	166	142	99				
CD (0.05)	3.09	1.61	1.71	1.30	591	485	416	290				

Table 2: Economics of weed control in sunflower

Treatments	Gross Returns(Rs/ha)				Cost of Cultivation(Rs/ha)				B:C Ratio			
	1994	1995	1996	Mean	1994	1995	1996	Mean	1994	1995	1996	Mean
Fluchloralin @ 1 l/ha	14,907	8547	10,741	11,398	5,111	4,733	5,045	4963	2.92	1.81	2.12	2.28
Pendimethalin @ 1 l/ha	16,012	9075	10,974	11,960	5,566	5,188	5,553	5435	2.88	1.75	1.94	2.19
Metalochlor @ 1 l/ha	17,263	7986	10,794	12,014	5,228	4,850	5,180	5086	3.30	1.34	2.08	2.24
Alachlor @1.5 l/ha	15,841	6479	10,353	10,891	5,073	4,695	5,010	4926	3.12	1.70	2.06	2.29
Tr1+1HW+IC at 35 DAS	22,088	9306	11,289	14,230	5,536	5,133	5,445	5371	3.98	1.81	2.07	2.62
Tr2+1HW+IC at 35 DAS	21,064	10,156	12,978	14,733	5,991	5,588	5,953	5,844	3.52	1.88	2.18	2.52
Tr3+1HW+IC at 35 DAS	21,246	9,339	12,001	14,195	5,653	5,250	5,580	5494	3.76	1.78	2.15	2.56
Tr4+1HW+IC at 35 DAS	21,588	8,448	10,930	13,655	5,498	5,095	5,410	5334	3.92	1.66	2.02	2.53
1HW+IC at 25 DAS	18,857	8,360	10,447	12,555	5,130	4,702	4,900	4910	3.67	1.78	2.13	2.52
2IC at 25 & 40 DAS	15,943	6,567	8,988	10,499	4,480	4,102	4,400	4327	3.56	1.60	2.04	2.40
Weed free check	21,451	10,208	11,424	14,361	5,555	5,402	5,400	5452	3.86	1.89	1.99	2.58
Unweeded check	12,108	5,643	7,560	8,437	4,820	3,902	4,200	4130	2.82	1.45	1.88	2.05

sant rains during crop growth period. During 1994, all the pre-emergence herbicides viz., fluchloralin, pendimethalin, metolachlor and alachlor with one hand weeding (HW) and intercultivation (IC) at 35 days after sowing (DAS) recorded comparable seed yield with that of weed free check and significantly superior yields over use of herbicides alone and unweeded check. During 1995 and 1996 also a similar trend was observed and the treatment pendimethalin @ 1 1 ai/ha+1HW+1IC at 35 DAS gave maximum seed yield (9.50 q/ha and 12.3 q/ha respectively). On an average of three years, the seed yield recorded with application of herbicides along with 1 hand weeding and one intercultivation at 35 DAS were on par with each other and significantly superior to use of herbicides alone barring metalochlor. The treatment Pendimethalin @ 1 1 ai/ha with one HW and one IC at 35 DAS recorded significantly superior seed yield (13.4 q/ha) compared to local method of one HW and IC at 35 DAS (11.3 q/ha). This is in agreement with the findings of Reddy et at, 1993.

On an average, integrated methods recorded 14 and 23 per cent higher seed yield than local method and application of herbicides alone respectively. Similarly, application of herbicides alone also recorded 23 per cent higher seed yield compared to unweeded check.

The economics of different weed control treatments revealed that, among various weed management practices, highest gross returns (Rs. 14,733/ha) and net returns (Rs.8,859/ha) were obtained with Pendimethalin @ 1 1 ai/ha with one HW and IC at 35 DAS which is closely followed by Fluchloralin @ 1 1 ai/ha + 1 HW and IC at 35 DAS (Rs.14,230/ha and Rs.8,859/ha respectively) (Table 2). The lowest net returns (Rs.4,307/ha) was obtained with unweeded check. On an average integrated methods gave an additional returns of Rs.2,229/ha, Rs.1,047/ha and Rs.4,385/ha over application of herbicides alone, local method and unweeded check.

From the present study, it could be concluded that pre emergence application of pendimethalin or fluchloralin followed by one HW and IC at 35 DAS was found to be effective in suppressing the weeds and for obtaining higher sunflower yields under irrigated conditions.

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J. Oilseeds Res. 16(2) 1999 : 354-357
ISSN 0970-2776

DRY MATTER PARTITIONING IN DIFFERENT PLANT PARTS OF SPANISH AND VIRGINIA GROUNDNUT CULTIVARS IN MID-WESTERN PLAINS OF U.P.

Groundnut *(Arachis hypogaea* L.) contributes nearly 38 per cent of the total oilseed production in the country. About one-third of the total groundnut area of Uttar Pradesh (U.P.) lies in Rohilkhand division and wheat crop usually succeeds groundnut under irrigated condition. Information on the growth behaviour of promising groundnut cultivars is lacking. Therefore, the present investigation was conducted to find out suitability of various Spanish and Virginia groundnut cultivars in mid-western plains of U.P.

A field experiment was conducted at the G.B. Pant University of Agriculture & Technology Research Station, Ujhani, Budaun during *kharif* 1995-96 on loamy sand soil, with 7.5 pH, 0.68% organic matter, 0.07% total nitrogen, 26.0 kg/ha available P_2O_5 and 237.2 kg/ha available K_2O. Eight cultivars each of virginia and Spanish group were grown in two sets in randomised block design replicated thrice. Observations on drymatter partitioning were recorded at 30, 60, 90 days after sowing (DAS) and at maturity stage and pod weight/plant at 60, 90 DAS and at maturity stage on the basis of five randomly selected plants. The recommended dose of fertilizer (20 kg N, 30 kg P_2O_5, 45 kg K_2O and 125 kg Gypsum per ha) was applied as basal. Gypsum was applied at flowering stage. Plant protection measures were adopted as per recommendation. One irrigation was given at flowering stage to ensure better pegging.

Cultivar Chitra (Virginia group) has significantly higher stem and leaf dry weight at 30, 60, 90 DAS and maturity stage (Table 1). In Spanish group, SG-84 had higher dry weight at 90 DAS and maturity stage. Higher stem dry weight was recorded in cultivar SB-XI and higher leaf dry weight in AK-12-24 followed by ICGS-5 and SG-84. However, higher pod yield (Table 2) was recorded in cultivar SG-84 and Chitra. Cultivar SG-84 showed slightly lower dry weight in stem and root due to short duration and compact plant type, whereas cultivar AK-12-24 and SB-XI took more days to maturity. Higher pod yield in SG-84 was due to higher number of branches/plant over all the cultivars tested. Cultivar Chitra (Virginia group)had significantly higher dry matter accumulation per plant at 90 DAS and maturity over all other cultivars. Kaushal (Virginia group) had significantly more dry matter/plant at 60 DAS over all other cultivars. Cultivar Chitra recorded maximum dry matter accumulation at 30 DAS. TAG-24, SG-84,ICGS-11,Kaushal, ALR-1, TMV-10 and M-13 of Spanish group also followed the trend of Chitra. In Spanish group of cultivars, SG-84 has highest dry matter/plant amongst all other Spanish cultivars tested. It has been found that pod yield of groundnut cultivars was directly correlated with no.of branches (0.583*) and total dry matter accumulation (0.755**) per plant. Ratnam (1979) reported positive corelation between total dry matter production at vegetative

Received for publication in July, 1998

Table 1. Dry matter aacumulation/plant (g) in different plant parts of groundnut cultivars at different growth stages.

Cultivars	Stem				Leaves				No.of branches/plant		
	Days after sowing										
	30	60	90	Maturity	30	60	90	Maturity	60	90	Maturity
A.Spanish group											
SB-XI	0.21	2.73	14.96	15.16	0.55	2.71	6.96	1.45	13.6	21.0	21.0
TAG-24	0.42	4.18	7.83	8.43	0.76	3.51	6.96	1.97	10.3	16.0	21.0
SG-84	0.50	2.28	11.76	11.83	0.86	5.33	10.50	2.76	27.0	33.3	39.6
AK-12-24	0.12	2.18	7.43	7.60	0.46	2.93	10.90	3.06	14.0	20.6	31.3
ICGS-5	0.18	3.63	11.73	12.13	0.29	3.48	8.36	2.93	12.6	21.0	22.6
DH-45	0.18	3.06	13.46	12.90	0.40	3.20	6.70	5.66	10.6	18.0	22.3
ICGS-44	0.27	4.28	15.73	15.13	0.49	3.65	9.20	3.93	20.6	26.6	32.0
ICGS-11	0.45	1.16	10.20	10.03	0.90	3.86	4.30	1.40	11.0	17.6	23.0
S.Em. ±	0.021	0.10	0.36	0.57	0.031	0.10	0.25	0.21	0.7	1.3	0.7
CD (0.05)	0.060	0.29	1.04	1.64	0.090	0.29	0.71	0.60	2.2	3.8	2.2
B. Virginia group											
BG-3	0.09	4.55	14.26	14.16	0.75	4.48	9.16	2.20	33.3	41.3	41.4
Kaushal	0.24	5.16	8.86	9.56	0.86	7.13	10.86	3.60	27.0	33.6	34.0
TG-19A	0.12	2.78	9.90	10.03	0.64	3.66	6.46	1.70	8.3	15.6	20.3
ALR-I	0.25	3.36	8.73	9.33	0.91	5.30	7.10	2.70	18.6	29.3	30.0
Kadiri-3	0.29	2.93	6.46	7.13	0.66	3.60	3.66	1.37	12.3	17.0	18.3
TMV-10	0.20	4.78	10.06	10.33	0.84	2.23	8.33	2.66	14.0	20.6	21.3
M-13	0.31	3.40	16.56	16.40	0.71	3.65	9.56	7.06	20.6	33.6	39.3
Chitra	0.56	6.10	16.86	17.13	1.43	8.31	22.06	14.93	30.0	42.6	42.3
S.Em. ±	0.022	0.11	0.39	0.59	0.034	0.11	0.29	0.26	0.8	1.6	0.8
CD (0.05)	0.063	0.31	1.13	1.71	0.098	0.31	0.83	0.77	2.5	4.7	2.5

Table 2. Dry matter aacumulation in root nodules (mg), pods (g) and total dry matter accumulation/ plant (g) of groundnut cultivars at different growth stages.

Cultivars	Dry matter in root nodules/ plant (mg)				Dry matter in pods/plant (g)			Total dry matter/plant (g)				Pod yield (kg/ha)
	30	60	90	Maturity	60	90	Maturity	30	60	90	Maturity	
A.Spanish group												
SB-XI	7.20	8.86	8.53	7.96	1.49	8.09	22.86	0.79	6.92	30.0	39.48	1870
TAG-24	9.06	9.40	11.33	19.00	8.56	24.13	27.13	1.20	16.27	37.4	37.38	1960
SG-84	8.40	8.63	72.90	89.63	7.30	24 73	40.32	1.36	11.81	44.5	55.00	2643
AK-12-24	6.63	8.06	8.56	8.46	2.36	11.73	22.03	0.38	7.45	30.3	32.50	1990
ICGS-5	4.63	4.86	7.66	7.93	1.13	12.46	27.46	0.49	8.61	32.5	42.00	2260
DH-45	2.09	2.13	3.90	4.06	1.70	3.73	17.96	0.64	7.92	23.9	36.04	1696
ICGS-44	9.56	16.30	21.33	23.33	5.96	16.96	22.30	0.83	13.91	41.9	42.00	2060
ICGS-11	11.33	16.30	21.33	22.33	5.43	15.00	19.60	1.36	10.50	29.5	31.06	1983
S.Em.±	0.46	0.76	8.26	14.21	0.12	0.86	1.13	0.29	0.18	0.63	0.99	100.3
CD(0.05)	1.34	2.18	23.78	40.92	0.36	2.92	3.25	0.85	0.53	1.82	2.89	289.8
B. Virginia group												
BG-3	6.76	6.90	8.03	34.53	3.41	7.80	29.36	0.90	12.4	31.2	45.7	2166
Kaushal	8.00	8.30	9.16	8.66	6.43	11.96	21.53	1.13	18.7	32.2	34.7	1850
TG-19A	10.53	149.00	210.00	266.00	2.46	8.80	18.23	0.74	9.0	25.3	30.2	1580
ALR-I	7.30	7.63	8.56	9.00	0.93	4.43	24.03	1.15	9.6	20.2	36.0	1844
Kadiri-3	9.09	9.13	9.33	10.00	1.56	6.00	30.00	0.95	8.1	16.3	38.5	2131
TMV-10	8.10	8.30	8.50	9.23	2.23	5.13	20.40	1.09	12.3	25.7	33.4	1553
M-13	8.36	8.50	9.26	9.63	0.61	8.73	25.83	1.01	7.6	34.9	49.3	1993
Chitra	11.20	14.40	27.66	26.66	1.29	13.63	34.40	2.0	15.7	52.6	66.5	2436
S.Em.±	0.48	16.40	15.85	22.04	0.13	0.61	1.17	0.36	0.20	0.78	1.26	102.4
CD(0.05)	1.41	47.51	45.64	63.67	0.39	2.07	3.38	1.05	0.59	2.26	3.67	295.9

stage and number of branches per plant. Similar observations were reported by Shelke and Khuspe (1982). Dry matter accumulation in different plant parts and total dry matter per plant was characterised by plant type and pattern of growth in a particular environment. Bhattacharya and Sarkar (1977) recorded increased pod yield with increase in number of branches and dry matter accumulation in different cultivars of groundnut.

