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GENETIC IMPROVEMENT - CHALLENGES AND FUTURE STRATEGIES IN SUNFLOWER IN INDIA

S.S.Sindagi A.Seetharam K.Virupakshappa
Project Co-ordinating Unit (Sunflower) GKVK, Bangalore - 560 065

INTRODUCTION:

Sunflower (*Helianthus annuus L)* as an edible oilseed crop was introduced to India about 30 years back. But, the crop did not receive much attention because of low oil content in the varieties then introduced and high susceptibility to diseases. Interest in this crop revived again when Russian varieties with high oil content (> 50%) were available in late 1960s. In 1969, four varietie of Russian origin - VNIIMK 8931 (EC-68413), Peredovick (EC-68414), Armavirskij 3497 (EC-68415) and Armaverts (EC-69874) were introduced. These varieties along with an earlier introduction from Canada 'Sunrise' were extensively tested under the aegis of ICAR during *Rabi* 1969-70 and *Kharif* 1970-71. These trials indicated that Sunflower can be successfully grown in the country and to begin with all the above five varieties were recommended for commercial cultivation. Out of these five, two varieties - EC-68414 and EC-68415 became popular with the farmers and are still being cultivated over a large area. The variety EC-68415 is popular in Karnataka State while EC-68414 in other states of the country. Subsequently, one early maturing accession EC-101495 was identified in the course of screening and evaluation of germplasm collections at Bangalore (Seetharam *et al,* 1978). This accession was nothing but "Cernianka - 66", an early ripening variety developed in USSR which was called by the name Morden on its introduction to Canada. This strain was released under the name 'Morden' in the year 1979 for cultivation in Karnataka and in 1980 in all states. This variety even to-day is widely grown in the country because of its early maturity, short stature and suitability to multiple and mixed cropping systems. Salient features of Morden variety as compared to EC-68415 are given in Table - 1.

Genetic improvement of sunflower in India started in 1972 with the establishment of five Research centres at - Coimbatore, Bangalore, Digraj, Akola and Kota under AICORPO .The research in the first few years was quite broad based and embraced many facets. Both basic and applied research was conducted

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on a variety of aspects and this helped to gain an insight into the genetic architecture of the crop. Though the value of hybrids and heterosis breeding was recognised quite early 15 years ago, their exploitation has not been appreciable. During the last 10 years there has been too much of emphasis in introduction of exotic hybrids and their commercialization rather than promoting capabilities to develop indigenously new hybrids, composites and synthetics. In this paper an attempt has been made to review breeding research so far made in India, the challenges and future strategies to be adopted to make Sunflower a competitive oilseed crop in the coming years.

BREEDING RESEARCHES IN INDIA SINCE 1972 VARIETIES DEVELOPED IN AICORPO:

During the last 15 years many open pollinated varieties have been developed and this has widened the varietal base. A high yielding variety 'Surya' was evolved at Akola centre by mass selection using Latur bulk as the base material. This variety was released in 1980 and recommended for cultivation in Maharashtra State. Another very early maturing strain 'CO-1' was developed and released from Coimbatore centre for cultivation in Tamilnadu State. This variety matures in 65-70 days as compared to 80-85 days taken by Morden. The variety CO-1 is a further selection from Cernianka - 66 or Morden. Another variety 'CO-2' was developed and released for Tamilnadu in the year 1986. This variety matures in 90-95 days. During 1988 another early maturing variety 'SS-56' evolved at Sholapur was released for cultivation in Maharashtra State. A number of promising open pollinated populations developed at Kanpur (KSP-1, KSP-7 and KSP-11), Sholapur (KRS-1), Kovilpatti (SFL-8) and Amreli (GAU-SUF-3 and GAU-SUF-4) are in various stages of testing in the Co-ordinated trials. A list of varieties and hybrids released since 1972 is given in Table - 2.

Heterosis Breeding:

The value of hybrids and the importance of heterosis breeding in Sunflower was recognised quite early soon after the inception of Sunflower project under AICORPO

During 1974-75, four CMS lines (CMS-2, CMS-124, CMS-204 and CMS-

234) and two restorer lines (RHA-266 and RHA-274) were introduced from USA. Eight experimental hybrids were developed by crossing the above lines in Bangalore and their performance was studied in comparison with EC-68415 as check (Seetharam, 1976 and Seetharam *et al,* 1977). All hybrids were distinctly superior to the check variety both in seed and oil yield (Table -3). Multilocation trials conducted at ten locations in the country also confirmed the superiority of hybrids over populations. Based on seed yield, oil content, yield stability and synchronization of flowering in male and female parents, the hybrid BSH-1 (CMS-234 RHA-274) was released for commercial cultivation in 1980 (Seetharam *et al* 1980). This was the first Sunflower hybrid to be released in the country. The hybrid base has been further widened in the country through extension of work on heterosis breeding to other centres. Recently three hybrids have been released for cultivation - 1) APSH-11 developed at Hyderabad centre for cultivation in Andhra Pradesh; 2) LDMRSH-1 and LDMRSH-3 evolved at Latur centre have been released for Maharashtra State. The later two hybrids are resistant to downy mildew disease and are recommended for cultivation in Marathwada region which is endemic to this disease. The female lines of these two hybrids are again introductions and supplied from the germplasm collections maintained at the Project Co-ordinating Unit, Bangalore. Another hybrid, KBSH-1 developed at Bangalore is in pre-release multiplication stage.

Hybrid Sunflower offers following distinct advantages over open pollinated varieties (Sindagi, 1979; Seetharam, 1981).

a) Hybrids have more production stability and are suited for input intensive agriculture

b) They are superior in their seed filling ability and are comparatively more self fertile

c) The crop stand is uniform and facilitates easy harvesting. The harvested product is also uniform.

d) They are more tolerant to diseases and pests

e) The hybrids can withstand drought much better than the open pollinated varieties.

Development of New CMS lines:

A number of inbred lines have been developed at Bangalore centre from the Canadian gene pool material. This gene pool was generated at the Morden Research Station, Manitoba (Canada) by crossing *inter se* more than 600 inbred lines maintained at that station. Some of the promising inbred lines developed from this gene pool - F-44, F-48, F-50, F-64, F-73, F-75, F-83, F-89, F-96, F-97, F-102 and F-106 have been converted into CMS lines and are being used in hybrid development.

Development of New Restorers:

As a part of programme of developing new restorers, a Male sterile plant of the line 3CR 37 (from France) was pollinated with a pollen mixture of RHA 273, 274,RHA 266 and Krasnodarets in 1977 in Bangalore. A number of new restorer lines with high oil content were developed from this polycross material and they are being used in the breeding programme at Bangalore centre. The restorer line 6D-1 which is the male parent for the hybrid KBSH-1 is a derivative from the above cross. Another hybrid KBSH-9 developed by using the restorer line of the above cross is in the National Hybrid Trial.

Many new restorer lines have been identified in the course of germplasm evaluation both in cultivated and wild species. They are GMUS-602, GMUS-414, *H.petiolaris* ssp *petiolaris* and H. *praeco* ssp *praecox*.

Self Fertile Lines:

A few self fertile lines have been developed at Bangalore centre from the Composite 381. The autogamy percentage in these lines ranges from 58.37 to 96.90 (Table - 4). Autogamy in hybrids is farily high compared to open pollinated varieties such as Surya, EC-68414 and EC-68415 where autogamy is almost absent. Seed increase of these self fertile lines is being done for evaluation of these lines for yield in the Co-ordinated trials. Of the 12 self fertile lines developed at Coimbatore, the line CSFL-24 has given higher yield than EC-68414.

GERMPLASM RESOURCES:

The germplasm management unit came into being during 1983 in the Project Co-ordinating Unit at Bangalore. About 1100 accessions pooled from different countries are presently conserved at this unit. These collections include populations, CMS lines, restorers, inbred lines and wild species. Four hundred accessions have been evaluated and characterised for 22 qualitative and quantitative characters. A catalogue has been prepared and circulated to the Sunflower Scientists (Virupakshappa and Sindagi, 1987). High yielding, high oil content, rust *(Puccinia helianthi)* and downy mildew *(Plasmopara halstedii)* resistant types are listed in this catalogue. Rust and downy mildew resistant accessions are give in Table 5.

Multilocation testing of promising accessions revealed the superiority of GMUS-61, GMUS-88, GMUS-101 and GMUS-179 over the checks. These populations are further tested in the AICORPO trials during 1988. Besides base collections maintained at Bangalore, working collections are maintained at Akola (181), Coimbatore (308) and Kanpur (90).

Role of wild germplasm :

Twenty wild species of *Helianthus* are maintained in the germplasm unit. Most of these species are diploids while *H. rigidus* and *H. tuberosus* are hexaploids (2n = 102). Some of these species have been tested for their resistance to downy mildew at Latur centre both under field conditions and artificial inoculation. The resistant and immune species are listed in Table 5. The four species immune to this disease are all diploids and cross compatible with *H. annuus* (Thompson *et al*, 1981). The two species *H. praecox* ssp *praecox* and *H. petiolaris* ssp *petiolaris* possessing restorer genes could be used for diversifying the sources for restoration.

Among 21 annual and 37 perennial *Helianthus* species screened for resistance to *Alternaria helianthi*, only *H. hirsutus*, *H. regidus* ssp *subrhomboides* and *H. tuberosus* were moderately resistant (Morris *et al*, 1983). The species *H. hirsutus* is a tetraploid while the other two are hexaploids.

The detailed cytomorphological investigations carried out in three diploid wild species - *H. deblis*, *H. argophyllus* and *H. lenticularis* and cultivated species *H. annuus* have shown in them close homology in the chromosome compliments and easy crossability and gene flow (Ramakanth and Seetharam, 1977). In the Cytogenetics section at the University of Agricultural Sciences, Bangalore, the hexaploid species *H. tuberosus* has been crossed with the cultivated species *H. annuus* witht the objective of transferring multiple disease resistance from *H. tuberosus* to cultivated species. Nevertheless, the hybrid is totally sterile and attempts so far made for backcrossing the hybrid with *H. annuus* have not been successful (Kusuma Kumari, Personal Communication).

Collecting local germplasm :

Although India is not the centre of diversity for the genus *Helianthus*, wild and ornamental types are being grown continuously over a long time. There is a need to collect these types. One important attribute that could be looked for in local germplasm is resistance to *Alternaria* leaf spot.

FUTURE CHALLENGES :

One of the major challenges would be to develop superior hybrids and populations which can surpass the presently grown varieties in both yield and oil content. These varieties should combine high yield, high oil content, resistance to *Alternaria* leaf spot, rust and downy mildew. There is also an immediate need to develop early maturing hybrids of 75-80 days duration superior to Morden. The variety Morden is susceptible to rust, *Alternaria* and downy mildew. Early maturing hybrids should be resistant to these diseases besides having high yield and oil content than Morden. Early maturing CMS lines (CMS 291, CMS 300, CMS 301, CMS 302 and CMS 338) and restorers (RHA 272, RHA 274 and RHA 296) available in the germplasm unit could be utilized to evolve early maturing hybrids. RHA 274 and RHA 296 are resistant to downy mildew and rust.

Another important area of breeding research is the development of self fertile populations and lines. Sunflower being a self incompatible crop depends on insect pollinators particularly bees for cross pollination. Lack of pollinators in adequate numbers during flowering results in poor seed set and low yields. Genetical rectification of this problem would be to develop self fertile populations. Further, inbred lines can be developed from these populations to be used as parental lines in the development of hybrids showing high self fertility. Fick (1978) observed that inbred lines with 100 percent seed set upon selfing can be developed.

Resistant sources for rust and downy mildew diseases are available. But the sources of resistance for *Alternaria* leaf spot have not been located. Nevertheless, field tolerance to this disease has been observed in some accessions in the disease screening nurseries. The task would be to screen the entire germplasm including B lines, R lines and wild species both in field and laboratory. Since resistance to *Alternaria* leaf spot is polygenically controlled, it may be difficult to find lines completely free from this disease and we may have to think of horizontal resistance only. What is important is to reconfirm genotypic difference among the lines for the level of resistance and use these resistant lines in population improvement to raise level of field resistance gradually in the populations reconstituted and hybrids newly developed.

Breeding for rust resistance inspite of physiological specialization of the fungus may not pose problems as many sources of resistant genes are available besides resistance controlled by one or two major genes.

FUTURE BREEDING STRATEGIES :

The breeding strategies to be adopted in any crop improvement programme should be of both short and long term depending on the problem. Seetharam (1979) has discussed the breeding approaches to be adopted for developing high yielding varieties of Sunflower.

Keeping in view the major challenges in Sunflower improvement, the strategies of breeding to be adopted are discussed hereunder.

Development of superior hybrids :

About 30 CMS lines and 20 restorer lines are available in the germplasm unit. By crossing these lines 600 hybrids can be synthesized. Evaluation of these hybrids should result in identifying the hybrids better than those presently available. This should form the part of short term strategy.

Diversification of population base :

There is an immediate need to develop superior open pollinated varieties than the existing ones. The presently grown varieties are susceptible to the diseases and are highly self-incompatible. To rectify these defects, the pre-requisite should be to generate broad-based gene pools. To develop such gene pools, lines with high yield, high oil content, self-fertility, resistance to diseases like rust, *Alternaria* and downy mildew should serve as component lines. The ruling commercial varieties should also be included as component lines of gene pools since they are high yielding with wide adaptability.

Once the gene pools are generated, the next step is to initiate selection in them. Following selection methods may be followed :

1. Mass Selection
2. Head-to-Row and Remnant Seed Method
3. Recurrent Selection (Intra Population)
4. Development of Synthetics

The details of the procedure of these methods are discussed by Fick (1978), Sindagi and Virupakshappa (1986) and Virupakshappa (1987). Initial selections of individual plants should be based on all characters mentioned above following the selection criterion of independent culling (Falconer, 1980).

Sunflower is ideally suited for the development of synthetics and their commercialisation. The value of synthetics in sunflower improvement has not been properly assessed. The recent advent of hybrids using CMS lines has further lessened the scope of synthetics.

Nevertheless, in a country like ours where production of quality hybrid seed is difficult, the development of synthetics should offer maximum scope for cultivation in place of open pollinated varieties. One of the advantages of synthetics could be its resynthesis after every 3-5 years using the same old inbred lines. Besides, hybrids and synthetic development programmes are complementary to each other and thus do not involve separate infrastructure in terms of materials and personnel.

Diversification of Hybrid Base :

The hybrids developed so far in the country have been largely based on the introduced CMS and restorer lines. Major lacunae in our breedng programme has been the lack of strong programmes to develop large number of inbred lines and evaluate them for their nicking ability and convert the promising ones into CMS and restorers. Sooner than later we should have parental lines developed in our own programmes. Hybrids developed from such lines will have better adaptability to our agro-climatic conditions.

To derive inbred lines also one should establish strong gene pools or composites. Separate gene pools for maintainer and restorer lines should be established. Inbreeding may be done in the gene pools to develop inbred lines and their subsequent conversion into CMS and R lines. It may be mentioned here that at the Co-ordinating Unit, B line and R line composites have been constituted and are being distributed to Sunflower breeders to develop CMS and restorer lines.

Steps in developing hybrids :

Following steps are followed in producing hybrid Sunflower :

1. Development of inbreds
2. Evaluation of inbreds for combining ability
3. Conversion of inbreds into CMS and restorer lines
4. Development of hybrids

In some breeding programmes, steps 2 and 3 are interchanged. For instance, several breeders in the USA have converted a large number of inbreds to cytoplasmic male sterile lines and then tested for combining ability using fertility restorer lines or populations as testers.

a. Development of inbred lines :

The most common procedure of developing inbred lines involves inbreeding of individual plants from base populations. Base populations could be open pollinated cultivars, gene pools or planned crosses. Phenotypically superior plants are selfed at the time of flowering. Further selection is made at harvest for disease resistance, maturity and other agronomic characters. Seeds of individual selfed plants are further analysed in laboratory for seed and kernel characteristics and oil content.

The plant-to-row progenies are raised in the following season and the desirable plants are again self-pollinated. Selection is done both among and within progenies. Best plants in best rows are chosen for further selfing. About 5-6 generation of inbreeding would be required before lines are tested for combining ability. However, in some breeding programmes the progenies are tested for combining ability at S2 or S3 stage itself. This is referred to as "early generation testing". Progenies showing poor combining ability may be rejected in early generations and only those progenies with good combining ability may be continued for further inbreeding.

Another way of producing inbreds is doubling of haploids produced through another culture to produce homozygous diploids. This method takes far less time to develop inbred lines compared to 3-5- years required in the inbreeding method.

Evaluation of inbred lines :

Inbred lines are tested for their general combining ability by top-cross test using best open pollinated varieties as testers. The problem of producing adequate quantities of hybrid seeds in top crosses can be overcome by inducing male sterility using gibberellic acid. Application of GA (100 ppm) at star bud stage consecutively for three days gives best results (Seetharam and Kusuma Kumari, 1976). If the inbred lines are already converted into CMS lines, they could be directly crossed with restorer lines to evaluate hybrid performance.

Conversion of inbred lines into CMS and restorer lines :

The promising inbred lines are converted into CMS lines by repeated backcrossing using the already available cytoplasmic male sterile lines. The inbred line is crossed to a CMS line and the progeny is backcrossed 5 to 6 times using the inbred line as recurrent parent. Conversion programme can be accomplished in a relatively short time if 3 to 4 generations are raised per year.

Embryo culture technique is followed in some breeding programmes in France for rapid generation turn over in the conversion programmes. It is possible with this technique to advance the material 5-6 generations per year. Thus a given inbred line can be converted into CMS line in one year.

Fertility restorer lines are developed by incorporating dominant restorer gene or genes by backcrossing using inbred lines of proven performance as the recurrent parent. The problem with this method is identification of plants in the backcross progenies that carry genes for restoration. Such identififcation involves test crossing of selected plants to a male sterile line to determine whether they carry the restorer gene. The F1 plants of these test crosses will be fully male fertile if the selected plants carry restorer gene.

Another method that is often followed to develop new restorers involves crossing R line to a cytoplasmic male sterile line. From such crosses fertility restorer lines coupled with other agronomic characters are isolated by continuous selfing and selection. The widely used restorers - 'RHA 271', 'RHA 273' and 'RHA 274' were developed using this procedure. The ideal method to develop CMS and R lines is through having parallel programmes for developing inbreds separately from maintainer and restorer gene pools. maintained. The best inbreds ultimately identified form maintainer gene pool are used for CMS line development and best inbreds from restorer gene pools are used as male lines in hybrid synthesis.

Production of hybrids :

The CMS lines thus developed after repeated backcrossing are again crossed to the restorers to develop single cross hybrids. Superior hybrids are identified by multilocation trials and released for commerical cultivation.

Hybrid mixtures :

Because of cross pollinated nature of the crop, the seed produced in open pollinated varieties or hybrids can be expected to be heterogenous. There is evidence to demonstrate that oil content and test weight of the seed is considerably influenced by the pollen parent that takes part in fertilization (Seetharam *et al,* 1977). This is referred to as metaxenia effect. This suggests that there may be scope for growing selected hybrid mixtures as commercial crop instead of one hybrid. In pearl millet mixture of hybrids in certain combinations and proportions have been shown to give singificantly higher yields than monohybrid cultures. The hybrid mixtures may also impart more plasticity and insurance against diseases. This area needs further detailed investigations.

Resistance Breeding :

As the crop is grown more and more extensively the disease and pest problems become more intense. So, resistance breeding should form an integral part of our breeding programmes. Rust, Alternaria leaf spot and downy mildew are the diseases which need immediate attention.Root rot caused by *Macrophomina phaseolina* is becoming severe in some parts of Tamil Nadu. The resistance to rust and downy mildew diseases is controlled by one or two dominant genes (oligogenes). The selection and fixing of lines with resistance to these diseases is relatively easier compared to Alternaria leaf spot which is polygenically inherited.

The resistant sources available for rust and downy mildew are given in Table 5. These lines should invariably be used as component lines while generating gene pools for selection programmes. Also, the resistance may be incorporated into the open pollinated varieties and breeding lines through backcross breeding. At the Co-ordinating Unit, Bangalore, three backcrosses to EC-68415 have been completed using 'Bekecks' as the donor parent for rust resistance.

Recurrent selection :

Genetic upgradation of gene pools could be planned following recurrent selection procedures as long range projects. Since, in sunflower individual plants are not amenable for selfing and at the same time crossing as required in the recurrent selection programmes, certain modifications in classical methods of recurrent selection are necessary (Allard, 1960).

Inter-population recurrent selection programme are being followed in some breeding programmes in France (Virupakshappa, 1987). In these selection programmes 'B' and 'R' line composites are used as base populations and the salient steps followed are outlined below :

a) Two composites - B and R are taken as base populations.
b) A number of plants in B composite are selfed and at the same time crossed to CMS 89. The resultant sterile hybrid (A x B) is crossed to 'R' source. This three-way hybrid ((A x B) x R) is yield tested for one year.
c) The best plants are recombined using the remnant seeds.
d) Similarly a number of plants from R composite are selfed and at the same time crossed to CMS-89. The resultant hybrids are yield tested for one year.
e) The best plants are recombined using remnant seeds.
f) The procedure is repeated for several cycles.

Inbreds could be developed from the improved B and R line composites to develop superior hybrids.

Presently in India improvement of commerical open pollinated varieties is mainly attempted through Pustovoit method - a system of recurrent selection mainly developed and practiced in USSR. The inter-population recurrent selection method described above appears to be equally simple and convenient to adopt. The value of the above method needs to be investigated and adopted for genetic upgradation of presently cultivated open pollinated varieties in India.

Diversification of CMS base :

Without exception all CMS lines now used in our heterosis breeding programmes have the same cytoplasm - *H. petiolaris* for male sterility (CMS F) discovered by Leclereq (1969). This source is now largely used in the world in commercial hybrid production without any problem. But the use of single cytoplasm may limit genetic basis of the parental lines and represent a potential risk if it becomes susceptible to a new strain of disease.

Seven new stable CMS sources have been developed in France. These sources are different from CMS F and they are designated as follows (Pers. communication from Dr. Series) :

-	CMS	PF	*H.*	*petiolaris* fall x *H. annuus*
-	CMS	BOL	*H.*	*bolandari* x *H. annuus*
-	CMS	EXI	*H.*	*exilis* x *H. annuus*
-	CMS	397	*H.*	*annuus* wild
-	CMS	517	*H.*	*annuus* wild
-	CMS	519	*H.*	*annuus* wild
-	CMS	521	*H.*	*annuus* wild

Besides these 7, the following five more CMS sources have been reported in USSR, USA and Canada :

- CMS K	from *H. lenticularis* (A.Anaschenko, 1974, USSR)
- CMS I (Indiana)	1) discovered in *H. annuus* ssp *lenticularis* (Charles Heiser, 1982, USA)
- CMS CMG 1	*H. petiolaris* x *H. annuus* (E.D.P. Whelan, 1980, Canada)
- CMS CMG 2	*H. gigantus* x *H. annuus* (E.D.P. Whelan, 1980, Canada)
- CMS CMG 3	*H. maximiliani* x *H. annuus* (E.D.P. Whelan, 1980, Canada)

So, in all 12 new CMS sources have been reported besides now used Leclereq source (CMS F). The new sources CMS PF and CMS I are available at the germplasm Unit, Bangalore. The remaining ten sources need to be added to our collections.

Alloplasmic lines :

Similar to isogenic lines differing for single genes one can also develop lines having same nuclear background in different cytoplasms. Selected inbred lines may be converted into male sterile lines in different CMS backgrounds. These lines having same nucleus but different cytoplasm are referred to as alloplasmic lines. With these lines, it will be possible to study the influence of cytoplasm on agronomic performance, combining ability and more particularly disease resistance.

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TABLE 1:
COMPARISON OF MORPHOLOGICAL AND YIELD ATTRIBUTES OF MORDEN AND EC-68415

Variety	Height (cm)	Head Size (cm)	Days to 50% flowering	Days to maturity	Oil content %	Seed yield (Kg.ha) Av. of 1973 to 77
EC-68415	130-150	13-15	60-63	95-100	40.00	1222
Morden	80-90	12-13	48-50	75-80	38.00	1037

TABLE 2 :
VARIETIES AND HYBRIDS RELEASED IN THE SUNFLOWER PROJECT

Sl. No.	Variety/ Hybrid	Year of Release	State for which recommended	Remarks
1.	EC-68414	1972	Maharashtra, Andhra-Pradesh, Tamilnadu, U.P., West Bengal.	Suitable for late planting
2.	EC-68415	1972	Karnataka	Prone for lodging under high fertility conditions.
3.	Morden	1979	Karnataka, Andhra-Pradesh, Maharashtra, West Bengal, Tamilnadu	Suitable for multiple and mixed cropping
4.	Surya	1983	Maharashtra	Seed color grey with white stripes.
5.	CO-1	1983	Tamilnadu	A closer spacing of 20 cm x 15 cm has to be followed.
6.	CO-2	1986	Tamilnadu	--
7.	SS-56	1988	Maharashtra	--
			HYBRIDS	
1.	BSH-1	1980	Karnataka	Resistant to rust and tolerant to Alternaria leaf spot
2.	APSH-11	1987	Andhra Pradesh	--
3.	LDMRSH-1	1988	Maharashtra	Resistant to downy mildew.
4.	LDMRSH-3	1988	-do-	-do-

TABLE 3: YIELD PERFORMANCE OF PROMISING HYBRIDS

Hybrids/ open pollinated variety	Seed yield Kg/ha		Oil content %		Oil yield Kg/ha	
	A	B	A	B	A	B
CMS 234 x RHA 266	2270.9	1208.0	52.0	46.9	1134.3	566.1
CMS 2 x RHA 266	2612.5	1581.9	46.0	44.3	1201.5	700.0
CMS 234 x RHA 274	2563.4	1106.6	50.9	44.4	1303.5	490.8
CMS 204 x RHA 274	2605.8	1250.3	47.4	43.6	1231.1	545.2
EC-68415 (Check)	2104.7	643.4	47.4	45.7	998.5	294.2
LSD (5%)	488.4	461.1	5.5	NS	301.1	236.0

A, Summer irrigated (1976); B, Kharif rainfed (1976)

TABLE 4: COMPARATIVE AUTOGAMY PERCENT OF FIVE LINES IN SIXTH GENERATION OF SELFING

Sl. No.	Lines	Autogamy %	Oil content %
1.	381-8-29-2	96.90	36.88
2.	381-8-20-2	91.70	38.30
3.	381-14-1-5	88.09	38.60
4.	381-15-61-2	83.19	38.86
5.	381-9-9-6	58.37	38.36
6.	KBSH-4 (Hybrid)	56.97	39.50
7.	KBSH-1 &	42.35	37.33
8.	BSH-1	11.82	39.00
9.	Modern (O.P. Variety)	5.30	39.00
10.	EC-68415	NIL	39.95*
11.	Surya	NIL	35.18*

* based on open pollinated plants.

TABLE 5:
SUNFLOWER GERMPLASM ACCESSIONS RESISTANT TO RUST AND DOWNY MILDEW

Disease	Resistant Accessions		
Rust	HA 207	GMUS-414	*H. tuberosus*
	HA 338	GMUS-512	*H. praeceox* ssp *praecox*
		GMUS-602	*H. praecox* ssp *reunyonii*
	RHA 265	HA R-1	*H petiolaris* ssp *petiolaris*
	RHA 272	HA R-2	
	RHA 274	HA R-3	
	RHA 298	HA R-4	
	RHA 299	IB-29	
Downy mildew	HA 207		*H. petiolaris* ssp *petiolaris*
	DM 1		*H. praecox* ssp *praecox*
	DM 2		Species immune to the disease
	RHA 265		*H. argophyllus*
	RHA 273		*H. praecox* ssp *runyonii*
	RHA 274		*H. debilis* ssp *tardiflorus*
	RHA 296		*H. debilis* ssp *cucumerifolius*
	RHA 297		
	RHA 298		
	RHA 299		
	RHA 586		
	RHA 587		
	RHA 801		

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GENETIC IMPROVEMENT OF RAPESEED-MUSTARD, ACHIEVEMENTS, CRITICAL GAPS AND FUTURE PRIORITIES

P.R.Kumar and Prakash Kumar
All India Coordinated Research Project on Oilseeds, Haryana Agricultural University, Hissar - 125 004, INDIA

Oilseed comes next to food grains in volume and value in the country. There has been a sizeable increase in area and production of oilseed during the last 37 years. The area and production which were 10.867 million hectares and 5.260 million tonnes in 1949-50, increased to 18.69 million hectares and 11.45 million tonnes, repectively in 1986-87. The upward trends in area and production are striking in case of rapeseed-mustard and sunflower. The growth rate of area, production and productivity of major edible oilseeds for the period 1950-51 to 1983-84 when studied revealed asignificant growth rate for area (1.37%) and production (3.21 per cent) of rapeseed-mustard in comparison to groundnut and Sesamum (Table 1).

Oilseed Brassicae (commonly referred to as rapeseed-mustard in India) and groundnut are the major oilseed crops accounting for 75 per cent of the total oilseed production and 80 per cent of edible oilseed production. It constitutes a group of oilseed crops comprising two distinct types, autogamous Yellow, Sarson and *tora* type Brown Sarson (*Brassica Campestris* L.) and Indian Mustard *(Brassica juncea* Coss & Czern.) and allogamous Brown Sarson *(lotni* type) and Toria *(Brassica campestris* L.) and Taramira (*Eruca sativa* Lam.). Apart from these, there is another species of the genus *Brassica*, *B.napus* (commonly known as Gobhi Sarson) which in recent years, has gained popularity in Punjab. All these oilseed crops are grown under a wide range of agro-climatic conditions. Mustard is the most important crop accounting for more than 75 per cent of the area under rapeseed-mustard followed by Toria, Yellow Sarson, Taramira, Gobhi Sarson and Brown Sarson. Mustard and Sarson group of plants are grown both on sandy and heavy soils, under irrigated as well as rainfed conditions.

EARLY PHASE

Research work on the improvement of *Brassica* oilseed was initiated in early part of this century by collecting land races and cultivars of Brassica oilseed, their purification and selection of apparently good yielding types. It resulted into the development *of 7 improved varieties of rapeseed-mustard i.e., four varieties of mustard, two from UP* (Type 11 and Loha 101), one from Punjab (RL-18), one from Bihar (BR-13) and 3 varieties of Toria from Bihar (BR-23, BR-29 and BR-36), by the end of forties. A significant progress by way of developing high yielding varieties of rapeseed-mustard was made after establishment of the Indian Central Oilseeds Committee in 1946-47. This scheme of

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Govt. of India which functioned till 1966, provided 20 improved varieties of rapeseed-mustard. Mustard varieties Type 16 and Varuna (UP), BR-40 (Bihar), B-85 (West-Bengal) and Patna Mustard-67 (Gujarat), Yellow Sarson varieties like YSPB-24 (Punjab), T-42 and T-151 (UP) and Patan Sarson-66 (Gujarat); Brown Sarson varieties like BSA and BSH-1 (undivided Punjab), BS-70 (UP) and B-65 (West Bengal); Toria varieties M-2, M-3 and M-27 (Assam), B-54 (West Bengal), ITSA (Undivided Punjab) were recommended by the concerned states during this period.

The research work on the improvement of rapeseed-mustard got a fillip when the All India Coordinated Research Project on Oilseeds started in 1967-68. Research programmes involving inter-disciplinary approach to improve/develop high yielding varieties of rapeseed-mustard possessing resistance/tolerance to biotic and abiotic stresses were formulated for specific agro-climatic situations. The progress in research and salient features of accompliments are as under:

PROGRESS IN RESEARCH

Germplasm

The All India Coordinated Research Project on Oilseeds started with very limited germplasm of tribe Brassiceae. During the last 20 years, the total number of accessions in the germplasm have increased to 15059. These include duplicates, triplicates. Out of these, nearly 6500 germplasm lines have been evaluated, characterised and documented. Several lines of mustard such B-38, B-169, CSR-164, RC-1288, CSR-164, B-15, RH-7811, NC-56137, IB-2033, IB-314, NC-58632, IB-1632, JMG-152, IC-37870, IC-58298, etc., were identified possessing one or the other desirable plant attributes.

High yielding varieties :

Breeding for high seed yield has been major objective. The average yield of rapeseed-mustard in the country is 700 kg/ha. However, with the use of mass selection, population improvement, recurrent selection, progeny selection and backcross breeding methods, a good number of promising varieities have been developed and recommended for general cultivation by different states. After the inception of the All India Coordinated Research Project on Oilseeds in 1967 till 1980, 16 varieties of rapeseed-mustard were recommended for general cultivation by different states. Out of these, 7 varieties of mustard, viz., Laha-101 and Shekhar (UP); Durgamani (Rajasthan); RLM-198 and RLM-514 (Punjab) and Prakash and RH-30 (Haryana); 5 varieties of Toria, viz., T-9 (UP), TL-15 (Punjab), Sangam (Haryana), DK-1 (H.P.) and TS-29 (Assam); two varieties of Brown Sarson, viz., Pusa Kalyani (All India), KOS-1 (Kashmir) and a variety of Taramira, T-27 (Haryana). During 1981 to 1988, as many as 19,5 and 2 varieties of mustard, Toria and Yellow Sarson, respectively, for irrigated areas; and 8, 1 and 2 varieties of mustard, Toria and Yellow Sarson, respectively, for rainfed areas have been recommended for different zones of the country. The recommended varieties have the potential of giving yields ranging from 18 to 36 q/ha in Toria and 22 to 42 q/ha in mustard. The increased yields of recommended varieties ranged from 9 to 53 per cent over the standard checks under irrigated conditions. Under rainfed conditions, the increased yield ranged between 8.92 to 45 per cent (Table 2). In recent years, hybrid programme has been intensified. The literature/reports available indicate the yield superiority of F1 hybrids over the best national variety of more than 150 per cent. The heterosis available in such hybrids are being exploited through known sources of male sterility for achieving break through in yield levels of this crop commodity. With the discovery of eytoplasmic male sterility, their maintainers and restorer sources in both *B.napus* and *B.juncea* and the genic male sterility in *B.juncea* and *B.campestris*, var. Toria, the possibility of exploiting the hybrid vigour for oil yield productivity seems to be almost a reality in the near future. Three forms of male sterility, viz, petaloid, stigmoid and rudimentary showed lower protein content than the normal fertile line in *Brassica juncea*. The RC and RN restorers also showed lower protein content than the three CMS forms. RC and RN sources when combined exhibited higher protein content than the normal by 2 per cent.

Using mutation breeding as a tool, efforts are being made to improve the productivity of rapeseed-mustard. Two tier approach has been adopted for this purpose. The first step involves the induction of micro- and macro-mutations in the recommended varieties and the second step aimed at inter-mutant crosses with other promising varieties. Using these techniques, a good number of strains have been developed. Two of the good varieties of mustard like TM-2 and TM-4 have been recommended for general cultivation in Assam. Two more strains TM-21 and TM-17 are giving encouraging performance in Andhra Pradesh and Maharashtra States.

Disease resistant/tolerant varieties

Alternaria blight, white rust and downy mildew are the major diseases causing substantial damage (10-70 per cent) to the crop. Sources for resistance/tolerance were identified for all the three diseases. Utilizing the resource genes in hybridization programme, varieties like RH-8113 and KRV-Tall and strains RH-8114, PR-8701, and PR-8705 of mustard have been identified. These varieties/strains, besides possessing moderate tolerance against Alternaria disease also gave marginally incresed seed yields.

Likewise, for white rust and downy mildew diseases, rsource genes like RC-781, YRT-3, PHR-1 and EC-126743 of mustard were identified. They have been extensively utilized in breeding programme. A good number of lines are in early generation testings.

Insect-pest tolerant/resistant varieties

Control of insect-pests is of significance for successful cultivation of the rapeseed & mustard crops. Among the various insect-pests, mustard aphid (*Lipaphis erysimi* kalt) is most important causing damage to the extent of 99 per cent. Besides directly devastating the plants, the aphid also acts as vector for various diseases and virus thereby causing indirect damage to the plant. A large number of insecticides are available to control aphids, but practically its use by farmers is restricted because of higher cost and other local problems. Therefore, the isolation of aphid resistant/tolerant lines from the available genetic stock and to incorporate these genes into agronomically superior variety would be most appropriate. The work on these lines has resulted into the development of improved strains of mustard, viz., RH-7846, RH-7847, CSR-1017 and Glossy B-85 possessing high seed yield and tolerant/moderate resistant reaction against aphid-pest.

Frost tolerant varieties

Rapeseed-mustard crops are most commonly known as uncertain crops in the areas where they are grown because of their frost susceptibility. Although it is not a regular phenomenon, in a frosty year which occurs unpredictably, the extent of damage is more than 90 per cent. Studies on frost resistance using Movable Frost Chamber have resulted in identification of five varities/strains of *B.Juncea*, namely, RH-781, RC-199, RH-7361, RH-848 and RH-8520, two varieties of *B.campestris* span and Torch as relatively frost tolerant.

CRITICAL GAPS

A perusal of the data on area, production and productivity of rapeseed-mustard during 1949-50 to 1986-87 reveals a highly fluctuating pattern (Table -3). The changes in area from year to year can partly be attributed to the price and marketing. However, the changes in production and productivity is largely attributed to weather conditions and the prevalence of insect-pests and diseases and frost injury during the crop season. The data bring to the fore the problem of highly unstable productivity and consequently the production of rapeseed-mustard in the county. It calls for stablizing and further improving the productivity to bridge the gap and to meet the domestic requirements of fats and oils.

FUTURE PRIORITIES

The progress made in terms of developing high yielding varieties though satisfactory, however, the varieties developed are not stable in performance. They are highly influenced by abiotic and biotic stresses. With a view to bring stability and to further increase the productivity of rapeseed-mustard in the country, the following priority areas of research are suggested:

(i) Development of diseases resistant/tolerant varieties

Sources of resistance to diseases though identified, there is no resistant variety to the known diseases like Alternaria blight, white rust and downy mildew diseases of rapeseed-mustard. Intensive efforts are required to develop disease resistant-high yielding varieties.

(ii) Insect-pest resistant/tolerant varieties

Although strains like RH-7846, RH-7847, CSR-1017 and Glossy B-85 of mustard showing moderate resistant/tolerant reaction against aphid pest have been developed, the yield levels of these strains are not comparable to the national varieties. There is, therefore, need to develop aphid resistant/tolerant varieties using identified lines/sources as donor parents.

iiii) Development of frost tolerant varieties

Varieties/strains developed as frost tolerant are not **comparable** in **seed yield to** national standards *and, therefore, require further improvement.*

(iv) Development of salt tolerant varieties

With the increasing availability of canals as wells as ground water for irrigation, the area under salinity/alkalinity is increasing day by day. Researches on the screening and development of salt tolerant varieties of mustard need to be intensified.

(v) Development of drought resistant/tolerant varieties

More than 53 per cent area under rapeseed-mustard is rainfed. There is no high yielding-drought tolerant variety of rapeseed-mustard. Efforts should be made to develop high yielding drought tolerant varieties of rapeseed-mustard.

(vi) Development of hybrid varieties

With a view to get a qunatum jump in productivity and production of rapeseed-mustard, it is necesary that hybrid varieties are developed. With the available genic male sterile lines and CMS lines, maintainers, and restorers in *B.juncea, B.napus* and *B.campestris*, programme on hybrids needs to be intensified.

(vii) Development of thermo-insensitive varieties

Sowing of rapeseed-mustard during the periods coinciding with receding monsoon for better establishment becomes crucial. Early sowings, particularly of Toria, result in reduced yields. Efforts, therefore, need to be made to select lines/varieties which can withstand higher temperature during the cotedonary leaf stage to take the advantage of residual moisture.

(viii) Development of varieties with increased oil content

Besides improving seed yield, it is of paramount importance to improve the quality of oil. From breeding point of view, it is easier to increase/improve the per cent oil content instead of raising the seed yield as the former is less influenced by environment and is governed by fewer genes than the seed yield.

(ix) Development of varieties with balanced fatty acid composition

The presence of fatty acids in oils determine the use of oil for either edible or industrial purposes. Rapeseed-mustard oil contains higher concentration of erucic acid which when fed to experimental animals resulted in the deposition of fibre tissue in the heart causing myocardial fibrosis. Linolenic acid which is also present in higher concentration in the oil, create definite chemical instability especially rapid auto-oxidation. It is, therefore, necessary that higher concentration of eruic acid and linolenic acid present in the oil are eliminated or reduced (to the extent of less than 2 per cent in case of erucic-acid and less than 8 per cent in case of linolenic acid) to make the rapeseed-mustard oil as nutritionally desirable with excellent keeping quality.

(x) Development of varieties with low glucosinolate content

The presence of sulphur based toxic compound called glucosinolate limits the utilisation of rapeseed - mustard seed meal as a high quality feed. These compound given pungent odour and biting taste. In order to improve seed meal quality of rapeseed - mustrard it is necessary to eliminate or reduce these toxic compounds to the level of 30 moles.

(xi) Management of genetic resources

India is the centre of diversity fo oilseed *Brassiceae. Brassica campestris* vars. Toria and Sarson, *Brassica juncea* and *Eruca vericaria* are considered as Indian Gene Centre and distributed in eight phytogeographical zones of the country. These types exhibit preponderance of variable forms/land races. It is therefore,necessary to collect the valuable genetic resources available in the country, maintain, evaluate, characterize, document and utilize them in hybridization programme.

Table 1:
Compound growth rates of major edible oilseeds from 1950-51 to 1984-85.

Crop	Area	Production	Yield
Total Oilseeds	1.5408 (0.0945)	2.3419 (0.1793)	8.7840 (0.1588)
Groundnut	1.2274 (0.1772)	1.7205 (0.2363)	0.5028 (0.2053)
Rapeseed-Mustard	1.3706 (0.3951)	3.2111 (0.2522)	1.4279 (0.2197)
Sesamum	0.0241 (0.1183)	0.2875 (0.2592)	0.3037 (0.2457)

In parenthesis is the standard error

Table 2:
Recommended varieties of rapeseed-mustard for release/pre-release multiplication during 1981-88.

Variety	Suitable for irrigated/ rainfed areas	Year of recomme-ndation	Av. yield (kg/ha)	Per cent increase over the standard variety
		All India level		
Mustard				
Kranti	Irrigated	1983	1,478	18.43
RLM-198	Irrigated	1981	1,425	9.00
Krishna	Irrigated	1983	1,372	12.70
RLM-514	Rainfed	1982	931	11.56
Toria				
Pant Toria-303	Irrigated	1985	991	9.32
		North-Western Zone		
		(Jammu and Kashmir, H.P., Punjab, Haryana, Delhi, Rajasthan and Gujarat)		
Mustard				
RLM-619	Irrigated	1985	1,950	17.52
RH-8113	Irrigated	1985	1,923	16.00
RH-7859	Irrigated	1984	1,918	22.71
RH-7361	Rainfed	1983	1,575	8.92
RH-30	Rainfed	1984	1,615	16.86
RH-819	Rainfed	1986	1,339	45.00
Toria				
TH-63	Irrigated	1985	1,125	31.80
		Central Zone		
		(Uttar Pradesh and Madhya Pradesh)		
Mustard				
RLM-185	Irrigated	1983	1,295	11.00
Vardan (RK-1467)	Irrigated	1985	1,327	14.00
Rohini (KRV-24)	Irrigated	1984	1,431	20.66
KRV-47	Irrigated	1984	1,566	32.04

Table 2 Contd .....

