

ISSN 0970 - 2776

VOLUME 11

NUMBER 2

DECEMBER 1994

12/24
DOR-344
30-
3/4/95

JOURNAL OF OILSEEDS RESEARCH

**INDIAN SOCIETY OF OILSEEDS RESEARCH
DIRECTORATE OF OILSEEDS RESEARCH
RAJENDRANAGAR HYDERABAD - 500 030 INDIA**

THE INDIAN SOCIETY OF OILSEEDS RESEARCH

COUNCIL FOR 1994-95

President	:	Prof.. V.L. Chopra
Vice President	:	Dr. M.V.R.Prasad
General Secretary	:	Dr. B.N. Reddy
Joint Secretary	:	Dr. J.V. Rao
Treasurer	:	Dr. R. Kalpana Sastry
Editor	:	Sri. J.A. Sastry
Councillors	:	Dr. S.C. Gupta (North Zone)
		Dr. J.N. Sachan (Central Zone)
		Dr. N. Venugopal (Southern Zone)
		Dr. K.V. Pethani (Western Zone)
		Dr. S.K.Samantha (Eastern Zone)

Editorial Board for 1994-95

Editor	:	Sri J.A. Sastry
--------	---	-----------------

Members

Dr. Ghafoorunissa	Prof. S. Jayaraj
Dr. M.Uday Kumar	Dr. S.N. Nigam
Dr. P.B. Parthasarathy	Dr. R.P. Singh
Dr. S.L. Mehta	Dr. Nawab Ali
	Dr. S.J. Kolte

Editorial Assistance	:	Dr. S.N. Sudhakara Babu
		Sri T. Damodaram

PATRONS

M/s. Vanaspati Manufacturers Association
 M/s. A.P. Seed Certification Agency
 M/s. National Dairy Development Board
 M/s. Maharashtra Hybrid Seeds Company Ltd.,
 M/s. Indian Soap & Toiletie Makers' Association
 M/s IOPEA-Oilseeds Scientific Research Institute
 M/s. Bharat Pulverising Mills Pvt. Ltd.,
 M/s ITC Ltd., - ILTD Division Seed Unit

Journal of Oilseeds Research is the official organ of the Indian Society of Oilseeds Research published half yearly.

Journal of Oilseeds Research

Volume 11

DECEMBER 1994

Number 2

- Effect of stage of harvesting and nitrogen levels on yield and oil quality of linseed (*Linum usitatissimum* L.)
--P.M. Nimje and A.P. Gandhi. 141-151
- Growing season and productivity of rainfed groundnut
--D.D.Sahu, P.S.N.Sastry and S.K.Dixit. 152-159
- Population dynamics of linseed budfly, *Dasyneura lini* Barnes (Diptera : Cecidomyiidae) on linseed (*Linum usitatissimum*)
--Nikhil Shrivastava, O.P.Katiyar, S.Shrivastava and S.B.Das. 160-164
- Suitability of crop-weather relations for sunflower production during *kharif* season at Raichur
--P.S.Kavi, Y.B.Palled, B.K.Desai, and K.Manjappa. 165-169
- Stability for yield and yield attributing characters in sesame under rainfed conditions
--A.K.Verma and Jay Lal Mahto. 170-173
- Germination of safflower (*Carthamus tinctorius* L.) seeds as influenced by soil moisture and depth of sowing
--P.G.Patel and Z.G.Patel 174-178
- Assessment of yield losses in yellow sarson due to mustard aphid, *Lipaphis erysimi* (Kaltenbach.)
--C.P.Singh and G.C.Sachan 179-184
- Influence of induced mutation on heterosis for seed yield and its attributes in sunflower (*Helianthus annuus* L.)
--R.K.Sugoor, K.Giriraj and P.M.Salimath. 185-188
- Performance of soybean - pigeonpea intercropping system in Malwa plateau of Madhya Pradesh
--O.P.Joshi, V.S.Bhatia and V.P.S.Bundela 189-192
- Response of sulphur and phosphorus on groundnut
--S.Dimree and K.N.Dwivedi. 193-195
- Influence of specific gravity on vigour and viability of sunflower seeds
--S.Rajendra Prasad, A.Sathyanarayana Reddy, K.Seenappa and T.N.Venkata Reddy. 196-200

OFFICE OF PROJECT CO-ORDINATOR
(RAIPUR)

Inward No. 345.....

Dated : 3/6/95.....

Performance of groundnut varieties under different dates of sowing during rabi/summer season --A.K.Guggari, K.Manjappa, P.S.Dharmaraj, Y.B.Palled and Sathyanaarayana Rao.	201-203
Provenance effect on seed quality of groundnut (<i>Arachis hypogaea</i> L.) in Karnataka --S.Narayana Swamy and K.G.Shambulingappa.	204-209
Effect of date of sowing and irrigation on the diurnal variation in physiological processes in the leaf of Indian mustard (<i>Brassica juncea</i>) --P.K.Chakraborty.	210-216
Influence of spatial arrangement and nitrogen levels on light utilization and productivity in maize-soybean intercropping system --R.S.Sharma, K.K.Agrawal and K.K.Jain.	217-221
Evaluation of predictability of oil content of groundnut kernels on the basis of their specific gravity --S.K.Yadav and J.B.Misra.	222-228
Evaluation of germplasm collections of safflower (<i>Carthamus tinctorius</i> Linn.) in India for morphological characters and it's association with reaction to aphid infestation --R.Balakrishnan, K.Venkateswara Rao, R.V.Dathkhele and R.C.Patil.	229-236
Phenotypic stability analysis of soybean varieties in kharif and summer seasons --S.P.Taware, V.M.Raut, G.B.Halvankar and V.P.Patil.	237-241
Seed and oil quality of safflower genotypes --G.Nagaraj	242-244
Potentials of improved oilseed crop production technologies in India - An assessment through frontline demonstrations --V.Kiresur and M.V.R.Prasad.	245-258
Prospects for utilization of genotypic variability for yield improvement in groundnut --R.C.Nageswara Rao, A.K.Singh, L.J.Reddy, and S.N.Nigam.	259-268

SHORT COMMUNICATIONS

- | | |
|---|---------|
| Intercropping of oilseed crops with niger
-- <i>R.K. Paikaray, R.C. Misra and P.K. Sahu</i> | 269-272 |
| Yield and oil quality of mustard as affected by rates of N and S in Inceptisols
-- <i>Asha Arora, Vijay Singh and R.R. Das</i> | 273-276 |
| Feasibility of double cropping with oilseeds in rainfed areas of Madhya Pradesh
-- <i>M.L.Kewat, R.S. Sharma and K.K. Jain</i> | 277-279 |
| Seed mycoflora of castor and its control
-- <i>B. Srinivasulu, P. Narayana Reddy and A.Sudhakar Rao</i> | 280-281 |
| Response of groundnut genotypes to graded levels of sulphur in Alfisols of Southern Karnataka
-- <i>S.Y. Wali, B. Shivaraj and Andani Gowda</i> | 282-284 |
| Influence of herbicides on yield, quality and economics in rainfed groundnut
-- <i>B.G.Murthy, C.A. Agasimani and N.C. Prathibha</i> | 285-287 |
| Performance of sunflower in relation to nitrogen and phosphorus in acid soils of Orissa
-- <i>A. Mishra, P. Das and R.K. Paikaray</i> | 288-290 |
| Groundnut seed production practices adopted by the farmers in southern dry region of Karnataka
-- <i>S. Rajendra Prasad, T.N. Venkata Reddy, N. Vijayamohan Reddy, G.V. Jagadish and B. Siddappa</i> | 291-294 |
| Genotypic variation in yield loss due to leaf miner, <i>Chromatomyia horticola</i> G.o. infecting linseed
-- <i>Ajai Srivastava</i> | 295 |
| New record of <i>Dolycoris indicus</i> Stal (Hemiptera : Pentatomidae) as a minor pest of linseed in Himachal Pradesh
-- <i>Ajai Srivastava and Hira Lal Thakur</i> | 296 |
| Weed management studies in <i>kharif</i> sunflower
-- <i>G. Suresh and N. Venkat Reddy</i> | 297-299 |
| Response of soybean to Va mycorrhizal fungi at varied levels of P
-- <i>B.S. Lingaraju, M.N. Sreenivasa and H.B. Babalad</i> | 300-302 |

<i>Cladosporium herbarum</i> on sunflower (<i>Helianthus annuus</i> L.) head - A new record in India --S. Appaji and C. Chattopadhyay	303
Development of suitable germination medium for trinucleate pollen grains : An illustration with sunflower --M.N. Keshava Murthy, Y.A. Nanja Reddy and K. Virupakshappa	304-307
Residues of endosulfan and lindane in sunflower (<i>Helianthus annuus</i> L.) --M.D. Dethle and V.D. Kale	308-309
Castor leaf miner <i>Acrocerope conflua</i> Meyrick (<i>Gracillariidae</i> : <i>Lepidoptera</i>) - A new record on <i>Jatropha</i> spp. and castor in India --T.B. Gour, T.V.K. Singh and M. Sriramulu	310
HARDF Awards	311-312
Guidelines for Authors	313-315
New Book from ISOR	316

EFFECT OF STAGE OF HARVESTING AND NITROGEN LEVELS ON YIELD AND OIL QUALITY OF LINSEED (*Linum usitatissimum* L.)

P.M. NIMJE and A.P. GANDHI

Central Institute of Agricultural Engineering, Bhopal 462 018, Madhya Pradesh

ABSTRACT

Linseed genotypes belonging to early (R 17 and T 397) and medium duration (Mukta and Neelum) categories were compared at three nitrogen levels and harvested at six maturity stages at 5 days interval starting from 20 days after heading (DAH) in deep Vertisols of Bhopal. Optimum yields of grain, oil and protein were recorded when the crop was harvested at 30 to 37 DAH in early genotypes and at 33 to 38 DAH in medium duration genotypes. The moisture content of grains varied from 14 to 7%. Early harvesting at 20 DAH resulted in yield loss of 13 to 19 % owing to the presence of high percentage of immature grains (30 %). Late harvesting by even 5 to 10 days caused 5 to 11 % reduction in grain yield. Nitrogen fertilization up to 40 kg N ha⁻¹ produced significantly higher grain, oil and protein yields and increased the oil content up to 80 kg N/ha. It did not however, influence the optimum time of any of the genotypes. Seed germination and seedling vigour were directly related to nitrogen application and were increased significantly up to the optimum stage of harvesting. The iodine and saponification values changed with nitrogen but were significantly decreased with time of harvesting indicating the formation of fatty acids with lesser unsaturation. The contents of oleic and linoleic acids and stability index were increased up to the optimum stage. The oleic acid contents decreased thereafter. Nitrogen also increased oleic acid but decreased the linoleic and linolenic acid contents and stability index of oil.

Keywords: Harvesting stage; Nitrogen; Vigour; Germination; Oil; Protein; Fatty acids; Stability index.

INTRODUCTION

The crop maturity is influenced by environmental conditions and seed moisture content. But the physiological maturity is reached before the seed moisture content is sufficiently reduced to allow safe harvest and storage (Robertson *et al.*, 1978). It also varies with genotypes (Nagaraj, 1990). Gupta (1962) reported that oil formation in linseed was completed in 30 days from the day of fertilization. Harvesting the crop too early results in reduced seed and oil yields and protein contents, whereas harvesting too late increase shattering losses in the field and loss in seed

quality (Tekrony *et al.*, 1979). The stage of harvesting also determines the quality of oil (Nagaraj, 1990).