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J. Oilseeds Res. 16(2) 1999 : 358-359
ISSN 0970-2776

DIFFERENTIAL RESPONSE OF SOYBEAN VARIETIES TO PHOSPHORUS UPTAKE UNDER FIELD CONDITIONS

Soybean [*Glycine max (L.)* Merrill, an important leguminous oil seed crop rich in protein, is grown extensively in northern parts of Karnataka. Phosphorus is one of the important growth contributing factor for increased crop production (Bureau *et al.*, 1953). Generally the availability of P in acid soils is low due to ionic binding phenomenon. Hence it is necessary to find out the optimum level of P application for effective crop growth and yield. In this context, an attempt was made to find out the P uptake differences among soybean varieties and to find the optimum level of P application for maximizing the yields of soybean in North Karnataka.

A field experiment was conducted at main research station, University of Agricultural Sciences, Dharwad during *Kharif*, 1988. The experimental soil was sandy loam in nature (coarse sand 25.20%, fine sand 30.20%, silt 9.36% and clay 33.6%) with pH 6.2, OC 0.46%, EC 0.16 dsm^{-1}, available phosphorus 5.40 kg/ha (Olsens method) and available potash of 270.4 kg/ha (Flame photometer method). The soybean varieties tested were short to long duration in nature which included Hardee (100 to 110 days), Monetta (80 to 85 days) and KHSb2 (110 to 115 days). The seeds were treated with soybean *Rhizobium* culture and were sown. The experiment was laid in factorial Randomized Block Design with 12 treatments and replicated thrice. Four levels of P application viz., 0, 40, 80 and 120 kg/ha were maintained in the experiment to find out the optimum level of P application. The plot size was 3.6m x 4.0m (14.4 m^2) with a spacing of 30 x 10cm. A basal dose of 37.5 kg N and K per hectare was applied uniformly to all the plots. The P uptake at different stages of crop growth was determined by Vanadomolybdate phosphoric yellow colour method (Jackson, 1967).

The results of the study showed that P uptake varied with the varieties. Hardee variety recorded maximum P uptake followed by Monetta and KHSb 2. Irrespective of the varieties the trend of P uptake showed increase from flower initiation stage to harvest. However maximum P uptake in plants was observed at the time of harvest. Such increased P uptake with the advancement of crop age also has been reported in Soybean by Harper (1971). Among the three soybean varieties tested, Hardee recorded the maximum yield (1817 kg/ha) which was significantly superior to Monetta (1602 kg/ha) and KHSb 2 (1512 kg/ha). In the present study significant differences were noticed between the fertilizer treatments. Phosphorus application at 80 kg P_2O_5 per hectare was found economical in increasing the grain yield (1807 kg/ha) compared to control (1258 kg/ha) and other P levels. Though higher levels of P application (120 kg/ha) resulted in increased yields (1908 kg/ha) it was only marginal compared to 80 kg P_2O_5/ha (1807 kg/ha). It is indicated that application of P at 80 kg P_2O_5 per hectare is advantageous for obtaining maximum yields of soybean in the slightly acidic soils of north Karnataka.

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Received for publication in July, 1998

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Table 1 : Phosphorus content (mg/pl) at different growth stages and grain yield (Kg/ha) of Soybean as influenced by varieties and Phosphorus levels.

Treatments	Growth stages P content (mg / Pl)				Grain Yield (Kg/ha)	% increase in yield
	At flowering	End of flowering	Mid pod formation	At Harvest		
Varieties						
Monetta	14.21	29.53	40.62	68.64	1602	
Hardee	15.55	33.90	47.68	77.47	1817	
KHSb2	12.83	28.91	40.53	62.97	1512	
SEm ±	0.34	0.74	0.64	1.71	41.7	
CD (0.05)	0.98	2.18	1.86	5.01	122.3	
Phosphorus (kg P2O5/ha)						
0	12.39	25.83	38.45	61.68	1258	--
40	13.69	29.86	42.12	69.66	1612	28.14
80	15.16	33.63	44.91	73.58	1807	43.64
120	15.53	33.79	46.27	73.84	1908	51.67
SEm±	0.39	0.86	0.73	1.97	48.1	
CD (0.05)	1.14	2.51	2.15	5.79	141.2	
V x P interaction						
SEm±	0.67	1.48	1.27	3.42	83.4	
CD (0.05)	NS	NS	NS	NS	NS	

J. Oilseeds Res. 16(2) 1999 : 360-361
ISSN 0970-2776

RESPONSE OF NIGER TO LEVELS OF NITROGEN AND PHOSPHORUS

Niger (*Guizotia abyssinica* Cass.) is one of the important oilseed crop which is extensively grown in tribal areas of Madhya Pradesh under rainfed conditions. However, the productivity is low (1.76 q/ha) in the state as compared to its potential yield of about 4.5 q/ha. The inadequate use and untimely application of fertilizers is the main reason for low yields. The crop has shown positive response to N and P fertilization (Thorat *et al.*, 1991). Further, the application time of fertilizer also plays an important role in boosting crop yield (Patel and Pali, 1992). Hence, the present investigation was undertaken.

A field experiment was conducted at the Indira Gandhi Krishi Vishwavidyalaya, Baronda Farm, Raipur (M.P.) during *kharif* 1992. The trial was laid out in split plot design with three replications. The treatments consisted of all combinations of four levels of N (0,15,30 and 45 kg/ha) and three levels of P_2O_5 (0,15 and 30 kg/ha) as the main plot treatments and time of N application (all basal, all at 30 days after sowing (DAS), 1/2 basal + 1/2 30 DAS, 3/4 basal + 1/4 30 DAS and 1/4 basal + 3/4 30 DAS) as the sub plot treatments. The soil was red laterite having pH 5.9 and available N (182 kg/ha), P (9 kg P_2O_5/ha) and K (172 kg K_2O/ha). Niger CV. Ootacamund was sown at a spacing of 30x10 cm on 2nd Agugust, 1992. A common basal dose of 20 kg K_2O/ha and all P (as per treatment) was given at the time of sowing, while N was applied as per treatments. The source of fertilizers was urea, single suerphosphate and muriate of potash. The crop was raised as per recommended package of practices.

Every incremental dose of 15 kg N/ha in general, exhibited increasing trend in yield components viz; plant height, number of branches./plant, capitula/plant, seeds/capitula and 1000-seed weight as well as seed and stalk yield from 0-45 kg N/ha (Table 1). However, differences were non-significant beyond 30 kg N/ha for the above characters except plant height, capitula/plant and stalk yield. The increase in seed yield with 15 and 30 kg N/ha was 27.53 and 76.45 per cent, respectively compared with no nitrogen treatment. Increase in yield was due to positive improvement in yield attributes by N fertilization (Trivedi and Ahlawat, 1991).

Each incremental dose of P gave significantly higher seed yield over its preceeding dose and it was maximum at 30 kg P_2O_5/ha. Consequently, the stover yield and plant height increased up to 15 kg P_2O_5 and further increase in P level did not improve these parameters significantly. The beneficial effects of P on seed yield could be seen through more branches and capitula per plant, seeds/capitula and weight of 1000-seed (Table 1). Similar results have been reported by Thakuria and Gogai (1992).

Application of N in two splits viz; one-fourth at sowing + three-fourth at 30 DAS and half at sowing + half at 30 DAS being on par resulted in significantly higher seed and straw yield than other applications (Table 1). Similarly, all split doses also proved their superiority over single doses. The lowest yields were obtained when all N was given in a single dose at the time of sowing (basal dose). Probably the losses could be through leaching at early stage of crop. All yield attributing characters also followed similar trend of seed yield. The results confirm the findings of Patel and Pali (1992).

The results of the present study suggests that better yield of niger could be obtained with

Received for publication in July, 1998

Table 1. Effect of nitrogen and phosphorus on yield and yield components of niger

Treatment	Seed yield (q/ha)	Stalk yield (q/ha)	Plant height (cm)	Branches/ plant	Capitula/ plant	Seeds/ capitula	1000-seed weight (g)
Nitrogen (kg/ha)							
0	2.76	28.12	105.21	5.27	24.61	20.22	4.30
15	3.52	31.73	115.73	6.52	27.53	23.24	4.41
30	4.87	37.34	118.64	7.41	31.64	24.92	4.54
45	5.28	40.55	121.55	7.82	34.52	25.18	4.57
SEm ±	0.18	0.68	0.78	0.26	0.91	0.51	0.03
CD (0.05)	0.55	2.01	2.31	0.81	2.71	1.51	0.09
Phosphorus (P_2O_5 kg/ha)							
0	2.42	36.31	118.60	5.73	23.82	24.24	4.54
15	3.51	38.34	120.77	6.22	27.37	26.63	4.64
30	4.77	40.10	121.54	7.17	30.55	27.80	4.76
SEm ±	0.12	0.67	0.66	0.14	0.68	0.38	0.02
CD (0.05)	0.34	1.99	1.97	0.43	2.02	1.11	0.06
Time of N application							
All basal	3.03	33.31	110.37	4.51	22.51	22.36	4.28
All 30 DAS	3.57	34.61	109.75	6.33	28.42	25.11	4.30
1/2 basal+1/2 30 DAS	4.92	39.37	122.63	7.72	31.84	26.72	4.52
3/4 basal+1/4 30 DAS	4.08	36.42	117.54	5.53	25.11	25.35	4.41
1/4 basal+3/4 30 DAS	5.11	41.52	121.81	8.24	31.68	27.37	4.59
SEm±	0.15	0.58	0.51	0.16	1.07	0.34	0.03
CD (0.05)	0.45	1.74	1.52	0.48	3.21	1.02	0.08

DAS = Days after sowing

the application of N and P_2O_5 individually @ 30 kg/ha. The study also indicates that application of N in 25:75 or 50:50 ratio as basal and top dressing at 30 DAS respectively appears to be beneficial for higher yield of niger.

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J. Oilseeds Res. 16(2) 1999 : 362-366
ISSN 0970-2776

EFFECT OF TILLAGE AND PHOSPHORUS FERTILIZATION ON GROWTH AND YIELD OF GOUNDNUT GROWN AFTER PUDDLED RICE

Groundnut cultivation in rice fallows is to be encouraged in place of rice during *rabi* season in light soils because of its low water requirement, better remuneration and from soil health point of view. As the soil physical environment required for optimum growth of groundnut differs with that of rice, the same can be created only through suitable tillage practices. Khan and Datta (1983) reported that tillage operations provide a conducive soil environment around seed for germination and root growth. The role of phosphorus in stimulating root formation and nodulation as also in enhancing the growth and pod development needs no emphasis. Increased pod yield due to increased phosphorus fertilization was reported by several workers (Tomar *et al.*,1983 and Singh and Ahuja, 1985). The present investigation was undertaken to study the effect of tillage practices and P fertilization on the growth and yield of groundnut in rice based cropping system.