Variety	Suitable for irrigated/ rainfed areas	Year of recommendation	Av. yield (kg/ha)	Per cent increase over the standard variety
Vaibhav (RK-1418)	Irrigated	1985	1,303	12.00
NDR-8501	Irrigated	1988	1,333	13.78
Vaibhav (RK-1418)	Rainfed	1985	1,499	20.02
RK-9	Rainfed	1984	1,480	18.57
RK-14	Rainfed	1985	1,494	25.30
<u>Toria</u>				
Plant Toria-30	Irrigated	1985	995	9.82
*Bhawani	Irrigated	1985	804	
<u>Yellow Sarson</u>				
YSK-1	Rainfed	1986	845	21.00

Eastern Zone

(Bihar, West Bengal, Orissa and Assam)

Variety	Suitable for irrigated/ rainfed areas	Year of recommendation	Av. yield (kg/ha)	Per cent increase over the standard variety
<u>Mustard</u>				
Pusa bold	Irrigated	1984	1,322	17.00
RW-351 (Bhagirathi)	Irrigated	1985	1,401	25.04
RW-85-59 (Sarma)	Irrigated	1983	1,449	29.38
RH-30	Irrigated	1983	1,401	25.09
RH-781	Irrigated	1985	1,394	24.46
RW-4-C-6 (3-II) (Sanjucta Asesh)	Rainfed	1985	824	29.00
<u>Toria</u>				
Pt-507 B	Rainfed	1985	607	17.00
TWC-3 (Panchali)	Irrigated	1985	573	10.65
<u>Yellow Sarson</u>				
YSB-9 (Binoy)	Irrigated	1985	1,235	23.33
YSB-19-7-C	Irrigated	1986	1,036	53.00
YSP-6	Rainfed	1984	928	31.26

* Recommended by the U.P. State Variety Release Sub Committee because of its extra-early maturing (<80 days) habit.

Table 3:
Area, Production and Productivity of Rapeseed & Mustard

Year	Area (Million Hects)	Production (Million Tonnes)	Productivity (Kgs/Hect.)
1949-50	1.94	0.81	417
1950-51	2.07	0.76	368
1951-52	2.40	0.94	393
1952-53	2.11*	0.86	408
1953-54	2.24	0.87	389
1954-55	2.44	1.04	425
1955-56	2.56	0.86	336
1956-57	2.54	1.04	411
1957-58	2.41	0.93	387
1958-59	2.45	1.04	426
1959-60	2.91	1.06	365
1960-61	2.88	1.35	467
1961-62	3.17	1.35	425
1962-63	3.13	1.30	417
1963-64	3.05	0.92	300
1964-65	2.91	1.47	507
1965-66	2.91	1.30	446
1966-67	3.01	1.23	408
1967-68	3.24	1.57	483
1968-69	2.87	1.35	469
1969-70	3.17	1.56	493
1970-71	3.32	1.98	594
1971-72	3.61	1.43	396
1972-73	3.32	1.81	545
1973-74	3.46	1.70	493
1974-75	3.68	2.25	612
1975-76	3.34	1.94	580
1976-77	3.13	1.55	496
1977-78	3.58	1.65	460
1978-79	3.54	1.86	525
1979-80	3.47	1.43	411
1980-81	4.11	2.30	560
1981-82	4.40	2.38	541
1982-83	3.83	2.21	577
1983-84	3.87	2.61	673
1984-85	3.99	3.07	771
1985-86	3.80	2.64	694
1986-87	3.73	2.63	700

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AGRONOMY OF RAPESEED AND MUSTARD AND THEIR PLACE IN NEW AND EMERGING CROPPING SYSTEMS

J.S.SAINI, T.S.SAHOIA AND A.S.DHILLON
Punjab Agricultural University, Ludhiana - 141 004

Introduction

It is paradoxical that India, which is one of the major oilseed growing countries of the world, is not able to feed its population with regard to oils and had to import edible oils worth Rs.3884 crores during the preceding five years ending 1985-86. The import bill is escalating every year and has already touched a mark a Rs.1400 crores. The greatest challenge before us is to make India self-sufficient in vegetable oils with a view to reducing our dependence on imports at the expense of valuable foreign exchange.

India with about 19.85 m.ha (equal to 13% of the net cultivated area) under oilseeds ranks first in the would as far as area under groundnut, linseed, sesame and niger are concerned. It is third in the world in respect of acreage (3.73 m.ha) under rapeseed-mustard; Canada being first followed by China. But in productivity of rapeseed-mustard (707 kg/ha), we are far below the world average of 1262 kg/ha and of other countries like france (2991 kg/ha), Canada (1235 kg/ha) and China (1243 kg/ha).

Rapeseed-mustard comprise three sub-species of *Brassica campestris*, namely *toria*, yellow sarson and brown sarson, *raya/rai* or Indian mustard, hereafter referred as mustard (B. juncea L. Coss), gobhi sarson or Swede rape (B. napus) besides taramira (Eruca sativa). Amongst oilseeds, the group is next to groundnut both in area and production (Fig. 1). Most of the area under rapeseed- mustard is, however, covered by mustard and *toria*. Gobhi sarson is replacing mustard in some areas of Punjab. The cultivation of these crops is confined mainly to U.P., Rajasthan, M.P., Haryana, Assam, W.B., Gujarat and Punjab. Uttar Pradesh and Rajasthan alone account for about 50 per cent of the area under rapeseed-mustard. About 55 per cent of the area under these crops is unirrigated as against 85 per cent for the oilseeds as a whole. But in U.P., Rajasthan, Haryana and Punjab, the irrigated area under rapeseed-mustard ranges between 47 to 91 per cent.

There is a considerable scope of raising the low productivity level of these crops by narrowing down the apparent gap between the realisable and realised yields. Vigorous efforts to transfer the available agro-techniques and further technological breakthroughs hold the key to achieve the desired results.

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2. Status of Oilseeds Research Prior to mid- 70's

2.1 Historical background

Research on oilseeds was initiated under the aegis of the erstwhile Indian Central Oilseeds Committee - set up in May, 1947. After its dissolution in 1966, research on oilseeds was more systematically organised by the ICAR. In the beginning the work was initiated only on groundnut, rapeseed-mustard, sesamum, linseed and castor. Later on safflower, sunflower and niger were also included.

Looking into the deficiencies in the earlier projects, the ICAR started an All-India Coordinated Research Project on Oilseeds (AICORPO) in the year 1967 with the philosophy of (i) multidisciplinary approach to problems. (ii) free exchange and flow of material, information and ideas amongst research scientists, (ii) planning of technical programmes of research by common discussions and consent among the scientists at the Annual Workshop meetings and (iv) compulsory analysis, reporting and discussion of research results before sowing crops in the subsequent season. The project has been rejuvenated from time to time through deployment of more and better trained scientists, provision of more funds, establishment of additional research centres, including the pivoted Directorate of Oilseeds Research (in 1977), headed by a Project Director, who is assisted by seven crop coordinators posted in different states. The project is under operation till date.

2.2 Improved varieties

A total of 42 varieties (10 of toria, 13 of mustard, 8 of brown sarson, 9 of yellow sarson and 2 of taramira), suitable for different agro-climatic regions/states, were identified and recommended. Many of these varieties, have, however, gone out of cultivation for reasons of non-availability of seed or loss of identity at farmers' fields (Singh, 1984). The number of varieties, released upto mid-70's, which are still on the recommended list of various states include mustard (3), toria (5), brown sarson (4), yellow sarson (2) and taramira (3).

2.3 Agro-production and protection technology

Suitable production technology, such as optimum sowing time, plant population and its geometry, fertilizers - their economic optimum rates, time and method of application, proper irrigation schedules, suitable herbicides - their safe and economical dosages and time of application, remunerative multiple cropping systems, including intercropping, involving rapeseed-mustard and a number of other techniques conducive to high yields of different genotypes of rapeseed-mustard, was evolved and recommended to oilseed growers.

Similarly, appropriate control measures against the prevailing important pests (aphids, mustard saw fly) and diseases (alternaria blight, white rust, powdery mildew) were worked out and made known to the cultivators.

2.4 Impact on area, production and productivity

2.4.1 Upto mid 70's:

The development of agro-technology and its dissemination has brought a spectacular increase in the area, prodcution and productivity of rapeseed-mustard upto mid-70's (Fig.2)

During the period 1950-51 to 1974-75, the area, production and productivity of these crops which stood at 2.07 m.ha., 0.76 m.tonnes and 368 kg/ha in 1950-51 rose to 3.68 m.ha (78%), 2.25 m.tonnes (196%) and 612 kg/ha (66%) respectively.

2.4.2 After mid 70's :

The increase in area (1.2%), production (17%) and productivity (16%) between 1974-75 and 1986-87 was relatively samll as compared to preceding 25 years.

3. Agronomic Reseach on Rapeseed-Mustard After Mid-70's

The agronomic research on rapeseed-mustard was reviewed by Bhan (1977). This article is, therefore, focussed mainly on the research carried out after 1977. Salient findings of the review by Bhan (1977) have, however, been briefly incorporated, where necessary.

3.1 Preparatory tillage

Rapeseed and mustard, because of their small seed size, require fine seedbed. Toria in particular requires a moist seedbed. Two to three ploughings each followed by planking are usually sufficient for obtaining fine seed bed. Under irrigated conditions, mustard cv. Varuna gave 10 per cent higher yield in tilled than in untilled soil, because the root development was improved by tillage (Kumar, 1983). Root weight was 11-29 per cent higher in the tilled plots than that in the untilled plots. In the rainfed areas, disc-harrowing, after every effective shower, is the best method of conserving moisture in Kharif fallows. On cessation of monsoon rains, harrowing should invariably be followed by planking to prepare a fine and compact seed bed (Kumar, 1983).

3.2 Improved varieties

Replacement of old low yielding varieties by the improved ones alone can bring yield improvement of about 20 per cent. Agro-economic evaluation lead to the recommendation of about 50 improved varieties of rapeseed-mustard for various states/regions/situations in India (ICAR, 1986).

3.3 Time of sowing

- Time of sowing is the basic factor of production and is governed mainly by temperature. Ganagsaran and De (1979) reported that mid-October was the ideal time for sowing rainfed rapeseed at Delhi when the mean daily temperature ranged between 25-26°C. In the subsequent studies, the same temperature range was found optimum for mustard (Gangasarn et al., 1985). Kumar (1986) opined that rapeseed and mustard should be sown when the maximum temperature is around 30°C. Early or delayed sowing would invariably decrease yields (Fig. 3). High temperature in early sowing results in improper canopy development and branching of stem which are not conducive to maximum number of pods and seeds/plant. The incidence of seedling eating pests. viz., Bagarada hilaris and Athalia lugens proximo is also high under early sowing. Under late sowings, there is severe infestation by aphids, reduction in the reporductive phase and the oil content is also reduced. The differences at the species level, however, cannot be ignored. Bhan (1977), for example, reported that toria needs early sowing and should be sown in second fortnight of September, sarson can be sown in the first fortnight of October, while for mustard, mid-October is the optimum time for sowing. The crop can also be cultivated in the hills from May to September, where cvs. Seeta (B-85) and RW 351 of mustard gave better performance than other varieties (Kumar, 1983).

The optimum time for sowing taramira at Jobner (Rajasthan) was around October 10 and that for toria and mustard at Pantnagar was third week of September and first week of October, respectively (Kumar and Singh, 1984). Delay in toria sowing from September 27 to October 18 reduced the yield by 42 per cent at Pantnagar (Kumar and Singh, 1984), besides increasing the incidence of downy mildew and aphids. Toria sown on September 17 produced 33 and 20 per cent higher yield at Gurdaspur and 13 and 17 per cent higher yield at Ludhiana as compated to its sowing on September 25 and September 10, repsectively (Saini *et al.*, 1977). Yield of mustard at Ludhiana and Pantnagar was highest when sown on October 1 and a 15-60 days delay of sowing reduced the seed yield by 12-66 and 25-59 per cent at the two places(Saini,1984). Similary, a delay in sowing of gobhi sarson by 15,30, 45 days from october 10, reduced the seed yield by 7,33 and 52 percent respectively at Ludhiana (Saini and Gupta,1986). Based on all India work ICAR (1986) compiled the optimum time of sowing of rapeseed-mustard (Table 1).

3.4 Seed Rate

A desired plant population of 2-2.5 lakh/ha can be obtained by a seed rate of 2.4 kg/ha but to avoid the risk of poor stand establishment, due to small seed size and variability of soil moisture, a seed rate of 5 kg/ha is usually recommended (Kumar, 1984). Increasing seed rate from 5 to 10 kg/ha did not increase the seed yield of toria at Ludhiana (Saini *et al.*, 1977). With adequate soil moisture in the surface layer, which ensures good emergece, seed rate can be reduced to 4 kg/ha (Bhola and Yadava, 1982).

3.5 Seed treatement

Seed treatment with fungicides such as Apron (0.2%) or Bavistin/Thiram/ Captan @ 2 g/kg seed or Dithane M-45 @ 3-4 g/kg seed protects the crops from seedling diseases and ensures adequate crop emergence and stand (Kumar, 1986). Even seed soaking in water is reported to improve the seedling vigour. Water soaking or keeping the seed in moist soil overnight can be practised for improving crop stand in the rainfed areas.

3.6 Depth and method of sowing

Apart from seed rate and seed treatment, plant stand is governed mainly by depth and method of sowing. In irrigated areas, seeds should not be sown deeper than 2-4 cm (Saini, 1982), whereas in the rainfed areas, seeds can be sown at a depth of 4-5 cm (Kumar, 1986). Deep sowing would reduce emergence because of small seed size, while shallow sowing would reduce emergence if the surface soil is dry or temperature at sowing is quite high.

To have a perfect stand and better conservation of soil moisture, seeds should be sown in furrows with ridger-seeder (Kumar, 1986) and the fertilizers should not come in contact with the seeds. Studies conducted at Hissar, Pantnagar and Durgapur have shown that line sowing of mustard was better than broadcast only when thinning was done to maintain the optimum intra-row spacings (Table 2). Thinning should be done twice, first within 15 and second within 25 days after sowing. On the contrary, studies at Ludhiana on mustard and toria showed that seed and oil yields were not affected by thinning when recommended seed rates of 3.75 kg/ha were used (Saini et al., 1980 and Saini and Gupta, 1982).

Average of eight experiments on mustard at Kanpur showed that border method of sowing i.e. sowing in three rows continuosly and leaving fourth row unseeded and unfertilized to provide alleys for spray, particularly at pod formation stage, gave a seed yield of 28.6 q/ha as compared to 27.7 q/ha with regular sowing (Srivastava and Pathak, 1980). The border method, thus economised 25 per cent seed as well as fertilizers. The yield compensation in border method is made for by increased seed yield of three rows in comparison to seed yield of each individual row in regular sowing (Table 3). A better alternative to border sowing could be to harvest 2 rows of mustard after every 10 rows at 50-60 days after sowing (Kumar, 1983). This practice not only provided 24 q/ha green fodder, but also increased the mustard yield by 23 per cent (Table 4).

At Kanpur, sowing of mustard in north-south direction produced 10.2 per cent higher seed yield than sowing in east-west direction (Kumar, 1984). At Ludhiana, bidirectional sowing of mustard (cvs. RLM-514 and RLM-619) and gobhi sarson, at a row spacing of 30 cm in one direction and 45 cm in the other direction gave an additional seed yield of 2.1 q/ha as compared to their unidirectional sowing (Sharma et al., 1986). This is attributed to enhanced LAI, PAR interception as well as chlorophyll 'a' and 'b' contents by the bi-directional sowing.

3.7 Spacing/plant population

Maintenance of optimum and uniform plant population is a pre-requisite for obtaining high yields. The optimum plant population and crop geometry (spacing between and within the rows) would, however, vary with the species/variety, soil type, soil fertility, fertilizers and availability of water etc. (Saini, 1982). Bhan (1977) concluded that for toria, yellow sarson and dwarf mustard a spacing of 30 x 10-12 cm and for brown sarson and mustard a spacing of 45 x 10-12 cm was optimum. Saini (1982) reported that at Ludhiana, Hissar and Kanpur optimum spacing for RLM 198, Parkash and Varuna varieties of mustard were 30 x 10-15 cm (2.72 lakh plants/ha). 30 x 15 (2.18 lakh plants/ha) and 45 x 15 cm (1.45 lakh plants/ha), respectively. At Durgapur, row spacings of 15 and 30 cm produced similar yield of mustard which was 25.7 to 28.5 per cent higher than that at 45 cm wide rows (Kumar and Singh, 1984). At Pantnagar, optimum spacing for mustard was 45 x 15 cm and that for toria 30-40 x 15 cm (Kumar and Singh, 1984)

Increasing row spacing from 30 to 60 cm at Kanpur decreased the mustard (Varuna) seed yield by 16 per cent under irrigated conditions, but increased it by 5.5 per cent under rainfed conditions. Increase in intra-row spacings from 15 to 22.5 cm,, decreased the seed yield by 8.3 per cent under both the conditions. For irrigated yellow sarson, row spacing of 22.5 to 45.0 cm had similar seed yield at Kanpur (Srivastava and Pathak, 1980). Mustard cv. Parkash gave similar yileds at Hissar at row spacings of 22.5 to 40 cm (Kumar and Singh, 1984). At Jobner, a row spacing of 30 cm gave 16.5 and 10.2 per cent higher yield than 60 and 45 cm row spacings (Kumar and Singh, 1984). Likewise, increasing row spacing from 45 to 60 cm decreased the mustard seed and oil yield by 10.7 and 13.8 per cent, respectively, at Ludhiana (Singh *et al.*, 1975).

The adjusment in row spacing has, therefore, to be done depending upon the species, varieties, location, etc. The optimum plant spacings in rapeseed - mustard for various places in India has also been complied by ICAR (1986).

3.8 Fertilization

Oilseeds are energy-rich crops but they are generally grown under energy-starved conditions. This fact has been amply proved by the results given in Table 21 where the application of fertilizers alone brought a yield improvement of about 55 per cent in mustard. The fertilizers should preferably be drilled 3-5 cm deeper than the seed (Kumar, 1986) to avoid their adverse effect on germination/or emergence.

3.8.1 Nitrogen

Nitrogen is the most limiting nutrient in Indian soils. This is particularly true for rapeseed-mustard which are mostly grown in marginal and sub-marginal soils. Increase in seed yield by N is brought by improvement in the number of primary and secondary branches, siliqua/plant., seeds/siliqua and seed weight. Oil content in the seed is either decreased or unaffected, but the total oil yield is always increased by N application. Table 5 shows that optimum N rates for irrigated mustard varied from 80 to 180 kg N/ha which increased the seed yield by 3.45-16.60 q/ha at various places in India. The response to N in irrigated mustard varied from 2.90 to 10.38 kg seed/kg N with an average value of 7.25 kg/ seed/kg N. Under rainfed conditions, 40-60 kg N/ha, with an average response of 7.4 kg seed/kg N, seemed to be sufficient for mustard. Economic optimum rates of N for toria were 60-90 kg N/ha. The seed yield response at these rates were 1.52-8.32 q/ha or 1.90 to 13.87 kg seed/kg N, with a mean value of 7.00 kg seed/kg N (Table 5). For yellow sarson and taramira, about 30 kg N/ha was an adequate dose which produced 7.21 and 8.73 kg seed/kg N, in the two crops, respectively (Table 5).

Application of entire dose of N at planting in rapeseed-mustard either gave 15-19 per cent higher (Saini and Gupta, 1982 & Singh *et al.*, 1978) or similar yield as compared to that with 2-3 split dressings at Ludhiana (Pasricha *et al.*, 1987). At Bichpuri, however, 75 per cent N at sowing and the remaining as a foliar spray outyielded the full dose of N applied at sowing or half at sowing and half as foliar spray (Vir and Verma, 1979). Similarly, at Pantnagar, application of N in two splits is recommended for toria (half N at sowing and half N 25 days after sowing) and mustard (two-third at sowing and one-third 25 days after sowing) [Kumar and Singh, 1984].

A considerable saving in N-fertilizers could be made through phyllospheric bacteria. Three sprays of the bacteria on rainfed mustard, supplied with 20 kg N/ha, produced a sed yield (about 119 q/ha) equivalent to 80 kg N/ha, without bacterial spray at Kanpur, Kalyani and Shillongani (Kumar, 1984).

3.8.2 Phosphorus

Application of N, without P, will result in depletion of soil-P at a faster rate. The P removal per tonne of produce in rapeseed and mustard (21 kg P_2O_5/ha) is about 16 per cent higher than the total P removal by rice-wheat sysem (Tandon, 1987). Adequate P fertilization helps in improving the seed weight as also development of deeper and proliferous root system leading to extraction of water and nutrients from deeper layers *of soil profile. Addition of P, along with N, improves the seed yield further (Fig. 4). The* optimum rates of P, for rapeseed-mustard are, in general, one-half of the N rates. In over 1014 farm field trials, conducted all over India, application of 40 kg P_2O_5/ha increased the seed yield of rapeseed and mustard by 300 kg/ha i.e. 7.5 kg seed/kg P_2O_5 (Kumar and Singh, 1988). The data from some of the places are shown in Table 6. It may be important to note that the average responses to P in irrigated and rainfed areas were almost identical. Lack of response to P is also indicated at 1-2 places e.g. Anand, Gujarat (Pandey *et al.*, 1979 and Chaniara and Damor, 1984). In fact the response to P could be expected only if soil P was below 34 kg P_2O_5/ha (Kumar and Singh, 1988). The optimum rates of P for different places are given in Table 7. All phosphate is applied at sowing.

3.8.3 Potassium

Yield maximization with fertilizers in rapeseed and mustard cannot be realised without K application (Fig. 4). Mustard response to 15 kg K_2O /ha at Ludhiana was 10.67 kg/K_2O. In Bihar and Gujarat, too, mustard response to K @ 40 kg K_2O/ha was significant; the average response being 4.5 to 5.5 kg seed/kg K_2O (Tandon, 1988). Gangasaran and Kinra (1979) had also reported that 40 kg K_2O/ha was optimum for rapeseed-mustard. The **optimum NPK ratio** in these crops is generally **considered to be 2:1:1.**

3.8.4 Sulphur

Sulphur is not only a constituent of aminoacids and enzymes, but it is also a constituent of glucathione, which plays an important role in the synthesis of oil. While both N and S increase the protein content (Fig.5) oil content is increased only by S (Table 8). The S increases the oil yield mainly by increasing the oil content in the seeds, whereas N increases the oil yield by increasing the seed size. The S removal per tonne of produce (12 kg/ha) is the highest in oilseeds (Tandon, 1986). About 20 kg S/ha is considered to be optimum for rapeseed-mustard giving an average response of aobut 12 kg seed/kg S (Table 9), even though response to S was observed upto 30 kg/ha at Ludhiana (Saini, 1982) and 90 kg/ha at Varanasi (Biswas et al., 1986). Gypsum (calcium sulphate) was a better source of S than zinc/or potassium sulphate (Table 10). In brown sarson, seed yield, protein content, oil content and oil yield with S application @ 60 kg S/ha increased by 30 kg, 5.1 per cent, 5.5 per cent and 70 kg/ha respectively at Ludhiana (Pasricha *et al.*, 1987). The mean response to taramira with 90 kg S/ha was 3.7 kg seed/kg S (Tandon, 1986).

Critical level of S in plant tissue of mustard was 0.21 per cent, while critical N:S ratio was 15.5:1 in the plant tissue and 7.5:1 in the seed (Pasricha *et al.*, 1987).

3.8.5 Micronutrients

Application of 10 kg Zn/ha improved the seed yield of mustard at all the places except Berhampur (Table 9). Maximum response (35 per cent increase) was obtained at Pantnagar, where the response to B was exceptionally absent. At Ludhiana and Berhampur too, the response to B was only marginal. Sulphur, Zn and B together improved the mustard seed yield by 40 per cent (Table 9).

3.8.6 Nutrient interactions

Generally, there is a strong positive interaction between N x P. N x S, P x S, N x K, P x K in rapeseed-mustard. At Ludhiana, the economic optimum dose of N for mustard was 113 kg N/ha without P and 85 kg N/ha with 40 kg P_2O_5/ha; acutal seed yields were highest with 80 kg N + 40 kg P_2O_5/ha (Dhillon and Vig, 1985). Similarly, 80 kg N + 30 kg P_2O_5/ha, produced the maximum (24.7 q/ha) mustard seed yield at Delhi (Reddy and Sinha, 1988). For rainfed mustard, optimum NP rate was 54 kg N + 30 kg P_2O_5/ha at Ludhiana (Kapur *et al.*, 1984). The beneficial effect of P in improving N-use efficiency was better marked in cv. RLM 514 than in RLM 198 (Pasricha et al., 1987). In a positive interaction between N and S, at Ludhiana, maximum seed yield (16.2 q/ha) of mustard was recorded with 150 kg N + 60 kg S/ha (Pasricha *et al.*, 1987). A pot experiment conducted by the same scientists indicated a positive interaction between S and K in toria; the best yield obtained with 50 ppm S + 50 ppm K, was about 3 times higher than that in the control. These nutrients improved the uptake of each other. The implication of such studies is that for maximising seed and oil yields, all these nutrients should be applied together in matching amounts. This is also essential to maintain the soil fertility, because the nutrients removal by mustard is as high as 144 kg N, 87 kg S, 35 kg P_2O_5, 40 kg K_2O, 115 kg Ca and 7 kg Mg/ha (Srivastava and Pathak, 1980).

3.9 Other Factors Affecting Nutrient Responses

3.9.1 Preceding crops

Under unirrigated conditions of Varanasi, mustard produced 15 per cent higher seed yield when it followed black gram than that after maize *in the absence of N application*, But the average response to 60 kg N/ha was about 130 per cent higher in the latter than in the former case (AICRPDLA, 1981). At Hissar, N requirements of mustard were 30 kg N/ha less when it was grown after cowpeas and clusterbean than afer sorghum and pearl millet grown for fodder (Singh et al., 1983).

Under irrigated conditions, mean mustard yields at Ludhiana were 13.2 per cent higher when it followed cowpeas (green manure) - maize as compared to fallow-maize, but the magnitude of response of 120 kg N/ha was similar in both the cases (Fig. 6) At the same place, direct (positive) effect of clusterbean (green manuring) on mustard seed yield was about 58 per cent, but in this case too, the magnitude of response to 150 kg N/ha with or without green manuring was more or less the same (Fig. 7). However it may be significant to note that yield with green manure (without N) equalled that with N alone @ 100 kg N/ha. In *toria,* however, the magnitude of response to 60 kg N/ha without green manuring was 48 per cent higher than that with green manuring (Table 11). Green manuring increased the *toria* seed yield by 105 per cent and that of wheat, following toria, by 22 per cent The effect of green manuring was equal to 60 kg N/ha in toria and 30 kg N/ha in the following wheat (Table 11). These studies indicate that benefits from N application can be derived even after green manuring.

Unlike green manuring, incorporation of green gram residues in the soil, after picking pods, reduced the mustard yield at Ludhiana by 14.8 per cent even at recommended levels of N (Bahal *et al.*, 1986). This is attributed to immobilisation of N resulting from slow rate of decomposition, because of low temperature in the rabi season.

3.9.2 Available soil moisture

Availability, mobility and uptake of plant nutrients is primarily dependent upon soil-water. Increasing available soil moisture from 25 to 75 per cent at Agra improved the mustad response to 60 kg N + 40 kg P_2O_5 by 2.3 times (Table 12). The data amply shows that yield maximisation through fertilizers cannot be achieved wihout adequate maintenance of soil moisture.

3.9.3 Row spacing

Toria yield at Pantnagar with 90 kg N/ha at 30 cm (15.7 q/ha) and 40 cm (14.9 q/

ha) row spacings equalled that with 120 kg N/ha (15.5 q/ha) at 20 cm row spacings (Kumar and Singh, 1984). Excessive population, because of severe interplant competition, decreased the fertilizer efficiency.

3.9.4 Variety

Mustard cv. RLM 198 produced higher yield than RL 18 and Prakash under adequate N supplies, whereas the latter two gave higher yield without N at Ludhiana (Singh *et al.*, 1978). Differential response of mustard varieties to N is also repored by Nayak and Mondal (1985).

3.10 Irrigation

Table 12 shows that seed yield of mustard did not increase with increase in soil moisture under nutrient deficient conditions, but significant response to moisture (8 q/ha) was obtained with 60 kg N + 40 kg P_2O_5/ha. This indicates that fertilizers improved the water use efficiency. Rapeseed and mustard yields under irrigated conditions (15-20 q/ha) are usually 43-88 per cent higher than those under rainfed conditions (8-14 q/ha).

Under limited water supply situations, adjustment in crop geometry can make a substantial saving in irrigation water. For example, adjusting crop geometry at 45 + 15 cm and making channels in mustard produced 23.9 q seed/ha as against 23.2 q/ha with flat sowing at 30 cm. But the water use in the former case (412 thousand 1/ha) was only about one third of that (1453 thousand 1/ha) under the latter, though the number of irrigations in each case was two (Kumar, 1983).

Mustard sown after a heavy pre-sowing irrigation at Ludhiana produced maximum seed yield with one irrigation three weeks after sowing, which was 30-40 per cent higher than that of no post-sowing irrigation (Prihar *et al.*, 1981). Irrigation at this stage stimulates root extension into deeper soil layers which helps in the greater extraction of water from the soil profile. However, the first irrigation could be delayed upto 25-35 days after sowing (ICAR, 1986) which helps the plants to branch well resulting in turn in profuse flowering and fruiting. More than one irrigation at 0.6 and 0.8 IW:CPE ratios or at various growth stages tended to depress the seed yield (Prihar *et al.*, 1981). In case irrigation could not be applied at 3 weeks after sowing,one irrigation at flowering increased the yield by 26 per cent compared to only 9 per cent gap increase with irrigation at pod formation. (Saini, 1984). Two irrigations at flowering and late pod formation gave the highest yield in *toria* yellow *sarson* and msutard at Pantnagar, whereas 6 irrigations in mustard had given better returns in Gujarat (Kumar and Singh, 1984; Kumar, 1986). Laer studies on mustard revealed that the crop could be adequately irrigated at 60-75 per cent depletion of available soil moisture or at 1W:CPE ratio of 0.4-0.6 (Khan and Agarwal, 1985 and Reddy and Sinha, 1988). Excessive irrigations are reported to increase the aphid infestations (Kalra *et al.*, 1983) and the disease incidence (Saini, 1982). It may be important to note (Table 13) that rapeseed and mustard gave higher returns thatn gram. barley and safflower under limited moisture supply at Jobner and the returns from mustard exceeded those from *taramira* (Kumar and Singh, 1984). Under delayed sowing (end-November-early-December), however, *taramira* gave about 34 per cent higher yield than mustard at Agra (Kumar, 1983).

3.11 Weed Control

Full benefits from high yielding varieties, fertilizers and water cannot be derived without adequate weed control. Weeds are known to reduce the yield of rapeseed-mustard by 10-70 per cent depending upon the composition and intensity of weed flora. Competition from weeds is most severe upto 5-6 weeks after sowing (Kondap *et al.*, 1983). Interculture at 20-25 days after sowing would not only remove weeds, but also conserve soil moisture. Weeds can also be effectively and economically controlled by herbicides. At Pantnagar, mustard yields from isoproturon (pre-emergence) and fluchloralin (preplant incorporated in surface soil) @ 1 kg/ha equalled those from the weed free plots (Kumar and Singh, 1984). Whereas, at Hissar pendimethalin (pre-emergence) @ 0.75 kg/ha was the most effective (Kumar and Singh, 1984). Recent studies at Ludhiana have revealed that the dosage of fluchloralin and isoproturon in mustard can be reduced to 0.5 kg/ha (Gill *ett al.*, 1984). Isoproturon @ 0.5 kg/ha can also be applied as post-emergence after 25 days of sowing in mustard. It might give temporary phytotoxic effect, but it has no adverse effect on the seed yield.

3.12 Mulching

Mulching with plat materials @ 20-25 t/ha after first thinning and weeding, conserved moisture and gave 25-60 per cent increase in mustard yield under rainfed conditions (Bhan, 1977 and Kumar, 1986).

3.13 Plucking Leaves for Vegetable (Saag)

Plucking of mustard tops for *saag* (leafy vegetable) and then leaving the crop to set seed is a common practice, particularly in Punjab. Studies at Ludhiana revealed that three pluckings gave the highest yield of tender shoots (129 q/ha) and a seed yield of 8.2 q/ha. Though the seed yield after 3 pluckings was 52,61 and 75 per cent of the seed yield obtained with 0, 1 and 2 pluckings respectively, but the total returns were highest with 3 pluckings (Saini *et al.*, 1980). In an intercropping experiment at Ludhiana, on *toria* and *gobhi sarson* sown simultaneously in mid-September, Gobhi sarson plucked once for *saag* at 50-60 days after sowing followed by seed setting gave better returns than those from *toria*-wheat, *torai* + *gobhi sarson* and *gobhi sarson* unplucked (Gupta and Saini, 1986).

3.1.4. Growth regulators

Interestingly, both the growth promoters and the retardants had a favourable effect on the growth and yield of mustard. Foliar sprays of IAA or Kinetin (15, 20 or 25 ppm) or GA (25 ppm) at flowering and pod filling stages improved the leaf area index leaf, chlorophyll content, pods/plant, seed weight and **finally the seed yield of mustard and** *gobhi sarson* at Ludhiana (Cheema et al., 1987).

Chlormequat/Cycocel (2-chloroethyl-trimethyl-ammonium chloride) spray @ 80 ml/ha in mustard at flower initiation stage increased the mean seed yield at Ludhiana by about 4.5 q/ha (Saini *et al.*, 1987). The response was more pronounced in unirrigated crop than in irrigated one. The yield increase is attributed to more number of primary branches, higher number and length of siliquae, more seed weight and higher seed oil content. Similar results are also reported by Cheema *et al.* (1987). They also reported that the effect of etheral (ethephon) spray @ 500 ppm on mustard and *gobhi sarson* was similar to that of Cycocel. The interaction between cycocel/etherel and N was significant. At 50 kg N/ha, the response to cycocel and etherel was restricted upto 250 and 500 ppm, respectively, whereas at 100 kg N/ha yields increased consistently with the increasing levels of cycocel (upto 500 ppm) and etherel (1000 ppm). Cycocel can also be sprayed in conjunction with insecticides.

3.15 Cropping Systems Research in Rapeseed-Mustard

In the irrigated areas, inclusion of rapeseed-mustard in the promising intensive cropping systems as a second or third crop or as intercrop in the main crops holds the key to boost the production of edible oils in India.

3.15.1 Substitution/addition in the crops in a cropping system

Toria, being a short duration crop, fits conveniently in rice/maize-wheat system. The sowing time of the crop (s) has to be adjusted in such a way that even if the yield of one crop is reduced, the net return from the system is always maximum. In toria-wheat system at Pantnagar, toria yield increased from 6.78 to 13.05 q/ha with a delay in sowing from August 18 to September 15, whereas the yield of following wheat decreased from 38.2 to 24.9 q/ha. The returns were, however, maximum when toria was sown on September 15 (Kumar, 1986). Toria can also be grown prior to spring cane/or groundnut, and winter maize/*gobhi sarson* (both transplanted) in N-W India. In the event of delayed monsoon or insufficient/excessive rain leading to failure of *kharif* crops, *toria* can be grown from September onwards with irrigation/or residual moisture.

Mustard can conveniently replace wheat in coarse-textured soils (Cheema and Sahota, 1987). Even in potato growing areas of Kanpur, mustard gave 109 per cent higher profit than potato (Rathi *et al.* 1980). Mustard yields were generally better when it followed legumes rather than cereals; the maximum yield being after cowpeas (fodder) and lowest after maize (Chatterjee *et al.*, 1986).

3.15.2 Intercropping systems

Mustard can also be grown advantageously in the intercropping systems with wheat, gram, potato, sugarcane, etc., in a wide range of water supply situations. The intercropping of mustard with autumn cane gave and additional seed yeld of 2.83 q/ha as compared to its pure crop at Pantnagar (Kumar, 1983). At Kanpur, mean yields of mustard and *toria* intercrops in sugarcane were about 10 and 16 per cent higher than their pure crops (Table 14). Similarly, companion cropping of mustard with potato (in 1:3 ratio) proed to be 122 per cent more rewarding than mustard alone (Table 15). The superiority of potato + mustard (3:1) over the pure crops was also established at Pantnagar, Faizabad and Hissar in the experiments conducted under the AICORPO during 1982-83 to 1986-87. Sowing one row of mustard alternating with 8-9 rows of wheat gives an additional oilseed yield of 2-3 q/ha without affecting wheat yield. For intercropping with wheat, suitable varieties of mustard were PR-43 at Pantnagar, RH-781 at Hissar, Varuna at Kanpur, Faizabad and Navgaon and RW-43/II at Berhampore (Kumar, 1986). Mustard and gram can also be grown together because of their similar growth duration and climatic requirements. The productivity from mustard + gram (1:4 or 1:3 system) exceeded that from either of the two crops grown seperately at Kanpur and Ludhiana (Rathi *et al.*, 1980 and Cheema and Sahota, 1987). The microclimate is favourably altered by such systems. The returns from wheat + mustard (irrigated) and mustard + gram (rainfed) exceeded those from pure crops and intercropping practices of the farmers (Tables 16 and 17).

Toria + gobhi sarson is a potential new introduction in intercropping systems, by Gupta and Saini (1986) and holds a considerable promise in increasing the oilseed yield/unit area/unit time in the irrigated alluvial soils. These crops sown simultaneously around mid-September, in alternate rows, 22.5 cm apart, gave 27.4 q/ha equivalent seed yield of gobhi sarson at Ludhiana. This was 58, 99 and 83 per cent higher than equivalent seed yields from gobhi sarson (sole crop), *toria - gobhi sarson* and toria - wheat systems, respecively (Gupta and Saini, 1986). Cultivation of *gobhi sarson*, alone or in combination with *toria* should be encouraged because it has several advantages as compared to other rapeseed-mustard crops (Saini and Gupta, 1987).

The performance of short duration varieties (e.g. TL-15 of toria) is usually better than other varieties under such systems (Saini and Gupta, 1982). The fertilizer requirements of intercropping systems with rapeseed-mustard are either the same as that for main crops (e.g. wheat, gram, potato, *gobhi sarson*, etc,) or are proportional to their area in the main crop e.g. sugarcane.

3.15.3 Emerging (New) Cropping Systems

Maize + cowpeas (fodder) - toria - transplanted winter maize and paddy - transplanted gobhi sarson - summer green gram are the two emerging cropping systems in the irrigated arreas. The returns from these two cropping systems were over 1.5 times more than those from maize - wheat and paddy - wheat systems (Sahota et al., 1988).

Table 20 shows that transplanted gobhi sarson gave more than double the seed yield of direct seeded crop. Even the seed yield from the crop transplanted on December 15 was 23 per cent higher than the direct seeded crop 30 days earlier on November 15. This practice thus has a great potential to replace late-sown wheat, in vast areas, which usually gives low return. Numerous advantages of transplanted *gobhi sarson* vis-a-vis its direct seeding are listed below:

- Double the seed yield
- Saving in energy (less preparatory tillage required)
- About 75% saving in seed rate
- Less weeds problem
- Thinning operation eliminated
- Early maturity (12-20 days)

  (i) Less risk of high temperature near maturity
  (ii) Permits bonus crop of summer pulses
  (iii) Higher yield of following crop

- Can replace wheat, sown late after cotton, *toria*, sugarcane and even paddy (long duration varieties)

3.15.4 Effect of preceding crops

Effect of preceding crops/green manuring in various cropping systems involving rapeseed-mustard has been discussed in Section 3.9.1. The most commonly followed cropping systems centred around rapeseed-mustard in India are listed by ICAR (1986) and are, therefore, not discussed here.

3.16 Harvesting

The crops should be harvested at the right stage to avoid shattering losses particularly in mustard and *gobhi sarson* Table 18 shows that for maximum seed and oil yield, mustard should be harvested at yellow pod stage when moisture in the seed is about 42 per cent. The same stage was optimum for harvesting toria (Table 19). This resulted in a gain of 7 days in mustard and 8-14 days in toria. This has a special significance for intensive cropping systems in which even a weeks delay in sowing of subsequent crop could result in substantial reduction in seed yield.

4. Efficacy and Relevance of Agro-Production Technology

4.1 General

Experimental evidence suggest that with the adoption of improved prodcution technology in package form, the yield of mustard (irrigated) can be increased upto 165 per cent, of toria upto 87 per cent and of taramira (rainfed) upto 80 per cent (Table 21 to 23). In general, fertilizer application, irrigation, improved seed and plant protection measures besides optimum and uniform plant stand, are the most important production factors in rapeseed-mustard crops. However, to realise the maixmum yield potential, adoption of the above mentioned factors in package form is a must. In order to save on the cost of these inputs, it is advisable to identify the local constraints and remove them through malady remedy analysis. In certain cases, a change in one component alone may result in a spectacular gain in yield, in others a chain of changes may be required. The most limiting factor withholding the yield in no case be ignored.

4.2 Research Station Trials

In mustard, the overall means of 18 trials conducted at five locations (table 21) revealed that the improved variety gave an increase of 18 per cent over the local one. Among the single factors fertilizers application brought the highest increase of 55 per cent, followed by 43 per cent with pest control (Fig. 8). Combination of fertilizer and plant protection, and fertilizer and irrigation enhanced the seed yield by 112 and 105 per cent, respectively. The highest increase of 165 per cent was achieved with adoption of full package of practices, over the local variety.

In *toria*, the package of practices brought 52 per cent increase in seed yield, over the local variety at Pantanagar and 69 per cent at Berhampur (Table 22). Fertilizer application at Pantnagar and disease control at Berhampur were the most important single factor which brought a respective increase of 51 and 32 per cent over the local variety. Replacement of local variety with the standard variety alone increased the seed yield by 13 and 20 per cent, respectively, at the two places. At Hissar, adoption of package of practices enhanced the seed yield by 87 per cent over farmers' practices.

In rainfed *taramira* adoption of improved practices with local and improved variety caused an increase of 67 and 80 per cent, respectively, over the farmers practices (Table 23).

4.3 Farmers' Field Demonstrations

4.3.1 Trials by Oilseed scientists

The research based production technology on rapeseed-mustard was compared with farmers' practices in half-plot demonstrations in farmers' fields. In The improved practices showed a superiority of 18-65 per cent in toria and 41 per cent in mustard, over farmers' practices (Table 24).