Nitrogen fertilization normally does not affect oil content and iodine value except at high levels (Kamal, 1973) but increases seed and oil yields (Jaipurkar and Puri, 1985 and Jain *et al.*, 1989). Application of nitrogen is also reported to late flowering but whether it will also affect the date of harvesting of linseed in semi-arid deep Vertisols region is not known. The experiment was therefore conducted (1) to find out the most optimum time of harvest of various genotypes for maximizing the seed

and oil yields and quality and (2) to evaluate the effect of nitrogen fertilization on time of harvest and quality of the produce.

MATERIAL AND METHODS

Field experiments were conducted for 2 years (1987-88 and 1988-89) on a deep Vertisol at Central Institute of Agricultural Engineering, Bhopal, India. The soil was black clayey with a pH of 7.8, and available organic carbon 0.054%, N 180 kg ha⁻¹, P 11 kg ha⁻¹, K 255 kg ha⁻¹ and cation exchange capacity 45 meg g⁻¹ soil. The average annual rainfall of the area was 1200 mm (90% during monsoon i.e., June-September). The rainfall received during the season was 114 mm in 1987-88 and 70 mm in 1988-89. The area faces shortage of soil moisture from November onwards. The temperature during ripening stage of the crop (January to March) ranged between 30 °C to 39 °C.

The treatments consisted of four genotypes, three nitrogen levels and six times of harvest. The twelve treatment combinations of genotypes and nitrogen levels were assigned to main plots and six times of harvest to sub-plots in a split plot design having 4.5 x 3 m plot size and three replications. The genotypes belonging to two groups viz., early maturing (115-120 DAS) R 17 and T 397 and medium maturing (135-140 DAS) Mukta and Neelum varieties were evaluated. Nitrogen levels were varied from 0 to 80 kg ha⁻¹. The genotypes were harvested at 5 days interval starting from 110 days after sowing (DAS) in early maturing genotypes (EMG) and 125 DAS in medium duration genotypes (MDG). This date usually corresponded to 20 days after heading (when 50 % heads have emerged).

The crop was sown in rows 30 cm apart on 12th November, 1987 and 15th November,

1988. Fertilizers were drilled below the seed at sowing to supply half the dose of nitrogen, 40 kg P₂O₅ and 20 kg K₂O/ha. The remaining half dose of nitrogen was applied at 45 DAS alongwith a light irrigation of 6 mm. The crops were harvested from 1st March, 1988 and 5th March, 1989 onwards.

At each harvest, the grain yield was determined at 8% moisture content which was estimated through gravimetric method, Germination (%), seedling vigour, immature seed (%) and 1000 grain weight were determined from the samples drawn at harvest. Seed oil and protein contents and oil quality in terms of iodine and saponification values and fatty acid composition were estimated as per AOAC (1980) methods.

Prediction equations were obtained to determine the expected values of various parameters with respect to days after sowing by fitting the equation of parabola to the observed data by Least Square Method as given below :

$$\hat{Y} = a + bX - cX^2$$

In order to determine the theoretical day of biological maturity of the crop, this equation was differentiated with respect to X (days after sowing) as follows :

$$\frac{dy}{dx} = 0 = b - c \times 2x$$

$$\text{or } x = \frac{b}{2c}$$

RESULTS AND DISCUSSION

Flowering was initiated 90 and 85 DAS and reached 50% heading at 90 and 105 DAS in early and medium duration genotypes respectively.

The effect of time of harvesting and genotypes on grain yield are shown in Fig. 1 and Table 2. Grain yield increased between 20 to 30 DAH in 1987-88 and 20 to 35 DAH in 1988-89 and decreased thereafter in all the genotypes. The genotypes significantly differed among themselves in grain yield. Genotype R 17 produced the highest yield of 1.52 and 1.32 tonnes ha⁻¹ in the two years whereas T 397 produced lowest yield of 0.93 tonnes ha⁻¹ in 1987-88. Although Mukta and Neelum were medium duration genotypes, their mean yields (1.16 and 1.08 tonnes ha⁻¹ respectively), were lower than EMG R 17 (1.42 tonnes ha⁻¹).

Harvesting the crop early at 20 DAH, resulted in the yield loss of 13.3 and 18.9 % from the optimum yields (1.25 and 1.27 t/ha) during the two years, due to high seed moisture (24.4%), high percentage of immature grains (30%), low 1000-grain weight and fewer grains plant⁻¹. As the harvesting was delayed, more number of grains got filled up and consequently, their percentage and the weight of 1000-grains increased and moisture content decreased. These changes brought about rapid increases in grain yield in all the four genotypes up to 30 to 35 DAH. The grain yield was decreased when harvested late after 30 or 35 DAH because of field losses of heads and grains during harvesting and transportation to the threshing yard. These losses accounted for 7.8 to 15.7 % during 1987-88 and 2.8 to 6.5% during 1988-89 when harvested at 40 and 45 DAH, respectively. The reduction in yield occurred despite decreases in the percentages of immature grains and increases in the weight of 1000-grains. Thus the decreases in grain yields with delayed harvesting were more related to the number and weight of head plant⁻¹ and number of grains plant⁻¹ which were also decreased after 30 and 35 DAH (Table 1).

By using the differential equation, the biological maturity of the four genotypes was determined. It was found that the biological maturity of the EMG reached at 30.5 DAH and of MDG at 33.5 DAH in 1987-88. The same was reached 4 or more days later in 1988-89. The genotype R 17 matured in 34 DAH, T 397 and Mukta in 37 and Neelum in 38 DAH.

The maximum grain yield was obtained when the crop reached its biological maturity. The range of optimum time of harvesting without significant reduction in grain yield was between 30 to 37 DAH in EMG and 33 to 38 DAH in MDG. The moisture content of the grain was decreased with the delay in the date of harvesting. It was found to be optimum (Fig. 2) during 27 to 37 DAH in EMG and 32 to 41 DAH in MDG. The optimum moisture content varied between 15 to 7% in 1987-88 and 13 to 8% in 1988-89. Delay in harvesting by another 4 to 8 days resulted in reduction of moisture content by 4 to 6 % and consequently, in the grain shedding and reduction of yield.

The percentage of seed germination was poor (76%) when the crop was harvested at 20 DAH in all the genotypes. It became optimum at 30 DAH and remained almost constant thereafter. It was found to be highly positively correlated with grain moisture content ($r = 0.992$ and $r = 0.996$) and 1000 grain weight ($r = 0.874$ and $r = 0.993$) and negatively correlated with percentage immature seeds ($r = -0.99$ and $r = -0.98$) during 1987-88 and 1988-89, respectively. The vigour of the seeds harvested at different times (Table 1) showed that it was improved up to the biological maturity and declined rapidly as the harvesting was delayed further. Tekrony *et al.* (1979) also reported loss in seedling vigour with delayed harvesting after

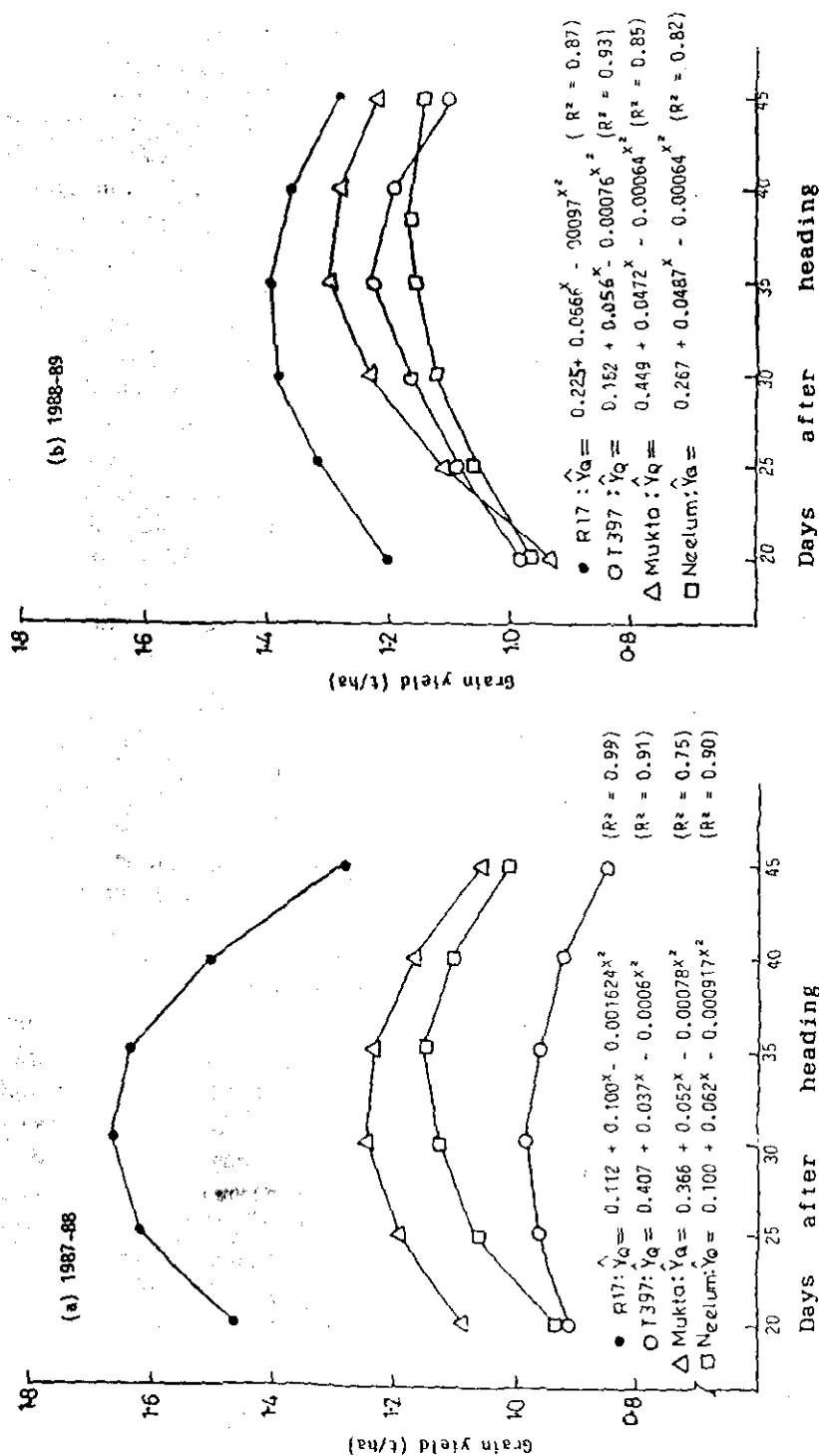


Fig.1. Effect of time of harvest on grain yields of R17, T397, Mukta and Neelum
(Average of three nitrogen levels)

Table 1. Effect of time of harvest and nitrogen levels on seed characters, germination and vigour of different genotypes of linseed

Treatment	Grains plant ⁻¹	Weight of grains plant ⁻¹ (g)	Heads plant ⁻¹	Weight of heads plant ⁻¹	1000 grain weight (g)	Germination (%)	Seedling vigour (mg plant ⁻¹)
Genotypes							
R 17	459	3.85	91.5	5.53	8.97	97.0	6.57
T 397	387	3.36	76.3	5.17	7.90	92.6	6.39
Mukta	350	3.60	74.6	5.43	8.80	85.2	6.25
Neelum	353	3.65	72.0	5.30	9.00	88.4	6.00
LSD (P=0.05)	23	0.38	5.9	0.25	0.23	6.4	0.31
N levels (kg ha⁻¹)							
0	331	3.03	65.4	4.54	8.22	82.6	5.40
40	393	3.71	80.6	5.48	8.83	92.0	6.48
80	438	4.11	89.9	6.05	9.30	97.6	7.03
LSD (P=0.05)	20	0.49	5.2	0.60	0.30	5.5	0.27
Time of harvest (DAH)							
20	377	3.14	70.9	4.77	8.21	76.0	5.15
25	402	3.46	75.7	4.93	8.54	85.6	5.70
30	425	3.67	83.5	5.44	8.79	92.8	6.38
35	405	3.75	86.6	5.97	8.84	95.4	6.98
40	372	3.80	80.9	5.68	8.98	96.9	6.86
45	343	3.88	74.2	5.37	9.07	97.8	6.75
LSD (P=0.05)	17	0.25	5.3	0.33	0.24	6.8	0.53
LSD (P=0.05) for							
Genotypes X N	40	NS	NS	NS	NS	NS	NS
Genotypes X Harvest	33	0.50	NS	0.66	NS	NS	NS
N X Harvest	29	NS	0.53	NS	NS	NS	NS

the biological maturity was reached and attributed it to the reduced moisture content.