A field experiment on groundnut was conducted at the Agricultural College Farm of Acharya N.G.Ranga Agricultural University, Rajendranagar, Hyderabad during summer season of 1990-91 in rice based cropping system. The soil was red loamy sand; neutral in reaction(pH 7.6); non-saline;low in organic carbon (0.30%), available N (185 kg per hectare), and P(17.9 kg P_2O_5 per hectare): and medium in available K (128 kg K_2O per hectare). There were 16 treatment combinations comprising four tillage treatments viz., country ploughing (CP) twice (TI); CP followed by disc harrow twice (bullock drawn) (T2); CP twice followed by power tiller operated rotavator twice (T3) and disc plough once followed by disc harrow once (both tractor drawn) (T4) and four phosphorus levels viz., 0,30,60 and 90 kg P_2O_5 per hectare. The experiment was laid out in a split plot design with three replications with tillage as main plot treatments and phosphorus as sub-plot treatments. A common fertiliser dose of 40 kg N (in two splits) and 50 kg K_2O (basal) per hectare was applied uniformly to all plots. Phosphorus was applied as basal as per the treatments in the form of single super phosphate. Groundnut var. TMV-2 was sown on 22nd January, 1991 by hand dibbling adopting a spacing of 30cm x 10cm. Five plants were uprooted at 40,60 and 90 days after sowing (DAS) and at harvest for dry matter estimation. Nodules were counted and expressed as number per plant. The effect of tillage practices, P levels and their interacations on root growth, nodulation, dry matter accumulation and pod yield was studied.

Significant effect of tillage and P levels on root growth at 40,60 and 90 DAS and at harvest was observed while their interaction effect in general was not significant (Table1). The tillage effects on root growth were less pronounced during the early stage of the crop. However, as the age of the crop advanced the effects were clearly visible. The root weight was significantly higher in tractor drawn disc plough and rotavator treatments which were comparable throughout the crop growth over cattle drawn implements. This might be due to better tilth achieved in these treatments. In general, lowest root weight was recorded when tillage was done with country plough alone (control). Successive increase in level of P application significantly increased root growth and its weight. This obviously has become possible due to more favourable effect of P on growth of root system (Jana *et al.*, 1990).

Dry matter accumulation (Table 2) was significantly influenced by tillage treatments, P lev-

Received for publication in August, 1998

Table 1 : Root weight (q/ha) of groundnut as affected by tillage and phosphorus application during the crop growth period.

Teatment	Stage of the Crop			
	40 DAS	60 DAS	90 DAS	Harvest
Tillage				
Ploughing with country plough (CP) twice (control)	18.3	51.6	63.6	89.8
CP twice+disc harrow twice (cattle drawn)	16.2	55.0	84.5	129.0
CP twice+rotavator twice (power tiller operated)	22.0	70.0	116.6	175.4
Disc plough once+disc harrow once (both tractor drawn)	23.4	64.9	111.7	177.3
C.D (0.05)	4.3	5.5	5.5	10.1
Phosphorus levels (kg/ha)				
0	16.6	51.6	84.6	112.6
30	19.2	57.7	90.1	136.2
60	21.0	62.8	96.2	150.7
90	22.7	69.3	105.4	172.0
CD (0.05)	1.3	3.3	7.5	5.3

els and their interactions at 40,60, and 90 DAS and at the time of harvest. Irrespective of crop growth stage, disc plough followed by disc harrow (tractor drawn) treatment recorded the highest dry matter accumulation closely followed by rotavator which were on par but significantly superior to the tillage done with cattle drawn implements. CP followed by disc harrow twice was also significantly superior to CP alone. Successive increase in P levels significantly increased the dry matter accumulation at all stages. Among interactions, throughout the crop growth the lowest dry matter was associated with CP alone and no P application, while it was highest with disc plough once + disc harrow once (tractor drawn) in combination with either 60 or 90 kg P_2O_5 per hectare.

The difference in dry matter production among tillage treatments might be due to differences in seedling emergence and stand establishment. Moreover even after emergence, the fine tilth due to rotavation and deep ploughing with tractor drawn implements and application of P at higher doses encouraged the root growth (Table1) which inturn might have increased the uptake of nutrients and water from greater volumes of soil resulting in higher dry matter production. Similar observations were made by Awadhwal and Theirstein (1984) and Singh and Ahuja (1985).

Pod yields (Fig.1) were significantly influenced by tillage practices, P levels and their interactions. It ranged from 14.3 q (CP with no P) to 25.0q (rotavation + 90 kg P_2O_5 per hectare).

Table 2: Dry matter accumulation (q/ha) as affected by different tillage treatments and P levels at various stages of crop growth.

Tillage(T)	P - levels (kg/ha) (P) 0	30	60	90	Mean
		40 DAS			
T1	3.3	3.9	4.1	3.9	**3.80**
T2	3.5	4.1	4.4	4.5	**4.13**
T3	5.0	4.9	5.1	5.1	**5.03**
T4	4.9	4.9	5.2	5.1	***5.03***
Mean	**4.18**	**4.46**	**4.69**	**4.65**	
	S.Em ±		CD (0.05)		
Tillage	0.48		1.66		
Phosphorus	0.15		0.50		
T at same P	0.75		2.22		
P at same T	0.88		2.73		
		60 DAS			
T1	19.6	20.1	22.1	22.5	**21.08**
T2	20.9	22.1	23.8	26.4	**23.30**
T3	23.3	26.4	28.2	29.8	**26.93**
T4	22.9	26.2	28.8	29.9	***26.95***
Mean	**21.68**	**23.70**	**25.73**	**27.15**	
	S.Em ±		CD (0.05)		
Tillage	0.28		0.96		
Phosphorus	0.87		0.30		
T at same P	0.41		1.21		
P at same T	0.49		1.51		
		90 DAS			
T1	35.6	39.3	42.3	43.5	**40.18**
T2	38.4	41.8	45.4	50.5	**44.03**
T3	43.1	49.3	53.0	56.4	**50.45**
T4	42.4	48.8	54.0	56.6	**50.45**
Mean	**39.88**	**44.80**	**48.68**	**51.75**	
	S.Em ±		CD (0.05)		
Tillage	0.50		1.72		
Phosphorus	0.16		0.56		
T at same P	0.78		2.32		
P at same T	0.91		2.83		
		At Harvest (Haulms yield)			
T1	37.1	41.1	44.4	45.5	**42.03**
T2	40.0	43.7	47.5	52.2	**45.85**
T3	44.9	51.6	55.5	59.1	**52.78**
T4	44.2	51.1	56.6	59.3	**52.80**
Mean	**41.55**	**46.88**	**51.00**	**54.03**	
	S.Em ±		CD (0.05)		
Tillage	0.52		1.80		
Phosphorus	0.17		0.58		
T at same P	0.81		2.42		
P at same T	0.95		2.96		

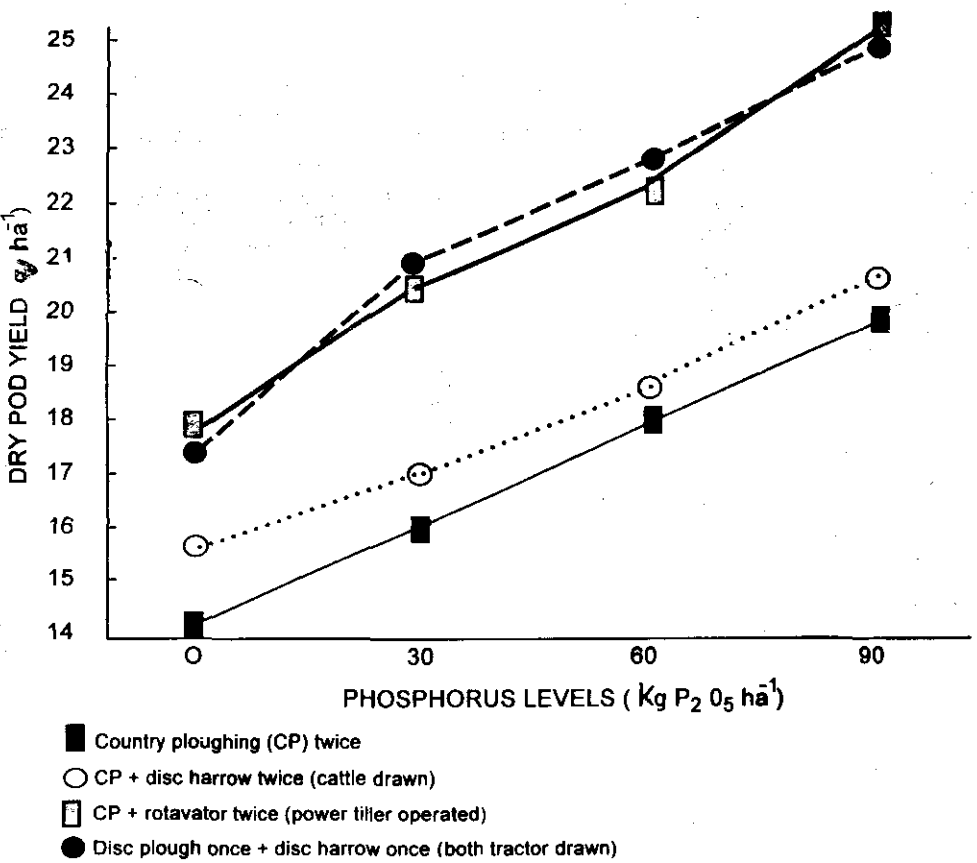

Fig. 1: Dry Pod yield (q ha^{-1}) of groundnut as affected by different **tillage treatments and P levels**

Among tillage treatments mean pod yield was highest with disc plough once + disc harrow once (tractor drwn) closely followed by that of rotavator and were significantly superior to the other treatments. This might be due to better (seed bed) soil physical environment resulted in tractor drawn and power tiller operation treatments. Reports of Batcheldor *et al.*, (1978) and SPCIP (1986-87) lend support to the present findings.

Pod yields increased significantly with increment of P application from 30 to 90 kg P_2O_5 per hectare. This might be due to low soil available P status with high P fixation capacity. Many workers reported good response of groundnut to P fertilisation (Tomar *et al.*, 1990; and Rao and Mittra, 1991).

Tillage with tractor and power tiller under 60 and 90 kg P_2O_5 per hectare resulted in relatively higher pod yields over other treatments probably due to combined favourable influence of soil physical environment and increased P availability.

From the results it can be indicated that tillage with either power tiller-operated rotavator or tractor drawn implements (disc plough + disc harrow) and P fertilisation upto 90 kg P_2O_5 per hectare gives higher yields of summer groundnut grown after puddled rice in red loamy sandy soils in Southern Telangana Zone of Andhra Pradesh.

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J. Oilseeds Res. 16(2) 1999 : 367-368
ISSN 0970-2776

ESTIMATION OF YIELD LOSS DUE TO SESAME POWDERY MILDEW *(Oidium acanthospermi)*

Powdery mildew of sesame was first reported from Uttar Pradesh in 1951 (Mehta, 1951). Although the disease does not appear in serious proportion, may spread considerably under favourable conditions. Incidence of mildew starts as small whitish spots on upper surface of leaves. The severely infected leaves drop off. The affected plants produce shrivelled seeds and the yields are reduced (Kolte, 1985). In Tamil Nadu, it causes appreciable economic damage throughout seasme growing areas during post rainy season (November to January). Rabindran and Jeyarajan (1983) reported that mildew in early stages of crop growth is due to *Oidium acanthospermi* (Chiddarwar), which decrease with age. In the present investigation, the loss in grain yield of sesame due to powdery mildew was assessed.

To estimate the yield loss due to powdery mildew of sesame, field trails were conducted during *rabi* 1995-96 and 1996-97 with four varieties viz., Co 1, G.Til 1, JT 7 and No.8 received from the Project Coordinator (S&N), Jabalpur. Each entry was raised under both protected and unprotected conditions in a net plot size of 3.0 x 2.1 m^2 adopting a spacing of 30 x 30 cm. A fertilizer schedule of 60:40 kg of NP/ha was followed. The trial was conducted in randomized block design with four replications. Under protected conditions, the crop was sprayed with tridemorph 0.1% or wettable sulphur 0.2% at weekly intervals to control powdery mildew incidence. The recommended management practices for weeds and other pests were followed uniformly in all the treatments. Under unprotected conditions, conidial suspension ($x10^5$ conidia/ml) of the pathogen was sprayed at regular intervals in the evening hours to create powdery mildew infection. Occurrence of disease was first noticed from 35 to 40 days after sowing (DAS) and the peak incidence was observed from 65 to 75 DAS. The disease occurred in all the varieties with varying intensity and it was recorded on 0-5 scale, based on the leaf area damage and per cent disease index (PDI) was calculated. The grain yield was recorded and analyzed statistically.

The results of *rabi* 1995-96 indicated that the loss in yield due to powdery mildew ranged from 5.50 (Co 1) to 10.71 (JT 7)percent. The other two varieties *viz.*, No.8 and G. Til 1 registered a yield loss of 8.23 and 10.17%, respectively. The variety Co 1 was found to be least affected (61.5%) whereas the highest incidence was recorded in G. Til 1 (95.0%) under unprotected conditions. Under protected conditions, the disease incidence was less than 10% only. The same trend in yield loss was observed in *rabi* 1996-97 also. Occurrence of powdery mildew was noticed between 35 and 40 DAS in all the varieties tested during the period under experimentation. Rabindran and Jeyarajan (1983) reported the decreased susceptibility to disease with increased age. The present investigation revealed that the estimated loss in yield due to powdery mildew of sesame ranged between 6.04 and 11.18 per cent.