The yield potential achievable with improved producton technology using standard variety as demonstrated in 485 farmers' fields trials in various states revealed that the productivity of rapeseed-mustard can be increased mani-fold (Table 25) over the national average of about 7 q/ha.

4.3.2 National Demonstrations

The results of 176 National Demonstrations conducted by the staff working in the National Demonstration Project during 1980-84 in various states on irrigated mustard (Table 26) showed that the mean seed yield ranged from 10.48 q/ha to 15.33 q/ha with the highest yield range of 18.75 to 27.50 q/ha.

Fifty-nine demonstrations on rainfed mustard showed that the mean and the highest yield ranged from 8.2 to 9.7 and 11.5 to 20.0 q/ha respectively (Table 27).

5. Transfer of Technology

Taking a realistic view of the available levels of technology and their production potential, which has been adequately tested and demonstrated at the research stations as well as in farmers' fields, there is hardly room for any scepticism about the capabilties of the country to keep date with the targets. The need is to extend it urgently and effectively in farmers fields in large areas by launching massive technology-transfer programmes backed with timely supply of inputs. Credit and adequate and well-trained extension services. Fortunately, a good number of extension programmes/projects like National Demonstrations, Operational Research, Lab to Land, National Oilseeds Development Project, Oilseeds Production Thrust Project and other Extension Organisations already exist. A 'Technology Mission on Oilseeds' has been set up to coordinate and integrate the oilseeds' work at the National Level. Sincere and concerted efforts made by all concerned organizations/departments are apt to boost the oilseed production and achieve the desired goals in the very near future.

6. Research Gaps/Bottlenecks

- Susceptibility of present, varieties to diseases (alternaria blight, white rust), pests (mustard aphid) and frost.
- Lack of varieties for drought, saline/alkaline soils.
- Lack of suitable short-duration varieties for intercropping and late sowing.
- Inadequae production technology for dry land farming and for low-input management.
- Inadequate mechanism to produce and supply adequate quantity of quality seeds of improved varieties.
- Absence of suitable post-harvest technology
- Lack of improved farm machinery

- Non-existence of forecasting system for pests and diseases occurrence.
- Lack of sound procurement system.

7. Future Priorities and Thrusts

7.1 Research

- Development of high yielding varieties having high oil and better stability against diseases and insect-pects.
- Development of early maturing varieties, suitable for different cropping systems and diverse agro-climatic conditions.
- Development of hybrids in Indian mustard and *Brassicanapus*.
- Strengthening seed multiplication and distribution programmes of quality seeds of improved varieties.
- Development of remunerative agro-technology to realise the Genetic potential of improved varieties under different cropping patterns.
- Development of appropriate low-cost technology, for rainfed areas, in particular.
- Development of suitable farm implements.
- Modern post-harvest technology for better processing and storage.
- Formulation of effective integrated disease and pest control measures.

7.2 Development

- Launching of massive programmes on transfer of technology with supply of necessary inputs, credit and adequate extension services.
- Organising field demonstrations on a massive scale with improved package of practices.
- Popularising suitable and economically viable intercropping systems involving oilseed crops.
- Passing on timely advice on the control of pests, diseases, weeds and frost.
- Extending oilseed crops in new potential areas.
- Increasing Area under irrigation

8. Summary and Conclusions

Based on agronomic research conducted on rapeseed-mustard in India in the last decade, the following conclusions have emerged:

(i) Preparatory tillage is conducive to high yield.

(ii) Optimum sowing time varies with the species and the regions. Sowing may be done when the maximum temperature is around 30°C.

(iii) Optimum and uniform plant stand is a pre-requisite for obtaining maximum yield. Thinning may be resorted to 15-25 days after sowing if the plant population is more than required.

(iv) Bi-directional sowing of mustard and *gobhi sarson* is better than uni-directional sowing.

Border method of sowing (every fourth row left unseeded) saves 25 per cent seed and fertilizer without reduction in mustard yield.

(v) Balanced fertilization with macro (N,P,K and S) and micro-nutrients (Zn and B) is essential for achieving high yields.

On an average, one kg N produced 7.25-7.40 kg mustard, 7 kg *toria*/brown sarson, 7.2 kg yellow sarson and 8.73 kg *taramira*. The average responses to one kg P_2O_5 was about 7 kg seed in all these crops except *taramira* (6.25 kg seed/kg P_2O_5). Mean response to K was *4.5-5.5 kg seed/kg K_2O and that to S it was about 12 kg seed/kg S. In general, the responses* to N and P were similar in irrigated as well as rainfed crops, though the economic optimum rates of N in rainfed areas were one-half to one-third of that for irrigated areas.

(vi) The effect of green manuring on seed yield was equivalent to 60 kg N/ha in *toria* and 100 kg N/ha in mustard, though N application increased the yield of these crops even after green manuring.

(vii) Weeds can also be effectively controlled by timely application of herbicides. Fluchloralin (pre-sowing) and isoproturon (pre-emergence) @ 0.5-1.0 kg/ha were the most effective in mustard, and *gobhi sarson* and *toria*. Isoproturon @ 0.5 kg/ha can also be applied as post-emergence (25 days after sowing).

(viii) Under water scarcity conditions, irrigation almost doubles the seed yield. Irrigation scheduling at IW:CPE ratio of 0.4-0.6 is considered ideal in mustard. Generally two irrigations - first at 21-35 days after sowing and the second at flowering/fruiting are needed in mustard and *toria*

(ix) The spray of growth regulators, especially Cycocel, at flower-initiation appreciably enhanced the mustard seed yield. The effect of Cycocel was better marked under rainfed conditions.

(x) For maximising returns, mustard can be intercropped with wheat (1:8-9), potato (1:3), and autumn cane (2:1) in irrigated areas and with gram (1:3-4) in rainfed areas.

(xi) Intercropping of gobhi sarson in toria is a potential tool to boost oilseed production in irrigated areas of some states.

(xii) Transplanting, about 60 days old seedlings, of gobhi sarson almost doubles the seed yield as compared to its direct seeding. The magnitude of improvement in yield is accelerated with delay in sowing/transplanting. The practice will help to favourably replace late-sown wheat. Besides numerous other advantages, it permits a bonus crop of summer pulse.

(xiii) Harvesting of *toria* at yellow pod stage (rather than at full maturity) cuts short the delay in sowing of following wheat and results in increased returns from *toria* wheat system.

(xiv) For yield maximisation, adoption of improved practices in package form, has established its credibility in on-station as well as on-farm trials. This needs to be carried to farmers fields on large scale on war footing.

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TABLE 1:
Optimum time of sowing of rapeseed-mustard in different states

State	Mustard	Toria	Brown sarson	Yellow sarson	Taramira	Gobhi sarson
N.E.Hill Region	Mid Oct. to Nov.	Mid Oct. to Nov.	-	Mid Oct. to Nov.	-	-
Assam	-	Mid Oct. to Mid Nov.	-	-	-	-
West Bengal	Mid Oct. to early Nov.	End Sept. to early Oct.	-	Mid Oct. to early Nov.	-	-
North Bengal	End Oct. to end Nov.	Mid Oct to early Nov.	-	Last week Oct. to last week Nov.	-	-
Orissa	-	End Sept. to mid Nov.	-	End Sept. to mid Nov.	-	-
Bihar	II-III week of Oct.	Sept. 25 to Oct. 10	-	Ist fortnight of October.	-	-
Uttar Pradesh	Ist fortnight of October	Early or mid Sept.	-	-	-	-
Madhya Pradesh	Early Oct.	Early Sept. to III week of Sept.	-	-	-	-
Gujarat	IInd week of Oct.	-	-	IInd week of Oct.	-	-

(Contd.)

(Table 1 Contd.)

State	Mustard	Toria	Brown sarson	Yellow sarson	Taramira	Gobhi sarson
Rajasthan	Mid Sept. to early Oct.	End Aug. to early Sept.	Mid Sept.	Mid Sept.	Nov./Dec.	-
Haryana	Mid Oct.	End Aug. to Mid Sept.	End Sept. to early Oct.	End Sept. to early Oct.	Nov.	-
Himachal Pradesh	Oct. 1-15	Before Sept. 20	Last week of Sept.	-	-	-
J & K	-	-	Mid Sept. to Mid Oct.	-	-	-
Punjab	Mid Oct to Mid Nov.	Sept. 1-15	-	-	Oct.	Oct. 10-30 for direct seeding and Nov. 1 to Dec. 15 for transplanting

Source: ICAR (1986) with modifications for Punjab by the authors

Table 2:
Influence of sowing method on seed yield of mustard

Treatment	Mustard Yield (q/ha) at Hissar	Pantnagar	Durgapur	Mean
Broadcast	18.9	18.7	20.0	19.2
Line sowing without inter row thinning	19.1	17.9	18.3	18.8
Line sowing with inter row thinning	23.3	19.3	23.0	21.9

Data Source : Kumar and Singh (1984)

Table 3:
Mustard yield of individual rows in border and regular method of sowing

Rows	Mustard seed yield (q/ha)	Contribution to total yield (%)
Border Method		
Eastern	10.4	37.5
Centre	7.9	28.7
Western	9.4	33.8
Regular Method		
Individual row	6.7	25.0

Data Source : Srivastava and Pathak (1980)

Table 4:
Effect of partial harvesting of mustard on fodder and seed yield

Treatment	Mustard seed yield (q/ha)	Green fodder yield (q/ha)
All lines uncut	13.4	-
Two lines harvested after 10 lines	16.5	29.4
Two lines harvested after 15 lines	15.1	18.7

Data Source : Kumar (1983)

Table 5:
Average response of rapeseed and mustard to N in India

Crop	Rate of N (kg/ha)	Seed yield (q/ha) Without N	With N	Response q/ha	Response kg/kg N	No. of experi-ments averaged
(i) Irrigated Conditions						
Mustard	125 (80-180)*	10.53	19.26	8.96 (3.45-16.60)	7.25 (2.90-10.38)	15
Yellow Sarson	30	7.12	9.28	2.16	7.21	1
Brown Sarson	80	2.80	8.40	5.60	7.00	1
Toria	73 (60-90)	7.10	12.01	4.91 (1.52-8.32)	7.00 (1.90-13.87)	7
(ii) Rainfed Conditions						
Mustard	55 (40-60)	7.62	11.73	4.11	7.40	4
Taramira	30	11.47	14.09	2.62	8.73	1

* Figures in () indicate range.
Data Source : A number of experiments conducted by several oilseed scientists in India.

Table 6:
Response of rapeseed and mustard to P application at various locations

Location	P_2O_5 (kg/ha)	Seed yield (q/ha) Without P	With P	Response q/ha	Kg seed/ kg P_2O_5
1. Mustard					
(a) Irrigated areas					
Patiala	40	7.32	8.96	1.64	4.10
Aligarh	40	13.45	17.27	3.82	9.55
Bareilly	40	7.51	10.44	2.93	7.33
Hardoi	40	10.79	13.42	2.63	6.58
Mean	**40**	**9.77**	**12.52**	**2.76**	**6.89**
(b) Rainfed areas					
Tehri Garhwal	40	8.14	9.20	1.06	2.65
Bhilwara	40	12.75	17.39	4.64	11.60
Sikar	40	8.25	10.87	2.63	6.58
Mean	**40**	**9.71**	**12.49**	**2.78**	**6.95**
Toria-Irrigated					
Hissar	50	20.62	24.13	3.51	7.02 (3.52 oil)
Taramira-rainfed					
Jobner	30	12.67	13.82	1.25	6.25

Data Source : Kumar and Singh (1984 and 1988).

TABLE 7:
Some general phosphorus recommendations for rapeseed-mustard in India

Crop	Recommended phosphorus doses (kg P_2O_5 /ha) for different states				
	10	20	30	40	50
Toria (I)	-	Raj., Punjab	U.P.	Bihar, H.P.	-
Toria (R)	**Raj.**	U.P., M.P., Bihar, H.P.	-	-	-
Mustard (I)	-		Haryana	U.P., Raj. Delhi, H.P.	**Pb.**
Mustard (R)	-	Bihar, U.P., Raj., H.P., Haryana, Pb.	-	-	-
Brown Sarson (I)	-	Haryana, Pb.,	U.P.	Bihar, Raj., H.P.	-
Brown Sarson (R)	-	Bihar, U.P., Raj.. H.P., Haryana	Kashmir	-	-
Yellow sarson (I)	-	Haryana, Pb.	U.P.	Bihar	-
Yellow Sarson (R)	-	Haryana	-	-	-

I = Irrigated; R = Rainfed
Data Source: Kumar and Singh (1988)

Table 8:
Effect of N and S on protein content, oil content and oil yield of mustard at Ludhiana (mean 3 years)

N (kg/ha)	Oil (%)	Oil yield (q/ha)	S (kg/ha)	Oil (%)	Oil yield (q/ha)
0	38.7	2.0	0	36.2	3.8
50	39.0	3.4	30	38.8	4.0
100	39.2	5.0	60	42.2	4.5
150	39.4	6.1			

Data Source : Pasricha *et al.* (1987)

Table 9:
Response of mustard to S,Zn and B at various places

Nutrient	Rate (kg/ha)	Mustard Seed Yield (q/ha)						
		Kanpur	Hissar	Berham-pur	Durga-pur	Pant-nagar	Ludh-iana	Mean
Control	-	16.0	13.3	9.6	10.9	12.0	4.0	11.0
S	20	18.5	13.4	11.2	13.9	15.3	8.2	13.4
S+Zn	20+10	19.4	14.2	10.8	14.6	20.6	9.1	14.8
S+Zn+B	20+10+1	20.3	15.2	11.2	15.7	19.9	9.5	15.3

Data Source : Kumar and Singh (1984)

Table 10:
Effect of Sources of S on mustard

Source	Mean seed Yield of 3 year (q/ha)	Increase in yield (%)
Control	10.0	-
Calcium Sulphate (gypsum)	13.9	39
Zinc Sulphate	12.6	26
Potassium Sulphate	11.2	12

Data Source: Chatterjee *et al.* (1985)

Table 11:
Direct and residual effect of green manuring on yield of *toria* and wheat at Ludhiana

N (kg/ha)	Direct effect		N (Kg/ha)	Residual effect Wheat yield (q/ha)	
	Without green manuring	With green manuring		Without green manuring	With green manuring
0	2.17	10.48	30	6.6	11.0
20	6.10	13.64	60	17.8	19.9
40	8.53	15.62	90	20.2	24.8
60	10.49	16.10	120	23.9	27.5
Mean	**6.82**	**13.96**	-	**17.1**	**20.8**

Data Source: Pasricha *et al.* (1987)

Table 12.
Response of mustard to fertilizer under varying soil moisture regimes at Agra.

Available moisture (%)	Soil Seed yield (q/ha) N_0P_0	$N_{20}P_{20}$	$N_{60}P_{40}$
25	8.1	12.4	13.9
50	9.6	14.7	17.1
75	8.7	16.2	21.9

Data Source : Singh and Das (1984).

Table 13:
Production potential of rabi crops under limited moisture supply

Crop	Yield (q/ha)	Gross returns (Rs./ha)
Gram	5.86	1488
Safflower	6.07	1565
Barley	10.41	1960
Taramira	9.98	3162
Mustard	10.74	4400

Data Source : Kumar and Singh (1984)

Table 14:
Performance of mustard and toria as pure crops and as intercrops in sugarcane

Crop	Seed Yield (q/ha)		Increase over
	Pure Crop	Intercrop	Pure Crop 1%
Mustard	27.0	29.6	9.7
Toria	14.7	17.1	16.1

Data Source : Rathi *et al.* (1980)

Table 15:
Yields and profit from mustard as sole crop and as intercrop with potato

Cropping system	Yields (q/ha)		Net profit from
	Potato	Mustard	mustard (Rs./ha)
Pure Crops	292	28.7	4537
Potato + Mustard	262	22.7	10056

Data Source: Rathi *et al* (1980)

Table 16.
Returns from Mustard + Wheat intercropping system

Cropping system	*Gross returns (Rs.Ha)
Pure Wheat	6150
Wheat + Mustard (9:1) (Recommended practice)	7438
Wheat + Mustard (Farmers practices)	6145

Data Source: Annual Report, Rapeseed - Mustard, All India Coordinated Research Project on Oilseeds for 1985-86 (pp.225-229)

*Mean of 2-3 years over 5 places, viz. Faizabad, Hissar, Navgaon, Pantnagar and Berhampur.

Table 17:
Returns from intercropping of mustard in gram under rainfed conditions

Cropping system	Gross returns (Rs./ha)
Pure gram	6892
Pure mustard	6222
Gram + mustard (3:1)	8731
Gram + mustard (4:1)	8311
Gram + mustard (Farmers' practices)	6393

Data Source: Annual Report Rapeseed-Mustard, All India Coordinated Research Project on Oilseed for 1985-86 (pp. 230-234) 1984-85 (pp.203)
* Mean of 2-3 years over 4 places, viz., Pantnagar, Kanpur, Hissar and Durgapur

Table 18:
Effect of stage of harvesting on mustard (cv. Prakash)

Growth stage	Crop duration (days)	Yield (q/ha)	Moisture (%)	Oil content (%)
Green pod	127	9.22	72	34.3
Few pods turning	134	13.81	52	40.9
Yellow				
Yellow pods	142	20.37	42	42.9
Full mature	149	18.87	34	42.3
Over mature	158	9.11	12	42.8

Source: Kumar (1986)

Table 19:
Effect of stage of harvesting of Toria on seed yield

Treatment	Seed yield* (kg/ha)	Maturity (days)
Green pod stage	1414	78-85
Yellow pod stage	1829	88-100
Full maturity	1737	96-114

* Mean of 3 varieties for 2-3 years at Ludhiana, Hissar, Kanpur and Pantnagar.

Data Source: Annual Reports Rapeseed-Mustard, All India Coordinated **Research** Project on Oilseeds, for 1982-83 (pp.41), 1983-84 (pp.281), 1984-85 (pp.209-212)

Table 20:
Mean seed yield (q/ha-average of 4 years) of direct seeded and transplanted gobhi sarson

Date of sowing/ transplanting	Seed yield (q/ha)		Increase over direct seeding (%)
	Direct seeding	Transplanting 60 days old seedlings	
November 15	11.7	24.6	110
November 25	9.8	21.5	119
December 5	8.4	17.5	108
December 15	5	14.4	171
December 25	3.6	10.8	200
January 5	1.7	7.0	312
Mean	**6.8**	**16.0**	**135**

Data Source : Saini and Gupta (1987)

TABLE 21:
Effect of different production factors on the seed yield (kg/ha) of mustard

Treatment	Hissar		Ludhiana		Kanpur		Durgapur		Kalyani		Overall mean	
	Mean of 5 yrs	% inc-rease	Mean of 3 yrs	% inc-rease	Mean of 2yrs	% inc-rease	Mean of 4 yrs	% inc-rease	Mean of 4 yrs	% inc-rease	Yield	% inc-rease
Local variety	589	-	632	-	865	-	565	-	694	-	669	-
Standard variety (S.V.)	709	20	699	11	1040	20	742	31	754	9	789	18
SV + Fertilizer (F)	1113	89	883	40	1384	60	901	59	912	31	1039	55
SV + Irrigation (I)	806	37	912	44	1091	26	727	29	967	39	901	35
SV + Pest Control (P)	1053	79	894	41	1398	62	707	25	841	21	960	43
SV + Disease control (D)			904	43	1511	75	612	8	727	5	938	40
SV + F + I	1443	145	1143	81	1717	99	1080	91	1484	114	1373	105
SV + F + P + D	1364	132	1133	79	2095	142	1328	135	1157	67	1415	112
SV + I + P + D	1019	73	1131	79	1585	83	881	56	1311	89	1185	77
Full Package	1778	202	1391	120	2328	169	1628	188	1751	152	1775	165

% denotes percentage increase over local variety.

Data Source : Annual Reports, Rapeseed-mustard, All India Coordinated Research Project on Oilseeds for 1980-81 (pp. 101), 82-83 (pp. 20) and other reports.

TABLE 22:
Effect of different production factors on the seed yield (kg/ha) of toria

Treatment	Pantnagar Yield	Pantnagar % increase	Berhampur Yield	Berhampur % increase	Treatment	Hissar Yield	Hissar % increase
Local variety	1006		790	-	Farmers practices	681	-
Standard variety (SV)	1135	13	951	20	SV + Plant population	970	42
SV + Fertilizer (F)	1517	51	980	24	SV + Fertilizer (F)	1141	68
SV + Irrigation (I)	1176	17	-	-	SV + Plant protection (PP)	991	46
SV + Pest control (PC)	1387	38	807	2	SV + F + PP	1444	112
SV + Disease control (DC)	1274	27	1045	32	Full Package	1272	87
SV + F + I	1488	48	-	-	C.D. 5%		
SV + F + P + D	1378	37	1040	32			
SV + I + P + D	1269	26	-	-			
Full Pack	1533	52	1320	67			
C.D. 5%	152		54				

% denote percentage increase over local variety.

Data Source : Annual Report, Rapeseed-mustard, All India Coordinated Research Project on Oilseeds for 1980-81 (pp. 23) and 83-84 (p. 286)

Table 23:
Effect of different production factors on seed yield of Taramira at Jobner

Treatment	Mean seed yield (kg/ha) at 3 locations	Increase (%)
Local variety with farmers' practices	423	-
Local variety with improved practices	707	67
Improved variety with improved practices	763	80

Data Source : Annual Report Rapeseed-Mustard, All India Coordinated Reserach Project on Oilseeds for 1982-83 (pp.19)

Table 24:
Results of rapeseed-mustard demonstrations in farmers' fields during 1983-84 and 1984-85

Crop	State	No. of demonstrations	Seed yield (q/ha) Farmers' practices	Improved practices	% increase
Toria	Assam	10	5.55	9.13	65
Toria	U.P.	2	13.97	16.40	18
Mustard	U.P.	3	12.92	18.30	41

Data Source : Annual Reports Rapeseed-Mustard, AICORPO

Table 25:
Seed yield obtained in farmers' fields demonstrations in various states

Crop	State	No. of demonstrations	Seed yield range (kg/ha)
Mustard	Punjab	8	1550-2158
-do-	Himachal Pradesh	4	1400-1620
-do-	Madhya Pradesh	5	2000-2600
-do-	Delhi	8	2140-3150
-do-	Haryana (varieties)	14	1852-2815
-do-	Haryana	89	750-2700
-do-	Gujarat	201	1120 (mean)
-do-	Haryana	71	1698 (mean)
-do-	U.P.	26	1679 (mean)
Toria	Madhya Pradesh	5	2000-2600
-do-	Haryana	14	900-1600
-do-	U.P.	40	1273 (mean)

Data Source : Annual Report, Rapeseed-Mustard, AICORPO

TABLE 26 :
National Demonstration Trials on Mustard (Irri) in Various states

	State	No. of demons-tration	Yield (q/ha) Mean	Yield (q/ha) Highest*	Gross returns (Rs./ha)	Cost of production (Rs./ha)	Return over operational cost (Rs./ha)
1980-81	Gujarat, J&K, Orissa, U.P. and W.B.	37	11.72	23.23	4865	1530	3335
1981-82	Gujarat, J&K and W.B.	20	12.57	23.50	NA	NA	NA
1982-83	Bihar, Gujarat, Haryana, Orrisa, Rajasthan, U.P. & W.B.	22	10.48	18.75	4611	1785	2826
1983-84	Bihar, Gujarat, Haryana, J&K, Orissa, Rajasthan, U.P., W.B. and Tripura	41	15.33	27.50	6778	2291	4487
1984-85	Bihar, Gujarat, Haryana J&K, Orissa, Rajasthan, U.P., W.B., Nagaland and Manipur	56	13.37	25.00	6549	2106	4443

Data Source: Annual Reports of National Demonstration Project publised by ICAR.

* Highest yield were obtained at Gujarat from 1980-81 to 1983-84 and at Rajasthan in 1984-85.

TABLE 27:
National Demonstration trials on rainfed Mustard in Various states

Year	State	No. of demons-tration	Yield (q/ha) Mean	Yield (q/ha) Highest	Gross returns (Rs./ha)	Cost of production (Rs./ha)	Return over operational cost (Rs./ha)
1981-82	Gujarat, J&K and W.B.	8	8.5	12.5	NA	NA	NA
1982-83	U.P., W.B., Haryana & J&K	24	8.2	11.5	4199	1363	2836
1983-84	Haryana, J&K, Orissa, Punjab, Rajasthan & U.P.	20	9.0	15.0	4290	1552	2738
1984-85	Haryana, J&K and W.B.	7	9.7	20.0	5233	1326	3907

Data Source: Annual Reports of National Demonstration Project published by ICAR.

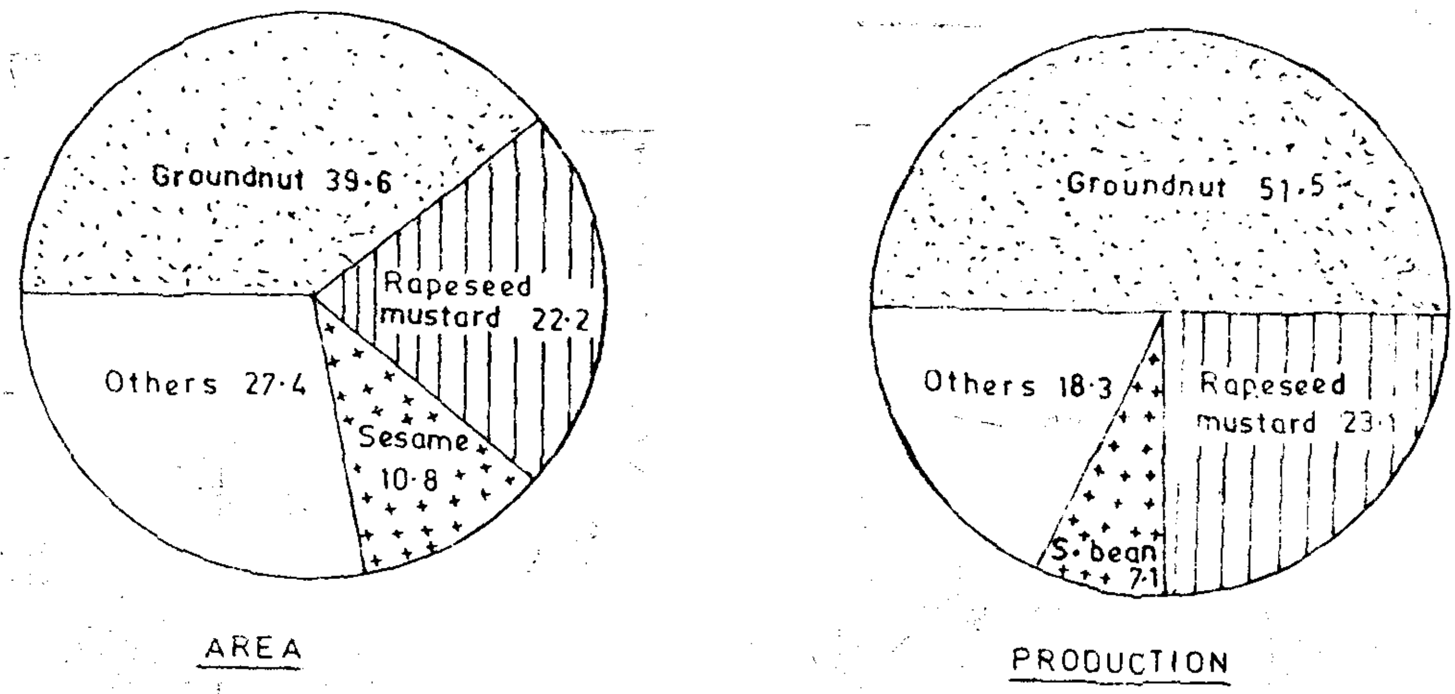


FIG. 1 PERCENTAGE DISTRIBUTION OF DIFFERENT OILSEED CROPS IN TOTAL AREA AND PRODUCTION IN INDIA (1984–85)

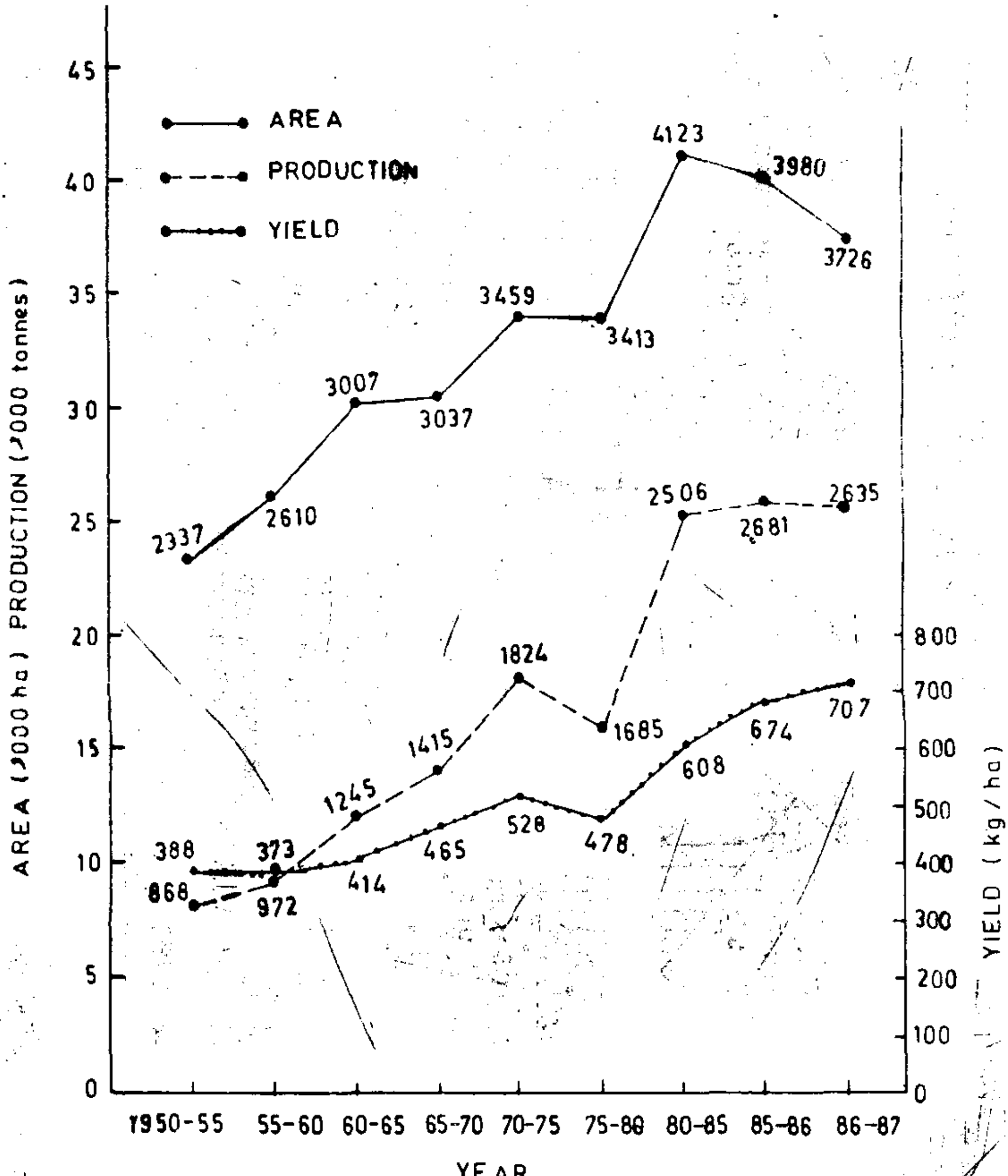


FIG.2 AREA, PRODUCTION AND PRODUCTIVITY OF RAPESEED-MUSTARD IN INDIA DURING 1950-55 TO 1986-87

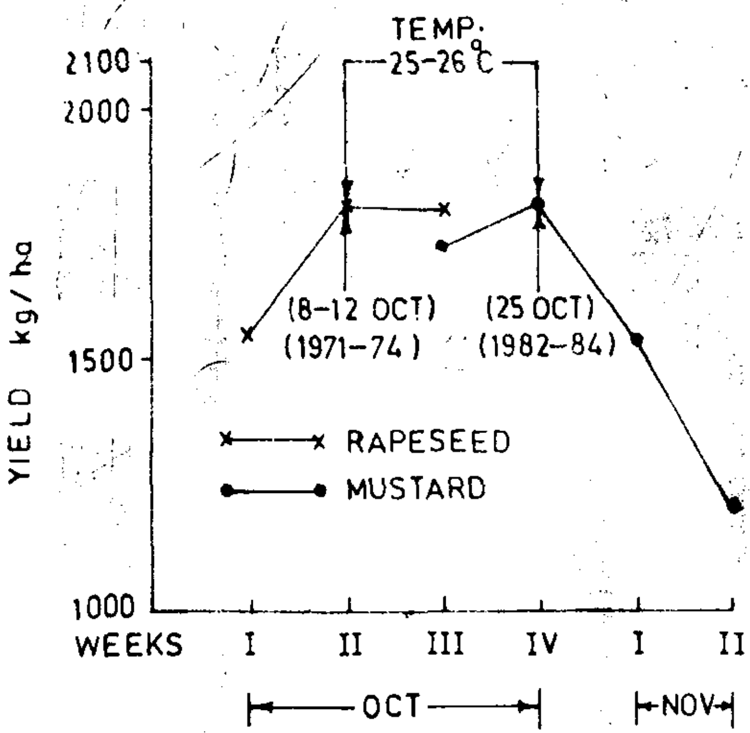


FIG. 3 INFLUENCE OF SOWING TIME ON RAPESEED-MUSTARD AT DELHI
SOURCE: GANGA SARAN et al (1985)

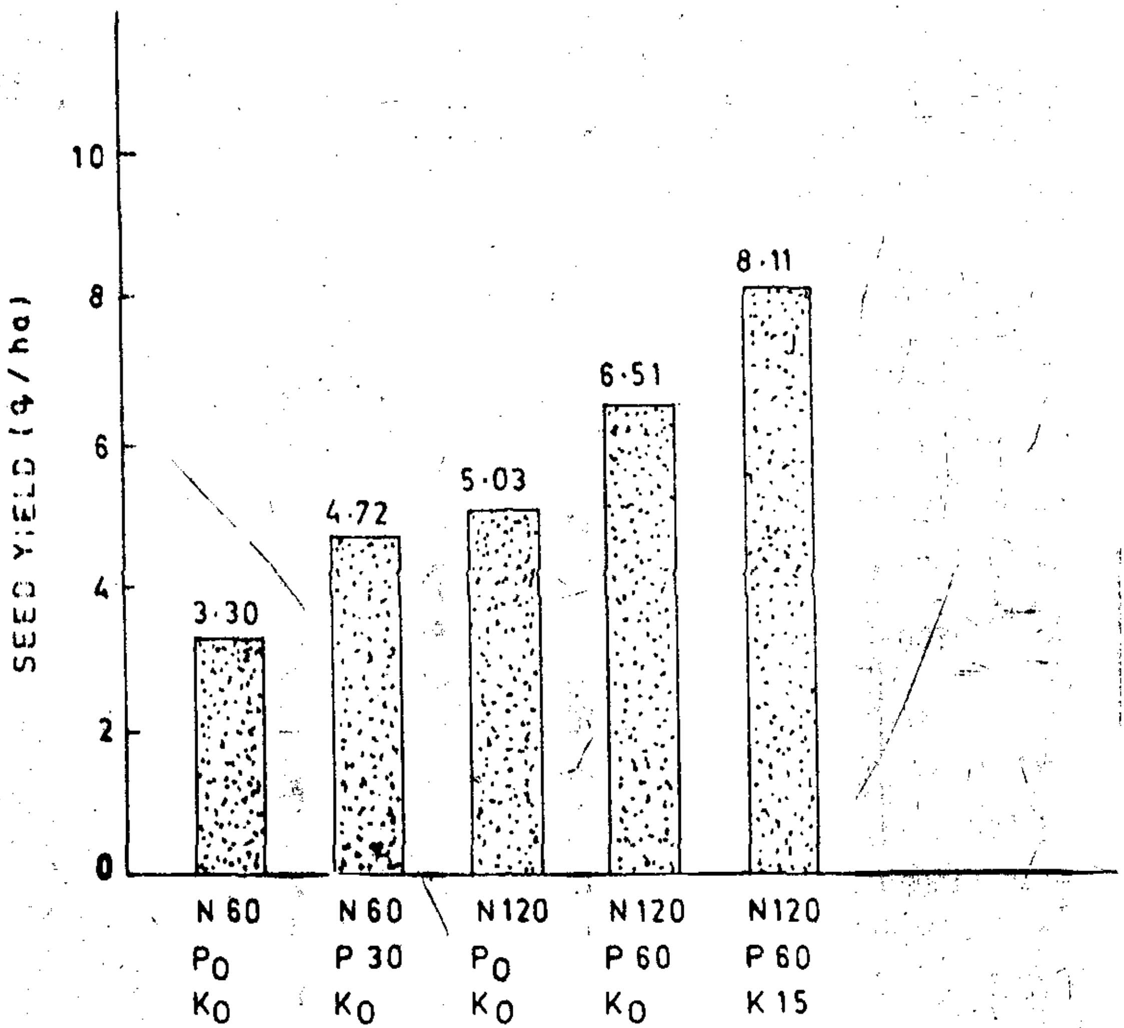


FIG. 4 RESPONSE OF MUSTARD TO N, P AND K AT LUDHIANA

SOURCE: PASRICHA *et al* (1987)

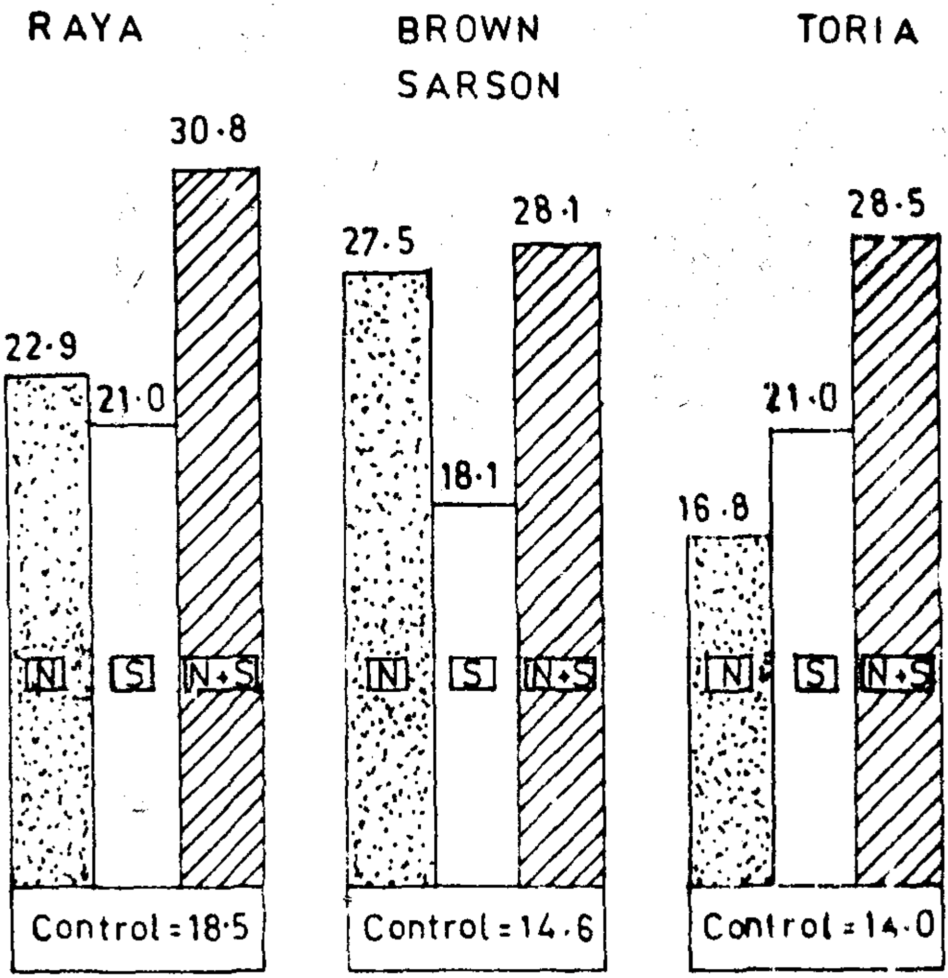


FIG.5 EFFECT OF N AND S ON PROTEIN CONTENT (%) OF RAPESEED–MUSTARD AT LUDHIANA
SOURCE: PASRICHA *et al* (1987)

