ISSN 0970-2776
Volume 29 Number 2 December 2012

DOR-382.

Journal of Oilseeds Research

Indian Society of Oilseeds Research
Directorate of Oilseeds Research
Rajendrangar, Hyderabad-500 030, India

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(Founded in 1983, Registration Number ISSN 0970-2776)

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The National Academy of Agricultural Sciences has enhanced the rating of the Journal of Oilseeds Research to **3.3** from 2011 instead of 1.0 assigned in 2007.

Journal of Oilseeds Research is published biannually by the Indian Society of Oilseeds Research

JOURNAL OF OILSEEDS RESEARCH

Previous Issue : Vol. **29**, No. 1, pp. 1-115

Vol. **29**, No. 2 December, 2012

DOR-382
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CONTENTS

Variation in blanchability in Virginia groundnut (*Arachis hypogaea* L.)

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(Received: December, 2011; Revised: November, 2012; Accepted: November, 2012)

ABSTRACT

Blanchability is ease of testa /skin removal and cleaning of the groundnut (*Arachis hypogaea* L.) kernel surface. It is a trait of economic importance in processed groundnut food products. The blanching conditions of pre-heating temperature of 110°C for 35 min, with 200 g kernel sample at a blanching time of 2 min and blanching air pressure of 17.6 psi, which gave satisfactory results, were standardized. Ten Virginia bunch large-kernel groundnut varieties grown in 2007 rainy season and 2007/08 postrainy season at the ICRISAT Centre were evaluated for their blanchability. There was large variation in total blanchability among the genotypes, ranging from 14 to 60% in the rainy and 35 to 55 % in the postrainy season. ICGV 03137 (60% in rainy season and 54% in postrainy season) had the maximum total blanchability. The whole kernel blanchability was also the highest (>40%) with <3% unblanched splits in ICGV 03137 in both the seasons. No physical (100-kernel weight, kernel length, width and length to width ratio) or chemical (oil and protein contents) trait was associated with blanchability parameters (total blanchability, whole blanched kernels and fully blanched splits) in the 2007 rainy season. However, in the 2007/08 postrainy season, oil content showed positive and protein content and kernel length negative association with blanchability parameters. Preliminary studies by other workers indicate that blanchability character gets fixed in early generations. It is, therefore, important to select parents carefully with high blanchability in a confectionery breeding program to ensure that progenies have high probability of retaining high performance for the trait.

Keywords: Confectionery trait, Seed testa, Virginia groundnut

Groundnut (*Arachis hypogaea* L.) is a multi-purpose crop used for food, edible oil, feed for livestock, and industrial raw material. Globally, over half of the groundnut produced is crushed into oil for human consumption and slightly less than 40% is used directly as food. However, the pattern of utilization varies widely across the regions. In North and Central America, over 75% of the production is used as food while in Asia only 35% is used for the same purpose. Thus, breeding groundnuts for confectionary traits is important, to meet the growing domestic groundnut demand for food purposes in the country and to harness the International trade of confectionary groundnuts for the benefit of groundnut farmers of the developing countries.

Blanchability is the capacity of a groundnut genotype to recover kernels with all the testa removed. It is a confectionery trait of economic importance in processed groundnut food products, which include peanut butter, salted groundnuts, candies, bakery products, groundnut flour and others. If a groundnut cultivar has poor blanchability, the cost of processed food increases as more efforts are needed to remove the skin from kernels. Blanching treatment gives a whiter and more homogeneous appearance to groundnut products. This process further enhances the product quality, as it subjects the kernels to an additional pre-cleaning and sorting stage. Removal of the groundnut skin facilitates electronic eye sorter detection of any damaged kernels which may have been concealed by the skin and therefore not previously visible under regular cleaning and sorting procedures. Blanching of kernel followed by removal of damaged or discolored kernels using electronic color sorter reduces aflatoxin in all market types and grades of groundnut (Whitaker, 1997). The skins are removed from groundnut kernels by a combination of different processes: drying, heating, rubbing between hard and soft surfaces, and blowing a current of air through them. The rate of heating or drying of groundnuts during blanching as well as the rate of cooling is important in maintaining crispiness and white color. Rapid heating and quick cooling gives a much more crisp and white appearance; while prolonged heating causes the oil to flow throughout the tissue which becomes translucent in color and gummy when crushed. Blanchability of groundnut kernel is affected by genotype, kernel grade and harvest date (Mozingo, 1979) and pre-treatment of kernels (Farouk *et al.*, 1977).

Blanchability remains a neglected trait in most of the breeding programs in developing countries. However, at the processors' level, where commercial blanchers are used, it is an important economic trait. Often an otherwise good cultivar receives discounted price in the market to compensate the increased cost of blanching if the blanchability of a cultivar is poor. This discourages farmers to grow such cultivars. For programs engaged in breeding groundnut for food use, blanchability should be a regular trait in evaluating the performance of advanced breeding lines. Several laboratory-scale blanchers have been fabricated to assist the breeding programs (Barnes Jr. *et al.*, 1971, Wright and Mozingo, 1975, Hoover, 1979 and Singh *et al.*, 1996). The American Society of Agricultural and

Biological Engineers (ASABE) in 2006 published the following protocol for determining blanchability using laboratory blancher developed by Wright and Mozingo (1975): kernel sample weight 250 g, pre-heating at 200°C for 9 min (the pre-heat should lower the kernel moisture content between 3.75-4.0%) and then allow to cool to room temperature, blanching duration 180±25 sec for extra-large kernels and 240±25 sec for medium size kernel and air pressure at 121±0.5 kPa (17.6 ± 0.1 psi).

The present experiment was aimed to study variation in blanching traits among 10 large-kernel Virginia groundnut advanced breeding lines and to identify the best genotype(s) for use in breeding programs.

MATERIALS AND METHODS

Blanching protocol was standardized using a bulk sample of large-kernel (kernel moisture content 5.2% and 100-kernel weight 97 g) Virginia groundnut variety, ICGV 98426, which was grown in the postrainy season. A laboratory type blancher, based on the model developed by Wright and Mozingo (1975), was fabricated at ICRISAT Center (Singh *et al.*, 1996). Blanching conditions such as heating temperature and time before blanching (pre-heating), blanching time, air pressure and quantity of sample were standardized. Initially, blanching protocol of Wright and Mozingo (1975) was followed. But at 200°C temperature, the groundnut kernels got overheated. We tried a range of temperature from 76°C to 200°C for 9 min, but within these parameters either a sample did not blanch properly or the sample got overheated. Then, we followed the temperature protocol (pre-heating temperature of 100°C for 35 min with a sample weight of 250 g) used by Cruickshank *et al.* (2003) with an Ashton abrasive-roller blanching unit. However, this protocol resulted in only 65% of totally blanched kernels. By increasing the pre-heating temperature to 110°C for 35 min and reducing the weight of sample to 200 g, the per cent total blanched kernel increased to 92%. Thus, for the present experiment, a pre-heating temperature of 110°C for 35 min, with 200 g sample for blanching time of 2 min and blanching air pressure of 17.6 psi was standardized.

Blanchability trait was studied in the kernel samples of 10 different large-kernel Virginia groundnut genotypes grown in two cropping seasons. Two controls, ICGV 86564 (popular large-seeded variety from ICRISAT) and Somnath (national large-seeded control in India), were included in the experiment. The experiment was laid out on raised beds in an Alfisols field in a randomized block design with two replications during the 2007 rainy season (R 07) and with three replications in the 2007/08 postrainy season (PR 07/08) at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT, 17° 30' N; 78° 16' E; altitude 549 m), Patancheru. The plot size was four rows of 4 m length. A distance of 30 cm between rows and 10 cm between plants within a row was maintained. P_2O_5 @ 60 kg/ha was applied basally and gypsum @ 400 kg/ha was top dressed at peak flowering stage followed by intercultivation. The experiment was kept weed free by application of pre-emergence herbicide Alachlor @ 4 L/ha and two manual weedings. The crop was regularly monitored for diseases and insect pest incidence in both the seasons and necessary chemical sprays were carried out to protect the crop. During the rainy season, the experiment received 6 irrigations and in the postrainy season 15 irrigations to avoid moisture stress to the crop. It took 135 days in the rainy season and 145 days during the postrainy season for the crop to reach maturity. After harvest, the produce was shade-dried, pods were shelled and kernels were stored at room temperature (20±1°C) until blanching.

In both rainy and postrainy season, observations on the pod yield, kernel yield, shelling outturn, 100-kernel weight, kernel length and width, oil content, protein content and oleic/linoleic fatty acid ratio were taken in all the 10 genotypes and controls. In the postrainy season, the kernels were graded and sound mature kernel (SMK) yield of grade 1-3 kernels (described later) was recorded. Kernel length and width were an average of twenty randomly selected grade 1 kernels. During the rainy season, blanching studies were carried out after storing the kernel for 3-4 months, but in the postrainy season, the studies were carried out soon after harvest and drying. The first grade kernel of each variety (200 g) was used for blanching studies. For this control, a pooled sample of all the three replications was used. The percentage of total blanched (TB, includes fully blanched intact kernels and fully blanched splits), whole blanched (WB, fully blanched intact kernels), whole unblanched (UB, unblanched intact kernels), partially blanched (PB, partially blanched intact kernels), blanched splits (SB, fully blanched splits) and unblanched splits (UBS) were determined on weight basis. Nuclear magnetic resonance (NMR) was used for oil estimation. The protein content was analyzed using a Technicon autoanalyser II (Technicon industrial systems, Tarrytown, New York). Using gas chromatography (GC) oleic and linoleic fatty acid contents were estimated.

In the rainy season, blanching tests were carried out with ungraded kernel samples. However, in the postrainy season, where yields were nigh and kernel size was large (and associated variation in seed size was more), the kernels were graded to eliminate the effect of varying seed size on blanchability. Kernels were graded using a mechanized grader with different sieve sizes as per US standard grades (extra-large grade: rides over 20/64 x 1 inches screen; medium grade: rides over 18/64 x 1 inches, No. 1 grade: rides over 15/64 x 1 inches screen and No.2 17/64 inches round screen) (NPCA, 1988). Extra-large kernels were used for the blanchability study in the postrainy season.

Data from individual seasons were analyzed using GENSTAT (8.0 Version) separately and summary statistics

were tabulated. Angular transformed values were used for analysis. As sufficient quantity of grade 1 kernel in Somnath was not available in the 2007/08 postrainy season, the grade 1 kernels from two replications were pooled and the third replication, where no grade 1 kernel was available, was treated as missing value.

RESULTS AND DISCUSSION

The standardized blanching protocol included 200 g kernel sample, pre-heating temperature of 110°C for 35 min, blanching time of 2 min and blanching air pressure of 17.6 psi. The protocols standardized earlier (Barnes *et al.*, 1971 and Singh *et al.*, 1996) also reported satisfactory laboratory blanching by operating the device for 120 sec at 17.6 psi pressure.

As observations on blanchability parameters were recorded in different manners (on bulk kernel sample in the 2007 rainy season and on grade 1 kernel in the 2007-08 postrainy season) in both the seasons, no pooled analysis was carried out. The data for both the seasons were analyzed separately. Genotypes differed significantly for all the six blanchability parameters in both the seasons (Table 1). The genotypes also differed in moisture loss during blanching. In spite of apparent uniform drying/storage conditions, genotypes retained different levels of moisture in kernels. The total blanchability (TB%) among genotypes ranged between 14 and 60.4% (average 34.3%) in the rainy season and between 35 and 62.5% (average 46.3%) in the postrainy season. The lower shelling turnover (SH%) and 100 seed weight (HKW) in the rainy season reflect poor seed development (shriveling of seeds), which might have contributed towards lower TB. In a study conducted on 35 Spanish and 45 Virginia genotypes, a high range for total blanchability in Spanish (10.8% - 90.6%) and Virginia (8.6-86.7%) types was observed (Singh *et al.*, 1996).

Table 1 Blanchability parameters of advanced Virginia breeding lines of groundnut during the 2007 rainy season (R 07) and the 2007/08 postrainy season (PR 07/08), ICRISAT, Patancheru, India

Genotype	MOL (%)		WBL (%)		UBL (%)		PBL (%)		SBL (%)		USBL (%)		TB (%)	
	R 07	PR 07/08	R 07	PR 07/08	R 07	PR 07/08	R 07	PR 07/08	R 07	PR 07/08	R 07	PR 07/08	R 07	PR 07/08
ICGV 01369	10.8	11.3	8.8	24.5	46.7	36.0	24.2	21.9	15.7	28.6	10.4	9.4	18.2	40.2
	(3.5)	(3.9)	(2.6)	(18.7)	(53.0)	(34.6)	(17.4)	(13.9)	(7.5)	(23.1)	(6.3)	(4.6)	(10.1)	(41.8)
ICGV 01395	9.8	10.8	22.8	24.4	31.2	36.57	28.3	19.0	28.6	32.4	14.9	7.8	38.1	42.7
	(2.9)	(3.5)	(15.1)	(17.2)	(27.0)	(35.5)	(22.5)	(10.8)	(23.0)	(28.8)	(6.7)	(2.9)	(38.1)	(46.0)
ICGV 01432	10.6	12.8	8.7	24.7	49.3	35.8	29.0	15.0	10.9	30.1	16.6	9.3	14.0	41.7
	(3.4)	(4.9)	(2.3)	(18.2)	(57.3)	(34.9)	(23.9)	(9.9)	(3.7)	(26.1)	(8.5)	(4.1)	(6.0)	(44.4)
ICGV 01434	10.8	11.8	11.2	23.9	45.2	31.8	31.3	29.9	11.0	24.6	18.2	15.4	15.8	35.8
	(3.6)	(4.2)	(4.0)	(16.7)	(50.4)	(27.9)	(27.2)	(25.7)	(4.1)	(17.6)	(9.7)	(7.0)	(8.1)	(34.3)
ICGV 05168	10.3	12.0	32.2	31.7	33.9	25.8	22.1	16.6	23.0	36.8	10.5	8.2	41.5	53.1
	(3.2)	4.3)	(28.3)	(28.0)	(31.6)	(19.0)	(14.6)	(8.3)	(15.6)	(35.9)	(3.4)	(3.1)	(43.9)	(63.9)
ICGV 03136	9.7	11.5	24.2	28.9	40.0	26.8	21.6	12.7	23.9	41.1	14.8	2.99	35.3	54.8
	(2.9)	4.0)	(16.9)	(23.4)	(41.3)	(20.4)	(13.8)	(7.1)	(16.5)	(43.2)	(6.7)	(0.8)	(33.3)	(66.6)
ICGV 03137	10.2	12.1	48.6	41.3	21.49	19.9	12.6	11.2	25.8	26.9	0.0	2.6	60.4	54.1
	(3.2)	(4.6)	(56.3)	(44.2)	(13.5)	(14.2)	(4.9)	(5.8)	(19.1)	(21.1)	(0.0)	(0.6)	(75.4)	(65.3)
ICGV 05191	10.4	11.1	20.2	37.2	42.5	33.1	29.3	14.4	15.0	22.4	15.2	6.47	25.8	46.0
	(3.3)	(3.7)	(12.0)	(36.6)	(45.8)	(30.1)	(24.6)	(9.1)	(6.9)	(15.1)	(7.1)	(1.9)	(18.9)	(51.7)
ICGV 05195	9.3	11.6	18.1	30.5	36.1	25.5	28.5	17.7	23.0	37.6	19.6	6.5	30.1	52.7
	(2.6)	(4.1)	(9.7)	(25.8)	(34.8)	(19.1)	(22.8)	(9.6)	(15.4)	(37.3)	(11.7)	(2.1)	(25.1)	(63.1)
ICGV 05200	10.3	11.7	15.7	23.2	41.7	43.2	25.9	20.0	20.8	24.6	19.7	9.1	26.5	35.0
	(3.2)	(4.1)	(7.3)	(15.6)	(44.4)	(46.8)	(19.1)	(11.7)	(12.7)	(17.4)	(11.7)	(4.1)	(20.0)	(33.0)
Controls														
*Somnath	9.5	7.2	35.81	59.2	30.1	21.3	19.8	-	28.0	21.6	0.0	-	48.8	62.5
	(2.7)	(1.4)	(34.3)	(73.0)	(25.2)	(13.4)	(11.6)		(22.3)	(13.2)	(0.0)		(56.6)	(78.0)
ICGV 86564	9.5	11.4	41.4	28.9	20.8	26.2	17.1	18.9	31.6	31.4	2.9	6.1	57.7	46.9
	(2.7)	(3.9)	(43.8)	(24.4)	(12.6)	(20.0)	(8.8)	(16.7)	(27.5)	(28.9)	(0.5)	(3.3)	(71.3)	(53.2)
GM	10.1	11.3	23.97	31.5	36.6	30.2	24.2	16.3	21.4	29.8	11.9	6.7	34.3	46.3
	(3.1)	(4.0)	(19.4)	(25.7)	(36.4)	(27.1)	(17.6)	(11.3)	(14.5)	(26.4)	(6.0)	(3.0)	(33.9)	(52.1)
LSD at 5% level of significance	1.8	2.14	7.01	10.3	8.5	11.34	8.15	16.79	2.78	11.39	9.6	10.1	6.7	14.8
	(1.11)	(1.61)	(9.1)	(15.7)	(14.5)	(16.8)	(10.9)	(15.9)	(3.72)	(17.8)	(7.2)	(5.7)	(8.8)	(24.4)
CV (%)	8.2	11.2	13.3	19.2	10.5	22.1	15.3	60.4	5.9	22.4	36.8	89.4	8.9	17.8
	(16.3)	(22.4)	(21.4)	(34.0)	(18.1)	(34.4)	(28.2)	(78.2)	(11.6)	(37.6)	(54.6)	(103.4)	(11.9)	(26.1)

* In the absence of sufficient quantity of Grade I kernel in each replication, first grade kernel from all replications was pooled to carry out blanchability experiment.
MOL: Moisture lost during blanching, WBL: whole blanched intact kernels: UBL: Unblanched intact kernels; PBL: Partially blanched intact kernels: SBL: Fully blanched splits; UBSL: Unblanched splits; TB : Total blanchability; Note-Numbers in parenthesis are angular transformed values.

Whole blanched intact kernels (WBL%) are fancied and have visual appeal. In some confectionery products such as groundnut with chocolate coatings, fully blanched whole seeds are required. Like TB%, the WBL% was also affected by the season. In the postrainy season more intact fully blanched kernels were recovered (31.5%) compared to the rainy season (24.0%). Among the advanced breeding lines, genotype ICGV 03137 had high WBL% in both the seasons. This genotype also had low proportion of UBL in both the seasons. Genotypes such as ICGV # 01369, 01432, 01434

and 05200, which had higher proportion of UBL, will add to the processing cost if they are to be used in a blanched form. The same will happen with genotypes with higher partially blanched kernels. On average, more fully blanched splits were recovered in the postrainy season than in the rainy season. The greater HKW and better kernel development in the former season might have resulted in higher full blanching and as well as splits. Diener *et al.* (1982) noted that blanching followed by photoelectric color sorting and hand picking provides a reliable method to remove *Aspergillus flavus*/aflatoxin contaminated kernels from the lot. Blanched splits, after photoelectric color sorting, are preferred for peanut butter and other processed peanut food preparations, as they permits easy removal of germs and also have reduced or nil aflatoxin contamination. Genotypes ICGV 03136 (41%) and ICGV 05168 (36.8%) in the postrainy season and ICGV 01395 (28.6%) and ICGV 03137 (25.8%) in the rainy season gave the highest percentage of blanched splits. These genotypes would be suitable for candies and peanut butter preparation. As reported by Farouk *et al.* (1977) and Singh *et al.* (1996) in their studies, the influence of growing season on the blanching quality of groundnut genotypes was also evident in our study.

Commercially, kernel is initially graded before being blanched. The postrainy season kernel was graded with the sieves of different sizes as per US standard grades (NPCA, 1988). The mean quantity of grade 1 kernel obtained (1102 kg/ha) was significantly higher than the quantities in grades 2 and 3 (Table 3). The percent recovery of grade 1 kernel was high in test genotypes. ICGV 01395 (79%), ICGV 05200 (73%), ICGV 03136 (72%), ICGV 01434 (70%) and ICGV 01432 (66%) recorded significantly superior recovery of grade 1 kernel over the best check ICGV 86564 (50%). Grade 1 kernel with higher HKW is preferred for table purposes. The test entries recorded high HKW (91 g-108 g) for the grade 1 kernel. ICGV 01395 (Grade 1 kernel yield 1689 kg/ha and HKW 91 g), ICGV 05200 (Grade 1 kernel yield 1591 kg/ha and HKW 96 g) and ICGV 01432 (Grade 1 kernel yield 1392 kg/ha and HKW108 g) are suitable for the table purpose (Table 3).

Table 2 Performance of groundnut breeding lines during the 2007 rainy season at ICRISAT, Patancheru, India

Genotype	PYD (kg/ha)	KYD (kg/ha)	SH (%)	HKW (g)	OIL (%)	PRO (%)	O/L	KL (cm)	KW (cm)	KL/W
ICGV 01369	1850	1131	62	53	42	22	1.61	1.8	0.85	2.12
ICGV 01395	2706	1739	64	52	43	20	1.34	1.6	0.90	1.78
ICGV 01432	2028	1314	65	52	44	22	1.87	1.75	0.85	2.06
ICGV 01434	2161	1341	62	50	41	21	1.6	1.75	0.85	2.06
ICGV 05168	2367	1491	63	57	44	21	1.3	1.75	0.85	2.06
ICGV 03136	2322	1505	64	58	40	20	1.61	1.7	0.9	1.89
ICGV 03137	1617	1041	64	48	48	18	1.41	1.6	0.8	2.01
ICGV 05191	2378	1538	65	54	41	21	1.38	1.6	0.85	1.89
ICGV 05195	1511	989	65	51	43	24	1.77	1.7	0.8	2.13
ICGV 05200	*2889*	*1834*	*63*	*61*	*43*	*20*	*1.34*	*1.6*	0.9	1.94
Controls										
Somnath	1667	1068	65	41	46	21	2	2	1	2.14
ICGV 86564	2450	1696	70	51	46	20	2	2	1	1.89
GM	2162	1391	64.36	52.33	43.33	21.03	1.57	1.675	0.85	1.99
SE	209.1	133.7	1.25	1.79	1.26	0.50	0.10	0.074	0.07	0.09
CV	11.85	11.77	2.36	4.18	3.55	2.9	8.03	5.36	9.2	5.61
LSD	460.3	294.2	2.74	3.93	2.77	1.09	0.23	0.16	0.13	0.20

The oleic (O)/ linoleic (L) fatty acid ratio is an indicator of shelf-life of groundnut products. Although the differences for O/L ratio among the genotypes were significant, they were marginal and all genotypes had an O/L ratio value of 2. High protein content is desirable in groundnut used for direct consumption and in confectionery products. Similarly, low oil content (low calorific value) is favoured in genotypes meant for direct consumption. The data on these traits are given in table 2 and 3. In both rainy and postrainy season, the protein content of the genotypes, ICGV 05195 (24% and 27%), ICGV 01369 (22% and 24%) and ICGV 01432 (22% and 24%) was significantly high. All the tested genotypes recorded <45% oil content in rainy season except ICGV 03137 (48%). In the postrainy season, the range of oil content between genotypes was 42% to 46%.

Agronomic performance of ten genotypes in rainy and post rainy seasons is given in tables 2 and 3. The test genotypes in general yielded on par with the best check in both rainy and postrainy seasons. The contribution of grade 1 kernel to the SMK yield was significantly superior in test genotypes (>57% in seven genotypes) over the best check (50%). Mean pod (by 948 kg/ha) and kernel yield (by 768 kg/ha), HKW (by 20 g) and protein content (by 3%) were higher in the postrainy season compared to the rainy season.

Kernels were more elongated in the rainy season than in the postrainy season (Tables 2 and 3).

The capacity to select for improved blanchability in a confectionery breeding program is essential for economic reasons. Based on their limited genetic data, Shokraii *et al.* (1985) reported dominant or semi-dominant nature of poor blanchability. From their study on blanchability in early generation breeding materials, Cruickshank *et al.* (2003) that early generation selection for blanching (%) was very effective and genes conferring better blanchability were fixed early. Thus, the parents selected for hybridization should have high blanchability to ensure that resultant progenies are also high in the trait. Mozingo (1979) also came to the similar conclusion from his study. Further, this is also important as the selection for blanchability cannot be done on a single plant basis due to significant kernel quantity requirement for blanching test.

Table 3 Performance of groundnut breeding lines during 2007/08 post rainy season at ICRISAT, Patancheru, India

Genotype	PYD (kg/ha)	KYD (kg/ha)	SH (%)	HKW (g)	OIL (%)	PRO (%)	SMK (kg/ha)	SMK yield (kg/ha)			IMK (kg/ha)	SMK yield (%)			IMK (kg/ha)	GR 1 HKW	GR 1 KL (cm)	GR 1 KW (cm)	KL/W	O/L
							Total	GR 1	GR 2	GR 3	GR 4	GR1 (%)	GR2 (%)	GR3 (%)	GR 4 (%)					
ICGV 01369	3594	2150	66	79	45	24	1890	1187	276	427	260	63	15	23	12	104	2	1.09	1.68	1.85
ICGV 01395	4267	2417	66	64	46	22	2142	1689	241	213	274	79	11	10	11	91	2	1.07	1.56	1.43
ICGV 01432	3922	2424	68	79	46	24	2067	1392	269	406	357	66	13	21	15	108	2	1.14	1.68	1.71
ICGV 01434	4017	2616	68	80	45	24	2211	1543	325	342	406	70	15	15	17	105	2	1.29	1.50	1.71
ICGV 05168	3450	2004	69	78	44	20	1624	789	271	565	380	49	17	35	18	99	2	1.11	1.75	1.20
ICGV 03136	3928	2419	66	66	44	24	1766	1277	220	268	653	72	13	16	27	95	2	1.12	1.74	1.64
ICGV 03137	3972	2304	67	73	46	22	1904	946	333	625	399	47	17	36	17	96	2	1.07	1.82	1.34
ICGV 05191	3406	2024	67	76	42	25	1624	1023	237	364	400	63	15	22	20	99	2	1.13	1.66	1.30
ICGV 05195	3172	1738	68	80	44	27	1541	853	247	440	198	55	16	29	11	103	2	1.06	1.66	1.92
ICGV 05200	3972	2406	70	79	44	24	2125	1591	273	262	281	73	14	13	12	96	2	1.06	1.77	1.65
Somnath	3356	1454	61	51	45	23	1142	136	121	886	312	11	11	78	22	83	1	0.75	1.82	1.49
ICGV 86564	3450	1958	67	69	46	23	1557	798	245	514	401	50	15	35	21	95	2	1.10	1.75	1.67
GM	3709	2159	67.31	72.64	45.3	23.9	1799	1102	254.7	442.6	360.1	58.2	14.17	27.63	16.9	98.19	1.83	1.08	1.70	1.58
SE	448.4	336.4	4.09	10.84	1.05	0.76	296.3	262.7	62.87	123.9	133.7	7.62	2.146	8.036	5.274	5.14	0.07	0.07	0.11	0.09
CV	14.81	19.08	7.45	18.27	2.85	3.93	20.16	29.2	30.23	34.28	45.47	16.0	18.54	35.62	38.22	6.418	4.57	8.14	8.27	7.36
LSD	986.9	740.4	9.01	23.86	2.32	1.69	652	578.2	138.4	272.7	294.3	16.7	4.723	17.69	11.61	11.33	0.15	0.15	0.25	0.20

PYD: Pod yield; KYD: Kernel yield; SH: Shelling percentage; HKW: Hundred kernel weight; PRO: Protein; SMK: Sound mature kernel yield; IMK: Immature kernel yield; GR1: Grade 1; GR2: Grade 2; GR3: Grade 3; GR 4: Grade 4; GR1 HKW: Grade 1 hundred kernel weight; GR1 KL: Grade 1 kernel length; GR1 KW: Grade 1kernel width; SD L/W: Kernel length, width ratio; O/L: ratio of oleic to linoleic fatty acid

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Effect of integrated nutrient management on growth, yield, quality and economics of soybean (*Glycine max* L.)

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(Received: January, 2012; Revised: August, 2012; Accepted: December, 2012)

ABSTRACT

A field experiment was conducted during rainy seasons of 2010 and 2011 at experimental farm of Nagaland University, Medziphema to evaluate the integrated nutrient management practices on productivity, quality, nutrient uptake and economics of soybean (*Glycine max* L. Merrill) variety JS-97-52 grown in acidic soils. Results indicated that application of FYM @ 5 t/ha + RDF (20-60-30 kg/ha N-P_2O_5-K_2O) + biofertilizer + S @ 30 kg/ha + Co @ 1 kg/ha was found to be effective in improving the soybean grain yield (2690.5 kg/ha), protein (40.31%) and oil content (20.11%) and nutrient (221.1-20.9-82.2-17.71 kg/ha N-P-K-S) uptake. Similarly, net return (₹59775.0) and benefit cost ratio (2.85) was also recorded higher. The next best treatment was FYM @ 2.5 t/ha + RDF + biofertilizer + S @ 30 kg/ha + Co @ 1 kg/ha. The minimum seed yield (1080 kg/ha), protein (36.56%) and oil content (16.20%), nutrient (85.6-7.5-35.2-5.74 kg/ha N-P-K-S) uptake, net return (₹16625) and benefit cost ratio (1.05) was recorded under control.