Oil and protein per cent (Table 2) were significantly influenced by the genotypes. Oil content also was highest in T 397 followed by Mukta, Neelum and R 17. Protein content also was highest in genotype T 397 followed by Neelum, Mukta and R 17 in that order. The oil content was significantly improved by the delay in harvesting time up to the biological maturity

stage and showed a declining trend thereafter. Scott *et al.* (1973) also reported similar trend. As against this, the protein content was increased up to the last date of harvest although significantly only up to the biological maturity stage. This indicated that the time of harvesting has a favourable effect on availability of assimilates for protein conversion. Sanchez *et al.*, (1989) also reported that oil and protein contents were effected by genotypes and harvest dates. The interaction of the genotypes and

harvest dates was however, not significant with respect to oil and protein contents. Oil and protein yields were also improved significantly up to the biological maturity stage and decreased thereafter (Table 2) confirming the findings of Sandhu *et al.*, (1970) for soybean. Rao and Singh (1985) also reported a direct influence of days to maturity and oil content on oil yield.

The iodine and saponification values of oil of the four genotypes were significantly influenced by the date of harvesting (Table 3). The iodine value of T 397 was highest as compared to other genotypes. A declining trend in iodine and saponification values in all the genotypes with the date of harvesting suggested formation of increased amounts of unsaturated fatty acids.

The effects of time of harvest of fatty acids composition of oil (Table 4) showed that the oleic and linoleic acids, all increased until the biological maturity. The per cent of oleic acid decreased thereafter until 45 DAH, whereas, linoleic acid continued to increase until 45 DAH. The reduced rate of accumulation of oleic acid together with the rise of linoleic acid appears to support the hypothesis that linoleate is formed by desaturation of oleate (Harwood, 1975). The oil stability index was increased up to 30 DAH and then decreased due to decrease in oleic acid content. The linolenic acid content and total saturates decreased as the time of harvesting was prolonged.

Nitrogen fertilization to linseed significantly increased the grain and oil and protein yields in both the years confirming the results obtained by Jain *et al.* (1989). The increase being basically due to greater number of seeds and heads plant⁻¹ and 1000 grain weight

Scott *et al.*, 1973). The effects were significant up to 80 kg N ha⁻¹ in 1987-88 but only up to 40 kg N ha⁻¹ in 1988-89 (Fig. 3). The lower response to nitrogen in the second year may be due to the build up of N residues in the soil. There was also a significant increase in oil content with increase in nitrogen application up to 80 kg/ha (Khurana *et al.*, 1989). This was directly related to rise in protein content also which was increased significantly up to 40 kg N ha⁻¹.

The effects of interaction between nitrogen levels and time of harvesting on grain yield and oil and protein contents were not significant in any of the years. Thus the grain yield, oil and protein contents reached their peaks at about same time in fertilised and unfertilised plots. There was a difference of only 1 or 2 days in the biological maturity of the crop at different nitrogen levels. In control (no nitrogen) plot the crop reached its biological maturity later by 1 or 2 days as compared to the nitrogen treated plots. All the genotypes also produced non-significant influence on grain yield and oil and protein contents at different nitrogen levels.

The germination and seedling vigour were found to be directly related to nitrogen application (Table 1). The germination percentage was significantly increased from 82.6 to 92 and 97.6 % with nitrogen at 40 and 80 kg ha⁻¹ respectively. Seedling vigour after 30 days of germination was also found to increase significantly with nitrogen application at 40 and 80 kg N ha⁻¹, the increase being 20 and 30 % over zero nitrogen level. Srivastava (1978) also showed that germination and seedling vigour were directly related to nutritional environment.

Table 2. Effect of time of harvest and nitrogen levels on grain yield, oil and protein content and yield of different genotypes

Treatment	Grain yield (tonnes ha ⁻¹)		Oil yield (tonnes ha ⁻¹)		Protein yield (tonnes ha ⁻¹)		Oil content (%)	Protein content (%)
	1987-88	1988-89	1987-88	1988-89	1987-88	1988-89		
Genotypes								
R 17	1.524	1.321	0.515	0.447	0.322	0.279	33.8	21.1
T 397	0.928	1.127	0.364	0.442	0.208	0.252	39.2	22.4
Mukta	0.152	1.174	0.415	0.423	0.244	0.249	36.0	21.2
Neelum	1.054	1.095	0.368	0.382	0.235	0.244	34.9	22.3
LSD (P = 0.05)	0.065	0.130	0.135	0.054	0.046	0.047	1.9	0.7
N levels (kg N ha⁻¹)								
0	0.945	1.001	0.318	0.337	0.196	0.208	33.7	20.8
40	1.216	1.224	0.440	0.443	0.269	0.271	36.2	22.2
80	1.352	1.305	0.515	0.497	0.304	0.294	38.1	22.5
LSD (P = 0.05)	0.056	0.113	0.101	0.094	0.034	0.035	1.6	0.6
Time of harvesting								
20	1.084	1.030	0.352	0.335	0.229	0.217	32.5	21.1
25	1.212	1.120	0.428	0.395	0.264	0.244	35.3	21.8
30	1.275	1.199	0.472	0.444	0.283	0.266	37.0	22.2
35	1.225	1.303	0.462	0.490	0.281	0.298	37.7	22.9
40	1.153	1.234	0.432	0.462	0.270	0.289	37.5	23.4
45	1.054	1.187	0.381	0.430	0.251	0.283	36.2	23.8
LSD (P = 0.05)	0.116	0.069	0.068	0.053	0.038	0.030	1.3	0.5

Interactions of genotypes X N, genotypes X harvesting and N X harvesting were not significant.

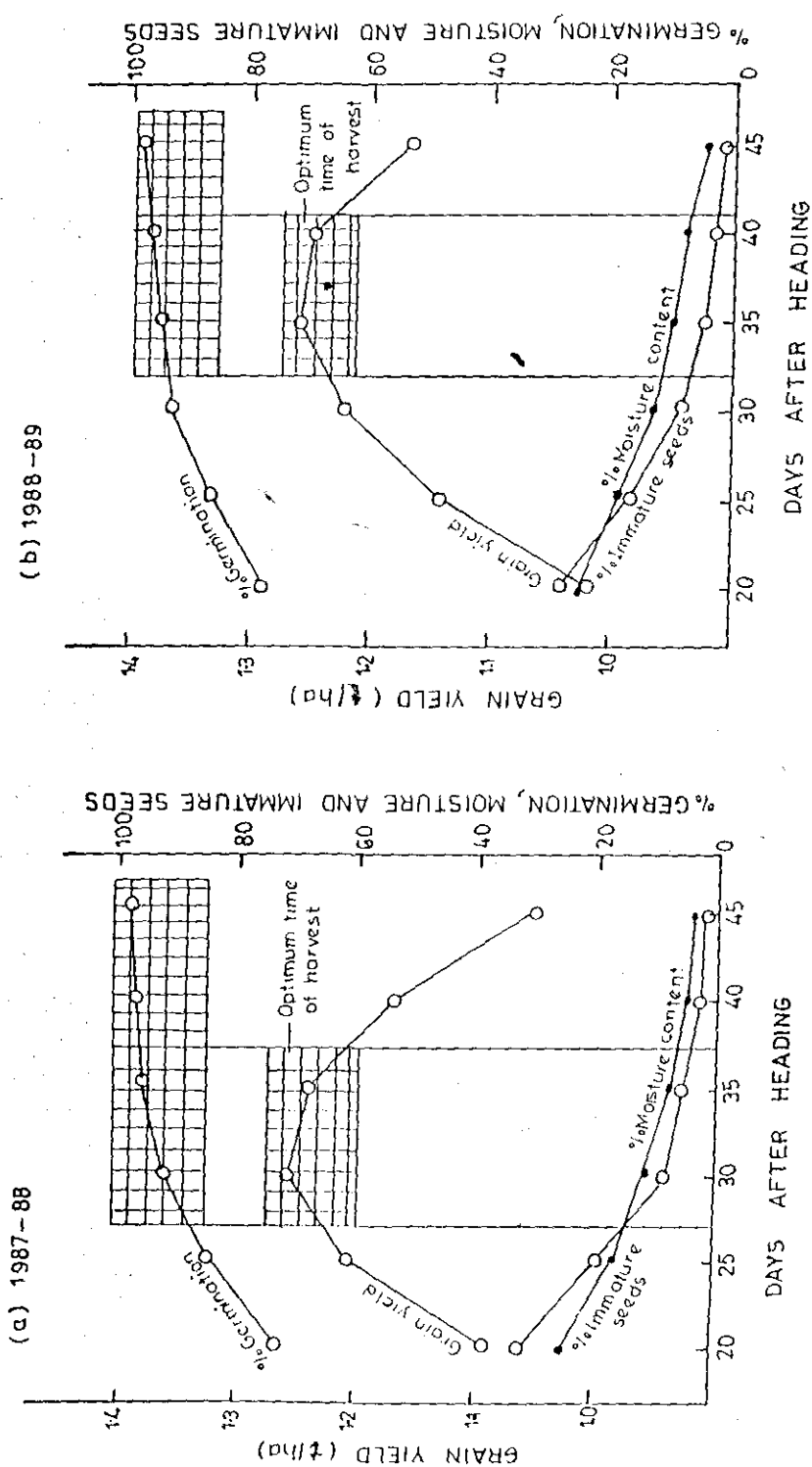


FIG. 2. OPTIMUM TIME OF HARVEST OF LINSEED

Table 3. Effect of time of harvesting on iodine and saponification value of different genotypes