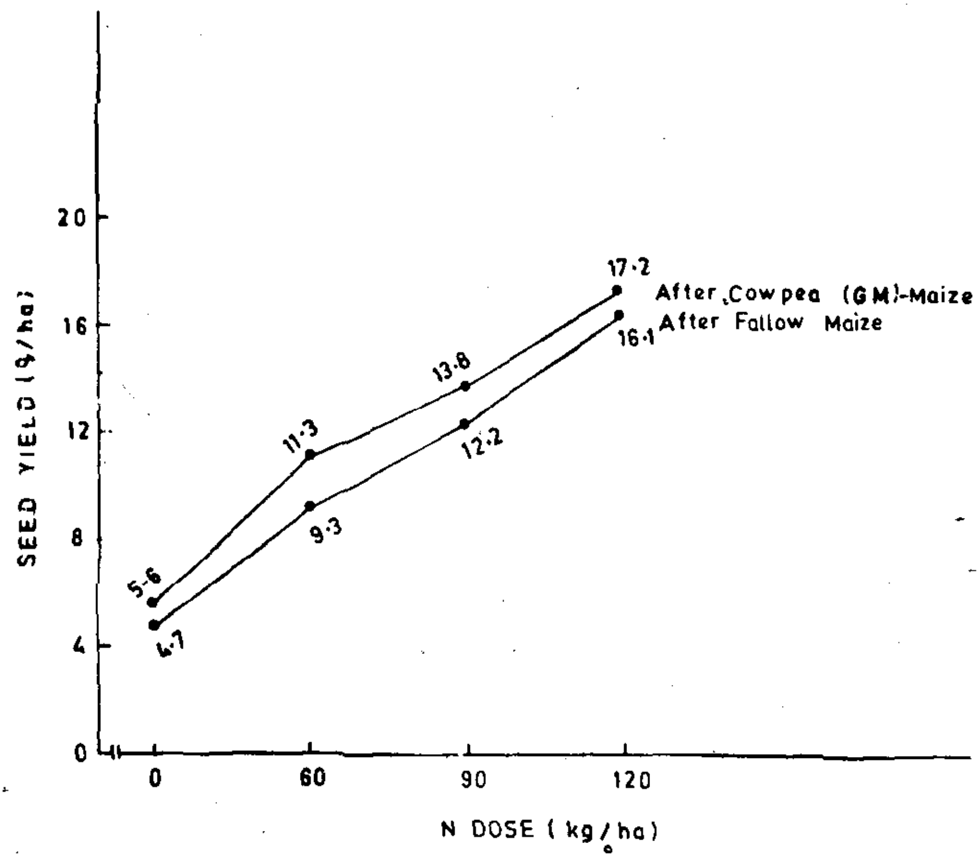
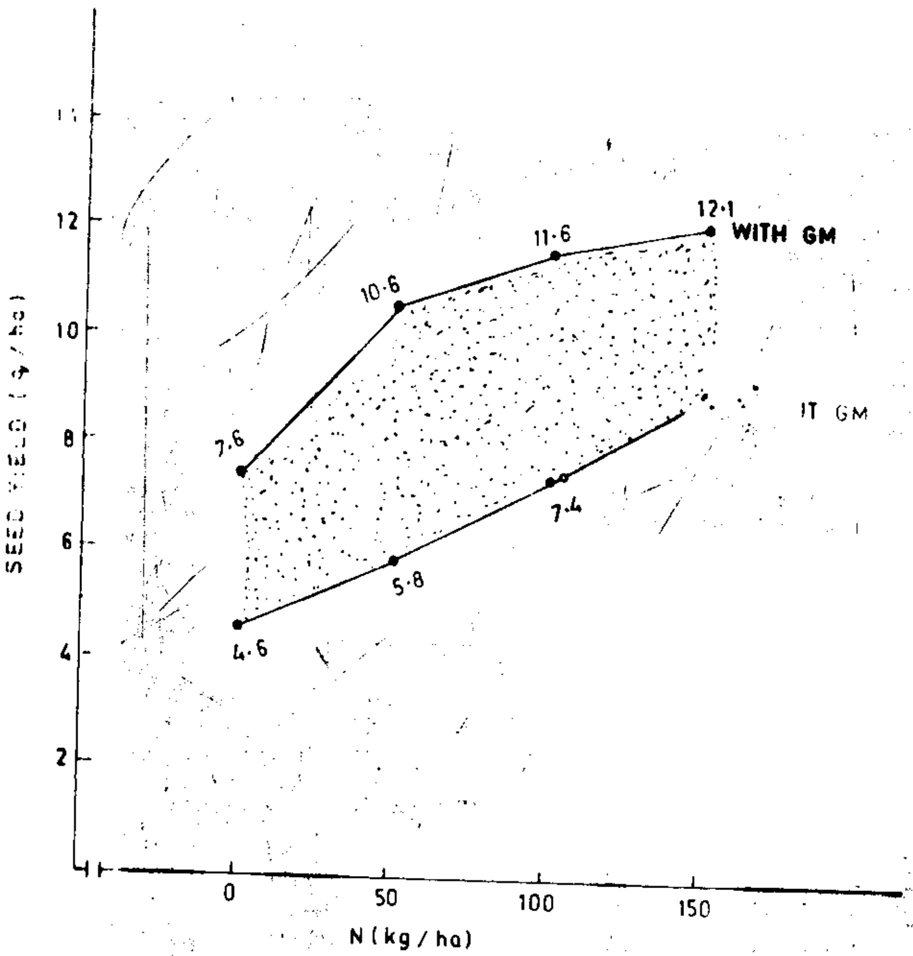


FIG. 6 RESIDUAL EFFECT OF GREEN MANURING/MAIZE ON MUSTARD AT LUDHIANA

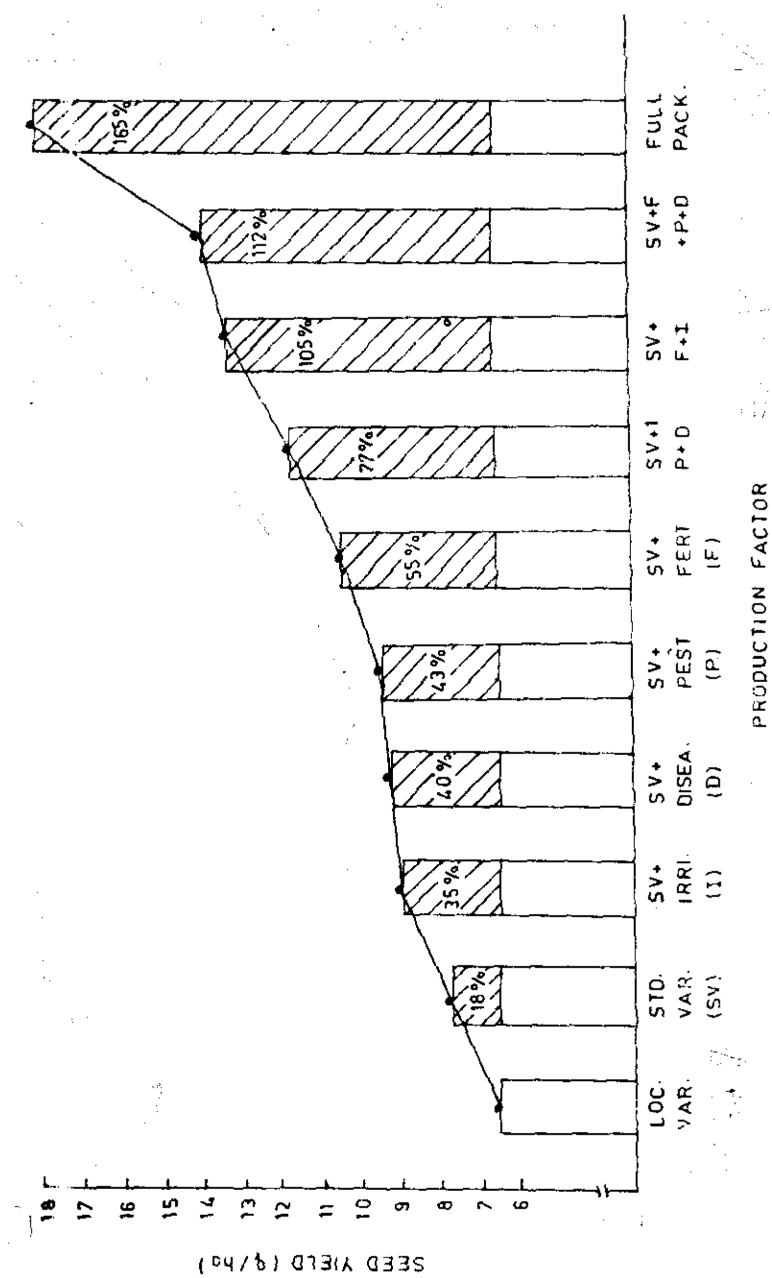
SOURCE: PASRICHA *et al* (1987)



FIG·7 EFFECT OF GREEN MANURING ON N RESPONSE TO MUSTARD AT LUDHIANA

SOURCE: PASRICHA et al (1987)

FIG. 8 EFFECT OF PRODUCTION FACTORS ON MUSTARD YIELD
(mean of 18 trials / 5 locations in India)



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INSECT PESTS AND THEIR MANAGEMENT IN RAPESEED - MUSTARD

D.R.C.Bakhetia and B.S.Sekhon
Punjab Agricultural University, Ludhiana - 141 004 India

ABSTRACT

Thirty eight insect pests are known to be associated with different stages of rapeseed-mustard crops in India. The mustard aphid, *Lipaphis erysimi* (Kaltenbach) is the key pest throughout the mustard growing belt. Yield losses due to this nefarious pest vary with the variety, agro-technological practices and the environemental factors. Different aspects of aphid-plant relationship, its bio-ecology and management have been reviewed in detail. Other major, minor and new pests are also discussed. Developing insect reistant varieties, particularly against the mustard aphid, will prove highly rewarding. A mission-oriented team approach involving inter-disciplinary, inter-institutional and inter-national cooperation/collaboration is essential for evolving aphid resistant varieties. Effective bio-contral agents are yet to be explored. Suitable methods for need-based use of insecticides and cultural control need to be developed for different agro-ecological regions. Integr- ted pest management is considered an ideal approach for these oil-rich crops. Future research strategies of pest management programmes embracing the complex biological and economical inter-relationships are suggested.

INTRODUCTION

In India, Rapeseed and mustard are the important oleiferous crops, contributing about 23 per cent of the production (13.2 million tonnes) and 22 per cent of the area (19.8 million hectares) of total oilseeds in the country. Their productivity (668 kg/ha) is very low due to many reasons such as non-adoption of improved production technology and large areas being rainfed on marginal lands of low fertility. In addition, the pests and diseases cause heavy damage to these crops. Owing to these adverse factors, their area and production remain fluctuating year after year.

So as to minimise this fluctuation and increase the productivity, the development of better technology and its adoption by the farmers are considered of paramount significance. Pest management is an important component of this techology. Considerable amount of infromation has been generated after mid-seventies, which is very useful in developing a research-based improved pest management technology for rapeseed and mustard.

Recevied in Aug.1988

Insect Pests

Upto 1970, the number of insect species infesting rapeseed and mustard crops in India was reported as 24 by Rai (1976). However, with the increased cropping intensity in the changing cropping patterns under different agro-climatic conditions, the pest and disease complex of the crops have also changed a great deal. New crops such as *Brassica napus* and *B.Caranata* are being introduced to have a diverse nature of cultivars. Besides, more intensive researches to study the bio-ecology of important insect-pests and to devise more efficeint pest control strategies, had been in progress. Eventually the number of insect species associated with *Brassica* crops has also increased to 38 (Bakhetia and Sekhon, 1984). On the basis of their economic importance, these are grouped as:

Key pest

The mustard aphid, *Lipaphis erysimi* (Kalt.)

Major pests

i)	The saw fly,	*Athalia lugens proxima* (Klug)
ii)	Painted bug,	*Bagrada hilaris Burm.*
iii)	Pea leaf-miner,	*Chromatomyia horticola* (Goureau)
iv)	Bihar hairy caterpillar,	*Diacrisia obliqua Walker*

Minor pests

i)	Cabbage butter fly,	*Pieris brassicae* (Linn.)
ii)	Flea breathe,	*Phyllotreta cruciferae* (Goeze)
iii)	Green aphid,	*Myzus persicae* Sulzer
iv)	Diamond back-moth,	*Plutella xylostella* (Linn.)

New pests

i)	The larger moth,	*Crocidolomia binotalis* Zeller
ii)	Cabbage top borer	*Hellula undalis* Fab.
iii)	Cabbage x aphid	*Brevicoryne brassicae* Linn.
iv)	The white fly,	*Bemisia tabacii* (Gen.)
v)	Cabbage semi-looper,	*Plusia orichalciea* (Fab.)
vi)	Turnip moth,	*Agrotis segetum* Dennis and Schiff.

Out of these minor and new pests, *Myzus persicae* is gaining importance and thus replacing *Lipaphis erysimi*, particularly in irrigated crop or where mustard is intercropped with potato (Personnal communication from Dr. Y.K. Mathur, Kanpur). *Agrotis* (Ochropleura) *flammetra* Schiff. caused heavy damage to rainfed crop of mustard in Punjab during winter 1987-88. *Agrotis segetum, Crocidolomia binotalis, Plutella xylostella, Myzus persicae* and *Monomorium* sp. were recorded as new potential threats to rapeseed mustard in Haryana (Singh and Singh, 1983). The cabbage butter fly is also known to cause considerable damage to *B.napus* and *B.carinata* particularly near **maturity**. However, *L.erysimi* continues to be a key pest on rapeseed mustard in India.

BIO-ECOLOGY OF MUSTARD APHID

Knowledge of the biology and ecology of a pest is essential to find out the weak links in its life history so that they are exploited in evolving integrated pest management programme for the target pests. An excellent review on the life history, population dynamics and dispersal in the mustard aphid has been prepared by Laudin (1982). Detailed studies on the biology of *L.erysimi* were made by Sidhu and Singh (1964) in Punjab and Rout and Senapati (1968) in Orrisa. These were subsequently suplemented by many other workers. Nevertheless there are still many gaps in our knowledge, particularly in relation to the changed spectrum of cultivars and other cultural practices in different states of India.

Sidhu and Singh (1964) and some other authors noted the mustard aphid on some vegetables and wild crucifers during summer months. Sachan and Srivastava (1972) could not locate the pest on cabbage in Rajasthan from July to October, whereas Lal (1977) stated that it was not traceable in the plains of India during summer. In view of these conflicting reports, the followning points deserve more systematic investigations :

i) Off-season biology of the aphid to know as to where and how it spends the hot summer and rainy seasons.

ii) Colonization and dispersal paterns of the aphid in and out side the Cruciferous oilseeds.

iii) Key regulatory factors in the population of the aphid.

The study would require installation of traps Sticky/suction/water traps) on a number of locations in the country and record observations year round on the number of alate *L.erysimi*. Subsequently the rise and fall in aphid population on *Brassica* and allied hosts will have to be measured at all locations. Finally this data should be complied on all India basis to provide necessary clues about field behaviour and the migration of the aphid, if it occurred. This information will help considerably in developing a forecasting or early warning system of aphid outbreaks and thus ensure an effective and economical management of this serious menace. The population dynamics of mustard aphid on rapeseed-mustard during the crop season is well studied and forms a regular part of the AICORPO programme. The immigrant alate of *L.erysimi* appear on rapeseed-mustard in October when these crops are just in the seedling stage. The aphid multiplies gradually and the peak population is recorded from end-December to mid-March on different host plants in different agro-ecological regions (Table 1). During this period, the apteroid morphs are most abundant. It is followed by a decline during February-March, when the propotion of alaloid viviparae increases to help in aphid dispersal (Sachan & Srivastava, 1972; Roy, 1975; Ghosh, 1980; Singh, 1982; Ghosh & Mitra, 1983; Bakhetia *et al.* 1985).

The important factors governing the aphid population in the field are:

i) the compostion and phenology of the host plants; generally the **plants at** booting and flower stage are preferred by the aphid

ii) mean minimum temperature : 4 to 12°C

iii) mean maximum temperature 16 to 30°C

iv) mean relative humidity : 50 to 78 per cent

v) *Rainfall* : A reasonably good amount of rainfall (above 1cm) reduces aphid population through washing and drowning. Very recently, Sekhon and Bakhetia (1987) observed that the aphid population was drastically reduced due to a hail storm in the Punjab. However, it built-up again, indicating thereby its ability to withstand the vegaries of weather.

NATURAL ENEMIES OF MUSTARD APHID

A number of insect predators and parasites have been reported as natural enemies of the mustard aphid. The more important of these are the coccinellid beetles (*Coccinella septumpuctala Menochilus sexmaculatus*, and few others), several speices of syrphid flies (*Syrphus* spp., *Metasyphus corrolae*, *Xanthogranima* spp., etc.), *Chrysopa* spp. and *Micromus timidis* as the insect predators, and *Diaretialla rapae*, *Aphidius* spp., *Lipolexis gracilis* and *Ephedrus plagiator* as the insect parasitoids (Bakhetia and Sidhu, 1983; Mathur, 1983; Roy & Basu, 1977; Agarwala & Raychaudhary, 1981). However, these are often more active towards the end of season i.e. end-February onwards. At this stage the aphid population starts declining due to rise in temperature, maturity of the host tissue and the increased intraspecific competition in aphid colonies. Hence the biotic agents do not play any significant role in the natural suppression of aphid population on rapeseed-mustard crops in North-Eastern India.

CULTURAL CONTROL OF MUSTARD APHID

The information available on the effect of different cultural practices such as sowing time, fertilizer dosages, spacing, irrigation, inter-cropping etc, is very scanty.

In general, it has been reported that the early sown crops (i.e upto 20th October) suffered very less damage by the aphid as compared to that sown during end-October onwards under different agro-climatic regions such as in West Bengal (Pal, *et al* 1976); Punjab (Bakhetia 1986); Haryana (Singh *et al.* 1984); Madhya Pradesh (Rawat & Singh, 1983) Uttar Pradesh (Sachan *et al.* 1983) and Bihar (Bhattarcharjee, 1961).

The reports on the effect of fertilizers on the population build-up of mustard aphid are contradictory. Rawat *et al.* (1968) reported 2 and 3 times higher aphid population in treatments with 40 and 60 kg N/ha respectively as compared to that in control. At Ludhiana (Punjab), Sidhu and Kaur (1977) observed that higher the nitrogen levels (0, 30, 60, 90 and 120 ppm) applied to rapeseed-mustard, better it was for the development of mustard aphid. Similary, Kalra *et al* (1983) reported that the crop receiving heavy dose of nitrogen (60 kg/ha) suffered more by the aphid attack at Hissar (Haryana). However, reports by Kundu & Pant (1967), Bakhetia and Sharma (1979), Sachan *et al.* (1983) and Rawat and Singh (1983) contradicted the *per se* conclusion, as they did not observe any appreciable effect of increaing N levels of different combination of N, P, K on the population build-up of mustard aphid on *Brassica* crops.

Bakhetia (1986) reported that the early sown crop of(*rai* (i.e upto 20th October) at Ludhiana (Punjab) suffered less from aphid infestation, harboured lower aphid population, needed much lower dose of pesticides and gave good returns as compared to the late sown crop which suffered heavy damage by the aphid, needed high protection and still gave lower yields.

The spacing between lines had no significant effect on *L.erysimi* infestation while the irrigation resulted in increased aphid attack without any appreciable loss in yield of mustard at Hissar, Haryana (Kalra *et al* 1983). In Punjab, Bahkhetia and Brar (1988) observed that rainfed crop suffered heavily from aphid ravages and the plants succumbed to aphid injury in almost all the strains/varieties while the irrigated crop, despite supporting high aphid population, had apparetly a good growth. A consistently decreasing trend in the fecundity of *L.erysimi* on radish plants growing under increasing water stress in the screen-house was recorded by Sidhu and Kaur (1976).

It is a well known phenomenon of aphid-plant relationship that initially an intermittent or moisture mositre stress in plants benefits the aphids through the enriched levels of soluble nitrogen and sucrose in the phloem sap, while a continuous moisture stress inhibits aphid performance due to hampered uptake of nutrients resulting from reduced turgidity and increased sap viscosity. Since, rapeseed-mustard are largely grown rainfed, it is of paramount significance to investigate the stage-linked interspecific and inter-varietal varations in aphid response under the irrigated and water stress conditions.

CHEMICAL CONTROL OF MUSTARD APHID

A great deal of reserach work has been done on the chemcial control of mustard aphid in India before and after mid-seventies. Out of a large number of compounds tested, more than 36 have been reported to be effective in controlling this pest. The more common on the recommended list of insecticides are chlorphyriphos 20 EC, dimethoate 30EC, endosulfan 35EC, formothion 25EC, malathion 50EC, oxydemeton methyl 25EC, phosphamidone 100SC and quinalphos 25EC as foliar sprays, and aldicarb 10G, carbofuran 3G, disulfoton 5C and phorate 10G as soil application (Bakhetia, 1987).

Many workers have tested different parts of the plant and seeds of Rapeseed-mustard for residue of toxic materials applied for the control of mustard aphid, but none has ever reported the residue of insecticides in seeds after harvest. However, the toxic residue of different insecticides above tolerance limits were observed in the leaves within three days after malathion spray and upto 28 days for parathion (Kavadia and Lal, 1968 a&b). Insecticides like endosulfan, menazon and methamidophos have been identified as comparatively safter for the natural enemies of mustard aphid and insect polliantors of the *Brassica* crops.

Though not tested at field level, one Juvenila harmone analogue guaianolide @ 0.1% spray, resulted in malformed individuals of the aphid (Arora *et al.* 1982).

The increased use of presticides as a result of prophylactic and opportunistic treatments may not always be economicaly optimal or ecologically acceptable. There are reports that mustard aphid has developed high level of resistance to most of the insecticides recommended for its control (Personal communication from Prof. K.N.Mehrotra, I.A.R.I., New Delhi). Earliest report of *L.erysimi* showing resistance to endosulfan in India is that of Udean and Narang (1985).

Public attention, therefore, needs to focussed on the broader implications of unrestrained use of pesticides. It is in this very context that considerable attention has been given in recent years to integrated pest management following an increased recognisation of the harmful effects of sole reliance on insecticidal methods of pest control.

APHID RESISTANCE IN RAPESEED-MUSTARD

The use of resistant varieties is one of the important components of integrated pest management. It provides insect control at no additional cost to farmers, is safe, compatible with other pest management tactics and does not involve any elaborate effects in technology transfer to farmers. The research work on evolving a resistant variety generally proceeds on the following lines.

i) Development of reliable, efficient and easy screening techniques.

ii) Screening of available germplasm for resistance to pests;

iii) Understanding the bases of resistance; and

iv) The use of resistant sources in breeding programme. The third and fourth programmes generally are taken up simultaneously.

The subject of aphid resistance in *Brassica* crops has been reviewed by Bakhetia and Labana (1978). Useful efforts were made before mid-seventies to develop efficient screening techniques in Rapeseed-mustard aganist aphid (Pathak 1961; Rajan 1961; Teatia and Lal 1970 and Bakhetia and Sandhu 1973). Different types of methods depending upon aphid population and aphid injury grades were developed and perfected. Till now the system of injury grades developed by Bakhetia and Sandhu (1973) are being used in AICORPO programme for field screening. It is reproduced below:

The varieties/strains of *Brassica* species were classified into 6 categories according to the following scoring system:

Score/grade	Description
0	Free from aphid infestation. Even when a single wingless aphid was present, the plant was considered as infested. Plants showed excellent growth.
1	Normal growth, no curling or yellowing of the leaves, except only a few aphids aqlongwith little or no symptoms of injury. Good flowering and pod setting on almost all the branches.
2	Average growth, curling and yellowing of a few leaves. Average flowering and pod setting on all the branches.
3	Growth below average, curling and yellowing of the leaves on some branches. Plants showing some stunting, poor flowering and very little pod-setting.
4	Very poor growth, heavy curling and yellowing of the leaves, stunting of a plants, a little or no flowering and formation of only a few pods. Heavy aphid colonies on plants.
5	Severe stunting of plants, curling, crinkling and yellowing of almost all the leaves. No flowering and pod formation, plant full of aphids.

Every plant was observed for aphid injury and given a definite grade. The aphid infestation was calculated as follows:

$$\text{Aphid-infestation} = \frac{0xa + 1xb + 2xc + 3xd + 4xe + 5xf}{a + b + c + d + e + f}$$

where a,b,c,d,e and f are the number of plants(frequencies) falling in each grade. The aphid-infestation index served as the estimate of aphid resistance in the test entry, higher the index number lower the resistance.

A significant development in the screening procedures was the seedling screening technique standardized by Bakhetia (1975) and Bakhetia and Bindra (1977). According to these reports the population levels of 10, 20, 20 and 30 apterae and 1ml and 3ml aphid colony (1ml = about 600 nymphs + apterae) per plant proved optimum for resistance screening at thecotyleodorary, 2-leaf, 4-leaf, 6-leaf, flower-bud initiation and flowering stages respectively. Studies on biology of the aphid revealed that survival of nymphs, fecundity, longevity, reproductive as well as pre and post reproductive periods and the aphid reproduction rate were similar to the cotyledonary, 2-leaf, 4-leaf and flowering stages. The grouping of different cruciferous cultivars tested for aphid resistance was similar at cotyledonary, 2-leaf, 4-leaf and flowering stages when tested under the optimum level of aphid population per plant. Hence it was concluded that the *Brassica* germplasm can be screened for aphid resistance at any stage of plant growth provided the optimum level of aphid population per plant was used under the screen-house conditions. However, the seedling stage was considered preferable owing to the efficiency and ease in handling.

Mechanism of aphid resistance

Tolerance as the component of resistance has been reported in some strains of *B. juncea* (Pathak, 1961; Bakhetia & Sandhu, 1973; Singh *et al*, 1984). However, Teotia and Lal (1970) reported that the three components of resistance i.e. non-preference, antibiosis and tolerances, with a cumulative action were present in *B. juncea* var. Laha 101.

The plants of *Eruca sativa* showed an adverse effect on the longevity, fecundity and development of *L. erysimi* and hence considered to carry some factor for antibiosis (Kundu & Pant, 1967; Narang, 1982; Dilawari, 1985). However, Singh *et al* (1965) and Jarvis (1970) considered *E. sativa* as tolerant species. According to these workers, *B.napus* possesses an antibiosis factors for aphid resistance.

Rajan (1961) stated that the colchicine induced tetraploid *toria* possessed the antibiosis factors of resistance and thus influenced the life processes of the aphid. The other species namely, *B.alba, B.carinata, B.integrifolia* and *B.townefortii* are reported to be tolerant to the aphid (Singh et al. 1965; Bakhetia & Sandhu, 1973).

The morphological and biochemical factors/characters associated with aphid resistance have been summarised in Table 2 and 3. Apparently such modalities of aphid resistance are not very well understood. With the advancement in biotechnology, it should now be possible to further probe into this subject. The chemical analysis of the cell sap at the aphid feeding site in relation to its biological parameters will provide good clues for precise understanding of the mechanism of aphid resistance in *Brassica* oilseeds.

Before mid-seventies and after that a large number of strains/varieties of different *Brassica* species have been screened by various workers and some of these have been reported as moderately resistant/tolerant to mustard aphid (Table 4). It is known that the level of resistance in identified sources is mild or very low and it may be further lost to some degree in the process of transfer to agronomically adapted varieties. It is, therefore, desirable that the level of resistance in these sources should be increased before utilizing them as a source of resistance in the breeding programme. It may be accomplished by multiple crosses, recurrent selection and diallal selective mating system.

Another important approach will be to utilize these sources of aphid resistance as donors in the intervarietal/interspecific crosses aimed at developing aphid resistant varieties. The more important breeding procedures are the pedigree method, backcross method, modified recurrent mass selection, interspecific hybridization, genome substitution, chromosome substitution, gene introgression and creating new sources of aphid resistance through mutation and polyploidy.

ECONOMICS OF APHID CONTROL

The importance of any pest can be gauzed only if the damage caused by it to the crop is estimated precisely. Prior to mid-seventies only limited data were available on the losses caused by the mustard-aphid to *Brassica* crops. The first report in which estimates of monetary loss were made, was that of Bindra (1970), who calculated an annual loss of Rupees 900 crores in rapeseed and mustard in India. However, his report was based on comparatively limited data.

With the inception of the All India Coordinated Research Project on Oilseeds in 1967, the work on yield losses due to insect pests with particular reference to mustard aphid was started in almost all the coordinating centres and subsequently supplemented by work outside the project. This led to the generation of volumnous data and eventually a large number of reports have appeared in literature.

Phadke (1980) stated that the losses due to mustard aphid varied from 24 to 96 per cent in different mustard growing regions in India. Assuming an overall 15 per cent loss in yield, he calculated monetary losses of rupees 70 and 73 crores for 1976-77 and 1977-78, respectively. Bakhetia (1983) collected the information from 21 papers containing yield data of infested plots in comparison with the plots protected against the aphid. Besides, some data were used from the Annual Reports (1976 to 1982) of AICORPO. It was calculated that the mean loss in yield of Rapeseed mustard varied from 35.4 to 73.3 per cent under different agro-climatic conditions. On all India bases, the mean loss was worked out as 54.2 per cent. In terms of monetary value the loss came out to about rupees 378 crores. Another study revealed that the aphid caused an average reduction of 45 per cent in seed yield of mustard (Singh *et al* 1983 a,b). It thus highlights the importance of the aphid pest and dire necessity for its efficient management.

The economic-injury level is the lowest pest population that causes economic damage and the economic threshold is the population density at which control measures should be initiated to prevent the increasing pest population from reaching the economic-injury level. These parameters serve as valuable tools in the judicious use of toxic agrochemicals in the pest management programme, which ought to be ecologically sound and economically viable.

The research work to be establish economic thresholds of mustard aphid has been in progress during last one decade at different institutions covering a wide range of agro-ecological conditions in India. Bakhetia *et al* (1979) reported that initiation of spray operations against the mustard aphid at 30 per cent plants showing aphid infestation was economical for *B.juncea* var. RLM 198 under Punjab conditions. Singh *et al* (1983a) obtained the highest cost/benefit ratio from *rai* crop when the aphid population was not allowed to exceed 50 aphids/shoot.

The relationship between aphid incidence (population and per cent plant-infestation) and the yield of mustard was studied by Mishra and Singh (1986) and Singh and Mishra (1986) under Varanasi conditions in Uttar Pradesh. They reported that the EIL on mustard ranged between 9.42 to 13.32 aphids per plant (per 15 cm top terminal shoot) and 15.21 to 23.49 aphids/plant for folilar sprays of the insecticides at 0.025 and 0.05 per cent respectively, whereas for soil application of granular insecticides at 1 and 2 kg a.i./ha, it was 9.42 to 15.21 aphids and 18.08 to 30.60 aphids per plant respectively. The corresponding EIL on the basis of per cent plant infestation ranged between 2.65 to 3.80 per cent and 5.36 to 6.76 per cent for foliar sprays and 2.24 to 3.45 per cent and 4.10 to 6.94 per cent for soil application of insecticides. An increase in EIL was reported with an increase in the cost of control measures.

The group of entomologists working in the All India Coordinated Research Project on Oilseeds, during the 1987 Annual Rabi Oilseeds Workshop, concluded that the economic threshold for the mustard aphid is 50-60 aphids/10-cm terminal shoot and/or 40-45 per cent plants infested with the aphid. Simultaneously it has been confirmed by Bakhetia and Ghorbandi (1986 and 1987) andGhorbandiand Bakhetia (1987). Further these workers have reported that the criteria of aphid population counts on terminal shoots and the percentage of plants infested by the aphid gave equally reliable results. However, the latter criteria seemed preferable by the extension workers and the farmers owing to greater convenience in its adoption in the field.

The time of appearance/initiation of aphid infestation in the field influences the crop yield to a great extent. Singh(1982 b)reported that the yield loss was maximum when aphid appeared at 81 and 91 days after sowing of *rai* and *sarson* respectively at Ludhiana (Punjab). However, Singh and Singh (1986) found that the control measures were economical and more efficient when applied at 40 and 70 days after sowing the mustard crop at Varanasi (Uttar Pradesh). However, these workers did not study any corelation between the crop yield and aphid population.

Keeping in view the practical utility of economic threshold for the mustard aphid, a pest of national importance, there is a need to carry out more detailed investigations for further refinement and perfection in the available economic threshold levels. The effects of the aphid pest on *Brassica* crops need to be evaluated carefully for a particular farming area since differences in cultural practices, cropping systems and environmental factors will influence the severity of pest damage. Ideally, such assessments are made for more than an year at a number of sites to measure seasonal effects and the impact of introducing a new variety or a new agro-technological practices. Hence it is of paramount importance to base pest management decisions on up-to-date information.

Considerable variation in crop loss assessment willl acrue between different areas growing the same crop and/or protected under the same insecticidal control recommendations used in the field. Other important factors leading to differences are the climate, pest attack, soil type, fertilizers and the agronomic practices. Hence, pest management in agricultural sector requires a careful analysis of the complex biological and economic inter-relationship.

OTHER INSECT PESTS

The saw fly, *Athalia lugans procima* is a serious pest of young of cruciferous plants. Its larvae bite holes in the leaves and sometimes at seedling stage the entire crop is eaten away, necessitating the resowing of the crop. The plant species distantly related to the primary host (*B. campestris* var. *toria*), *Eruca sativa, Iberis amara, Cheiranthys cheiri* and *Iropaeolus* majus seem to have evolved high degree of natural defences (Sehagal and Ujagir (1977). Further studies revealed that seed extracts containing glucosinolates and isothiocynates particualry from plants showing strong natural defences when applied on *B.juncea* leaves, acted as feeding depresants for the grubs, reduced the survival of adults, larval weight and fecundity of developing females (Ahuja and Sehgal 1982a). Glucosinolates from *B.napus, E.sativa* and *T.majus* and with isothiocynates extracts from *E.sativa* and *T.majus* greatly reduced oviposition preference of femals (Ahuja and Sehgal, 1982b).

The information on bionomics, natural enemies and chemical control of the saw fly had been collected by Tripathi (1963), Jagtap and Kadam (1978), Rai *et al* (1978) and Kapadia *et al.* (1980). Pandey *et al.* (1979) at Kanpur (Uttar Pradesh) tested various plant extracts for the conrol of this pest and reported that ether extract of *Acorus calamus* gave high mortality of grubs. Low concentration (0.5 to 1.0%) extract of bitter-gourd *Momordica charantia* showed antifeedent and insecticidal properties. Sachan *et al.* (1983) screened one hundred and fifty six lines for resistance to saw fly and observed that 40 lines remained free from pest injury. Dusting with BHC 10% dust @ 25 kg/ha gives an effective control of this pest.

The Painted bug, *Bagrada hilaris* (Burm.) damages the crop first in the seedling stage and then at pod stage. It can cause appreciable loss even to the harvested crop in the threshing floors. The nymphs and the adults suck sap from leaves, shoots, inflorescence or pods on the plants. Due to its heavy attack the produce of mustard crop suffered a loss of 30.09 and 2.75 per cent in seed weight and oil content, respectively (Singh *et al*. 1980a). Most of the work on its life history, seasonal history and bionomics was carried out before mid-seventies. Recently, Laxminarayana (1984) prepared the life table of *B.hiloris* on rapeseed crops. Dhuri (1980) observed that its nymphal development did not take place at or above 40°C. Panday *et al*. (1982) have tested a number of plant products (extracts) for insecticidal properties against the bug. They observed 100 per cent mortality of bugs with acetone extract of rhizomes of *Aconus calamus*. Many insecticides had also earlier been found effective against this pest. The use of BHC 10% @ 25 kg/ha when the population of the bug is quite high in young crop and quick disposal of the produce and trash from the threshing floor are effective control measures.

Chromatomyia horticola Goureau is the most predominant among leaf miners in India. It infests a large number of host plants including rapeseed-mustard. Although the female flies also inflict some injury to the plants by making feeding and oviposition puncures, but the major damage is done by the larvae which make tunnels through the epidermis and feed on the leaf tissue. The reports on its habit and habitat, chemical control, cultural control, range of host plants, life history, and its natural enemies have been reviewed and studied by Singh (1980) and Singh and Mavi (1982). The insect-plant relationship of *C.horticola* and different *Brassica* species have been studied in detail at Ludhiana (Punjab) (Bakhetia and Sandhu, 1977; Singh, 1980 & 1985; Singh *et al.* 1985, 1987). The salient findings are as detailed below:

a) *Varietal resistance: B.juncea* cv. Blaze, *B.napus* cv. Regent and a strain each of *B.tournefortii, B.carinata, B.alba* and *Crambe abyssinica* showed moderate to high resistance to the leaf-miner.

b) Investigations on modalities of leaf-minar resistance in *Brassica* species revealed that

* High apparency of susceptible strains was due to their architecturally complex plant type, high caratene and high volatile ITC contents.

* Total glucosinolates did not influence the host selection behaviour of flies.

* Thick epidermal and cuticular layers with closely packed mesophyll cells served as defence mechanism against oviposition by flies and feeding on leaves by the larva.

* Rapid tissue proliferation at the puncturing site proved fatel to the eggs in the leaf.

* Deficiency of histidine and arginie hampered the reproduction of the flies.

* High amounts of glucosinolates and phenolic compounds served as chemical defense against the miner.

* Glucosinolates greater than 0.40 per cent inhibited oviposition and induced feeding by the flies.

* Higher concerntration of glucosinolates (more than 0.44 per cent checked larval feeding and its development.

* Phenolic acids particularly the sinapic acid at more than 0.50 per cent concentration inhibited the oviposition in the flies and caused a significantly higher larval mortality.

The flee beetle, *Phyllotreta curciferae* Goeze is a minor pest of rapeseed-mustard. The minute, shining blue beetles feed and make holes in host plants. Singh *et al.* (1980b) found that carbofuron was most effective followed by phorate for the control of this pest.

Plutalla xylostella Linn, the diamond-back moth, is of little economic importance on rapeseed and mustard. With the introduction of *gobhi sarson*, it is feared that it may become a predominenet pest of this crop. Its incidence get accentuated in Tamil Nadu due to the introduction of rapeseed-mustard crops (personal communication from prof.

S.Jayraj). It is considered a very notorious pest and has developed resistance to a number of insecticides. Hence its management on cruciferous crop has become a very ticklish proposition.

The cabbage butter fly, *Pierisbrassicae*also attacks the rapeseed mustard especially *B.napus*, occasionally late in the season. The cabbage web worm, *Gujhia* weevil, and white fly and some birds as well ocassionally infest the crop and incure considerable damage.

TRANSFER OF PROTECTION TECHNOLOGY

That the plant protection technology developed in laboratories goes to the farmers as quickly as possible and in turn it is adopted on a large scale by majority of the farmers is an assential component of pest management strateigies of any crop including rapeseed-mustard. It can be made easy and more effective if our research projects are oriented to the level of cultural practices in vogue with a common farmer. Also a good feed-back of field problems faced by farmers to the scientists through the extension agencies is equally important. It will help in reorganising and reorienting the aims and objective of the on-going research programme to meet the requirement and aspirations of the farming commuity. Thus it becomes a two-way channel and both are complementary to each other.

It is common experience that the available research-based protection technology in rapeseed-mustard in particular and other oilseeds in general, is being adopted only partially and that too by a fraction of the farming community, though known to pay rich dividends if adopted religiously on community basis. It would be in the larger interest of our oilseed production programme that some concrete steps are taken up immediately, to educate the farmers about the usefulness and economics of pest management recommendations in rapeseed-mustard crops.

SUMMARY OF MAJOR RESERACH ACCOMPLISHMENTS

The insect pest problems of rapeseed-mustard are very complex. Thirty eight insects are associated with these crops in India. Among these, the mustard aphid, *Lipaphis erysimi* (Kalt.) is a key pest. Other economicaly important pests are *Athalia lugens proxima* Klug, *Bagada hilaris* (Burm.), *Chromatomyia horticola* (Goureau) and *Diacrisia obliqua* Walker. Remaining are minor or economically less important and/or new potential pests. As a result of competitive displacement, *Myzus persicae* is gaining importance over *L.erysimi*. The salient research findings are summarised below:

The Mustard Aphid

i) Yield losses due to mustard aphid varied from 35.4 to 73.3 per cent in different agro-climatic regions with a mean loss of 54.2 per cent on all India basis.

ii) Different aspects of its biology, behaviour, seasonal history and population dynamics are well studied.

iii) *Altoid* viviparae are responsible for dispersal during October-November (immigration) and March-April (emigration) whereas apteroid viviparae are abundat from end-November to end-February on rapeseed-mustard crops. Peak population period varies with host species/variety, agronomic practices and environmental conditions.

iv) Altoid viviparae are formed owing to intraspecific competition, depletion in food quality, high temperature and low humidity.

v) Most favourable mean minimum and mean maximum temperature and relative humidity are ; 4 to 12°C, 15 to 30°C and 50 to 78%. Above 30°C and sub-zero winter temperature are lethal.

vi) Good rainfall (above 1cm) is detrimental to aphid colonies, through washing effect and drowning.

vii) Six coccinellids, 16 syrphids, one speices each of chamaemyliids, chamaemyiids hemerobiids as insect predators, four species of hymenopterous parasites, four species of entomogenous fungi and one predatory bird, are the known natural enemies of the aphid.

viii) Early sowing helps in reduced aphid damage. Reports on aphid population in relation to different dosages of nitrogen applied to the plants are contradictory.

ix) For screening varieties/germplasm for aphid resistance, the seedling technique, indexing the aphid injury and population counts are considered very appropriate.

x) More than three thousand germplasm lines, elite progenies from breeding material and other strains of different *Brassica* species have been tested for resistance to the aphid, some have been reported as resistant.

xi) Among morphological characters, plant succulency, pattern of arrangement of buds in inflorescence, leaf colour, non-waxiness, branching pattern, hairiness, etc. have been reported to be associated with varietal resistance to aphid.

xii) Aphid resistance is related with phenolic compounds, glucosinolates, flavonoids, sulphur and total sugar contents, etc.

xiii) Chemical control is most extensively studied. Very good package recommendations for aphid control are available.

xiv) Economics threshold for mustard aphid is determined as 50-60 aphids/10-cm central shoot or 40-45 per cent plants infested by the aphid, It is applicable to the flower-bud initiation and further grown up stages of the plant.

xv) Integrated pest management is considered ideal for these crops.

OTHER INSECT PESTS

The mustard sawfly, *Athalia lugens proxima* Klug is a serious pest of young crop. It prefers rapeseed, mustard, cabbage and turnip than other plant species of Cruciferae and Tropaeolaceae. The bio-ecology has been studied in detail by several workers. It aestivates in summer, Over 156 varieties have been tested and 40 remained free from its attack, Insect-plant relationship studies have shown that *B.napus, Eruca sativa, Cheiranthus cheiri, iberis amara* and *B. juncea* contained substances which act as ovipositional depressant and/ or larval feeding deterent. The feeding activity of the grubs was reduced to a greater extent by seed extracts of *Eruca sativa* and *Tropaeolum majus* as compared to that of *B.campestris* var. *toria*, *B.juncea* and *B. napus*. This is attributed to the presence of glucosinolates (2-4%) and isothiocyanates (0.1-1.0%) in the seed extracts. These substances at 0.1-1.0% and 0.01% respectively cause only very little reduction in larval feeding. Sinigrin is known to act as phagostimulant to the sawfly. Out of several insecticides tested, malathion, BHC, monocil, carbaryl, quinalphos and phosphamidon are very effective against the larvae of sawfly.

The painted bug, *Bagrada hilaris* (Burm.) damages the rapeseed and mustard crops in the seedling and maturity stages. It also infests the harvested produce on the threshing floor. The pest is active throughout the year. Its field biology, seasonal cycle, behaviour and host range have been studied in detail. A technique to mass rear it on soaked seeds in the laboratory is available. Most favourable weather conditions are 17-18^{0}C temperature, 61-81% RH and 60-130 cm plant height. Detailed infromation on the insecticidal toxicity of some plant products/extracts aganist the bugs, chemical control and cultural control have been investigated.

The peaf leaf-miner, *Chromatomyia horticola* (Goureau) is cosmopolitan in distribution and highly polyphagous in nature (127 plant species know as hosts). The details on its biology, ecology, feeding and ovipositional behaviour, natural enemies chemical control, cultural control and insect-plant relationship (resistance) are very well studied.

The information regarding the biology, behaviour, plant resistance and management practices for several minor and new potential pests is also avaiable.

FUTURE RESEARCH PRIORITIES

The on-going research programme on insect pests of rapeseed-mustard in India needs to be reoriented and strengthened on the following aspects:

The mustard aphid

i) Sampling technique for aphid population: Standardization of sample size and number in relation to the crop phenology, sampling time, method of collecting and countring the aphids, etc.

ii) Colonizaion pattern of alate forms.

iii) Population dynamics of the aphid on *Brassica* **oilseeds in main season.**

iv) Dispersal and off-season biology of the aphid.

v) To search natural enemies which can check the aphid during December-**January.**

vi) Determination of economic threshold and estimation of yield losses.

vii) Resistant varieties: (a) Collection of world germplasm at one place, (b) Classifying it into early, medium and late maturing groups according to different species, (c) Screen-house testing through the seedling techniques, (d) Field and screen-house testing of promising lines, (e) Study the factors responsible for aphid resistance.

viii) Cultural control: Manipulation of cultural practices such as sowing time, use of macro-and micro-nutrients, irrigation, spacing etc. These factors should be studied in relation to the use of chemicals for aphid control and the resistant varieties.

ix) Developing the aphid forecasting and early warning systems.

x) Formulation of integrated pest mangement strategies.