Keywords: Biofertilizer, Cobalt, Farmyard manure, Nutrient uptake, Soybean, Sulphur

Soybean (*Glycine max* L. Merrill) is established as premier oilseed crop covering an area of 9.3 million ha with the production of 10.47 metric t. in India (AICRP, 2010). Soybean being a high protein and energy rich crop and its productivity is often limited by the low availability of essential nutrients or imbalanced nutrition in India. Hence, a balanced nutrient application is must to harness the productivity of the crop. Soybean being a legume crop can fixes nitrogen (N) from the atmosphere in conjunction with its microbial symbiont Rhizobium. Continuous use of chemical fertilizers has reduced productivity and resulted in imbalance of nutrients in the soil, which has adverse effects on soil health. Use of organic manures alone or in combination with chemical fertilizers will help to improve physico-chemical properties of the soils (Prasanna and Kumar, 2011). Sulphur (S) is an important secondary nutrient which helps in synthesis of amino acids (cystein, methionine), chlorophyll, vitamins, metabolism of carbohydrates; oil content and protein content and also associated with growth and metabolism (Najar *et al.*, 2011). Sulphur also helps in nitrate reduction and assimilation of nitrogen by root nodule bacteria. Bacteria on root nodules of legumes require cobalt (Co) to synthesize B_{12} for nitrogen fixation. Application of Co decreased inhibitory effect of nitrate on nodulation and significantly increased number and size of the nodule (Jain and Nainawatee, 2000). Cobalt also promotes many developmental processes including stem and coleoptiles elongation, opening of hypocotyls hooks, leaf disc expansion and development (Kandil, 2007). Under condition of Co deficiency, methionine synthesis is depressed which leads to lower protein synthesis of heme (iron porphyrins) in the bacteriods. Keeping these facts, a field experiment was conducted to investigate the effect of farmyard manure (FYM), biofertilizer, S and Co on growth, yield, quality, nutrient uptake and economics of soybean.

MATERIALS AND METHODS

The field experiment was carried out during rainy seasons of 2010 and 2011 in the Experimental Research Farm of School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema, Nagaland. The farm is located at an altitude of 310 m with the geographical location of 25°45'45" N latitude and 93°53'04" E longitude. The soil of the experimental farm is sandy loam in texture with pH 4.5 and 13.0 g/kg organic carbon. The available N, P_2O_5, K_2O and S content are 250.8, 17.9 and 165.3 and 9.82 kg/ha, respectively. The experiment was laid out with three replications in randomized block design with twelve treatments (Table 1). A common dose of nitrogen @ 20 kg, phosphorus @ 60 kg and potassium @ 30 kg/ha were applied as basal through diammonium phosphate and muriate of potash, respectively. Before one month of sowing FYM (0.46-0.22-0.52% N-P-K, respectively) was applied as per treatments and seeds were treated with biofertilizer (*Bradyrhizobium japonicum* + phosphotica) @ 20g/kg seed except control (T_1) and RDF (T_2). Sulphur and Co @ 30 and 1 kg/ha was applied through phosphogypsum and cobalt chloride, respectively as per treatments. Soybean variety JS-97-52 was used as the test crop. Seeds were sown during second fortnight of June and harvested at physiological maturity during both the years. All the cultural practices were followed as per package of practices. The data on dry weight, nodule number, nodule dry weight and branches/plant were

Efficacy of soil amendments with neem cake and bio-control agent on the incidence of Macrophomina stem and root rot of sesame (*Sesamum indicum* L.)

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(Received: May, 2012; Revised: November, 2012; Accepted: December, 2012)

ABSTRACT

Stem and root rot of sesame (*Sesamum indicum* L.) caused by *Macrophomina phaseolina* infects high percentage of plants and consequently leads to significant yield losses in rainfed crop especially in Rajasthan. The continuous use of chemicals has deleterious effect on the beneficial microorganism in soil, in addition to the residual problem and development of resistance by the pathogen. Field experiments were conducted during rainy seasons of 2006 and 2007 at Agricultural Research Station, Mandor - Jodhpur (Rajasthan) to find out the efficacy of soil amendments with neem cakes and with bio-control agent (*Trichoderma viride*) on the incidence of stem and root rot of sesame. Minimum incidence of stem and root rot (3.32%) and highest seed yield (924 kg/ha) was recorded in soil application of neem cake (250 kg/ha) + seed treatment with *Trichoderma viride* (0.4%) + soil application of *Trichoderma viride* @ 2.5 kg/ha. This treatment gave 82.27% disease control and 43.92% yield increase with B:C ratio of 2.88.

Key words: Bio-agent, *Macrophomina phaseolina*, Neem cake, Seed treatment, Soil application, *Trichoderma viride*

Sesame (*Sesamum indicum* L.), commonly known as til is the oldest indigenous oilseed crop. Sesame diseases under favourable conditions in rainy season cause significant loss in yield (10-100%). Stem and root rot of sesame caused by *Macrophomina phaseolina* infects high percentage of plants and consequently leads to yield losses in rainfed crop especially in Rajasthan. The continuous use of chemicals has deleterious effect on the beneficial microorganism in soil, in addition to the residual problem and development of resistance by the pathogen. In earlier studies, it was observed that seed treatment with *Trichoderma viride* was found effective for the management of Macrophomina stem and root rot of sesame (Rajpurohit, 1999). Integrated disease management plays a vital role in increasing the productivity. On the basis of results of earlier studies, efforts were made to test seed treatment in combination of soil application of bio agent and neem cake for management of Macrophomina stem and root rot under field conditions in the present study.

An experiment was conducted in randomized block design with five treatments and four replications with plot size of 4 m x 2.4 m, on sesame during rainy season of 2006 and 2007 at Agricultural Research Station, Mandore, Jodhpur (Rajasthan) to find out the efficacy of soil amendments with neem cakes and with bio-control agent on the incidence of Macrophomina stem and root rot. Details of the treatments were neem cake (500 kg/ha), neem cake (250 kg/ha), neem cake (250 kg/ha) + seed treatment with *Trichoderma viride* (0.4%) + soil application of *Trichoderma viride* @ 2.5 kg/ha, seed treatment with *Trichoderma viride* (0.4%) + soil application of *Trichoderma viride* @ 2.5 kg/ha and control. The cake was incorporated in soil and mixed thoroughly before sowing. The bio-agent *Trichoderma viride* was added in farm yard manure 15 days prior to its application and kept in shade and the incidence of Macrophomina stem and root rot was recorded before harvesting.

Minimum incidence of Macrophomina stem and root rot (3.32%) and highest seed yield (924 kg/ha) was recorded in soil application of neem cake (250 kg/ha) + seed treatment with *Trichoderma viride* (0.4%) + soil application of *Trichoderma viride* @ 2.5 kg/ha this was followed seed treatment with *Trichoderma viride* (0.4%) + soil application of *Trichoderma viride* @ 2.5 kg/ha (percentage disease index 6.08%, seed yield-816 kg/ha). Highest disease (18.17%) was recorded in control. The sesame stem and root rot can be managed by soil amendment with neem, castor, and mustard cake @ 1.0 t/ha (Rajpurohit, 2008). The efficacy of cakes might be due to antifungal substances which inhibited the growth of the pathogen but not so inhibitory against natural antagonist micro biota especially fungal antagonists present in the soil (Dubey and Patel, 2000). Two years experimental results revealed that soil application of neem cake (250 kg/ha) + seed treatment with *Trichoderma viride* (0.4%) + soil application of *Trichoderma viride* @ 2.5 kg/ha reduced Macrophomina stem and root rot from 18.17 to 3.32% and increased seed yield from 642 kg/ha to 924 kg/ha with B:C ratio of 2.88 (Table 1). Hence, for organic sesame production soil application of neem cake (250 kg/ha) + seed treatment with *Trichoderma viride* (0.4%) + soil application of *Trichoderma viride* @ 2.5 kg/ha may be recommended for management of stem and root rot disease of sesame.

Table 1 Studies on the efficacy of soil amendments with neem cakes and bio-control agents on the incidence of stem and root rot in sesame

Treatment	Macrophomina stem and root rot (%)			Seed yield (kg/ha)			B:C
	2006	2007	Mean	2006	2007	Mean	ratio
Neem cake (500 kg/ha)	6.40 (14.65)*	5.79(13.88)*	6.09	696	1042	869	1.72
Neem cake (250 kg/ha)	8.43(16.85)*	8.53(16.94)*	8.48	553	944	748	1.61
Neem cake (250 kg/ha) +seed treatment with *Trichoderma viride* (0.4%) – soil application of *Trichoderma viride* @ 2.5 kg/ha	4.87 (12.74)*	1.78(7.40)*	3.32	708	1140	924	2.88
Seed treatment with *Trichoderma viride* (0.4%) + soil application of *Trichoderma viride* @ 2.5 kg/ha	7.31(15.67)*	4.85 (12.64)*	6.08	625	1008	816	5.46
Control	15.31 (22.95)*	13.03 (21.08)*	18.17	423	861	642	-
SEm ±	0.80	1.24		35.1	31.4		
CD (P=0.05)	2.63	2.71		114	68.4		
CV (%)	8.4	12.3		10.2	5.4		

*Angular transformation value.

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ERRATA

The following is the errata for the Review Paper entitled "Sesame improvement – Present status and future strategies", **29**(1): 1-26, June, 2012.

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ANNOUNCEMENT

The Indian Society of Oilseeds Research introduces two biennial awards viz., ISOR Best Research Paper Award (ISOR-BRPA) and ISOR Best Ph.D. Thesis Award (ISOR-BPTA) from the years 2009-2010. The nature and guidelines of the awards are presented hereunder:

ISOR BEST RESEARCH PAPER AWARD (ISOR-BRPA)

Name of the Award	:	**ISOR Best Research Paper Award (ISOR-BRPA)**
Donor of the Award	:	Indian Society of Oilseeds Research, Hyderabad
Nature of the Award	:	It is a biennial award consisting of ` 5000/- (Rupees five thousand) cash prize and certificate for the best research paper published in the Indian Journal of Oilseeds Research.
Purpose of the Award	:	To motivate high quality research amongst the oilseed researchers and to recognise outstanding work done in the field of oilseeds research.
Administration of the Award	:	• The Indian Society of Oilseeds Research shall retain the right to designate the general areas of scientific endeavour in which the award shall be made. • The Society shall have the sole right of selection of the recipient of the award and of the formulation of the rules governing such selection
Eligibility for the Award	:	• All the full research papers published in two calendar years are eligible for the award. The award shall be made for notable and original research work and not for routine investigations. The candidates shall be judged on the basis of the original and or applied research work done. • The article should be contributed exclusively to the Journal of Oilseeds Research. • If any of the selected article is written jointly by more than one author, the award amount will be equally divided among the authors.
Subject matter of the article	:	• The article should be based on original or applied research. Articles which have been reproduced from other publications, seminar papers, etc., are excluded from competition. • The article should made an important contribution to the understanding related to oilseeds.
Expression and Presentation	:	• Advanced concepts should be clearly and concisely expressed in the simplest possible language. The article should be well arranged in that the facts, data and discussion are presented in a logical sequence. • Where the illustrations are appropriate and important for clarify of presentation and it should be judged on its quality and effectiveness. Judges are also expected to consider whether or not illustrations (in its absence) or additional illustrations might have contributed to the clarity and effectiveness of presentation. • Facts and data presented should be documented as to source and verified either from the author own research or by reference to work performed or opinions advanced by other authorities. On the basis of a consensus of the judges, the article should be chosen for the award giving weightage as indicated below keeping in view the points mentioned above.

Judging Committee :

- The society shall constitute a Panel of Judges to select the recipient(s) of the award.
- The Panel of Judges shall judge the relative merits of the research contribution made and recommend to ISOR the name(s) of the candidate(s) to whom the award may be made in accordance with the procedure laid down.

Presentation of the Award : The award shall be presented at the Biennial Seminar of the Society or on any their suitable occasion.

ISOR BEST Ph.D. THESIS AWARD (ISOR-BPTA)

ISOR has instituted an award viz., **ISOR Best Ph.D. Thesis Award (ISOR-BPTA)** to motivate high quality fundamental and applied research amongst Ph.D. Scholars in India in the field of oilseeds. This is a biennial award open to all Indian students in the field of oilseeds research. The award carries a citation and cash prize of ₹ 5000/- (Rupees five thousand only). Only those theses are considered for this award for which final viva-voce is completed by 31st December of the second year of the two year period for the award is meant. For example: applicants for 2010 and 2011 should have completed their final viva-voce examination by 31st December, 2011.

Research workers in the field of oilseeds interested to apply for this Award are required to send their nominations through proper channel along with a copy of the thesis submitted by them for their Ph.D. Degree together with seven copies of synopsis, highlighting the significance of research. The nominations should be accompanied by a certificate from the concerned Head of the Department that the research work of the candidate has been a significant factor in obtaining the data presented in the thesis leading to the conferment of Ph.D. Degree.

All the nominations together with appropriate certificates should be send to Secretary, Indian Society of Oilseeds Research through the concerned Head of Department by the notified date to be announced while inviting nominations.

All the theses submitted would be judged by a panel of judges appointed by Executive Committee. The Executive Committee, whose decision is final, shall approve the report of the judges.

The candidate whose work is judged to be the best will be awarded a citation and ₹ 5000/- (Rupees five thousand only) as cash at the Biennial Seminar of the Society or on any their suitable occasion. The recipient of the award is expected to deliver an illustrated talk based on his significant research work submitted for the award.

TA/DA as admissible shall be paid to recipient of the award for his journey from his place of work to the place where meeting is being held, in the case the recipient fails to get the same from his organisation.

Applications for both the above awards can be had by sending a request letter to:

The General Secretary
Indian Society of Oilseeds Research
Directorate of Oilseeds Research
Rajendranagar, Hyderabad-500 030
Andhra Pradesh, India.

the highest seed yield during the course of study as well as pooled analysis except the year 2008-09 where it was at par with DCH 177. Hybrid DCH 177 ranked on second position followed by GCH - 4. Similar findings were also reported by Anonymous (2010).

Table 1 Seed yield of castor (kg/ha)

Treatment	Year			
	2007-08	2008-09	2009-10	Pooled
Fertility level (% RDF)				
0	2388	2040	1819	2082
50	2899	2490	2364	2585
100	3332	2922	2902	3052
150	3696	3179	3228	3367
SEm ±	105	123	54	49
CD (P=0.05)	365	426	187	147
CV (%)	13.3	17.9	8.1	13.8
Genotypes				
48-1	2834	2527	2488	2617
GC-2	2865	2418	2282	2521
GCH 4	3032	2605	2493	2710
DCH 177	3144	2833	2671	2883
GCH 7	3519	2905	2958	3128
SEm ±	114	83	66	52
CD (P=0.05)	329	238	186	144
CV (%)	12.8	10.7	8.8	11.2
F x G	NS	NS	sig	sig

Table 2 Seed yield (kg/ha) of castor influenced by F x G interaction (Pooled)

Fertility level (% RDF)	Genotype					Mean
	48-1	GC 2	GCH 4	DCH 177	GCH 7	
0	*2109*	*1990*	*2022*	*2029*	*2262*	*2082*
50	2483	2310	2519	2578	3034	2585
100	2841	2769	2908	3341	3400	3052
150	3034	3016	3389	3584	3814	3367
Mean	2617	2521	2710	2883	3128	
	Fertility levels	Genotypes	F x G			
SEm ±	49	52	104			
CD (P=0.05)	147	144	289			
C.V. (%)	13.7	11.2	11.2			

Table 3 Economics of different treatments (Main effect)

Treatment	Seed yield (kg/ha)	Gross returns (₹/ha)	Cost of cultivation (₹/ha)	Net returns (₹/ha)	BCR
Fertility level (% RDF)					
0	*2082*	*72870*	*31340*	*41530*	*2.33*
50	2585	90475	33133	57342	2.73
100	3052	106820	34000	72820	3.14
150	3367	117845	34868	82977	3.38
Genotype					
48-1	2617	91595	31340	60255	2.92
GC-2	2521	88235	33133	55102	2.66
GCH 4	*2710*	*94850*	*34000*	*60850*	*2.79*
DCH 177	2883	100905	34868	66037	2.89
GCH 7	3128	109480	33336	76144	3.28

Selling price of castor seeds: 35 ₹/kg

Interaction effect of F x G: The interaction effect between fertility levels and genotypes was found significant in pooled analysis. The results indicated that seed yields of castor genotypes were found to be increased with increase in fertility levels from 0 to 150% RDF. Significantly highest seed yield of castor was observed with GCH-7 when it was fertilized with 150% RDF followed by DCH-177. GCH-7 hybrid responds to high fertility because it has profuse branching ability and high yielding capacity under irrigated condition.

Economics: The figures on economics of different treatments presented in table 3 indicated that the maximum gross returns, net returns and benefit cost ratio (BCR) recorded with application of 150% RDF followed by 100% RDF. In case of genotypes, GCH-7 registered the highest gross returns, net realization and BCR followed by DCH 177. The economics of different treatment combinations revealed that the maximum gross returns, net returns and BCR were registered by GCH-7 followed by DCH 177 hybrid when fertilized with 150% RDF.

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Strategies to increase castor (*Ricinus communis* L.) production in India through effective resource-use management practices

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(Received: April, 2011; Revised: November, 2012; Accepted: December, 2012)

ABSTRACT

A scale was developed and standardized to assess the resource use management (RUM) behaviour of castor (*Ricinus communis* L.) growers. The purpose was to suggest strategies to increase the castor production and productivity in India through effective RUM practices. Analysis of the data collected through the standardized scale in Andhra Pradesh and Gujarat with 120 and 180 randomly selected castor growers, respectively as respondents revealed that the castor growers had low to medium and medium to high level of RUM behaviour, respectively in Andhra Pradesh and Gujarat. Castor growers with small and medium farm size in Andhra Pradesh and with small farm size in Gujarat had low to medium level of RUM behaviour. Management of resources *viz*., cropping systems, seeds, soil-moisture, insect pests and diseases significantly contributed to castor productivity in Andhra Pradesh, whereas nutrient management, disease management and irrigation management had highly significant contribution towards castor productivity in Gujarat. Young farmers with higher income and education in Andhra Pradesh, whereas experienced and farmers with large farm size, higher educational status, annual income and those who directly participate in agriculture in Gujarat were effective in management of resources with respect to castor cultivation. Information about effective RUM practices needs to be popularized among castor growers through frontline demonstrations (FLDs), capacity building programmes and campaigns etc, in order to increase castor production and productivity in India.

Keywords: Castor growers, Castor production in India, Resource-use management practices, Strategies

Castor (*Ricinus communis* L.) is an important non-edible oilseed crop and occupies an important place in the country's vegetable oil and industrial economy. The crop is mostly confined to Gujarat, Andhra Pradesh and Rajasthan. Although other states like Tamil Nadu, Karnataka, Orissa, Maharashtra, parts of Madhya Pradesh, Bihar and Chhattisgarh also cultivate castor, their contribution to either area or production is limited. Presently, castor is grown over an area of 8.7 lakh ha with a production of 11.7 lakh t. and productivity of 1352 kg/ha in the country (Venkattakumar and Hegde, 2010). Gujarat and Andhra Pradesh put together contribute to 68.5% of the total castor area and 80% of the total castor production in the country. The crop has been cultivated under resource-rich irrigated conditions in Gujarat with very high productivity (1963 kg/ha), while in Andhra Pradesh, the crop has been cultivated under rainfed and poor resource management conditions, with very low productivity (509 kg/ha). There exists a wide gap between actual and potential yield levels of castor in both Gujarat and Andhra Pradesh, which is due to improper and ineffective RUM behaviour of the castor growers (Prasad, 2002; Ramanjaneyulu and Padmaiah, 2003; Raghavaiah *et al.*, 2006 and Padmaiah, 2007). Such gap resulted in near stagnation of castor production in the country over past decade (Fig. 1).

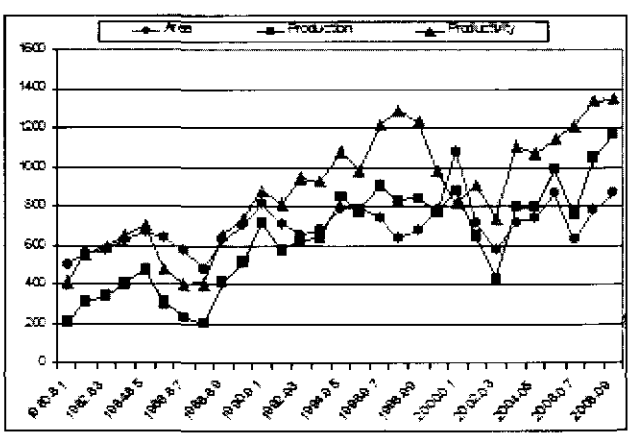

Fig. 1. Castor area ('000 ha), production ('000 t) and productivity (kg/ha) in India

The reasons for yield gap in castor and castor production constraints can be overcome through efficient RUM practices (Ramanjaneyulu and Padmaiah, 2003). Thus, there is a need to improve the RUM behaviour of castor growers under both irrigated and rainfed situations in order to overcome production constraints and increase castor productivity, for which, "assessing the actual RUM behaviour of the castor growers", is obviously, a pre-requisite. Hence, a project was formulated to assess the resource-use management behaviour of castor growers in the country, so that pragmatic strategies can be suggested to improve the castor productivity.

MATERIALS AND METHODS

In order to measure the RUM behaviour of castor growers in the country, it was decided to construct a summated-rating scale. An exhaustive list of RUM indicators was selected based on the review of literature, package of castor production technologies recommended and with thorough discussion with the researchers who have fairly sufficient research experience in castor. The list (18 indicators) was subjected to relevancy rating by castor researchers (41) working all over the country in Directorate of Oilseeds Research (DOR), Hyderabad and in All India Coordinated Research Project (AICRP) on castor on a five-point continuum (Most relevant, relevant, some what relevant, irrelevant and most irrelevant). The rating was analyzed using mean and standard normal variant (Z) measures. All the indicators (9) with positive 'Z' values and with mean values higher than overall mean were selected for constructing the final scale. The final scale was constructed by writing items to the selected indicators based on the recommended castor production technologies. A total of 51 such items were constructed. The content validity of the scale after construction was assessed through the castor researchers who have fairly sufficient experience. The validity of the scale was assessed through split-half method (odd-even method) using Spearman-Brown prophecy formula reported by Singh (2002) and the construct validity of the scale was assessed through correlation method (correlation between RUM behaviour of castor growers and their adoption behaviour towards recommended castor production technologies) in non-sampling area. Thus, the scale constructed was standardized to measure the RUM behaviour of castor growers all over the country. Surveys were conducted in Andhra Pradesh and Gujarat to assess the RUM behaviour of castor growers with the standardized scale following the methodology as furnished in table 1. Post-survey stratification was done to categorize the respondents into small (farm size - less than or equal to 2 ha), medium (farm size - between 2 and 5 ha) and large (farm size - more than or equal to 5 ha) and analyze their distribution with respect to resource-use management towards castor cultivation.

Table 1 Methodology followed

State*	Andhra Pradesh (Rainfed)	Gujarat (Irrigated)
District*	Mahabubnagar (major castor growing district of Andhra Pradesh)	Banas Kantha, Sabar Kantha and Mehsena (Major castor growing districts of Gujarat)
Sampling procedure	Simple random sampling	Proportionate random sampling
Number of farmers	120	180
Data collection	January-March 2009	January 2010
Instrument	Standardized scale to measure RUM behaviour of castor growers	
Statistical tools used	Difference in RUM behaviour of farmers' categories	Kruskal Wallis test, Chi-square test
	Level of RUM among farmers' categories	Mean, SD, percentage analysis
	Indicators of RUM contributing to castor productivity	Multiple regression
	Factor affecting RUM behaviour	Simple correlation

*Damodaram and Hegde, 2007

RESULTS AND DISCUSSION

Distribution of respondents according to their RUM behaviour: Majority of the castor growers had small to medium farm size. The difference between RUM behaviour of castor growers with small, medium and large farm size was highly significant at 1% level of probability both in Andhra Pradesh and Gujarat (Table 2). Most of the castor growers in Andhra Pradesh with small and medium farm size were having low to medium level, whereas most of the farmers with large farm size had medium to high level of RUM behaviour (Table 3). As far as Gujarat is concerned, most of the castor growers with small farm size were having low to medium level, whereas most of the farmers with medium and large farm size had medium to high level of RUM behaviour. The difference in distribution of castor growers with small, medium and large farm size with respect to their RUM behaviour was highly significant in both Andhra Pradesh and Gujarat. These results imply that intensive efforts are needed to improve the RUM behaviour of farmers with small and medium farm size in Andhra Pradesh and farmers with small farm size in Gujarat. Overall, the castor growers in Andhra Pradesh had low to medium level, whereas the castor growers in Gujarat had medium to high level of RUM behaviour. The indicator-wise distribution of respondents in Andhra Pradesh and Gujarat has been given in table 4.

Table 2 RUM behaviour of castor growers

Farmers' categories	Andhra Pradesh (N=120) % of farmers	K-W value	Gujarat (N=180) % of farmers	K-W value
Small	35.0		46.0	
Medium	40.0	14.80**	37.0	29.53**
Large	25.0		17.0	
Total	100.0		100.0	

** Significant at 1% level of probability

Table 3 Distribution of castor growers according to RUM behaviour

Level of RUM	Farmers' categories (%)							
	Andhra Pradesh				Gujarat			
	Small	Medium	Large	Mean	Small	Medium	Large	Mean
Low	42.9	35.4	6.7	30.8	22.9	6.0	6.7	13.9
Medium	50.0	52.1	60.0	53.3	71.1	67.2	83.3	71.7
High	7.1	14.5	33.3	15.9	6.0	26.8	10.0	14.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Mean		132				277		
SD		53				32		
X^2		16.50**				21.40**		

** Significant at 1% level of probability

Table 4 Indicator-wise distribution of castor growers with respect to RUM

Indicators of RUM management	Levels of RUM	
	Andhra Pradesh	Gujarat
Land	Low-medium	Low-medium
Cropping systems	Low-medium	Medium-high
Seed	Low-medium	Low-medium
Soil-moisture	Low-medium	Medium-high
Nutrient	Low-medium	Medium-high
Weed	Medium-high	Low-medium
Insect-pest	Medium-high	Medium
Disease	Medium-high	Medium-high
Irrigation	Medium-high	Medium-high
Overall	Low-medium	Medium-high

Indicators contributing to castor productivity and profitability: Management of cropping systems, seeds, soil-moisture, insect pests and diseases had highly significant contribution towards castor productivity in Andhra Pradesh (AP), whereas nutrient, disease and irrigation management had highly significant contribution towards castor productivity in Gujarat (Table 5). Soil-moisture management had significant contribution towards castor productivity in Gujarat. The results implicate that the castor growers have to effectively manage the resources *viz.*, cropping systems, seeds, soil-moisture, insect pests and diseases to increase castor productivity in Andhra Pradesh, whereas the resources *viz.*, nutrient, disease, soil-moisture and irrigation in Gujarat. Intensive transfer of technology efforts like frontline demonstrations (FLDs), capacity building programmes and campaigns to popularize this information are to be implemented on priority basis.

Table 5 RUM indicators contributing to castor productivity

Indicator of RUM	Unstandardised coefficients			
	Castor productivity-AP		Castor productivity-Gujarat	
	Beta value	SE	Beta value	SE
Constant	-77.80	53.9	-0.55	1081.65
Land management	0.17 NS	0.38	15.59 NS	40.92
Cropping system management	5.69**	2.05	19.32 NS	35.91
Seed management	3.72**	0.85	3.74 NS	5.63
Soil-moisture management	17.50**	3.20	53.40*	32.35
Nutrient management	5.87**	2.75	10.44**	3.43
Weed management	1.14 NS	7.32	8.81 NS	54.45
Insect pest management	8.72**	3.07	12.09 NS	15.97
Disease management	3.50**	1.45	135.23**	23.45
Irrigation management	2.76 NS	7.14	117.38**	32.33

SE Standard error; AP- Andhra Pradesh; **-significant at 1% probability; *-significant at 5% probability

Relationship between independent variables and RUM behaviour of the respondents: The socio-economic variables of castor growers that influenced the RUM of castor growers in Andhra Pradesh and Gujarat are given in table 6. These results imply that young farmers with higher income and education in Andhra Pradesh, whereas experienced farmers with large farm size, higher educational status, annual income and those who directly participate in agriculture in Gujarat were effective in managing the resources with respect to castor cultivation. Hence, such farmers can be selected for demonstration of significantly contributing RUM indicators and improved production technologies. They may also be utilized as resource persons in capacity building programmes of development departments and research institutes to convince other castor growers towards adoption of effective RUM in castor cultivation.

Table 6 Factors affecting RUM behaviour of castor growers in India

Factor	RUM of Andhra Pradesh farmers	RUM of Gujarat farmers
Age	-	0.296**
Education	0.33**	-
Farming experience	-0.20*	-
Farm size	-	0.170*
Annual income	0.23*	0.269**
Nature of agricultural participation	-	0.191*

The study concluded that the castor growers in Andhra Pradesh had low to medium level, whereas the castor growers in Gujarat had medium to high level of RUM behaviour. Castor growers ought to effectively manage the resources *viz.*, cropping systems, seeds, soil-moisture, insect pests and diseases to increase castor productivity in Andhra Pradesh, whereas the resources *viz*, nutrient, disease, soil moisture and irrigation in Gujarat. Intensive technology transfer efforts are needed to improve the RUM behaviour

of farmers with small and medium farm size in Andhra Pradesh and farmers with small farm size in Gujarat. Young farmers with higher income and education in Andhra Pradesh, whereas experienced farmers with large farm size, higher educational status, annual income and those who directly participate in agriculture in Gujarat were effective in management of resources with respect to castor cultivation and hence, such factors may be considered for selecting FLD farmers for demonstration of significantly contributing RUM indicators and improved production technologies and as resource persons for capacity building programmes of development departments and research institutes to convince the castor growers towards adoption of effective RUM in castor cultivation.