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Table :1 Incidence of powdery mildew, yield and yield loss in sesame varieties.

Variety	Rabi '95-96			Rabi '96-97			Mean		
	Powdery mildew (PDI)	Yield (kg/ha)	Yield loss (%)	Powdery mildew (PDI)	Yield (kg/ha)	Yield loss (%)	Powdery mildew (PDI)	Yield (kg/ha)	Yield loss (%)
1 CO 1 (P)	6.0 (13.99)	722.2		8.0 (16.27)	658.7		7.0 (15.13)	690.5	
2 CO 1 (UP)	61.5 (51.65)	682.5	5.50	58.5 (49.91)	615.1	6.62	60.0 (50.78)	648.8	6.04
3 No.8 (P)	9.5 (17.89)	674.6		9.5 (17.89)	527.8		9.5 (17.89)	601.2	
4 No.8 (UP)	81.0 (64.20)	619.1	8.23	86.0 (68.05)	484.1	8.28	83.5 (66.12)	551.6	8.25
5 G.Till (P)	10.0 (18.35)	702.4		9.5 (17.89)	543.7		9.8 (18.12)	623.1	
6 G.Till (UP)	95.0 (77.43)	631.0	10.17	94.0 (76.02)	492.1	9.49	94.5 (76.72)	561.5	9.87
7 JT 7 (P)	9.5 (17.89)	666.7		10.0 (18.39)	611.1		9.8 (18.14)	638.9	
8 JT 7 (UP)	94.0 (75.92)	595.3	10.71	97.5 (82.20)	539.7	11.68	95.8 (79.06)	567.5	11.18
S.Ed	1.23	16.3		2.13	11.6		1.23	9.9	
CD (0.05)	2.56	34.0		4.43	24.1		2.49	19.9	

P - Protected, UP _ Unprotected, Figures in parentheses are arc sine transformed values.

J. Oilseeds Res. 16(2) 1999 : 369-370
ISSN 0970-2776

RESISTANCE TO KALAHASTI MALADY (*Tylenchorhynchus brevilineatus*) IN ADVANCED VARIETIES OF GROUNDNUT*

A nematode causing disease in groundnut was first observed in 1975-76 post rainy season on irrigated groundnut crop in the Srikalahasti area of Chittoor District, in Andhra Pradesh (Reddy *et al.*, 1984). Since then the disease has been serious and widespread in Chittoor, Nellore and Cuddapah districts. Losses in pod yields of 20-60 per cent were common in severely nematode infested fields (Reddy *et al.*, 1984 and Siva Rao *et al.*, 1986). In recent years, efforts have been made to identify sources of resistance to this nematode disease of groundnut (Siva Rao *et al.*, 1986; Ratnakumar, 1988 and Mehan *et al.* 1993). Though they have identified some disease reistant genotypes, none of them had desirable seed and pod characters except TPT-3 with a longer duration of 135 days. Further, these varieties were not acceptable to the farmers for cultivation. Hence, efforts were made in the present study to evaluate disease resistant genotypes of groundnut with better pod and kernel yields possessing desirable pod and seed characters acceptable to the farmers for cultivation.

The trial was conducted at Andhra Pradesh State Seed Development Corporation (APSSDC) seed farm at Srikalahasti in Chittoor district of Andhra Pradesh during 1992-93 and 1993-94 *rabi* seasons. The trial was laidout in randomised block design with three replications having plot size of 3x4 m. Five promising varieties viz., TCGS-3, TCGS-18, TCGS-113, TCGS-114 and TCGS-115 and four cultivated varieties viz., K-3, TPT-2, TPT-3 including a susceptible check, JL-24 were grown in replicated plots with a row to row spacing of 30 cm and plant to plant spacing of 10 cm. The package of practices recommended by Acharya N.G.Ranga Agricultural University (ANGRAU) were followed for raising the crop. After harvesting of the crop, observations were recorded on disease severity on pods on 1-5 scale (Reddy *et al.*, 1984), pod and kernel yields.

The Pooled analysis (1992-93 and 1993-94) presented in the table 1 clearly showed that the varieties TCGS-115 and TPT-3 exhibited resistant reaction with a disease score of 2.0. The variety, TCGS-115 gave significantly highest pod and kernel yields of 31.82 and 24.34 q/ha with 52.28 and 58.67 percent increase in pod and kernel yield respectively over the check, JL-24. The variety, TPT-3 was found to be the second best with significantly better pod yield of 27.01 q/ha and kernel yield of 20.22 q/ha with 30 and 31.81 percent increase in pod and kernel yields, respectively over JL-24. Two varieties TCGS-18 and TPT-2 exhibited moderately resistant reaction with a disease score of 2.83 to 3.0. They gave significantly better pod yields of 24.16 and 23.7 q/ha with 16.38 and 14.16 percent increase in pod yield over JL-24, respectively.

Three varieties TCGS-3, K-3 and TCGS-113 were found susceptible to the nematode disease with a disease score of 3.17 to 4.0. Among them one variety TCGS-113 gave significantly better pod yield of 24.92 q/ha with 20.38 percent increase in pod yield over JL-24, and better kernel yield of 19.33 q/ha with 26.0 percent increase.

The variety, TCGS-114, though highly susceptible to the nematode disease with a disease score of 4.25, gave significantly better pod and kernel yields of 26.24 and 19.66 q/ha with 26.39 per cent increase in pod yield and 28.16 per cent increase in kernel yield over the susceptible check, JL-24 showing its nematode tolerant nature.

Unlike the earlier findings, the resistant genotypes investigated in the present study have pods with desirable pod and seed characters and possessed better agronomic traits besides giving better pod and kernel yields than the check, JL-24. However, the variety TPT-3 had longer dura-

Received for publication in July, 1998
*Part of Ph.D., Thesis of the Senior author submitted to A.N.G.R. Agricultural University, A.P.

Table 1: Reaction of different groundnut varieties to Kalahasti malady in field trials conducted at Srikalahasti (Pooled data of 1992-93 and 1993-94).

Entries/ Varieties	Disease score (1-5 scale)	Pod yield (q/ha)	Pod yield increase or decrease over control (%)	Kernel yield (q/ha)	Kernel yield increase or decrease over control (%)
TCGS 113	4.0	24.92	20.38	19.33	26.0
TCGS 114	4.25	26.24	26.39	19.66	28.16
TCGS 115	2.00	31.82	52.28	24.34	58.67
TCGS 18	2.83	24.16	16.38	17.95	17.01
TCGS 3	3.17	23.25	11.99	17.66	15.12
K 3	3.34	20.71	-2.4	15.26	-0.52
TPT 2	3.00	23.70	14.16	18.49	20.50
TPT 3	2.00	27.01	30.05	20.22	31.81
JL 24	4.60	20.76	-	15.34	-
CD (0.05)	0.55	2.92	-	2.94	

tion of 135 days compared to the traditional groundnut varieties like JL-24 and TMV-2 with a duration of 110 days in addition to seed dormancy. The variety, TCGS-115 can safely be recommended for growing in farmers fields where *T.brevilineatus* is a persistent problem.

Moderately resistant genotypes, TCGS-18 and TPT-2 and tolerant genotypes TCGS-113 and TCGS-114 may be developed further by the incorporation of resistant / tolerant genes by including them in future groundnut breeding programmes.

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J. Oilseeds Res. 16(2) 1999 : 371-373
ISSN 0970-2776

BIOEFFICACY OF SOME INSECTICIDES AGAINST MUSTARD APHID IN HIMACHAL PRADESH.

Rapeseed and mustard contribute substantially to the edible oil requirement in India after groundnut. The mustard aphid, *Lipaphis erysimi* (Kalt.) is the most serious pest of these crops and causes tremendous losses in yields (Bakhetia and Sekhon, 1984 and 1989 and Singhvi *et al.*, 1974). Good control of mustrad aphid can be obtained by spraying traditional organic insecticides (Bakhetia, 1984 and Khurana and Batra, 1989). Synthetic pyrethroids have also been used for aphid control (Tripathi *et al.*, 1985). In the present investigation efforts have been made to evaluate the traditional alongwith synthetic pyrethroid for the control of mustard aphid at research farm as well as farmers fields.

Present studies were conducted on mustard cultivar 'Varuna' in randomized block design with three replications at Oilseeds Research Station, Himachal Pradesh Krishi Vishvavidyalaya, Kangra during *rabi*, 1990-91 to 1992-93 by taking selected treatments. Except for plant protection, all the recommended practices for raising a good crop were followed. Comparative efficacy of various treatments was evaluated by taking precounts of aphid (24 hrs before sprying) in each experiment and again after 7 and 14 days of the spray. The population of mustrard aphid was recorded on 15 plants per treatment (10 cm central twig).

The results revealed that seven days after treatment lowest population during 1990-91 was recorded in cypermethrin which was at par with the decamethrin, fenvalerate and dimethoate. However during 1991-92, the population was lowest in dimethoate and it was at par with cypermethrin and fenvalerate. During 1992-93 cypermethrin was found at par with dimethoate, decamethrin and fenvalerate. During 1990-91 fourteen days after treatment all the insecticides were at par with control, however during 1991-92 all the insecitcides except endosulfan were significantly better than control and they were equally effective, whereas, during 1992-93 all the insecticides were significantly better than control. Lowest population was recorded in decamethrin and it was significantly superior to endosulfan and dimethoate (Table 1). Earlier workers have observed that cypermethrin (Ahmad *et al.*, 1989), Oxydemeton methyl (Baral *et al.*, 1986, Singh, *et al.*, 1984 and Prasad, 1997), Phosphamidon (Kalra and Gupta, 1986), fenvalerate and delatethrin (Singh *et al.*, 1986), fenvalerate, monocrotophos, dimethoate and cypermethrin (Khurana and Batra, 1989) were most effective against aphid. Tripathi *et al.*,(1985) observed that decamethrin and cypermethrin were relatively more toxic to aphid than phosphamidon, oxydemetonmethyl and monocrotophos. Besides these, bioefficacy of various insecticides have been studied in detail by many other workers, (Bakhetia *et al.*, 1986, Singh and Sachan, 1992, Yadav *et al.*, 1995). On the basis of pooled data, the yield per hactare in case of fenvalerate, decamethrin, cypermethrin and dimethoate was higher than with other insecticies (Table 1). Keeping in view the effectiveness, average yields per hactare and cost benefit ratio, the cypermethrin (0.01%), fenvalerate (0.02%) are recommended for the control of *Lipaphis erysimi* Kalt, on mustard. Similar results have also been obtained at two farmer's fields (Table 2).

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Received for publication in August, 1998

Table 1 : Efficacy of various insecticides against mustard aphid, *Lipaphis erysimi* (Kalt.) at Oilseeds Research Station, Kangra.

S.no. Treatment	Aphid Population/10cm Centraltwig (DAS)									
	1990-91		1991 - 92		1992 -93		Mean Yield(kg/ha)		CBR	
	7	14	7	14	7	14	7	14	7	14
1.Fenvalerate 20 EC (0.01%)	149.23 (12.07)	164.63 (12.86)	199.33 (12.38)	270.66 (15.92)	11.33 (3.40)	13.33 (3.72)	119.99 (9.28)	149.54 (10.83)	15.13	9.43
2. Fenvalerate 20 EC (0.02%)	85.42 (9.27)	160.23 (12.69)	149.60 (11.95)	295.33 (16.51)	9.33 (3.07)	14.33 (3.88)	81.85 (8.09)	156.63 (11.02)	17.38	9.84
3. Decamethrin 2.8 EC (0.008%)	67.66 (8.25)	123.15 (11.15)	172.60 (13.15)	195.00 (13.97)	10.33 (3.32)	10.66 (3.38)	83.53 (8.24)	109.60 (9.05)	14.96	1.14
4. Cypermethrin 10 EC (0.01%)	55.23 (7.46)	101.23 (10.11)	105.60 (10.18)	142.08 (11.92)	5.00 (2.42)	21.33 (4.54)	55.27 (6.68)	88.21 (8.85)	16.20	12.6
5. Oxydemeton methyl 25 EC (0.025%)	157.33 (12.36)	205.47 (14.36)	276.88 (16.64)	370.56 (19.25)	6.33 (2.66)	16.66 (4.03)	146.84 (10.55)	179.56 (12.54)	14.08	5.90
6. Endosulfan 35 EC (0.07%)	134.21 (11.57)	223.46 (14.98)	423.30 (20.54)	469.66 (21.63)	29.33 (5.20)	42.66 (6.52)	195.6 (12.43)	245.26 (14.37)	14.06	3.3
7. Dimethoate 30 EC (0.03%)	88.30 (9.16)	166.48 (12.90)	64.60 (8.05)	168.66 (12.05)	12.00 (3.59)	29.00 (5.42)	54.96 (6.93)	121.38 (10.12)	14.69	6.3
8. Control	229.41 (15.12)	273.89 (16.64)	521.30 (22.85)	862.33 (29.71)	154.66 (12.01)	132.33 (11.32)	301.79 (16.66)	422.85 (19.22)	12.16	--
CD (0.05)	3.14	(Ns)	6.86	9.52	(2.85)	(1.99)				

1. Figures in Parantheses are transformed values, DAS - Days after spray.

2. The pre-tretment population varied from 162.33 to 234.53,233.33 to 487.33 and 353.44 to 673.00 during 1990-91. 19991-92 and 1992-93, respectively and it was uniformly distributed.