Other insect-pests

The Cropping pattern is changing fast with the advancement in agro-technology. New crops like *B.napus* and *B,carinata* are becoming popular. The lacunae in our knowledge on the bioecology and management of major/minor pests should be filled in through more intensive and systematic research projects. Survey and monitoring of insect population in different agro-climatic regions should be a regular feature of the programme, with a view to know the changes in the status of major/minor pests and emergence of new pests. Special attention needs to be given to cultural control, plant resistance and pest forecasting systems.

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Table 1:
Period of peak aphid activity as influenced by different types of cruciferous plants

Period of peak aphid incidence	Host Plant	Locality	Reference
End Jan.-End Feb.	Cabbage	Ludhiana (Punjab)	Atwal and Sethi, 1963
Jan.-March	Crucifers	Patiala (Punjab)	Sidhu and Singh (1964)
Feb. 9-23, 1966	Cabbage	Ludhiana (Punjab)	Atwal *et al.*, 1971
Feb. 8-March 8, 1967	Cabbage	-do-	
Feb. 22-March 3, 1967	Mustard	-do-	
End Feb. 1972	Cabbage	Jobner & Jaipur (Rajasthan)	Sachan & Srivastava, 1972
Feb. 1-15, 1978	Mustard	Ludhiana (Punjab)	Bakhetia & Sidhu, 1983
1 Jan. - 6 March*	Mustard	-do-	
2 Jan. - 26 Feb.*	Rapeseed	-do-	Bakhetia *et al.* 1985
1-17 March **	B.napus	-do-	
Febrauary	Rapeseed	Delhi	Phadke, 1986

*Based on 6 years trials: ** Based on 3 years trials

Table 2:
Plant morphological characters associated with L.erysimi resistance in crucifers

Sl. No.	Plant character	Plant species	Aphid reaction	Reference
1.	Tender inflorescence and Thickly packed pattern of buds	*B. Campestris*	Susceptible	Rai & Sehgal (1975)
2.	Smaller and hardy inflorescence with loosely packed buds	B. juncea	Resistance	Rai and Sehgal (1975)
3.	Darker leaves	B. juncea, B. campestris var. brown sarson	Resistant	Pathak (1961)
4.	Lighter leaves	B. campestris var. brown sarson	More susceptible	Teotia & Lal (1970)
5.	Non-waxy plants	B. rapa	Higher reistance	Srinivaschar and Malik (1972)
6.	Various morphological characters	Cruciferous plants	No correlation	Anand (1976) Malik (1981)
7.	More branches and wider angle of orientation	B. juncea, B. campestris	Negative correlation with aphid population	Narang (1982)
8.	Hairiness of plant	Eruca sativa	Non-preference	Narang (1982)
9.	Yellow or greenish-yellow leaves	Brassica spp.	More attraction	Dilawari (1985)

TABLE 3:
BIOCHEMICAL FACTORS IN THE PLANT ASSOCIATED WITH *L. ERYSIMI* RESISTANCE IN CRUCIFEROUS SPECIES

Sl.No.	Biochemical constituents	Plant species	Reaction/Response to aphid	Reference
1.	Total sugar, total nitrogen, free amino acids and amides	*B. campestris* *B. juncea* *E. sativa*	No correlation with aphid developmental period	Kundu & Pant (1967)
2.	Total sugar and sulphur contents	*B. alba* *B. juncea* *B. campestris*	Negative correlation with aphid reproduction rate and population build-up	Bakhetia *et al.* (1982)
3.	Total sugar, phenolic compounds, potassium sulphur and iron	*E.sativa*	Higher concentration imparted high resistance	Narang (1982)
4.	Nitrogen, copper, zinc and manganase	*E. sativa* *B. juncea* *B. campestris*	No relationship with aphid resistance	Narang (1982)
5.	Protein, free amino acid, reducing sugars and total sugars	*20 cruciferous species*	Higher concentration responsible for high susceptibility	Malik (1981)
6.	Flavonoids, total sugars, and reducing sugars	*B. napus*	Higher contents gave higher resistance	Gill & Bakhetia (1985)

(Contd.)

(Table 1 Contd.)

Sl.No.	Biochemical constituents	Plant species	Reaction/Response to aphid	Reference
7.	Total ash, nitrogen and phosphorus	*B. napus*	Contents low in resistant varities	Gill & Bakhetia (1985)
8.	Glucosinolates, especially sinigrin	*Brassica sp.* *B. juncea* *B. carinata* *B. oleracaea*	Higher concentration responsible for resistance	Anand (1976)
9.	Total glucosinolates; Sinigrin as repellent and gluconapin as attractant	*Brassica spp.*	Negative correlation with aphid fecundity	Malik (1981)
10.	Ascorbic acid and glucosionalte contents	*Brassica spp.*	Negative correlation with aphid population	Labana *et al.* (1983)
11.	Allylisothicynate (1.0×10^{-4} mg Min^{-1} as the threshold level of activity)	*Brassica spp.*	Higher release rate as repellent and lower rate as stimulant (oi factory stimuli)	Dilawari (1985)

Table 4:
Strains/cultivars of cruciferous oilseeds reported to show resistance/tolerance to the mustard aphid

Strains/cultivars showing resistance/tolerance (1)	Reference (s) (2)
Brassica juncea	
T 11	Bindra & Deole (1962)
C 294,	Laha 101 Teotia & Lal (1970)
T 6342	Bakhetia & Sandhu (1973) Asthana & Das (1976), Brar & Sandhu (1978)
RL 18, RLM 198	Bakhetia & Sandhu (1973) Bakhetia & Bindra (1977) Brar & Sandhu (1978)
Rai T 3 Brar *et al.* (1976)	
P 26/21, RCU 10, RH 7326, RK 2, RLM 84, RLM 185, RLM 198, RLM 85-59, RLM 528	Bakhetia *et al.* (1984)
Rai 75-1	Singh *et al* (1982)
Pant *rai* series - 6, 15,34, and 52; B-85 (Glossy stem & white flower); RH series - 785, 7513, 7515; RK series - 1, 2, 8, 9; RC 781; KRV 79; KRV Tall; UVR 751; *RLC series- 1006, 1009, 1010;* RLM series - 29/22, 84, 142, 198, 2410, 514 and 528	Bakhetia (1985)
IB 680	Prasad (1983)
T 16	Premchand & Singh (1977)

(Contd.)

(Table 4 Contd.)

(1)	(2)
Brassica napus	
Gulliver, GSD. Regent, GSA, GSV 2	Gill & Bakhetia (1985)
Karat, Gulliver, GSB, GSC GS series - 47, 86, 123, 139 391 V series - 3, 6, 8 and 13	Bakhetia (1985)
Brassica campestris	
IB 787	Prasad (1983)
Torpe, Tora, CDA-Span, **Sariahi**	Bakhetia (1985)
Pusa Kalyani	Singh *et al* (1982)
B. Carinata, B. noddle, B. alba, B.napus, B. nigra, B. integrifolia	Bakhetia & Sandhu (1973) Sachan (1983) Singh *et al* (1965)
Crambe abyssinica (a strain)	Bakhetia & Sandhu (1973)
C. abyssinica PI 247310	Jarvis (1969)
Eruca sativa	Kundu & Pant (1967) Jarvis (1970) Singh *et al* . (1965)
E. sativa var, ITSA	Bakhetia & Bindra (1977)
S. alba	
Lethbridge 22 A Matopolaska	Sachan & Singh (1983)

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EFFECT OF FERTILIZER AND PLANTING PATTERNS IN CASTOR CLUSTERBEAN INTERCROPPING SYSTEM

G.SUBBA REDDY AND S.VENKATESWARLU
Central Research Institute for Dryland Agriculture (CRIDA),
Santoshnagar,
Hyderabad 500 659

ABSTRACT

A field experiment was conducted in Alfisols of Hyderabad from 1984 - 85 to 1986 - 87 on castor - clusterbean intercroppint system to study the effect of plating patterns and fertilizer levels under rainfed conditions. The planting patterns were uniform spacing (90 cm) of castor with one row of clusterbean; and paired planting (60/120 cm) of castor with one or two rows of clusterbean. The fertilizer levels were (1) No fertilizer (NoPo). (2) 10 Kg N and 10 Kg P_2O_5/ha, (3) 10 Kg N and 30 Kg P_2O_5/ha to clusterbean. The average yield of caster in intercropping system was about 80 per cent of that in sole castor. The results showed that uniform planting of castor + clusterbean in 1:1 row ratio and application of 10 Kg N and 30 Kg P_2O_5 to clusterbean component significantly increased the yeild advantage of the intercrop system (LER = 1.45) and the additional gross returns (Rs 1564/ha) over the sole crop of castor.

Key words: Intercropping: planting patterns; Fertilizer levels; Castor;Clusterbean

INTRODUCTION

Castor is a major non-edible oilseed grown under rainfed Alfisols of Telangana region in Andhra Pradesh. The productivity of this crop in the region is low (1.6 to 2.4 q/ ha) and often varied due to vagaries of monsoon and poor management practices. In order to increase and stabilise the productivity of castor, suitable intercrop system were developed at CRIDA. Amongst several intercrops clusterbean (*Cyamopsis tetragonoloba* (L)Taub) was found as a promising intercrop in castor (AICRPDA, 1984). Therefore, an attempt has been made to optimise the row ratio and planting pattern and also to rationalise the dose of fertilizer application in castor + clusterbean intercropping system.

MATERIALS AND METHODS

The experiment was conducted during 1984-87 seasons at Gunegal Research Farm of CRIDA. The soil of the experimental plot was sandy loam, low in available N (190 Kg/ ha) and P (15 Kg P_2O_5/ha) and medium in available K (212 Kg K_2O/ha). The treatments consisted of three planting systems (S 1: castor in 90 cm (uniform) rows + one row of clusterbean; S2: castor in 60/120 cm (Paired) rows + one row of clusterbean) and S 3: castor

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in 60/120 cm (paired) rows + two rows of clusterbean and three fertilizer levels (F O : no fertilizer; F1: 10 Kg N + 10 Kg P_2O_5/ha; and F2:10 Kg N + 30 Kg P_2O_5/ha) to clusterbean component. A common dose of 50 Kg N and 20 Kg P_2O_5/ha was applied to castor in sole and intercrop systems. In addition to sole crops, nine intercrop treatment combinations were tested in a factorial randomised block design with four replications. A uniform plant population of 0.75 lakh/ha was maintained in sole and intercropped castor (cv. Aruna). In clusterbean (cv.Navabahr) plant population of about 3 lakhs/ha was maintained in sole crop. Whereas in intercropped clusterbean replicement series was adopted. The bean yields of castor and green pod yields of clusterbean recorded in different pickings were pooled treatment - wise to obtain total bean yields. The values of land equivalent ratio (Mead and Willey, 1980) and staple land equivalent ratio (Reddy and Chetty, 1984) were taken as basis to compute yield advantages. Gross monetary returns were worked out, taking prevaling market prices of the produce.

A total of 297, 370 and 354 mm rainfall was received during the growth period of castor during 1984-85, 1985-86 and 1986-87, respectively. The clusterbean component received 288, 315 and 200 mm rainfall during its crop growth in 1984, 1985 and 1986, respectively. Low yield of clusterbean during 1984 was due to severe moisture stress at vegetative and flowering stages. Clusterbean yields were hiagher during 1985 due to receipt of higher quantum of rainfall and its favorable distribution. But early withdrawal of monsoon in 1985 had an adverse affect on the bean yield of castor. In 1986, the rainfall was not favorable to both castor and clusterbean due to prolonged dry spells during their critical growth periods.

RESULTS AND DISCUSSION

Effect of intercropping :

Castor planted in uniform (90 cm) rows significantly gave higher bean yield compared to paired (60/120 cm) row planting in 1985-86 (Table 1). However, no such difference was observed during 1984-85 and 1986-87. On an average, the bean yield of castor in intercropping system was reduced by 20 per cent compared to sole castor, whereas the green pod yield of clusterbean in intercropping decreased by 70% over its mean sole crop yeild (Table 1). The decrease in yield of castor was mainly due to reduction in capsule number and weight. In clusterbean, reduction in number of green pods/ plant decreased its yield in intercropping over sole crop. In castor based intercrop system, the yields of other legume component crops (cowpea, blackgram and pigeonpea) were also significantly reduced (AICRPDA, 1981).

Effect of planting patterns :

Intercropping of one row of clusterbean planted in uniform (90 cm) rows of castor (S 1) gave highest (22.24 q/ha) green pod yield of clustor bean followed by two rows of cluster bean (19.94 q/ha) planted in paired (60/120 cm) rows of castor (S 3) (Table 1). This increase in green pod yield of clusterbean in uniform rows (S 1) was mainly attributed to its higher plant density in the system over other planting systems. Increase in yields of cereals with increased plant densities were reported in cereal - legume intercropping system (Ro and Willey, 1983 and Reddy and Havanagi, 1986). Castor in uniform rows (S 1) intercropped with one row of clusterbean significantly gave higher bean yield in 1985-86 and 1986-87 seasons. But in 1984-85 season castor bean yield was the highest when one row of clusterbean was planted in paired rows (S 2). This variation in yield in different planting patterns was ascribed due to variation in rainfall distribution. Umrani *et al* (1984) found that yield of sorghum intercropped with pulses was dependent on the amount and distribution of rainfall in a particular year.

Effect of fertilizer:

In castor + clusterbean intercropping system, application of 10 Kg N and 20 Kg P_2O_5 to clusterbean rows (F 2) on respective row proportionate basis significantly increased (38 per cent) the green pod yield of clusterbean compared to no fertilizer application to clusterbean rows (F O)when a common dose of 50 Kg N and 20 Kg P_2O_5/ha was applied to castor rows in all the treatments (Table 1). Whereas, additional application of 10Kg N and 10 Kg P_2O_5/ha to clusterbean (F 1) also significantly (26 percent) increased its green pod yield over no fertilizer application. Application of additional fertilizer dose to the inter cropped legume along with recommended dose of fertilizer to the base crop of cereal increased the grain yield of legume (Hiremath 1979 and Reddy and Havanagi, 1986). There was no significant variation in bean yields of castor due to application of different levels of fertilizers to clusterbean in different planting patterns.

Yield advantages:

Application of F 2 level of fertilizer (10 Kg N and 30 Kg P_2O_5/ha) to clusterbean gave the highest (31 percent) yield advantage followed by F1 level (24 percent). Among the *planting patterns* S 1(90 *cm uniform rows*) system gave highest LER (1.38) followed by S3 system. Thus, the treatment combination of S1 F2 in castor + clusterbean intercroping system gave the highest yield advantage (LER = 1.45) (Fig.1). The SLER values in the S 1 F 2 system was also more productive and stable over the years (Fig.2).

Monetary advantages :

Intercropping of castor and clusterbean on an average gave 24 percent (Rs. 936/ha) and 36 percent (Rs. 1281/ha) additional gross monetary returns compared with sole crop of castor (Rs 3920/ha) and clusterbean (Rs. 3575/ha). Among the planting patterns S 1 system gave the highest gross return/ha. Application of F 2 level of fertilizers to clusterbean rows in intercropping gave 12 per cent additional gross returns (Rs 546/ha) over F 0 level. Thus, S 1 F 2 combination of castor and clusterbean intercropping gave higher additional gross retuns (Rs. 1564 /ha) than growing of sole castor.

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TABLE 1:

The bean yields of castor and clusterbean as influenced by varied fertilizer levels and planting patterns in intercropping system.

Treatments	Bean yeidls (q/ha)							
	Castor				Clusterbean			
	1984-85	1985-86	1986-87	Mean	1984-85	1985-86	1986-87	Mean
1. Sole castor 90 cm uniform rows	12.08	7.08	11.14	10.10	-	-	-	-
2. Sole castor 60/120 cm paired rows	11.17	6.22	10.22	9.20	-	-	-	-
3. Sole clusterbean (45 cm) rows	-	-	-	-	27.20	58.20	36.42	40.61
4. Castor planted in 90 cm uniform rows + 1 row of clusterbean F_0	10.81	5.20	9.44	8.48	15.21	28.30	10.62	18.04
5. Castor planted in 60/120 cm paired rows + 1 row of clusterbean F_0	11.23	4.83	7.95	8.62	7.47	17.18	9.02	11.22
6. Castor planted in 60/120 cm paired rows + 2 rows of clusterbean F_0	11.06	4.06	7.09	7.54	14.32	25.66	10.05	16.68
7. Castor planted in 90 cm uinform rows + 1 row of clusterbean F_1	11.93	5.24	9.45	8.87	19.05	35.20	15.80	23.35
8. Caster planted in 60/120 cm paired rows + 1 row of clusterbean F_1	11.04	4.83	8.88	8.25	8.49	22.02	11.04	13.85
9. Castor planted in 60/120 cm paired rows + 2 rows of clusterbean F_1	9.27	4.56	7.07	6.97	13.37	33.42	15.17	20.65
10. Castor planted in 90 cm uniform rows + 1 row of clusterbean F_2	10.74	5.43	9.62	8.59	19.99	38.72	18.75	25.15
11. Castor planted in 60/120 cm paired rows + 1 row of clusterbean F_2	11.00	4.77	8.74	7.83	9.44	21.26	14.03	14.91
12. Castor palnted in 60/120 cm paired rows + 2 rows of clusterbean F_2	10.01	4.50	7.31	7.29	16.26	33.04	17.89	23.40
C.D. (0.05)	1.10	0.44	1.0	-	1.25	0.94	0.84	-

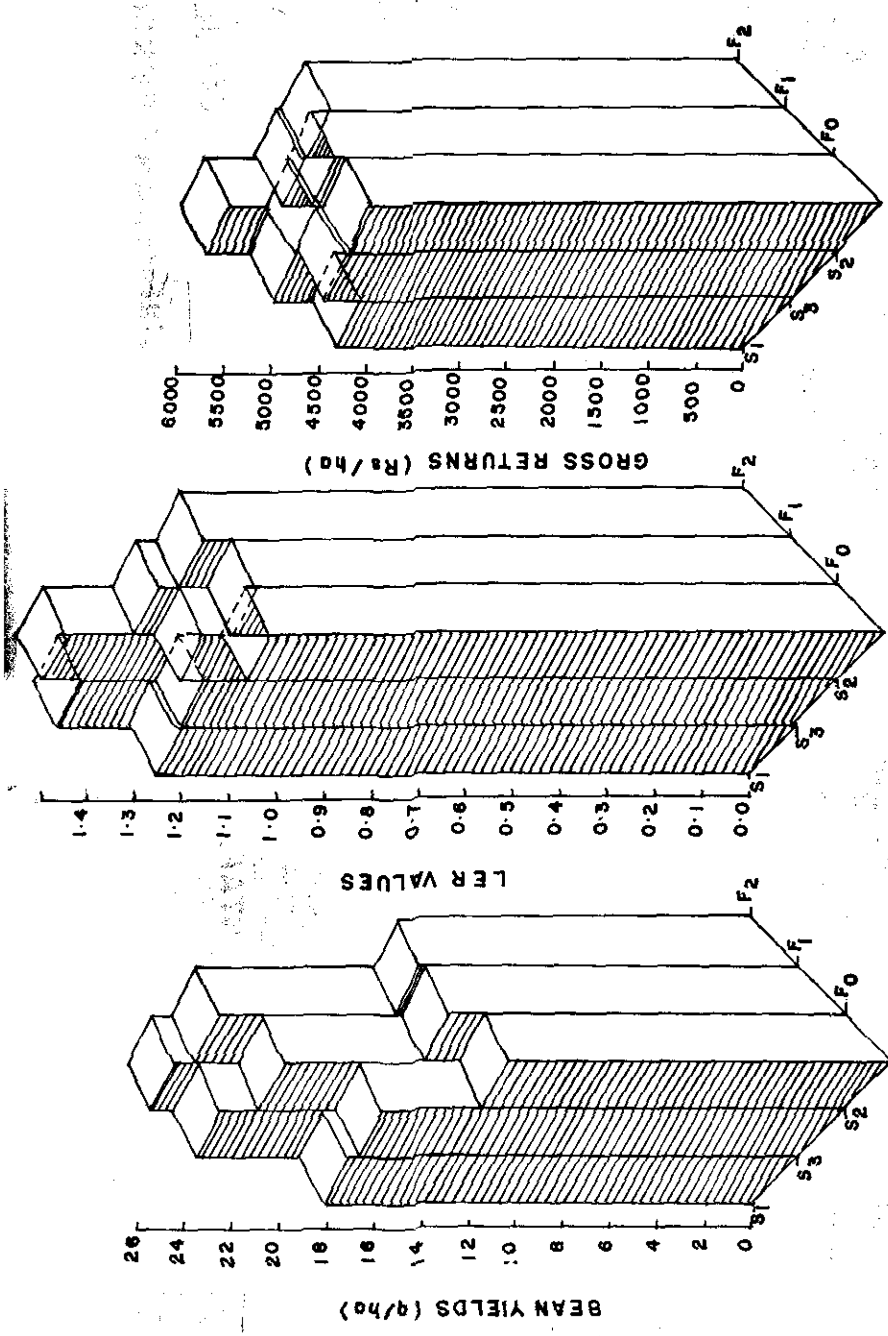

Fig. 1 THE BEAN YIELDS OF CLUSTER BEAN, LAND EQUIVALANT RATIO AND GROSS RETURNS (Rs/ha) AS INFLUENCED BY THE PLANTING PATTERNS AND FERTILISER LEVELS IN INTERCROPPING SYSTEMS

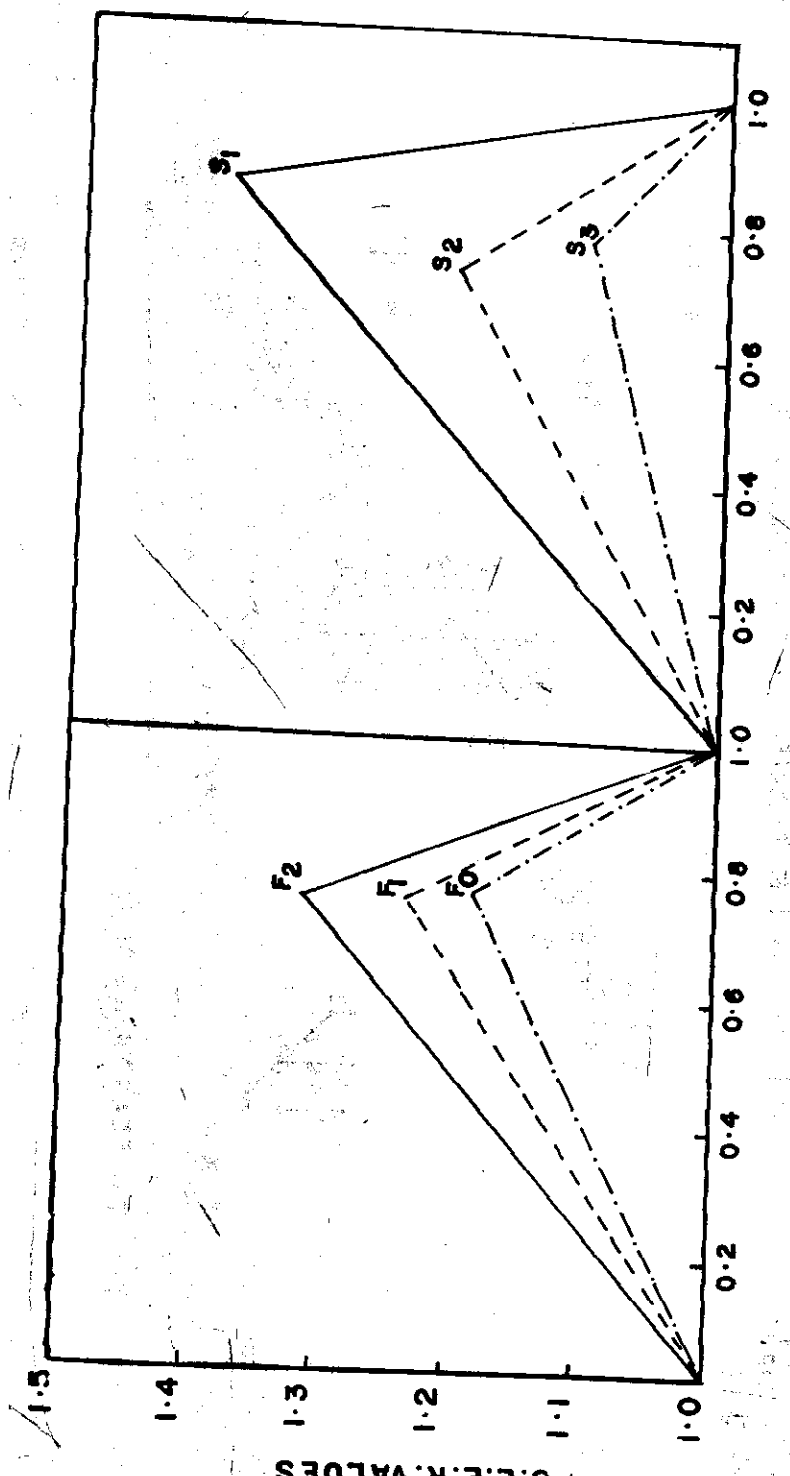

Fig. 2 THE MEAN STAPLE LAND EQUIVALENT RATIO (S.L.E.R.) VALUES OF CASTOR BEAN AS INFLUENCED BY THE DIFFERENT FERTILISER LEVELS AND PLANTING PATTERNS IN INTERCROPPING SYSTEM

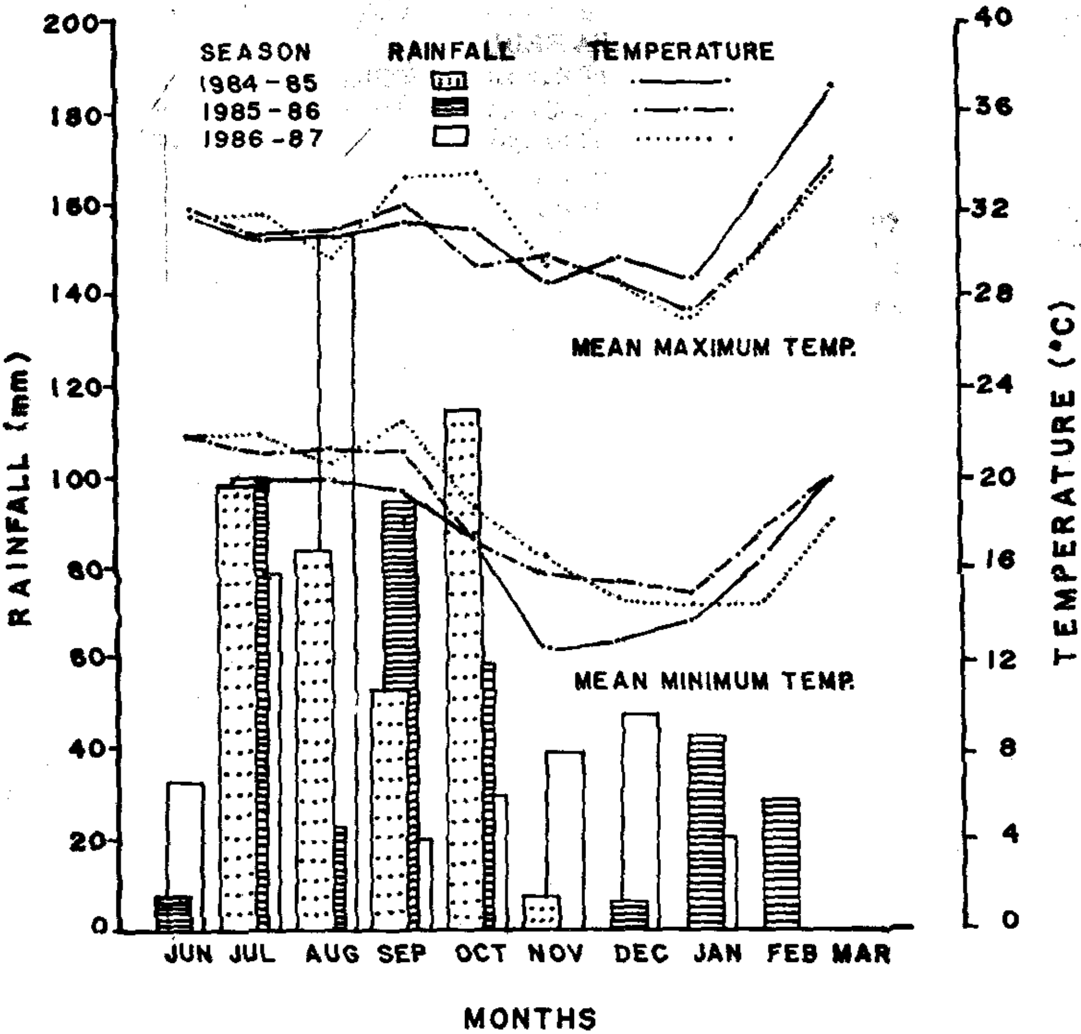

Fig.1 WEATHER CONDITIONS DURING 1984-87 CROP SEASONS

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EFFECT OF TIME OF PLANTING OF COMPONENT CROPS ON PRODUCTIVITY OF CASTOR + CLUSTERBEAN INTERCROPPING SYSTEM

S.VENKATESWARLU AND G.SUBBA REDDY
Central Research Institute for Dryland Agriculture (CRIDA)
Santoshnagar,
Hyderabad (A.P.)

ABSTRACT

Field experiments were conducted under rainfed conditions during 1984-1986 seasons on Alfisol to find out the optimum time of planting of the component crops in castor + clusterbean intercropping system to improve the productivity. Bean yield of castor and green pod yield of clusterbean were the highest when both these crops were sown timely. Yield of castor and clusterbean decreased in intercropping situation and more particularly in a drought year. Mean yield data of three years showed that castor + clusterbean sown timely gave bean yield 73 per cent of sole castor while clusterbean gave 57 per cent of its sole crop. This system gave an LER of 1.30 and an additional return of Rs. 1776 ha^{-1} over sole crop of castor. Staggering the planting time of either castor or clusterbean did not improve the total productivity of the intercropping system.

Key words: Intercropping; Planting time; paired rows; Castor; Clusterbean.

INTRODUCTION

Castor, a long duration oilseed Crop grown mainly as a sole crop in the semi-arid Alfisols of Telangana region (Andhra Pradesh) which receives on an average of 630 mm rainfall with an effective growing season of 22 weeks. Crop geometry studies showed that castor can be planted in rows upto 135 cm wider without reduction in yield per unit area. Preliminary studies conducted in Operational Research Project, Hyderabad (AICRPDA, 1984) indicated that a short duration 'Pusa Navabahr' clusterbean variety for vegetable purpose can be grown in the interspace (90 cm) of castor. Further, experimental results at CRIDA Experimental Station (Venkateshwarlu, 1987) have shown that clusterbean can be planted in the space between paired 60/105 cm) rows of castor to minimize the competition between the component crops. In order to improve the productivity of the system, information is required on optimum planting time of both the component crops. Therefore, a field experiment was designed to find out the optimum time of seeding of castor and clusterbean by staggered planting.

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MATERIALS AND METHODS

A *field trial was conducted at* Hayathnagar *Experimental Station of Central* Research Insititute for Dryland Agriculture, Hyderabad during 1984-85 to 1986-87. The experiment was conducted in a randomised block design with eleven treatment combinations. The treatments consisted of three planting dates in sole castor and clusterbean sown with the onset of monsoon, sown 15 and 30 days later after first date and five intercrop combinations (Table 4).

Sole crops of castor and clusterbean received an uniform basal dose of 11 Kg N and 40 Kg P_2O_5 ha^{-1}.In intercropping castor received 11 Kg N and 30 Kg P_2O_5 ha^{-1}. as basal and 39 Kg N ha^{-1} was side placed in two equal splits, one at vegetative stage and the other at pre-flowering stage. The insecticide BHC (10%) was applied at the rate of 50 Kg ha^{-1} with the last ploughing to control termite and root grub incidence. Recommended chemical protection against pest and diseases were followed.

Castor was dibbled at 25 cm in paired rows of 60/120 cm. Clusterbean was sown in uniform rows in sole crop system and in intercfropping two rows of clusterbean were sown (45/30 cm) in 120 cm wide space between paired rows of castor. Sowings were carried out on July 4 July 19 and August 3 in 1984, on June 22, July 5 and July 22 in 1985 and on June 17, July 2 and July 16 in 1986. Castor was harvested as primaries, secondaries and tertiaries while clusterbean was harvested in different pickings as green pods for vegetable purpose.

The minimum and maximum temperature and total rainfall for the three cropping seasons have been depicted in Fig.1.

RESULTS AND DISCUSSION

Castor sown in time i.e. with the onset of monsoon recorded the higher mean bean yield (8.35 q ha^{-1}) than late sown castor(Table 1).Similar results were reported with sole castor in trails conducted under All India Coordinated Research Project on Oilseeds (DOR, 1980). Significant improvement in plant height and number of effective capsules (Table 2) in timely sown castor was observed during 1986-87 due to favourable rainfall and temperature conditions as compared to late sown castor. But the trend in yield attributes was the reverse in 1984-85 due to moisture stress (scanty rainfall conditions) during the development of primaries in timely sown castor and favourable rainfall in the reproductive phase of late sown castor.

Seasonal variation caused differences in the production of primaries, secondaries and tertiaries (Table 2) in timely sown castor. During 1984-85 and 1985-86 greater contribution to the total bean yield was mostly (about 70 per cent) from secondaries and tertiaries. While in 1986-87 the yield contribution was mostly (about 70 per cent) from primaries.

Green pod yield of clusterbean was the highest when it was sown in time (Table 3). Higher green pod yield (61.4 q ha^{-1}) in timely sown clusterbean was due to higher number of green pods m^{-1} and greater 100 pod weight compared to late sown clusterbean.

In intercropping, when castor and clusterbean were sown in time in a proportion of 2:2, the bean yield of castor decreased in comparison with that of sole castor crop by 32 per cent during 1985-86 and 36 cent during 1986-87 , whereas the reduction in yield was negligible during 1984-85 (Table 1). Castor suffered more Competition from clusterbean in intercropping situation during 1985-86 and 1986-87 because the well developed canopy of clusterbean interfered with the growth of castor under favourable rainfall conditions. Field trails conducted at CRIDA Experimental Station, Hyderabad (Venkateswarlu and Bala Subramanian, 1989) have shown that yield reduction in castor was to the extent of 20 to 28 per cent in castor + clusterbean (1:1) intercropping compared to sole castor, respectively. Intercropping with timely sown castor and delay in the sowing of clusterbean by 3o days gave of castor bean yield equivalent to that of sole crop in 1984-85 and 1986-87. It was because of lack of perceptible degree of competition from late sown clusterbean.

Yield reduction in intercropped clusterbean was 36,39 and 46 per cent when castor + clusterbean were sown in time in 1984, 1985 and 1986, respectively. Similarly, Venkateswarlu and Bala Subramanian (1989) also reported that the yield of clusterbean decreased by 50 per cent in castor + clusterbean (1:1) intercropping system. There was a drastic reduction in the yield of intercropped clusterbean when castor was sown in time but clusterbean sown 15 and 30 days later. This was probably due to shading effect of timely sown castor on late sown clusterbean. On the otherhand, the yield of timely sown intercropped clusterbean was relatively higher when castor sowings were delayed.

Mean LER was the highest (1.30) when castor + clusterbean were sown timely (Table 4) . Castor gave 73 per cent yield (PLER = 0.73) of its sole crop while clusterbean gave 57 per cent.(PLER = 0.57) yield of its sole crop. Castor + clusterbean when sown timely got the benefit of more amount of rainfall (Fig.1) during their growth and development which ultimately resulted in higher productivity from this intercropping system. Trials conducted at CRIDA Experimental Station, Hyderabad during 1986 (Venkateswarlu and Bala Subramanaian, 1989) indicated that timely sown castor + clusterbean gave an yield advantage of 30 per cent (LER = 1.30) over their sole crop system. Staggering the planting time of either castor or clusterbean did not have much beneficial effect on the total productivity.

When the sowing date of either base or intercrop was delayed, the late sown crop suffered more and gave low partial LER values resulting in very low or no advantage to the total productivity.

To compare the productivity of different intercrop systems the yield of main crop (castor) and intercrop (clusterbean) were converted into monetary values (Table 4). On the basis of mean yield data of three years, it was found that castor + clusterbean when sown in time higher additional gross monetary return (Rs. 1776 ha^{-1}) compared to timely sown sole crop of castor.

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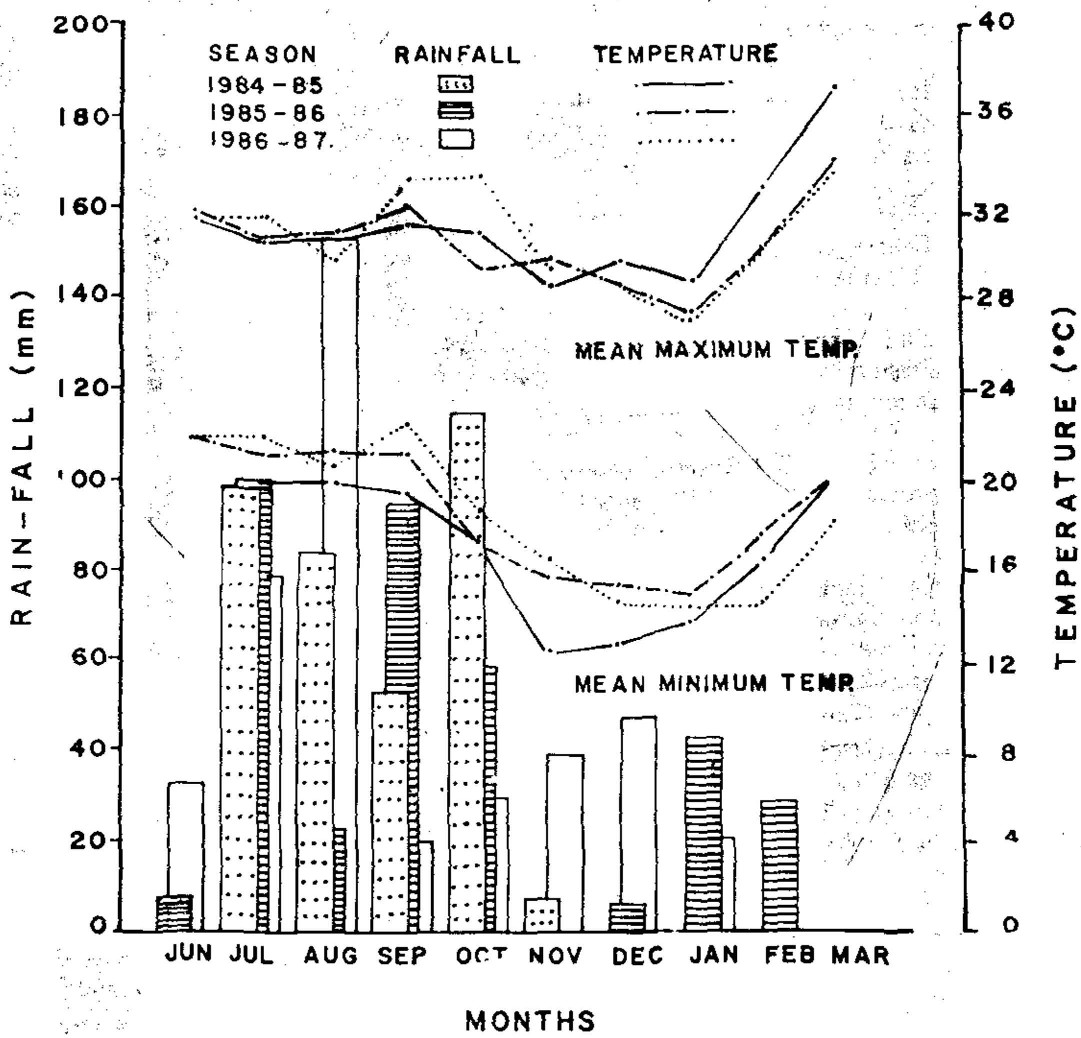

Fig. 1 : Weather conditions during 1984-87 crop seasons

TABLE 1:

Effect of sowing date on bean yield of castor primaries, secondaries and tertiaries and the total bean yield in sole and intercropping system.

Treatment	Primaries (q ha^{-1})			Secondaries & Tertiaries @ (q ha^{-1})			Total bean yield (q ha^{-1})			Mean bean yield (qha^{-1})
	1984	1985	1986	1984-85	1985-86	1986-87	1984-85	1985-86	1986-87	
Sole castor sown timely	2.24	2.77	4.24	5.85	8.34	1.60	8.09	11.11	5.84	8.35
	(27.7)*	(24.9)	(72.6)	(72.3)	(75.1)	(27.4)				
Sole castor sown 15 days later	3.19	2.54	2.56	1.90	5.35	3.21	5.09	7.89	5.77	6.25
	(62.7)	(32.2)	(44.4)	(37.3)	(67.8)	(55.6)				
Sole castor sown 30 days later	2.86	1.61	1.97	0.54	3.97	2.81	3.40	5.58	4.78	4.59
	(84.1)	(28.9)	(41.2)	(15.9)	(71.1)	(58.8)				
Castor + clusterbean sown timely	2.02	2.47	3.13	5.23	4.84	0.60	7.25	7.31	3.73	6.10
	(27.9)	(33.8)	(83.9)	(72.1)	(66.2)	(16.1)				
Castor sown timely + Clusterbean sown 15 days later	1.99	1.92	3.47	4.63	5.60	1.16	6.62	7.52	4.6[illegible]	6.26
	(30.1)	(25.5)	(74.9)	(69.9)	(74.5)	(25.1)				
Castor sown timely + Clusterbean sown 30 days later	2.38	2.34	4.11	5.71	5.00	1.53	8.09	7.34	5.64	7.02
	(29.4)	(31.9)	(72.9)	(70.6)	(68.1)	(27.1)				
Clusterbean sown timely + castor sown 15 days later	2.52	1.51	1.02	0.99	3.18	1.81	3.51	4.70	2.83	3.68
	(71.8)	(32.1)	(36.0)	(28.2)	(67.9)	(64.0)				
Clusterbean sown timely + castor sown 30 days later	2.11	1.06	0.78	0.53	2.48	1.06	2.64	3.54	1.84	2.67
	(79.9)	(29.9)	(42.4)	(20.1)	(70.1)	(57.6)				
SEm ±	0.27	0.51	0.28	0.24	0.98	0.43	0.75	1.363	0.61	
CD (P=0.05)	NS	NS	0.82	0.73	2.96	1.26	2.27	4.107	1.81	

* Figures in paranthesis are percentage yield contribution to total bean yield

@ During 1986-87 contribution from secondaries only (since tertiaries were not formed)

TABLE 2:
Effect of sowing date on growth (plant height) and yield components of castor primaries in sole and intercropping system.