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Character association and path analysis for seed yield in soybean [(*Glycine max* (L.) Merril]*

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(Received: November, 2011; Revised: September, 2012; Accepted: November, 2012)

ABSTRACT

Seed yield is a complex character governed by several contributing characters. Hence, character association was studied in the present investigation to assess the relationship among yield and its components for enhancing the usefulness of selection criterion to be followed while developing varieties. Correlation and path analysis was made for nine characters in 30 genotypes of soybean [*Glycine max* (L.) Merril], The seed yield was positively and significantly associated with plant height (cm), number of pods/plant, number of primary branches/plant but negatively correlated with the test weight. Path coefficient analysis reveled that number of pods/plant and number of seeds/pod, test weight had positive direct effect on seed yield/plant.

Key words: Correlation, Path analysis, Soybean

The soybean, [*Glycine max* (L.) Merril] has emerged as one of the major edible oilseed crop in the world. The estimation of genetic correlation coefficient between yield and its component characters has been immense help for the indirect selection of the desired plant ideotype. Yield being dependent on morpho-physiological characters of the developing effective selection strategies. Path analysis divides correlation coefficients into direct and indirect effects. With this the breeder can determine the magnitude of direct and indirect effect of different characters on seed yield. Hence for a better insight into the cause and effect relationship between different pairs of characters study of correlation in conjunction with path analysis is essential.

A Field experiment was conducted with 30 genotypes including three checks were grown during the rainy season of 2008, in a randomized block design replicated thrice at research farm of the Botany Department, College of Agriculture, Latur. The spacing adopted was 45 cm x 5 cm. Each genotype was sown in three row of 3 m length. Recommended agronomic practices were followed to grow a healthy crop. Observations were recorded on randomly selected five plants from each genotype for nine characters *viz.*, days to 50% flowering, days to maturity, plant height (cm), number of primary branches/plant, number of pods/plant, number of seeds/pod, test weight (g), oil content (%) and seed yield/plant (g). Genotypic and phenotypic correlation coefficients were calculated as per Johnson *et al.* (1955b). The direct and indirect contribution of various characters of seed yield/plant was calculated through path coefficient analysis as per Dewey and Lu (1959).

*Part of M.Sc. Thesis submitted by senior author to MAU, Parbhani-431 402 (MS).

The genotypic and phenotypic correlation among the yield and yield contributing characters in soybean are presented in table 1. The genotypic and phenotypic correlations were at par with each other suggesting the negligible role of environment on the genotypic expression. Seed yield/plant component character was found to be significantly and positively associated with number of pods/plant, plant height and number of primary branches/plant. Similar results were also reported by Taware *et al.* (1997).

The character association of days to 50% flowering with days to maturity, plant height with number of pods/plant and test weight with oil content per cent recorded significant and positive association both at genotypic and phenotypic level. However, number of pods/plant with test weight recorded significant and negative association both at genotypic and phenotypic level. Mukhekar *et al.* (2004) supported negative significant association between test weight and number of pods/plant. They also reported negative and non significant association between days to maturity and test weight.

Direct and indirect effects of the yield components on seed yield/plant showed, number of pods/plant exerted maximum direct effect followed by seeds/pod and test weight (Table 2). The direct effect of pods/plant on yield has also been reported by Rasaily *et al.* (1986); Taware *et al.* (1997) and Mukhekar *et al.* (2004). Hence, selection based on above traits would be effective in increasing yield. Plant height, number of seeds/pod and oil content had positive and direct effect on seed yield/plant. Similar result also reported by Sharma *et al.* (1983) and Samaiya *et al.* (1990). However, these effects are of low magnitude. In contrast, days to 50% flowering had negative direct effect on seed yield/plant (Sharma *et al.*, 1983). The yield contributing characters plant

height, number of primary branches/plant and days to maturity via number of pods/plant had positive indirect effect and high magnitude on yield both at genotypic and phenotypic level. These results are in conformity with the results of Rasaily *et al.* (1986 b).

Through the study of path analysis it was apparent that maximum direct effects were exerted by number of pods/plant, number of seeds/pods and test weight. Out of these three pods/plant exhibited positive and significant correlation with seed yield/plant, therefore, these characters may be considered as the most important yield contributing characters and due emphasis should be placed on these characters while breeding for high seed yield in soybean.

Table 1 Genotypic and phenotypic correlation coefficients for nine characters in soybean

Character		Days to 50% flowering	Plant height (cm)	No. of primary branches/ plant	No. of pods/ plant	No. of seeds/ pod	Days to maturity	Test weight (g)	Oil content (%)	Seed yield/ plant (g)
Days to 50% flowering	G	1.000	0.227	-0.358*	0.109	0.229	0.529**	0.177	-0.029	0.141
	P	1.000	0.209	-0.307	0.109	0.222	0.519**	0.163	-0.024	0.130
Plant height (cm)	G		1.000	0.267	0.547**	0.115	0.336	-0.003	0.082	0.672**
	P		1.000	0.211	0.493*	0.096	0.295	0.012	0.077	0.595**
No. of primary branches/plant	G			1.000	0.305	0.130	-0.229	-0.007	0.018	0.496**
	P			1.000	0.266	0.112	-0.193	0.016	0.034	0.431*
No. of pods/plant	G				1.000	-0.212	0.248	-0.574**	-0.101	0.800**
	P				1.000	-0.208	0.247	-0.549**	-0.097	0.775**
No. of seeds/pod	G					1.000	0.013	0.080	-0.114	0.101
	P					1.000	0.014	0.065	-0.102	0.103
Days to maturity	G						1.000	-0.024	0.243	0.326
	P						1.000	-0.022	0.227	0.314
Test weight (g)	G							1.000	0.524**	-0.215
	P							1.000	0.464**	-0.196
Oil content (%)	G								1.000	0.168
	P								1.000	0.145

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

Table 2 Genotypic path analysis for direct and indirect effects of yield component on seed yield of soybean/plant

Character	Days to 50% flowering	Plant height (cm)	No. of primary branches/plant	No. of pods/ plant	No. of seeds/ pod	Days to maturity	Test weight (g)	Oil content (%)	Genotypic correlation coefficient with yield
Days to 50% flowering	-0.06752	0.01937	-0.06536	0.09362	0.06003	0.06956	0.03557	-0.00394	0.141
Plant height(cm)	-0.01532	0.08540	0.04871	0.46884	0.03010	0.04412	-0.00057	0.01109	0.672**
No. of primary branches/plant	0.02416	0.02277	0.18272	0.26123	0.03412	-0.03013	-0.00144	0.00248	0.496**
No. of pods/plant	-0.00738	0.04672	0.05570	0.85702**	-0.05548	0.03257	-0.11545	-0.01363	0.800**
No. of seeds/pod	-0.01549	0.00982	0.02382	-0.18163	0.26179	0.00175	0.01603	-0.01540	0.101
Days to maturity	-0.03575	0.02868	-0.04191	0.21248	0.00349	0.13137	-0.00481	0.03278	0.326
Test weight(g)	-0.01193	-0.00024	-0.00130	-0.49154**	0.02085	-0.00314	0.20130	0.07079	-0.215
Oil content (%)	0.00197	0.00701	0.00336	-0.08650	-0.02986	0.03189	0.10553	0.13503	0.168

Residual Effect = 0.3566386; * and ** indicates significance at 5% and 1% level respectively.

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Combining ability analysis for yield and its contributing traits in Indian mustard [*Brassica juncea* (L.) Czern and Coss]

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(Received: August, 2010; Revised: November, 2012; Accepted: December, 2012)

ABSTRACT

The experiment carried out using diallel analysis excluding reciprocal comprised of seven parents and their 21 straight F_1 mustard [*Brassica juncea* (L.) Czern and Coss.] hybrids. The ratio of general combining ability (*gca*) to specific combining ability (*sca*) genetic variance for various characters indicated that, additive type of gene action was predominant for expressing traits like earliness, plant height, length of silique, seed/silique and oil content. Parent IC- 385682 manifested good general combining ability for length of silique, 1000 seed weight and oil content. Parent SKM-0820 depicted good general combining ability for seed yield and oil content. Parent RGN 145 expressed good general combining ability for seed/silique and seed yield. The cross combinations IC-385682 x NDR 5-1, SKM 0820 x NDR 5-1, and NDCC28 x NDR 5-1 exhibited positive and significant *sca* effects for seed yield/plant. These combinations for seed yield involved A x P, G x P and A x G combiners.

Key words: Combining ability, Diallel analysis, GCA, SCA

Mustard [*Brassica juncea* (L.) Czern and Coss.] is one of the second most important oilseed crop in India. Rapeseed-mustard account for 22.7% of the total oilseed production and 19.2% of the total cropped area in the country. The success of any breeding programme is determined by the useful gene combination organized in the form of good combining lines and isolation of valuable germplasm. Diallel analysis gives an overall genetic picture of the test material in a single generation.

The material was grown in randomized block design with three replications during the winter season of 2009 at Main Castor and Mustard Research Station, Saradarkrushinagar (Gujarat). The seven parents *viz.*, IC 385682, SKM 0820, NDCC 28, RLM 619, NDR 5-1, SKM 0450 and RGN 145 and their 21 F_1 hybrids were planted in two row of 5 m length having an inter and intra row spacing of 45 cm x 15 cm, respectively. Observations were recorded on 5 randomly taken plant from parents and F_1 in each replication for days to flowering, days to maturity, plant height (cm), length of main branch (cm), number of branches/plant, number of siliqua plant, Length of siliquae (cm), seed/silique, 1000 seed weight (g), seed yield plant (g) and oil content (%). Oil content was estimated using NMR method. Combining ability analysis was carried out as per Griffing (1956).

The analysis of variance for combining ability (Table 1) revealed that, mean sum of square for *gca* was significant to highly significant for all the traits except days to flowering, days to maturity and number of branches/plant while the *sca* effects were significant for all the traits except days to maturity, length of main branches length of silique, seed silique and oil %. The ratio of *gca* to *sca* genetic variance for various characters indicated that, additive type of gene action was predominant for earliness, plant height (Monpara and Dobariya, 2007), length of siliquae (Singh *et al*, 2003), seed/silique and oil content (Srivastava *et al.*, 2003).

General combining ability: None of the parents recorded good general combining ability for all the character under study (Table 2). The parent IC- 385682 was good general combiner for length of silique, 1000 seed weight and oil content. SKM-0820 was good general combiner for seed yield and oil content. Parent RGN 145 was good general combiner for seed/silique and seed yield.

The parents with good *gca* had fixable component of variance like additive and epitasis component and hence, these parents (IC-385682, SKM 0820 and RGN 145) may be used in future hybridization programmes as donor parents in Indian mustard. The findings were in conformity with the findings of Singh *et al.* (2006).

Specific combining ability: Analysis of *sca* is an important parameter for evaluating a combination for exploiting it through heterotic breeding programme. A perusal of data revealed that none of the crosses had high ranking *sca* effects for all the characters (Table 3).

IC-385682 x NDR 5-1 and NDCC28 x RGN 145 for early flowering , NDCC28 x SKM 0450, SKM 0820 x RLM 619, NDCC28 x NDR 5-1 for dwarfness, IC385682 x SKM820 for number of branches/plant, IC 385684 x SKM 0820, SKM 0820 x NDR 5-1, SKM 0820 x RGN 145 for number of silique/plant.IC-385682 x SKM0820, IC-385682 x NDCC 28, IC-385682 x SKM0820 for test weight, whereas for seed yield/plant positive and significant *sca* effects were

found in F_1 hybrids IC-385682 x NDR 5-1, SKM 0820 x NDR 5-1, and NDCC28 X NDR 5-1. None of the crosses were found positive and significant effects for length of main branch, length of silique and oil content. The combination for seed yield had involved A x P, G x P and A x G combiner.

Table 1. Analysis of variance for combining ability for various characters in mustard

Source of variation	d.f.	Days to flowering	Days to maturity	Plant height	Length of main branches	Number of branches plant	Number siliqua/ plant	Length of siliquae	Seed/ siliquae	1000 seed weight	Seed yield/ plant	Oil (%)
GCA	6	2.92	12.45	450**	45.21*	1.46	267.88	0.22**	1.51**	0.29**	270.96**	3.18**
SCA	21	5.33*	30.68	105.6*	30.09	2.77**	1055.71**	0.03	0.44	0.11**	313.23**	0.40
Error	54	2.70	30.17	59.73	18.16	0.83	369.62	0.02	0.32	0.03	42.86	0.67
σ^2 GCA		-0.27	-2.02	38.27	1.67	-0.14	-87.53	0.02	0.12	0.02	-4.69	0.31
σ^2 SCA		2.62	0.51	45.87	11.93	1.94	686.09	0.02	0.12	0.08	270.37	-0.27
σ^2 GCA/σ^2 SCA		-0.10	-3.97	0.83	0.14	-0.08	-0.13	1.28	0.99	0.27	-0.02	-1.14

* and ** indicate significant at $P = 0.05$ and $P = 0.01$ levels, respectively.

Table 2 Estimation of general combining ability (GCA) effects of different characters

Parent	Days to flowering	Days to maturity	plant height	Length of main branches	Number of branches/ plant	Number siliqua/ plant	Length of siliquae	Seed/ siliquae	1000 seed weight	Seed yield/plant	Oil (%)
IC 385682	0.34	-1.41	-0.095	-1.34	-0.62*	-2.68	0.21**	0.17	0.37*	2.09	0.65*
SKM 0820	-0.72	-1.56	-13.44**	-2.11	0.04	3.17	0.01	0.26	-0.05	8.28**	0.96**
NDCC 28	-0.14	1.58	-0.42	0.68	0.64*	-0.61	-0.191**	-0.32	-0.11*	-0.66	-0.54*
RLM 619	-0.59	-0.04	9.07**	-3.01*	0.04	0.77	-0.14**	-0.55**	-0.15*	-3.05	-0.15
NDR 5-1	0.96	0.14	6.01*	3.03*	-0.36	-9.37	-0.13**	-0.39*	-0.05	-5.85*	-0.64*
SKM0450	0.12	1.14	-0.15	0.57	0.09	8.52	-0.16**	0.31	-0.09	-6.04*	-0.11
RGN 145	0.03	0.14	-0.97	2.20	0.18	0.19	0.07	0.51**	0.07	5.23*	-0.17
S.E.(gi) ±	0.51	1.70	2.39	1.31	0.28	5.93	0.04	0.17	0.05	2.02	0.25
S.E.(gi-gi) ±	0.78	2.59	3.64	2.01	0.43	9.06	0.06	0.27	0.08	3.09	0.39

* and ** indicate significant at P = 0.05 and P = 0.01 levels, respectively.

Table 3 *Sca* effects of three best crosses along with *per se* performance and *gca* combination for six characters in mustard

Character	hybrids	sca	gca	*per se* performance (Rank)
Grain yield/plant	SKM 0820 x NDR 5-1	46.17**	G x P	117.97 **(1)**
	IC 385682 x NDR 5-1	26.53**	A x P	92.17 **(2)**
	NDCC 28 x RGN 145	18.05**	A x G	79.50 **(-)**
Days to flowering	IC 385682 x NDR 5-1	-4.09**	A x A	40.87 **(1)**
	NDCC 28 x RGN 145	-3.23*	A x A	40.93 **(2)**
	-	-	-	-
Plant height	SKM 0820 x RLM 619	-23.81**	G x P	126 (1)
	-	-	-	-
	-	-	-	-
Number of branches/plant	IC 385682 x SKM 0820	2.64**	P x A	16.13 (1)
	-	-	-	-
	-	-	-	-
Number of siliqua/plant	IC 385682 x SKM 0820	40.64*	A x A	270.93 **(1)**
	SKM 0820 x NDR 5-1	38.86*	A x P	262.47 **(-)**
	SKM 0820 x RGN 145	34.50*	A x A	267.67 **(3)**
1000 seed weight	IC 385682 x NDCC 28	0.44*	G x P	4.54 **(1)**
	IC 385682 x SKM 0820	0.32*	G x A	4.47 **(2)**
	IC 385682 x SKM 0450	0.32*	G x A	4.43 **(-)**

G = Good; A = Average; P = Poor; * and ** indicate significant at P = 0.05 and P = 0.01 levels, respectively

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Variability and genetic divergence in sesame (*Sesamum indicum* L.)

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(Received: July, 2011; Revised: December, 2012; Accepted: December, 2012)

ABSTRACT

Sixty sesame (*Sesamum indicum* L.) varieties were evaluated for their variability and genetic divergence. There was a considerable variability in the sesame genotypes for all the traits studied. The heritability estimates and genetic advance were high for seed yield/plot and plant height indicating the predominance of additive gene effects for these characters. Seed yield/plot had significant positive correlation with capsules/plant, plant height and primary branches/plant, whereas 1000 seed weight had significant negative correlation with all the traits studied barring seed yield/plot. The genotypes were grouped into eleven clusters and maximum intercluster distance was observed between cluster IX and X followed by cluster VI and IX. Considering cluster means and intercluster distances hybridization between Punjab Til-1 with cluster IX entries (CO-1, E-8, Swetha-Til, Hima, Tarun) and cluster IV entries (PKDS-11, Kanak, Uma, Nirmala, Prachi, Tilothama, Goutama, Chadana, Varaha) with cluster VI entries (TC-25, N-32, TKG-306) are expected to give promising and desirable recombinants.

Key words: Correlation, D^2 analysis, Genetic variability, Sesame

Sesame (*Sesamum indicum* L.) is the oldest oilseeds known and used by man. India is the largest producer and exporter of sesame in the world. The crop has largest diversity in cultivars and grown throughout the country. A huge number of high yielding varieties were released so far in India for cultivation in different agro-climatic situation. The released varieties have obvious divergence with respect to plant type, seed colour, boldness etc., as per the specific local preference and demand. However, the increase in productivity of sesame in India is not so impressive as compared to other sesame growing countries in the world. Hence, there is an immediate requirement to develop highly heterotic hybrids and obtaining desirable transgressive segregants.

A quantitative estimation of the genetic diversity present among the genotypes helps the breeder to attempt crosses between desirable diverse genotypes for generating sufficient genetic variability (Solanki and Gupta, 2001). Hence, present study aimed at revealing the extent of diversity available among the released sesame varieties to enable selection of better parents in hybridization programmes.

The present investigation consisted of 60 sesame varieties released in India received from Sesame and Niger Project Coordinating Unit, Jabalpur. The material was raised during rainy season of 2007 at Regional Agricultural Research Station, ANGRAU, Jagtial in randomized block design with two replications. Each genotype was raised in five rows of 3 m long adopting a spacing of 30 cm x 10 cm. Normal recommended cultural practices were followed. Five randomly selected plants were observed for recording biometric measurements on three traits *viz.*, plant height, primary branches/plant and capsules/plant whereas, the traits *viz.*, days to 50% flowering, days to maturity, 1000 seed weight and seed yield were recorded on whole plot basis. The data was subjected to statistical methods of analyses of variance (Panse and Sukhatme, 1961). The coefficient of variation (Burton, 1952), heritability in broadsense (Lush, 1940), genetic advance (Johnson *et al.*, 1955), correlations (Robinson *et al.*, 1951) were calculated as per the standard statistical methods. The genetic divergence was estimated using the Mahalanobis D^2 statistic and the populations were grouped into clusters by following Tocher's method described by Rao (1952).

The analyses of variance revealed highly significant differences among the genotypes for all the traits indicating the presence of considerable amount of variability. Genotypic and phenotypic coefficient of variations were high for seed yield/plot, capsules/plant, primary branches/plant and plant height whereas, the lowest for days to maturity. These results were in conformity with Solanki and Gupta (2001). The differences between genotypic and phenotypic coefficients of variation were low indicating the little role of environment on these characters.

The higher estimates of heritability coupled with higher genetic advance for seed yield/plot and plant height indicating that heritability of these traits is mainly due to additive effects and direct selection is effective.

For performing efficient selection, genotypic and phenotypic correlations were calculated and presented in table 1. The genotypic correlations were slightly higher than phenotypic correlations indicating very little environmental effect for the traits. Seed yield/plot had significant positive correlation with capsules/plant, plant height and primary branches/plant. Similar results were reported by Biswas and

Akbar (1995); Solanki and Gupta (2001); Mukhekar *et al.*, (2003). However, 1000 seed weight had significant negative correlation with primary branches/plant, capsules/plant, days to 50% flowering, days to maturity and plant height.

Based on relative magnitude of D^2 values 60 genotypes were grouped into eleven clusters (Table 2). Maximum number of 21 varieties were accommodated in cluster I followed by 9 in cluster IV, 7 in cluster II and 5 each in cluster III, VII and IX. Interestingly, the varieties released from Tindivanam (TMV varieties) were grouped in cluster III, V, VII and XI suggesting that genetic diversity may not be necessarily related with geographic diversity. Therefore selection of genotypes for hybridization should be based on genetic diversity rather than geographic diversity (Swain and Dikshit, 1997). The maximum intercluster distance (15.14) was observed between cluster IX and X followed by clusters VI and IX (13.75), clusters X and XI (12.58), clusters I and IX (12.46) and clusters IV and VI (12.21) suggesting a wide diversity between them.

The characters contributing most to the divergence should be given emphasis while identifying cluster selection or choice of parents for hybridization. The highest contributors in this regard were seed yield, days to 50% flowering, plant height and days to maturity (Table 3). These results are akin to the reports of Solanki and Gupta (2001); Manivannan and Nadarajan (1996) for plant height and seed yield.

On considering cluster means in respect of these traits and intercluster distances, the importance of cluster X and cluster IX, cluster IV and cluster VI becomes obvious. Seed yield was higher in cluster X (Punjab Til-1) with earliness and bold seed indicating its potentiality in using as one of the parent in hybridization. Similarly hybridization between varieties falling in these clusters *viz*., cluster X (Punjab Til-1) with cluster IX entries (CO-1, E-8, Swetha-Til, Hima, Tarun), cluster IV entries (PKDS-11, Kanak, Uma, Nirmala, Prachi, Tilothama, Goutama, Chadana, Varaha) with cluster VI entries (TC-25, N-32, TKG-306) may result in exploiting maximum heterosis and is likely to produce desirable transgressive segregants for further crop improvement.

Table 1. Genotypic (G) and phenotypic (P) correlations among seven characters in sesame

Character		Days to 50% flowering	Days to maturity	Plant height (cm)	Primary branches/plant	Capsules/ plant	1000 seed weight (g)	Seed yield/ plot (g)
Days to 50% flowering	G	1.0000	0.6649**	0.8189**	0.5938**	0.3735**	-0.4944**	-0.0735
	P	1.0000	0.6484**	0.7497**	0.5188**	0.2943**	-0.2977**	-0.0691
Days to maturity	G		1.0000	0.6139**	0.2370**	0.1852*	-0.3790**	-0.0476
	P		1.0000	0.5675**	0.2393**	0.1461	-0.1470	-0.0317
Plant height (cm)	G			1.0000	0.5713**	0.4998**	-0.3726**	0.2396**
	P			1.0000	0.4832**	0.4679**	-0.2320*	0.2167*
Primary branches/plant	G				1.0000	0.9600**	-0.7329**	0.2124*
	P				1.0000	0.7352**	-0.3278**	0.2010*
Capsules/plant	G					1.0000	-0.6381**	0.4821**
	P					1.0000	-0.3042**	0.3785**
1000 seed weight (g)	G						1.0000	0.0815
	P						1.0000	0.0770

*, ** Significant at 5 % & 1 % level, respectively

Table 2. Spread of sesame genotypes in different clusters based on seven traits

Cluster No.	No. of genotypes	Genotypes
I	21	RT-127, N-8, TKG-22, TKG-55, JTS-8, RT-46, PKDS-12, JLT-26, JT-7, TKG-21, GT-1, GT-2, Kapli, TC-289, T-4, T-12, Pragati, SVPR-1, T-78, RT-103, Shekar
II	7	Phule-til-1, RT-125, JLT-7, Usha, T-13, AKT-64, Haryana-Til-1
III	5	GT-10, TMV-4, Thilathara, VRI-1, Thilak
IV	9	PKDS-11, Kanak, Uma, Nirmala, Prachi, Tilothama, Goutama, Chadana, Varaha
V	1	TMV-5
VI	3	TC-25, N-32, TKG-306
VII	5	Vinayaka, TMV-3, Madhavai, RT-54, Thilothama
VIII	1	AKT-101
IX	5	CO-1, E-8, Swetha-Til, Hima, Tarun
X	1	Punjab-Til-1
XI	2	TMV-6, Krishna

Table 3. Cluster mean values and character contribution towards genetic divergence of seven characters in sesame

Cluster	Days to 50% flowering	Days to maturity	Plant height (cm)	Primary branches/plant	Capsules/ plant	1000 seed weight (g)	Seed yield/plot (g)
I	32.1	80.5	95.9	3.18	54.0	2.96	134.8
II	33.1	81.1	117.5	3.54	75.5	3.04	207.7
III	37.0	80.8	123.6	5.50	87.8	2.49	127.9
IV	35.6	82.7	132.1	4.58	88.1	2.80	278.3
V	38.5	85.5	133.8	4.60	87.6	2.74	200.5
VI	31.3	85.8	94.8	3.23	59.8	2.96	133.0
VII	34.0	82.0	131.9	4.12	71.3	2.74	242.3
VIII	37.5	83.0	86.9	3.00	50.3	2.97	100.0
IX	43.7	87.6	170.1	4.26	66.0	2.84	125.0
X	30.0	80.0	91.1	3.00	49.9	3.19	275.0
XI	37.8	89.0	136.4	4.45	89.4	2.32	141.3
Times ranked 1st	353	218	235	35	52	62	815
Contribution %	19.94	12.32	13.28	1.98	2.94	3.50	46.05

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Genetic diversity analysis among castor (*Ricinus communis* L.) genotypes using isoenzyme markers

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(Received: June, 2011; Revised: August, 2012; Accepted: November, 2012)

ABSTRACT

Genetic diversity in 22 castor (Ricinus communis L.)*genotypes was assessed using peroxidase and esterase* isoenzymes. In isoenzymes analysis, a total six alleles were generated and all were found to be 100% polymorphic. Isoenzymes descriptors revealed six clusters of genotypes. The genotypes JP-95 with VP-1, 48-1 and JI-96 showed high genetic distance means low similarity compared to other genotypes. Gene diversity or expected heterozygosity (He=0.563) which showed existence of high variability among the genotypes. Average gene flow (*Nm*=1.3766) obtained from two isoenzymes surveys showed relatively high, this could be because of high level of cross pollination between each pair of genotypes, out crossing at the trial areas or other environmental factors.

Keywords: Castor, Genetic diversity, Isoenzymes

Castor (*Ricinus communis* L.) is a highly polymorphic species; normally monoecious with pistillate flowers are situated on the upper part and staminate flowers on the lower part of raceme. Production of female and male flowers is highly influenced by environmental conditions (Weiss, 1983). Though it is a cross-pollinated crop, most of the cultivars have been developed through hybridization followed by selection. New genetic approaches like molecular marker technology have been adopted to map the sugarcane genome, in order to select better cross combinations to develop popular hybrids. Isoenzyme markers are the oldest among the molecular markers. Isoenzyme markers have been successfully used in several crop improvement programmes (Baes and Custsem, 1993). Isoenzymes have proven to be reliable genetic markers in breeding and genetic studies of plant species (Heinz, 1987) due to consistency in their expression, irrespective of environmental factors. Isoenzyme provides a valid biochemical basis of varietal identification and may be used as legitimate evidence of novelty (Bhatt and Saxena, 2003). The esterase and peroxidase system is the most conclusive isoenzyme system for varietal identification due to the complexity and quality of its patterns. The esterases peroxidases are perhaps the most variable isoenzymes in plants and have been used to evaluate genetic affinities in several Gramineae (Gottlieb, 1981). In the present investigation, an attempt has been made to study genetic diversity in peroxidase and esterase isoenzymes for understanding the species interrelationship and variation among castor genotypes.

The experimental material consisted of 22 diverse castor genotypes of Junagadh, Vijapur, S.K. Nagar, Hyderabad and Palem *viz.*, GC-3, GCH-4, GCH-6, GCH-7, JP-65, JP-91, JP-92, JP-95, JP-101, JP-102, JI-96, JI-220, JI-344, JI-353, JI-377, JI-385, PCS-124, SKP-84, SKI-215, DCS-9, VP-1 and 48-1. Methods for both isoenzymes, were taken using two different methods: a) Peroxidase; b) Esterase. The experiment was conducted at Biotechnology Lab, Department of Agricultural Botany, Junagadh Agriculture University, Junagadh, Gujarat.

a) Peroxidase: Leaf extracts of 15 days old seedlings were homogenated in 0.1 M phosphate buffers (pH 7.0) and centrifuged at 10,000-12,000 rpm at 40°C for 10 min. The supernatant was used as enzyme source within 2-4 hrs and stored on ice till the assay was carried out. Native PAGE of the sample extracts was carried out. For the detection of peroxidase on gels, staining solution was prepared by dissolving 2 g of O-dianisidine in 40 ml of methanol, and 10 ml of acetic acid and 100 ml of distilled water were added to it. Then hydrogen peroxide (3%) was carefully added drop by drop in the gel up to the appearance of brown band (Sadasivam and Manikam, 1992).When the bands were stained sufficiently, the reaction was arrested by immersing the gel in 7% acetic acid solution for 10 min (Van Loon, 1971).

b) Esterase: The sample material was homogenized in 5-fold volume of 10 mM sodium phosphate buffer (pH 7.0). The homogenate was centrifuged at 10,000 rpm for 10 min and the supernatant was used as enzyme source. Native PAGE of the sample extracts was carried out. For the detection of esterase on gels, staining solution was prepared by dissolving 2.8 g of sodium dihydrogen phosphate, 1.1 g disodium hydrogen phosphate,0.2 g Fast blue RR salt, 0.03g α-naphthyl acetateand 200 ml distilled water. Then the gel was incubated in a solution given below at 37°C for 20-30 min, in dark conditions. The enzyme reaction was stopped by adding a mixture of methanol: water: acetic acid: ethyl alcohol in the ratio 10:10:2:1 (Desborough and Peloquin, 1967).