Table2 : Efficacy of various insecticides against mustard aphid, *Lipaphis erysimi* (Kalt.) on farmer's field

S.No.	Treatment	Aphid population / 10cmCentral twig		yield (kg/ha)
		7 DAS	14 DAS	
1.	*Fenvalerate 20 EC* (0.02%)	10.99 (3.38)	37.99 (5.56)	1083
2.	Decamethrin 2.8 EC (0.008%)	8.33 (3.02)	16.66 (4.10)	1000
3.	Cypermethrin 10 EC (0.03%)	6.00 (2.61)	22.94 (4.62)	1006
4.	Dimethoate 30 EC (0.03%)	10.16 (3.26)	31.99 (5.63)	904
5.	Endosulfan 35 EC (0.07%)	21.33 (4.49)	52.49 (7.08)	836
6.	Control	280.49 (16.88)	171.99 (12.59)	764
	CD (P = 0.05)	1.33	NS	130

Pre-treatment population varied from 273.16 to 433.66 and there was no significantdifference between them., DAS - Days after spray.

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J. Oilseeds Res. 16(2) 1999 : 374-376
ISSN 0970-2776

EFFECT OF BOTANICALS AGAINST GROUNDNUT BUD BORER, *Anarsia ephippias* (Meyrick)

Groundnut (*Arachis hypogaea)* is attacked by more than 90 species of insects and mites in India, of which only few are economically important. Among the foliage feeding insects, the leaf miner *Aproaerema modicella*, red hairy caterpillar *Amsacta* sp., tobacco caterpillar *Spodoptera litura, jassids Empoasca kerri* and thrips are recognised as important pests (Amin and Mohammad, 1980). Though the groundnut bud borer, *Anarsia ephippias* (Meyrick) (Lepidoptera; Gelechiidae) was reported as a pest of groundnut, but considered as a minor pest in Northern India (Wightman and Ranga Rao, 1993). But moderate incidence of the bud borer for the first time was observed at National Pulses Research Centre, Vamban, Tamil Nadu during winter 96-97. The larvae are chocolate brown to dark brown in colour and bore into the terminal buds and shoots. The emerging leaves have only the midribs or several feeding holes. The larvae also found to tunnel the tip of the stem and thus resulted in the arrest of further growth.

Field trials were conducted during winter 96-97 in alfisols of National Pulses Research Centre, Vamban, Tamil Nadu to assess the effect of different botanicals against groundnut leaf miner. During the season, the leaf miner did not occur, but the occurrence of bud borer was moderate. Thus the treatments programmed for the leaf miner were given against bud borer to know the pest status, economic importance and find out control measure. The trials (one with neem based products and another with indigenous plant extracts) were conducted under irrigated conditions using the popular local groundnut variety TMV 7 with three replications. In both the trials, the botanicals namely neem products, leaf extracts (LE), plant extracts (PE) rhizome extract (RE) of different indigenous plants and the check insecticide monocrotophos (0.05%) were sprayed twice at 30 DAS and 45 DAS using hand operated high volume sprayer. Observations were made on per cent damaged shoots of ten randomly selected plants prior to first spray and 7 and 14 days after each spray. Net plot yield was taken after harvesting and drying of pods.

Table 1. Effect of neem products against the bud borer of groundnut

Treatment	Mean damaged shoots(%)	Per cent over control	Pod yield (kg/ha)	Per cent over control
NSKE 5%	28.6(32.2)	-5.6	1848	18.6
Neem oil 3%	25.7(30.1)	-11.7	1700	9.2
Neem leaf extract 5%	27.0(31.1)	-8.8	1686	8.2
Nimbecidine 3ml/l	25.8(30.5)	-10.6	1583	1.6
Neem gold 3ml/l	26.6(31.0)	-9.1	1556	-0.1
Neem azal 2ml/l	26.9(31.0)	-9.1	1708	9.7
Achook 3g/l	26.3(30.8)	-9.7	1568	0.6
Monocrotophos 0.05%	24.0(29.2)	-14.4	1643	5.5
Control	33.4(34.1)	-	1558	-
SE	0.80		103.7	
CD (P=0.05)	2.22		NS	

Figures in parentheses are arc sin transformed means.

Received for publication in September, 1998

During the course of the study, the damaged shoots due to bud borer ranged between 20 to 35 per cent. The mean data showed a significant difference among the treatments. In both the trials, the check monocrotophos (0.05%) recorded low damage (44 and 25 per cent less over control). The results revealed that all the neem products were superior to control. However, neem oil (3%) was found to be effective with 12 per cent less damaged shoots than control (plants in control plot had 33% damaged shoots) (Table 1). Gunathilagaraj *et al*, (1987) found that spraying of Neem oil 3 per cent after seed treatment with NSKE 10 per cent was effective for the control of galerucid beetle and stem fly in *urd* bean. Neem oil 2 per cent was found effective in reducing pod damage due to pod borers in pigeonpea (Akhauri *et al.*, 1996). The yield was maximum in NSKE 5 per cent (1848 kg/ha), which was 19 per cent superior to control (1558 kg/ha).

All the indigenous plant extracts tested were superior to control in controlling the bud borer. But Vitex LE (5%) alone was effective with 21 per cent less damaged shoots than control, which registered 34 per cent damaged shoots. The yield data did not show significant difference. However, the yield was maximum in monocrotophos and *Ipomaea* LE (5%) (1570 kg/ha), while it was 1360 kg per ha in control. (Table 2). *Vitex negundo* leaf extract was found to be effective against *Spodoptera* in groundnut (Sahayaraj and Sekar, 1996)and *Achaea janatha* in castor (Muthukrishnan and Ananthagowri, 1994). The present study shows that the control of bud borer did not give yield advantage. Thus, it was found that bud borer can not cause greater crop loss, if the infestation occurs at the vegetative stage of groundnut. Present study also indicates that neem oil (3%) and *Vitex ne gundo* LE (5%) can be utilized for the control of *A . ephippias* in groundnut, instead of monocrotophos (0.05%).

Table 2. comparative efficacy of indigenous plant products against bud borer of groundnut.

Treatment	Mean damaged shoots (%)	Per cent over control	Pod yield (kg/ha)	Per cent over control
Eucalyptus LE 5%	26.0(30.5)	-13.8	1547	13.7
Tribulus PE 5%	24.9(29.7)	-16.1	1376	1.2
Vitex LE 5%	22.3(28.0)	-20.9	1380	1.5
Achorus RE 5%	24.6(29.6)	-16.4	1350	-0.7
Crotons PE 5%	29.2(32.5)	-8.2	1473	8.3
Ipomaea LE 5%	27.4(31.4)	-11.3	1570	15.4
Jatropa LE 5%	25.5(30.0)	-15.3	1470	8.1
Datura LE 5%	25.8(30.4)	-14.1	1470	8.1
Monocrotophos 0.05%	20.2(26.5)	-25.1	1570	15.5
Control	33.7(35.4)	-	1360	-
SE	0.72		106.2	
CD (P=0.05)	2.11		NS	

Figures in parentheses are arc sin transformed means.

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J. Oilseeds Res. 16(2) 1999 : 377-379
ISSN 0970-2776

EVALUATION OF MUSTARD (*Brassica juncea* L. CZERN and Coss.) GERMPLASM UNDER LATE SOWN CONDITIONS

In India, oilseed *Brassicas* are being cultivated under diverse agro climatic conditions. This diversity in cultivation exposes the crop to varied temperature, solar-radiations, humidity, disease and insect-pests ultimately affecting the growth and yield,thus varietal requirement differs widely. Further, diseases and pests cause considerable yield reduction. Yield losses ranging from 24 to 96% due to aphids (Phadke, 1980 ; Rohilla *et al.* 1987); 10 - 75% due to *Alternaria* blight (Saharan, 1992) and upto 90% due to white rust (Saharan and Lakra, 1988, Lakra and Saharan, 1989) have been reported. In the present investigation 242 accessions were evaluated under late sown conditions for agromorphological traits and for *Alternaria* blight *[Alternaria brassicae* (Berk.) Sacc.], white rust *[Albugo candida (Lev.)* Kunze] and aphid *(Lipaphis erysimi* Kalt) infestation to identify superior genotypes for utilisation in the breeding programme.

Two hundred and forty two accessions were planted in augmented design during *rabi* season 1996-97 at National Research Centre on Rapeseed-Mustard, Bharatpur. Each accession was planted in one row (0.4 g/sq.m seed), of 3 m length with spacings of 10 cm and 30 cm plant-to-plant and row-to-row, respectively under late sown conditions. Recommended doses of fertilizers 40 N : 17.5 P kg/ha were applied basally and the remaining 40 kg N / ha was top dressed after first irrigation. The recommended package of practices was followed for raising the crop.

Observations were recorded on 5 competitive plants taken randomly. The characters investigated were plant height (cm), primary and secondary branches/plant, main shoot length (cm), siliquae on main shoot, siliqua length, seeds / siliqua, 1000 - seed weight (g) and oil content (%). The range, mean and coefficients of variation were calculated to assess and compare variability using standard statistical methods.

Aphid infestation was recorded as per the method of Bakhetia and Sandhu (1973). Ten plants from each entry were visually observed at 50% flowering and at full-pod setting stage and aphid infestation index (A.I.I.) was computed as follows:

$$\text{A.I.I.} = \frac{0a+1b+2c+3d+4e+5f}{a+b+c+d+e+f}$$

where 0,1,2,3,4,5 : Grade / index given to each plant.

a,b,c,d,e,f : Frequencies of the plants under different grade / index.

Reactions to alternaria blight and white rust were recorded visually on five competitive randomly chosen plants as per the rating scale (Anonymous, 1994) described below :

O = No visible symptoms (H.R.), 1=1 - 10% leaf or pod area covered with small pin head spot in the leaves and superficial pinhead spots on pods (R), 2 = 11-25% leaf or pod area covered with small (majority less than 3 mm) spots on leaves and superficial pinhead on pods (MR), 3 = 26-50% leaf or pod area covered with bigger (more than 3mm) spots with initiation of coalesing on leaves and deep lesions on pods (S), 4=51-75% leaf or pod area covered with bigger commonly coalesing spots on leaves and deep lesions on the pods (HS), 5 = 76-100% leaf or pod area covered giving blighting appearance (HS).

The range, mean and coefficients of variability for nine agro-morphological traits under

Received for publication in October, 1998

Table -1 : Variability in agromorphological traits of mustard germplasm under late sown conditions.