Time of harvest (DAH)	Iodine value				Saponification value			
	R 17	T 397	Mukta	Neelum	R 17	T 397	Mukta	Neelum
20	165.8	194.6	168.3	167.8	197.8	198.1	198.9	198.6
25	161.7	191.6	165.6	165.4	194.8	196.1	196.9	196.8
30	159.9	190.2	163.3	162.6	193.8	194.9	196.4	195.5
35	158.2	188.3	161.2	161.1	193.4	193.6	195.3	194.6
40	154.8	187.5	159.1	158.4	192.3	192.4	194.0	194.0
45	153.9	186.6	158.5	155.5	190.9	191.6	193.0	193.1
LSD (P=0.05)								
Genotype			2.03				NS	
Harvesting			0.99				1.12	
Genotype X Harvesting			NS				NS	

Table 4. Effect of stage of harvesting on fatty acid composition of seed oil

Days after heading	Oleic acid (18 : 1)	Per cent of total fatty acids			Oil stability index (18 : 1/18 : 2)
		Linoleic acid (18 : 2)	Linolenic acid (18 : 3)	Total saturates	
20	20.6	10.1	54.2	15.0	2.04
25	26.2	12.4	48.7	12.8	2.11
30	28.5	13.1	47.7	11.5	2.17
35	30.3	14.7	46.1	10.0	2.06
40	29.2	15.2	46.2	10.5	1.92
45	28.5	15.9	46.5	10.0	1.79
LSD (P=0.05)					
	1.4	0.7	2.5	1.2	-

Nitrogen application has changed the seed-oil constituents altering the oleic and linoleic acid ratios (Table 5). Oleic acid content was increased from 24.5 % (0 kg N) to 28.5% (80 kg N), the increase being 16% whereas linoleic acid content was decreased from 14.4 % to 12.7 % (12% decrease). The oil stability index was however decreased. Coic (1975) also

reported similar trend. Iodine and saponification values did not change with nitrogen application

The study showed that, in linseed, harvesting the crop at biological maturity, 30 to 37 DAH in EMG or at grain moisture content of 14 to 7% produced maximum grain, oil and

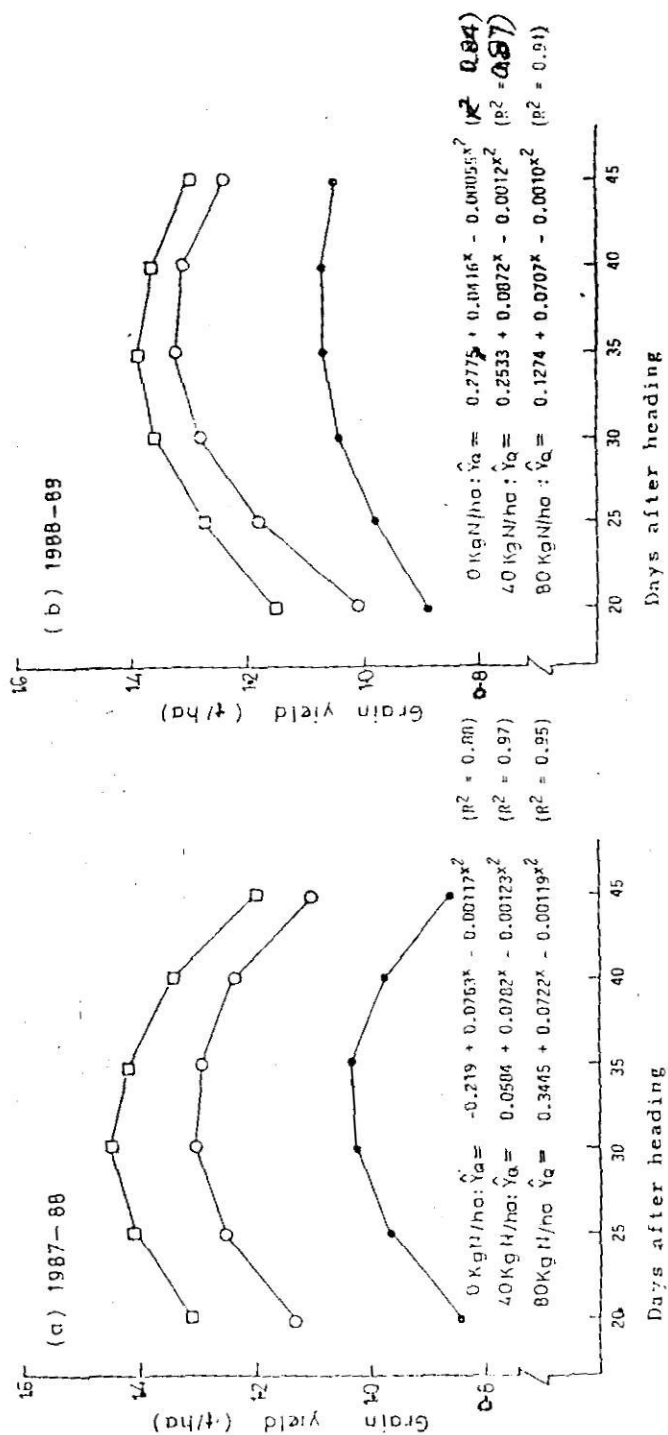


Fig.3. Effect of levels of nitrogen on the grain yield plotted against time of harvest (Average of four varieties)

Table 5. Effect of nitrogen on fatty acid composition and iodine and saponification value

N levels (kg ha ⁻¹)	Iodine value	Per cent of total fatty acids			
		Saponification value	Oleic acid	Linoleic acid	Linolenic acid
0	168.3	194.8	24.5	14.4	51.1
40	168.4	194.9	27.2	13.6	48.2
80	168.5	195.2	28.5	12.7	46.5
LSD (P=0.05)	NS	NS	1.1	1.3	0.5

protein yields and improved seed germination and vigour and quality of seed and oil. Nitrogen fertilization did not influence the time of harvesting but improved the seed and oil quality.

LITERATURE CITED

- AOAC. 1980. Methods of Analysis, Association of Official Analytical Chemists : pp 437 - 461.
- Coic, Y. 1975. Cumulative and antagonistic effects of fertilizers on the protein and oil contents of dual purpose pulses *Proc. 11th Symp. Intl. Potash Inst.* Berne, Switzerland. pp. 161-68.
- Gupta, G.P. 1962. Synthesis of oil at various stages of seed development in linseed. *Indian Oilseeds J.* 6 (3) : 207-210.
- Harwood, J. L. 1975. In: *Recent Advances in the Chemistry and Biochemistry of Plant Lipids* pp 65-69 Eds T. Galliard and E.I. Mercer. Academic Press, London.
- Jain, V.K., Cahuhan, Y.S., Khandekar, M.P., Sharma, R.P. and Yadav, M. P. 1989. Effect of nitrogen and phosphorus on growth and yield of linseed. *India J. Agron.* 34: 122-129.
- Jaipurkar, S.A. and Puri, G. 1985. Influence of soil fertility status and NPK application on chemical composition and oil production of major oilseeds in Vertisols of Madhya Pradesh. *J. Oilseeds Res.* 2 : 62-71.
- Kamal, K.F. 1973. The effect of different levels of NPK fertilizers on the physical and biochemical properties of safflower oil. *Egyptian J. Bot.* 6 (1/3) : 43-48.
- Khurana, D.K., Dubey, D.P. and Namdeo, K.N. 1989. Response of linseed to nitrogen and phosphorus. *Indian J. Agron.* 34 (1) : 142 - 143.
- Nagaraj, G. 1990. Biochemical quality of oilseeds. *J. Oilseeds Res.* 7 : 47-55.
- Rao, S.K. and Singh, S.P. 1985. Relationship of maturity with seed characteristics and their implications in selection of linseed. *J. Oilseed Res.* 2 : 86-92.
- Robertson, J.A., Chapman, G.W. and Wilson, R.L. 1978. Relation of days after flowering to chemical composition and physiological maturity of sunflower seed. *J. Am. Oil Chem. Soc.* 55 : 266-269.
- Sanchez, A., Duringan, J.F. and Asis, G.M. de 1989. Soybean genotype responses to harvest delays with respect to protein and oil contents of the seeds. *Cientifica* 17 (1) : 121-125.
- Sandhu, R.S., Mehrotra, N., Arora, S.K. and Sharma, A.K. 1970. Effect of harvesting at different stages of maturity on the yield and quality of soybean. *Indian J. Agric. Sci.* 40 (4) : 295-297.
- Scott, R.K., Ogunremi, E.A., Ivins, J.D. and Mendham, N.T. 1973. The effect of fertilizers and harvest dates on growth and yield of oilseed rape sown in autumn and spring. *J. Agric. Sci. Camb.* 81 : 287 - 293.
- Srivastava, A.K. 1978. Effects of fertilizer on the composition and emergence of sunflower seeds. *Expt. Agric.* 14 : 213-214.
- Tekrony, D.M., Egli, D.B. and Phillips, A.D. 1979. Effect of field weathering on the viability and vigour of soybean seed. *Agron. J.* 72 (5) : 749 -753.

GROWING SEASON AND PRODUCTIVITY OF RAINFED GROUNDNUT

D.D SAHU¹, P.S.N. SASTRY and S.K. DIXIT²

Division of Agricultural physics, Indian Agricultural Research Institute, New Delhi 110 112

ABSTRACT

Frere and popov's method of cumulative crop water balance was adopted to determine the commencement of growing period and productivity of groundnut in Junagadh district of Gujarat state. The average productivity of groundnut for the years 1965 to 1989 was 993 kg/ha. The productivity was above average during the years of normal sowing that is, between June 18 to July 1 (25th and 26th standard meteorological weeks). The risk of below average production increased with delay in commencement of growing period beyond 2nd July when Water Requirement Satisfaction Index (WRSI) was below 89 per cent. The relationship between the WRSI (X) and Yield (Y) was observed to be of the form

$$Y = \frac{X}{-0.002079 \times X + 0.281}$$

The predictability of the crop yield through WRSI varies to the tune of 90 per cent.

Keywords: Groundnut; Water requirement satisfaction index; Growing season; Crop water balance; Productivity.

INTRODUCTION

Among the various meteorological parameters rainfall plays a significant role in determining sowing time for *kharif* crops. Frere and Popov (1979) developed a simple crop water balance model to estimate the water availability to the crop using rainfall, reference crop evapotranspiration and water holding capacity of the soil as inputs. In this method it is assumed that the sowing at the beginning of the monsoon season can commence during any week when rainfall exceeded the estimated water requirement of the crop under consideration. Popov (1984) demonstrated the relationship between the water requirement satisfaction index (WRSI) and the yield of groundnut at Bambay, Senegal. He suggested that it would be possible

to derive quantitative estimates of yield, based on the potential yield of crops which will depend on the local climatic conditions. Victor *et al.* (1988) and Srivastava *et al.* (1989) studied the utility of this concept in quantifying pearl millet yields under rainfed conditions for Jodhpur district in Rajasthan and for identification of production constraints for groundnut in Rajkot district of Gujarat state respectively. Groundnut (*Arachis hypogaea* L.) is grown under rainfed conditions in Junagadh district. in 3.7 lakh ha contributing 29 percent of production. The present study was undertaken to identify the growing period and quantify the yields of groundnut crop grown under rainfed conditions in the semi-arid region of South Saurashtra agroclimatic zone of Gujarat state.

1. Department of Agrometeorology, College of Agriculture, Junagadh 362 001.

2. Department of Agricultural Statistics, College of Agriculture, Junagadh 362 001.

Received for publication on December 5, 1992.