After staining, the gel was placed over the white lamp and photograph. The photographs were analysed using image analysis software AlphaEaseFC™ ver. 4.0.0. (Alpha Innotech Corporation). The relative mobility of each band was calculated by following formula.

$$Rm = \frac{\text{Distance traveled by band}}{\text{Distance travelled by tracking dye}}$$

Calculations for polymorphic loci, number of alleles per locus, effective number of alleles (Ne), observed heterozygosity (Ho), gene diversity or expected heterozygosity (He), total genetic diversity (Ht), genetic differentiation (Fst), and fixation index (Fis) were performed with POPGENE Version 1.32 (Yeh *et al.*, 1997) and UPGMA cluster dendrogramswere performed with NTSYS-pc version 2.02 between the genotypes using Jacard coefficient. Values for the polymorphic information content (PIC; Botstein *et al.*, 1980) calculated by using following formula:

$$PIC = 1-\Sigma pi^2$$

Where,

n = total number of allele detected for a locus of a marker. Pi = frequency of the i^{th} allele in the set of twenty-two castor genotype.

A total of six alleles were observed from two enzyme system (peroxidase and esterase) surveyed. Peroxidase produced maximum four alleles, whereas esterase produced only two alleles. The total number of putative alleles at each locus and the relative mobility (RM) of these alleles are given in table 1. The RM ranged from 0.047 to 0.223 in peroxidase and 0.086 to 0.173 was observed in esterase isoenzymes, which reflects remarkable difference in the number of alleles. The polymorphism observed by the isoenzymes was 100%. The mean effective number of alleles per locus was 2.3045. Calculated PIC values were 0.661 and 0.474 in peroxidase and esterase, respectively. Polymorphism information content of peroxidase was larger (PIC > 0.5) than esterase so that it was identified as informative marker than esterase (Table 1). To examine the genetic relationship among 22 castor genotypes studied based on isoenzymes results, the data scored from two isoenzymes were compiled and analyzed using Jaccard (1908) coefficient by using NTSYS software program and is given in table 2. Genetic similarity was found in the ranged of 0.40 to 1.00. Maximum genetic similarity (1.00) was recorded between many pairs of genotypes i.e., first VP-1, 48-1, GCH-7, JI-96, JI-377 and JI-385; second with SKI-215, GC-3, DCS-9, PCS-124, JP-65, JP-91, JP-92, JI-344 and JI-353; third with GCH-4, SKP-84 and JP-101 and forth with JP-102 and JI-220. Minimum genetic similarity (0.40) was found in between GCH-6 with GCH-4, JP-101 and SKP-84. The dendogram based on the Jaccard's coefficient matrix is given in Fig.1. Twenty two castor genotypes were grouped into six clusters (cluster I to VI). First cluster comprises six genotypes namely VP-1, 48-1, GCH-7, JI-96, JI-377 and JI-385. Second cluster comprised of nine genotypes *viz.*, SKI-215, GC-3, DCS-9, PCS-124, JP-65, JP-91, JP-92, JI-344 and JI-353. Cluster IV consisted of three genotypes namely GCH-4, SKP-84 and JP-101. Cluster III and V consisted of only two genotype *viz.*, GCH-6 and JP-95, respectively while cluster VI consisted of only two genotypes *viz.*, JP-102 and JI-220. Dendogram showing the 0.75 similarity index of parent VP-1 and 48-1 with its hybrid GCH-4 as well as 0.75 between SKP-84 and GCH-7. Likewise, similarity index of 0.80 was found between parent SKI-215 and hybrid GCH-7. The lowest genetic similarity means high genetic distance (0.40) was found in between GCH-6 with GCH-4, JP-101 and SKP-84. The similarity, reported in present investigation was found similar with previous study of Park (2004) in different Euphorbia species.

Genetic diversity within genotypes: The total observed heterozygosity (Hos) and total expected heterozygosity (Hes) were 0.669 and 0.563, respectively. The average of mean gene diversity of all genotypes (Hep) equals 0.137 using the formula Hep = (1-Fst) Hes. Where Hes is the total genetic diversity and Fst is the mean genetic differentiation (Nei, 1987). In present study, level of isoenzyme variation found in genotypes (Hes = 0.137) was almost equivalent to (Hep = 0.162) narrow endemic and widespread species of Far East *Euphorbia* fauriei (Park, 2004).

Genetic diversity between genotypes: In this survey, the mean Fst for all the genotypes is 0.1537, and average gene flow (Nm) among genotypes was equals to 1.3766. The degree of genetic differentiation (Fst) of the both peroxidase and esterase loci were 0.0579 and 0.2810, respectively. When all the genotypes considered, significant deviation from Hardy Weinberg expectations was revealed for both polymorphic loci (Table 3). From these two loci with negative fixation index (Fis) (peroxidise and esterase) showed significant heterozygote indicating a high level of inbreeding in the studied genotypes. The mean genetic differentiation between genotypes over both loci (Fst) was 0.1537, which indicated that between genotype components accounts for approximately 15.37% of detected variation. The negative value of Fis indicates heterozygosity while significant negative values of castor genotypes indicated an excess of heterozygotes when compared to Hardy-Weinberg expectation. The level of isoenzyme variation between genotypes (Fst = 0.1537) is nearby similar with average value (F_{ST} = 0.1663) reported in *Euphorbia heterophylla* (Marileia *et al.*, 2009).

Gene flow among the genotypes using Wright (1951) method revealed Nm = 4.0652 in peroxidase and 0.6395 in

esterase isoenzyme which was higher as compared to previous study of Park (2004), reported gene flow in ranged of 0.133 to 0.463 in Far East *Euphorbia* species. The reasons for this higher value of gene flow could be because of the genotypes are more related by other factors than geographical location. Similar environmental factors such as rainfall, soil characters or similar selection by farmers for similar agronomic traits can affect certain genotypes. Another reason for high level of Nm values possibly resulting from high level of cross pollination between each pair of genotypes. Castor is a highly cross pollinated crop and mostly pollination is carried out by wind. It is, therefore, highly likely that cross-pollination by wind and other castor plant outside trial area will occur.

Table 1 Summary of genetic variation within castor genotypes including: relative mobility (RM), observed number of alleles (NA), effective numbers of alleles (Ne), observed heterozygosity (Ho), expected heterozygosity or gene diversity (He), Nei's gene diversity (Nei), polymorphism information content (PIC), Shannon's information index (I), genetic differentiation (Fst), gene flow (Nm) and polymorphism percentage (Pp) detected by two isoenzymes in the twenty two castor genotypes

Locus	RM	NA	Ne	Ho	He	Nei	PIC	I	Fst	Nm	(Pp)
Peroxidase	0.047-0.223	4	2.707	0.657	0.639	0.631	0.661	1.087	0.0579	4.0652	
Esterase	0.086-0.173	2	1.901	0.682	0.485	0.474	0.474	0.667	0.2810	0.6395	100
Mean		3	2.304	0.669	0.563	0.552	0.567	0.877	0.1537	1.3766	
S. D.				0.109	0.109	0.110					

Table 2 Genetic similarity matrices computed according to Jaccard coefficient from isoenzymic banding pattern of 22 castor genotypes

	VP-1	GCH-4	48-1	SKP-84	GCH-7	SKI-215	GC-3	DCS-9	PCS-124	GCH-6	JP-65	JP-91	JP-92	JP-95	JP-101	JP-102	JI-96	JI-220	JI-344	JI-353	JI-377	JI-385
VP-1	1.00																					
GCH-4	0.75	1.00																				
48-1	1.00	0.75	1.00																			
SKP-84	0.75	1.00	0.75	1.00																		
GCH-7	1.00	0.75	1.00	0.75	1.00																	
SKI-215	*0.80*	*0.60*	*0.80*	*0.60*	*0.80*	*1.00*																
GC-3	0.80	0.60	0.80	0.60	0.80	1.00	1.00															
DCS-9	*0.80*	*0.60*	*0.80*	*0.60*	*0.80*	*1.00*	*1.00*	*1.00*														
PCS-124	0.80	0.60	0.80	0.60	0.80	1.00	1.00	1.00	1.00													
GCH-6	0.60	0.40	0.60	0.40	0.60	0.80	0.80	0.80	0.80	1.00												
JP-65	0.80	0.60	0.80	0.60	0.80	1.00	1.00	1.00	1.00	0.80	1.00											
JP-91	0.80	0.60	0.80	0.60	0.80	1.00	1.00	1.00	1.00	0.80	1.00	1.00										
JP-92	*0.80*	*0.60*	*0.80*	*0.60*	*0.80*	*1.00*	*1.00*	*1.00*	*1.00*	*0.80*	*1.00*	*1.00*	*1.00*									
JP-95	0.50	0.60	0.50	0.60	0.50	0.67	0.67	0.67	0.67	0.50	0.67	0.67	0.67	1.00								
JP-101	0.75	1.00	0.75	1.00	0.75	0.60	0.60	0.60	0.60	0.40	0.60	0.60	0.60	0.60	1.00							
JP-102	0.60	0.75	0.60	0.75	0.60	0.80	0.80	0.80	0.80	0.60	0.80	0.80	0.80	0.80	0.75	1.00						
JI-96	1.00	0.75	1.00	0.75	1.00	0.80	0.80	0.80	0.80	0.60	0.80	0.80	0.80	0.50	0.75	0.60	1.00					
JI-220	0.60	0.75	0.60	0.75	0.60	0.80	0.80	0.80	0.80	0.60	0.80	0.80	0.80	0.80	0.75	1.00	0.60	1.00				
JI-344	0.80	0.60	0.80	0.60	0.80	1.00	1.00	1.00	1.00	0.80	1.00	1.00	1.00	0.67	0.60	0.80	0.80	0.80	1.00			
JI-353	0.80	0.60	0.80	0.60	0.80	1.00	1.00	1.00	1.00	0.80	1.00	1.00	1.00	0.67	0.60	0.80	0.80	0.80	1.00	1.00		
JI-377	1.00	0.75	1.00	0.75	1.00	0.80	0.80	0.80	0.80	0.60	0.80	0.80	0.80	0.50	0.75	0.60	1.00	0.60	0.80	0.80	1.00	
JI-385	1.00	0.75	1.00	0.75	1.00	0.80	0.80	0.80	0.80	0.60	0.80	0.80	0.80	0.50	0.75	0.60	1.00	0.60	0.80	0.80	1.00	1.00

Table 3 Fixation index (Fis) of all 22 castor genotypes revealed by two isoenzyme markers

Allele /locus	Peroxidase	Esterase
Allele A	-0.0145	-0.4379
Allele B	-0.2281	-0.4379
Allele C	-0.4583	****
Allele D	0.4281	****
Total	-0.0421	-0.4379

*Chi-square test of the locus for the deviation from Hardy-Weinberg equilibrilium is significant at P=0.001

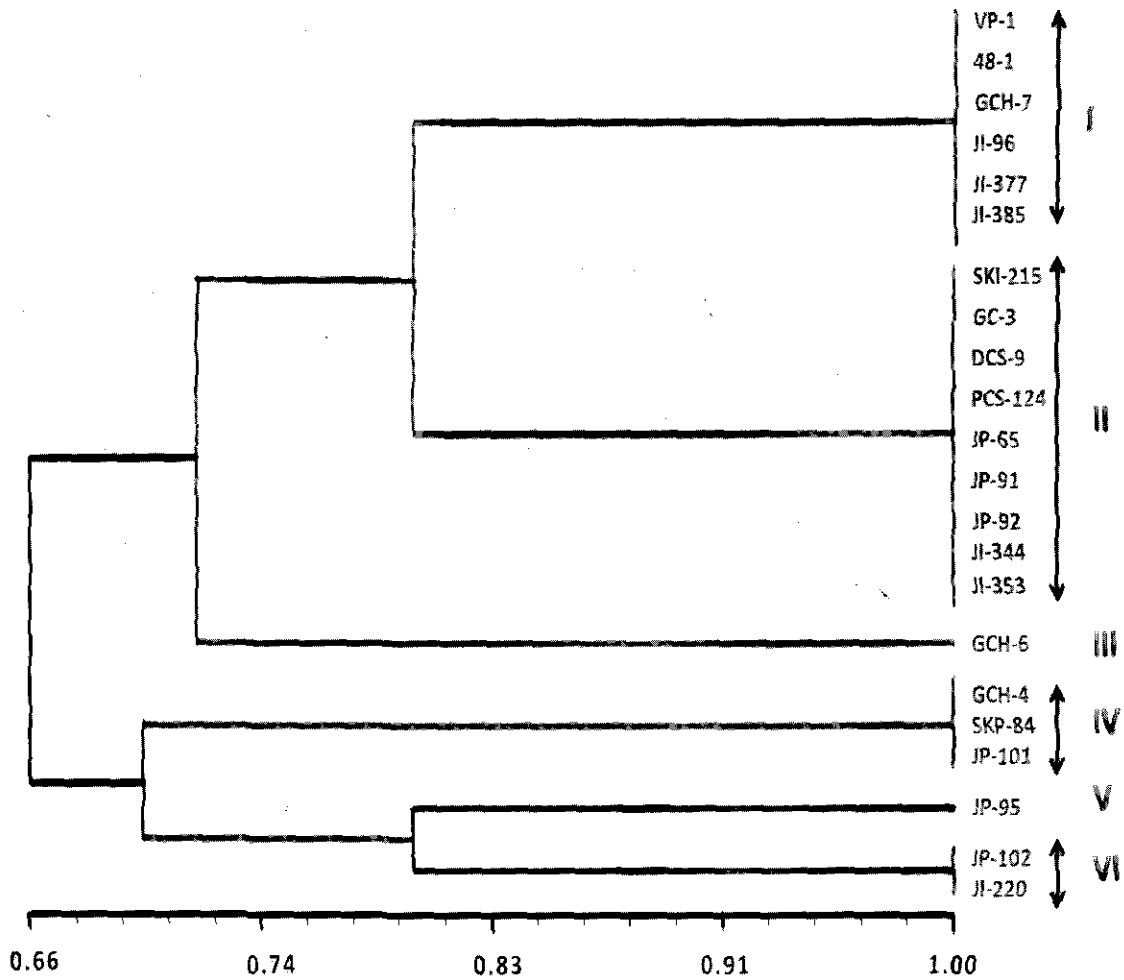

Fig. 1. Dendogram resulting from an UPGMA cluster analysis of 22 castor genotypes based on Jaccard similarity coefficient

Peroxidase isozyme diversity thus has useful utility in castor-breeding programmes for selecting the desirable individuals. This can identify cultivar variation which can be used for identifying diverse lines for use as parents in further studies. They can also be used toward a better understanding of phylogentic relationships of different species. If the goal of maintaining plant germplasm is to document and preserve the genetic diversity of agriculturally or scientifically important species, then additional steps must be taken to broaden the genetic base of castor. One-way to attempt this is to conduct comparative genetic surveys of field collected "natural populations" and germplasm collections of castor. The data revealed from two isoenzymes markers that genotypes GCH-6 and JP-95 showed high genetic distance (low genetic similarity) so, it is very important to improve the castor crop with the help of hybridization and crop improvement program. The information gathered here would be helpful in genomic mapping studies and for the development of castor genotypes with wider and diverse genetic background to obtained improved crop productivity. However, it is necessary to use molecular markers like RAPDs, RFLPs, AFLPs and ESTs to map the entire castor genome, which could be used to generate novel cultivars through marker-assisted selection, mapbased cloning and transgenesis.

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Correlation and path coefficient analysis in castor (*Ricinus communis* L.)

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(Received: November, 2011; Revised: November, 2012; Accepted: November, 2012)

ABSTRACT

Estimation of correlations and path coefficient analysis were taken up for ten attributes as components of yield in castor (*Ricinus communis* L.) to understand the association of different characters on seed yield. In the present investigation, seed yield exhibited high positive correlations with number of capsules/plant and 100 seed weight. Higher direct effects on seed yield were recorded by the same traits i.e., number of capsules/plant and 100 seed weight.

Key words: Castor, Correlation, Path coefficient, Seed yield

Castor (*Ricinus communis* L. (2n = 20), a non edible, industrial oilseed crop plays an important role in Indian economy. The crop is grown for its non-edible oil (45-50 % oil in seeds) which is completely biodegradable with its tremendous industrial applications. Though, a number of high yielding varieties are available, their impact in increasing productivity especially under rainfed conditions is limited. A multitude of biotic and abiotic factors are responsible for low yields under rainfed situations. Hence, there is an urgent need to develop early maturing varieties and hybrids to enhance castor production and productivity.

The estimation of genetic correlation coefficient helps to measure the mutual relationship between different genetic components with seed yield which greatly aids in indirect selection of desired plant ideotype in crop improvement. As yield is influenced by several factors, selection based on simple correlation without taking into consideration the interaction between the component characters can be misleading. Hence, an analysis of path coefficient is of much importance in any breeding program.

The material for the present study consisted of 36 F_1 hybrids resulting from three diverse males (48-1, DCS-107 and JC-2) with 12 females (PPL-11, PPL-12, PPL-13, PPL-14, PPL-15, PPL-16, PPL-17, PPL-18, PPL-19, PPL-20, PPL-21 and PPL-22) (100 % pistillate lines) and all the 15 parents. The experiment was laid out in a randomized block design with 3 replications at Regional Agricultural Research Station (RARS), Palem, Mahaboobnagar, Andhra Pradesh, during winter 2007. Observations were recorded on five randomly selected plants in each replication on ten quantitative characters *viz*., days to 50 % flowering, days to maturity, plant height, number of nodes upto primary spike, effective spike length, number of spikes/plant, 100 seed weight, oil content, number of capsule/ plant and seed yield/plant. Correlation coefficients were calculated following Fisher and Yates (1967) and Path coefficient analysis as per the procedure suggested by Dewey and Lu (1959).

The results revealed that in most of the cases genotypic correlations were higher than corresponding phenotypic correlations which indicated that the traits were inherently associated among themselves. However, a few traits showed higher phenotypic correlations than genotypic correlation indicating that though the traits were inherently associated among themselves they were also affected by the environment. The effects of effective spike length, number of spikes/plant, 100 seed weight, oil content and number of capsules/plant were positively associated with one another and with seed yield/plant (Table 1). The correlation coefficients were highly significant. These findings are in agreement with the findings of Manivel and Manivannam (2006). The traits which showed highest correlation with seed yield/plant were the number of capsules/plant (r= 0.967) and 100-seed weight (r=0.645). However, Manivel and Manivannan (2006) reported that days to 50% flowering, days to maturity, plant height and number of nodes upto primary spike have negative correlation with yield. The possible reason for deviation may be due to different material used in the present study and also due to very low direct and indirect effect.

The path analysis studies revealed that the direct influence on seed yield was largest through number of capsules/plant followed by 100 seed weight (Table 2). These results are in consonance with the earlier reports of Yadav *et al*. (2004) and Manivel and Manivannan (2006). Oil content and number of spikes/plant though had negative phenotypic and genotypic direct effect on seed yield, their correlation with yield was positive, whereas, negative genotypic and phenotypic direct effect on seed yield was exhibited by days to 50% flowering and number of nodes upto primary spike. These results are in conformity with earlier findings of Manivel and Manivannan (2006).

Table 1 Phenotypic (P) and genotypic (G) correlation coefficients of seed yield and yield components in castor

Source		Days to 50% flowering	Days to maturity	Plant height (cm)	Number of nodes upto primary spike	Effective spike length (cm)	Number of spikes/ plant	100-seed weight (g)	Oil content (%)	Number of capsules/ plant	Seed yield/ plant (g)
Days to 50% flowering	P	1.0000	0.5458**	0.6010**	0.7619**	-0.4356**	-0.3984**	-0.5365**	-0.5442**	-0.4128	-0.4847**
	G	1.0000**	0.5771**	0.7186**	0.9910**	-0.5096**	-0.4659**	-0.6050**	-0.5693**	-0.4328	-0.5204**
Days to maturity	P		1.0000	0.4082**	0.4408**	-0.4285**	-0.3103**	-0.3990**	-0.4117**	-0.3232	-0.3703**
	G		1.0000	0.4488**	0.6039**	-0.4626**	-0.3714**	-0.4561**	-0.4358**	-0.3315**	-0.3895**
Plant height (cm)	P			1.0000	0.5523**	-0.5350**	-0.3336**	-0.5734**	-0.4754**	-0.3755**	-0.4580**
	G			1.0000	0.7682**	-0.6763**	-0.4178**	-0.6496**	-0.5609**	-0.4518**	-0.5246**
Number of nodes upto primary spike	P				1.0000	-0.3429**	-0.3027**	-0.4792**	-0.4144**	-0.3042**	-0.3860**
	G				1.0000	-0.4937**	-0.4876**	-0.6313**	-0.5384**	-0.3682**	-0.4681 **
Effective spike length (cm)	P					1.0000	0.5059**	0.4916**	0.6473**	0.5065**	0.5640**
	G					1.0000	0.6775**	0.6558**	0.7688**	0.5833**	0.6578**
Number of spikes/plant	P						1.0000	0.3987**	0.5209**	0.4149**	0.4642**
	G						1.0000	0.4685**	0.5990**	0.4898**	0.5364**
100-seed weight (g)	P							1.0000	0.4734**	0.4064**	0.6123**
	G							1.0000	0.5290**	0.4563**	0.6455**
Oil content (%)	P								1.0000	0.5651**	0.6040**
	G								1.0000	0.5891**	0.6369**
Number of capsules/plant	P									1.0000	0.9512**
	G									1.0000	0.9673**
Seed yield/plant (g)	P										1.0000
	G										1.0000

*–Significant at 5% level; ** Significant at 1% level

Table 2 Phenotypic (P) and genotypic (G) path coefficient of seed yield components on seed yield in castor

Source		Days to 50% flowering	Days to maturity	Plant height (cm)	Number of nodes upto primary spike	Effective spike length (cm)	Number of spikes/ plant	100-seed weight (g)	Oil content (%)	Number of capsules/ plant	Seed yield/ plant (g)
Days to 50% flowering	P	**0.0148**	0.0081	0.0089	0.0113	-0.0065	-0.0059	-0.0079	-0.0081	-0.0061	-0.4847**
	G	**-0.0535**	-0.0309	-0.0385	-0.0530	0.0273	0.0249	0.0324	0.0305	0.0232	-0.5204**
Days to maturity	P	0.0064	**0.0117**	0.0048	0.0052	-0.0050	-0.0036	-0.0047	-0.0048	-0.0038	-0.3703**
	G	0.0081	**0.0140**	0.0063	0.0084	-0.0065	-0.0052	-0.0064	-0.0061	-0.0046	-0.3895**
Plant height (cm)	P	0.0150	0.0102	**0.0249**	0.0138	-0.0133	-0.0083	-0.0143	-0.0118	-0.0093	-0.4580**
	G	0.0463	0.0289	**0.0644**	0.0495	-0.0436	-0.0269	-0.0418	-0.0361	-0.0291	-0.5246**
Number of nodes upto primary spike	P	-0.0152	-0.0088	-0.0110	**-0.0199**	0.0068	0.0060	0.0095	0.0082	0.0061	-0.3860**
	G	0.0235	0.0143	0.0183	**0.0238**	-0.0117	-0.0116	-0.0150	-0.0128	-0.0087	-0.4681**
Effective spike length (cm)	P	-0.0069	-0.0068	-0.0084	-0.0054	**0.0158**	0.0080	0.0078	0.0102	0.0080	0.5640**
	G	-0.0047	-0.0043	-0.0062	-0.0046	**0.0092**	0.0062	0.0060	0.0071	0.0054	0.6578**
Number of spikes/plant	P	-0.0036	-0.0028	-0.0031	-0.0028	0.0046	**0.0092**	0.0037	0.0048	0.0038	0.4642**
	G	0.0015	0.0012	0.0013	0.0016	-0.0022	**-0.0032**	-0.0015	-0.0019	-0.0016	0.5364**
100-seed weight (g)	P	-0.1485	-0.1105	-0.1588	-0.1327	0.1361	0.1104	**0.2769**	0.1311	0.11250	0.06123**
	G	-0.1693	-0.1276	-0.1818	-0.1767	0.1835	0.1311	**0.2798**	0.1480	0.1277	0.6455**
Oil content (%)	P	0.0002	0.0002	0.0002	0.0002	-0.0003	-0.0002	-0.0002	**-0.0004**	-0.0002	0.6040**
	G	-0.0039	-0.0030	-0.0038	-0.0037	0.0053	0.0041	0.0036	**0.0069**	0.0004	0.6369**
Number of capsules/plant	P	-0.3469	-0.2716	-0.3155	-0.2556	0.4256	0.3486	0.3415	0.4748	**0.8403**	0.9512**
	G	-0.3684	-0.2821	-0.3845	-0.3133	0.4965	0.4169	0.3883	0.5014	**0.8511**	0.9673**

Bold = Direct effect; Normal = Indirect effect; Residual effect = 0.18 (Phenotypic) and 0.09 (Genotypic)

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Extent of heterotic effects for seed yield and component characters in castor (*Ricinus communis* L.) under rainfed condition

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(Received: November, 2010; Revised: December, 2012; Accepted: December, 2012)

ABSTRACT

Forty eight F_1 crosses were evaluated along with their 12 parents (4 pistillate lines and 12 inbreds) and one check hybrid GCH 7 of castor (*Ricinus communis* L.) under rainfed condition of middle Gujarat. The magnitude of heterobeltiosis was positive for seed yield and important yield contributing attributes; whereas, for secondary yield contributing attributes it was in both the directions. However, crosses VP 1 x DCS 47, SKP 24 x PCS 124, Geeta x EB 16, Geeta x SPS 44-1 and SKP 24 x EC 38538 were found as promising hybrids for seed yield.

Key words: Heterobeltiosis, Inbred, Monoecious, Pistillate, Rainfed, Secondary, Yield attributes

In castor (*Ricinus communis* L.) with the establishment of stable pistillate lines, plant breeders have extensively explored and utilized heterosis in enhancing seed yield. The crop is highly sensitive to environmental differences, mainly fertility status of soil, moisture availability and sowing period. The crop grown in normal environment in middle Gujarat, results in excess vegetative growth; therefore, to check the vegetative growth, the response of castor hybrids under rainfed condition was examined in middle Gujarat and heterotic performance of newly developed hybrids was studied.

An experiment material consisted of four pistillate lines, 12 monoecious inbreds, their 48 hybrids and one check hybrid were grown in randomized complete block design with three replications. An experimental unit was represented by single row of 7.2 m length with inter and intra row distances of 120 cm and 60 cm, respectively. The experiment was sown at Regional Research Station, AAU, Anand on 1st August of the year 2007, i.e. normal crop sowing period without irrigation.

The observations on five randomly selected competitive plants recorded were seed yield, four yield contributing characters and oil content (Table 1). Mean value of different treatments were subjected for estimation of heterotic effects. The heterobeltiosis and standard heterosis were estimated as per Fonseca and Patterson (1968) and Meredith and Bridge (1972), respectively.

The estimates of mean square (Table 1) due to genotypes were significant; accordingly parents and hybrids differed among themselves for all the characters under study. The contrast comparisons of parents vs hybrids were significant for all the characters suggesting considerable differences between parents and hybrids for their *per se* performance, therefore possibility for heterotic crosses.

The estimates of heterobeltiosis (HB) and standard heterosis (SH) for various characters revealed that both the heterotic effects varied with crosses irrespective of characters. For seed yield/plant total 14 crosses depicted significant and positive heterobeltiosis as against seven crosses had negative and significant estimates; whereas, none of the crosses exhibited significant and positive standard heterosis, but total 22 cross had significant and negative estimates. Thereby revealing positive magnitude for heterobeltiosis and negative magnitude for standard heterosis, accordingly same extent of heterotic effects were observed for major yield contributing character number of capsules/plant. However, for rest of the component characters more or less equal number of crosses; had positive and negative estimates of heterobeltiosis.

The results confirm the findings of Saiyad *et al.* (1997) and Joshi *et al.* (2001). Whereas, for test weight and oil content it was negative; the findings are in agreement with reports of Saiyad *et al.* (1997). The comparative performance of the most five heterotic crosses for seed yield/plant and other attributes have been presented in table 2.

The perusal of table 2 revealed that hybrid VP 1 x DCS 47 showed the highest heterobeltiosis (106.72 %) for seed yield, and it had the maximum *per se* performance and SCA effect as well, it also registered desired heterobeltiosis for number of capsules/plant. Another promising hybrid SKP 24 x PCS 124 depicted 95.96 % heterobeltiosis for seed yield, and it had also significant SCA effect and above 200 g seed yield/ plant; the same hybrid also exhibited significant and desired heterobeltiosis for important yield attributes *viz.*, number of capsules on primary spike and total number of capsules/plant. The remaining top ranking heterotic hybrids for seed yield *viz.*, Geeta x EB 16 (279.55%), Geeta x SPS 44-1 (80.17%) and SKP 24 x EC 38538 (78.01%) also exhibited significant heterobeltiosis for number of capsules/plant, suggesting the said character as the major yield contributing character.