Character	Range	Mean ± SEm	CV(%)	Useful donors
Plant height (cm)	85-174	127.5±1.2	15.2	TM 12, CSR 1044, CSR 611
Primary branches / plant	1.6-9.0	5.4 ± 0.1	20.9	NC 62894,JMG 429, TM 16
Secondary branches / plant	1.2-25.5	7.2 ± 0.3	53.8	S 29, NC 62894, CSR 278
Main shoot length (cm)	24-74	47.0 ± 0.5	18.3	CSR1096,R 17-26, MDOC 4
Siliquae on main shoot	12-52	28.6 ± 0.4	20.9	CSR 290, CSR 247, S 60
Siliqua length (cm)	2.8-6.2	4.4 ± 0.04	13.4	TM 18, JMG 391, CSR 807
Seeds / siliqua	*6.7-15.9*	*10.1 ± 0.1*	*12.5*	*CSR 499, RK 56-10,MDOC 53*
1000 - seed weight (g)	1.20-5.55	3.29 ± 0.04	21.0	KRV 718,JMG 408,JMG 421
Oil content (%)	*26.1-39.6*	36.1 ± 0.1	4.8	MDOC 27,MDOC 53,MDOC 4

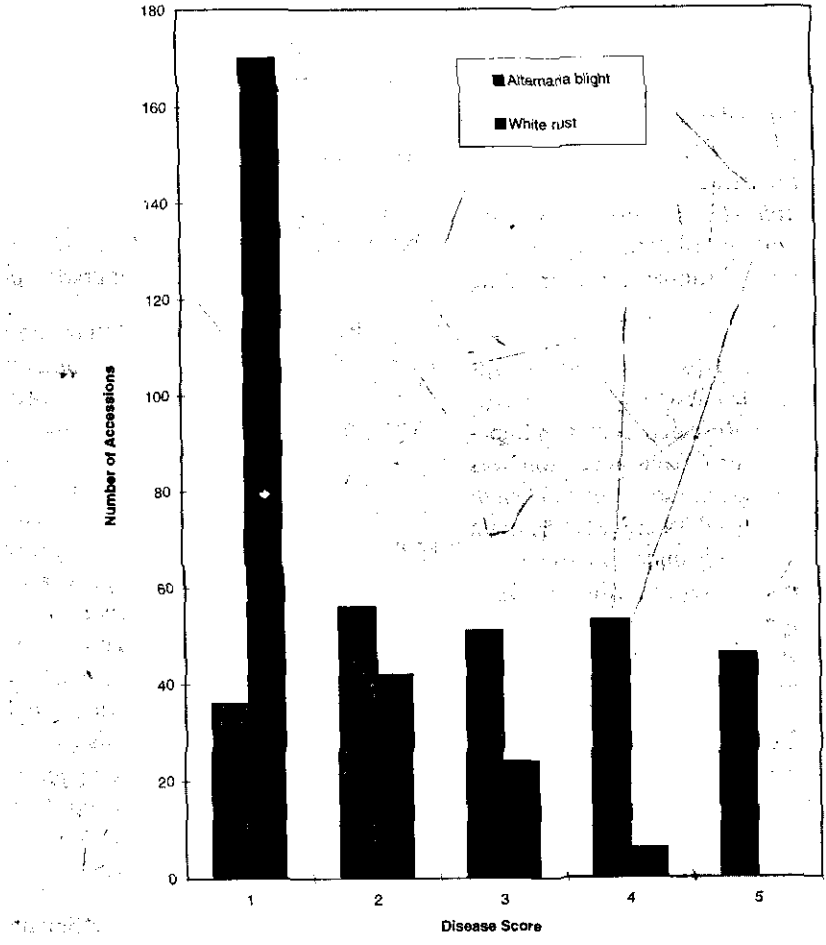

Fig. 1 Distribution of germplasm based on disease score

late sown conditions have been persented in Table 1. The secondary branches/plant had the maximum variation followed by 1000-seed weight, primary branches / plant and siliquae on main shoot. The oil content varied the least (CV 4.8%). In earlier studies (Yadav *et.al.* 1997) similar results were reported. The accessions MDOC 4, MDOC 27, and MDOC 53 exhibited high mean oil content among the accessions evaluated. Of these, MDOC 53 also had high number of seeds / siliqua. The three top most accessions for each trait are also listed in Table 1.

The aphid infestation index ranged from 0.7 to 1.8 and 4.4 to 5.0 respectively, at 50% flowering and full-pod setting stage. None of the accessions was tolerant to aphid infestation. The aphid infestation was very high. Of the 242 accessions, 37 (15.0%) exhibited resistance (field reaction) to alternaria leaf spot disease. About 62% of the accessions were susceptible and fairly a high proportion (70.0%) of the accessions showed resistance to white rust (Fig 1).

The promising accessions which could be utilised in the breeding programme to develop alternaria blight and white rust resistant / tolerant varieties of mustard are IB 1571, IB 1639, NC 60448, NC 50456, NC 60467, CSR 741 and CSR 820.

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J. Oilseeds Res. 16(2) 1999 : 380-381
ISSN 0970-2776

EFFECT OF DATE OF SOWING AND VARIETIES ON THE INCIDENCE OF MUSTARD APHID, *Lipaphis erysimi* (KALT.) ON RAPESEED-MUSTARD.

Thirty eight insects are known to be associated with rapeseed-mustard crop in India (Bakhetia and Sekhon, 1989). Mustard aphid, *Lipaphis erysimi* (Kalt.) is the key pest amongst them. Losses in yield due to this notorious pest have been worked out in different parts of India. Losses are known to vary from 35.4 to 77.3 per cent (Bakhetia, 1983). Studies were therefore conducted to determine the suitable date of planting for rapeseed-mustard so as to avoid incidence of the aphid.

Present studies to find out the effect of sowing time and varieties on the incidence of mustard aphid, *Lipaphis erysimi* was conducted in a split plot design with three replications at the Oilseeds Research Station, Kangra during *rabi* season 1993-94 and 1994-95. Four varieties HPN-1 *(B.napus)*, BSH-1(*B.campestris* var brown sarson), Varuna *(B. juncea)*, HPC-1(*B.carinata)* were sown in first and third week of October, 1993 and 1994 and first and third week of November, 1993 and 1994. All the recommended management practices were adopted to raise the rapeseed-mustard crop and no insecticidal spray was given throughout the crop period. The occurence of mustard aphid and its population build up were recorded at full flowering stage and full pod setting stage of the crops. The yield of various varieties was recorded at harvest.

Rapeseed-mustard varieties sown during first and third week of October, 1993 and 1994 experienced minimum level of aphid infestation, while those sown in first and third week of November, 1993 and 1994 were infested heavily (Table 1). Among the varieties, the *gobhi sarson* (HPN-1) was highly susceptible to the aphid attack while *B. carinata* (HPC-1) was least infested as compared to other varieties. Varieties sown early provided greater yield, while Varuna and HPC-1 gave higher yield than the rest, irrespective of sowing date (Table 2). It was concluded that early sown crops (first week to third week of October,) were less damaged by the aphid infestation, hence gave the highest yields. Similar observations have earlier been made (Bhadauria *et al.,* 1992; Phadka and Prasad, 1987).

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Received for publication in October, 1998

Table 1 : Effect of date of sowing and varieties on mustard aphid population (Pooled data 1993-94 and 1994-95).

Varieties	Mean aphid population / plant				
	Dates of Sowing				
	05 Oct.	20 Oct.	4 Nov.	19 Nov.	Mean
HPN -1	7.47	7.1	17.21	9.57	10.33
BSH -1	3.94	4.89	9.61	8.09	6.63
Varuna	2.26	4.32	7.86	9.2	5.91
HPC - 1	4.41	5.11	7.9	5.4	5.70
Mean	4.52	5.35	10.64	8.06	

CD at 5% for date of sowing = 1.95, CD at 5% for varies= NS, CD at 5% for D / S & V = NS.

Table 2 : Effect of date of sowing and varieties on yield of mustard (Pooled data 1993-94 and 1994 -95).

Varieties	05 Oct.	20 Oct.	04 Nov.	19 Nov.	Mean
HPN - 1	2118	1212	1279	909	1380
BSH - 1	1205	1140	773	606	931
Varuna	1539	1745	1273	1177	1439
HPC - 1	2287	1733	1279	1178	1620
Mean	1787	1458	1151	968	

CD at 5% for date of Sowing = 147.79, CD at 5% for varieties = 161.69, CD for interaction (D/S x V) = 353.

J. Oilseeds Res. 16(2) 1999 : 382-390
ISSN 0970-2776

Summaries of Research Papers

Abha Agnihotri. 1999. Screening techniques for evaluation of double low characteristics in Oilseed Brassicas. *J.Oilseeds Res.* 16 (2) : 183-195.

Oilseed Brassicas are the second most important edible oilseed crop of India. Of late, with the growing awareness about nutritional quality of oil and meal, emphasis has been shifted towards breeding for quality traits Indian Rapeseed-mustard have higher amounts of antinutritional components such as erucic acid and glucosinolates which are governed by multiple recessive genes. Lack of cost-effective, efficient and precise analytical methods may restrict breeding efforts towards development of double low ('00' or canola quality) cultivars. This review article discusses various analytical methods for estimation of erucic acid and glucosinolates.

Gupta, P.C and Sharma, G.S. 1999. Combining ability and heterosis for seed yield and its related traits in Indian mustard (*Brassica juncea* (L) Czern & Coss). *J.Oilseeds Res.* 16 (2) : 196-202.

Combining ability analysis through a diallel set involving 9 genotypes of Indian mustard for 12 characters in 2 environments revealed the importance of both additive and non additive gene action. Varieties RH781 and Creampool in stress environment and PHR-1, RC781, T59, Pusa Bold and Creampool in normal environment were identified as good general combiners for seed and oil yields. The hybrid creampool x RH781 in stressed and RG781 x RC781 in nonstressed environment were superior on *per-se* performance basis and *sca* effects.

Bhand, D.J. and Patel, D.R. 1999. Genetics of resistance to reniform nematode in castor (*Ricinus Communis* L). *J. Oilseeds Res.* 16 (2) : 203-209.

Nine crosses of castor were evaluated for reaction to reniform nematode (*Rotylenchulus reniformis*) in pots at GAU, Anand. High magnitude of additive and non additive gene effects in expression of resistance in hybrid combination SPS 43-3 x 48-1 with greater mean and significant heterosis (-41.42%) and heterobeltiosis (-40.98%) was observed in desirable negative direction. This suggests that the isolation of homozygous recombinants having desirable level of resistance to reniform nemetode from advance segregating generations would be feasible.

Rajanna, M.P., Seetharam, A., Virupakshappa, K. and Nagaraju. 1999. Reaction of diverse CMS sources, testers and their hybrids to downy mildew caused by *Plasmopara halsteidii* in sunflower (*Helianthus annuus* L.). *J. Oilseeds Res.* 16(2) : 210-212.

Thirty six sunflower hybrids developed using 3 diverse sources of CMS *H. petiolaris* (CMSF), *H. Petiolaris* SSP fallax (CMS-PF) and *H. annuus* SSP *lenticularis* (CMS-1) along with their male and female parents were screened in sick plots at UAS Bangalore. Among these CMS-F recorded 86% susceptibility while CMS-PF and CMS-1 exhibited complete resistance. Restorer varied from highly resistant to complete susceptibility in their reaction. The hybrids derived from CMS-F background varied in susceptibility from 30.3 to 100%, while those derived from CMS-1 showed 0 to 60% susceptibility. All hybrids of CMS-PF background were free from downy mildew. Female parents seems to have greater influnce on level of resistance of bybrids.

Gupta, T.R., Pal, S.S and Inderjit Singh. 1999. Parameters of genetic variability and correlation studies in linsced (*Linum usitatissimum* L). *J.Oilseeds Res.* 16 (2) : 213-215.

Studies conducted at PAU, Gurdaspur showed higher genetic variation for all characters barring plant height. High heritability coupled with high genetic advance was observed for no. of capsules/plant, primary and secondary branches. Grain yield was postitively correlated with all characters except plant height.

Bera, S.K and Das, P.K. 1999. Study of genetic devergence in groundnut over locations. *J. Oilseeds Res.* 16 (2) : 216-218.

Studies made at Midnapur and Purulia of West Bengal revealed that cluster composition and intercluster genetic divergence varied with location. The first 2 cononical roots accounted for 55% and 70% of the total variability for Midnapur and Purulia, respectively. Pod yield/plant, Harvest index and test weight were major contributors of total genetic divergence.

Verma, S.S., Tomer, R.P.S. and Verma, U. 1999. Studies on physiological and biochemical aspects of seed quality in natural aged seeds of Indian mustard (*Brassica juncea* L.). *J. Oilseeds Res.* 16 (2) : 219-226.

Eight seed lots of mustard comprising RH30 and RH8113 varieties were subjected to various physiological and biochemical tests. It was found that seed quality and vigour of all the lots declined considerably after 2 years and the decline was more rapid in 3 and 4 year old seed of both the varieties. With increase in age of the seed there was decline in germination, speed of germination, seedling vigour, respiration rate, protein, peroxidase activity, and grain yield. However, there was increase in electrical conductivity and total soluble carbohydrates with age.

Abha Agnihotri and Nutan Kaushik. 1999. Transfer of double low characteristics in early maturing *Brassica napus*. *J. Oilseeds Res.* 16 (2) : 227-229.