MATERIAL AND METHODS

Junagadh (21° , 31° N, 70° , 33° E, 60m MSL) situated in the semi-arid region of Gujarat in South Saurashtra Agroclimatic zone receives a seasonal rainfall of 910 mm from 22nd to 44th meteorological week.

The area and production of groundnut in Junagadh district for the period 1965 to 1989 were taken from the Agricultural Situation in India published by the Ministry of Agriculture, Govt. of India and publications of Directorate of Agriculture, Gujarat State. The total weekly rainfall and other weather parameters for the corresponding period were collected from the agrometeorological observatory at Junagadh and used in the calculations. The soils in Junagadh district are shallow medium black and calcareous, with soil depth ranging from 25 to 75 cm with a water holding capacity of 100 mm/m depth (Anonymous, 1984).

The reference evapotranspiration (ET₀) values were derived at weekly intervals using modified Radiation method (Doorenbos and Pruitt, 1979). Crop coefficients given by Doorenbos and Kassam (1986) were used to estimate water requirement of crops on weekly basis. The 16 week period groundnut crop is considered to be in germination and flowering phases for 5 weeks (P₁), Pegging for 4 weeks (P₂), pod development for 3 weeks (P₃) and pod filling and maturity for 4 weeks (P₄), respectively from the commencement of the sowing week each year.

Weekly water balance and water Requirement Satisfaction Index (WRSI) computations were carried out using the cumulative crop water balance model of Frere

and Popov (1979) by developing a computer programme. A sample calculation sheet showing input and output values is given in Table 1.

Computation of WRSI

The WRSI indicates (in terms of percentage) the extent to which the water requirements of a crop have been satisfied in a cumulative way at any stage of its growth cycle. The index is assumed to be 100 at the time of sowing and continues to remain at 100 for the successive weeks until the occurrence of water deficit. In case of groundnut crop it is considered that the productivity is adversely affected not only due to water deficits but also due to excessive moisture during the last four weeks of maturity stage. If a deficit occurs then the percentage ratio of the water deficit (WD) and the total water requirement of the crop is calculated and subtracted from the index value obtained at the end of the preceding week. In this study, for groundnut crop, if a surplus of more than 100 mm occurred in any week during the pod filling and maturity stage as suggested by Frere and Popov (FAO, 1986), the index was reduced by 3 units for the particular week. Thus, the WRSI was calculated for successive weeks of crop growth period from sowing to harvest.

Sowing weeks in the different years were identified when rainfall exceeded the estimated water requirement of the crop in the same week for individual rainy season and a single fixed calendar week was not taken as the starting point. Weekly WRSI values were estimated for each growing season for the data period. The optimum value of WRSI below which the yield of groundnut would be less than the average was obtained by using a graphical method proposed by Azzi (1956).

Table 1. Computerized work sheet sample for crop water balance method (Frere and Popov, 1979)

Station : Junagadh

Crop : Groundnut

Year : 1985

Field Capacity : 100 mm

WK	RF	KC	RAD	WR	RF-WR	RS	S/D	WRSI
28	40	0.40	30.8	12	28	28	0	100
29	75	0.40	30.8	12	63	90	0	100
30	30	0.40	33.6	13	17	100	7	100
31	82	0.40	29.4	12	70	100	70	100
32	19	0.40	31.5	13	6	100	6	100
33	19	0.70	30.8	22	-3	97	0	100
34	15	0.70	32.0	23	-8	89	0	100
35	3	0.70	39.9	23	-25	64	0	100
36	5	0.70	35.0	25	-20	45	0	100
37	10	0.85	34.3	29	-19	26	0	100
38	17	0.85	35.7	30	-13	12	0	100
39	0	0.85	42.0	36	-36	0	-23	94
40	0	0.65	34.3	22	-22	0	-22	88
41	0	0.65	39.9	26	-26	0	-26	81
42	0	0.65	43.4	28	-28	9	-28	73
43	0	0.65	44.1	29	-29	0	-29	65
315			568.4	360				

WK = Week Number, RF = Rainfall, KC = Crop Coefficient,

RAD = Reference Evapotranspiration by Radiation method

WR = Water Requirement,

Rs = Soil moisture storage

RF-WR = Rainfall minus water requirement,

S/D = Storage for positive values, Deficit for negative values,

WRSI = Water Requirement Satisfaction Index.

RESULTS AND DISCUSSION

The mean weekly rainfall at Junagadh is more than 25 mm during the period for 25th to 38th week (18th June to 23rd September). The growing seasonal rainfall for groundnut, based on the actual commencement of the sowing (early, normal and late categories) along with yield and WRSI is shown in Table 2. Based on

the relationship between rainfall and estimated water requirement ($RF > WR$) the commencement of the growing season was identified and classified as early (23-24 weeks) normal (25-26 weeks) and late (27th week and beyond) to distinguish different rainfall patterns. The average rainfall for the 16 week growth period of groundnut during the years 1965-1989 is

842.4 mm with a coefficient of variability of 63 per cent.

The average productivity of groundnut (Table 2) for the period 1965-1989 was 993 kg/ha with a cv of 63%. However, the highest average yield (1156.4 kg/ha) was recorded when the growing season commenced during 25th to 26th weeks which is also locally considered normal for sowing operations. The early commencement of growing season has higher WRSI value (90.6%) with higher seasonal average rainfall (1113 mm), but the average yield is lower than those in the years with normal sowing period. The decrease of yield in the seasons with early commencement of the growing season is attributable to higher than seasonal average rainfall which is considered detrimental to groundnut crop due to water logging. During the years when the growing season commenced beyond 27th week onwards (in the late sown years) the average yield fell below 25 per cent of the normal productivity. Fig.1 indicates the optimum value of WRSI to obtain more than average productivity of groundnut (89 per cent). The WRSI was below optimum in 6 out of 8 years with late commencement of growing season whereas in the nine years when the commencement of

growing season was normal (25th and 26th weeks), only in two years it was below optimum. Higher average yields with optimum WRSI values and highest probability (60%) of getting above-average yields (and also with the lowest probability of getting below 75% average yields) corresponds to the years when the growing season commenced in the 25th and 26th standard weeks (Tables 3 and 4).

For the total growing season, the index was found to be less than optimum in 9 out of 25 years. It is significant to note that it fell below the optimum value during grain filling and maturity stage in 7 out of 9 years. Therefore, the risk of getting below average productivity increases with delay in the commencement of growing season as summarized in Table 3.

The relationship between the value of WRSI at the end of the growing season (X) and yield of groundnut (Y) was worked out (Fig.2) and found to be of the form :

$$Y = \frac{X}{(AX + B)}$$

Where $A = -0.002079$ and $B = 0.281$. The R^2 value was found to be 0.90 (significant at 1 per cent level) indicating that the correlation be-

Table 3. Effect of commencement of growing season on getting below optimum water requirement satisfaction index during different phenophases of groundnut

Commencement of growing season	No. of years of occurrence	No. of years with WRSI falling below optimum value during phases				
		P1	P2	P3	P4	Total
Early	8	-	1	0	0	1
Normal	9	-	-	1	1	2
Late	8	-	-	-	6	6
Total	25	-	1	1	7	9

P1 = Germination and flowering phases for 5 weeks; P2 = Pegging for 4 weeks;

P3 = Pod development for 3 weeks; P4 = Pod filling and maturity for 4 weeks

Table 2. Effect of rainfall pattern and commencement of growing season on productivity and WRSI during phenophases of groundnut

Commencement of sowing period	No. of years of occurrence	Rainfall during phenophases (mm)				Seasonal average rainfall (mm)	Mean yield (kg/ha)	WRSI (%)	Probability of getting pod yield	
		P ₁	P ₂	P ₃	P ₄				Above average	Below 75% of the average
Early (23th-24th week)	8	628.4	253.2	105.7	125.2	1113.0	1006.7	90.6	55.5	11.1
Normal (25th-26th week)	9	366.7	258.1	123.7	51.5	800.0	1156.4	89.0	60.0	10.0
Late (27th week onwards)	8	459.6	105.0	44.2	11.9	619.5	795.2	78.0	22.2	44.4
Mean/Total	25	480.2	207.5	92.5	62.4	942.4	993.0	86.0	-	-
CV%		78.0	99.1	114.2	130.6	130.6	63.0	42.6	22.6	

P₁ = Germination and flowering phases for 5 weeks; P₂ = Pegging for 4 weeksP₃ = Pod development for 3 weeks; P₄ = Pod filling and maturity for 4 weeks.

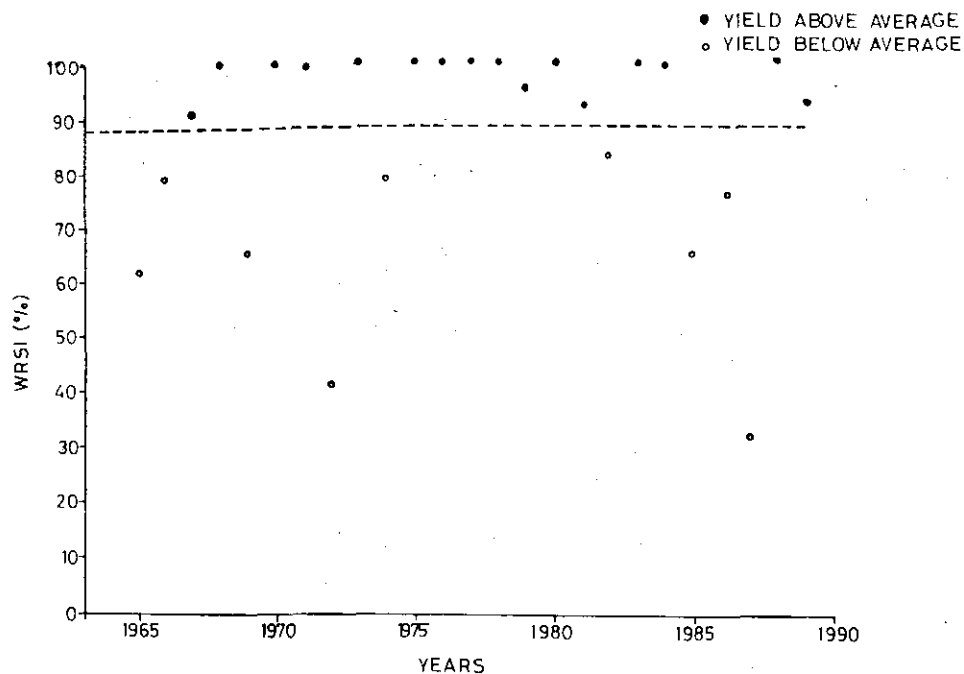


Fig. 1. Water Requirement Satisfaction Index and average yield during different years.