Table 1. Analysis of variance for different yield attributing traits

Source	df	Number of capsules on primary spike	Total number of capsules /plant	Seed yield/ plant	Shelling out turn (%)	Test weight of 100 seed	Oil content (%)
Replications	2	1.40	91.98	19.49	3.38	0.22	0.86
Genotypes	63	1335.92**	11730.66**	8984.58**	98.21**	37.99**	13.18**
Parents	15	1647.96**	7556.14**	6444.10**	93.83**	69.56**	16.11**
Lines	03	692.87**	3674.18**	3441.59**	13.00	9.05**	26.71**
Testers	11	1951.72**	8754.12**	7493.29**	124.40**	92.19**	14.25**
Lines vs Testers	01	1171.92**	6024.35**	3910.63**	0.00	2.22**	4.75**
Hybrids	47	*1229.85***	*12352.96***	*9047.33***	*97.75***	*28.20***	*12.22***
Parents vs Hybrids	1	1640.45**	45100.48**	44142.36**	185.45**	24.40**	14.36**
Error	126	74.38	266.46	326.02	6.89	0.50	0.86

Note: ** significant at 0.01 probability level

Table 2. Magnitude of heterotic effects and promising heterotic crosses for *different yield attributing traits*

Character	Range of heterosis (%)		Significant crosses				*Five promising crosses in respect to heterosis*							
							For heterobeltiosis				For standard heterosis			
	HB	SH	HB		SH		Cross	*Per se performance*	HB (%)	SCA effect	Cross	*Per se performance*	HB (%)	SCA effect
			+ ve	-ve	+ ve	-ve								
Number of capsules on primary spike	-39.07 to -61.04 80.60 to 36.08		13	20	05	30	SKP 24 X EC 38538	68.27	80.60**	23.08**	SKP 84 X SKI 147	113.40	36.08**	26.55**
							SKP 24 X PCS 124	80.47	76.72**	20.90**	VP 1 X SPS 44-1	110.47	32.56**	19.94**
							VP 1 X EB 16	89.67	69.40**	29.44**	SKP 84 X SKI 202	108.13	30.08**	17.99**
							SKP 84 X SKI 147	113.40	37.73**	26.55**	Geeta X SKI 192	100.53	20.64**	16.28**
							VP 1 X SPS 44-1	110.47	32.45**	19.94**	SKP 84 X DCS 47	96.27	15.52**	8.09
Number of capsules/plant	-49.35 to -59.57 93.82 to 35.26		14	06	04	20	*Geeta X PCS 124*	*345.00*	93.82**	69.24**	*Geeta X PCS 124*	345.00	35.26**	69.24**
							VP 1 X DCS 47	300.40	87.13**	12.01**	Geeta X SPS 44-1	333.60	30.79**	36.96**
							Geeta X EB 16	326.73	83.56**	82.78**	Geeta X EB 16	326.73	28.10**	82.78**
							SKP 24 X EC 38538	208.67	76.14**	80.48**	SKP 84 X SKI 270	326.27	27.91**	56.32**
							SKP 24 X PCS 124	247.53	75.14**	27.36**	-	-	-	-
Seed yield/ plant (g)	*-51.69 to -64.41* 106.72 to 20.91		14	07	00	22	VP X DCS 47	228.68	106.72**	77.34**				
							SKP 24 X PCS 124	191.38	95.90**	22.02*				
							Geeta X EB 16	279.55	82.18**	65.82**	-	-	-	-
							Geeta X SPS 44-1	285.85	80.17**	39.36**				
							SKP 24 X EC 38538	231.76	78.01**	90.79**				
Shelling out turn (%)	-29.60 to -29.61 15.95 to 9.67		18	18	08	21	SKP 84 X GC 2	69.58	15.95**	7.75**	SKP 84 X GC 2	69.58	09.67**	7.75**
							SKP 84 X DCS 47	69.45	15.74**	7.19**	Geeta X EB 16	69.47	09.50**	4.00**
							VP 1 X SKI 270	65.49	15.06**	5.45**	SKP 84 X DCS 47	69.45	09.47**	7.19**
							SKP 24 X SPS 44-1	65.09	14.73**	1.51	SKP 84 X SH 41	69.26	09.18**	4.28**
							Geeta X SPS 44-1	69.04	13.60**	1.19	Geeta X SPS 44-1	69.04	08.82**	1.19
Test weight of 100 seeds (g)	-31.82 to -32.71 15.73 to 13.91		19	26	03	44	SKP 24 X SKI 270	31.37	15.73**	1.05**	SKP 24 X EC 38538 Geeta X EC 38538 SKP 84 X EB 16	37.08	13.91**	2.65**
							VP 1 X SKI 270	29.11	13.78**	3.26**		33.25	2.14**	0.42
							Geeta X SH 41	31.75	11.93**	1.84**		32.95	1.24**	2.04**
							SKP 24 X SH 41	*30.99*	9.26**	*-0.52*				
							SKP 84 X SKI 202	31.86	8.38**	1.44**				
Oil content (%)	-16.07 to -8.91 to 5.58 9.60		09	34	28	12	VP 1 X SPS 44-1	49.74	5.58**	0.44	VP 1 X EC 38538	53.09	9.60**	1.11**
							VP 1 X DCS 9	49.94	5.38**	1.87**	SKP 84 X GC 2	52.52	8.42**	3.07**
							Geeta X DCS 9	49.71	4.88**	1.70**	VP 1 X SKI 270	52.32	8.00**	1.79**
							VP 1 X SKI 270	52.32	4.63**	1.79**	SKP 84 X EC 38538	52.19	7.74**	0.23**
							SKP 84 X GC 2	52.52	3.98**	3.07**	SKP 24 X EC 38538	51.21	5.70**	0.14

Note: ** Significant at 0.01 probability level

The magnitude of heterotic effects for different characters revealed that for seed yield and major yield contributing characters, it was positive; whereas, for seed quality characters it was negative. Therefore, it would be difficult to develop a single hybrid with earliness, short plant stature, higher yield and high oil content.

The crosses depicted high estimates of heterobeltiosis for different characters also registered significant SCA effects in accordance to direction/ magnitude of heterobeltiosis of respective cross; thereby, revealing that parents involved in different crosses could be carrier of interacting genes resulting in preponderance of non additive gene effect and

for the crop like castor heterosis breeding would be the most remunerative approach for its improvement.

To have a detail account of performance of castor hybrids, those should be grouped and evaluated according to their earliness/ maturity period. However, parents of the promising hybrids, pistillate lines VP 1, SKP 84, Geeta and SKP 24, and inbreds DCS 47, PCS 124, SPS 44-1, DCS 9, EB 16 and SKI 147 need to be mated among themselves in group; i.e., mating among pistillate lines and mating among monoecious inbreds, and developed crosses may be advanced for a promising segregates as a pistillates and inbreds with earliness and higher yield. The resultant pistillate lines and inbreds may be used in castor heterosis breeding work for development of different maturity group higher yielding hybrids.

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Assessment of genetic diversity in non/sparsely spiny safflower (*Carthamus tinctorius* L.)

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(Received: June, 2012; Revised: September, 2012; Accepted: December, 2012)

ABSTRACT

Diversity for agro-morphological traits was assessed in 77 non/sparsely spiny safflower (*Carthamus tinctorius* L.) accessions originating from 25 countries including India along with four indigenous cultivated varieties. The study revealed that among the 12 traits evaluated, wide variability was present for number of capitula, number and location of branches, number of seeds/capitulum and seed yield/plant with a coefficient of variation (CV) above 25%. Principal component analysis (PCA) revealed that 79.35% of the total diversity was explained on the basis of the first five principal components. The distribution of accessions within ten well defined clusters was variable with no apparent relationship with the geographical origin. The greatest inter-cluster distance separated cluster III and VIII (214.83) while it was least for cluster I and II (40.18). Oil content and plant height were the primary traits contributing to genetic diversity based on D^2 values and PCA scores. Diverse non-spiny accessions with desirable agro-morphological traits were identified for utilization in breeding programmes.

Key words: D^2 analysis, Genetic diversity, Non/sparsely spiny, Principal component analysis, Safflower

Safflower (*Carthamus tinctorius* L.) is one of humanity's oldest crops traditionally cultivated for the orange red dye extracted from its florets and for the oil extracted from its seeds. In recent years, development of non-spiny cultivars has been a major objective of safflower breeding in order to overcome constraints encountered during harvesting of seeds and petals.

A set of 77 non/sparsely spiny germplasm accessions including 58 exotic accessions from 24 countries and 19 Indian accessions were evaluated along with 4 cultivated varieties as checks for the identification of promising accessions. The experiment was laid out in simple lattice (8x8) design with two replications during winter season of 2007 at ICRISAT-DOR Research Farm, Patancheru, AP. Each genotype was sown in single-row plot of 3m length with a spacing of 45 cm x 20 cm on Vertisols. Recommended agronomic practices and prophylactic measures were adopted for growing the crop. Observations were recorded for 12 traits on five plants from each replication and mean values were used for analysis. The traits evaluated were days to 50% flowering, plant height at maturity, branch location, branch angle with respect to main stem, branch length, number of branches, number of effective capitula/plant, diameter of main capitulum, number of seeds in main capitulum, hundred seed weight and seed yield/plant. Oil content was estimated using Nuclear Magnetic Resonance technique (AOAC, 1970).

Data collected were subjected to analysis of variance. Mean and standard deviation (S.D.) computed for twelve quantitative traits were used to categorize accessions into three discrete classes *viz.*, low, medium and high (Zar, 1996). Principal component analysis (Rao, 1964) was carried out using WINDOSTAT statistical software (Indostat Services). Genetic divergence was computed by multivariate analysis using Mahalanobis D^2 technique and the genotypes were grouped into clusters following Euclidean method as described by Rao (1952).

Performance of genotypes: The safflower germplasm assessed exhibited wide variability for seed yield/plant, number of seeds/capitulum, branch location and number, number of capitula/plant as illustrated by the high coefficient of variation (> 25%) recorded for these characters (Table 1). High level of phenotypic polymorphism for traits like plant size, spininess and corolla colour which are of interest for improvement have been reported by Johnson *et al.* (2001). Amini *et al.* (2008) reported relatively higher range of genetic variation for seeds/capitula and seed yield/plant among the 20 genotypes evaluated by them. Jaradat and Shahid (2006) reported high levels of variability for branch angle among a set of 631 accessions from 11 countries, while the variability recorded for this character was low in the present investigation. Number of days to 50% flowering and oil content recorded the least variation among the accessions evaluated. Earlier studies have revealed considerable variation in accessions collected from different safflower growing regions of the world (Ranga Rao *et al.*, 1980; Agarwal *et al.*, 1982; Patil *et al.*, 1991; Diwakar *et al.*, 2006; Mukta *et al.*, 2008).

Frequency distribution based on categorization of accessions into three discrete classes (Zar, 1996) indicated that maximum number of accessions belonged to the medium category whereas the low and high categories included 9.88-16.05% and 11.11-22.22% accessions, respectively among all the traits evaluated. The accession GMU 7467 was found to be significantly superior in seed yield/plant (22.62g) than the best non-spiny check JSI-7 (15.67g) (Table 2). Additionally, three accessions from India (GMU 3205, 4122, 6955) and one accession each from Egypt (GMU 4056), Australia (GMU 1303) and Iran (GMU 7370) also recorded higher seed yield (Table 2) and were identified as promising for further selection and improvement of non-spiny safflower.

Genetic divergence studies: Principal component analysis (PCA) performed to analyse the structure of the genetic diversity in the germplasm set revealed that 79.35% of the total diversity was explained on the basis of the first five principal components (Table 3) based on the Eigenvalue-one criterion. The first principal component (PC1) had an Eigenvalue of 10.68 and explained 26.81% of the total variation. Plant height and oil content had the highest positive Eigenvectors in PC1 while 100 seed weight had the highest negative Eigenvector. The second principal component (PC2) was responsible for 24.94% of the total variation and was positively correlated with number of days to 50% flowering, branch location, plant height, capitulum diameter, number of seeds/capitula whereas oil content had the highest negative Eigenvector. Although the contribution of PC3 (11.02%) was similar to PC4 (10.16) with respect to total variability, the former emphasised the importance of branch location and capitulum diameter towards total diversity. The fifth principal component accounted for only 6.42% of the variation with higher positive contribution of number of capitula/plant and negative from capitulum diameter and 100 seed weight. Oil content along with days to flowering and seed yield explained the major variation recorded in fifty germplasm lines of safflower evaluated by Agarwal *et al.* (1982) under rainfed conditions in India. Jaradat and Shahid (2006) reported that a minimum of four PCs were required to explain about 80% of the total variation among the 591 safflower accessions characterised and evaluated by them for eight qualitative traits.

Table 1 Range of variation and frequency for agro-morphological traits of 81 safflower germplasm accessions

Characteristic	Mean	Minimum	Maximum	SD	CV%	Frequency (%)		
						Low	Medium	High
Days to 50% flowering	89.57	80	100	3.64	4.06	13.58	75.31	11.11
Branch location (cm)	29.80	6.2	62.65	9.54	32.01	12.35	71.60	16.05
Branch angle (°)	38.06	31	46	3.72	9.77	9.88	71.60	18.52
Length of longest branch (cm)	36.32	23.2	48	4.87	13.41	14.81	71.60	13.58
No. of branches	9.57	4.5	16.2	2.47	25.81	16.05	69.14	14.81
Plant height (cm)	76.08	54.7	94.1	10.40	13.67	13.58	64.20	22.22
Capitulum diameter (mm)	16.55	11.25	26.92	2.48	14.98	11.11	75.31	13.58
No. of capitula/plant	23.97	5.95	37.1	5.99	24.99	16.05	67.90	16.05
No. of seeds/capitulum	19.31	9.5	47.6	6.53	33.82	11.11	76.54	12.35
100 seed weight (g)	4.43	2.71	6.83	0.84	18.96	16.05	69.14	14.81
Seed yield/plant (g)	9.15	2.06	22.62	3.86	42.19	13.58	72.84	13.58
Oil content (%)	27.19	21.65	29.6	1.60	5.88	11.11	74.07	14.81

Table 2 Characteristics of high yielding safflower germplasm accessions

Genotype	Days to 50% flowering	Branch location (cm)	Branch angle (°)	Length of longest branch (cm)	No. of branches	Plant height (cm)	Capitulum diameter (mm)	No. of capitula/ plant	No. of seeds/ capitulum	100 seed weight (g)	Seed yield/plant (g)	Oil content (%)
GMU 7467	97.5	27.7	35.5	39.6	10.8	79.5	13.76	22.9	15.5	5.20	22.62	28.65
GMU 7370	91.5	28.3	35.0	23.2	7.6	94.1	15.81	16.6	23.3	3.84	18.44	26.75
GMU 3205	87.5	34.7	42.5	37.1	7.0	66.5	16.00	29.2	23.6	4.00	17.45	28.30
GMU 6955	90.0	19.9	34.5	28.8	9.1	91.1	16.04	20.9	21.8	4.84	16.73	28.45
GMU 4056	89.0	32.8	37.0	40.0	10.3	84.3	22.05	22.6	31.3	4.36	16.06	27.10
GMU 4122	89.5	31.1	37.5	34.5	16.2	78.2	11.25	34.8	22.5	4.08	15.88	29.05
GMU 1303	89.0	31.2	41.5	41.9	8.0	79.6	26.92	21.2	47.6	4.15	15.73	26.40
JSI 7 (check)	89.0	20.5	46.0	42.6	11.1	66.0	14.29	28.9	15.5	4.12	15.67	29.05
CD(P=0.05)	3.73	12.50	6.20	6.37	3.53	10.10	3.03	8.46	8.40	1.13	5.65	1.09

Clustering of 81 accessions using Ward's minimum variance technique grouped the accessions into 10 discrete and well defined clusters. Clusters VI and X were the largest consisting of 14 genotypes (Table 4) whereas the smallest clusters were VIII and IX with 3 genotypes each. The pattern of distribution of genotypes into various clusters was at random; all the clusters had at least one accession from India except cluster IX. Cluster VI possessed maximum number of Indian accessions (5). This suggested that geographical origin was not related to genetic diversity and was in concurrence with reports by other researchers on safflower (Patil *et al.*, 1991; Diwakar *et al.*, 2006; Elfadl *et al.*, 2010. This can be due to the exchange of plant materials across the regions during the history of safflower cultivation (Amini *et al.*, 2008).

The maximum intra-cluster distance was observed in cluster VIII (60.71) (Table 5) whereas cluster I (20.07) displayed the least intra-cluster distance revealing the similarity of the eight genotypes within the cluster. Based on the inter-cluster distance, it was found that cluster III was highly divergent from cluster VIII (214.83), cluster IV (181.42), cluster VII (170.72) and cluster VI (169.35).

Presence of variability in the 81 germplasm accessions was also reflected in the cluster means for the 12 traits evaluated (Table 6). Clustering pattern indicated that genotypes in cluster I were early to flower, short statured and possessing maximum branching angle while genotypes with maximum 100 seed weight and minimum number of seeds formed cluster III. Cluster IV comprised of genotypes with bold capitula with maximum number of seeds and maximum seed yield. Early flowering accessions with many branches, small sized capitula and high oil content characterized cluster VI. Highest cluster mean for plant height and least branch angle was recorded for Cluster X which included accessions from Bangladesh, India, Iran, Israel, Mexico, Russian Federation and USA. Various characters *viz.*, height of branching from ground level, size and number of capitula, seed number and weight, yield/plant and hulling percentage exerted marked influence on genetic diversity at inter and intra-cluster levels among 30 germplasm accessions evaluated by Ranga Rao *et al.* (1980). Among the set of accessions evaluated in the present study, the contribution of oil content was the highest followed by plant height. However, Agarwal *et al.* (1982) reported that oil content, days to flowering and seed yield explained the major variation among the 50 lines of safflower germplasm grown under rainfed conditions in India. Patil *et al.* (1991) found plant height, days to flowering, number of seeds/capitulum and 100 seed weight to be important sources of variation among the 30 genotypes evaluated. Ranga Rao *et al.* (1980) reported that since traits like branching height, 1000 seed weight and plant height contributed more towards diversity in the collections evaluated by them, these basic attributes of plant architecture needed greater attention. Senapati *et al.* (1999) concluded that number of capitula/plant was the most important yield component.

Analysis for estimating the contribution of various quantitative characters towards the expression of genetic diversity (Table 7) indicated that oil content (31.67%) and plant height (19.41%) together contributed to 51.08% of the total genetic diversity of the collection. Number of days to 50% flowering (8.24%), capitulum diameter (7.93 %), seed yield/plant (6.08%), branch location (5.83%), 100 seed weight (5.43 %), number of seeds in main capitulum (4.54%), branch length (4.01%), number of branches (2.84%), number of effective capitula/plant (2.78%) and branch angle (1.23%) contributed to the remaining 48.72% of the total diversity in decreasing order.

Table 3 Eigenvectors and eigenvalues of principal Components (PC)

Trait	Eigenvectors				
	PC1	PC2	PC3	PC4	PC5
Days to 50% flowering	0.53	1.19	0.48	1.11	0.43
Branch location (cm)	-0.08	0.99	0.73	0.55	0.23
Branch angle (°)	-0.52	-0.41	0.22	0.14	0.01
Length of longest branch (cm)	-0.10	-0.53	0.44	0.77	-0.45
No. of branches	0.37	-0.23	-0.31	-0.16	0.11
Plant height (cm)	0.74	1.83	-1.08	-0.12	-0.15
Capitulum diameter (mm)	0.13	0.96	0.87	-0.62	-0.84
No. of capitula/plant	-0.26	-0.52	-0.59	0.00	0.65
No. of seeds/capitulum	0.58	0.90	0.00	-0.69	0.03
100 seed weight (g)	-0.78	-0.45	-0.59	0.48	-0.88
Seed yield/plant (g)	0.52	0.30	-0.79	0.87	-0.39
Oil content (%)	2.85	-1.18	0.20	0.05	-0.14
Eigenvalue	10.68	9.93	4.39	4.04	2.56
Variance (%)	26.81	24.94	11.02	10.16	6.42
Cumulative variance (%)	26.81	51.76	62.78	72.93	79.35

Table 4 Clustering pattern of 81 safflower germplasm accessions

Cluster No.	No. of accessions	Accession number
I	8	GMU 625 (India), 965 (Turkey), A-1* (India), GMU 4808 (Iran), GMU 6970 (Turkey), GMU 5775 (China), GMU 7384 (China), GMU 1253 (Syria)
II	8	GMU 1323 (Egypt), GMU 2091 (India), GMU 3236 (India), GMU 4087 (China), GMU 1743 (Turkey), GMU 7434 (Russian federation), GMU 3184 (India), GMU 3732 (India)
III	4	GMU 651 (India), GMU 1428 (Turkey), GMU 754 (E. Germany), GMU 4845 (Portugal)
IV	6	GMU 753 (E. Germany), GMU 6940 (India), GMU 4056 (Egypt), CO-1 (India), GMU 7439 (Kazakhstan), GMU 1303 (Australia)
V	11	GMU 1196 (Jordan), GMU 7409 (USA), GMU 4866 (Australia), GMU 3454 (India), GMU 7387 (USA), GMU 1242 (Spain), GMU 3194 (India), GMU 3124 (Iran), GMU 6035 (Russian federation), GMU 3258 (India), GMU 7380 (Iraq)
VI	14	GMU 999 (Morroco), GMU 3643 (India), GMU 628 (India), GMU 1877 (USA), GMU 1162 (Egypt), GMU 1181 (Iran), GMU 2034 (Iran), GMU 1415 (Iran), GMU 4803 (Egypt), GMU 4052 (Iran), GMU 4122 (India), GMU 6939 (India), JSI-7 (India), GMU 3205 (India)
VII	10	GMU 763 (USA), GMU 1880 (USA), GMU 1954 (USA), GMU 7419 (Denmark), GMU 6964 (India), NARI 6 (India), GMU 7374 (Iran), GMU 1198 (Israel), GMU 3119 (Pakistan), GMU 7467 (Cyprus)
VIII	3	GMU 6942 (Bulgaria), GMU 7429-1 (Kuwait), GMU 7373 (Iran)
IX	3	GMU 7460 (Uzbekistan), GMU 7463 ((Uzbekistan), GMU 4045 (Egypt)
X	14	GMU 800 (USA), GMU 2939 (India), GMU 6955 (India), GMU 7370 (Iran), GMU 842 (USA), GMU 1241 (Israel), GMU 7379 (Iran), GMU 1240 (Israel), GMU 7388 (USA), GMU 5282 (Bangladesh), GMU 3257 (USA), GMU 6958 (India), GMU 4716 (Mexico), GMU 7433 (Russian Federation)

*Italicized accession numbers indicate sparsely spiny genotypes, only A-1 is spiny check; all other accessions are non-spiny

Table 5 Intra and inter-Euclidean2 cluster distances

Cluster No.	I	II	III	IV	V	VI	VII	VIII	IX	X
I	**20.07**	40.18	74.60	96.82	48.65	53.21	76.45	137.833	95.05	78.55
II		**32.98**	72.87	84.86	60.69	90.08	82.41	100.23	70.39	77.39
III			**41.28**	181.42	147.25	169.35	170.72	214.83	148.81	152.39
IV				**49.45**	65.61	99.68	76.03	93.64	77.48	84.87
V					**33.35**	55.13	62.70	106.02	81.19	73.64
VI						**41.88**	69.41	168.22	120.36	93.22
VII							**38.10**	99.17	61.06	67.75
VIII								**60.71**	74.96	107.02
IX									**29.72**	60.83
X										**42.35**

(values in bold are intra-cluster distances)

Table 6 Cluster means for evaluated traits of 81 safflower accessions

Cluster No.	Days to 50% flowering	Branch location (cm)	Branch angle (°)	Length of longest branch (cm)	No. of branches	Plant height (cm)	Capitulum diameter (mm)	No. of capitula/ plant	No. of seeds/ capitulum	100 seed weight (g)	Seed yield/ plant (g)	Oil content (%)
I	88.31	27.68	41.91	37.51	9.97	66.83	15.69	28.58	14.30	4.57	8.22	25.93
II	89.31	41.79	40.13	34.48	6.71	71.50	16.42	18.25	18.64	4.54	5.76	25.56
III	89.50	32.04	40.31	40.50	8.38	71.78	16.06	25.61	13.94	5.56	7.46	22.75
IV	89.08	31.53	37.67	39.22	10.62	80.41	22.24	19.70	31.52	4.36	13.80	28.21
V	88.77	27.34	35.76	36.46	9.19	68.56	17.55	23.56	19.36	3.94	6.21	27.58
VI	87.04	24.07	41.31	39.52	11.41	67.73	14.78	28.94	15.89	4.71	9.94	28.39
VII	93.15	31.50	36.30	38.56	9.88	80.31	15.23	23.16	17.63	4.29	11.80	28.20
VIII	96.67	48.92	37.58	29.20	6.93	86.03	20.45	15.72	22.82	3.22	6.02	27.48
IX	95.83	29.86	34.96	32.84	8.90	82.98	15.32	16.02	29.68	4.28	8.98	26.95
X	88.39	24.40	34.83	31.57	9.80	91.02	16.21	25.40	20.48	4.50	10.46	27.44

Table 7 Contribution of different characters towards genetic divergence (D^2)

Source	No. of times ranked first	Per cent contribution towards divergence
Days to 50% flowering	267	8.24
Branch location (cm)	189	5.83
Branch angle (°)	40	1.23
Length of longest branch (cm)	130	4.01
No. of branches	92	2.84
Plant height (cm)	629	19.41
Capitulum diameter (mm)	257	7.93
No. of capitula/plant	90	2.78
No. of seeds/capitulum	147	4.54
100-seed weight (g)	176	5.43
Seed yield/plant (g)	197	6.08
Oil content (%)	1026	31.67

Based on D^2 values and PCA scores, oil content and plant height were identified as the most important traits contributing towards diversity among the non/sparsely spiny accessions evaluated. This indicates that it is essential to lay greater emphasis on these characters for the purpose of further selection and choice of parents for hybridization. Genotypes from two most divergent clusters, GMU 651, 1428, 754 and 4845 from Cluster III and GMU 6942, GMU 7429-1, GMU 7373 from Cluster VIII were identified as potential parents in future endeavour's for improvement of non/sparsely spiny safflower. Therefore, above seven accessions were short-listed on the basis of higher seed yield for improvement through further selection.

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Effect of organic, inorganic, bio and chemical amendments on rhizosphere mycoflora and yield of groundnut (*Arachis hypogaea* L.)

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(Received: November, 2011; Revised: November, 2012; Accepted: December, 2012)

ABSTRACT

The field experiment was conducted during the winter season of 2009 in the Krishi Vigyan Kendra, Reddipalli and Agricultural Research Station, Rekulakunta, Anantapur, Andhra Pradesh to study the effect of organic, inorganic, bio and chemical amendments on rhizosphere mycoflora and yield of groundnut (*Arachis hypogaea* L.). The results showed that the rhizosphere mycoflora increased from a day before sowing to harvest in combined application of *Pseudomonas fluorescens* + gypsum+ neem cake + mancozeb (69.55 cfu/g of soil) followed by *Pseudomonas fluorescens* + gypsum (56.32 cfu/g), gypsum + mancozeb (52.36 cfu/g) treatments compared to others. The combined application of *Pseudomonas fluorescens* + neem cake + gypsum + mancozeb was found significantly superior to all other treatments in improving plant characters (at 75 days after sowing) besides increasing pod yield (1391 kg/ha), haulm yield (2248 kg/ha), shelling percentage (73) and test weight (37 g).

Key words: Groundnut, Gypsum, Mancozeb, Neem cake, *Pseudomonas fluorescens*, Rhizosphere mycoflora, Soil amendments, Yield and yield attributes

Groundnut (*Arachis hypogaea* L.) is a premier oilseed crop in India mainly in Rayalaseema districts of Andhra Pradesh (A.P), grown under rainfed (nearly 80%) and low erratic rainfall (about 552 mm) situation. In Anantapur, monocropping of groundnut both in rainy and winter seasons is in vogue. The average yields are low (750 kg/ha) (Johnson, 2006) due to several production constrains, which include biotic and abiotic stresses. In addition to this farmers do not apply recommended dose of fertilizer with an assumption that the chemical fertilizers may not be effective under moisture stress condition. Soil bacteria and fungi play pivotal roles in various bio, geo chemical cycles and are responsible for the recycling of organic compounds by contributing to plant health, soil structure and soil fertility. The metabolic activity of microbes in the rhizosphere region plays vital role for plant growth and management of soil born pathogens. Root exudates have direct influence on rhizosphere micro biota (Rovira,1965) *Pseudomonas fluorescens* produces plant growth promoting substances and induces systemic resistance in plants (Rama moorthy *et al.*,.2001). It is the induced resistance developed systematically in response to colonization of plant roots by certain rhizobacteria or PGPR (Van Loon *et al.*, 1998). Soil amendments in the form of plant debris, green manures, farmyard manures, compost, oil cakes and fertilizers are known to improve crop productivity in the rhizosphere to suppress certain soil born diseases (Sivaprakasam, 1991). Inorganic fertilizers are essential for growth and high yield with good quality of groundnut (Ibrahim and Elaiwa, 2008). Application of gypsum as soil amendment is the most effective and cheapest source of calcium and sulfur in increasing the pod yield when applied @ 500 kg/ha followed by neem cake @ 150 kg/ha as basal (Johnson *et al.*, 2006). Chemical seed treatment has resulted in significant reduction in losses caused by a variety of diseases with enhancement of quality and quantity of yields. Hence, the present study was undertaken with integration of organic, inorganic, bio and chemical amendments and their influence on rhizosphere mycoflora and yield of groundnut.

The present investigation was carried out in the Department of Microbiology, Sri Krishnadevaraya University and Krishi Vignana Kendra, Reddipalli, Anantapur (Dt).during the winter season of 2009. The general laboratory techniques followed were those described by Nene and Thapliyal (1993), Dhingra and Sinclair (1995) and Aneja (2001) for the preparation of media, sterilization, isolation and maintenance of fungal culture, for isolation of rhizosphere mycoflora. Potato dextrose agar media was used. Soil samples were collected from the rhizosphere of groundnut cultivar TMV-2, (which is of 105-110 days duration). Sampling was done at the rhizosphere of healthy groundnut plants as described by Sharma and Sen (1991). The soil adhering to the roots was collected and mixed to provide a composite rhizosphere soil. The sampling was done at two phases of plant growth *i.e.* 75 and 105 days after sowing (DAS), for isolation of rhizosphere mycoflora the dilution plate method proposed by Aneja (2001) was followed and isolated mycoflora were identified based on their cultured and morphological characteristics and transferred to culture tubes containing appropriate medium for further studies.