The work carried out at Tata Energy Research Institute, New Delhi reports transfer of low erucic acid and low glucosinolate characters from exotic sources (*B.napus* var. Regent and Cyclone) to the early maturing lines of *B.napus* through interspecific hybridisation and half seed analysis. Fatty acid and glucosinolates were analysed by GLC and HPLC. The new double low strains TERI (00) R985 and TERI (00) R986 have zero erucic acid in oil and low glucosinolate (12-15 μ m/g) in the oilfree meal. The former variety is dwarf, early maturing and suits rainfed conditions.

Ramesh Kumar; Sah, J.N and Ghosh, J. 1999. Genetic divergence in mutant cultures of groundnut (*Arachis hypogaea* L.). *J.Oilseeds Res.* 16 (2) : 230-233.

At Pusa, 21 mutant cultures of groundnut (M_7 generation) were evaluated for genetic divergence on the basis of 13 characters. The culturers were grouped into 16 clusters. The divergence was due to genetic distance as the cultures were derived from AK-12-24 parent by mutagenesis. Crossing between cultures in cluster VI and XVI may bring about desirable types because of greater inter-cluster distance.

Viswanathan, P.L., Nadarajan, N and Ramamoorthy, N. 1999. Comparison of macro mutation frequency in homozygous and hetero zygous genotypes of groundnut by gammarays. *J.Oilseeds Res.* 16 (2) : 234-240.

Seeds of 6 parents and 9 crosses were subjected to 20 Krad of gamma rays at Coimbatore. The F_2, M_2

and F_2M_2 progenies were scored for frequencies of morphological variants. F_2M_2 had the highest frequency of variations followed by M_2 generation. Variants with erect type, dwarf type, imparipinnate leaflets, bifurcated leaflets, bold pods and variagated testa colour were identified.

Hegde, D.M., Patil, H.S., Singh, B.R and Goswami, U. 1999. Phenotypic stability for seed yield in niger. *J.Oilseeds Res.* 16 (2) : 241-244.

Eight niger genotypes were evaluated at 7 locations for yield. The genotypes JNS-7, GA-10, BNS-9, SNS-8 and No.71 were found to be well adopted across environments for seed yield. Genotypes with high mean performance were better responsive to favourable environments. A positive and significant correlation between regression coefficient and coefficient of determination was observed suggesting that the stability parameters were governed by independent genotypic system in niger.

Jain, H.C., Deshmukh, M.R and Hegde, D.M. 1999. Integrated weed management in Kharif sesame (*Sesamum indicum* L.). *J.Oilseeds Res.* 16 (2) : 245-249.

Field experiments carried out during 1994-1997 at 5 locations showed that on alfisols at Vriddhachalam, Alachlor granules 2 kg ai/ha+ hand weeding at 30 DAS recorded highest yield. Considering economics, one hand weeding (20DAS) at Vridhachalam, 2 hand weedings at Amreli and Mandore, 3 hand weedings at Tikamgarh and 2 hoeings and hand weedings (20&30 DAS) at Jalgaon are recommended for effective weed management in sesame.

Mudalagiriyappa, Nanjappa, H.V and Ramachandrappa, B.K. 1999. Effect of soil solarization on certain soil properties, growth and yield of groundnut. *J.Oilseeds Res.* 16 (2) : 250-252.

Studies conducted at Bangalore revealed that solar heating of soil by polyethylene sheets during summer increased the soil temperature by 9-11°C in upper soil layers and enhanced plant growth of groundnut even in the absense of known pathogens. Solarized soils had increased nitrate nitrogen content and available phosphorus.

Reddy, M.D and Kumar, K.A. 1999. Effect of irrigation scheduling on performance of groundnut. J.Oilseeds Res. 16 (2): 253-256.

Field investigations made at Jagtial revealed that the crop irrigated at 0.8 Eta/Etm throughout crop growth period though resulted in lower pod yield, enhanced water use efficiency (6.49 kg/mm water) as compared with other irrigation schedules.

Chandrasekhar Reddy, K and Riazuddin Ahmed. 1999. Soil test based fertilizer recommendations for groundnut grown in rice fallows (inceptisols) of Jagtial in Andhra Pradesh. *J.Oilseeds Res.* 16 (2) : 257-262.

Multiple regression models for predicting pod yield through soil fertilizer nutrients and their interaction have been calibrated. Fertilizer adjustment equations based on targetted yield concept have been developed. A ready reckoner of fertilizers at varying soil test values for yield targets of 25 and 30 q/ ha have been worked out. Field verification trails have been conducted in farmers fields of Nizamabad and Kurnool districts to verify the results. Soil test crop response recommendation of fertilizers has given higher B:C ratios compared with farmers practice.

Pujari, B.T. and Sheelvantar, M.N. 1999 Effect of pigeonpea-based intercropping on the dry matter accumulation in plant parts of soybean. *J.Oilseeds Res.* 16 (2) : 263-266.

Field trials conducted at Gulbarga on vertisols during 1992 & 1993 showed that sole soybean at 50 DAS produced significantly higher dry matter (14.77g/pl) compared with intercropped soybean (12.39 g/pl). Similar trend was noticed at harvest stage. The intercropped soybean under 2:4 and 1:2 (12.69g/pl) row ratios of pigeonpea + soybean produced substantially greater dry matter at harvest than 2:1 ratio (9.3 g/plant).

Agrawal, K.K., Tiwari, J.P and Gautam, S.P. 1999. Response of linseed varieties to irrigation and fertility levels. *J. Oilseeds Res.* 16 (2) : 267-270.

Studies made at Jabalpur during 1989 & 1990 revealed that two irrigations improved plant growth, yield attributes and seed yield than one irrigation in linseed. Highest yield was obtained with 60-30-15 NPK kg/ha coupled with 2 irrigations in JL-23 cultivar. Variety JL-23 out yielded T-397 and JLS-1.

Raghavaiah, C.V and Anjani, K. 1999. Certified seed production of safflower hybrids in relation to plant density and nutrition in alfisols under irrigated conditions. *J.Oilseeds Res.* 16 (2) : 271-275.

Field investigations carried out at DOR, Hyderabad for 3 years showed that maximum DSH-129 hybrid seed yield was obtained with a spacing of 45x30cm. Spacings had not influenced the yield of DSH-130 hybrid in 1995. In 1996 sowing at 45x30cm along with application of 80-80-40 kg NPK/ha gave significantly higher yield of pollen parent A-1. Application of 80-80-40 kg NPK/ha gave maximum hybrid seed yield of DSH-129. Plant densities or fertilizer did not significantly alter the test weight of hybrid seed. The differential behaviour of safflower hybrids could be due to *per se* performance of their male sterile lines and their combining ability with pollen parent. Pollen availability and honey bee population at flowering time may influence seed production.

Nagavallemma, K. P and Ramachandra Reddy, D. 1999. Studies on available sulphur status and groundnut response in coastal alluvial soils of Nellore district (A.P). *J. Oilseeds Res.* 16(2) : 276-280.

Studies on sulphur status of Nellore district soils revealed that the S content ranged from 104-166 ppm. Studies under green house condition showed that Sulphur application significantly increased dry matter and Sulphur uptake by groundnut at 30 and 60 DAS. Sulphur had synergestic effect on uptake of N,P,K. The available S extracted with 0.15% $Cacl_2$, 1% Nacl and NNH4oAc pH (7.0) was positively and significantly correlated with drymatter yield and uptake by groundnut at 60 DAS.

Tripathy, S.K., Patra, A.K., Samui, R.C and Mohapatra, S. 1999. Response of groundnut (*Arachis hypogaea*) seeds to drying and storage methods. *J.Oilseeds Res.* 16(2) : 281.284.

The influence of different methods of drying and storage on seed viability, fungal invasion, moisture and sugar content in seed of JL 24 groundnut was studied at kalyani for 2 seasons. It was observed that with increase in storage period, viability of seeds decreased, while the activity of fungal flora, moisture and sugar contents in seeds increased. Pods dried adopting farmers method and stripping of pods and direct exposure to sunlight lost viability rapidly. Shade drying of pods and adopting DOR method maintained seed viability for longer period. Storage of groundnut in plastic silo and in polythene lined gunny bag containing anhydrous $CaCl_2$ proved better.

Gupta, S.K., Bhagat, K.L., Khanna, Y.P and Gupta, S.C. 1999. Performance of Abyssinian mustard *Brassica Carinata*) under rainfed conditions of Jammu. *J.Oilseeds Res.* 16(2) : 285-288.

Experimnets conducted during winter 1995 through 1997 under rainfed conditions at Jammu showed hat genotypes PC-5, PCC5 and NPC2 performed better in respect of growth and outyielded the rest in seed yield and oil content.

Jadhav, G.S., Bhoje, V.S and Karanjikar, P.N. 1999. Optimum sowing time for groundnut (*Arachis hypogaea* L.) genotypes during postmonsoon season in Marathwada. *J.Oilseeds Res.* 16 (2) :289-294.

Field studies made at Parbhani during rabi 1995 and 1996 revealed that sowing groundnut on 15 September gave significantly higher pod yield than delayed seeding. Early maturing spanish bunch variety TAG-24 followed by semi spreading spanish bunch varieties like ICGS-44, ICGS-11 gave higher pod yield than others.

Raghavaiah, C.V. 1999. Performance of castor (*Ricinus communis* L.) hybrids under different levels of fertilizer in rainfed conditions on alfisols. *J.Oilseeds Res.* 16 (2) : 295-298.

Experiments conducted at DOR, Hyderabad during 1996-1998 under rainfed conditions showed that the hybrid DCH-177 outyielded DCH178, DCH30 and GCH-4 hybrids. In seasons of adequate rainfall the crop responded upto 150% recommended dose of fertilizer (60-60-0 NPK/ha). Genotype x fertilizer interaction showed that DCH-177 when fertilized with 75% RDF + Fym 5 t/ha showed distinct increase in seed yield. In seasons of scanty rainfall the response to applied fertilizer was not discernible. Hybrids differed in oil content, while fertilizer had a desirable effect on oil content of castor.

Vimala Devi, P.S and Prasad, Y.G. 1999. Efficacy of *Bacillus thuringiensis* against castor semilooper *Achoea janata* Linn. (Lepidoptera Noctuidae). *J.Oilseeds Res.* 16 (2) : 299-302.

Studies made at DOR, Hyderabad on the efficacy of B.t.formulations against castor semilooper showed that feeding cessation occured in larvae exposed to B.t. sprayed castor leaves. Both the varieties of B.t were comparable to monocrotophos 0.05%. Effective control of semilooper (84.3% mortality) was obtained in the field with B.tvar.Kurstaki (0.5%) even under high pest load (10-15 larvae/plant). B.t was found safe for the larval parasitoid *Microplitis maculipennis*.

Praveena, B.; Srinivas, C.V.S and Nagaraj, G. 1999. Utilization of sunflower cake and its protein isolate in some Indian snack items. *J.Oilseeds Res.* 16 (2) : 303-305.

Wholeseed sunflower cake, partially dehulled cake and fully dehulled cake flours and their protein isolates were used in preparation of biscuits and Indian foods like *Pakodi* and *Chapathi*. Different grades of sunflower cake added @ 10% enhanced the protein of the snacks from 11-21g/100g in control to 13-24g/100g. Protein isolate addition @ 5% increased protein of food items to 14.5 - 25g over control. The acceptability of food items was 50-90% for the protein biscuits and snacks based on taste panel report.

Dubey, C.S and Ali, M. 1999. Yield, economics and sustainability parameters in linseed frontline demonstrations in Kota division. *J.Oilseeds Res.* 16 (2) : 306-309.

Results of 68 frontline demonstrations conducted during *rabi* 1991 to 1995 in Kota division of Rajasthan showed that cultivation of linseed under high fertility was more profitable than those under rainfed

and low fertility conditions. Sustainability parameters like sustainable yield index (sy1) and sustainble value index (SV1) were greater with improved technology.

Padmaiah, M., Ramamohan Rao, M.S., Chandrappa, M and Govind Prasad. 1999. Impact of conservation practices on soil moisture and crop yield in a water shed- A case study. *J.Oilseeds Res.* 16 (2) : 310-313.

Attempts made to understand the effect of moisture conservation measures at terrace and inter terrace levels on farmers fields in water shed areas of Kurnool district revealed that lowcost measures like compartmental bunding and contour cultivation are equally effective in conserving soil moisture and in positively influencing yields of groundnut and sorghum crops.

Singh, A.K; Chauhan, Y.S. and Kumar, K. 1999. Combining ability analysis in rapeseed (*Brassica Campestris* L.) using recessive genic male sterility. *J. Oil Seeds Res.* 16 (2) : 314-316.