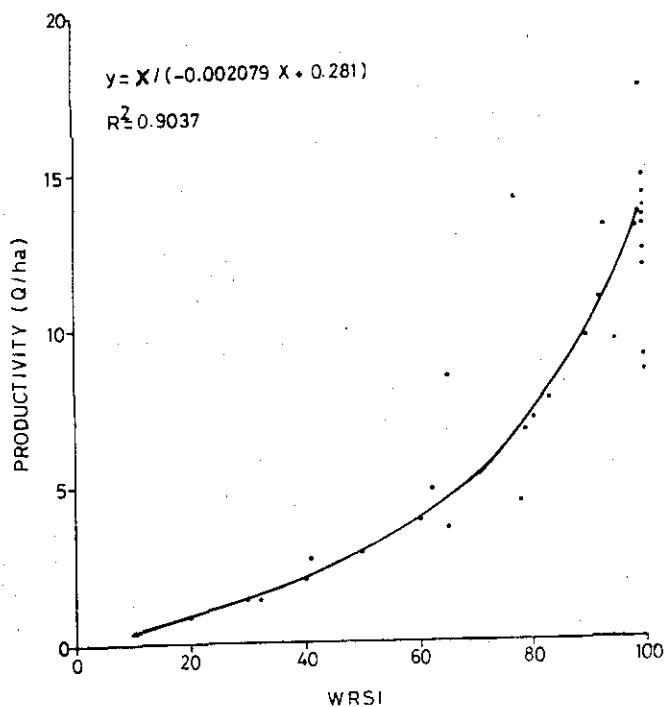


Fig. 2. Water Requirement Satisfaction Index and productivity.

Table 4. Observed, Estimated Groundnut yields (q/ha), Water requirement satisfaction index (WRSI) and Error values for different growing seasons

Category of sowing period	year	Sowing week	WRSI	Yield (q/ha)		
				Observed	Estimated	Error
Early (23-24th standard week)	1968	23	100	8.87	13.67	-4.80
	1973	23	100	12.20	13.67	-1.47
	1977	24	100	12.37	13.67	-1.30
	1980	23	100	12.36	13.67	-1.21
	1983	24	100	8.46	12.67	-5.21
	1984	24	100	11.82	13.67	-1.85
	1987	24	32	1.32	1.49	-0.17
	1989	23	93	13.14	10.61	+2.53
Normal (25-26th standard week)	1967	26	89	9.64	9.27	+0.37
	1970	26	100	13.19	13.67	-0.48
	1971	26	99	12.94	13.17	-0.23
	1972	26	41	2.64	2.09	+0.52
	1975	25	100	14.12	13.67	+0.44
	1976	25	100	13.43	13.67	-0.25
	1978	25	100	14.66	13.67	+0.98
	1979	25	95	9.41	11.38	-1.97
	1986	25	77	14.07	6.37	+7.70
	1988	27	100	17.63	13.67	+3.95
Late (27th standard week onwards)	1965	29	62	4.76	4.07	+0.68
	1966	29	79	6.56	6.76	-0.20
	1969	28	85	8.38	4.45	+3.92
	1974	28	78	4.37	6.56	-2.19
	1981	28	92	10.80	10.25	+0.55
	1982	27	83	7.57	7.65	-0.08
	1985	28	65	3.55	4.45	-0.90
	1988	27	100	17.63	13.67	+3.95

tween the observed and the expected yields using this relationship is as high as 0.95.

Table 4 shows the observed and estimated yields of groundnut together with WRSI and error values for the groups of years with early, normal and late commencement of rainy season. These results indicate reasonable agreement between observed and estimated groundnut yields. Hence from the above study

it is observed that the concept of WRSI can be used to assess the commencement of growing season and to quantify the predicted crop yield level successfully, as 90 per cent of the variation in the yield of groundnut could be explained even by adopting the district average yield data as used in the present study. The advantage of this method is that as the season progresses, at the end of every week, using real time data on rainfall, the calculated WRSI provides suffi-

cient indication of the yield level that one could expect in any season.

LITERATURE CITED

- Anonymous, 1984. Atlas of Agroclimatic zones of Gujarat. Gujarat Agricultural University, Anand Campus, Anand.
- Azzi, G. 1956. Agricultural Ecology. Constable Co, Ltd. London.
- Doorenbos, J. and Kassam, A.H. 1986. Yield response to water. FAO Irrigation and Drainage Paper No.33, Rome, Italy.
- Doorenbos, J. and Pruitt, W.O. 1979. Guidelines for predicting crop water requirements. FAO Irrigation and Drainage Paper No 24, Rome, Italy.
- Food and Agricultural Organization, 1986. Early agrometeorological crop yield assessment. FAO Plant Production and Protection Paper 73, Rome, Italy.
- Frere, M. and Popov, G.F. 1979. Agrometeorological crop monitoring and forecasting. FAO Plant Production and Protection Paper 17, Rome, Italy.
- Popov, G.F. 1984. Crop monitoring and forecasting. In Agrometeorology of sorghum and millet in the semi-arid tropics. Proc. the Int. Symp. 15-20 Nov. 1982, ICRISAT, India.
- Srivastava, N.N., Victor, U.S. and Ramana Rao, B.V. 1989. Commencement of growing season and productivity of groundnut in Rajkot district. *Mausam* 40(4): 399-402.
- Victor, U.S., Srivastava, N.N. and Ramana Rao, B.V. 1988. Quantification of crop yields under rainfed conditions using a simple soil water balance Model. *Theor. Appl. Climatol.* 39:73-80.

POPULATION DYNAMICS OF LINSEED BUDFLY *Dasyneura lini* BARNES (DIPTERA : CECIDOMYIIDAE) ON LINSEED (*Linum usitatissimum*)

NIKHIL SHRIVASTAVA, O.P. KATIYAR, S. SHRIVASTAVA and S.B. DAS
Department of Entomology, College of Agriculture J.N.K.V.V., Jabalpur - 482 004 (M.P.)

ABSTRACT

Population dynamics of linseed budfly on variety 'neelum' indicated that the climatic factors such as average temperature and morning relative humidity % had direct effect on maggot population.

Keywords : Population dynamics; Linseed; Budfly.

INTRODUCTION

Linseed is one of the important oilseed crops, cultivated in North and Central India, and Madhya Pradesh ranks first in area and production but is poor in yield potential (Anonymous, 1985). One of the reasons for low yields is due to the insect pest damage. The linseed budfly *Dasyneura lini* Barnes is the most injurious one out of all the pests. It appears regularly and causes moderate to severe damage to the extent of 80 per cent (Gupta, 1955; Anonymous, 1957) and yield losses to the extent of 150 kg/ha (Katiyar and Shrivastava, 1985).

Thorough study of factors responsible for population build-up of budfly is required for prediction of the occurrence of the pest. The present investigation on population dynamics was taken during the active season to know the peak period of *D. lini* and its correlation with weather parameters.

MATERIALS AND METHODS

To study the population dynamics of the pest, observations were recorded during Rabi

seasons of 1984-85 and 1985-86 on cultivar 'Neelum' sown in an area of 20 x 16 m² and the mean of 2 years is used for analysis. Daily observations were taken on 25 randomly plucked buds. Each bud was split open separately to count the number of maggots present in each bud. Observations were continued till the maggots were not available any more. Average weekly counts of maggots were calculated from 3rd standard week (15th to 21st January). Corresponding weekly record of meteorological parameters on population dynamics of budfly was studied by graphical superimposition technique. Further, path coefficient analysis was carried out using the method proposed by Dewey and Lu (1959) and Wright (1921).

Path coefficient is a standardized partial regression which measures the direct influence of one variable component on another variable and partitions the correlation coefficient into components of (a) direct and (b) indirect effects. The unexplained residual variation was calculated by the formula:

$$\text{Residual Factor (R)} = \sqrt{1 - \sum d_i^2 r_{ij}}$$

Where :

d_i = direct effect of i th character.

r_{ij} = Correlation coefficient of i th character with the j th dependent character.

RESULTS AND DISCUSSION

The first appearance of the pest was noticed on 14th January during 1985 and 20th January during 1986 which continued upto 22nd March, 1985 and 27th March, 1986 respectively. Its peak activity based on maggot population was observed during third to tenth standard week (i.e. 3rd week of January to 2nd week of March). During this period the minimum, average and maximum temperatures ranged from 11.1 to 16.3° C, 18.4 to 23.8° C and 25.2 to 31.2° C respectively (Figure 1). Morning, average and evening relative humidity recorded ranged from 86 to 93 per cent; 62.5 to 78.0 per cent and 38.0 to 65.0 per cent respectively with a rainfall ranging from 0 to 87.4 mm. Hence combination of minimum and average temperatures (11 and 23° C respectively) with morning, evening and average relative humidity (86, 62 and 41 per cent respectively) and rainfall (18 mm) which coincided with the proper stage of bud formation of the crop appeared to be congenial for budfly infestation. Rainfall seemed to play a little role in favouring the pest.

The present findings are in accordance with that of Sood *et al.* (1981). He also reported that higher level of infestation is preceded by maximum and minimum temperatures of about 23° C and 14° C respectively.

The estimates of simple correlations revealed significantly positive correlation of maggot population with evening RH (0.7694), average RH (0.7490), minimum temperature

(0.7058) and maximum temperature (0.6856). Where as rainfall exhibited non-significant positive relationship with maggot population.

Maggot population is influenced both by biotic and abiotic factors. The various abiotic components studied influences the maggot population and estimates of simple association among its components do not provide real picture because these components are inter-related. The path coefficient analysis is a more realistic approach.

The estimates of path effects given in Figure 2 showed that the direct effect of maximum temperature on its correlation with maggot population was very high and negative (-13.532). However, it had maximum positive but indirect effect on maggot population via average temperature (6.853) which was followed by morning RH (5.345), minimum temperature (3.580), average RH (2.068) and rainfall (0.00501). Its contribution through evening RH was negative (-3.639). Minimum temperature had a positive direct effect on its correlation with maggot population (3.659). Indirect effect of this trait via maximum temperature and evening RH was negative. The direct effect of average temperature on maggot population was highest and positive (6.868). Its indirect effects via minimum temperature, morning RH, average RH and rainfall were positive but via maximum temperature and evening RH it was negative.

Morning RH also had positive and direct contribution to maggot population (5.562). Its indirect effect via maximum temperature and evening RH were negative. Evening RH had negative, direct contribution (-4.065) to maggot population. Its indirect effects via all the parameters studied except maximum temperature were positive. The direct