Field experiment was laid out in a randomized block design with 12 treatments (Table 1) and replicated thrice in a plot size of 2 x 2m^2 of 30 cm x 10 cm spacing. Physico-chemical properties of the experimental red soil were pH: 7.21 and total nitrogen 0.047%. Sand, silt and clay ratio was 74.2:20.2:5.6, respectively. The treatments were applied as soil amendments at sowing. Nitrogen, phosphorus and potassium were applied in the form of urea @ 67.5 kg/ha, single super phosphate @ 250kg/ha, murate of potash @ 67.5 kg/ha, respectively. Observations were made on plant characters and yield parameters *viz.*, plant height, nodule number, nodule weight, root length, root weight at 75 DAS/plant were recorded, from five randomly selected plants from each plot. The data pertaining to pod, haulm yield, shelling percentage and test weight were recorded at harvest and results were analyzed by following statistical procedures (Panse and Sukhatme, 1978).

Among various treatments combined application of neem cake + *Pseudomonas fluorescens* + gypsum + mancozeb supported more number of 69.55 cfu/g of soil, followed by combined application of *Pseudomonas fluorescens* + gypsum (56.32 cfu/g) and combined application of gypsum + mancozeb (52.36 cfu/g) treatments (Table 1), while lowest was observed with control (25.70 cfu/g). The identified mycoflora from rhizosphere of groundnut cultivar in red soil were *Aspergillus flavus, Aspergillus niger, Alternaria, Drechslera, Cuvularia, Fusarium, Pencillium, Rhizopus* and *Trichoderma* species. Saralamma (2000) observed in four groundnut cultivars an increasing occurrence of microbial colonies from 30 DAS to harvest at every stage of observation and found that the number of colonies of *Sclerotium rolfssi* per g. of soil was more over other mycoflora. Qualitative estimation of rhizosphere mycoflora among the treatments might be due to differences in the root exudates (Rovira, 1965). According to Pandey and Upadhay (2000) the fungal population increased in the rhizosphere due to increase in the soil temperature and further provide congenial micro climate for the soil microbial population than cool temperature. The variation in fungal flora of groundnut under certain conditions was possible due to differences in chemical composition of root exudates. In the present study, more number of fungal colonies was observed in red soil may be due to more leaf drop which served as feed for colonization of mycoflora.

Combined application of neem cake + *Pseudomonas fluorescens* + gypsum + mancozeb was found significantly superior to all other treatments and improved plant chacters at 75 DAS *viz.*, plant height, haulm weight, nodule number, number of branches, root length and root weight, number of pods and pods weight (Table 2).

Table 1 Effect of neem cake, gypsum, *Psuedomonas fluorescens* and mancozeb soil amendments on rhizosphere mycoflora

	Treatment	Mean rhizosphere mycoflora (cfu/g of dry soil)			Average rhizosphere mycoflora (cfu/g)
		Before sowing	At 75 DAS	At the time of harvest (105days)	
T_1	Application of neem cake @ 150 kg/ha as soil amendment	21.58 (26.69) *	26.35 (30.87) *	27.49 (31.60) *	25.14 (29.72)
T_2	Application of *Psuedomonas fluorescens* @ 2.5 kg/ha at 30 and 45 days	23.05 (28.69)	30.71 (33.64)	37.96 (38.08)	30.57 (33.47)
T_3	Application of gypsum @ 500 kg/ha as basal at 45 days	22.42 (28.26)	33.54 (35.38)	38.75 (38.49)	31.57 (34.04)
T_4	Seed treatment with mancozeb @ 3 g/kg seed	20.55 (26.95)	29.09 (32.59)	31.45 (34.09)	27.03 (31.21)
T_5	$T_1 + T_2$	20.84 (27.16)	31.8 (34.32)	37.82 (37.94)	30.15 (33.14)
T_6	$T_1 + T_3$	20.86 (27.16)	42.02 (40.40)	50.41 (45.24)	37.76 (37.60)
T_7	$T_1 + T_4$	20.04 (26.59)	29.69 (33.01)	34.39 (35.90)	28.04 (31.83)
T_8	$T_2 + T_3$	21.33 (27.49)	46.95 (43.24)	56.32 (48.64)	41.53 (39.79)
T_9	$T_2 + T_4$	20.89 (27.15)	30.05 (33.23)	34.93 (36.21)	28.62 (32.19)
T_{10}	$T_3 + T_4$	20.09 (26.62)	43.63 (41.23)	52.36 (46.36)	38.69 (38.07)
T_{11}	$T_1 + T_2 + T_3 + T_4$	21.48 (27.60)	48.87 (44.35)	69.55 (56.52)	46.63 (42.82)
T_{12}	Control	21.36 (27.52)	24.02 (29.29)	25.70 (30.41)	23.69 (29.07)
	CD (P=0.05)	1.73	3.10	3.26	---

* Figures in parentheses are angular transformed values; DAS: Days after sowing

Further, the same treatment increased the pod yield, haulm yield, shelling percentage and more test weight (Table 3). Harinath Naidu and Subbarami Reddy (1996) noticed that the use of soil amendments with organic and inorganic form (20 kg N+ 10 kg P + 10 kg K + 250 kg gypsum + 25 kg zinc sulphate) resulted in higher pod yields. This may be due to the application of both macro and micro nutrients and also application of organic, inorganic soil amendments might have enhanced the antagonistic soil microorganisms and increased crop yields to the considerable extent. Christopher Lourduraj *et al.* (1998) observed high pod yield with the application of nitrogen, phosphorous, potassium (NPK), and gypsum and micronutrient mixture. Application of N, P and K together improved the yields significantly over their

application alone. Gypsum might have increased availability of calcium and sulfur in the fruiting zone, which is essential for proper pod filling (Sridhar *et al.*, 1985). The effectiveness of gypsum increase kernel weight due to nutritive value of calcium in addition to its physiological role of offsetting the action of the oxalic acids and cell wall degrading enzymes being produced by the pathogens might have strongly increased the test weight of kernel in the present study (Mehan *et al.*, 1995). Meena *et al.* (2000) recorded maximum pod yield at 1823 kg/ha with *Pseudomonas fluorescens* treatment against late leaf spot in groundnut this was due to induced systematic resistance and stimulated plant growth by secreting auxins, gibberellins, cytokinins, and by suppression of deleterious microorganisms.

Correlation studies: The correlation analysis between rhizosphere mycoflora and plant characters at 75 DAS revealed that final plant population (r=0.863**), plant height (r=0.951**), haulm weight (r=0.773**), root length (r=0.943**), number of nodules (r=0.973**), root weight (r=0.878**), number of branches (r=0.988**), number of pods (r=0.972**) and pod weight (r=0.963**) showed highly significant positive correlations. The correlation matrix was analyzed to know the effect of different treatments between rhizosphere mycoflora and yield of groundnut, indicated final plant population (r=0.863**), pod yield (r=0.940**), haulm yield (r=0.896**), shelling percentage (r=0.839**), test weight (r=0.905**) showed highly significant positive correlations.

Present study, indicated that the presence of organic, inorganic, bio and chemical amendments enhanced the antagonist soil microorganisms and improved the groundnut seed yield.

Table 2. Effect of neem cake, gypsum, *Psuedomonas fluorescens* and mancozeb soil amendments on plant characters

	Treatment	Plant characters at 75 DAS							
		Plant height (cm)	Haulm weight (g/plant)	Root length (cm)	Root weight (g/plant)	No. of nodules/ plant	No. of branches/ plant	No. of pods/ plant	Pod weight/ plant (g)
T_1	Application of neem cake @ 150 kg/ha as soil amendment	24.8	6.05	5.53	1.89	27.4	4.5	6.4	3.2
T_2	Application of *Psuedomonas fluorescens* @ 2.5 kg/ha at 30 and 45 days	25.9	6.25	6.07	2.32	35.4	4.7	8.5	4.1
T_3	Application of gypsum @ 500 kg/ha as basal at 45 days	26.3	6.29	6.07	2.33	38.3	4.7	9.5	4.2
T_4	Seed treatment with mancozeb @ 3 g/kg seed	25.0	6.11	5.73	2.05	30.8	4.5	7.3	3.7
T_5	$T_1 + T_2$	25.3	6.22	6.07	2.27	35.3	4.7	8.0	3.9
T_6	$T_1 + T_3$	27.1	6.31	6.13	2.39	40.7	5.0	10.4	4.3
T_7	$T_1 + T_4$	25.2	6.13	5.80	2.17	31.0	4.6	7.6	3.9
T_8	$T_2 + T_3$	27.5	6.51	6.27	2.50	41.8	5.1	10.3	4.8
T_9	$T_2 + T_4$	25.3	6.21	5.87	2.25	32.2	4.6	8.0	3.9
T_{10}	$T_3 + T_4$	27.3	6.31	6.13	2.39	40.9	5.1	10.3	4.6
T_{11}	$T_1 + T_2 + T_3 + T_4$	27.7	6.55	6.93	2.56	49.1	5.3	12.7	5.4
T_{12}	Control	24.7	5.41	5.53	1.77	27.3	4.4	6.0	3.0
	CD (P=0.05)	NS	0.52	1.19	0.43	16.78	NS	4.93	2.25

Table 3. Effect of neem cake, gypsum, *Psuedomonas fluorescens* and mancozeb soil amendments on groundnut yield

	Treatment	Mean yield and yield attributes at 105 DAS*			
		Pod yield (kg/ha)	Haulm yield (kg/ha)	Shelling percentage	Test weight (g)
T_1	Application of neem cake @ 150 kg/ha as soil amendment	822	1822	68	31
T_2	Application of *Psuedomonas fluorescens* @ 2.5 kg/ha at 30 and 45 days	1063	2058	70	34
T_3	Application of gypsum @ 500 kg/ha as basal at 45 days	1085	2084	71	35
T_4	Seed treatment with mancozeb @ 3 g/kg seed	706	1823	70	32
T_5	$T_1 + T_2$	1059	2022	69	33
T_6	$T_1 + T_3$	1109	2118	73	35
T_7	$T_1 + T_4$	963	1763	69	32
T_8	$T_2 + T_3$	1239	2228	73	36
T_9	$T_2 + T_4$	978	1930	69	33
T_{10}	$T_3 + T_4$	1152	2167	72	35
T_{11}	$T_1 + T_2 + T_3 + T_4$	1391	2248	73	37
T_{12}	Control	690	1763	64	29
	CD (P=0.05)	147.9	386.65	4.84	4.44

*DAS: Days after sowing

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Effect of inorganic and biofertilizers on performance of summer soybean (*Glycine max* L.)

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(Received: June, 2011; Revised: October, 2012; Accepted: November, 2012)

ABSTRACT

A field experiment was carried out in summer 2010 to study the influence of inorganic and biofertilizers on yield and yield attributes of soybean (*Glycine max* L.) variety MAUS-71. Results revealed that application of higher levels of fertilizer NPK (40:70:40) resulted in higher number of pods/plant (37.08), pod yield/plant (8.91 g), grain yield (1399 kg/ha) and test weight (78.38 g) as compared to other treatments. Biological and straw yields were also found higher with high level of inorganic fertilizer application. Duel application of Rhizobium spp + Phosphate solubilising bacteria recorded higher grain yield (1253 kg/ha) over individual inoculation of biofertilizers.

Key words: Biofertilizers, Inorganic fertilizers, Soybean

Soybean (*Glycine max* L.) has emerged as an important grain legume crop which contains about 40-44% protein, 20% oil. There is vast scope for increasing soybean production in the country due to its high nutritional quality, higher productivity and short duration (90-110 days). Being a leguminous crop and capable of withstanding moisture stress it helps in improving the fertility and productivity of soil. The inorganic fertilizers are used to supply essential nutrients for better growth and development. Hence, to maintain soil fertility, productivity and to reduce cost of cultivation, it is necessary to integrate biofertilizers in soybean cultivation. Commonly used biofertilizers are Rhizobium and phosphate solubilising bacteria (PSB) for leguminosae family crops to ensure adequate nodulation, nitrogen fixation and enhanced availability of phosphorus, respectively for maximum growth and yield of pulse crop. The production of soybean crop can be increased through enhanced area and productivity. The first priority would be to raise the productivity of soybean in traditional areas during rainy season. Alternately, it is important to extend its cultivation to non-traditional seasons mainly during summer season through judicious and integrated nutrient management along with inorganic and biofertilizers.

The experiment was conducted during summer season of 2010 at the experimental farm of College of Agriculture, Latur. The experimental plot was a deep black soil with good drainage and slightly alkaline in reaction (pH 7.35). The experiment was laid out in factorial randomized block design with three replications. Nine treatment combinations of three levels of inorganic fertilizers (20:50:20, 30:60:30 and 40:70:40 kg NPK/ha) and three levels of biofertilizers (*Rhizobium* spp., PSB and dual application of *Rhizobium* spp. + PSB). The seed treatment with biofertilizers was done @ 25 g/kg grain. The soybean variety MAUS-71 was the test crop. The gross plot and net plot size were 6 m x 3.6 m and 5 m x 2.7 m, respectively. The field experiment was initiated on January 19, 2010 by dibbling method of sowing. As per treatments, 100% inorganic fertilizers were applied as basal dose. Seed was treated with biofertilizers and protective irrigations were given at specific intervals as per the need. Grain yield was calculated on net plot basis and reported as per hectare yield and other growth and yield attributes were recorded at harvest by selecting five plants randomly from the net plot.

Yield attributes of soybean *viz.*, number of pods/plant, pod yield and test weight (1000 grain weight) were significantly influenced by different treatments. Application of higher levels of NPK (40:70:40 kg/ha) was found to be significantly superior in recording more number of pods, pod yield, grain yield and test weight. This was followed by application of 30:60:30 kg NPK/ha. Application of higher level of inorganic fertilizer was found significantly superior over other levels of NPK in respect of grain, straw and biological yield. Similar result was reported by Jadhav *et al.* (2009).

Dual inoculation of *Rhizobium* spp. + PSB was found significantly superior over inoculation of *Rhizobium* spp. or PSB alone with respect to number of pods/plant, pod yield, grain yield/plant and test weight. Pods/plant due to dual application of PSB and *Rhizobium* were found significantly superior over single application of biofertilizers. However, it was at par with seed inoculation with either *Rhizobium* spp. or PSB in recording more number of pods/plant, grain yield/plant and test weight. Jadhav *et al.* (2009) reported similarly.

Table 1 Effect of inorganic fertilizers and bio-fertilizers on performance of summer soybean

Treatment	No. of pods/ plant	Pod yield/ plant (g)	Test weight (g)	Grain yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)
Inorganic fertilizers (NPK kg/ha)							
20:50:20	29.20	7.14	75.86	865	896	1761	49
30:60:30	34.48	7.96	76.69	1085	1020	2105	52
40:70:40	37.08	8.91	78.38	1399	1375	1774	50
SEm±	0.42	0.15	0.27	26	28	44	-
CD (P=0.05)	1.27	0.45	0.80	77	85	132	-
Biofertilizers							
Rhizobium spp.	30.34	7.26	76.36	1037	1038	2075	49
PSB	31.17	7.82	76.78	1058	1038	2096	50
Rhizobium spp. + PSB	38.24	8.93	77.78	1253	1216	2469	51
SEm±	0.42	0.15	0.27	26	28	44	-
CD (P=0.05)	1.27	0.45	0.80	77	85	132	-
Interaction							
SEm±	0.73	0.26	0.46	45	49	77	-
CD (P=0.05)	2.19	NS	NS	NS	147	NS	-
General Mean	33.25	8.00	76.98	11161	1097	2213	50

PSB: Phosphate solubilising bacteria

Interaction effect was significant in influencing number of pods/plant. The interaction of higher level of NPK with dual grain treatment of *Rhizobium* spp. + PSB was found significantly superior. The interaction of higher level of NPK and dual treatment of *Rhizobium* spp. + PSB was found to be significantly superior in recording higher grain yield.

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Effect of nitrogen nutrition on yield and protein content of soybean [*Glycine max* (L.) Merr.]

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(Received: April, 2011; Revised: December, 2012; Accepted: December, 2012)

ABSTRACT

An experiment was conducted at research farm of Ch. Charan Singh Haryana Agricultural University, Hisar (Haryana) (29° 10'N latitude, 75° 48'E longitude and 215 M altitude) during the rainy season of 2009. The soil of experimental field was sandy loam in texture and slightly alkaline in reaction (pH 7.7). The fertility status of soil was low in available nitrogen (N), medium in available phosphorus, fairly high in available potassium and moderate in organic carbon. The treatments comprised four nitrogen levels *viz*., 20, 40, 60 and 80 kg/ha applied full as basal at sowing, half as basal + half at 50 DAS and half as basal + half at 80 DAS. *Rhizobium* inoculation alone and in combination with 20, 40 and 60 kg/ha levels of N in addition to a control. The soybean *Glycine max* (L.) Merr. yield attributing characters *viz*., number of pods/plant, number of seeds/pod and 100 seed weight, seed yield and protein content in seed were found to increase with increasing levels of N and recorded maximum with combined application of N @ 60 kg/ha and *Rhizobium* inoculation. Split application of N did not improve the soybean yield and protein content significantly. However, split dose of N at 50 DAS was found better than at 80 DAS.

Key words: Growth, Nitrogen, Quality, *Rhizobium* inoculation, Soybean, Yield

Soybean [*Glycine max* (L.) Merr.], being a leguminous crop is capable to fix atmospheric nitrogen (N). Soybean offers good potential in cropping sequence being a short duration legume, energy rich oilseed crop. Although some high yielding varieties of soybean have been introduced but, the desired level of yield could not be attained. The main reasons for not realizing its full yield potentials are improper and under use of nitrogenous fertilizer, lack of specific information about biofertilizers and their proper inoculation. For getting higher yield, it is necessary to optimize the nutrient inputs. To assure continuous N supply to the crop and to improve its efficiency the split application of N will increase crop yield and reduce soil and water pollution due to leaching. Keeping this in view a field investigation was carried out to improve production of soybean by way of biofertilizer and split application of N.

The experiment was carried out at the Agronomy research farm of Ch. Charan Singh Haryana Agricultural University, Hisar (Haryana) during the rainy season of 2009. The soil of experimental field was sandy loam in texture and slightly alkaline in reaction (pH 7.7). The experimental soil was low in available nitrogen, medium in available phosphorus, fairly high in available potassium and moderate in organic carbon 155.4, 20.3, 254.8 kg/ha and 0.40%, respectively. There were seventeen treatments (Table 1) laid out in randomized block design with three replications. Prior to sowing, a common pre-sowing irrigation of 6 cm depth was applied in the field to obtain a uniform crop stand. As per treatments, seed was inoculated with *Rhizobium* by adopting standard procedure, thoroughly mixed and dried in shade. Soybean variety JS-335 was sown in the third week of July by using 80 kg seed/ha at row spacing of 30 cm and thinning was done after 15 days of sowing to maintain plant to plant spacing of 10 cm. All other cultural operations were followed as per package of practices for the crop. Five randomly selected plants were taken for recording yield attributes, yield and protein content in seed.

Soybean yield and yield attributes were found to increase with increasing levels of nitrogen (Table 1). *Rhizobium* inoculation as well as its combined application with different doses of N also significantly affected yield and yield attributes of soybean crop. Although all the yield attributes *viz*., number of pods/plant, number of seeds/pod, 100 seed weight and seed yield were highest in treatment T_9, but, it was at par with the treatment T_5, T_{13} and T_{17}. This might be due to increase in crop growth and longer crop growth period. Yield components were significantly influenced due to combined application of N and inoculation, which resulted in good growth of plant because of higher and easy availability of N. An increase in grain yield of 14.5, 23.1, 29.2 and 34.5% was recorded over control with the application of 20, 40, 60 and 80 kg N/ha, respectively, while, it was 10.1, 5.3, 9.4, and 8.5% with inoculation alone and combined application of N @ 20, 40 and 60 kg/ha with inoculation over uninoculated control (T_1) and at their respective levels of N applied alone at sowing, respectively. *Rhizobium* inoculation provided favourable conditions for the multiplication of nodule bacteria which in turn produced more number of nodules and thereby more nitrogen was fixed for the use of the plant in treatments T_6-T_9 over the

treatments T_1-T_5. This has helped the plant in getting sufficient nitrogen and better growing conditions, which resulted in more growth, more number of pods/plant, number of seeds/pod, 100 seed weight, and ultimately more seed yield/ha. Correlation studies showed a positive significant correlation between yield and number of pods/plant (r= 0.95), number of seeds/pod (r=0.97), 100 seed weight (r= 0.94). A linear regression was found between yield and number of seeds/pod, number of pods/plant and 100 seed weight (yield = $-331 + 3.1x_1 + 330.7x_2 + 87.4x_3$; $r^2 = 0.96$). Boroomandan *et al.* (2009) also obtained positive significant correlation between yield attributes and yield.

Higher harvest index (HI) in T_{13}, T_8 and T_9 was because of better development of yield attributes and yield in comparison to low N dose treatments and late N application in the treatments, where half dose of N was splitted at 80 DAS till then 50% of reproductive phase has already been completed its ample availability in those treatments through fertilizer and inoculation resulted in increase in yield and yield attributes. These results corroborate with the findings of Kumudini *et al.* (2008). Highest yield have been obtained in treatment T_9 followed by T_{13}, T_8, T_5 and T_{17}. All these treatments were of higher doses of N which may have made more N available to the crop through soil solution. Nitrogen being an essential constituent of chlorophyll, protoplasm and various enzymes which governs the utilization of other nutrients.

All the levels of N above 20 kg N/ha application recorded significantly higher protein content in seed over control. Inoculation of seed had non-significant effect on enhancing protein content of seed over uninoculation but combined application of N and inoculation recorded highest protein content in seed in treatment T_9. This may be due to *Rhizobium* application has resulted in more number of nodules, which in turn fixed more atmospheric N. Hence, increased availability of N to the plant resulted in higher protein content of seed. Increased N availability increased N translocated in seed at the time of seed formation which resulted in higher protein content in seed in treatments with higher N doses. Nitrogen being integral part of amino acid which is the structural unit of protein. Boroomandan *et al.* (2009) and Tahir *et al.* (2009) also reported the same.

Table 1 Effect of inoculation, dose and time of nitrogen application on yield, yield attributes and protein content in seeds of soybean

Treatment	Yield attributes			Yield (kg/ha)				Protein content in seed (%)
	Pods/plant	Seeds/pod	100 seed weight (g)	Grain yield	Straw yield	Biological yield	Harvest index (%)	
T_1 : control	51.0	2.16	10.3	1405	4333	5738	24.4	32.5
T_2 : 20 kg N/ha as basal dose	64.7	2.36	11.0	1610	4724	6334	25.4	34.2
T_3 : 40 kg N/ha as basal dose	72.0	2.46	11.2	1730	4828	6558	26.3	35.7
T_4 : 60 kg N/ha as basal dose	79.6	2.60	11.3	1813	4971	6784	26.7	36.2
T_5 : 80 kg N/ha as basal dose	84.1	2.83	11.7	1891	5143	7034	26.8	37.4
T_6 : *Rhizobium* inoculation alone	54.0	2.30	11.1	1547	4611	6158	25.1	33.8
T_7 : 20 kg N + *Rhizobium* inoculation	68.9	2.43	11.3	1696	4758	6454	26.2	36.0
T_8 : 40 kg N + *Rhizobium* inoculation	78.8	2.66	11.8	1893	4890	6784	27.9	37.4
T_9 : 60 kg N + *Rhizobium* inoculation	85.0	2.86	12.4	1968	5075	7044	27.9	39.5
T_{10} : 10 +10 kg N/ha as basal & 50 DAS	65.6	2.36	11.0	1620	4577	6197	26.1	35.3
T_{11} : 20 +20 kg N/ha as basal & 50 DAS	74.9	2.56	11.2	1735	4725	6461	26.8	36.3
T_{12} : 30 +30 kg N/ha as basal & 50 DAS	82.3	2.70	11.4	1843	4810	6653	27.6	37.4
T_{13} : 40 +40 kg N/ha as basal & 50 DAS	87.8	2.83	12.2	1915	4916	6831	28.0	38.3
T_{14} : 10 +10 kg N/ha as basal & 80 DAS	49.8	2.40	10.6	1548	4602	6151	25.1	35.1
T_{15} : 20 +20 kg N/ha as basal & 80 DAS	64.4	2.46	10.9	1656	4885	6541	25.3	36.0
T_{16} : 30 +30 kg N/ha as basal & 80 DAS	72.2	2.60	11.7	1796	5103	6899	26.0	36.6
T_{17} : 40 +40 kg N/ha as basal & 80 DAS	79.2	2.73	12.0	1880	5289	7169	26.2	36.9
SEm±	5.2	0.05	0.2	39	85	112	0.3	0.7
CD (P=0.05)	15.0	0.16	0.8	115	246	324	1.0	2.0

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Effect of imazethapyr on plant morphology in soybean [*Glycine max* (L.) Merr.] cv. JS 335

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(Received: September, 2010; Revised: October, 2012; Accepted: November, 2012)

ABSTRACT

Soybean [*Glycine max* (L.) Merr.] cultivars differ in their sensitivity to herbicide damage. The impact of herbicide- imazethapyr application on the growth and yield on soybean cultivar JS 335 was examined. Morphological changes resulted from herbicide application, including leaf elongation and formation of large shoots at the cotyledonary node. Herbicide treatment significantly reduced main stem height, branches/plant, number of nodes on the main stem, internodal length, leaf length and width, seed index and seed yield/plant relative to the controls (not treated with herbicide). Although herbicide application significantly impacted several growth variables, but had no significant impact on yield.

Key words: *Glycine max*, Height, Herbicide, Imazethapyr, Nodes, Seed weight, Soybean

Soybean [*Glycine max* (L.) Merr.] is an important commercial crop in India and worldwide. The complete exploitation of soybean yield could be possible when pest complex managed timely. Among the different components of pest complex, weeds ranked first which causes maximum yield loss ranging from 35 to 70% (Billore *et al.*, 2001). The use of herbicides in soybean crop is increasing day by day due to shortage and high wage of labourer and incessant rains during crop season particularly in rainy season. Among the herbicides, imazethapyr, 2-[4,5-dihydro-4-methyl-4-(1-ethylethyl)-5-oxo-1H-imidazol-2-yl]-5-ethyl-3-pyridine carboxylic acid) is often used for the post-emergence control of weeds in legumes, especially soybean. This compound belongs to the imidazolinone (imazethapyr) herbicide class, which cause phytotoxicity though the inhibition of acetohydroxy acid synthase and the synthesis of branched chain amino acids. Selectivity of these herbicides is based on the rate and/or extent of metabolism (detoxification) of the active ingredient by the plant (Brown, 1990; Shaner and Mallipudi, 1991). Within hours following imazethapyr application to soybean, fresh weight of shoots and roots was increased, but dry weight was decreased, indicating higher water concentrations in imazethapyr-treated plants (Scarponi *et al.*, 1996). Enzyme activities and glucose and starch contents were also affected within hours after imazethapyr application (Scarponi *et al.*, 1995; Scarponi *et al.*, 1996). Imazethapyr has been shown to decrease protein and branched-chain amino acid contents of legumes (Scarponi *et al.*, 1997). Some studies have indicated no growth (Adcock and Banks, 1991) or yield response to soybean treatment with imazethapyr (Krausz *et al.*,1992). Multiple stresses affecting plant growth and metabolism have the potential to result in increased (or decreased) plant response. Information is scarce on the response of soybean to herbicide treatment i.e., imazethapyr. The field experiment was conducted during rainy season of 2009 at research farm of Directorate of Soybean Research, Indore. The experiment was conducted with two soybean cultivars namely JS 335 and Ahilya 3 (NRC 7) with 6 herbicides *viz.*, Fluchloralin @ 1 kg a.i./ha and Trifluralin @ 1 kg ai/ha (both as PPI), Clomazone @ 1 kg ai/ha and Pendimethalin @ 1 kg ai/ha (both as PE) and Imazethapyr @ 100 g ai/ha and Quizalofop ethyl @ 50 g ai/ha (both as PoE). Formulated herbicide i.e., ammonium salt of imazethapyr (Pursuit) are labeled for post-emergence weed control in soybeans. Imazethapyr was applied at 100 g ai/ha with ammonium sulphate @ 2 g/l of water and cyspread (Sticker, spreader and activator) @ 2 ml/l/water according to the label instructions at 20 days after sowing. Seeds were sown on 4th July 2009 and harvesting was done on 13th Oct 2009. A knapsack sprayer was used to apply 750 l/ha herbicide solution uniformly to the treated area, with much of the solution intercepted by the leaf surfaces. Plant growth variables were measured 30 days after herbicide treatment. Plant height was measured from the soil surface to the main shoot apex. The number of nodes on the main stem was counted, including the cotyledonary node. Some plants exhibited significant growth from shoots emerging from the cotyledons, so the number of nodes on the cotyledonary shoots was also measured. Leaf area was measured separately for leaves on the primary shoot.

The plant reaction with reference to morphological and yield attributes were recorded only in soybean cultivar JS 335 and imazethapyr treatment, hence the pertaining data on JS 335 were explained and discussed. Other test herbicides do not have any effect on either of the variety and imazethapyre does not have any effect on NRC 7.