Cropping System	Plant height (Cm)		Spike length (Cm)		Effective No.of Capsules spike^{-1}	
	1984-85	1986-87	1984-85	1986-87	1984-85	1986-87
Sole castor sown timely	62.7	82.3	8.2	16.2	15.1	31.0
Sole castor sown 15 days later	54.5	65.8	12.6	9.5	24.2	17.5
Sole castor sown 30 days later	43.5	54.6	11.6	7.0	23.4	15.4
Castor + Clusterbean sown timely	57.4	78.6	8.0	11.7	14.5	19.4
Castor sown timely + Clusterbean sown 15 days later	58.4	79.4	7.6	15.2	13.8	24.1
Castor sown timely + clusterbean sown 30 days later	61.3	80.6	8.1	15.5	15.5	26.4
Clusterbean sown timely + castor sown 15 days later	49.4	50.2	11.4	5.1	23.1	11.1
Clubsterbean sown timely + castor sown 30 days later	41.2	45.1	11.0	4.0	18.3	9.2
SEm ±	3.5	3.2	0.9	0.7	1.9	2.6
CD (P = 0.05)	10.5	9.5	2.7	2.0	5.9	10.4

Table 3:
Effect of sowing date on pod yield and yield components of clusterbean in sole and intercropping system.

Cropping system	Green pod yield of clusterbean (q ha^{-1})			Mean pod Yield (q-ha^{-1})	Yield Components (19869	
	1984	1985	1986		No.of green pods m^{-2}	100-green Pod wt (g)
Sole clusterbean sown timely	18.5	60.4	105.2	61.4	920	113.8
Sole clusterbean sown 15 days later	8.6	32.3	39.4	26.8	409	96.1
Sole clusterbean sown 30 days later	6.5	17.3	21.2	15.0	221	92.1
Castor sown timely + clusterbean sown timely	11.9	37.0	56.0	35.0	451	121.4
Castor sown timely + clusterbean sown 15 days later	3.9	15.6	8.8	9.4	94	91.6
Castor sown timely + Clusterbean sown 30 days later	2.9	8.6	5.2	5.6	62	75.1
Clusterbean sown timely + castor sown 15 days later	10.4	40.3	69.0	39.9	547	125.9
Clusterbean sown timely + castor sown 30 days later	12.8	44.6	71.4	42.9	565	127.5
SEm ±	2.7	3.4	3.8	-	43	3.6
CD(P = 0.05)	8.1	10.4	11.2	-	127	10.5

TABLE 4:
Effect of time of sowing on Land Equivalent Ratios (LERs) and gross monetary returns in sole and intercropping systems

Tr. No.	Cropping syustem	Total LER 1984-85	Total LER 1985-86	Total LER 1986-87	Average LER	Gross monetary return (Rs. ha^{-1}) 1984-85	Gross monetary return (Rs. ha^{-1}) 1985-86	Gross monetary return (Rs. ha^{-1}) 1986-87	Average return (Rs. ha^{-1})
1.	Sole castor sown timely	1.00	1.00	1.00	1.00	2832	3889	2044	2922
2.	Sole castor sown 15 days later	1.00	1.00	1.00	1.00	1782	2762	2020	2188
3.	Sole castor sown 30 days later	1.00	1.00	1.00	1.00	1190	1953	1673	1605
4.	Sole clusterbean sown timely	1.00	1.00	1.00	1.00	1850	6040	5260	4383
5.	Sole clusterbean sown 15 days later	1.00	1.00	1.00	1.00	860	3230	1970	2020
6.	Sole clusterbean sown 30 days later	1.00	1.00	1.00	1.00	650	1730	1060	1147
7.	Castor + Clusterbean sown timely	1.54	1.27	1.17	1.30	3728	6259	4106	4698
8.	Castor sown timely + Clusterbean sown 15 days later	1.03	0.94	0.87	0.90	2707	4196	2061	2988
9.	Castor sown timely + Clusterbean sown 30 days later	1.16	0.80	1.02	0.93	3122	3429	2234	2928
10.	Clusterbean sown timely + Castor sown 15 days later	0.99	1.09	1.14	1.09	2255	7459	4491	4718
11.	Clusterbean sown timely + Castor sown 30 days later	1.02	1.06	1.00	1.02	2204	5699	4214	4039

	Market rates (Rs. q^{-1}) 1984-85	1985-86	1986-87
Castor beans	350	350	350
Clusterbean	100	100	50

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SHORT TITLE : Water Production Functions For Indian Rape.

COMPARISON OF SOME CROP - WATER PRODUCTION FUNCTIONS FOR INDIAN RAPE (Brassica Napus L.Var.napus)

Harbir Singh, K.P. singh, S.D. Jarwal, T.Singh, D.s. Tonk and A.s. Faroda
Department of Agronomy,
Haryana Agricultural University,
Hisar - 125 004

ABSTRACT

Field studies were conducted on Indian rape (*Brassica napus* L. var napus) at crop Research Centre, Haryana Agricultural University, Hissar. Some crop-water production functions, relating seed yield with seasonal evapotranspiration without considering the time of water deficit during crop growth season, were derived and compared using experimental data. Seasonal evapotranspiration had significant correlation with seed yield of Indian rape. Non-linear functions slightly improved the results in terms of R^2 values as compared to linear one. The inclusion of a stress factor, which was not attempted in present study, is suggested for possible improvement in the prediction of crop- water production function.

Key Words : Brassica napus L.Var.Napus, Crop - water production function, evapotranspiration.

INTRODUCTION

Crop production is dependent on the environment and genetic constitution of crops. The crop environment includes climatic, biotic and edaphic parameters. Some of these may be manipulated by management towards increased crop yields (Flinn, 1971). Water is one such parameter which can be controlled under irrigated environments. Plant responses are the result of complex interactions of many physiological processes each of which may be affected differently by periods of limited soil moisture availability. Since the beginning of the twentieth century researchers have been studying the relationships between crop yield and water use (Briggs and Shantz, 1913; Kisselbach, 1916, De wit, 1958). In order to apply these relationships to crop production, a knowledge of the functional forms of the relationships between yield and some measure of water use by the plants is required. For many crops information on these relationships is available (Hanks *et al.* 1969, Hanks and Rasmussen, 1982, Musick *et al.* 1976 Singh *et al.* 1987, and Vaux and Pruitt. 1983). Very little work has, however, been done on Indian rape (Brassica napus) on this aspect. This study is aimed at comparing some relationships between yield

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and seasonal evapotranspiration (consumptive use) in Indian rape.

MATERIALS AND METHODS

The data used in this study were published by Singh et al. (1986). Indian rape was grown at the Haryana Agricultural University, Hisar 29° 10'N and 75° 46' E and 215 m above MSL with semi - arid climate. The field experiments were conducted in plots of 5.0m x 4.2 m with a buffer of 1m on all sides. The soil, a sandy loam (Typic Ustochrepts) consisted of 66% sand, 16% silt, and 18% clay in 120 cm profile. The soil moisture (gravimetric) was 17.4% at field capacity and 7.5% at wilting point. The bulk density of the profile was 1.41 to 1.48 g/cm^3; Ec and PH (1:2 soil: water) were 0.33 to 0.53 m mhos/cm and 7.9 to 8.2 , respectively. The crop was sown on 15 September 1982 and 20 September 1983. The crop waas harvested at maturity on 21 December 1982, and 2 January 1984. Total seasonal evapotranspiration (Consumptive use) was computed as ET = Water added + effective rainfall + Soil. Due to low intensity of rainfall turing both the crop seasons, the total amount of rain received was consisdered as effective rainfall.

The mathematical relationships between crop yield and seasonal evapotranspiration (ET) of following type were developed and compared;

$$Y = a + b\,(ET) \quad (1)$$
$$Y = a + b\,(ET) + c\,(ET) \quad (2)$$
$$Y = a + b\,(ET) + c\,(ET)^2 + d\,(ET)^3 \quad (3)$$
$$Y = a + b\,(ET) + c\,(ET)^{0.5} \quad (4)$$
$$Y = a\,(ET)^b \quad (5)$$
$$Y = a + b\left(1\ \frac{ET}{ETm}\right) \text{ after stewart (1972)} \quad (6)$$
$$Y = a + b\left[1-\left(1-\frac{ET}{ETm}\right)^2\right] \text{ after Singh } et\ al.\ (1987) \quad (7)$$

Where,

Y = Seed yield

a = regression constant,

b, c, and d are regression coefficients,

ET is seasonal evapotranspiration (mm)

ETm = maximum seasonal evapotranspiration (mm)

The F values were worked out to test the statistical significance of coefficient of determination (R^2) of different crop - water production functions.

RESULTS AND DISCUSSION

The estimated values of the regression constants and coefficients and other statistical perameters for various production functions are presented in Tables 1 and 2. The crop production functions compared here did not account for the timing of water deficits. The values of the coefficient (s) of determination (R^2) for crop production functions varied from

0.868 to 0.988 during 1982 and 0.774 to 0.964 during 1983. The ratios of variance (F value) for testing R^2 were significant at P = 0.01 level of significance in all the cases during both the years except in case of three degree polynomial in 1983. Where F was significant at P = 0.05 level of significance though the R^2 was very high. It may surmised that most of the functions compared explained variations in yield. Statistical implication of regression coefficients of these functions was tested using t - test. One or all of the regression coefficients were non - significant for quadratic, third degree polynomial and square root functions. Therefore,the non-linear functions expressed by equations 2 (except in 1982) 3 and 4 did not represent the date well.

Crop production function developed by Stewart (1972) may be written in the form of linear function (6). Probably that is why R2, F and t values for regression coefficients for Stewart model (6) and linear function (1) came out to the equal (tables 1 and 2). The regression coefficients for both functions (1 and 6) were highly significant. Significant Singh *et al* (1987) developed a modification of the Stewart (1972) model to account for increase in crop yield at a decreasing rate as Et increases from zero to ETm (Equation 7). The modification proposed by Singh *et al* (1987) represent the data well and its regression coefficient was highly significant, but it had relatively lower R^2, F and t value as compared to Stewart function (6). These results are contrary to the work reported by Singh *et al* (1987) for wheat. It may, however be noted that fitting of non - linear functions (Equations 2,3, 4 and 5) imporved the results (in terms of R^2 values) slightly over the linear functions (Equations 1 and 6).

Various functions compared herein performed well (Table 1 and 2 Nagel 1974, Barrett and Skogerboe, 1980 show that the marginal yield should decrease with increase in evapotranspiration and, therefore, the relationship between yield and seasonal evopotranspiration should be non-linear. Therefore the quadratic function (2), power function (5) and the Singh et al (1987) function may be considered more appropriate. The linear functions (1 and 6) however are simple.

There have been many studies suggesting that water deficits during critical crop growth stages have more effect on yield than on ET or transpiration (Stewart, 1972, Jenson, 1968 and Barrett and Skogerboe, 1980) We therefore suggest that work on the crop production functions in relation of various crop growth stages may be taken up.

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TABLE 1:
Estimated values of regression constants and coefficients and statistical parameters for testing some crop-water production functions in Indian rape (1982)

Crop production function	Regression Constant	Coefficeients and t values (parentheses)			R^2	F value for testing R^2
	a	b	c	d		
Linear	127.90	5.49 (19.12) **	--	--	0.99	365.59 **
Quadratic	167.89	4.76 (2.84) *	2.96×10^{-3} 90.44) NS	--	0.99	153.51**
Third Degree Polynomial	385.79	-1.46 (-0.07)NS	5.47×10^{-2} (0.31) NS	-1.32×10^{-4} (0.30) NS	0.99	79.05**
Square Root	303.22	7.07(2.09)NS	33.92 (-0.47)NS	--	0.99	154.39**
Power	17.30	0.80(19.48)**	--	--	0.99	379.35**
Stewart (1972)	1180.12	-1052.22(-19.12)**	--	--	0.99	365.59**
Singh et al (1987)	-264.84	1305.26 (5.75)**	--	--	0.87	33.04**

* Significant at P = 0.05 level, ** Significant at P = 0.01 level, NS - Non Significant

TABLE 2:

Estimated values of *regression constants and coefficients and statistical parameters for* testing some crop-water production functions for Indian rape (1983)

Crop production function	Regression Constant a	Coefficeients and t values (parentheses) b	c	d	R^2	F value for testing R^2
Linear	127.68	5.61(7.47)**	--	--	0.92	55.81**
Quadratic	324.25	2.61 (0.54)NS	0.01(0.63)NS	--	0.93	24.75**
Third Degree Polynomial	-2437.49	67.67 (1.84)NS	-0.45(-1.74)NS	1.04×10^{-3}(1.78)NS	0.96	26.55*
Square Root	800.81	10.71(1.09)NS	118.70(-0.52)NS	--	0.92	23.96**
Power	16.36	0.8159(9.19)**	--	--	0.94	84.53**
Stewart (1972)	1330.53	-1202.86(-7.47)**	--	--	0.92	55.81**
Singal et al (1987)	399.25	1577.20(4.13)**	--	--	0.77	17.07**

*Significant at P =0.05 level, ** Significant at P = 0.01 level, NS = Non Significant

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PHENOTYPIC STABILITY FOR YIELD AND YIELD CONTRIBUTING CHARACTERS OF NIGER UNDER RAINFED CONDITIONS.

S.B.VERULKAR AND P.C.UPADHYAY
J.N.K.V.V., Regional Agricultural Research Station,
Chhindwara - 480 002 (M . P.)

ABSTRACT:

Nine varieties of niger were evaluated for stability parameters with respect to seed yield and its components in nine environments, created by agronomic manipulations under rainfed conditions. The varities included were CHH - 1, CHH - 2, GA - 10, KEC - 1, IGP - 76, N -71, ONS - 4 ONS - 8 and Gaudaguda-1. Presence of genotype - environment interaction was observed. Linear as well as non - linear component accounted for the interactions present. CHH - 1 was the only genotype founbd to be stable and desirable for seed yield/plant. Varieties Gaudaguda-1 and N-71 yielded significantly higher than other cultivars but significant deviation from regression render them unstable.

Key words : Niger, agonomic manipulation, , environments, stability.

INTRODUCTION:

Stability in performance is a desirable attribute for crops grown under rainfed conditions. Nigher (*Guizotia abyssinica* cass.) is a rainfed crop grown mostly by the marginal farmers on undulating lands. Crop yield fluctuates much with the different dates of sowing (AICORPO-NIGER - 1982-83). But all the genotypes of niger may not respond to such environmental conditions. Therefore, in the present study an attempt was made to collect information as to whether varieties of niger respond differentially when grown at different times and if they do so, how important these genotype - environment interactions are for yield and yield contributing characters.

MATERIALS AND METHODS:

The experimental material consisted of nine genotypes of niger (CHH - 1, CHH - 2, GA - 10), KEC - 1, IGP - 76, N - 71, ONS - 4, ONS- 8 and Gaudaguda - 1). In all, nine environemnts were created by sowing this material on three different dates and by applying three different doses of fertilizers in the year 1988 at Regional Agricultural Research Station, Chhindwara. The dates of sowing were 7th July 22nd, July and 6th August. Fertilizer doses were 0:0:0, 20:20:10 and 40:40:20 N:P:K: kg/ha respectively.

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The material was sown in the triple replicated Randomized Block Design in 2 m long rows spaced 30 cm apart with a plant to plant distance of 10 Cms. Observations were recorded on five randomly selected plants in each plot on seven characters i.e. days to 50% flowering; days to maturity; plant height (cm); number of branches/plant; number of capsules/plant; seed yield/plant (g) and 1,000-seed weight (g). Statistical analysis was done according to the method proposed by Eberhart and Russell (1966).

RESULTS AND DISCUSSION:

Results of analysis of variance (Table-1) revealed significant differences among the nine genotypes of niger for all the characters being investigated. Significant differences were also observed among the nine environments as revealed by significances of mean square for environments. Thus, creation of environments by manipulating dates and fertilizer doses was effective in generating variability in environments. Eberhart and Russell (1966) suggested that variation in envournments could be created by varying dates of planting, fertilizer levels and plant density etc,. There were significant differences among the *'bi'* values of nine genotypes as indicated significance of mean square for genotypes X environments (linear) for all the characters. This also suggested that variation in the performance of varieties when grown over environments could be predicted. Mean squares for pooled deviation were also significant for all the attributes, except 1,000 seed weight. Thus, the performance of varieties with respect to 1,000 - seed weight was entirely predictable in nature; while that of other was not.

The estimates of stability parameters are given in Table - 2 which indicate that none of the genotype was desirable for all the seven traits simulataneously. CHH - 1 was the only genotype found to be stable and desirable for seed yield per plant with its mean *at par* with over all mean; also unit regression and deviation from regression approaches zero. This variety was found stable for plant height and 1,000 - seed weight as well. Variety Gaudaguda - 1 and N- 71 yielded significantly higher than other cultivars but the presence of significant deviation from regression renders them unstable and hence undesirable. Variety ONS - 4 with lowest yield was found to be the most unstable and undesirable for all the traits except 1,000 -seed weight.

While considering environments, late sowing (6th August, 88 with 40:40:20 N:P:K Kg/ha) was observed to be the most suitable environment for realizing the yield potential (3.022 g/plant) of the genotypes as compared to other environments created by agronomic manipulations.

The significant correlation between $\bar{X}$ and bi for days to 50% flowering; days to maturity and number of capsules/plant, and between $\bar{X}$ and S^2d for days to maturity and number of capusules/plant suggested that simple use of mean values of these characters could be made to judge the stability of these genotypes. The lack of association between these parameters with respect to the other characters indicate involvement of different genertic systems in the control of these charaters. In view of this fact, genotypes exhibiting above average stability can be used in a breeding programme for crossing with an unstable but otherwise possesing high mean performance.

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TABLE 1:
Stability analysis for various characters of nigher (mean squares)

Sources of variance	df	Days of 50% flowering.	Days to maturity	Plant height (cm)	No. of braches/ plant.	No.of capitual/ plant.	1,000-seed weight (g)	Seed yield/ plant. (g)
Genotypes	8	850.47**	344.31**	258.43**	10.76**	776.13**	0.24**	0.33**
Environments	8	168.11**	218.35**	7251.94**	23.46**	616.55**	0.30**	3.01**
Genotypes x environments	64	16.23**	17.16**	69.21**	0.88**	36.28**	0.08**	0.11**
Envi. + (Genotype x env.)	72	33.11**	39.52**	867.36**	3.39**	100.76**	0.11*	0.43**
Environment (linear)	1	1341.30++	1745.73++	6837.53++	187.62++	4932.43++	2.41++	24.08++
Genotypes x environments (linear)	8	99.02++	95.40++	6461.96++	1.86++	78.48++	0.05	0.28++
Pooled deviation	63	3.98**	5.34**	62.17**	0.66**	26.89**	0.08**	0.08**
Pooled error	144	0.49	0.59	22.47	0.18	7.11	0.04	0.01

*P = 0.05 **P = 0.01 against pooled error +P = 0.05 ++P = 0.01 against pooled deviation

TABLE 2:
Estimates of stability parameters and correlation coefficients between them for various characters of niger.

Genotypes	Days to 50% flowering.			Days to maturity			Plant height (cm)			No.of branches/ Plant		
	$\bar{X}_i$	b_i	S^2d_i	$\bar{X}_i$	b_i	S^2d_i	$\bar{X}_i$	b_i	S^2d_i	$\bar{X}_i$	b_i	S^2d_i
CHH-1	70.15	0.88	1.50**	118.20	0.59**	01.71**	145.50	1.06	19.63	9.68	1.32	0.31**
CHH-2	71.30	0.91	0.13	118.36	0.72*	01.68**	152.28	0.94	54.79**	9.99	0.70	1.18**
GA-10	90.81	2.47**	7.13**	131.93	2.33**	14.21**	152.87	0.94	10.99	7.09	0.45	0.43**
KEC-1	68.38	0.51**	0.40	116.90	0.67*	01.53**	144.62	1.10	46.34 **	9.60	1.00	0.14
IGP-76	66.64	0.33**	3.87**	116.72	0.66**	01.55**	140.04	1.06	33.27**	8.74	1.18	0.12
N-71	68.48	0.42*	6.78**	117.52	0.67*	01.94**	149.33	1.10	7.65	9.21	1.33*	0.16
ONS-4	90.44	2.30**	7.01**	131.02	2.12**	17.16**	148.34	0.84	73.74	7.38	0.79	0.73**
ONS-8	67.30	0.47*	4.51**	117.27	0.62**	00.45	137.11	0.94	48.77**	8.93	0.99	0.72**
Gaudaguda-1	69.41	0.67**	0.01	117.60	0.55*	02.85**	149.82	0.98	62.08**	10.19	1.19	9.50**
Mean	73.660			120.616			146.666			8.983		
CD at 5%	1.38			1.60			5.44			0.56		
r ($\bar{x}$ and b)	0.992**			0.991**			-0.232			0.599		
r ($\bar{x}$ and S^2d_i)	0.594			0.982**			-0.085			0.027		
r (b and S^2d_i)	0.524			0.971**			-0.611			-0.542		

Estimates of stability parameters and correlation coefficients between them for various characters of niger.

Genotypes	No. of capitula/ Plant.			1,000-seed weight (g)			Seed yield/plant (g)		
	$\overline{X}_i$	b_i	S^2d_i	$\overline{X}_i$	b_i	S^2d_i	$\overline{X}_i$	b_i	S^2d_i
CHH-1	42.90	1.20	19.67**	3.64	0.52	-0.01	1.59	0.88	0.01
CHH-2	47.08	0.85	46.32**	3.57	0.77	-0.01	1.79	1.06	0.05**
GA-10	22.77	0.24**	-1.26	3.89	2.45	0.26**	1.48	0.79	0.07**
KEC-1	44.80	0.85	17.45**	3.78	0.40	0.08**	1.78	0.90	0.04**
IGP-76	38.94	1.28	23.08**	3.78	0.99	0.03	1.54	1.08	0.02**
N-71	42.62	1.33	11.68**	3.94	0.60	-0.01	1.83	0.98	0.04**
ONS-4	34.60	0.63	7.50*	4.11	1.59	0.01	1.31	0.39**	0.02**
ONS-8	40.53	1.30	10.73*	3.84	0.87	0.01	1.66	1.56	0.14**
Gaudaguda-1	46.52	1.27	42.74**	3.93	0.76	-0.02	1.92	1.31	0.17**
Mean	40.087			3.025			1.657		
CD at 5%	3.59			0.19			0.19		
r ($\overline{X}$ and b)	0.715*			0.428			0.663		
r ($\overline{X}$ and S^2d_i)	0.715*			0.100			0.457		
r (b and S^2d_i)	0.392			0.752*			0.710*		

*P = 0.05 **P = 0.01 (The significance of regression coefficient was tested from unity).

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EVALUATION OF MAIZE FOR OIL CONTENT

S.L.Godawat* and R.Dwivedi
Department of Genetics and Plant Breeding, **Rajasthan College** of Agriculture, Udaipur - 313 001 (Rajasthan)

ABSTRACT:

Fourten lines were identified for high general combining ability out of 52 lines studied in maize (*Zea mays* L.) for oil content as fourteen top crosses revealed significantly higher oil percentage than average oil content. Economic heterosis was calculated over check hybrids (Ganga - 5 and Deccan - 103) and composites (Vijay and Ageti - 76). The Economic hetrosis was found maximum 14.26% 7.21% 13.17% and 15.37% over Ganga - 5, Deccan - 103, Vijay and Ageti - 76, respectively. Top crosses 2279x2201, 2278x2201, 2289x2201, 2229 x 2201 and 2240x 2201 exhibited significant increase in oil percentage over all the 4 chech varities studied hence the lines 2279, 2278, 2289, 2229 and 2240 are suggested for oil improvement programme in maize.

Key words: *Zea mays* L.; oil content ; economic hetrosis ; general combining ability; top crosses.

INTRODUCTION

Corn oil is an important bi - product of starch industry. Most of the oil is present in the germ of seed (Earle *et al* ., 1946). Strains having high oil content have larger germ and reduced endosperm size (Jugenheimer, 1961). Industrial processors of corn have encouraged studies on oil content of maize as increase in the quantity of corn - oil could increase the value of grain. High oil strains of corn have higher biological value than low oil corn (Schneider *et al*., 1952). Greater awareness of the nutritional importance of poly - unsaturated fatty acids in the diet has resulted in increased public interest in the corn - oil, since it possesses a very high proportaion of the unsaturated fatty acids. In India practically no work has been done for exploiting the potentiality of maize as a source of edible oil. It has a great future as supplementary oil crop in addition to being a traditional cereal crop. There fore, in the present study an attempt has been made to isolate high oil strains (lines) having good general combining ability by evaluating 52 top crosses. Economic

*Present Address: Associate Professor, (Plant Breeding) Agricultural Research Station, Sumerpur - Pali - 306 902

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heterosis was also estimated over hybrids (Ganga-6 and Deccan - 103) and composites (Vijay and Ageti - 76).

MATERIALS AND METHODS

The experimental material for the present study comprised 52 top crosses derived by crossing 52 lines with single cross hybrid (2201) and four standard check varieties (Ganga - 5, Deccan - 103, Vijay and Ageti - 76) Which were planted in Randomized Block Design with four replications. Name and pedigree of material used for present investigation are given in Table - 1. Row length was 5 m with plant to plant and row to row distances were maintained 22 cm and 75 cm respectively. One random sample of 5 gram seeds from each repliction for each treatment was grinded and powder was used for oil estimation by the Soxhlet extraction method using petroleum ether (BP 40-60°C). Economic heterosis was calculated over the best hybrids (Ganga - 5 and Deccan - 103) and composites (Vijay and Agete - 76) as per usual formula given below:

$$\text{Economic hetrosis} = \frac{F_1 - SV}{SV} \times 100$$

Where,

$\overline{F1}$ = Average performance of top cross
$\overline{SV}$ = Mean of check variety/ Standard variety.

RESULT AND DISCUSSION

The mean and economic heterosis of 52 top crosses for oil content are presented in Table 1. A perusal of data indicated that oil content varied from 3.71% (2281 X 2201) to 7.13% (2279 X 2201) with an average of 5.56%. Poneleit and Bauman (1970) also reported 2.6 to 7.3% oil content in their study of diallel analysis of fatty acids in corn - oil. Out of 52 crosses studied in the present investigation 14 crosses . Viz., 2279 x 2201 (7.13%), 2228 x 2201 (6.94%), 2289 x 2201 (6.86%), 2240 x 2201 (6.84%), 2229 x 2201 (6.65%), 2280 x 2201 (6.40%), 2283 x 2201 (6.38%), 2233 x 2201 (6.38%), 2275 x 2201 (6.36%), 2231 x 2201 (6.34%), 2235 x 2201 (6.33%), 2208 x 2201 (6.28%), 2288 x 2201 (6.25%) and 2261 x 2201 (6.22%) showed significant higher oil percentage than average of fifty two top crosses, suggested that the lines 2279, 2278, 2289, 2240, 2229, 2280, 2283, 2233, 2275, 2231, 2235, 2208, 2288 and 2261 showed high general combining ability for oil content, therefore, showed their utility for oil improvement progamme in maize.

The range of economic heterosis was observed from -, -40.54 to 14.26% (over Ganga-5) - 44.22 to 7.21% (over Deccan - 103), - 41.12 to 13.17% (over Vijay) and -39.97 to 15.37% (over Ageti - 76). The useful heterosis over Ganga - 5 was found maximum in 2279 x 2201 (14.26%) followed by 2278 x 2201 (11.21 %) and 2289 x 2201 (9.93%). Significant increase of 7.21% was recorded in 2279 X 2201 over Deccan 103. High manifestation of 13.17% economic heterosis over Vijay was shown by 2279 x 2201, increase of 15.37%, 12.29% and 11.00% in oil was found in 2279 x 2201, 2278 x 2201 and 2289 x 2201 respectively over Ageti - 76. Top cross 2281 x 2201 exhibited the highest negative economic heterosis followed by 2268 x 2201 over all the four check varieties as their oil content are lowest in comparison to other crosses. In general top crosses 2279 x 2201, 2278 x 2201, 2289 x 2201, 2229 x 2201, and 2240 x 2201 showed remarkable increase in oil content over best hybrids and composites studied. Therefore, the lines 2279, 2278, 2289, 2229, and 2240 appear to be the most promising ones for oil breeding programme in maize.

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Table 1.
Name and pedigree of material used for the present investigation

S.No.	Entries	Pedigree
1.	2203 x 2201	Sarhad (W) x (CM 400 x CM 300)
2.	2204 x 2201	Waxy hybrid Phillipin x (CM 400 x CM 300)
3.	2208 x 2201	(AC 7643-425-3-1-1-Q-H)X " "
4.	2226 x 2201	Trop Whitedent QPM (HO)C-12-3 X (CM 400 X **CM 300**)
5.	2227 x 2201	" 4 x "
6.	2228 x 2201	" 5 x "
7.	2229 x 2201	" 6 x "
8.	2231 x 2201	" 8 x "
9.	2233 x 2201	" 10 x "
10.	2234 x 2201	**Trop whitedent QPM (HO)C-12-11 x (CM 400 x CM 300)**
11.	2235 x 2201	" 12 x "
12.	2236 x 2201	" 13 x "
13.	2237 x 2201	" 14 x "
14.	2238 x 2201	" 15 x "

(Contd.)

Table 1 Contd.

S.No.	Entries	Pedigree		
15.	2239 x 2201	"	16 x	"
16.	2240 x 2201	"	17 x	"
17.	2241 x 2201	"	18 x	"
18.	2243 x 2201	"	20 x	"
19.	Ganga - 5	(CM 202 x CM 111)x CM 500		
20.	2255 x 2201	Trop whitedent QPM(HO)C-12-32x	(CM 400 X CM 300)	
21.	2256 X 2201	"	33 x	"
22.	2259 x 2201	"	36 x	"
23.	2261 x 2201	"	38 x	"
24.	2265 x 2201	"	42 x	"
25.	2266 x 2201	Poll 16 TEWD	1 x	"
26.	2267 x 2201	"	2 x	"
27.	2268 x 2201	"	3 x	"
28.	2269 x 2201	"	4 x	"
29.	Vijay J1			
30.	2270 x 2201	Poll 16 TEWD	5x (CM 400 x CM 300)	
31.	2271 x 2201	"	6 x	"
32.	2272 x 2201	"	7 x	"
33.	2273 x 2201	"	8 x	"
34.	2274 x 2201	"	9 x	"
35.	2275 x 2201	"	10 x	"
36.	2277 x 2201	"	12 x	"
37.	2278 x 2201	"	13 x	"
38.	2279 x 2201	"	14 x	"
39.	Single Cross	CM 400 x CM 300		
40.	2280 x 2201	Poll 16 TEWD	15 x (CM 400 x CM 300)	
41.	2281 x 2201	"	16 x	"
42.	2282 x 2201	"	17 x	"
43.	2283 x 2201	"	18 x	"
44.	2284 x 2201	"	19 x	"
45.	2285 x 2201	"	20 x	"
46.	2286 x 2201	"	21 x	"
47.	2287 x 2201	"	22 x	"
48.	Ageti - 76	Twenty two elite inbred lines selected from Vijay and few other varieties		
49.	2288 x 2201	Poll 16 TEWD	23 x (CM 400 x CM 300)	
50.	2289 x 2201	"	24 x	"
51	2290 x 2201	"	25 x	"
52.	2291 x 2201	"	26 x	"
53.	2292 x 2201	"	27 x	"
54.	2293 x 2201	"	28 x	"
55.	2294 x 2201	"	29 x	"
56.	2295 x 2201	"	30 x	"
57.	Deccan 103	(CM 120 x CM 118)	(CM 208 x CM 119)	

Table.2.
Economic heterosis and oil content (%) of different top crosses in maize.

Top Crosses	Oil Content (%)	Percent increase over Ganga - 5	Deccan - 103	Vijay	Ageti - 76
2203 x 2201	6.06	-3.04**	-9.02**	-3.96**	-2.11**
2204 x 2201	5.43	-13.14**	-18.50**	-13.96**	-12.30**
2208 x 2201	6.28	0.64**	-5.56**	-0.31**	-1.61**
2226 x 2201	4.66	-25.16**	-29.78**	-25.87**	-24.44**
2227 x 2201	5.47	-12.33**	-17.75**	-13.17**	-11.49**
2228 x 2201	4.14	-33.65**	-37.75**	-34.28**	-33.01**
2229 x 2201	6.65	6.57**	0.00	5.55**	7.60**
2231 x 2201	6.34	1.60**	4.66**	0.63**	2.58**
2233 x 2201	6.39	2.24**	-4.06**	1.26**	3.23**
2234 x 2201	5.67	-9.13**	-14.74**	-10.01**	-8.26**
2235 x 2201	6.34	1.44**	-4.81**	0.47**	2.42**
2236 x 2201	5.78	-7.37**	-13.01**	-8.36**	-6.48**
2237 x 2201	5.71	-8.49**	-14.14**	-9.37**	-7.61**
2238 x 2201	4.56	-26.92**	-31.43**	-27.62**	-26.22**
2239 x 2201	5.67	-9.13**	-14.74**	-10.01**	-8.26**
2240 x 2201	6.84	9.61**	2.85**	8.57**	10.67**
2241 x 2201	4.94	-20.67**	-25.57**	-21.43**	-19.91**
2243 x 2201	6.01	-3.68**	- 9.63**	-4.61**	-2.76**
2255 x 2201	6.06	-2.88**	-8.82**	-3.81**	-1.95**
2256 x 2201	5.11	-18.10**	-23.16**	-18.89**	-17.32**
2259 x 2201	5.72	-8.33**	-13.99**	-9.21**	-7.45**
2261 x 2201	6.22	-0.32	-6.46**	-1.27**	0.64**
2265 x 2201	5.11	-18.10**	-23.16**	-18.89**	-17.32**
2266 x 2201	6.14	-1.60**	-7.66**	-2.54**	-0.64**
2267 x 2201	5.36	- 14.10**	-19.40**	-14.93**	-13.27**
2268 x 2201	3.74	-40.22**	-43.91**	-40.80**	-39.65**
2269 x 2201	5.10	-18.26**	-23.31**	-19.05**	-17.48**
2270 x 2201	5.37	-13.94**	-19.25**	-14.77*	-13.11**
2271 x 2201	4.46	-28.52**	-32.94**	-29.21**	-27.84**
2272 x 2201	5.82	-6.73**	-12.49**	-7.62**	-5.83**
2273 x 2201	4.69	-24.83**	-29.40**	-25.56**	-24.12**
2274 x 2201	5.96	-4.48**	-10.38**	-5.40**	-3.56**
2275 x 2201	6.36	1.92**	-4.36**	0.95**	2.91**
2277 x 2201	5.62	-10.09**	-15.64**	-10.96**	-9.21**
2278 x 2201	6.94	11.21**	4.36**	10.15**	12.29**
2279 x 2201	7.13	14.26**	7.21**	13.17**	15.37**
2280 x 2201	6.40	2.56**	-3.75**	1.58**	3.55**

(Contd)

Table 2 Contd.

Top Crosses	Oil Content (%)	Percent increase over Ganga - 5	Deccan - 103	Vijay	Ageti - 76
2281 x 2201	3.71	-40.54**	-44.22**	-41.12**	-39.97**
2282 x 2201	4.32	-30.76**	-35.04**	-31.43**	-30.10**
2283 x 2201	6.38	2.24**	-4.06**	1.26**	3.23**
2284 x 2201	5.06	-18.91**	-23.91**	-19.69**	-18.13**
2285 x 2201	6.07	-2.72**	-8.73**	-3.66**	-1.78**
2286 x 2201	4.78	-23.23**	-27.47**	-23.97**	-22.50**
2287 x 22.1	4.19	-32.85**	-37.00**	-33.50**	-32.21**
2288 x 2201	6.25	-0.16	-6.01**	-0.80**	1.13**
2289 x 2201	6.86	9.93**	3.15**	8.88**	11.00**
2290 x 2201	6.18	-0.96**	-7.07**	-1.91**	0.00**
2291 x 2201	5.76	-7.69**	-13.39**	-8.58**	6.80**
2292 x 2201	5.33	-14.58**	-19.85**	-15.40**	-13.76**
2293 x 2201	4.44	-28.84**	-33.24**	-29.53**	-28.16**
2294 x 2201	5.35	-14.26**	-19.55**	-15.08**	-13.44**
2295 x 2201	4.42	-29.16**	-33.54**	-29.85**	-28.48**
Average	5.56	Mean oil	Mean oil	Mean oil	Mean oil
Range	3.71-7.13	Content in Ganga - 5	Content in Deccan - 103	Content n Vijay	Content in Ageti -76
S.Em ±	0.12	=	=	=	=
C.D.at 5%	0.34	6.24(%)	6.65(%)	6.30(%)	6.18(%)
C.V.		4.24			

* Significant at 5 per cent level
** Significant at 1 per cent level

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EFFECT OF WEED CONTROL IN GROUNDNUT AND SUNFLOWER INTERCROPPING SYSTEM WITH REFERENCE TO NUTRIENT UPTAKE AND OIL YIELD*

G.K.GIRIJESH AND V.C.PATIL
Department of Agronomy, University of Agricultural Sciences,
Dharwad - 580 005.(India)

ABSTRACT

A field experiment was conducted at Agricultural College Farm, Dharwad to determine the effect of herbicides (Pendimethalin and Fluazifop - bhutyl) applied alone, mixed or in combination with physical methods and weedy check on the uptake of nutrients by crops and associated weeds and on oil yield. The weeds when allowed to complete till harvest depleted 84.31 Kg N, 21 Kg P_2O_5 and 31.39 K_2O per hectare. Weed control treatments resulted in higher total oil yield. The increase in total oil yield due to weed control treatments was to the extent of 20.75 to 55.37 per cent.

Key Words: Groundnut, Sunflower, Nutrient uptake, oil content, herbicides.

INTRODUCTION

Control of weeds is vitally important not only to check the loss caused by them, but also to increase the efficeincy of the applied fertilizers. Higher concentration of plant nutrients in the weed tissues than those in common plants has been reported by several workers (Shankaran and Mani, 1972 and Mukhopadhya, 1974.) Nutrient availability to crop can be increased by controlling the weeds (Yadav *et al.*,1986). The present investigation was therefore, carriedout to asses the losses caused by weeds and the extent to which these losses would be avoided by chemical and mechanical methods of weed control and to see the effect on oil yield per ha.

MATERIALS AND METHODS

A field experiment was conducted under rainfed condition during the *kharif* season of 1987 at the Agricultural college Farm, Dharwad. The experiment was laid out in randomized block design with 4 replications comprising of the following ten treatments:

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T_1 Unweeded check

T_2 Pendimethalin (Pre-em) @ 1.o Kg a.i. per ha.

T_3 Fluazifop - butyl (Pre-em)@ 0.25 Kg a.i. per ha.

T_4 Pendimethalin (Pre-em) @ 0.5 Kg a.i. per ha+ Fluazifop - buty 1(post-em) @ 0.125 Kg a.i.per ha.

T_5 Pendimethalin (Pre-em) @ 0.5 Kg a.i. per ha + Intercultivation at 21 DAS (Days after sowing)

T_6 PEndimethalin (Pre-em)@ 0.75 Kg a.i per ha + Intercultivation at 21 DAS.

T_7 Fluazifop - butyl (Post-em) @ 0.125 Kg a.i. per ha + hand weeding at 45 DAS.

T_8 Fluazifop-butyl (Post-em) @0.187 Kg a.i. per ha+ hand weeding at 45 DAS.

T_9 Intercultivation (25 DAS) + hand weeding (45 DAS).

T_{10} Hand weeding at 15, 30 and 45 DAS.

The soil was black clay with medium total nitrogen (0.053%) and available potassium (0.0247%), but low in available phosphorus (0.003%). The groundnut (var.Dh-3-30) and sunflower (BSH-1) seeds were sown in rows spaced at 30 cm in 3:1 row proportion. A common dose of fertilizers was applied to groudnut (25:50:25 Kg $N:P_2O_5:K_2O$ per ha) and sunflower (37.5:50:37.5 Kg $N:P_2O_5:K_2O$ per ha).

The total nitrogen in the composite sample was estimated by modified Keldahl's method (Jackson, 1967) and expressed in percentage on dry matter basis. Nitrogen percentage and total dry weight were used to calculate the total uptake of nitrogen at harvest and was expressed in Kg per ha.

Phosphorus content in plant samples was determined by Vanedomolydate phosphoric Yellow colour method using spectrophotometer at 470 n m as described by Jackson (1967). Using the phosphorus content, total uptake of phosphorus at harvest was calculated and expressed in Kg per ha. Potassium content in the plant sample was determined by Flame photometer method (Muhr *et al.*, 1965). Based on the content of the plant the total uptake of potassium at harvest was computed and expressed in Kg per hectrare.

Oil yield per hactare was worked out on the basis of seed oil content and seed yield. The estimation of oil content was done by Nuclear Magnetic Resonance (NMR) spectrometer (Bruker Minispe P^{20} models, against a standard reference).

RESULTS AND DISCUSSIONS

Nutrient removal by weeds

The removal of nitrogen, phosphorus and potassium by weeds was maximum (Table 1) in unweeded check. Removal of 84.31 Kg N, 21 Kg P_2O_5 and 31.39 Kg K_2O per ha by weeds was noticed in unweeded check as against lowest of 16.80 Kg N per ha in Pendimethalin (0.75 Kg/ha) + IC and 5.11 Kg P_2O_5 and 2.64 Kg K_2O per ha in hand weeded plot. Unweeded check was significantly superior to all others in the nutrients removed by weeds. In general, the nutrients removed by weeds in unweeded check, pendimethalin (1 Kg/ha) and fluazifop - butyl (0.25 kg/ha) treatments increased due to weed biomass (Table 2). The treatments which consisted both chemical and cultural methods reduced the uptake of nutrients by weeds significantly due to decreased weed growth.

Nutrient uptake by groundnut

All the weed control treatments registered a significant improvement in the uptake of nutrients by groundnut crop as compared to (Table 1) weedy check. The uptake of nitrogen by groundnut in fluazifop - butyl (0.187 Kg/ha) + HW was highest (76.38 Kg per ha) followed by pendimethalin (0.75 Kg/ha) + IC and hand weeding. The treatment fluzifop - buty1 (0.187 Kg/ha) + HW recorded 35.62 Kg more N per ha than the weedy check. The maximum phosphorus (22.4 Kg/ha) and potassium (80.35 Kg/ha) uptake by goundnut crop was noticed in hand weeding and was 16.14 Kg P_2O_5 and 53.59 Kg K_2O per ha more than in unweeded check. Minimum uptake of N, P and K by groundnut was noticed in unweeded check (Table 1). All the weed control treatments registered a significant improvement in the uptake of nutrients by groundnut crop as compared to weedy check.