Comparison of *Sca* effects in relation to *gca* effects of the parental lines showed that crosses with high *Sca* effects involved low x high, high x low and lowxlow general combiners. Crosses YSMS 8163xYST 151, MSTIxT9 and MST-1xYellow Toria with high *sca* effects and high *per se* performance may give rise to high yielding hybrids by using genic male sterility in rapeseed.

Lokendra Kumar; Mahendra Singh, Saroha, G.P; Sheoran, R.K. and Subhadra. 1999. Selection response in seed yield through direct and indirect selection in sunflower. *J.Oilseeds Res* 16(2) : 317-319.

Studies made at Hisar showed that seed yield and its components in EC-68414 population may be genetically improved through indirect selection based on days to 50% flowering. However optimum days to 50% flowering has to be ascertained through construction of multiple trait selection indices in sunflower.

Parameswari,C. and Muralidharan, V. 1999. Estimates of genetic variability in intermated progenies of sesame. *J.Oilseeds Res.* 16(2) : 320-322.

Investigation made at TNAU, Coimbatore to study extent of genetic vaariability created through intermating in F2 generation of sesame indicated that high heritability coupled with high genetic advance was recorded by the intermated progenies for all the characters except plant height, seed number/capsule and 1000 seed weight. Due to superior mean performance, higher GCV and heritability and genetic advance, the intermated progenies may be considered suitable for selection of superior plants compared to F3 generation.

Chavan, A.A; Patil, V.D and Mane, R.M. 1999. Correlation and path analysis in certain metric traits in safflower. *J.Oilseeds Res.* 16 (2) : 323-326.

The study revealed that plant height, no.of secondary branches, no.of capsules and seeds/capsule are most important characters as they showed greater positive effects on seed yield.

Hosmath, J.A and Patil, V.C. 1999. Evaluation of suitable intercrops for intercropping with sesame (*Sesamum indicum* L). *J.Oilseeds Res.* 16 (2) : 327-330.

Experiment conducted at Dharwad revealed that among the intercrops tried groundnut, frenchbean and greengram were found to be the best in terms of yield, yield advantages and economic returns.

Krishnamurthy, K.S, Umashanker, R and Ganeshaiah, K.N. 1999. Is the duration of seed dormancy influenced by water availability during reproductive growth period in sunflower? *J. Oilseeds Res.* 16 (2) : 331-334.

Studies conducted at UAS, Bangalore on 5 sunflower genotypes to assess the effect of moisture stress at early reproductive stage and seed filling stage on seed dormancy revealed that moisture stress increased the duration of dormancy in Morden, MSFH- 1 and EC 68 415. There was difference in frequency destribution of timing of germination between 3 pairs for most of the genotypes, which could be due to changes in promoter - inhibitor concentrations.

Patra, A.K., Nayak, B.C and Mishra, M.M. 1999. Agronomic practices for yield improvement of Kharif groundnut in Western Orissa. *J. Oilseeds Res.* 16 (2) : 335-336.

Experiments conducted for two seasons at Chiplima showed that application of higher level of phosphorus and spray of growth retardant MH @ 250 ppm at 42 DAS increased the no. of pods/plant and pod weight/plant, but no.of Kernels/pod and shelling percent remained unaltered.

Aruna, V. and Narasa Reddy, S. 1999. Influence of Integrated supply of nitrogen through organic and inorganic sources on growth, nutrient uptake and yield of soybean. *J.Oilseeds Res.* 16 (2) : 337-339.

Field trail conducted at Bapatla during rabi 1995-96 on soybean showed that biogasslurry @ 15 t/ha + 50 kg N/ha through urea gave significantly higher seed yield with greater uptake of NPK in seed and haulms than other sources at Corresponding level.

Tomar, H.S., Shrivastava, G.K., Tiwai, O.P. and Tripathi, R.S. 1999. *Influence of irrigation* schedules on growth and yield of summer sesame. *J. Oilseeds Res.* 16 (2) : 340-342.

Studies conducted at Raipur during summer 1997 revealed that irrigation at IW/CPE ratio of 0.5+0.7 (6 irrigations at 22,47,57,67,76 and 83 days) produced maximum sesame yield of 16.8 q/ha. Water stress should be avoided at vegetative, flowering and capsule formation stages to achieve better production of sesame.

Vishwakarma, S.K., Sharma, R.S and Upadhyaya, V.B. 1999. *Effect of sources and levels of* sulphur on chlorophyll, protein and oil output in soybean (*Clycine max*. L. Merrill). *J. Oilseeds Res.* 16 (2) : 343-345.

Studies conducted at JNKVV, Jabalpur during 1995 and 1996 rainy season showed that application of Sulphur increased Protein content in seeds over control but the differences between sources or levels of S were non significant. Oil content in seeds did not vary due to sulphur sources; however oil content increased upto 10 kg S/ha. Oil yield increased by 22.5, 32 and 35.5 percent with 10.20 and 40 kg S/ha, respectively.

Patel, J.R. 1999. Effect of spacing, nitrogen and phosphorus on summer groundnut. *J.Oilseeds Res.* 16 (2) : 346-347.

Experiments carried out at Raipur during 1993 revealed that sowing at 30x15cm and 30x10cm remaining comparable were superior to 30x20 cm in pod yield. The crop responded upto 25 kg N/ha and upto 60 kg P_2O_5/ha during summer season.

Kathiresan, G; Manickam, G and Gnanamurthy, P. 1999. Effect of enriched farmyard manure and time of gypsum application on growth and yield of soybean (*Glycine max*). *J. Oilseeds Res.* 16 (2) : 348-349.

Feild studies made at Vriddhachalam during *rabi* 1993, 1994 indicated that maximum soybean yield of 2031 kg/ha was obtained with enriched FYM application which was 32.4% higher than control Significant increase in yield (1986 kg/ha), net return (Rs. 10,470/ha) and B: C ratio (2.93) were also recorded with split application of gypsum @ 200 kg/ha.

Chandranath, H.T., Satyanarayana Guggari, A.K. and Nadagoud, V.B. 1999. Integrated weed management in sunflower. *J. Oilseeds Res.* 16 (2) : 350-353.

Experiments carried out at Raichur during 1994-96 elucidated that pre-emergence application of Pendimethalin 1.0l ai/ha or Fluchloralin 1.0 l ai/ha followed by one hand weeding and interculture at 35 DAS was found to be effective in suppressing weeds and for obtaining higher sunflower yields under irrigated condition.

Sanjeev Kumar and Arvind Kumar. 1999. Dry matter partitioning in different plant parts of Spanish and Virginia groundnut cultivars in mid-western plains of U.P. *J. Oilseeds Res.* 16 (2) : 354-357.

Investigation made at GBPUA & T during 1995-96 showed that among Spanish group of cultivars SG - 84 gave higher pod yield due to greater no.of branches/pl than others. Among Virginia group chitra and BG 3 were superior to other cultivars in terms of yield. Pod yield of groundnut was directly correlated with no.of branches (0.583*) and total dry matter production (0.755**) per plant.

Hanumanthappa, M; Sreeramulu, K.R. and Kalyanamurthy, K. N. 1999. Differential response of soybean varieties to phosphorus uptake under field conditions. *J. Oilseeds Res.* 16 (2) : 358-359.

Field trials conducted at Dharwad during 1988 with 3 soybean varieties and 4 phosphorus levels showed that Hardee variety had higher P uptake than Monetta and KHS b-2. The uptake of P increased from flower initiation to harvest stage. Hardee also recorded maximum yield. (18.1q/ha) which was superior to Monetta (16.0q/ha) and KHSb - 2 (15.1q/ha). Application of 80 kg P_2O_5/ha was found economical.

Patel, J.R. 1999. Response of niger to levels of nitrogen and phosphorus. *J. Oilseeds Res.* 16 (2) : 360-361.

Experiments laid out at Raipur indicated that higher yield of niger could be obtained with the application of nitrogen and phosphorus individually at 30 kg/ha. It was also found that split application of N in 25:75 or 50:50 proportion as basal and top dressing at 30 DAS is beneficial for higher yield of niger.

Vijaya Kumar, C; RamaRao, S; Singa Rao, M and Prabhu Prasadini, R. 1999. Effect of tillage and phosphorus fertilization on growth and yield of groundnut grown after puddled rice. *J. Oilseeds Res.* 16 (2) : 362-366.

Field trials executed at Rajendranagar, Hyderabad revealed that tillage with either power tiller operated rotavator or tractor drawn implements (disc plow + disc harrow) and P fertilization upto 90 kg P_2O_5 ha gave higher yield of summer groundnut raised after puddled rice in red loamy sandy soils in Southern Telengana Zone of Andhra Pradesh.

Dinakaran, D. and Dharmalingam, V. 1999. Estimation of yield loss due to sesame powdery mildew (*Oidium acanthospermi*). *J. Oilseeds Res.* 16 (2) : 367-368.

Trials conducted at Vriddhachalam for 2 years with four sesame varieties indicated that the estimated loss in yield due to powdery mildew ranged between 6.0 and 11.18 percent. The variety Co-1 was found to be least affected (61.5%) while G.Til-1 showed highest incidence of 95% under unprotected condition. Powdery mildew incidence occured between 35-40 days after sowing.

Harinath Naidu, P and Moses, G.J. 1999. Resistance to Kalahasti malady (*Tylenchorhynchus brevilineatus*) in advanced varieties of groundnut. *J. Oilseeds Res.* 16 (2) : 369-370.

Trials conducted at Srikalahasti during *rabi* 1992 and 1993 showed that the groundnut variety TCGS-115 gave significantly higher pod and kernel yields of 31.8 and 24.3 q/ha and exhibited resistant reaction. Two varieties TCGS-18 and TPT-2 showed moderately resistant reaction and tolerant genotypes are TCGS-113 and TCGS-114 which can be developed further.

Ajai Srivastava, 1999. Bioefficacy of some insecticides against mustand aphid in Himachal Pradesh. *J. Oilseeds Res* 16 (2) : 371-373.

Field investigations made at Kangra for 3 years (1990 to 1992) revealed that application of fenvalerate, Decamethrin, cypermethrin and Dimethoate gave higher yield than with other insecticides. Cypermethrin 0.01%, fenvalerate 0.02% are recommended for control of mustard aphid.

Senguttuvan, T and Dhanakodi, C.V. 1999. Effect of Botanicals against groundnut bud borer, *Anarsia ephippias* (meyrick). *J. Oilseeds Res.* 16 (2) : 374-376.

Studies made at Vamban (TN) in *rabi* 1996-97 showed that the control of bud borer did not result in yield advantage. It can not cause great crop loss if infestation occurs at vegetative stage of the crop. Neem oil 3% and Vitex negundo LE 5% can be used for the control of bud borer in groundnut instead of monocrotophos 0.05%.

Chauhan, J.S., Shukla, A.K., Singh, Y.P. and Kumar, P.R. 1999. Evaluation of mustard (*Brassica juncea* L.) Czern and Coss) germplasm under late sown conditions. *J. Oilseeds Res.* 16 (2) : 377-379.

Field evaluation made during *rabi* 1996-97 at Bharatpur revealed that the promising accessions which could be utilized in breeding programmes for tolerance to alternaria blight and white rust are IB 1571, IB 1639, NC 60448, NO 50456, NC 60467, CSR 741 and CSR 820.

Ajai Srivastava. 1999. Effect of date of sowing and varieties on the incidence of mustard aphid *Lipaphis erysimi* (kalt) on rapeseed-mustard. *J. Oilseeds Res.* 16 (2) : 380-381.

Studies carried out at Kangra (HP) indicated that early sown crop (first week to 3rd week of October) has less aphid infestation and provided greater yields. Varieties Varuna and HPC-1 gave higher yield than the rest irrespective of sowing date. Gobhisarson variety HPN-1 was highly susceptible, while *B. Carinata* variety HPC-1 was least infested by aphids.

The ISOR acknowledges with thanks the services of the following referees for their Cooperation and critical review of papers published in Volume 16(1&2), 1999.

1. Dr. C.A. Agasimani
2. Dr. N.N. Angiras
3. Dr. D.R.C. Bakhetia
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Indian Society of Oilseeds Research thankfully acknowledges the financial assistance received from Indian Council of Agricultural Research, New Delhi for Printing this Journal.

Edited and Published by the Indian Society of Oilseeds Research
Directorate of Oilseeds Research, Rajendranagar, Hyderabad - 500 030.
Printed at PROGRESSIVE PRESS PVT. LTD.
Balanagar, Hyderabad - 500 037 Phone Nos. : 3774221, 3770241