Table 1 Effect of imazethapyr (10% EC) on soybean plant characters

Plant character	Control (untreated)	SD±	CV (%)	Imazethapyr @ 100 g ai/ha as post emergence	SD±	CV (%)	Change over control (%)
Plant height (cm)	33.09	6.158	18.61	23.44	3.695	15.76	-29.16
Branches/plant	4.10	1.833	44.63	3.77	1.986	52.67	-8.04
Number of nodes/ plant	10.77	0.667	6.19	9.77	0.972	9.95	-9.29
Length of I internode (cm)	4.42	0.964	21.80	3.70	0.364	9.83	-16.29
Length of mean of internodes (cm)	3.11	0.638	20.51	2.42	0.372	15.37	-22.19
Total leaf number	17.33	5.077	29.30	12.43 (7.66 + 4.77)	2.645, 1.856	21.28	-28.27
Length and width of leaf							
Maximum length of leaf (cm)- normal	7.43	0.670	9.02	6.60	1.434	21.73	-11.17
Maximum width of leaf (cm)- normal	5.41	0.485	8.96	3.86	1.156	29.95	-28.65
Maximum length of leaf (cm)- changed	-			8.26	1.162	14.07	100.0
Maximum width of leaf (cm)- changed	-			3.77	5.843	154.98	100.0
Leaf area (cm^2)							
Unchanged (normal)	40.41	6.611	16.35	43.60	13.23	30.34	-
Changed	-			31.24	7.711		100.00
Total leaf area (cm^2)	700.31			482.99			-31.03
Number of leaves changed							
Unchanged	17.33	5.077	29.29	7.66	2.645	289.60	-55.80
Changed	-			4.77	1.856	38.91	100.00
Position of leaf changed in size (node)	-			2 to 3			-
Change in leaf number (%)	-			38.42			
Plant dry weight (g/plant)	4.67			3.57			-23.55
Seed yield/plant (g)	13.78			11.02			-20.03
Seed index	10.50			9.54			-9.14

Soybean untreated with herbicide (control) were 33.09 cm (41.17%) taller than plants treated with imazethapyr. Herbicide treatment significantly reduced the height of the main stem of soybean cultivar JS 335 to the tune of 29.16%. However, the variability in plant height was higher under untreated plants than imazethapyr treated plants. Untreated soybean produced higher number of branches/plant (8.75%) as compared to imazethapyr treated one which reduced branches to the extent of 8.04%. The higher variability in number of branches was recorded under imazethapyr treated plants. Application of imazethapyr also significantly reduced the node number/plant (9.29%) along with high variability as compared to untreated plants. Untreated soybean plants first internode length was higher (19.45%) than herbicide treated plants which reduced by 16.29% and also showed lower variation in first intermodal length. Herbicide application decline the internodal length by 22.19 % than untreated plants and untreated plants showed higher variability as compared to treated one. No leaf necrosis was evident for herbicide treatment in experiment. Morphological changes were observed in herbicide treated plants of JS 335 only. Herbicide treated soybean significantly reduced the leaf number plant (28.27 %) as compared to untreated plants. However, the higher variability was observed in untreated plants with reference to leaf number. Plants treated with imazethapyr demonstrated narrow elongated leaves uncharacteristic of soybean (Fig. 1). These elongated leaves developed after herbicide application, and these leaves were not yet formed when the herbicides were foliar applied. On these plants, while the leaves formed prior to herbicide application were normal, nearly all leaves formed after herbicide application exhibited elongation. Leaf area measurements further indicated the morphological changes observed in herbicide treated plants. The maximum length and width of normal leaves was also reduced by 11.17% and 28.65% with the herbicide treated plants which indicated that the leaf width was more sensitive than length and also indicated higher variation in leaf length. The length of changed leaf has been increased and the width of changed leaf decreased significantly due to herbicide as compared to normal leaf i.e., untreated plant which led to a significant decrease in photosynthetic surface area [(total leaf area) by 31.03%]. The changes in leaf morphology occurred on 2 to 3 nodes of treated plants.

Untreated soybean produced higher plant dry biomass to the tune of 30.81% as compared to herbicide treated soybean plant. Imazethapyr treated soybean showed a substantial reduction in seed index to the extent of 9.14% as compared to untreated plants. Similarly, seed yield/plant was also

showed a decrease trend which was to the tune of 20.03% over untreated soybean.

Thus, although herbicide treatment significantly impacted several growth variables and yield/plant of surviving plants. Although a large number of plants exhibited morphological effects in which the main stem comprised only a small portion of the total plant biomass, yield was generally not impacted by these morphological changes. Other researchers have also reported no loss in yield with imazethapyr application (Krausz *et al.*, 1992; Newsom and Shaw, 1992), while others have reported yield reductions under certain conditions (Newsom and Shaw, 1992; Griffin and Habetz 1989).

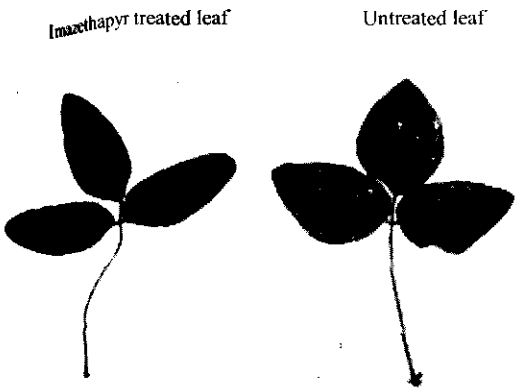

Fig.1. Morphological changes in soybean leaf due to herbicide imazethapyr application

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Effect of integrated nutrient management on yield, nutrient uptake and quality of Indian mustard (*Brassica juncea* L.) in central plain zone of Uttar Pradesh

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(Received: December, 2011; Revised: September, 2012; Accepted: November, 2012)

ABSTRACT

A field experiment was conducted during winter season of 2009 at Kanpur, Uttar Pradesh to find out the effect of integrated nutrient management on yield, uptake and quality of Indian mustard (*Brassica juncea* L.). The study revealed that integration of 40 kg sulphur (S) and 5 kg zinc (Zn) with 100 % recommended dose of fertilizer produced maximum grain yield, nutrient uptake, oil content and oil yield in comparison to other treatments. Application of 40 kg S/ha resulted 21.7 % higher grain whereas, application of 5 kg Zn/ha resulted 8.3 % higher grain than 100 % RDF.

Key words: Elemental sulphur, FYM, Mustard and Zinc chloride

Indian farmers, who are mostly marginal and small, do not apply the recommended doses of nutrients due to ever increasing cost of fertilizers. Indigenously available organic sources of nutrients have been found helpful to enhance the efficiency and reduce the requirement of costly chemical fertilizers. Indian soils are becoming deficient in sulphur (S) and zinc (Zn) due to intensive cultivation and use of high analysis fertilizers. Mustard (*Brassica juncea* L.) requires relatively large amount of these nutrients for realization of yield potential, but inadequate supply often leads to low productivity. Keeping this in view a field trial was carried out to explore the effect of integrated nutrient management on yield, nutrient uptake and quality of Indian mustard in central plain zone of Uttar Pradesh.

A field experiment was conducted at Students' Instructional Farm, C.S. Azad University of Agriculture and Technology, Kanpur during the winter season of 2009. The experiment was comprised of 12 treatments (Table 1). The treatments were arranged in randomized block design with three replications. The recommended dose of fertilizer was 120:60:60 kg NPK/ha. The quantity of FYM required for substituting a specified amount of nitrogen (N) as per treatments was calculated and incorporated in to plots 15 days before sowing of the crop. As per treatment, 40 kg S/ha and 5 kg Zn/ha were applied as basal through elemental sulphur and zinc chloride. All the treatments received a basal dose of phosphorus (P) and potash(K) through DAP and MOP. N in DAP was adjusted in the amount of urea. Half of N was applied as basal at the time of sowing and remaining half of N was applied at the time of first irrigation. The N content in the seed was multiplied by the factor 6.25 to calculate the crude protein content. The soxhlet method was adopted for the estimation of oil content in seed. Seed and stover samples were powdered and digested in a triacid mixture of concentrated H_2SO_4 : HNO_3 : $HClO_4$ (10:4:1). The P in the extract was determined by colorimeters and K by flame photometer. The seed and stover samples were digested in a diacid mixture of concentrated HNO_3 and $HClO_4$ (9:1) and sulphur in the extract was estimated by turbidimetric method and zinc was estimated by Atomic absorption spectrophotometer.

The results indicated that all the treatments significantly influenced the yield and quality of Indian mustard over control (Table 1). Highest grain yield of 21.6 q/ha and straw yield of 67.9 q/ha was recorded with 100 % RDF + 40 kg S/ha + 5 kg Zn/ha (T_4) which were 99.2 and 65 % higher than the yield in control. Substitution of 25 % N through FYM with 75 % RDF produced grain yield 15.5 q/ha and stover yield 54.2 q/ha which was found at par to the yield (16.4 q/ha grain and 55.4 q/ha stover) of 100 % RDF, indicating the possibility to reduce N fertilizer need by 25% through the application of FYM along with chemical fertilizers. These results are in confirmity with the finding of Chand and Ram (2000). Application of 40 kg S/ha produced 21.7% more grain and 16.5 % more stover yield than 100 % RDF. Likewise S application of 5 kg Zn/ha also produced 8.3% more grain and 3.4% more straw yields than 100% RDF + 40 kg S/ha. The enhancement in seed and stover yield with the addition of 40 kg S and 5 kg Zn/ha could be explained on the basis of proper nutritional environment for vegetative and reproductive growth of the crop. These results are in conformity with the findings of Singh *et al.* (2005) and Jat and Mehra (2007).

All the treatments showed significant increase in N, P, K, S and Zn accumulation over control (Table 2). Maximum uptake of N, P, K, S and Zn was recorded with 100% RDF + 40 kg S/ha + 5 kg Zn/ha followed by 75% RDF + 25%N FYM + 40 kg S ha + 5 kg Zn/ha. Integration of S and Zn

with 100% RDF showed maximum nutrient uptake in comparison to 75% RDF and 50% RDF treatments. Higher accumulation and uptake of nutrients under these treatments could be ascribed to better availability and synergistic effect of applied nutrients. These findings corroborate with the report of Singh *et al.* (2005) and Jat and Mehra (2007).

Highest protein content (23.4%), oil content (38.6%) and oil yield (831.8 kg/ha), in mustard seed were registered with the application of 100% RDF + 40 kg S/ha + 5 kg Zn/ha Table 1). These results are in accordance with those of Prasad and Singh (2004) and Kumar and Yadav (2007).

It may be concluded that integration of 40 kg S and 5 kg Zn/ha with 100% RDF is most beneficial and essential to get maximum yield. It is also concluded that substitution of 25% N through FYM with 75% RDF produced yield at par to 100% RDF indicating that the possibility to reduce N fertilizer need by 25% through the application of FYM along with the chemical fertilizers by small and marginal farmers of central plain zone of Uttar Pradesh to save fertilizer cost.

Table 1 Effect of integrated nutrient management on yield and quality of Indian mustard

Treatment	Yield q/ha		Quality		
	Grain	Straw	Protein content (%)	Oil content (%)	Oil yield (kg/ha)
Control	10.8	41.2	18.00	34.1	368.9
100 % RDF	16.4	50.4	20.93	36.8	602.5
100 % RDF - 40 kg S/ha	19.9	65.7	22.81	37.8	752.2
100 % RDF - 40 kg S/ha+ 5 kg Zn/ha	21.6	67.9	23.43	38.6	831.8
75 % RDF	14.4	53.1	20.12	35.7	512.3
75 % RDF + 25 % N F Y M	15.5	54.2	20.81	36.5	563.9
75 % RDF - 25 % N F Y M + 40 kg S/ha	18.6	69.3	22.75	37.3	683.7
75 % RDF - 25 % N F Y M + 40 kg S/ha+ 5 kg Zn/ha	20.1	64.2	23.18	37.8	758.8
50 % RDF	13.3	49.7	20.00	35.0	464.4
50 % RDF - 50 % N F Y M	14.3	50.6	20.68	35.5	506.5
50 % RDF - 50 % N F Y M + 40 kg S/ha	17.1	57.9	22.56	36.2	617.2
50 % RDF - 50 % N F Y M + 40 kg S/ha+ 5 kg Zn/ha	18.3	59.3	23.00	36.7	669.7
SEm±	1.02	1.87	0.09	0.1	48.0
CD (P=0.05)	2.11	3.88	0.19	0.3	99.0

Table 2 Effect of integrated nutrient management on nutrient uptake of Indian mustard

Treatment	N (kg/ha)		P (kg/ha)		K (kg/ha)		S (kg/ha)		Zn (g/ha)	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Control	31.2	20.1	5.6	5.8	7.3	48.2	9.2	6.9	40.0	123.5
100 % RDF	54.8	32.4	10.1	9.4	13.5	76.3	16.0	13.9	78.5	238.9
100 % RDF + 40 kg S/ha	72.6	40.1	13.7	12.0	17.3	96.9	23.5	21.7	103.5	315.4
100 % RDF + 40 kg S/ha+ 5 kg Zn/ha	80.6	49.2	14.3	13.2	17.7	101.3	26.9	24.6	122.8	353.1
75 % RDF	46.2	30.1	8.6	8.2	11.4	69.9	13.2	11.4	63.1	191.2
75 % RDF - 25 % N F Y M	51.4	30.9	9.5	8.7	12.7	72.6	14.8	12.9	72.6	216.6
75 % RDF - 25 % N F Y M + 40 kg S/ha	67.7	37.5	12.2	11.1	16.1	91.1	21.6	20.1	93.0	280.3
75 % RDF + 25 % N F Y M + 40 kg S/ha+ 5 kg Zn/ha	74.4	39.5	13.2	12.2	17.6	94.9	24.1	22.7	112.3	321.0
50 % RDF	42.1	27.5	7.9	7.4	10.5	64.7	11.8	10.2	54.3	164.0
50 % RDF + 50 % N F Y M	46.2	28.3	8.7	7.9	11.7	66.7	13.3	11.7	64.1	192.3
50 % RDF + 50 % N F Y M + 40 kg S/ha	61.6	33.9	11.1	10.1	14.4	83.1	19.3	17.5	81.8	246.2
50 % RDF + 50 % N F Y M + 40 kg S/ha+ 5 kg Zn/ha	67.2	35.9	11.9	10.9	15.6	86.6	21.4	20.5	100.4	272.8
SEm±	1.94	1.42	0.70	0.59	0.86	3.09	0.60	1.26	3.39	18.21
CD (P=0.05)	4.01	2.94	1.46	1.23	1.79	6.41	1.25	2.61	7.04	37.76

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Green house assessment of mustard (*Brassica juncea* L.) genotypes for salinity tolerance at seedling stage

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(Received: August, 2010; Revised: November, 2012; Accepted: December, 2012)

ABSTRACT

Thirty promising mustard (*Brassica juncea* L.) genotypes were evaluated under control and 12 dS/m artificially created salinity level under laboratory condition. Germination per cent, speed of germination, root length, shoot length, dry weight of seedling and seedling vigour index reduced significantly with salinity over control. Genotypes RH-8814, RH-9615, BPR-541-4, EJ-19 and PBR-331 were identified relatively more tolerant to salinity at seedling stage. These genotypes exhibited lower overall per cent reduction (< 15%) in growth parameter. Finding also indicated that seedling dry weight may be used as screening trait and identified genotypes may be used as suitable donor for crossing programme to develop salt tolerant mustard genotype at seedling stage.

Key words: Dry weight, Indian mustard, Salinity, Seedling stage

The problem of salt affected soils is global and is mainly confined to arid and semi-arid parts of the world. Salt stress is the major wide spread environmental stress that limits growth and development of plants (Greenway and Munns 1980). Extra expenditure of energy for osmatic adjustment under salt stress causes growth reduction (Pasternak 1987). Under saline condition, the germination and seedling growth of mustard (*Brassica juncea* L.) is critical one, and thus becomes a major limiting factor for full potential production of crop. Among various methods of management of such problem soils, growing of salt tolerant genotypes is considered to be very powerful tool for managing salinity. In mustard salt tolerance varies from variety to variety (Lallu *et al.* 2009). Present investigation was an attempt to evaluate the variability in salt tolerance among promising mustard genotypes and to identify genotypes tolerant to salinity at seedling stage.

An experiment was conducted at the Oilseed Research Unit of C.S. Azad University of Agriculture and Technology, Kanpur under laboratory condition adopting completely randomized design with thirty promising mustard genotypes under artificially created salinity level of 12 dS/m along with control. These genotypes were grown in plastic boxes contained soil saturated and fully homogenised before sowing with distilled water (control) and saline solution (12 dS/m) comprising NaCl, $CaCl_2$, $MgSO_4$ and $MgCl_2$ in distilled water to give Cl : SO_4 (4:1) and Ca : Mg (1.3:1) and SAR of 11.8. Each treatment was repeated four times during winter season of 2008. Twenty five seeds of uniform size, treated before sowing with 0.20% $HgCl_2$ solution to avoid fungus growth. Seedlings were grown for 10 days age and germination was recorded everyday and expressed in per cent. At the end, five seedlings were randomly taken for recording root and shoot length. These five seedlings were dried in an electric oven to a constant weight at 70°C and dry weights were recorded. The speed of germination and seedling vigour index was calculated by using the formula suggested by Mageuive (1962) and Abdul-Baki and Anderson (1973) respectively, as below.

Speed of germination = (No. of seeds germination on/first day) + (No. of seeds germination on/second day) − ..... + (No. of seeds germinated on/final day)

Seedling vigour index = Germination % x mean dry weight of seedling

Significant reduction in germination per cent, speed of germination and shoot length occured under saline medium in all the genotypes compared with check (Table 1). In saline medium, germination per cent ranged from 56.0 (JMM-071) to 84.0% (PBR-331), while in control the values recorded were between 88.0 (JMM-071, RB-55) to 100.0% (NPJ-113, CS-3000-1-1-5, BPR-549-9, SKM-531, RB-50, NRCDR-701 and PBR-330). Minimum per cent reduction in germination occured in genotype PBR-331 (12.5%) while maximum was noted in genotype JMM-071 (36.4%) under salinity over control. Significant varietal differences in speed of germination were recorded and the values ranged between 27.6 (JMM-071) to 33.2 (CS-3000-1-1-1-5) in control, while in saline medium the values recorded ranged between 14.0 (JMM-071) to 21.0 (RH-9615). Minimum per cent reduction was noted in genotype EJ-19 (27.3%) while maximum occured in genotype PBR-330 (50.9%) in salinity over control. In control shoot length varied from 7.5 (NPJ-124) to 13.5 cm (RGN-197), while in saline it varied from 6.5 (NPJ-124) to 9.9 cm (PBR-331). Minimum per cent

reduction was noted in RH-8814 (4.9%), whereas maximum in genotype JMM-071 (48.1%) in saline over control. The reduction in growth characters is due to ionic stress developed by salinity of growing media. Sharma (2003) and Lallu *et al.* (2009) reported similar findings of the salinity effect on mustard at seedling stage.

Significant varietal variations were observed in root length, dry weight of seedlings and seedling vigour index which declined significantly under saline medium compared with control (Table 2). In non-saline control the values of root length, dry weight of seedlings and seeding vigour index ranged between 5.3 (NPJ-112) to 7.1 cm (JMM-071); 18.8 (OMK-03) to 34.5 mg (RB-50) and 353.4 (OMK-03) to 690.0 (RB-50) while the values of these characters under saline stress ranged from 4.5 (BPR-549-9, SKM-531) to 6.6 cm (RH-9615, RB-50); 7.5 (OMK-03) to 33.8 mg (RB-50) and 108.0 (OMK-03) to 540.8 (RB-50), respectively. The per cent reduction in root length, dry weight of seedling and seedling vigour index were minimum 11.0 (EJ-19) to maximum 35.1% (PBR-330); 2.0 (RB-50) to 60.1% (OMK-03) and 14.7 (BPR-541-4) to 69.4% (OMK-03), respectively due to salt stress over control. The inhibitory effect of salt stress on different crops was reported earlier by many researchers (Raghavaiah *et al.*, 2006; Hebbara *et al.* 2003; Bagdi and Aferia, 2008). The mustard genotypes RH-8814, RH-9615, BPR-541-4, EJ-19 and PBR-331 were found salt tolerant at seedling stage as these exhibited lower value of reduction in growth parameters.

Table 1 Germination %, speed of germination and shoot length of mustard genotypes as influenced by salinity

Mustard genotype	Germination (%)				Speed of germination				Shoot length (cm)			
	Control	Saline	Mean	(%) reduction	Control	Saline	Mean	(%) reduction	Control	Saline	Mean	(%) reduction
RH-8814	94.0	80.0	87.0	14.9	30.8	19.2	25.0	37.7	8.2	7.8	8.0	4.9
RH-9615	98.0	80.0	89.0	18.4	30.0	21.0	25.5	30.0	9.2	8.7	9.0	5.4
RH-0216	90.0	74.0	82.0	17.8	29.8	18.4	24.1	38.3	9.0	7.5	8.3	16.7
NPJ-113	100.0	70.0	85.0	30.0	33.0	17.0	25.0	48.5	8.6	7.8	8.2	9.3
NPJ-124	98.0	72.0	85.0	26.5	31.2	17.4	24.3	44.2	7.5	6.5	7.0	13.3
RGN-73	98.0	70.0	84.0	28.6	32.6	17.8	25.2	45.4	7.7	7.0	7.4	9.1
CS-3000-1-1-1-5	100.0	74.0	87.0	26.6	33.2	18.8	26.0	43.4	7.6	7.0	7.3	7.9
RH-0305	98.0	68.0	83.0	30.6	32.0	16.8	24.4	47.5	9.0	6.6	7.8	26.7
RGN-152	94.0	72.0	83.0	23.4	31.6	17.6	24.6	44.3	9.1	8.6	8.9	5.5
BPR-541-4	94.0	82.0	88.0	12.8	30.8	20.6	25.7	33.1	8.9	8.4	8.7	5.6
BPR-549-9	100.0	70.0	85.0	30.0	31.8	17.4	24.6	45.3	8.0	6.6	7.3	17.5
SKM-531	100.0	64.0	82.0	36.0	30.2	15.0	22.6	50.3	8.1	7.3	7.7	9.9
RH-0116	94.0	66.0	80.0	29.8	30.4	16.4	23.4	46.1	8.9	7.5	8.2	15.7
BPR-543-2	96.0	80.0	88.0	16.7	31.8	20.4	26.1	35.8	8.4	7.7	8.1	8.3
NRCDR-02	94.0	74.0	84.0	21.3	30.0	18.8	24.4	37.3	8.9	7.1	8.0	20.2
RB-50	100.0	80.0	90.0	20.0	32.6	20.0	26.3	38.7	10.2	9.8	10.0	3.9
RB-55	88.0	66.0	77.0	25.0	28.0	16.4	22.2	41.4	9.1	8.4	8.8	7.7
EJ-19	94.0	82.0	88.0	12.8	27.8	20.2	24.0	27.3	9.5	9.0	9.3	5.3
NPJ-112	96.0	68.0	82.0	29.2	31.6	17.2	24.4	45.6	8.1	7.5	7.8	7.4
NPJ-114	94.0	74.0	84.0	21.3	32.2	18.0	25.1	44.1	10.2	7.6	8.9	25.5
RGN-193	94.0	66.0	80.0	29.8	30.6	16.8	23.7	45.1	12.5	7.0	9.8	44.0
JMM-071	88.0	56.0	72.0	36.4	27.6	14.0	20.8	49.3	13.3	6.9	10.1	48.1
PBR-331	96.0	84.0	90.0	12.5	29.6	20.6	25.1	30.4	10.4	9.9	10.2	4.8
OMK-03	94.0	72.0	83.0	23.4	28.4	18.4	23.4	35.2	10.7	7.4	9.1	30.8
RH-0508	98.0	70.0	84.0	28.6	29.4	17.2	23.3	41.5	11.7	7.2	9.5	38.5
NRCDR-701	100.0	74.0	87.0	26.0	28.8	19.2	24.0	33.3	9.8	6.8	8.3	30.6
NRCDR-601	94.0	70.0	82.0	25.5	28.8	17.2	23.0	40.3	9.5	7.3	8.4	23.2
PBR-330	100.0	64.0	82.0	36.0	32.2	15.8	24.0	50.9	11.3	6.7	9.0	40.7
RGN-197	96.0	70.0	83.0	27.1	31.6	17.0	24.3	46.2	13.5	8.4	11.0	37.8
CS-54	98.0	82.0	90.0	16.3	30.4	20.8	25.6	31.6	9.6	8.6	9.1	10.4
Mean	96.3	72.5			30.6	18.0			9.6	7.7		
CD (P=0.05)												
Genotype			3.7				8.2				1.0	
Salinity			1.0				0.7				0.3	
Genotype x Salinity			5.2				3.1				1.4	

Table 2 Root length, dry weight of seedling and seedling vigour index of mustard genotypes as influenced by salinity

Mustard genotype	Root length (cm)				Dry weight (mg)/5 seedlings				Seedling vigour index				Overall % reduction
	Control	Saline	Mean	(%) reduction	Control	Saline	Mean	(%) reduction	Control	Saline	Mean	(%) reduction	
RH-8814	6.6	6.3	6.5	13.0	33.8	32.8	33.3	3.0	635.4	524.8	580.1	17.4	6.0
RH-9615	6.9	6.6	6.8	12.1	33.3	32.5	32.9	2.4	652.7	520.0	586.4	20.3	11.4
RH-0216	6.5	6.0	6.3	25.1	25.0	13.8	19.4	44.8	450.0	204.2	327.1	54.6	32.8
NPJ-113	6.3	5.8	6.1	26.9	22.5	13.8	18.2	38.7	450.0	193.2	321.6	57.1	35.1
NPJ-124	6.1	5.6	5.9	23.7	23.8	17.5	20.7	26.5	466.5	252.0	359.3	46.0	30.8
RGN-73	6.5	6.0	5.3	25.4	27.5	17.5	22.5	36.4	539.0	245.0	392.0	54.5	33.2
CS-3000-1-1-1-5	6.6	6.0	6.3	21.0	27.5	22.5	25.0	18.2	550.0	333.0	441.5	39.5	26.1
RH-0305	6.2	5.7	6.0	28.0	27.5	20.0	23.8	27.3	539.0	272.0	405.5	49.5	34.9
RGN-152	6.1	5.8	6.0	16.5	28.8	24.5	26.7	4.5	541.4	352.8	447.1	34.8	21.5
BPR-541-4	6.8	6.5	6.7	11.6	32.0	31.3	31.7	2.2	601.6	513.3	557.5	14.7	13.3
BPR-549-9	6.3	4.5	5.4	27.9	23.0	18.8	20.9	18.3	460.0	263.2	361.6	42.8	30.3
SKM-531	6.2	4.5	5.4	27.9	31.3	26.3	28.8	16.0	626.0	336.6	481.3	46.2	31.1
RH-0116	6.9	6.2	6.6	21.8	28.3	26.3	27.3	7.1	532.0	347.2	439.6	34.7	25.9
BPR-543-2	6.3	6.0	6.2	13.8	31.	30.3	30.7	3.2	595.0	484.8	539.9	18.5	16.1
NRCDR-02	5.8	5.5	5.7	19.1	27.5	24.3	25.9	11.6	517.0	359.6	438.3	30.4	23.3
RB-50	6.9	6.6	6.8	13.8	30.5	29.5	30.0	3.3	690.0	540.8	615.4	21.6	16.7
RB-55	6.4	5.8	6.1	19.8	32.5	27.5	30.0	15.4	572.0	363.0	467.5	36.5	24.3
EJ-19	6.6	6.2	6.4	11.0	34.5	33.8	34.2	2.0	573.4	483.8	528.6	15.6	12.6
NPJ-112	5.3	5.0	5.2	20.2	30.3	26.3	28.3	13.2	581.8	357.7	469.8	38.5	25.7
NPJ-114	6.6	4.9	5.8	26.6	26.3	22.0	24.2	16.3	494.4	325.0	410.0	34.1	28.0
RGN-193	6.4	5.6	6.0	29.9	27.5	22.5	25.0	18.2	517.0	297.0	407.0	42.6	34.9
JMM-071	7.1	5.6	6.4	34.3	30.0	25.0	27.5	16.7	528.0	280.0	404.0	47.0	38.6
PBR-331	6.7	6.4	6.6	11.2	32.5	31.3	31.9	3.7	624.0	525.8	574.9	15.7	13.1
OMK-03	6.6	5.0	5.8	34.7	18.8	7.5	13.2	60.1	353.4	108.0	230.7	69.4	42.3
RH-0508	6.8	5.4	6.1	28.1	26.3	23.3	24.8	11.4	515.5	326.2	420.9	36.7	30.8
NRCDR-701	6.6	4.7	5.7	27.0	22.5	18.8	20.7	16.4	450.0	278.2	364.1	38.2	28.6
NRCDR-601	6.1	5.5	5.8	20.9	23.8	22.5	23.2	5.5	447.4	315.0	381.2	29.6	24.2
PBR-330	6.0	5.2	5.6	35.1	25.0	16.3	20.7	34.8	500.0	208.6	354.3	58.3	42.6
RGN-197	7.0	5.7	6.4	27.7	28.8	26.3	27.6	8.7	576.0	368.2	472.1	36.1	30.6
CS-54	6.8	6.5	6.7	13.2	31.0	30.0	30.5	3.2	607.4	492.0	549.8	19.0	15.6
Mean	6.5	5.7			28.1	23.8			539.5	349.0			
CD (P=0.05)													
Genotype			0.4				1.8				9.4		
Salinity			0.1				0.5				3.3		
Genotype x Salinity			0.6				2.7				16.1		

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Response of plant growth promoting rhizobacteria on the growth, phosphorus and potassium nutrition of sunflower (*Helianthus annuus* L.)