Nutrient uptake by Sunflower

All the weed control treatments were superior to unweeded check with respect to nutrient uptake by sunflower crop. Uptake of nutrients by the crop was inversely proportional to the uptake of nutrients by weeds. Hand weeding (53.10 Kg/ha), Pemdimethalin (0.75 Kg/ha) + IC (52.84 Kg/ha), intercultivation + hand weeding (51.86 kg/ha) fluazifop-buty1 (0.187 Kg/ha) + HW (50.90Kg/ha) and pendimethalin (0.5 Kg/ha) + fluzifop - buty1 (0.125 Kg/ha) (49.12q/ha) resulted in higher nitrogen uptake compared to others. Highest phosphorus uptake was noticed in pendimethalin (0.75 Kg/ha) + IC (12.04 kg/ha), closely followed by hand weeding (11.62 Kg/ha) and fluazifop-buty1 (0.187 Kg/ha) + HW (11.41 Kg/ha). Similar trend was also noticed with respect to potassium uptake (Table 1). Highest uptake in these treatments was due to lower weed weight which facilitated the crop to grow well and take up higher amount of nutrients. Kulandaivelu *et al.* (1974) also noticed removal of higher amount of nutrients by safflower crop in the weed control treatments as compared to unweeded check. The data suggested that the weed control methods could give up to 84.31 Kg N, 21.0 Kg P_2O_5 and 31.39 Kg K_2O per ha.

Table 1

Effect of different treatments on nutrient removal (kg/ha) by weeds, groundnut and sunflower at harvest in groundnut and sunflower intercropping system.

Treatments	Weeds			Groundnut			Sunflower		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
1. Unweeded check	84.31	21.00	31.39	40.76	6.26	26.76	33.55	7.28	50.60
2. Pendimethalin @ 1.0 kg a.i. per ha	26.42	6.95	15.26	65.05	16.75	67.71	44.84	9.16	69.40
3. Fluazifop-butyl @ 0.25 kg a.i. per ha	27.76	6.72	14.46	66.28	16.88	68.31	43.35	10.68	73.60
4. Pendimethalin @ 0.5 kg a.i. per ha + fluazifop-butyl @ 0.125 kg a.i. per ha.	19.90	6.46	4.05	71.86	18.73	75.95	49.12	11.03	72.96
5. Pendimethalin @ 0.5 kg a.i. per ha + Intercultivation at 21 DAS (IC)	19.11	6.61	4.21	72.71	20.12	79.02	45.85	11.42	74.23
6. Pendimethalin @ 0.75 kg a.i. per ha+Intercultivation at 21 DAS (IC)	16.80	5.40	4.11	74.49	21.75	80.12	52.84	12.04	79.96
7. Fluazifop-butyl @ 0.125 kg a.i. per ha + hand weeding at 45 DAS (HW)	24.20	6.35	5.05	71.13	18.78	76.70	44.86	11.22	71.91
8. Fluazifop-butyl @ 0.187 kg a.i. per ha + hand weeding at 45 DAS (HW)	20.26	5.16	4.95	76.38	21.50	78.55	50.90	11.44	77.31
9. Intercultivation (21 DAS) + hand weeding (45 DAS)	18.92	7.26	5.66	72.48	18.71	79.45	51.86	11.18	72.98
10. Hand weeding at 15, 30 and 45 DAS	17.54	5.11	2.64	76.08	22.40	80.35	53.10	11.62	77.95
S.Em ±	1.41	1.00	1.28	4.82	0.89	2.79	1.01	0.86	2.43
C.D. at 5%	4.10	2.90	3.71	13.98	2.39	8.09	2.94	2.50	7.05

DAS = Days after sowing.
IC = Intercultivation
HW = Hand Weeding

Influence on oil content and oil yield

The data on oil content (%) in groundnut seeds (Table 2) indicated that there were no significant differences among the treatments. However, the highest oil content *was observed in hand weeding (48.20%) followed by pendimethalin (0.75 Kg/ha) + IC* (47.95%). Dhindsa *et al.* (1974) obtained increased oil content with chemical weed content by lasso application.

Oil content in sunflower seeds was also influenced significantly by weed control treatment (Table 2). The highest oil content was recorded in hand weeding (40.38%) which was comparable with 39.10, 38.98, 38.80 and 38.38 per cent in case of pendimethalin (1 Kg/ha), pendimethalin (0.75 kg/ha) + IC, pendimethalin (0.5 kg/ha), + IC and fluazifop - buty 1 (0.187 Kg/ha) + HW, respectively. Raju and Shankaran (1974) also observed higher oil content in crop seeds in weed control treatments.

Oil yield of groundnut was significantly influenced by weed control treatments. The highest yield of 9.36 q/ha was obtained from the plot which received pendimethalin (0.75 Kg/ha) + IC (Table 2). Oil Yields of 9.26 and 9.16 q per ha were obtained from the plots which received hand weeding thrice and fluazifop - butyl (0.187 Kg/ha) + HW respectively which were on par with pendimethalin (0.75 Kg/ha) + IC. Highest oil yields in these treatments were attributed to higher kernel yield and oil content.

The oil yields of sunflower recorded in hand weeding (5.84 q/ha), pendimethalin (0.75 kg/ha) + IC (5.14 q/ha) and fluazifop - butyl (0.187kg/ha) + HW (5.09) were on par with each other and significantly higher than in unweeded check (3.20 q/ha) (Table 2). Weed control treatments resulted in higher oil yield. The increase in total oil yield due to weed control treatments was to the extent of 20.75 to 53.37 per cent.

The highest total oil yield was obtained from the hand weeded treatment (14.9 q/ha) which was significantly higher than in other treatments except in pendimethalin (0.75 Kg/ha) + IC (14.50 q/ha), Fluazifop - butyl (0.187 Kg/ha) + HW (14.25 q/ha), Pendimethalin (0.5 Kg/ha) + fluazifop - butyl (0.125 Kg/ha) (13.07 q/ha) and intercultivation + hand weeding (13.14 q/ha) (Table 2). Unweeded check recorded significantly lower oil yield (9.57 q/ha) as compared to all other treatments, except pendimethalin (1.0 Kg/ha) and fluazifop - buty1 (0.25 Kg/ha).

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Table 2:
Weed dry weight, oil content and oil yield of groundnut and sunflower and total oil yield as influenced by weed control treatments.

Sl. No.	Treatment	Weed dry wt. (q/ha)	Oil Content of Groundnut (%)	Oil yield of Groundnut (q/ha)	Oil Content of sunflower (%)	Oil Yield of sunflower (q/ha)	Total Oil yield (q/ha)
1.	Unweeded check	28.55	45.68	6.39	37.10	3.20	9.59
2.	Pendimethalin @ 1.0 kg a.i. per ha	16.77	46.98	7.77	39.10	3.75	11.52
3.	Fluazifop-butyl @ 0.25 kg a.i. per ha	19.24	46.20	7.70	36.78	3.95	11.66
4.	Pendimethalin @ 0.5 kg a.i. per ha + Fluazifop-butyl @ 0.125 kg a.i. per ha.	5.84	47.36	8.71	38.22	5.36	13.07
5.	Pendimethalin @ 0.5 kg a.i. per ha + Intercultivation at 21 DAS (IC)	6.06	47.20	7.96	38.80	4.19	12.15
6.	Pendimethalin @ 0.75 kg a.i. per ha + Intercultivation at 21 DAS (IC)	3.71	47.95	9.36	38.98	5.14	14.56
7.	Fluazifop-butyl @ 0.125 kg a.i. per ha + hand weeding at 45 DAS (HW)	6.95	47.15	7.71	38.22	4.42	12.13
8.	Fluazifop-butyl @ 0.187 kg a.i. per ha + one hand weeding at 45 DAS (HW)	5.55	47.62	9.16	38.38	5.09	14.25
9.	Intercultivation (21 DAS) + hand weeding (45 DAS)	7.36	46.98	8.65	37.38	4.39	13.14
10.	Hand weeding at 15, 30 and 45 DAS	3.78	8.20	9.26	40.38	6.84	14.90
	S.Em ±	2.88	0.71	0.45	0.61	0.63	0.81
	C.D. at 5%	8.35	NS	1.36	1.77	1.83	2.23

DAS = Days after sowing.
N.S. = Not significant

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Short Communication

DE-OILED SOYFLOUR TO SUPPLEMENT FOOD AND FEED REQUIREMENT

P.S.BHATNAGAR
National Research Centre for Soybean, Khandwa Road
Indore 452 001 (M.P.)

Consequent upon the launching of All India Coordinated Research Project on Soybean (ICAR) in 1967, spread of soybean to the present levels of about 20 Lakh ha in 1989, has been encouraging. However, the processing capacity in the country has inceased to about 30 lakh tonnes per year. The bulk of soybean goes for oil extraction and the deoiled soyflour which is an excellent high quality protein food is exported. Such a protein drain from a developing country which needs both protein and calory for its ever growing population is indeed paradoxical

De-oiled soyflour - a by - product of the soybean oil industry is a high quality protein concentrate (55.58% protein). A perusal of Table 1 establishes the nutritional value of *defatted soyflour as human food or cattle feed.*

Table 1
Chemical properties of wheat flour, animal protein (Egg and Milk) and soyflour

Sample	Moisture (%)	Fat (%)	Protein* (%)
Wheat flour	13.82	2.8	9.89
Egg powder	5.78	39.55	50.98
Non - fat dry milk	7.19	2.6	35.97
Full - fat soyflour	6.37	19.0	45.20
Defatted soyflour	7.10	0.8	56.79

*Protein content is N x 6.25, except N x 5.7 for wheat flour [Source : Beslagic (1981) and Chauhan (1982)]

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De - oiled soyflour is light yellow in colour and is produced by grinding deoiled flakes to the particles of desired size. With little care and hygienical conditions during and after soybean processing, this valuable by-product can be utilized in a number of ways for augmenting the availability of food on one hand and increasing the nutritional quality in terms of high quality protein content on the other.

In foreign countries, de-oiled soyflour is being extensively used for the production of extrusion products and meat analogues. In India as well, these texturised soyprotein products are being manufactured and are marketed under various names like 'Nutri Nuggetts', 'Nutralla' or 'Proteisnack', 'Meal Maker', 'Vital Feast', etc. However, these products, although manufactured from the cheapest source of high quality protein are sold at high price and as such are beyond the reach of common Indian.

For making this high protein food available mainly for poor, low cost product process development studies conducted at Pantnagar, Jabalpur, Bangalore and elsewhere have revealed that defatted soyflour can be directly used for the fortification of wheat flour upto 10%. Thus, besides improving the protein content of the wheat flour, it would also increase the available food by 10% i.e the availability of wheat flour can be increased by about 1.0 million tonnes. Chapaties prepared from such flour will contain 4.0% more protein.

In addition, there could be several other ways of its utilization.

a) It may be used in place of horse gram flour for preparation of variety of products at domestic and commercial level. As defatted soyflour does not contain starch, addition of horse gram flour upto 25% or any other low priced starch is recommended to improve its binding quality. This would have considerable ecnomic impact because defatted soyflour is by far cheaper than 'besan'.

b) Defatted soyflour can also be used for the production of 'Energy Food - 'Sattu' for the feeding programme.

c) It can replace black gram in 'idli', 'vada', 'dosa', and 'Uthappam' upto 50 - 70 % which will make the product much cheaper.

d) It can be used in a variety of ways for the production of bakery food. Correctly 'toasted' defatted soyflour can be mixed with wheat flour for making bread with excellent texture and high protein content. Soyflour to be used in bread production should be sufficiently heat treated to destroy enzyme activity and to improve flavour but not to the extent which may impair baking quality. The flour having PDI of 50 to 75 is suitable for use in bread making. For standardized bakery items like bread and buns, defatted soyflour can be used upto 3%. It increases water absorption power by 1 litre additional water for each kg of soyflour, improves crumb body and resiliance, improves crust colour (from sugar) and improves toasting characteristics (Dubois and Hoover, 1981).

e) Defatted soyflour can be used (3-6%) in cakes where water absorption and film forming characteristics are desired. This would result in formation of smoother batter having more even distribution of air cells and ultimately a cake with more even texture, softer and tender crumb can be made.

f) Defatted soyflour when used in the range of 2-4% for mixing with wheat flour, reportedly improves the quality of products like doughnut, buns etc. Soya protein functions as a structure builder producing a product with an excellent star formation. Fat absorption during frying is reduced which improves texture and eating properties. The increased absorption and moisture retention increases yield and shelf life (Dubois and Hoover, 1981).

g) Likewise, when mixed with wheat flour for the production of biscuits and cookies, the crispness increases in addition to the high quality.

h) Defatted soyflour has been used as an excellent economical functional and nutritional replacement for non-fat dried milk for production of various products.

i) Technology has also been standardized for the manufacture of soya milk from defatted soyflour or soya flakes. Soya milk could be used as low cost beverge or can be used for the production of various products like soyoghurt (Curds) or soypaneer (Tofu) etc.

j) With considerable economic and nutritional benefits it can be used as primary ingredient of dry breakfast cereal or as meat extender. It can be used in the same way as 'okara' (residue left after making soymilk) recommended to be used by Shurtleff and A. Aoyagi, 1980

Thus, this high protein by-product - the defatted soyflour of soy-oil industry can be used in a variety of ways as additional source of low cost high protein food. Since, it can replace high priced bengalgram flour and black gram (urad) being used in a large number of conventional dishes of all the regions of the country, deoiled soyflour can bring down the consumer price on the one hand and on the other increase the nutritional quality of food like chapati, savouries, bakery products, noodles, macaroni, beverages etc.

Use of de-oiled soyflour as nutritious feed of livestock, piggery and poultry is undisputed (Reid 1981 and Waldroup, 1981). While the food applications of defatted soyflour in Indian diet has been suggested (Mittal, 1986), the high protein defatted soyflour is presently being exported to feed animal population of foreign countries. The argument of earning foreign exchange to support the export is on a weak footing since the flour is being largely exported to soft currency countries.

In India, it is not being used on the pretext that the cost of the feed would increase. Nevertheless, looking to the higher protein content than nay other oil cake used in cattle feed, smaller quantities of defatted soyflour would be needed to attain the same percentage of protein in the cattle feed and thus its use should be economical than other oil cakes.

Sometimes, it is stated that insect larvae develop quickly in the de-oiled soyflour resulting in low shelf life. However, there is no difference in the keeping quality of other flours like 'maida', 'suji', and 'besan'. Development of insect larvae can be efficiently prevented by use of the machine 'Entolator' widely used with all flour making industries in developed countries for pulverizing the flour to destoy the insect eggs.

In India, one of the basic requirement is the availability of edible grade soymeal. Soybean solvent extraction plants presently use hexane as solvent to extract oil. Generally, there is no control on quality of beans and the hygienic conditions in the plant. Quality of meal, its residual hexane content, microbial load, degree of protein denaturation etc. should be established through research and development efforts by Government and/or autonomous organizations in order to recommend and implement the use of defatted soyflour for fortification of wheat flour and for other edible purposes.

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A NEW LEAF SPOT OF SAFFLOWER CAUSED BY *ALTERNARIA HELIANTHI* (HANSF.) TIBAKI AND NISHIHARA

M.S. Patil, K.H. Anahosur, Mahesh K. Patil and K.G. Parameshwarappa
Agricultural Research Station,
University of Agricultural Sciences, Annigeri, and U.A.S., Dharwad, Karnataka.

A leaf spot of safflower (*Carthamus tinctorius* L.) caused by *Alternaria helianthi* (Hansf.) Tubaki and Nishihara was noticed in a severe form in and around the Annigeri Farm during Rabi 1987-88. During November and December, the weather conditions were so congenial that the disease appeared in a epiphytotic form. The relative humidity was more than 87 per cent and daily temperature ranged between 28.5 and 30.0°C. Cloudy weather, rains and drizzling due to cyclonic depression favoured the disease out break.

Symptoms were noticed on leaves, stems and also on capitula. Lower most leaves exhibited symptoms first and were characterised by development of dark-brown circular spots. The center of the spot was grey-white in colour, surrounded by brown margin with concentric rings. Initially the spots were small and gradually increased in size. Fully developed spots eventually develop shot holes and in severe cases irregular cracking of leaf occured. Finally leaves were blighted and browning appeared (Fig. 1). The symptoms were also noticed on seedlings but only on leaves. As the disease advanced, spots appeared on stem and capitullum. In severe cases, seeds also got infected. Although plants were susceptible at all stages of growth, severity was more in the later stages i.e., at 55 to 60 days.

The isolation from surface sterilized diseased spots on potato dextrose agar medium yielded a pure culture, sporulation on PDA was observed and the spores formed were similar to those produced naturally on the host. Conidia were cylindrical to long, ellipsoid, rounded at both ends, without beaks, pale grey-yellow to pale brown coloured with 1 to 11 transverse septa and 1 to 2 longitudinal septa (Fig. 2). They were constricted at the septa and were not produced in chains. On the basis of morphological characters of spores and cross inoculation studies, the fungus was identified as *Alternaria helianthi* (Anahosur *et al.*, 1978).

The pathogenicity of the fungus and cross-inoculation studies on sunflower and safflower were carried out by spraying two weeks old culture spore suspension on healthy plants.

On safflower typical symptoms appeared on leaves as dark brown circular spots,the center of the spot was greyish-white in colour with concentric rings. Fully developed spot developed shot holes. On sunflower typical symptoms appeared on leaves as dark, necrotic lesions. Spots were irregular witha grey centre and surrounded by a dark margin. Reisola-

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tions yielded the original fungus. Allen *et al* (1983) reported that *Alternaria helianthi* caused sever infections to safflower under laboratory inoculations. However, the incidence of this fungus was not recorded under field conditions so far on safflower in India and in the world. The disease has been increasing because of cultivation of sunflower throughout the year.

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ESTIMATION OF OIL AND YIELD IN SOME EXOTIC SUNFLOWER LINES

S.Mandal and T.A.Thomas,Germplasm Evalution Divison,
National Bureau of Plant Genetic Resources., Pusa Campus,
New Delhi - 110 012.

Sunflower (*Helianthus annus* L.) has been identified as potential oil crop for boositng our oilseed production, particularly in the peninsular belt. The National Bureau of Plant Generic Resources is hence engaged in introducing wide variability of sunflower from different sunflower growing countries in the world and screen first in quarantine nursery and evaluate them for their agronomic and also quality parameters, so that the breeders can utilize the potential germplasm in the improvement programme. Sixty five sunflower collections received from Egypt (52), Hungary (11), Romania (1) and U.S.A (1) were grown during *Kharif* 1987 at the Post Entry Quarantine Nursery of N.B.P.G.R. at Pusa Campus, New Delhi. Oil content, seed yield per plant and 100 seed weight of the above sixty five lines were recorded on the basis of observations on 3 plants. From the freshly harvested seeds, some lines were again raised during *Rabi* (1987 - 88) at the Issapur Farm of the N.B.P.G.R. oil content of the seeds was again determined for comparative study.

Oil content of the filled seeds at 5 percent moisture level of each line was measured using New port NMR analyser Model 4000, at the AF (Audio Frequency) gain of 400, RF (Radio Frequency) current of 225μa and gate width of 1.5 gauss.

The head size varied from small to medium and large, seed yield varied from 5.0 to 76.7g per plant, and 100 seed weight varied from 2.08 to 7.4 g Oil content of the lines varied from 27.12 percent to 47.64 percent,40 percent being the mean value. Among them seventeen lines were found to have an oil content of more than 43 percent. The highly promising lines for oil content were EC 201846 (47.64%) received from Hungary followed by EC 198104 (46.01%), EC 198098 (45.49%) and EC 198094 (45.20%) received from Egypt. The first one had small head and the others had medium sized head. The strain EC 198095 received from Egypt was the most promising with very large head size., higher yield (76.7g) and 43.22 percent oil content.

Seventeen lines which were earlier selected for having more than 43 percent oil content, were again grown along with five check lines Surya, Morden, EC 68414, EC 68413 and EC 68415 during *Rabi* (1987-88) at issapur Farm of N.B.P.G.R. Oil percentage of seventeen lines was in the range of 41.63 to 48.81 against 36.37 to 41.58% oil in the above mentioned 5 check varieties. Of the seventeen lines only three lines showed oil content below 43 pertent. Mean oil percentage of *44.95* was recorded in the above seventeen lines

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grown during Rabi (1987-88) as compared to *44.42* percent obtained from the same lines grown during *Kharif*, 1987.

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EFFECT OF VARIETIES, ROW SPACINGS AND PLANT DENSITIES ON GROWTH AND YIELD OF MUSTARD UNDER DRYLAND CONDITIONS

R.P.SINGH, YASHWANT SINGH AND J.P.SINGH

Dryland Research Project, Department of Agronomy,
Institute of Agricultural Sciences, Banaras Hindu University,
Varanasi -221 005

ABSTRACT

An experiment was conducted at the research farm of Institute of Agricultural Sciences, Banaras Hindu University, Varanasi to study the effect of row spacing and plant densities on the performance of some mustard varieties under dyrland conditions. Variety PR 45 outyielded Kranti and Varuna. Row spacings of 45 and 30 cm proved equally effective in respect to seed yield. The growth and yield attributes decreased with increasing plant densities except plant height in which a reverse trend was observed. Plant density of 7 plants per meter row (about 15 cm plant to plant distance) proved to be optimum for higher yield of mustard in dryland conditions.

Key words: Mustard variety, rwo spacing, plant density, Dryland.

INTRODUCTION

In sub-tropical dryland regions of north-west India, deep rooted post rainy season crops like mustard have been reported to be more efficient than other crops (Bains *et al.*, 1971). Improved variety and optimum plant geometry i.e. row and plant spacings are important factors responsible for higher productivity. It was, therefore, planned to find out the suitable variety and optimum plant geometry level for mustard under dryland conditions of Eastern U.P.

MATERIALS AND METHODS

Field trials were conducted during *rabi* seasons of 1986 - 87 and 1987- 88. Three varietes (Varuna, Kranti and PR 45), two row spacings (30 and 45 cm) and three plant densities (5,7 and 10 plants/m) were tested in a split plot design replcated three times. Varieties were assigned to main plot and combination of row spacing and plant densities were kept in sub-plots. The soil of the experimental site was sandy loam with low in available N (156.5 Kg/ha), medium in available P_2O_5 (17.7 Kg/ha) and high in available K_2O

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(270.4 Kg/ha) having a pH of 7.4. The EC of the soil was 0.11 m. umhos/cm at 25°C and field capacity and wilting point were 19.4 and 5.7 per cent respectively. Crop was sown in first week of November and harvested in second week of March during both the years. The crop was fertilized with recommended dose of 40 Kg N, 20 Kg P_2O_5 and 20 Kg K_2O per hectare uniformly through urea, single super phosphate and muriate of potash, respectively. The entire amount of fertilizer was applied as basal in furrows below seed by Malviya seed-cum - fertilizer drill, Thinning of plants was done 15 days after sowing and plant densities of 5, 7 and 10 plants/m were maintained by varying plant to plant distances of approximately 20, 15 and 10 cm, respectively. The crop received 21.8 mm and 73.7 mm of rainfall during first and second year, respectively during crop duration.

RESULTS AND DISCUSSION

Effect of Varieties:

Varieties reflected marked differencess in growth and yield attributes. Dry matter/ m^2, seeds/siliqua and 1000 - grain weight increased significantly in PR-45 over Kranti and Varuna. However, rest of the characters as well as seed yield remained unaffected due to the varieties. Kranti and Varuna were found similar in respect of all the growth and yield attributes as well as seed yield. Though the data on oil content were not significant, PR-45 variety of mustard had higher percentage of oil than the others.

Effect of row spacing:

Dry matter plants/m^2 and plant height increased significantly with closer row spacings. Almost a reverse trend was observed in respect of branches/plant, siliquae/plant and seeds/siliqua which were markedly reduced with closer spacing. Length of siliqua, 1000 - grain weight and seed yield, however, remained unaffected by row spacing. Similar results were reported by Wankhede *et al* (1970) and Singh and Singh (1987). Closer spacing offered keen competition for various resources resulting in marked decrease in dry matter production per plant which Resulted in lesser number of branches/plant, thereby reducing the number of siliquae per plant. More number of siliqua/plant in widely spaced plants, however, did not increase the yield against the narrow spacing having higher plant population per unit area which nullified the positive effect of all the yield attributes in case of wider spacing. The differences in yield due to higher plant population in closer spacing could be compensated by increased siliquae per plant and bolder seed size in wider spacing (Singh *et al* 1986). However, oil content remained unaffected by row spacings.

Effect of plant densities :

Effect of plant density on dry matter production of mustard was found to be non-significant (Table 1). However, maximum dry matter (1.15 Kg/m^2) was produced with the medium plant density (7 plants/m) Plant height increased significantly with increasing plant densities. A plant density of 10 plants/m, being at par with 7 plants/m, significantly produced taller plants as compared to 5 plants/m.

Increasing plant densities adversely affected the various yield attributes. Number of branches/plant was maxmum with 5 plants/m plant density. Singnificantly more number of siliquae/plant was observed in the iowest plant density than in the rest. A similar trend was observed in the case of siliqua length, seeds/siliqua and 1000 - grain weight. Improvement in yield attributes at lower plant density could be attributed to availability of relatively more space per plant due to which competition was reduced. This is in conformity of the observations made by Madholkar and Ahlawat (1979) and Singh and Singh (1984).

Unlike yield attributes, yield was significantly higher at 7 plants/m plant density which was comparable to 10 plants/m. Optimum plant population per unit area was mainly responsible for higher yield in medium plant density as compared to others. Increasing densities, in general, adgversely affected the plant growth and other yield contributing characters but not the seed yield because the quantitative reduction in yield attributes was presumably compensated by the increase in plant population per unit area. Similar observations were made by Prakashvir and Verma (1981), Madholkar and Ahlawat (1979)and Singh and Singh (1984). An increasing trend in oil content was witnessed with increasing plant densities, though the differences were not significant.

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TABLE 1:
Effect of plant density and row spacing on growth and yield of mustard varieties (Two years pooled data).

Treatments	Dry matter (kg/ m^2)	Plant height (cm)	Branches/ plant	Siliquae/ plant	Siliqua length (cm)	Seeds/ siliqua	1000-grain weight (g)	Seed yield (q/ha) 86-87	Seed yield (q/ha) 87-88	Oil content (%)
Varieites										
Varuna	1.23	175.7	8.3	305.2	5.40	13.45	4.30	10.68	14.10	38.6
Kranti	1.27	180.0	9.1	299.1	5.45	13.20	4.45	11.05	14.95	39.0
PR 45	1.39	179.5	9.6	327.2	5.55	14.35	5.25	11.75	16.07	42.1
C.D, 5%	0.10	NS	NS	NS	NS	0.88	0.30	NS	NS	NS
Row spacing (cm)										
30	1.34	180.9	7.9	279.1	5.35	12.90	4.55	10.75	15.28	40.6
45	1.04	172.5	9.0	354.5	5.50	14.15	4.75	11.10	14.79	40.0
C.D. 5%	0.12	5.7	0.6	7.2	NS	0.85	NS	NS	NS	NS
Plant density (plant/m)										
5	1.12	174.1	9.6	384.5	5.65	14.65	4.80	10.50	14.07	38.4
7	1.15	180.3	8.8	301.1	5.45	13.50	4.60	12.80	15.87	38.8
10	1.13	182.1	7.5	248.4	5.25	12.30	4.50	11.20	15.15	39.1
CD 5%	NS	6.1	0.7	16.1	0.05	0.90	NS	1.75	0.69	NS

NS = Not Significant

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EFFECT OF FUNGICIDAL SEED TREATMENTS ON NODULATION AND YIELD OF SOYBEAN.

P.A. THOMBRE, B.P. KURUNDKAR, AND B.R. KAWALE
All India Coordinated Research Project on Soybean
Marathwada Agricultural University, Parbhani - 431 402

Fungicidal treatments of Soybean seed is found effective in improving germination and emergence of the crop (Kernkamp *et al.*, 1953; Ellis *et.al.*, 1975; Casela *et.al.*, 1979; Ganacharya 1979; Borelli *et.al.*, 1980; and Sundaresh and Hiremath, 1982). However, results on the effect of seed dressing chemicals on symbiosis of Rhizobium jazponicum are controversial (Ruhloff and Burton, 1975; Glard *et.al.*, 1973; Nedelchev, 1981; Kuchark, 1982; Sundaresh abd Hiremath, 1982; Bandopadhayay *et.al.*, 1983). It may be because of the in compatibility of certain chemicals with the rhizobia, variation in techniques and soil and environmental conditions existing at the time of experimentation. Present studies were undertaken with a view to findout the compatible seed protectants with R.*Japonicum* inoculation under rainfed conditions of Marathwada region of Maharashtra state.

A field experiment was conducted in the rainy season of 1984 in split plot design with three *replications on soybean cultivar*, MACS-13. There were three main treatments i.e. sowing after 0,24 and 48 hours of storage of seed after fungicidal seed treatments and R.Japonicum inoculation. There were nine sub - treatments in which the effect of seven fungicidal treatments and R.Japonicum inoculation was compared with R.Japonicum inoculated and un-inoculated controls. The doses of fungicidal treatments were thiram (Hexathir 75 WP) @ 4 g, captafol (Difolatan 80 WP)@ 3g, mancozeb (Dithane M 45 75 WP) @ 2.5g, quintazene (Brassicol 75 wp) @ 2.5 g, carbendazim (Bavistin 25 SD)@ 2.5 and 3g, and elemental sulphur (300 mesh fine)@ 6g, per kg of soybean seed. The gross and net plot sizes were 5.0 x 3.0m^2 and 4.0 x 1.8m^2 respectively. The distance of 60 cm. between rows and 5 cm. between plants was maintained at planting. One hundred seeds were sown per row. Plant stand at 30 and 60 days after sowing and number of nodules and their dry weight at 60 days after sowing were recorded. Grain yield and 1000 seed weight were recorded at crop harvest.

Sowing of soybean after 0,24 and 48 hours of rhizobial *inoculation and* fungicidal treaatments did not differ significantly in respect of plant stand, nodulation, grain yield and 1000 seed weight (Table 1). These results indicate that a storage period of 48 hours did at affect the nodulating ability of rhizobia on the seed. Curley anbd Burton (1975)*have also found that thiram* had no adverse effect on viable rhizobia or tap root nodulation even when seeds were held 24 hours before planting. Fungicidal seed treat-

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ments had significant effect on other parameters. Except plant stand at 60 days of crop growth (Table 1). Plant stand at 30 days of crop growth was significantly more in carbendazim, thiram and untreated control. These results show similar trend as that of Curely and Burton (1975); Ellis *et al.*, (1979); Borelli *et.al.*, (1980) and Sundaresh and Hiremath (1982) *who have reported increase in germination and emergence of soybean due* to fungicidal seed treatment. Number of nodules were significantly more in carbendazim and thiram seed treatments than both the controls. Nodule dry weight in carbendazim (3 g/kg) and sulphur was significantly superior to rest of the treatments. Grain yield in carbendazim (3 g/ka) was significantly superior over control (without R.Japonicum inoculation) white it was at par with rest of the treatments. There was significant increase in 1000 seed weight by carbondazim, thiram, sulphur and mancozeb seed treatments than both the controls. These results clearly indicate no adverse effect of seed dressing fungicides on rhizobial symbiosis and thereby on grain yield. Though the seed dressing chemicals may be lethal to rhizobia (Curely and Burton, 1975; Kuchark, 1982; and Bandopadhyaya *et.al.*, 1983) it is probable that the number of rhizobia surviving may be sufficient to bring about effective results under favourable conditions because of their high nodulating ability. On the contrary, the effect of carbendazim in on increased nodulation, dry weight grain yield may be due to good control of other pathogens. Nedelchev (1981) and Bandopdhyay et al.; (1983) have also reported increase in nodulation due to systemic seed protectants like carboxin and carbendazim. Similarly, Curley and Burton (1975). Ganacharya (1979) and Sundaresh and Hiremath (1982), also found no adverse effect of some fungicides on nodulating bacteria. Therefore, whereever necessary, seed treatment with carbendazim may be done safely along with rhizobial inoculants like *R.japonicum* under favourable conditions of planting.

Interaction between R.Japonicum inoculation and fungicidal seed treatments was absent (Table 1).

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TABLE 1:
Effect of R.japonicum inoculation and fungicidal seed treatment on plant stand, rhizobial symbiosis and grain yield of soyabean.

Treatment	Percent plant Stand (Arc sine) 30 days	60 days	Number of nodules/ 10 plants at 60 days	Dry weight of nodules/ 10 plants at 60 days (mg)	Grain yield (kg/ha)	1000 Seed weight (g)
Main treatment (Time of storage)						
0 hours	70.94	70.17	172.11	371.52	968	125.92
24 hours	71.57	70.77	181.81	414.26	1043	127.37
48 hours	69.35	66.53	150.33	336.41	882	125.07
S.E, ±	1.09	1.97	7.72	28.95	141	1.06
C.D: at 5%	NS	NS	NS	NS	NS	NS
Subtreatment (Fungicides)						
Thiram (Hexathir 75 WP) 4 g/kg	73.71	65.42	192.55	349.11	1009	127.67
Captafol (Difoltan 80 WP) 3 g/kg	69.32	69.06	163.33	282.22	866	124.25
Mancozeb (Dithane-M-45 75 WP) 3g/kg	71.82	71.09	173.00	354.22	1035	127.22
Quintazene (Brassicol 75 WP) 2.5 g/kg	68.33	67.81	177.44	321.89	892	124.89
Carbendazim (Bavistin 25 SD) 2.5 g/kg	74.47	74.25	218.11	389.44	1112	130.11
Carbendazim (Bavistin 25 SD) 3.0 g/kg	73.07	72.21	201.11	663.11	1294	129.22
Sulphur (300 mesh fine) 6 g/kg	68.36	66.83	154.44	647.44	863	127.33
Control (R. japonicum inoculated)	70.21	69.23	124.55	201.67	850	123.22
Control (Un inoculated)	66.30	66.52	108.22	158.67	758	120.89
SE ±	1.60	2.90	19.98	44.31	165	1.15
C.D. ± at 5%	4.45	NS	55.39	122.82	458	3.20
Interaction (Storage x fungicides)						
S.E. ±	2.78	5.02	34.61	76.75	111	1.98
C.D. at 5%	NS	NS	NS	NS	NS	NS

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EFFECT OF FUNGICIDES, INSECTICIDE, WEEDICIDE ON EMERGENCE AND YIELD OF SOYBEAN (*GLYCINE MAX (L)* MERRIL).

B.R. KAWALE, B.P.KURUNDKAR and P.A. ľHOMBRE
All India co-ordinated Res. Project on Soybean
Marathwada Agricultural Unviersity, Parbhani (M.S.)

Soybean (*Glycine max* (L) Merrril) is becoming a popular oilseed crop in Maharashtra state where area under the crop is steadily increasing. The seedling emergence may be adversely affected due to the infestation of fungi, bacteria, insects and emergence of weed seeds when the soil moisture is a limiting factor after sowing. The chemical seed treatments were reported to be effective in improving the seedling emergence (Nene *et al.*, 1969 Singh *et al.*, 1973; Tekrony *et al* 1974; Ellis *et al*, 1975; Maggione and Lam-Senchev, 1976; Tikhnov and Chalyi 1976). Present studies were conducted to find out the efficacy of some chemcials and their combintaions for seed and soil treatments for improving the seedling emergence.

The experiment was conducted using variety Bragg of Soybean in a Randomised Block Design with eleven treatments, replicated four times. Nine combinations of chemicals viz; thiram, carbandazim, mancozeb and captan (fungicides), disulfoton (insecticide) and prometryne (Gesagard) (weedicide) with *R. japonicum* seed treatments were compared with *R. japonicum* treated and untreated controls (Table 1). Fungicides were applied as seed dressings while insecticides and weedicides were applied to soil at 7.5 kg and 4 litres/ha., respectively. The row to row spacing of the crop was 45 cm and plant to plant spacing was 5 cm, Gross and net plot sizes were 5.0 x 2.25m and 4.0m x 1.35 m, respectively. Basal dose of 20 kg N and 80kg P O/ha was given at the time of sowing. The crop was kept weed and insect free by adequate interculture operations and foliar applications of recommended insecticides. Seedling emergence per plot was recorded at 15 days after sowing. At 60 days after sowing five plants/plot were carefully dugout with maximum possible root system. The roots were washed free of adhering soil and number of nodules per root were counted., Grain yield and 1000 seed weight were recorded at crop harvest.

All the chemicals and their combinations and *R. japonicum* seed treatment increased seedling emergence (Table 1) over control without *R. japonicum* seed treatment in seedling emergence. Combination of thiram with insecticide and weedicide increased grian yield significantly. In the other chemical combinations, captan + thiram + insecticide + weedicide, carbendazim + thiram + insecicide + weedicide have recoded significantly higher grain yield compared to controls. The treatments did not significantly influence nodule number and 1000 grain weight.

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TABLE 1. Effect of soil and seed treatment chemicals on emergence, and grain yield.

Treatment	Emergence (%)	Grain Yield (Kg/ha)
Thiram 75 WP (0.4%)	98.00	1297
Carbendazim (Bavistin 50 SP)+ thiram 75 WP (1:1) (0.3%)	98.00	1293
Mancozeb 75 WP (Dithane M-45) (0.3%)	97.00	1150
Captan 80 WP + thiram 75 WP (1:1) (0.3%)	98.00	1375
Thiram 75 WP + disulfoton (disyston 5G) + Prometryne (Gasagard) (Tok-E-25) 25 Ec.	98.00	1516
Mancozeb 75 WP (Dithane M-45) + (Disyston 5G) + Tok-E-25	98.00	1370
Carbendazim (Bavistin 50 SP) + thiram 75 WP + Disyston + Tok-E-25	98.00	1376
Captan 80 WP + thiram 75 WP + Disyston + Tok-E-25	98.00	1450
Disyston + Tok-E-25	96.00	1052
R. japonicum treated	91.00	904
R. japonicum untreated	70.00	849
S.E. ±	4.9	148
C.D. at 5%	14.17	430

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RESPONSE OF GROUNDNUT CROP TO FARMYARD MANURE, NITROGEN AND PHOSPHORUS IN RICE FALLOWS IN COASTAL SANDY SOILS*

C.A. AGASIMANI AND M.M. HOSMANI
Department of Agronomy, College of Agriculture,
Dharwad-580 005.

The present investigation was undertaken during the *rabi*/summer season of 1983-84, 1984-85 and 1985-86 with groundnut Cv. Dh-3-30 in West Coast of Karnataka under receding soil moisture conditions. These experiments were conducted at three locations in rice fallows namely Amadalli, Ankola and Holanagadde at all the three locations during 1983-84, whereas, during 1984-85 and 1985-86 conducted only at Ankola. Rainfall of Amadalli, Ankola and Holanagadde are 3010, 3296 and 3728 mm respectively and distributed from June-November. The soils of the experimental sites were sandy loam. Organic carbon % was 0.34, 0.63, 0.78 and available potash was 250, 375 and 500 Kg/ha in the experimental soil of Amadalli, Ankola and Holanagadde, respectively. Available phosphorus content in the soil samples was more than 80 Kg/ha at all the three sites. Rice crop was grown in the *Kharif* season for all the locations. The experimental fields were ploughed six times with a small wooden'malnad'plough. Each ploughing was followed by planking and levelled for proper seed bed preparation. Prior to sowing farmyard manure, nitrogen in the form of urea and phosphorus in the form of single super phosphate were applied and incorporated in the soil as per treatments. An uniform dose of 25 Kg K_2O as muriate of potash per ha was applied wherever necessary. The different nutrient and manurial treatments were, 0:0:0, 0:50:25, 0:100:25, 25:0:25, 25:50:25, 25:100:25, 50:0:25, 50:50:25, 50:100:25 N, P_2O_5 and K_2O kg per ha and 7.5 tonnes of FYM per ha.

During 1983 - 84, the differences in pod yield of groundnut due to varying levels of nitrogen and phosphorus were not significant at Amadalli, Ankola and Holanagadde. However, in all the three locations during the year, the maximum pod yield of 2854, 2052 and 2344 Kg per ha was recorded in the treatment receiving 7.5 tonnes of farmyard manure per ha at Amadalli, Ankola and Holanagadde, respectively. On an average over locations also the maximum pod yield (2417 Kg/ha) was registered in the treatment which received 7.5 tonnes of farmyard manure per ha. This yield was significantly higher than the other treatemnts except the treatments 50:100:25 kg of N, P_2O_5 and K_2O per ha (2299 Kg/ha) and 0:50:25 kg of N, P_2O_5 and K_2O per ha (2167 Kg/ha) which were on par with the treatment receiving 7.5 tonnes of farmyard manure per ha. Gopalswamy *et al.* (1978) reported 27 per cent increase in pod yield with farm yard manure. The increase in the pod yield is attributed to the manifold effect of farmyard manure on soil and plant growth. Cooke (1970) opined that the action of farmyard manure on crops is due to the combination of its physical effect's the nutrient it supplies and the way it supplies them.

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In the present studies, increase in pod yield with the treatment receiving 7.5 tonnes of farmyard manure per ha was mainly due to the increased rates of growth and yield attributing characters recorded in the treatments.

During 1984-85 at Ankola, the differences in pod yield of groundnut due to varying levels of nitrogen and phosphorus were significant. The maximum pod yield of 2531 kg/ha was recorded in the treatment receiving 7.5 tonnes of farmyard manure per ha which was on par with other treatments except 0:0:0 (688 Kg/ha); 0:50:25 (604 kg/ha), 0:100:25 (427 Kg/ha), 25:0:25 (1104 Kg/ha)50:0:25 (771 Kg/ha)and 50:50:25 (635 Kg/ha) of N, P_20_5 and K_2O per ha.

During 1985-86 at Amadalli, the differences in pod yield of groundnut due to varying levels of nitrogen and phosphorus were not significant.

Over all locations and years of reasearch, the differences in pod yield of groundnut due to varying levels of nitrogen and phosphorus were significant. The maximum pod yield (2602 kg/ha) was recorded in the treatment receiving 7.5 tonnes of farmyard manure per ha. This increase in pod yield was to the extent of 64 per cent as compared to the control where farmyard manure or fertilizers were not applied. The coastal sandy soils are low to medium in organic carbon (0.34 to 0.78%). The application of 7.5 tonnes of a farmyard manure has helped in increasing the plant height, number of branches per plant, haulm yield, hundred kernel weight, shelling percentage, kernel yield, oil yield and harvest index. Rudraksha *et al.* (1977)reported increased pod number, pod weight and pod volume with farmyard manure application, whereas Chittapur (1982) reported increased growth attributes and yield components with farmyard manure application. In the present investigation, increased growth attributes and yield componenets due to the applicaation of farmyard manure resulted in increased pod yield of groundnut. Positive correlations were also observed between yield and yield components. The application of farmyard manure improved the quality of nuts. It increased 100 - kernel weight (39.g) and shelling per cent (68).