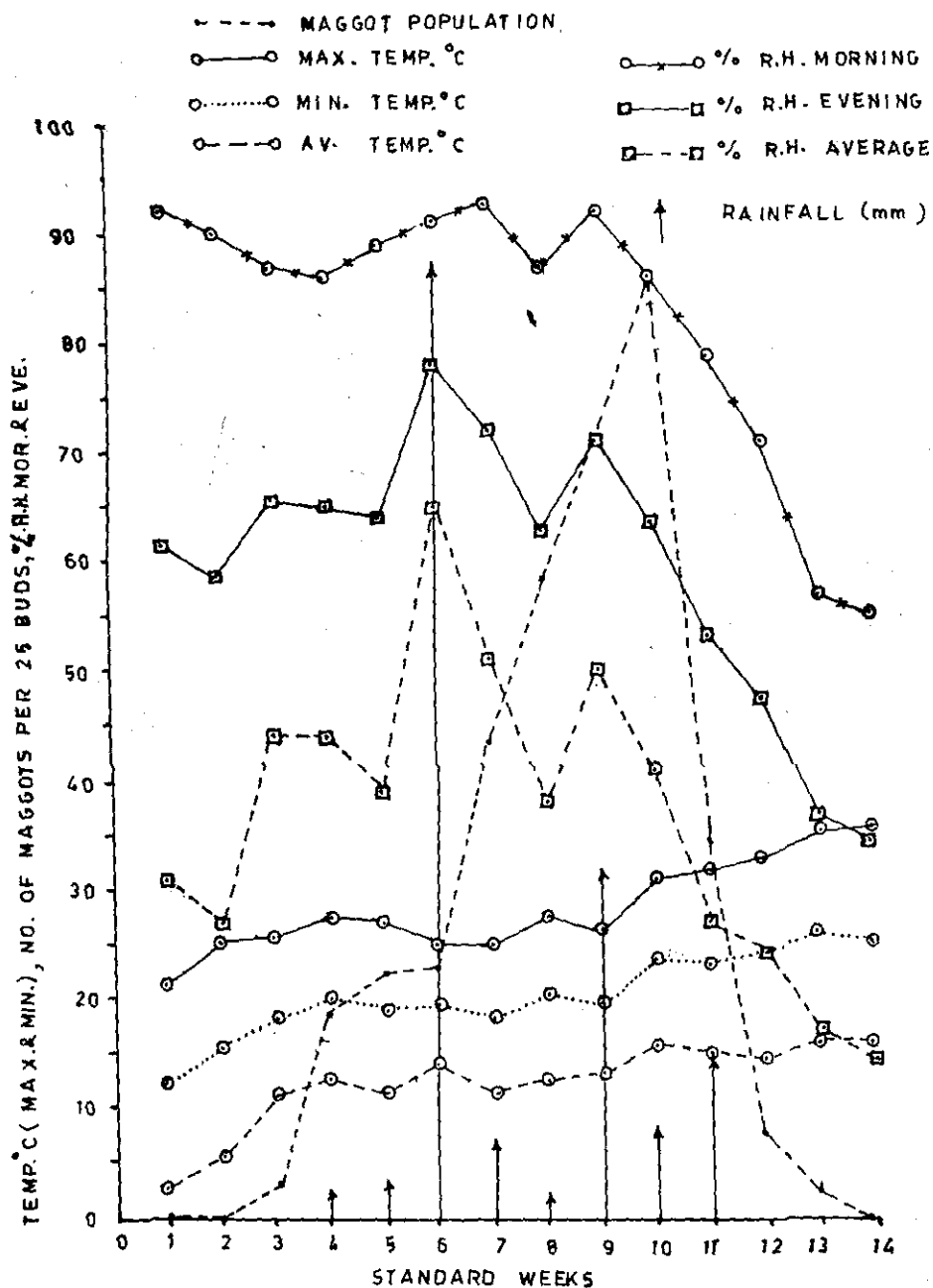


Fig. 1. Effect of weather parameters on the Population Dynamics of Linseed Budfly *Dasyneura lini* Barnes on Linseed cv. Neelum.

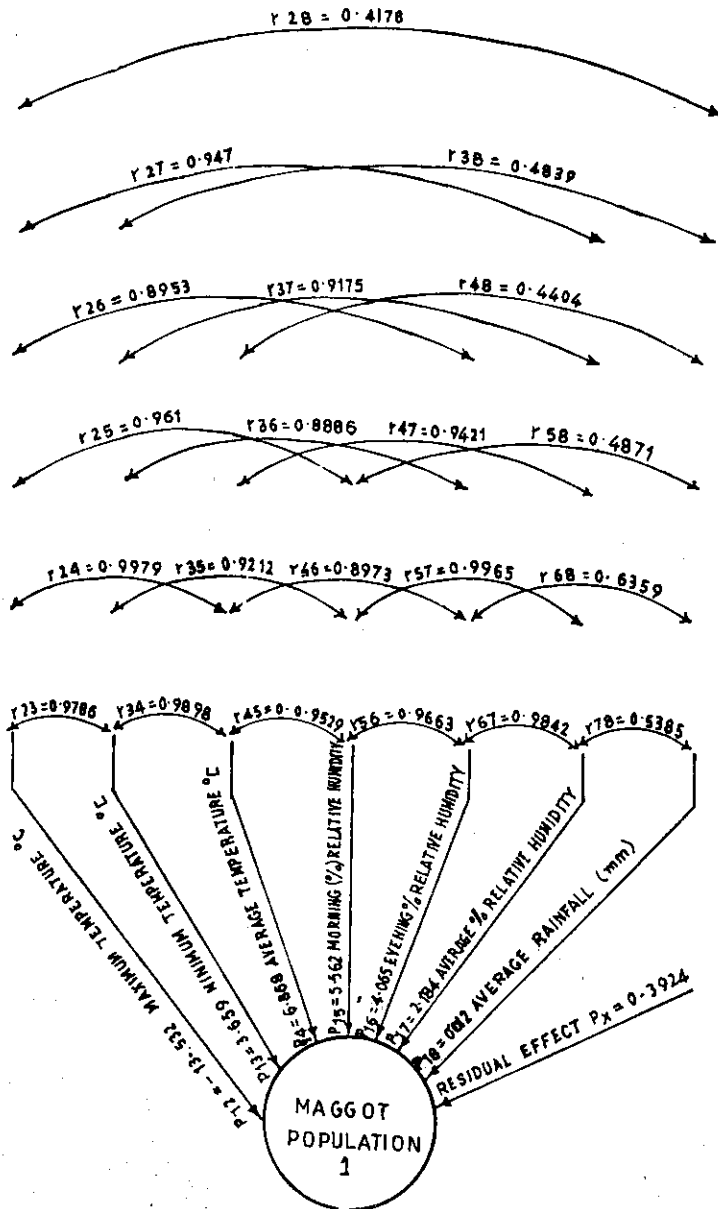


Fig. 2. Path coefficient diagram showing influence of various abiotic factors on Maggot population of Budfly in Linseed cv. Neelum.

effects of average RH and rainfall to their correlations with maggot population were positive (2.184 and 0.012 respectively). The indirect effects of average RH via all the parameters studied except maximum temperature and evening RH was positive. Similar magnitudes of direct and indirect effects of rainfall via parameters studied were also noted.

The residual effect for the path was of very low magnitude (0.3924) suggesting that the parameters studied are sufficient to express the relationship with maggot population.

LITERATURE CITED

- Anonymous 1957. Review of the results of research from schemes financed by Indian Central Oilseeds Committee. *Indian Oilseeds J.* 1 : 163 - 180.
- Anonymous 1985. Area and production of principal crops in India. Government of India, Ministry of Agriculture, New Delhi.
- Dewey, D.R. and Lu, K.H. 1959. A correlation and their coefficient analysis of components of crested wheat gross seed production. *Agronomy J.* 57 : 515-518.
- Gupta, R.L. 1955. Linseed gall fly *Dasyneura lini* Barnes and its control. *Proc. of Ind. sci. Congress Assoc.* 42 (3) : 294 and 381 (Abstracts, part III, 1955).
- Katiyar, O.P. and Shrivastava, N. 1985. "Studies on the mechanism of resistance of linseed to budfly, *Dasyneura lini* Barnes". Annual Progress Report, No. 3, pp. 1 - 49, Deptt. of plant Breeding and Genetics, J.N.K.V.V., Jabalpur.
- Sood, N.K., Pathak, S.C. and Pathak, Er. 1981. Relationship of temperature parameters to the extent of infestation by linseed budfly *Dasyneura lini* Barnes. *India J. Pl. Prot.* 9 (2) : 137 - 140.
- Wright, S. 1921. Correlation and causation. *J. Agric. Res.* 20: 557 -587.

SUITABILITY OF CROP-WEATHER RELATIONS FOR SUNFLOWER PRODUCTION DURING *Kharif* SEASON AT RAICHUR

P.S. KAVI, Y.B. PALLED, B.K. DESAI and K. MANJAPPA
College of Agriculture, R.R.S. Raichur, Karnataka, India.

ABSTRACT

Based on the recent thirty-years standard week-wise climatic data pertaining to *kharif* season at Raichur, the suitability of different sowing weeks for maximum sunflower production has been studied. The period from 28th to 30th standard weeks is the most suitable, as this period coincides favourably with different stages of crop-growth from sowing to seed setting and harvesting.

Keywords: Standard-week; Climatic data; Sunflower; Crop production.

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is one of the important oilseed crops, occupying increasingly larger areas under dryland agriculture in Raichur region in recent years. Being a photinsensitive and temperature responsive crop, it is generally sown, in this region from early June to late October, using different varieties. Some attempts were made to study the regional weather data relating to performance of crops and cropping systems by several workers (Kavi *et al.*, 1990; Buddar and Gopalaswamy, 1988). Robinson (1973) observed that critical period of moisture requirement for better seed yield starts about 20 days before flowering and continues up to 20 days after flowering stage. In this study, an attempt has been made to analyse different standard week-wise weather parameters of Raichur region so as to find out a suitable time of sowing to maximise sunflower production.

MATERIAL AND METHODS

The climatic data recorded at the agrometeorological observatory of Regional Research Station, Raichur during the recent thirty years period (1960-91) has been used in the present study. Standard week-wise mean values of various parameters like amount of rainfall, number of rainy days, maximum temperature, minimum temperature, duration of bright sun-shine hours and the amount of cloudiness have been determined using daily recorded data. Different phenological phases like the establishment (1-15 days), vegetative stage (16-40 days), budding stage (41-70 days), flowering (71-85 days), seed development and setting (86-105 days) stages have been worked out based on sowing times for different standard weeks. Then considering the above mentioned normal climatic parameters during each of these standard weeks of *kharif* season (25th to 39th standard weeks), their suitability has been assessed.

RESULTS AND DISCUSSION

The data based on recent thirty years as normal climatic parameters during different standard weeks are provided in Table 1. The prevailing normal rainfall (mm) and the number of rainy days as influenced by different weeks of prospective sowing at various crop growth stages is presented in Table 2. It is clear from Table 1 that a total rainfall of 584.7 mm is received from June to December (25th to 52nd standard weeks) with 36.6 rainy days. September (more precisely 39th standard week) is the peak rainfall month, as it belongs to monomodal type rainfall, followed by smaller peaks during July and August. The amount of rainfall decreases from second fortnight of October to December (42nd to 52nd weeks). The maximum temperature varied from 29.1 to 36.1°C and the minimum from 15.1 to 23.9°C between June to December. The cloud amount ranged from 5.1 to 6.3 *oktas* during June to September, and thereafter it decreased.

If sunflower is sown during 25th standard week (June third week), the crop in general faces moisture deficit during its establishment stage. The average rainfall during this period being only 67.0 mm, which is not sufficient to wet the soil profile. This also coincides with high value of maximum temperature of 35.7°C

During 26th week, the normal rainfall receivable is 72.5 mm, whereas the cumulative rainfall is 139.5 mm. The quantity of rainfall received is quite adequate for better establishment of the crop, which is further blessed with reduced maximum temperature of 33.9°C. It is clear from the data of this week that the critical stages of crop-growth usually experience moisture stress and therefore sowings during this standard week are not appropriate.

If the crop is sown during 27th standard week, on an average it gets 85.7 mm of rainfall in 5.6 rainy days with cumulative rainfall amounting to 224.9 mm. This is sufficient for the successful establishment of the crop and to obtain a good crop-stand. But considering the successive stages like vegetative, budding, flowering etc., the meteorological conditions like rainfall, number of rainy days, the cloud amount, the maximum and minimum temperatures, sunshine hours etc., are not so favourable.

The crop sown from 25th to 27th standard weeks is likely to be affected by the high amount of cloudiness during its flowering and seed setting stages thereby resulting in reduced yields as reported by Puech *et al.* (1975).