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(Received: July, 2012; Revised: September, 2012; Accepted: November, 2012)

ABSTRACT

A pot experiment was conducted during the winter season of 2010 in red sandy loam soil with the objective to study the effect of plant growth promoting rhizobacteria (PGPR), on the growth, phosphorus (P) and potassium (K) uptake of sunflower (*Helianthus annuus* L.) crop. The six PGPR isolates of Directorate of Oilseeds Research used in the study are: *Bacillus licheniformis, B. megaterium, B. circulans, B. polymyxa, B. subtilis* and *Psuedomonas fluorescens*. Inoculum was prepared by growing cultures in nutrient broth and mixing with talc in the ratio of 1:2. A uniform coating of inoculum to sunflower seeds was given and air dried, inoculum load of each bacterium was also worked out. The trial consisted of eight treatments, six plant growth promoting rhizobacteria, one absolute control (no P and no inoculum) and one with recommended dose of fertilizers (no inoculum). No P was applied to PGPR treatments. Three seeds of hybrid (DRSH-1) were sown in the 20 kg capacity pots. After germination, single plant/pot was maintained till harvest at 60 days stage. After harvesting, dry matter yield was recorded and P and K contents was analyzed to compute the uptake of these nutrients. The results indicated that, the significant highest dry matter yield (12.3g/plant), P and K concents (6.8 and 46.6mg/g drymatter, respectively) in sunflower was recorded due to the application of recommended dose of fertilizers (60:60:30 NPK kg/ha) over all other treatments. However, among the different inoculations, *P. fluorescens* recorded the highest drymatter yield (8.32 g/plant) followed by *B. circulans* and *B. megaterium*. The P content was highest due to *B. cirulans* (4.4 mg/g drymatter) and *B. polymyxa* (4.1 mg/g drymatter), while, high concentration of K was recorded in treatments with *B. polymyxa* (45.3 mg/g drymatter) and *B. circulans* (41.7 mg/g drymatter).

Key words: Concentration, Drymatter, Phosphorus, Potassium, Rhizobacteria, Sunflower, Uptake

Phosphorus (P) is a major growth-limiting nutrient and unlike the case for nitrogen (N), there is no large atmospheric source that can be made biologically available (Ezawa *et al.*, 2002). Root development, stalk and stem strength, flower and seed formation, crop maturity and production, N-fixation in legumes, crop quality, and resistance to plant diseases are the attributes associated with P nutrition. Large amount of P applied as fertilizer enters in to the immobile pools through precipitation reaction with highly reactive Al^{3+} and Fe^{3+} in acidic, and Ca^{2+} in calcareous or normal soils (Gyaneshwar *et al.*, 2002; Hao *et al.*, 2002). Soil microorganisms play a key role in soil P dynamics and subsequent availability of phosphate to plants (Richardson, 2001).

There are strong evidences that soil bacteria are capable of transforming soil P to the forms available to plant. Soil P precipitated as orthophosphate and adsorbed by Fe and Al oxides is likely to become bio-available by bacteria through their organic acid production and acid phosphatase secretion. Phosphorus solubilizing bacteria mainly *Bacillus* and *Pseudomonas* are very effective for increasing the plant available P in soil as well as the growth and yield of crops. So, exploitation of phosphate solubilizing bacteria through biofertilization has enormous potential for making use of ever increasing fixed P in the soil, and natural reserves of phosphate rocks. Hence, a pot experiment was conducted during the winter season of 2010 at Directorate of Oilseeds Research, Rajendranagar, Hyderabad to evaluate six plant growth promoting bacteria (PGPR) for solubilization of native phosphorus (i.e. fixed form) of red sandy loamy soil with 5.7 kg/ha, available P and for meeting the P and K nutrition of sunflower crop. The experiment soil had low available N (124 kg/ha) and high K_2O (284 kg/ha), the pH was slightly alkaline (7.6) and organic carbon content was 5.6 g/kg soil. Viable cultures of PGPR were obtained from plant pathology laboratory and they were multiplied in the nutrient broth, further, talc based inoculum (1:2 ratio *i.e.*, broth: talc) prepared in the laboratory was used for seed coating with carboxy methyl cellulose (CMC) sticker and the seeds were shade dried. The initial viable colony forming units for each treatment was assayed through serial dilution technique. The experiment comprised 8 treatments : T_1= *Bacillus licheniformis*; T_2=*Bacillus megaterium*; T_3=*Bacillus circulans*; T_4=*Bacillus polymyxa*; T_5=*Psuedomonas fluorescence*; T_6=*Bacillus subtilis*, T_7=only RDF (60:60:30 kg NPK/ha) and T_8=absolute control and three replication. Seeds were inoculated with respective bacteria in PGPR treatments and no inoculation was done in NPK and absolute control treatments. Uniform dose of nitrogen and potassium through urea and muriate of potash was applied to all treatments except in absolute control. Phosphorus was

applied only to the NPK treatment. Ten gram of dry fine farm yard manure was applied only to PGPR treatments, three sunflower seeds (DRSH-1) were sown in all pots (20 kg soil). After thinning at 10 DAS, one plant per pot was maintained up to 60 days. At harvest the drymatter yield of plants (without roots) was recorded and samples were processed for chemical analysis. Powdered plant samples were digested with diacid mixture containing nitric acid and perchloric acid in 9:1 ratio. Phosphorus concentration in the digests was estimated by yellow colour method using venadomolybdate and potassium by flame photometer. Soil samples from pots were collected at 0-15cm depth. Analysis for available P in soil samples was done by extracting with 0.5*M* sodium bicarbonate solution and measured the P concentrations by blue colour method as described by Olsen *et al.* (1965). CRD design was adopted, data was statiscally analyzed using M-STATC programme. The results showed that the drymatter yield of sunflower was improved due to seed inoculation with different PGPR. Among the PGPR, *Pseudomonas fluorescens* produced significantly highest drymatter yield (8.32 g/plant) followed by *B.circulans* (7.86 g/plant) over other PGPR treatments. The increase in drymatter yield could be attributed to improved P nutrition met by sunflower with seed inoculation as substantial high content of P and K contents in the shoots and coressponding uptake was recorded when compared to other PGPR treatments (Table 1). In a silmilar study, combined application of rockphosphate and phosphsate solubilizing microorganisms (PSM) improved the drymatter yields of mustard and wheat crops (Qureshi and Narayanasamy, 2005). Among the PGPR treatments, *B.circulans* showed superior effect on the potassium content and uptake, indicating that this bacterium has potential for improving K nutrition of sunflower. However, the application of NPK proved to be superior over all the PGPR treatments on the drymatter production (12.31 g/plant) and this could be obviously due to application of soluble form of P through fertilizer, that would provide higher quantity of avaiable P and K compared to slower rate of solubilizing from PGPRs resulting highest P content and uptake by sunflower shoot due to NPK application (Table 1). These finding are in corroboration with Qureshi and Narayanasamy (2005) who reported that application of TSP to soybean produced high drymatter yield over PSM in alluvial soils. Lowest dry matter was recorded in absolute control (2.44g/plant). Higher crop yields result from solubilization of fixed soil P and applied phosphates by PSB (Zaidi, 1999). Microorganisms with phosphate solubilizing potential increase the availability of soluble phosphate and enhance the plant growth (Ponmurugan and Gopi, 2006).

Table 1 Effect of plant growth promoting rhizobacteria on available P, sunflower drymatter yield, P and K content and uptake at 60 day stage

Treatment	Inoculum load (cfu/seed)	Available phosphorus (kg/ha)	DMY (g/plant)	P content (mg/g DM)	P uptake (g/plant)	K content (mg/g DM)	K uptake (g/plant)
B. licheniformis	5 x 109	7.8	3.2	3.4	0.011	29.9	0.09
B. megaterium	4 x 109	6.3	5.9	3.4	0.020	36.2	0.21
B.circulans	5.5 x 109	14.1	7.9	4.4	0.035	41.7	0.32
B.polymyxa	9.5 x 109	9.3	4.5	4.1	0.019	45.3	0.20
P.fluorescens	5 x 109	10.7	8.3	3.4	0.030	35.9	0.29
B.subtilis	7 x 109	7.3	5.5	3.2	0.018	39.9	0.22
NPK (60:60:30)	--	23.8	12.3	6.8	0.084	46.6	0.57
Control	--	5.8	2.4	2.7	0.007	22.8	0.22
CD (P =0.05)	--	1.27	1.15	0.36	0.006	3.07	0.57

DMY - Drymatter yield (above ground); DM Drymatter; cfu=colony forming unit

The P content in sunflower crop differed significantly due to PGPR treatments, *B.circulans* (4.4 mg/g drymatter) recorded highest P content followed by *B. polymyxa* (4.1 mg/g drymatter) over other PGPR treatments. It was noticed that *B. fluorescens* had produced highest drymatter yield over treatments having high P and K contents, which may be attributed due to beneficial effect of growth promoting compounds in rhizospere by this PGPR. The treatment receiving recommended doses of NPK recorded highest P content in the shoot (6.8 mg/g drymatter) and the lowest P content was noticed in absolute control (2.7 mg/g drymatter). The highest K content in the shoot was recorded due to inoculation with *B. polymyxa* (45.3 mg/g drymatter) follwed by *B. circulans* (41.7 mg/g drymatter) over other PGPR treatments. However, the highest K content in the shoot was observed in the treatment receiving RDF (46.6 mg/g drymatter) over all the other treatments. Reports showed that Pseudomonas spp. enhanced the number of nodules, dry weight of nodules, yield components, grain yield, nutrient availability and uptake in soybean crop (Son *et al.*, 2006). Phosphate solubilizing bacteria enhanced the seedling length of *Cicer arietinum* (Sharma *et al.*, 2007). The available soil P status after harvest of sunflower was found to differ significantly due to PGPRs over absolute control. Among the PGPRs the available P due to *Bacillus cirulans* (14.1 kg/ha) treatment was found superior. However, the highest available P was noticed in the treatment receiving NPK (23.8 kg/ha). The experimental

soils had high available K at initial and after sunflower harvest and hence the results are not presented.

To conclude, RDF application has recorded highest drymatter. P and K concentration and uptake. PGPRs improved the P and K nutrition when they were inoculated singly and without P fertilizer. *B. fluorescens* had produced highest drymatter yield over treatments which had recorded highest P and K contents.

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Effect of cow urine decoctions of different plants on *Lipaphis erysimi* (Kalt.)

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(Received: September, 2011; Revised: October, 2012; Accepted: November, 2012)

ABSTRACT

The present investigation was undertaken to study the effect of cow urine decoctions (CUDs) @5% of plants *viz., Allium cepa, Allium sativum, Annona squamosa, Azadirachta indica, Cariaca papaya, Parthenium hysterophorus, Calotropis gigantea, Cymbopogon citriodora* and neem oil (@ 0.005 and 0.003%) were evaluated against nymphs of *L. erysimi in vitro*. The success index of CUD was higher in *C. gigantea* (0.70) followed by *C. papaya* (0.69), *P. hysterophorus* (0.64), *C. citriodora* (0.63), *A. squamosa* (0.58), *A. sativum* (0.57), *A. cepa* (0.55), neem oil 0.003% (0.55), *A. indica* (0.49) and neem oil 0.005% (0.46). Howe's index value was 0.07 in control and 0.05 in *C. papaya, P. hysterophorus, C. gigantean, A. squamosa, C. citriodora* and 0.03 in neem oil, *A. indica*. On the basis of growth and development indices it revealed that *A. indica* was the best among all CUDs used.

Key words: Cow urine decoctions, Growth and development, *Lipaphis erysimi*

Out of various insect-pests associated with Rapeseed-Mustard, *Lipaphis erysimi* (Kalt.) is the key pest causing the total failing of these crops. In the era of environment awareness, more emphasis is given to the natural insecticides, as they are biodegradable and less harmful to environment. Considering the economic importance of the pest and to reduce the poisonous effect of chemical insecticides to natural enemies, cow urine decoctions (CUDs) of botanicals were tried for its efficacy against mustard aphid, *L. erysimi* by keeping in view the finding of Gupta (2005); Purwar and Yadav (2004) and Hasan and Singh (2008, 2009). The present investigation was undertaken to study the effect of CUDs @5% of plants *viz., Allium cepa, Allium sativum, Annona squamosa, Azadirachta indica, Cariaca papaya, Parthenium hysterophorus, Calotropis gigantea, Cymbopogon citriodora* and neem oil (@ 0.005 and 0.003%) were evaluated against nymphs of *L. erysimi in vitro*.

Cow urine decoction was prepared using 250 g leaves of various plants as well as neem oil 0.003 and 0.005% in 500 ml of cow urine and allowed it to boil slowly up to half of original volume and was cooled. Later the material was filtered with muslin cloth and filled in bottle and stored into the cool and dry place. The fresh leaves of Indian mustard (*Brassica juncea*) cv. varuna were put in petri plates and 10 healthy 3 days old nymphs of *L. erysimi* are released on leaves. Topical application method was applied for spraying the test solution on the leaf surfaces to assess the efficacy of CUDs against aphid. After that test nymphs ware also sprayed with acquired concentrations of cow urine decoction sprayed with leaves of the plants with the help of atomizer. Each treatment was replicated twice under laboratory conditions. After 24 hrs, treated leaves were replaced with fresh untreated leaves. A control experiment was also run parallel for each concentration. To assess the overall suitability of various CUDs of plants in supporting the growth and development, different indices were computed such as nymphal index, survival index, reproductive index, Howe's index (1971) and success index.

All the CUDs were found superior over control having nymphal index value >1; however the best cow urine decoction having higher nymphal index were 1.25 in *A. squamosa* and *C. citriodora*, 1.15 in *A. sativum* and *P. hysterophorus* and this was minimum 1.00 for control. Maximum Howe's index value represented maximum suitability of host plant for growth and development of aphid. Howe's index value was 0.07 in control and 0.05 in *C. papaya, P. hysterophorus, C. gigantean, A. squamosa, C. citriodora* and 0.03 in neem oil, *A. indica*. Reproductive index indicates that *P. hysterophorus* (0.32) were superior for reproduction of aphid to rest of CUDs. For control reproductive index is 1.00, which is far more superior for reproduction. The ability of reproduction reduces from *C. gigantea* (0.31), *Allium cepa* (0.31), *C. papaya* (0.29), *C. citriodora* (0.22), *A. squamosa* (0.20), neem oil 0.003% (0.20), *A. indica* (0.14), *A. sativum* (0.12) and neem oil 0.005% (0.09). Higher success index value indicates suitability of host plant for growth and development of aphid. Success index which accounts for fecundity, nymphal duration and survival of individuals. In present study, the value of success index of CUDs was higher in *C. gigantea* (0.70) followed by *C. papaya* (0.69), *P. hysterophorus* (0.64), *C. citriodora* (0.63), *A. squamosa* (0.58), *A. sativum* (0.57), *A. cepa* (0.55), neem oil 0.003% (0.55), *A. indica* (0.49) and neem oil 0.005% (0.46). Similar results were recorded by Hasan and Singh (2008) and Mathur *et al.* (2011). Gupta *et al.* (2005) reported the efficacy of neem in combination with cow urine against mustard aphid and its

effect on coccinellid predators. Sachan and Bansal (1975) reported that the first, second, third and fourth nymphal stages last for 1-2, 2, 2, 3 days, respectively and wingless females produce 70-87 nymphs in the lifetime while winged females produce 31-40 nymphs. On the basis of growth and development indices it revealed that *Azdirachta indica* was the best among all CUDs used. Thus, it was concluded that all the above CUDs were found to be less suitable for growth and development of aphid with respect to the control.

Table 1 Effect of cow urine decoction (CUD) of different plants on *Lipaphis erysimi* (Kalt.)

Treatment	Avg. nymphal period (days)	Potential fecundity (per female)	% adult formed	Nymphal index	Survival index	Reproductive index	Success index	Log of percent survival	Howe's index
Allium cepa (Onion)	13	8	30	1.15	0.43	0.12	0.57	1.48	0.04
Allium sativum (Garlic)	14	19	50	1.07	0.71	0.29	0.69	1.70	0.05
Annona squamosa (Sharifa)	14	20	50	1.07	0.71	0.31	0.70	1.70	0.05
Azadirachta indica (Neem)	13	21	30	1.15	0.43	0.32	0.64	1.48	0.05
Cariaca papaya (Papaya)	14.5	9	20	1.03	0.29	0.14	0.49	1.30	0.03
Parthenium hysterophorus (Congress grass)	14	20	20	1.07	0.29	0.31	0.55	1.30	0.04
Calotropis gigantean (Milk weed)	12	13	20	1.25	0.29	0.20	0.58	1.30	0.05
Cymbopogon citriodora (Lamon grass)	14	6	15	1.07	0.21	0.09	0.46	1.18	0.03
Neem oil (0.005%) (Neemerin)	13	13	20	1.15	0.29	0.20	0.55	1.30	0.04
Neem oil (0.003%) (Neemerin)	12	14	30	1.25	0.43	0.22	0.63	1.48	0.05
Untreated control	15	65	70	1.00	1.00	1.00	1.00	1.85	0.07

ACKNOWLEDGEMENTS

The research has been sponsored under the UGC Dr. D.S. Kothari Post Doctoral Fellowship Scheme.

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Efficacy of soil amendments with neem cake and bio-control agent on the incidence of Macrophomina stem and root rot of sesame (*Sesamum indicum* L.)

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(Received: May, 2012; Revised: November, 2012; Accepted: December, 2012)

ABSTRACT

Stem and root rot of sesame (*Sesamum indicum* L.) caused by *Macrophomina phaseolina* infects high percentage of plants and consequently leads to significant yield losses in rainfed crop especially in Rajasthan. The continuous use of chemicals has deleterious effect on the beneficial microorganism in soil, in addition to the residual problem and development of resistance by the pathogen. Field experiments were conducted during rainy seasons of 2006 and 2007 at Agricultural Research Station, Mandor - Jodhpur (Rajasthan) to find out the efficacy of soil amendments with neem cakes and with bio-control agent (*Trichoderma viride*) on the incidence of stem and root rot of sesame. Minimum incidence of stem and root rot (3.32%) and highest seed yield (924 kg/ha) was recorded in soil application of neem cake (250 kg/ha) + seed treatment with *Trichoderma viride* (0.4%) + soil application of *Trichoderma viride* @ 2.5 kg/ha. This treatment gave 82.27% disease control and 43.92% yield increase with B:C ratio of 2.88.

Key words: Bio-agent, *Macrophomina phaseolina,* Neem cake, Seed treatment, Soil application, *Trichoderma viride*

Sesame (*Sesamum indicum* L.), commonly known as til is the oldest indigenous oilseed crop. Sesame diseases under favourable conditions in rainy season cause significant loss in yield (10-100%). Stem and root rot of sesame caused by *Macrophomina phaseolina* infects high percentage of plants and consequently leads to yield losses in rainfed crop especially in Rajasthan. The continuous use of chemicals has deleterious effect on the beneficial microorganism in soil, in addition to the residual problem and development of resistance by the pathogen. In earlier studies, it was observed that seed treatment with *Trichoderma viride* was found effective for the management of Macrophomina stem and root rot of sesame (Rajpurohit, 1999). Integrated disease management plays a vital role in increasing the productivity. On the basis of results of earlier studies, efforts were made to test seed treatment in combination of soil application of bio agent and neem cake for management of Macrophomina stem and root rot under field conditions in the present study.

An experiment was conducted in randomized block design with five treatments and four replications with plot size of 4 m x 2.4 m. on sesame during rainy season of 2006 and 2007 at Agricultural Research Station, Mandore, Jodhpur (Rajasthan) to find out the efficacy of soil amendments with neem cakes and with bio-control agent on the incidence of Macrophomina stem and root rot. Details of the treatments were neem cake (500 kg/ha), neem cake (250 kg/ha), neem cake (250 kg/ha) + seed treatment with *Trichoderma viride* (0.4%) + soil application of *Trichoderma viride* @ 2.5 kg/ha, seed treatment with *Trichoderma viride* (0.4%) + soil application of *Trichoderma viride* @ 2.5 kg/ha and control. The cake was incorporated in soil and mixed thoroughly before sowing. The bio-agent *Trichoderma viride* was added in farm yard manure 15 days prior to its application and kept in shade and the incidence of Macrophomina stem and root rot was recorded before harvesting.

Minimum incidence of Macrophomina stem and root rot (3.32%) and highest seed yield (924 kg/ha) was recorded in soil application of neem cake (250 kg/ha) + seed treatment with *Trichoderma viride* (0.4%) + soil application of *Trichoderma viride* @ 2.5 kg/ha this was followed seed treatment with *Trichoderma viride* (0.4%) + soil application of *Trichoderma viride* @ 2.5 kg/ha (percentage disease index 6.08%, seed yield-816 kg/ha). Highest disease (18.17%) was recorded in control. The sesame stem and root rot can be managed by soil amendment with neem, castor, and mustard cake @ 1.0 t/ha (Rajpurohit, 2008). The efficacy of cakes might be due to antifungal substances which inhibited the growth of the pathogen but not so inhibitory against natural antagonist micro biota especially fungal antagonists present in the soil (Dubey and Patel, 2000). Two years experimental results revealed that soil application of neem cake (250 kg/ha) + seed treatment with *Trichoderma viride* (0.4%) + soil application of *Trichoderma viride* @ 2.5 kg/ha reduced Macrophomina stem and root rot from 18.17 to 3.32% and increased seed yield from 642 kg/ha to 924 kg/ha with B:C ratio of 2.88 (Table 1). Hence, for organic sesame production soil application of neem cake (250 kg/ha) + seed treatment with *Trichoderma viride* (0.4%) + soil application of *Trichoderma viride* @ 2.5 kg/ha may be recommended for management of stem and root rot disease of sesame.

Table 1 Studies on the efficacy of soil amendments with neem cakes and bio-control agents on the incidence of stem and root rot in sesame

Treatment	Macrophomina stem and root rot (%)			Seed yield (kg/ha)			B:C
	2006	2007	Mean	2006	2007	Mean	ratio
Neem cake (500 kg/ha)	6.40 (14.65)*	5.79(13.88)*	6.09	696	1042	869	1.72
Neem cake (250 kg/ha)	8.43(16.85)*	8.53(16.94)*	8.48	553	944	748	1.61
Neem cake (250 kg/ha) +seed treatment with *Trichoderma viride* (0.4%) + soil application of *Trichoderma viride* @ 2.5 kg/ha	4.87 (12.74)*	1.78(7.40)*	3.32	708	1140	924	2.88
Seed treatment with *Trichoderma viride* (0.4%) + soil application of *Trichoderma viride* @ 2.5 kg/ha	7.31(15.67)*	4.85 (12.64)*	6.08	625	1008	816	5.46
Control	15.31 (22.95)*	13.03 (21.08)*	18.17	423	861	642	-
SEm ±	0.80	1.24		35.1	31.4		
CD (P=0.05)	2.63	2.71		114	68.4		
CV (%)	8.4	12.3		10.2	5.4		

*Angular transformation value.

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Rajpurohit T S 2008. Studies on the efficacy of soil amendments with oil cakes on the incidence of Macrophomina stem and root rot of sesame. *Geobios*, **35**:225-226.

LIST OF REFEREES FOR THE YEAR 2012

1. Dr. A.R.G. Ranganatha, Jabalpur
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3. Dr. C.V. Raghavaiah, Hyderabad
4. Dr. D.M. Hegde, Bangaluru
5. Dr. G. Suresh, Hyderabad
6. Dr. Harvir Singh, Hyderabad
7. Dr. I. Singh, Mandore
8. Dr. I.Y.L.N.Murthy, Hyderabad
9. Dr. Jagannatha Raju, Hyderabad
10. Dr. K. Anjani, Hyderabad
11. Dr. M.Shantalakshmi Prasad, Hyderabad
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15. Dr. N. Sreedhar, Hyderabad
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19. Dr. R.D. Prasad, Hyderabad
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22. Dr. T.S. Rajpurohit, Jodhpur
23. Dr. V. Muralidharan, Coimbatore
24. Dr. Md. Aziz Qureshi, Hyderabad

ERRATA

The following is the errata for the Review Paper entitled "Sesame improvement – Present status and future strategies", **29**(1): 1-26, June, 2012.

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ANNOUNCEMENT

The Indian Society of Oilseeds Research introduces two biennial awards viz., ISOR Best Research Paper Award (ISOR-BRPA) and ISOR Best Ph.D. Thesis Award (ISOR-BPTA) from the years 2009-2010. The nature and guidelines of the awards are presented hereunder:

ISOR BEST RESEARCH PAPER AWARD (ISOR-BRPA)

Name of the Award	:	**ISOR Best Research Paper Award (ISOR-BRPA)**
Donor of the Award	:	Indian Society of Oilseeds Research, Hyderabad
Nature of the Award	:	It is a biennial award consisting of ` 5000/- (Rupees five thousand) cash prize and certificate for the best research paper published in the Indian Journal of Oilseeds Research.
Purpose of the Award	:	To motivate high quality research amongst the oilseed researchers and to recognise outstanding work done in the field of oilseeds research.
Administration of the Award	:	• The Indian Society of Oilseeds Research shall retain the right to designate the general areas of scientific endeavour in which the award shall be made. • The Society shall have the sole right of selection of the recipient of the award and of the formulation of the rules governing such selection
Eligibility for the Award	:	• All the full research papers published in two calendar years are eligible for the award. The award shall be made for notable and original research work and not for routine investigations. The candidates shall be judged on the basis of the original and or applied research work done. • The article should be contributed exclusively to the Journal of Oilseeds Research. • If any of the selected article is written jointly by more than one author, the award amount will be equally divided among the authors.
Subject matter of the article	:	• The article should be based on original or applied research. Articles which have been reproduced from other publications, seminar papers, etc., are excluded from competition. • The article should made an important contribution to the understanding related to oilseeds.
Expression and Presentation	:	• Advanced concepts should be clearly and concisely expressed in the simplest possible language. The article should be well arranged in that the facts, data and discussion are presented in a logical sequence. • Where the illustrations are appropriate and important for clarify of presentation and it should be judged on its quality and effectiveness. Judges are also expected to consider whether or not illustrations (in its absence) or additional illustrations might have contributed to the clarity and effectiveness of presentation. • Facts and data presented should be documented as to source and verified either from the author own research or by reference to work performed or opinions advanced by other authorities. On the basis of a consensus of the judges, the article should be chosen for the award giving weightage as indicated below keeping in view the points mentioned above.

Judging Committee	:	• The society shall constitute a Panel **of Judges to select the recipient(s)** of the award. • The Panel of Judges shall judge the relative merits of the research contribution made and recommend to ISOR the name(s) of the candidate(s) to whom the award may be made in accordance with the procedure laid down.
Presentation of the Award	:	The award shall be presented at the Biennial Seminar of the Society or on any their suitable occasion.

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ISOR has instituted an award *viz.*, **ISOR Best Ph.D. Thesis Award (ISOR-BPTA)** to motivate high quality fundamental and applied research amongst Ph.D. Scholars in India in the field of oilseeds. This is a biennial award open to all Indian students in the field of oilseeds research. The award carries a citation and cash prize of ₹ 5000/- (Rupees five thousand only). Only those theses are considered for this award for which final viva-voce is completed by 31st December of the second year of the two year period for the award is meant. For example: applicants for 2010 and 2011 should have completed their final viva-voce examination by 31st December, 2011.

Research workers in the field of oilseeds interested to apply for this Award are required to send their nominations through proper channel along with a copy of the thesis submitted by them for their Ph.D. Degree together with seven copies of synopsis, highlighting the significance of research. The nominations should be accompanied by a certificate from the concerned Head of the Department that the research work of the candidate has been a significant factor in obtaining the data presented in the thesis leading to the conferment of Ph.D. Degree.

All the nominations together with appropriate certificates should be send to Secretary, Indian Society of Oilseeds Research through the concerned Head of Department by the notified date to be announced while inviting nominations.

All the theses submitted would be judged by a panel of judges appointed by Executive Committee. The Executive Committee, whose decision is final, shall approve the report of the judges.

The candidate whose work is judged to be the best will be awarded a citation and ₹ 5000/- (Rupees five thousand only) as cash at the Biennial Seminar of the Society or on any their suitable occasion. The recipient of the award is expected to deliver an illustrated talk based on his significant research work submitted for the award.

TA/DA as admissible shall be paid to recipient of the award for his journey from his place of work to the place where meeting is being held, in the case the recipient fails to get the same from his organisation.

Applications for both the above awards can be had by sending a request letter to:

The General Secretary
Indian Society of Oilseeds Research
Directorate of Oilseeds Research
Rajendranagar, Hyderabad-500 030
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JOURNAL OF OILSEEDS RESEARCH

GUIDELINES TO AUTHORS

The Journal of Oilseeds Research is published half-yearly. The following types of material are considered for publication on meeting the style and requirements of the journal (details in July, 2010 issue).

1. **Articles on original research completed,** not exceeding 4000 words (up to 15 typed pages, including references, tables, figures, etc.) should be exclusive for the journal. They should present a connected picture of the investigation and should not be split into parts. Complete information of Ph.D thesis should preferably be given in one article.
2. **Short Communication,** not more than 1300 words (total 5 typed pages), which deal with (i) research results that are complete but do not warrant comprehensive treatment, (ii) descriptions of new material or improved techniques or equipment, with supporting data, and (iii) a part of thesis or study. Such notes require no headed sections.
3. **Critical Research Review Articles,** showing lacunae in research and suggesting possible lines of future work. These are mostly invited from eminent scientists.
4. The research article or note submitted for publication should have a direct bearing on agricultural production or open up new grounds for productive research. Articles on oilseeds research, economics, demonstrations, social sciences, extension, etc., are also considered. Basic type of articles and notes relating to investigation in a narrow specialized branch of a discipline may not form an appropriate material for this journal, nor do the articles of theoretical nature, or those of local importance, repetitive, based on old data, with no positive significance.
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Directorate of Oilseeds Research, Rajendranagar, Hyderabad-500 030, India,
Ph : (040) 24598150/24598132; Fax : (040) 24017969
Web site: http://www.isor.org.in; E-mail: oilseedsociety@gmail.com
Computer Typesetting : **Sasi Graphics**, Rajendranagar, Hyderabad Printed by **M/s Progressive Press Pvt. Ltd**, Hyderabad