The application of 50 kg of N and 100 kg of P_2O_5 per ha and half the quantities of both these nutrients also gave higher yields. The increase in pod yield due to the application of 50 kg of N and 100 kg of P_2O_5 per ha was to the extent of 46 per cent as compared to control, whereas, the increase in pod yield with 25 kg N and 50 kg P_2O_5 per ha. treatment was to the extent of 28 per cent as compared to control. In both these cases, the increase in pod yield is mainly due to the increased growth attributes and yield components recorded with the application of nitrogen and phosphorus. Higher pod yields with the application of 40 kg each of nitrogen and phosphorus per ha were obtained with spanish improved variety by Satyanarayana and Krishna Rao (1962). FYM application increased whereas, nitrogen and phosphorus application decreased nodulation was reported by Rayar (1986.)

The differences in pod yield between 7.5 tonnes of farmyard manure application, 50 Kg N + 100 Kg of P_2O_5 and 25 Kg of N + 50Kg of P_2O_5 per ha were not significant, whereas, the rest of the other fertilizer treatments significantly gave lower pod yield than these three treatments. The application of the balanced quantities of nitrogen and phosphorus (1:2 ratio) or the application of farmyard manure had resulted in the increased plant height, a greater number of branches per plant, a higher number of developed pods per plant, a higher haulm yield, a higher 100 Kernel weight, a higher shelling percentage, a higher percent of sound matured kernels and a higher harvest index, which ultimately resulted in a higher pod yield per ha.

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Table 1. Pod yield (kg/ha) of groundnut as influenced by varying levels of nitrogen and phosphorus during three seasons at different locations.

Sl. No.	Treatments ($N:P_2O_5:K_2O$ Kg/ha)	1983-84				1984-85	1985-86	Mean over locations and Years
		Amadalli	Ankola	Holanagadde.	Mean	Ankola	Amadalli	
1.	0:0:0	2500	1417	2229	2049	688	1905	1547
2.	0:50:25	2823	1406	2271	2167	604	1548	1440
3.	0:100:25	2625	1135	2219	1993	427	2024	1481
4.	25:0:25	2490	1208	2281	1993	1104	2262	1786
5.	25:50:25	2681	1344	2208	2078	1618	2262	1986
6.	25:100:25	2490	1312	2240	2014	1760	2024	1933
7.	50:0:25	2427	1000	2271	1899	771	1667	1446
8.	50: 50:25	2458	1427	2083	1989	635	1191	1272
9.	50:100:25	2844	1781	2271	2299	2104	2381	2261
10.	7.5 tonnes of FYM/ha	2854	2052	2344	2417	2531	2857	2602
	Mean	2619	1408	2241	2090	1224	2012	1775
	S.Em.±	396	229	177	146	531	583	294
	C.D.at 5%	NS	NS	NS	302	1115	NS	617

NS - Not significant.

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INHERITANCE OF LEAF HOPPER (*Empoasca Kerri* Pruthi) RESISTANCE IN GROUNDNUT (*Arachis Hypogaea* L.)

P. VINDHIYA VARMAN, F.J.S. KENNEDY and T.S. RAVEENDRAN
Agrl.Res.Station,
Aliyarnagar - 642 101.

Leaf hopper (*Empoasca Kerri* Pruthi) is one of the important sucking pests of groundnut causing yield losses upto 22% (Dwivedi *et al.*, 1986). This pest can be controlled by spraying systemic chemicals, However, since 80% of the groundnut is under rainfed cultivation, chemical control practices are not usually followed. Evolution of resistant/ tolerant groundnut varieties will be an ideal way to combat the pest problem under the above circumstances.

Amin *et al.* (1985) reported a few sources of strong resistance to this pest. Dwivedi *et al.* (1986) reported that the accession NcAc 2230 is the best parent for inducing resistance for, the pest. This Virginia runner type is a mutant of NC 4 obtained by X ray irradiation. Presence of long trichomes on the midrib and petioles in this accession confers stable resistance against jassids. In order to understand the inheritance of resistance the present study was undertaken as a prelude to developing stable resistant varieties.

The resistant donor NcAc 2230 was crossed with ALR1, a Virginia bunch Variety and ALG 33, a Valencia type of genotype in the advanced stages of testing during Kharif '87 season and the hybrid pods collected. The F1 generation was raised during Summer '88 season and the real hybrids were identified with reference to Crinkled levels, a marker trait present in the donor, NcAc 2230. The test populations were sown following a spacing of 30 cm between rows and 15 cm between plants in which the infector rows were raised 20 days ahead of the sowing of test lines.

The damage was assessed by visual rating (1-9 scale) on percentage of yellowing recorded on the third leaf from the top in the primary on 52nd day after sowing following the procedure suggested by Amin and Mohammed (1980). Leaf hopper resistance in groundnut has been associated with high density of trichomes (Campbell *et al.* 1976; Amin and Mohammed. 1980). Hence, density of trichome per mm^2 on the petiole were counted using sudan IV dye.

NcAc 2230 had resistant reaction with a mean grade of 2.0 compared to ALR 1(7.5) and ALG 33 (8.0). The two F1s were intermediate registering mean grade of 4.5 and 5.0 respectively, hence rated as susceptible. Similarly, the number of trichomes on the petiole were 30 in the resistant parent NcAc 2230 while it was as low as 13 in ALR 1 and 10 in ALG 33. However, the F1s were intermediate recording a mean number of 21 and 19

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respectively.

The F2 generation was raised during Kharif '88 season and the progenies were classified as resistant (grade 1 to 2) and susceptible (grade 3 to 9). In F2 generation, an array of variation for trichome number ranging from 8 to 30, was observed. Significant negative phenotypic correlation (r=-0.99**) was observed between the percentage leaf yellowing and trichome density on the petiole. The segregating population was subjected to Chi square test of goodness of fit.

The susceptible and resistant plants segregated in the ratio of 63:1 (Table 1) indicating the resistance to be controlled by three recessive genes.

To test the additive effect of the genes a frequency curve was constructed by assigning the frequency of individuals to 'Y' axis and class value to the 'X' axix (Fig). In both the crosses, the frequency distribution (Table 2) followed a normal distribution with a mean of 5.0 and 4.97 respectively.

Hence it may be concluded that resistance to leaf hopper is controlled by three recessive genes with additive effect. The study also revealed the possibility of infusing leaf hopper resistance in to adapted varieties by hybridisation followed by pedigree method of breeding.

ACKNOWLEDGEMENT

The authors are thankful to Dr.S.Chelliah, Director of Research (Agri.) for the encouragement.

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TABLE 1:
Chi square for 63 : 1 tri hybrid ratio.

Cross	Filial generations.	Plants showing susceptible reaction.	Plants showing resistant reaction.	Ratio	X^2 value	'P' value between
ALR1 x NcAc 2230	F1	29				
	F2	1085	15	63:1	0.28 NS	0.75 - 0.50
ALG 33 x NcAc 2230	F1	34				
	F2	1124	16	63:1	0.19 NS	0.75 - 0.50

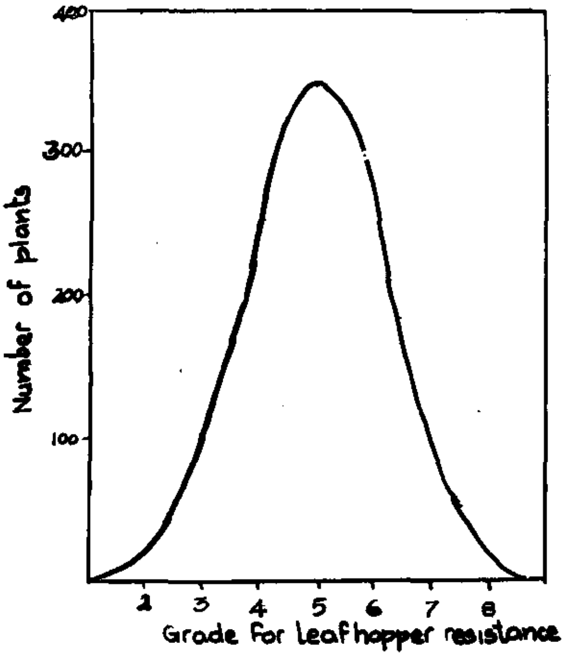
NS- Not Significantly deviating from zero

TABLE 2 : Frequency distribution of F2 generation for reaction against Jassids.

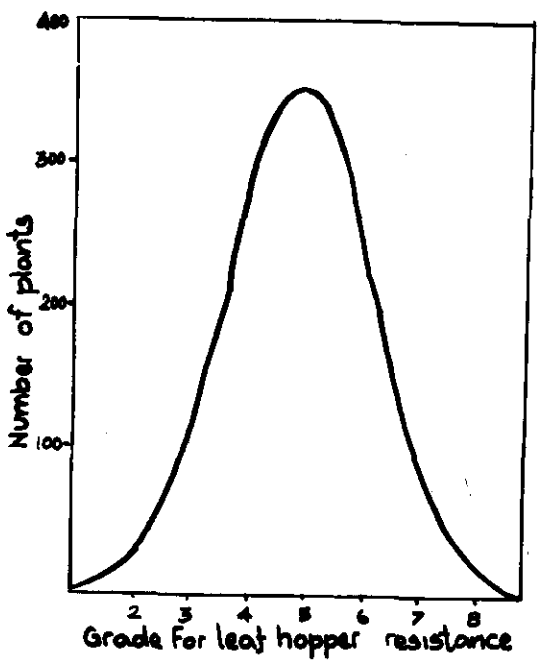
Grade (Class value)	Frequency		Ration	Probable genes
	ALRI X NcAc 2230	ALG 33X NcAc 2230		
1	-	-	-	-
2	15	19	1	$r_1r_1r_2r_2r_3r_3$
3	104	107	6	$R_1r_1r_2r_2r_3r_3$
4	253	278	15	$R_1R_1r_2r_2r_3r_3$
5	350	356	20	$R_1R_1R_2r_2r_3r_3$
6	263	265	15	$R_1R_1R_2R_2r_3r_3$
7	97	97	6	$R_1R_1R_2R_2R_3r_3$
8	18	18	1	$R_1R_1R_2R_2R_3R_3$
9	-	-	-	-

FREQUENCY DISTRIBUTION OF F_2 PROGENIES FOR LEAF HOPPER RESISTANCE

ALR.1 × NCAc 2230



ALG 33 × NCAc 2230



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ASSOCIATION AND PATH ANALYSIS IN GROUNDNUT (*Arachis Hypogaea* L).

P. VINDHIYA VARMAN and T.S. RAVEENDRAN
Agricultural Research Station,
Aliyarnagar, T.N. 642101.

In any crop, the knowledge on character associationand study of cause and effect relationship is of immense use for drawing up a systematic crop improvement programmes. Groundnut is the most important oilseed crop in which the yield level requires considerable improvement for enhancing the national oil production. Hence basic studies conducted to find out the important yield components will be useful identifying stable and high yielding varieties with greater precision and dependability. Keeping this in view the present investigation was undertaken to find out the desirable yield components in a set of genotypes comprising 37 spanish, two valencia and 11 virginia bunch cultures, tested under advanced yield evaluation trials in the Agricultural Research Station, Aliyarnagar.

Fifty genotypes were raised in RBD with three replications during Summer '88 and Kharif' 88 seasons. Data were collected on eight metric traits such as number of primary branches, number of secondary branches, length of the main stem (cm), length of the primaries (cm), length of secondaries (cm), number of pods per plant, haulms yield (g) and pod yield per plant (g) after randomly sampling five plants in each plot. Correlation coefficients and path relationship were worked out following Robinson *et al.* (1951) and Dewey and Lu (1959) respectively utilising the mean of the data for two seasons. Since the correlation between number of primaries and yield was negligible (r=.0073), the character for working out the path relationship was not considered. The estimates of genotypic correlation coefficients are presented in Table 1.

The pod yield was positively and significantly associated with length of main stem length of primaries, length of secondaries and haulms yield. Similar observations of significant positive relationship between yield and primary branches length and plant height were reported by Rao (1979). This could be due to the translocation of photosynthates from the vegetative plant parts to the sink (Duncan *et al.*, 1978). Significant positive correlations between number of primaries and number of pods, length of main stem and length of primaries, length of secondaries and haulms yield were observed among the yield components. Positive correlations between length of primaries, number of secondaries and number of mature pods were earlier reported by Balaiah *et al* (1980) in groundnut.

Negative relationship between number of secondaries and pod yield were also reported in groundnut by Chandola *et al* (1973) and Sangha (1973). Ibrahim (1983) was

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of the opinion that the pod yield had largely dependent on the number of branches in the virginia group rather than in bunch group. Since the present material consisted mostly of bunch types, a negative relationship was observed.

The correlation *coefficients were partitioned into direct and indirect effects and are* presented in Table 2. A perusal of the data indicated that among the different metrical traits considered, length of primaries and number of secondaries had positive direct effect on pod yield. Thje length of primaries, in particular, besides exerting direct effect also influenced the other components, length of main stem, length of secondaries and haulms which had large negative direct effects resulting in overall positive relationship with the pod yield. Thus, length of the primary proved the most important trait in the present study. Number of secondaries, although exhibited a positive direct influence, was found to possess no correlation with pod yield, its direct effect being nullified by the indirect effects of all the other characters including haulms yield. As there is a tendency for a negative relationship between the two important characters, length of primaries and number of secondaries, it would be desirable to work out the compensation mechanism between these two characters.

Thus the above study indicated the importance of length of primary branches in groundnut breeding .

We are thankful to Dr.S. Chelliah, Director of Researcn (Agri.) for the encouragement given during the course of the experimentation. We also acknowledge the financial assistance of ICAR through All India Coordinated Research Project on Oilseeds.

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TABLE 1.
Genotypic correlation coefficients of different traits in groundnut.

Characters	No. of secondaries	Length of main stem	Length of primaries	Length of secondaries	No. of pods	Haulms yield	Pod yield
No. of primaries	0.1269	-0.2655	-0.2136	-0.0579	0.2877**	-0.0194	0.0073
No. of secondaries	-	-0.0482	-0.0269	0.1710	0.2470	-0.1546	-0.0724
Length of main stem	-		0.9137**	0.4027**	0.1126	0.3478**	0.7562**
Length of primaries			-	0.4442**	0.1925	0.3720**	0.7531**
Length of secondaries				-	0.1920	0.3247**	0.4055**
No. of pods					-	0.1108	0.1421
Haulms yield						-	0.3688**

TABLE 2.
Direct (Diagonal) and Indirect (Off Diagonal) effects of different yield components

Characters	No. of secondaries	Length of main stem	Length of primaries	Length of secondaries	No. of pods	Haulms yield	Genotypic correlation with pod yield.
No. of secondaries	1.5086	0.0647	-0.5653	-0.2334	-0.1215	-0.7255	-0.0724
Length of main stem	-0.0974	-1.0023	3.9298	-0.4676	-0.1891	-0.4172	0.7562**
Length of primaries	-0.2080	-0.9606	4.1003	-0.5134	-0.2574	-0.4078	0.7532**
Length of secondaries	0.4780	-0.6363	2.8580	-0.7366	-0.2241	-1.3336	0.4055**
No. of pods	0.1538	-0.1591	0.8859	-0.1385	-1.1914	0.5914	0.1421
Haulms yield	0.5220	-0.6775	2.7533	-0.4686	0.3361	-2.0966	0.3688**

R value = 0.9799

Residual effects : 0.1419

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PERPETUATION AND CARRY - OVER OF GROUNDNUT RUST IN GUJARAT STATE INDIA*

V.A.Patel and M.U.Vaishnav
Department of Plant Pathology College of Agriculture,
Gujarat Agricultural University,
JUNAGADH.

Rust of groundnut (*Arachis Hypogaea* L.) caused by *Puccinia arachidis* Speg.is now a well established disease in India. Mayee et al(1977) hypothesized that continuous cultivation of groundnut is probably the single important factor in carry-over of rust in India. With a view to study the perpetuation and carry-over of groundnut rust particularly, When no teliospores, collateral or alternate hosts are found for this pathogen, the survey of appearance of the rust in different seasons was made is Saurashtra region of Gujarat state. In Winter, the wheat and mustard fields were also visited to see the presence of volunteer groundnut plants and occurence of rust.

The observations on the period of sowing, harvesting and appearance of rust at different places are summerized in the Table 1.

Table 1:
Groundnut sowing and harvesting period, and appearance of rust.

Groundnut crop Season	Period of sowing	Period of harvesting	Appearance of rust
Monsoon	2nd week of June to 1st week of July	2nd week of October to 1st week of November.	Severe*
Summer	2nd week of December to 3rd week of January	3rd week of April to 1st week of June.	Spare to* Moderate
Premonsoon	2nd Week of May to 1st week of June	1st week of October to 3rd week of October.	Severe*

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*Severe: 51-100 Pustules per leaflet
Moderate : 21-50 pustules per leaflet
Spare: 1-20 pustules per leaflet.

From the observation of the volunteer groundunt plants in wheat and mustard fields in rabi season, it was noted that the rust was also present on Volunteer groundnut plants. in this way, urediniospores of groundnut rust are carried over from one crop to another as the groundnut crop is present in parts of the Saurashtra region. These results support the hypothesis of Mayee et al (1977) and Subrahmanyam and Mc Donald (1982) who reported that the continuous cultivation of groundnut could result in an effective carry-over and spread of rust disease in India.

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EFFECT OF TEMPERATURE AND RELATIVE HUMIDITY ON DEVELOPMENT OF GROUNDNUT RUST*

V.A. Patel and M.U.Vaishnav
Department of Plant Pathology,
Gujarat Agricultural University,
College of Agriculture,
Junagadh - 362 001.

Rust of groundnut (Arachis hypogea L caused by *Puccinia arachidis* speg was reported from Punjab in 1969 (Chahal and Chohan, 1971) and has spread at an alarming rate in all major groundnut growing states in India (Subrahmanyam *et al*., 1979). It was first observed in Gujarat at Junagadh in 1973 by Vaishnav and Kapadiya (1982). Information, however, on factors influencing development of groundnut rust is not available. Hence it becomes imperative to study the factors affecting the development of groundnut rust.

Healthy groundnut leaves (GAUG-1) detached from plants grown in glasshouse were surface sterilized with 75 per cent alcohol for five minutes and give three to four washings in distilled sterilized water. For studying the effect of temperature the leaves were placed on moist filter paper in a Petridish in such a way that dorsal side of the leaflets was exposed to inoculation. The leaves in the Petriplates were then inoculated with 0.5 ml urediniospore suspension (50,000 to 60,000 spores/ml distilled water) with the help of a fine brush. Inoculated Petriplates were incubated at 5,10,15,20,22,25,2730,35 and 40^0C for 15 days in BOD incubators. Periodical spraying of sterilized distilled water was done for maintaining moisture in the Petriplates. For studying the effect of relative humidity the leaf was immersed in a test tube containing 20 ml of sterilized water. The leaves were then inoculated with 0.5 ml urediniospore suspension with the help of a fine brush. Inoculated leaves were then incubated at different relative humidity levels viz., 60,70,80,90 and 100 per cent at $25+1^0$C for 15 days in control cabinets. Each experiment was repeated five times and the results rust are presented in Tables 1 and 2.

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Table 1:
Effect of temperature on incubation period of P. Arachidis and on number of pustules.

Temperature (°C)	Incubation period (Days)		No.of pustules/ leaf (15 days after incubation)
	Chlorotic lesion	Pustule appearance	
5	*	*	*
10	*	*	*
15	11	13	14
20	10	12	105
22	7	9	180
25	8	10	195
27	8	10	190
30	9	10	115
35	11	12	18
40	*	*	*

*No rust development.

Table 2:
Effect of relative humidity on incubation period of P.Arachidis and development of rust.

No.	Humidity (Per cent)	Incubation period (days)		No. of pustules/ leaf (15 days after incubation)
		Chlorotic lesion	Pustules appearance	
1.	60	10	13	24.83
2.	70	9	12	41.00
3.	80	9	11	79.17
4.	90	8	10	132.50
5.	100	7	9	185.57
S.Em.±		-	-	1.375
C.D. at 5%		-	-	4.00

Effect of temperature

It is evident from the Table 1 that rust did not develop at 5,10 and 40°C, while it developed at 15 to 35°C. The number of pustules per leaf (10.2 cm² area) were more at 25°C followed by 27°C and 22°C temperature. The chlorotic lesions were found earlier at 22°C. Similar results were obtained by Munde and Mayee (1980) who reported that rust did not develop on detached inoculated leaves at 15°C, but the best rust development occurred at 27°C. Prasad *et al.* (1979) also reported that the range of temperatures between 20 to 24°C was congenial for infection and development of groundnut rust.

Effect of relative humidity

It is seen from the data in Table 2 that with the increase of relative humidity from 60 to 100 per cent, incubation period decreased from 10 to 7 days and also period of pustules appearance was decreased. Number of pustules per leaf(10.2 Cm² area) was the highest at 100 per cent relative humidity followed by 90 per cent. Similar results were obtained by Prasad *et al.*, (1970). Munde and Mayee (1980)and Subrahmanyam and McDonald (1983) reported that 100 per cent relative humidity was favourable for the infection and subsequent development of groundnut rust.

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Effect of Weather Parameters in Relation to Occurrence and Developments of groundnut rust

V.A.Patil[1] and M.U.Vaishnav[2]
Department of Plant Pathology,
College of Agriculture,
Gujarat Agricultural University,
Junagadh.

Rust of groundnut (*Arachis hypogaea* L.) caused by *Puccinia arachidis* Speg.is a well established disease in India. Rust poses a clear threat to this crop in India. Where continous cropping systems can provide inoculum sources. It is important, therefore, to study the effect of weather parameters in relation to occurrrence and development of groundnut rust.

Groundnut (cv.GAUG-1) was sown in 0.25 ha area on commencement of monsoon in kharif 1980 and 1981. One hundred plants were labelled randomly for observations in the field. Weekly observations on occurrence and spread of groundnut rust was recorded till the harvest of the crop. The observations were recorded as described by Nath and Indira (1975). The infection index was calculated according to the following formula.

$$\text{Infection index} = \frac{\text{Sum of individual rating}}{\text{Total number of leaves graded}} \times \frac{100}{\text{Maximum disease rating.}}$$

Weather parameters like maximum and minimum temperatures, relative humidity, sunshine hours and rainfall were taken from the meteorological laboratory for the Kharif 1980 and 1981 . The data presented in tables 1 and 2 reveal that the maximum rate of rust development occurred in standard week- 35 and 35 for 1980 and 1981 season, respectively . The correlation value (Table 3) of the weather parameters like maximum and minimum temperatures, relative humidity and sunshine hours were positive and rainfall was negative. It shows that the weather parameters like maximum and minimum temperatures, relative humidity and sunshine hours prevailed in standard week-32 and 34 for 1980 and 1981 season, respectively were most favourable for the highest relative rate of rust infection, which have significantly showed positive relation in the high rate of rust infection.

1. Research Scientist (Plant Pathology) Main Oilseeds Research Station, G.A.U., Junagadh.
2. Professor and Head.

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Incubation period for the rust is about 10 days (Subrahmanyam *et al.*, 1983, Munde and Mayee, 1980). It means that the weather 10 days before appearance of the symotms and sufficient availability of inoculum load must have favoured the infection of rust. The two years observations on the weather parameters in relation to high rate of appearance of rust showed the range of temperatures 25-29°C, relative humidity 74-89 per cent, bright sunshine hours 1-4.3 and rainfall 10-13 mm reamined in previous week and the continued congenial weather parameters in the following weeks which have initiated highest relative rate of rust infection. Many researchers have indicated that high infection of groundnut rust occurred at high relative humidity at the rate of temperatures 20-24°C (Fang, 1977, Prasad *et al.*, 1979, Munde and Mayee, 1980; Subrahmanyam and McDonald, 1983).

For accurate decision of relation of weather parameters and rust infection which may help in forecasting the occurrence of groundnut rust in particular area, the critical studies on weather parameters and occurrence of the rust should be carried out for many years at different locations so as to reach definite conclusion.

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TABLE 1:
Weather parameters in relation to occurence of groundnut rust during kharif, 1980.

No.	Std. week No.	Date	Mean Temp. °C		Mean relative humidity (per cent)		Bright sunshine hours	Total rainfall (mm)	Rust infection index	Relative rate of rust infection index
			Maxi-mum.	Mini-mum.	Morn-ing (7.30) hr.	After-noon (15.30) hr.				
1.	23	4-06-80	35.2	25.4	79	45	3.5	132.5	**0.0**	0.0
2.	24	11-06-80	37.7	25.2	85	54	5.6	108.2	**0.0**	0.0
3.	25	18-06-80	33.9	25.2	85	57	4.3	137.6	**0.0**	0.0
4.	26	25-06-80	30.2	25.2	93	63	0.5	619.0	**0.75**	0.75
5.	27	2-07-80	29.5	22.9	92	80	2.5	375.5	**2.50**	1.75
6.	28	9-07-80	31.9	25.2	90	70	3.8	0.0	**3.50**	1.0
7.	29	16-07.80	32.9	25.1	84	71	4.1	0.0	**8.75**	5.25
8.	30	23-07-80	31.2	23.9	92	86	1.4	42.4	12.45	3.70
9.	31	30-07-80	31.0	24.4	95	87	0.0	70.5	15.55	3.10
10.	32	6-08-80	29.6	25.0	89	87	1.0	13.0	25.75	10.20
11.	33	13-08-80	31.3	20.5	92	69	3.4	9.9	48.85	23.10
12.	34	20-08-80	31.8	23.9	92	76	4.0	43.8	65.80	16.95
13.	35	27-08-80	36.6	24.1	92	74	4.3	0.0	80.85	15.05
14.	36	3-09-80	32.0	24.4	90	62	6.0	4.0	85.35	4.50
15.	37	10-09-80	30.6	22.4	92	81	4.1	29.4	89.45	4.10
16.	38	17-09-80	31.1	22.4	90	62	7.6	0.0	93.55	4.10
17.	39	24-09-80	34.8	23.4	88	64	8.4	27.4	94.50	0.95
18.	40	1-10-80	35.8	22.0	91	50	9.9	0.0	94.50	0.0

TABLE 2:

Weather parameters in relation to occurrence of groundnut rust during Kharif 1981

No.	Std. week	Week Date	Mean Temp. °C Maximum	Mean relative humidity (per cent) Morning (7.30) hr.	Mean relative humidity (per cent) Afternoon (15.30) hr.	Bright sunshine hours index	Total rainfall (mm)	Rust infection index	Relative rate of rust infection
1.	28	09-07-81	30.7	74	67	2.2	454.2	0.0	0.0
2.	29	16-07-81	31.7	76	66	1.5	22.2	0.0	0.0
3.	30	23-07-81	30.4	82	84	2.8	171.0	0.25	0.25
4.	31	30-07-81	30.4	86	68	5.3	5.0	3.50	3.25
5.	32	6-08-81	28.9	77	77	2.8	128.0	10.45	6.95
6.	33	13-08-81	28.6	84	81	0.2	98.7	15.75	5.30
7.	34	20-08-81	26.7	88	74	4.3	10.7	22.80	7.05
8.	35	27-08-81	27.7	86	75	7.3	2.6	55.45	32.65
9.	36	3-09-81	29.8	87		7.5	0.0	65.35	9.90
10.	37	10-09-81	33.8	86	71	5.8	13.0	72.75	7.40
11.	38	17-09-81	33.8	82	79	6.3	38.0	79.35	6.60
12.	39	24-09-81	32.6	83	81	3.5	43.0	82.45	3.10
13.	40	1-10-81	33.5	83	84	8.0	0.0	90.75	8.30
14.	41	8-10-81	34.6	81	80	8.0	0.0	92.45	1.70
15.	42	15-10-81	36.8	81	80	7.7	0.0	93.45	1.00
16.	43	22-10-81	36.0	77	58	4.2	0.0	93.45	0.00

TABLE 3:
Correlation values of groundnut rust in relation to weather parameters

Season	Temperature		R.H. (per cent)		Bright sunshine hours	Rainfall
	Maximum	Minimum	Monrining	Afternoon		
Kharif 1980	0.501	0.5167*	0.0002	0.3583	0.7218*	-0.5325*
Kharif 1981	0.8226*	-	0.0113	0.7177*	0.7779*	-0.581*

* = Significant at 5 per cent level of probability.

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A METHOD OF ESTIMATION OF LEAF AREA IN CASTOR (Ricinus Communis L.)

S.J.PATIL, P.PALAKONDA REDDY, P.V.KENCHANAGOUDAR AND S.A.PATIL.
UNIVERSITY OF AGRICULTURAL SCIENCES,
RAICHUR CAMPUS,
RAICHUR - 584 101.

A non - destructive method of measuring leaf area is very much necessary for the study such as transpiration and photosynthesis. Also large screening of germplasm by the physiologist/breeder for productivity needs such a method involving less labour and time. Estimation of leaf area by linear measurement method is more rapid and accurate than the method involving tracting out the lines of leaves and using planimeter. Further, Wendt (1967) showed that there is close relationship between the castor leaf length and leaf area. In the present study, effort has been made to findout a leaf constant for castor so that the leaf can be measured by linear method.

Nine genotypes of castor were grown in randomized block design with three replications following the recommended package of practices during Kharif 1988 at Regional Research Station, Raichur. At the time of flowering of the primary raceme, fifty completely matured green leaves were collected randomly from different heights of the plant from each treatment. They were dipped in distilled water for one hour. After removing the adhering moisture their maximum length and width were recorded. One hundred discs (radius = 0.5 cm) were taken from these leaves using a leaf punch. These discs and the rest of the leaves were oven dried at 80°C and their dry weight was obtained. Actual leaf area was calculated based on this information. A leaf factor was worked out for all the genotypes following the method of Ashley *et al* (1963) by dividing the actual leaf area with the product of maximum leaf length and width (apparent leaf area) and was fixed to third decimal. Estimated leaf area was computed by multiplying the apparent leaf area with its constant. The data so collected was subjected to statistical analysis and co-efficient of correlation was worked out for actual leaf area with apparent and estimated leaf area.

The actual apparent and estimated leaf area varied (Table-1) from 168.9 to 398.7 Cm^{2-}, 335 to 747.9 cm^2 and 168.8 to 398.7 cm^2 respectively and there was statistical significant variation among the genotypes. While, the leaf constant which did not differ significantly ranged from 0.448 (TMV-5) to 0.574 (SHB - 62). The mean leaf constant for all the genotypes was 0.516.

The co-efficient of correlations worked out revealed strong positive relationship between apparent and actual leaf area($r = 0.967$) and between estimated and actural

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leaf area (r=0.999), which indicate that the leaf constants worked out are accurate to the nearest point. Jain and Misra (1966) have also reported similar information. However, they have used a single variety for the study.

It is concluded that the leaf constant 0.516 can be used in general for the easy estimation of leaf area in castor irrespective of genotypes by adopting the formula A = LxWx0.516 as the genotypes did not show statistical significant variation among them as against the cumbursome conventional planimeter method.

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TABLE 1.
Apparent, actual and estimated leaf area of nine genotypes of Castor.

Genotype	Leaf Area (cm^2)			Leaf constant
	Apparent	Actual	Estimated.	
SH-16	721.1	398.7	398.7	0.547
SH-21	712.3	379.6	379.5	0.530
SH-41	335.0	168.9	168.8	0.504
SHB-62	560.4	325.7	325.8	0.574
SBH-63	397.4	188.5	188.3	0.476
SHB-18	614.0	329.6	329.5	0.539
TMV - 5	503.7	225.4	225.4	0.448
RC-8	747.9	364.5	364.5	0.497
Aruna	419.7	219.5	219.4	0.534
Mean	556.8	288.9	288.9	0.516
SEm±	61.8	41.7	41.8	0.046
C.D.5%	185.2	125.1	125.2	NS

Co-efficient of correlation for

1) Apparent and actual leaf area = 0.967
2) Estimated and actual leaf area = 0.999

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PERILLA: AN OIL AND PROTEIN RICH UNDEREXPLOITED CROP OF NORTH EASTERN HILLS

B.D.Sharma D.K.Hore and S.Mandal
National Bureau of Plant Genetic Resources **Regional Station,**
Shillong - 793013 and N.B.P.G.Pusa Campus
New Delhi - 110012

Perilla (*Perilla frutescense* (Linn.) Britton, belonging to family Labiatae (Mukherjee 1940), is a coarse aromatic herb growing 50 cm to 1.5 cm tall occurring in tropical and temperate Himalaya and Khasi Hills. The plant grows well from an elevation of 300 m upto 3500 m above m.s.l. It has quadrangular stems, covered with white soft hairs, 5-12 by 2-7 cm ovate coarsely serrated leaves bearing white or light purple flowers in terminal or axiliary racemes. It is frequently cultivated for its small seeds (nutlets) used for food and the leaves are cooked as vegetable in Nagaland and Manipur. The seeds yield an aromatic oil which have been used for culinary purposes and burning by the hill people. The leaves and flowering tops also yield 0.3 to 1.3 per cent essential oil having 20 per cent citral in it (Chopra & Varma, 1980). Perilla is widely distributed in the Himalayas, China and Japan. Its primary centre of origin is considered to be China (Zeven & Žhukovsky, 1975). *Perilla* is cultivated in a limited scale in hills of the North - Eastern region, Kumaon, Garhwal and Himachal Pradesh and Kashmir hills in India; Nepal, Burma, Bangladesh (Chittagong hills), China, Japan and Korea. Being a rich source of oil and protein, the seeds are much relished by the hill people in the form of 'chutney'. In Meghalaya the 'chutney' of its seeds is very much enjoyed with 'Sohphlang' (*Moghania vestita)* tubers. The study of the accessions both indigenous and exotic was undertaken to evaluate the potential of this plant as an oil seed crop for hills in India.

Fifteen germplasm collections of *Perilla* from different parts of Meghalaya were made during Nov. - Dec., 1985. These collections were grown in single observational rows at Barapani Farm (Shillong)during *Kharif* season in 1986. The plants were spaced 50 cm from row to row and 20 cm within the row. At planting FYM was applied in rows and basal dose of 40N, 50 P, 40 K kg/ha was applied. No top dressing of nitrogenous fertilizer was given. Observations, on randomly choosen five plants in each accession, were recorded for plant height, number of branches per plant, days to flower, days to maturity and grain yield. Samples of nine *Perilla* introductions obtained from the Republic of Korea were also sown but the seeds of all these were non-viable. However these samples and samples from local collections were analysed for oil and protein content using standard methods.

The germplasm accessions studied showed striking, character variability among the accessions (Table 1) the highest plant height was observed in BD 26 and minimum in case of BD 13. Similarly minimum branches were observed in BD 13 and maximum in

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DKH 21. Earliest maturing variety was BD 2 whereas BD 15 took longest days to mature. Among the characters studied, plant height and grain yield showed maximum variability. Grain yield on per hectare basis was the highest (233 kg/ha) for accession DKH-20, followed by BD-1, DKH-21 and BD-24 and the lowest grain yield was harvested from BD 13. The greatest drawbacks in the material studied were its non-synchronous maturing habit, seed shattering and very short seed viability.

The results of chemical analysis for protein and oil content of seeds of indigenous and exotic collections (Table 2) and seed size also revealed interesting facts about the crop. Seed size showed striking variability as measured by its 100-seed weight as there were 6.4 times differences in size of the smallest to the largest sized seeds. This clearly brings out the possibility of improving grain yield by effecting improvement in the seed size. The oil content varied from 37.48 per cent (DKH 20) to 48.41 percent. EC 216368 with the highest oil content was comparable with local collections BD-6, and DKH-25. The seed size is much improved in all the exotic accessions, as the range for 100-seed weight varied from 0.25858g-(EC 216372) to 0.52780g (EC 216365), whereas for the indigenous collections it varied from 0.0831g (BD 8)*to* 0.12967g (BD 15). Similarly for protein content the range was from 15.665 percent (DKH 20) to 23.7 per cent (EC 216368). Protein content for the exotic material showed a range from 19.798 per cent (EC 216372) to 23.7 per cent whereas it varied from 15.665 per cent to 22.315 per cent (BD 13) in the indigenous collections.

The results discussed above thus demonstrate that the exotic material had undergone selection pressure and consequently the characters studied in these have improved (Leonard and Martin 1963) but this is not the case with indigenous collections. None of the accessions of the indigenously grown material had undergone any conscious selection pressure of the breeders. The possibilities of natural selection as well as selection at farmer's level cannot be ruled out. There is therefore large scope for exploiting the available high diversity for improving grain yield, oil content and protein content of the crop by a judicious breeding programme followed by selection for yield components and evolving short duration varieties with a non-shattering plant character.

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TABLE 1.
Grain yield and other characters of germplasm accessions of Perilla

S.No.	Accession No.	Plant height(cm)	No.of branches	Days to flower	Days to Maturity	Grain yield kg/ha
1.	BD 1	76	18	85	160	216.7
2.	BD 2	58	9	80	147	133.3
3.	BD 5	71	14	86	161	200.0
4.	BD 6	52	10	79	152	100.0
5.	BD 8	34	10	75	161	83.3
6.	BD 13	22	3	77	168	66.7
7.	BD 15	25	3	75	170	70.0
8.	BD 17	75	11	78	151	166.7
9.	BD 22	72	12	77	148	133.3
10.	BD 24	79	17	75	156	216.7
11.	BD 26	85	8	82	159	103.3
12.	DKH 20	83	8	88	156	233.3
13.	DKH 21	64	18	78	151	216.7
14.	DKH 23	40	12	76	158	116.7
15.	DKH 25	42	10	78	157	166.7
	Range	22-85	3-18	75-88	147-170	
	Mean	58.5	10.9	79.3	157.0	
	S.D.	21.4	4.61	4.2	6.63	

TABLE 2
OIL(%) content, protein (%) content and 100-seed weight (g) of Perilla germplasm

Variety	Oil(%)	Protein (%)	Seed Size (100-seed wt.) in grams.
Perilla Local	44.41	21.034	0.10420
EC 216365	40.92	21.705	0.52780
EC 216366	41.23	22.791	0.28525
EC 216367	47.80	22.968	0.29520
EC 216368	47.05	23.700	0.32038
EC 216369	48.41	23.295	0.29243
EC 216370	46.93	20.767	0.27586
EC 216371	40.60	20.737	0.45140
EC 216372	44.81	19.798	0.25858
EC 216373	43.34	21.203	0.44617
BD-1	46.78	21.314	0.09670
BD-2	48.19	19.326	0.11549
BD6	46.52	18.249	0.10322
BD-8	44.97	20.109	0.08310
BD-13	42.60	22.315	0.09924
BD-15	47.44	20.153	0.12967
BD-17	44.66	-	0.11755
BD-22	47.87	20.540	0.12457
BD-24	40.09	16.638	0.14872
BD-26	41.36	18.973	0.11255
DKH -20	37.48	15.665	0.12546
DKH-21	42.64	19.729	0.10790
DKH-23	45.10	18.784	0.12520
DKH-25	48.08	18.621	0.12300

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INDIAN SOCIETY OF OILSEEDS RESEARCH

DIRECTORATE OF OILSEEDS RESEARCH

Rajendranagar, Hyderabad-500 030.

HRDF AWARDS FOR OUTSTANDING OILSEEDS RESEARCH

Background of awards

Indian Society of Oilseeds Research founded in 1983 is a registered society of individuals and organizations/institutions engaged in oilseeds research and development and vegetable oil technology in India. The forempst amongst its objectives is the promotion of research in various aspects of oilseeds production. The society firmly believes that the initiative and dedication on the part of the scientific community is the prime driving force to accelerate the pace of oilseeds research in the country. In our endeavour to recognise outstanding research contributions in various disciplines of oilseeds research and to provide some incentive to the scientists it has been decided to institute fifteen awards, through the kind courtesy of Hexamar Agricultural Research and Development Foundation. The awards are named HRDF AWARDS FOR OUTSTANDING OILSEEDS RESEARCH.

Nature of awards

Cash awards of Rs. 3,000/- each and citation in the following disciplines of oillseeds research :

i) Four awards for varietal improvement of groundnut, rapeseed-mustard, sesame safflower, sunflower, soybean, castor, linseed and niger.

ii) Five awards for insect pest management. Of these one each is earmarked for groundnut and rapeseed-mustard and the rest for sesame, safflower, sunflower, soybean, castor, linseed and niger.

iii) Four awards for diseaes management. Of these one each is earmarked for groundnut and rapeseed- mustard and the rest for sesame, safflower, sunflower, syobean, castor, linseed and niger.

iv) Two awards, for chemical weed control one each in groundnut and soybean.

Eligibility for awards

i) All scientists essentially members of Indian Society of Oilseeds Research (for atleast three consecutive years preceeding the year of award and) working in research centers or departments or laboratories of universities, research institutes, directorates and national research centres under ICAR, CSIR, BARC etc. in India.

ii) Oroginal research work carried out during 5 years preceeding the year of award which has bearing on finding solution to any important problem in the disciplines and crops specified.

iii) Outstanding basic research leading to inventions or discoveries in the disciplines concerned duly supported by publications in journals of repute.

iv) Results of routine experiments and the research work alreday submitted or to be submitted for award of any degree or diploma are not considered.

Presentation of awards

i) Awards will be presented at Annual General Body Meeting of Indian Society of Oilseeds Research.

ii) Hexamar Agricultural Research and Development Foundation will pay TA and DA for recepients of awards as per their entitlement.

iii) Indian Society of Oilseeds Research reserves the right to publish the results of research works selected for the awards and/or submitted for the awards in Journal of Oilseeds Research.

Guidelines for submitting proposals for the awards

i) Nominations for the award may be made by the Directors of Research Institutes, Vice-Chancellors of Agricultural Universfties and Presidents of recognised Scientific Societies. The nominations should invariably be accompnied by eight typewritten copies of proposals containing

a) bio-data giving full name, designation, office address date of **birth, academic qualification** starting from bachelor's degree and experience.

b) an abstract of research contribution not exceeding 500 words

c) certificate stating the research work submitted for HRDF award is the original contribution of investigator (s) duly authenticated by the head of the institution where it was carried out, and

d) detailed technical report in the enclosed proforma.

ii) Nominations should reach the General Secretary, Indian Society of Oilseeds Research, Directorate of Oilseeds Research, Rajendranagar., Hyderabad-500 030 by January 30, 1990.

Judging Committee

i) Consists of (a) (President of Indian Society of Oilseeds Research or his representative from Executive Committee, (b) Director of HRDF or his representative and (c) three experts in each discipline nominated by the President or Executive Committee of ISOR.

ii) In all matters relating to the awards, the decision of the Judging Committee is final and no correspondence on this account shall be entertained.

PROFORMA FOR TECHNICAL REPORT OF THE WORK TO BE SUBMITTED FOR HRDF AWARDS

1. Title of the Project/ResearchProgramme
2. Address of Institute/Research centre/Laboratory where research was carried out
3. Investigator (s) with proportion of contribution of each
4. Year of initiation
5. Year of completion
6. Brief background of the project indicating the importance of the research project/programmes.
7. Objectives
8. Description of the work done
9. Pooled results
10. Implications of the research work
11. Publications in the journal of repute based on results of research work
12. Signature of the investigator(s)
13. Signature of the Head of the Institute.

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