When the crop is sown between 28th to 30th standard weeks, it receives fairly good amount of rainfall during almost of all its crop growth stages, particularly so from flower initiation to seed development stage. The critical period of adequate moisture requirement for better sunflower yield has been reported to be the period from 20 days before and an equal number of days after the flowering (Robellion, 1967 and Robinson, 1973).

For all the crop-growth stages within the above mentioned weeks of sowings, the maximum temperature remains around 32.0°C and the minimum temperature varies between 20.6 to 22.7°C. The duration of sunshine hours ranges from 6 to 8 hours per day in different crop growth stages, which is quite adequate. If the normal rainfall occurs as expected, there will be no moisture stress for the crop during the critical period as mentioned above.

If the sowings are delayed beyond 30th standard week, the crop suffers from severe

Table 1. Prevailing normal weather parameters at Regional Research Station, Raichur

Months	June				July				August				September			
	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	
Standard weeks	21.6	20.1	25.3	27.1	33.3	31.3	37.9	29.2	28.3	28.5	29.4	26.1	41.0	36.4	46.3	
Rainfall (mm)	1.8	1.6	1.7	1.7	2.2	2.0	2.2	2.1	1.8	1.9	1.8	1.4	2.0	2.1	2.1	
No. of rainy days	34.1	35.7	33.4	32.6	32.6	31.8	32.2	31.9	33.0	32.6	31.7	31.8	32.2	31.9	32.4	
Maximum temperature (C)																
Minimum temperature (C)	23.8	23.9	22.8	23.7	21.9	22.6	22.7	23.5	21.9	22.8	22.6	23.0	22.3	21.4	21.8	
Duration of sunshine (hrs.)	6.8	6.8	5.8	5.2	6.3	4.5	5.1	5.7	6.2	5.3	5.9	6.4	5.8	6.1	5.9	
Cloudiness (Okta)	5.7	5.8	5.8	5.7	6.3	6.1	5.2	6.0	5.8	6.2	5.9	5.1	5.4	5.9	6.0	

Table 1 Continued...

Months	October				November				December				
	40	41	42	43	44	45	46	47	48	49	50	51	52
Standard weeks	44.6	17.8	12.9	14.5	13.1	5.3	4.4	1.2	2.4	3.4	2.8	0.0	0.5
Rainfall (mm)	1.8	1.1	1.8	1.4	1.6	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0
No. of rainy days	32.1	31.8	31.3	32.1	32.2	30.3	30.2	30.1	29.8	29.6	29.3	29.1	29.1
Maximum temperature (C)													
Minimum temperature (C)	20.8	20.6	21.0	20.4	20.3	19.5	18.0	18.3	18.1	16.3	15.2	15.3	15.1
Duration of sunshine (hrs.)	6.1	5.8	7.1	6.6	7.3	8.1	8.3	7.9	8.6	8.7	8.3	7.9	8.4
Cloudiness (Okta)	3.8	3.6	4.3	4.6	4.2	3.1	3.2	2.8	2.6	2.1	1.6	1.8	1.3

Table 2. Prevailing normal rainfall and the number of rainy days as influenced by different weeks of sowing at various crop growth stages

Sowing time	Establishment stage		Vegetative stage		Budding stage		Flowering stage		Seed Development Stage	
	Rainfall (mm)	Rainy days	Rainfall (mm)	Rainy days	Rainfall (mm)	Rainy days	Rainfall (mm)	Rainy days	Rainfall (mm)	Rainy days
25th week	67.0	5.1	91.7	5.9	123.9	8.0	53.5	3.2	123.7	6.2
26th week	72.5	5.0	102.5	6.4	115.4	7.6	67.1	3.4	127.3	6.0
27th week	85.7	5.6	98.4	6.3	112.3	6.9	77.4	4.1	108.7	5.0
28th week	91.7	5.9	95.4	6.1	125.0	7.1	82.7	4.2	75.3	4.2
29th week	102.5	6.4	86.0	5.8	132.9	7.3	90.9	3.9	45.2	3.8
30th week	98.4	6.3	86.2	5.5	149.8	7.6	62.4	2.9	40.5	4.3
31st week	95.4	6.1	84.0	5.1	168.3	8.0	30.7	2.4	32.9	3.5
32nd week	86.0	5.8	96.5	5.2	145.1	7.1	27.4	2.7	22.8	2.6
33rd week	86.2	5.5	103.5	5.5	121.6	6.3	27.6	3.0	10.9	1.0
34th week	84.0	5.1	123.7	6.2	89.8	5.6	18.4	2.1	8.0	0.5
35th week	96.5	5.2	127.3	6.0	58.3	5.4	9.3	1.0	7.0	0.0

moisture stress, particularly during flowering and seed development stages if it is to depend only on rainfall. Since the rainfall declines very sharply from 41st standard week, the subsequent plant growth stages starting from budding itself, then flowering, seed development etc., all of them will be adversely affected resulting in the decreased yield.

It is therefore clear from the above that the normal prevailing climatic conditions of Raichur region during 28th to 30th standard weeks are very much conducive for sowing of sunflower crop for maximum production.

LITERATURE CITED

- Budhar, M.N. and Gopalaswamy, N., 1988. Rainfall, climatology and cropping systems for Nellur taluk of Salem district. *Madras J. Agric.* 75 : 418 - 422.
- Kavi, P.S., Prabhakar, A.S. and Ratnam, B.P. 1990. A study of rainfall characteristics of Dharwad, in relation to cropping programme. *Karnataka J. Agric. Sci.* 3 (3&4) : 153 -160.
- Puech, J., Lencrerot, P. and Decan, J. 1975. Effect of a reduction in light intensity on the overall p.s. of a crop of sunflower. Effect on the oil and protein production in the seed. *C.r. Acad. Sci. Ser. D* 281 : 387 - 390.
- Robellion, M. 1967. Effects and after effects of drought on growth and yield of sunflower. In: *Ann. Agron.* 18 (5): 579-99.
- Robinson, R.G. 1973. Production and culture. In: *Sunflower Science and technology*. Carter, J.F. (ed.) Agronomy 19, *American Society of Agronomy* pp.89-143.

STABILITY FOR YIELD AND YIELD ATTRIBUTING CHARACTERS IN SESAME UNDER RAINFED CONDITIONS

A.K. VERMA and JAY LAL MAHTO

Department of Plant Breeding and Genetics, Birsa Agricultural University,
Ranchi 834 006, Bihar

ABSTRACT

Sixteen genotypes of sesame (*Sesamum indicum*) were studied for stability parameters with respect to yield and yield attributes. Genotype x environment interaction was significant for all the characters. TC 326 was the most stable genotype among the five stable genotypes viz; TC 326, TC 25, CMT 11-6-5, RT 57 and OMT 34 for all the characters except number of branches/plant. On the basis of environment indices, environment I (monsoon 1989) was the most favourable for expression of all characters. No correlation among the three stability parameters was observed for any character. It is proposed to consider all the three parameters while breeding for stable varieties of sesame.

Keywords : Genotype x environment interaction; Environment index; Stability.

INTRODUCTION

Sesame is the major oilseed crop of Chotanagpur and Santhal Paragnas in Bihar. There has been large fluctuations in yield of this crop within the state. One of the reasons seems to be the sensitive behaviour of varieties to different growing seasons/ conditions. Breeding varieties for different regions of predictable environmental conditions or identifying stable varieties over environments are the solutions to exploit the G x E interaction. The information on stability of the crop varieties is very important for breeding and cultivation point of view. The differential response, if any, of some of the promising lines to environmental changes with respect to yield and maturity were evaluated in the present study. The rainfall was wide spread and intermittent during the crop growth period of sesame in monsoon 1989, which favoured the crop growth of sesame.

MATERIALS AND METHODS

The experimental material comprised 16 genotypes of sesame sown in a Randomised Complete Block Design at experimental area of Birsa Agricultural University, Ranchi. Six rows of 4 m length of each treatment were sown during four subsequent monsoon seasons (1989 to 1992) under rainfed condition, at 30 x 10 cm spacing. All the recommended agronomical practices were followed. Observations on yield and yield components (Table 1) were recorded on five randomly selected competitive plants. Statistical analysis was done as per Eberhart and Russell (1966).

RESULTS AND DISCUSSION

The mean squares due to genotypes and environments were significant when tested against pooled error and pooled deviation for all the traits, indicating genotypic as well as

seasonal variation for all the characters. The mean squares due to $G \times E$ interaction were highly significant for all the characters when tested against pooled error, but when tested against pooled deviation, mean squares were significant only in the case of days to maturity. Kumar (1988) observed significant $G \times E$ interaction for plant height, days to maturity, number of pods on main shoot and seed yield / plant, and Rathnaswami and Jagathesan (1982) and Moheim Bohn Faith and Mohmoud (1987) also reported similar results. Henery and Daulay (1987) reported similar results for seed yield. It may, therefore, be inferred that the genotypes interacted considerably with environment in the expression of all the characters. However, the magnitude of interaction was higher in the case of maturity than in yield. Highly significant mean squares due to environment (Linear) for all characters except number of branches/plant, were noted indicating considerable differences among environments and their predominant effects on all characters except number of branches per plant. Henery and Daulay (1987) reported that linear and non-linear components were significant for seed yield. The linear component of $G \times E$ interaction was significant for all traits except number of branches per plant, when tested against pooled error but was non-significant when tested against pooled deviation. Pooled deviation was significant for yield, thus $G \times E$ interaction was significant for all traits except number of branches per plant, when tested against pooled error but was non-significant when tested against pooled deviation. Pooled deviation was significant for yield, thus $G \times E$ interactions were linear for plant height, number of capsules per plant, days to maturity and seed yield, but the genotypes differed significantly with respect to their stability for yield.

In case of seed yield, both b_i and $\bar{S}^2 d_i$ were significant in most of the genotypes, suggesting that both linear and non-linear regression accounted for $G \times E$ interactions in all genotypes (Table 1). The linear regression accounted for interactions in RT 55 and OMT 10. The b_i values and $\bar{S}^2 d_i$ were significant in genotypes Kanke white, OMT 11-6-3, RT 167, TC 407, TNAU 28, BT 9-4-1 and Krishna, suggesting that both linear as well as non-linear components were responsible for $G \times E$ interaction and linear regression accounted for the remaining genotypes. Among the 16 genotypes, RT 57, TC 326 and OMT 11-6-5 were the strains with above-average performance, average response and average stability for yield, while all other genotypes were highly unstable. The genotypes TC 25 and OMT 26 showed their suitability for favourable environment. The most stable genotype was OMT 11-6-5 ($\bar{S}^2 d_i = 98.87$).

For plant height, the b_i values were significant in genotypes OMT 11-6-3, RT 167, OMT 10, OMT 11-6-5 and BT 9-4-1 showing their suitability under favourable environment. Kanke white, TC 25, OMT 34, OMT 26, TC 326, TNAU 28 and Krishna were stable genotypes with average performance. The remaining genotypes were unstable with average performance and average response. The most stable variety is Krishna ($\bar{S}^2 d_i = 5.19$) with respect to plant height.

The b_i values were significant in all genotypes for the number of branches per plant, except OMT 26, RT 167, TC 407 and BT 9-4-1, expressing their ability to do well in favourable environments. The genotypes, TC 25, OMT 11 and Krishna were stable genotypes with average performance and also responding

Table 1. Estimates of stability parameters of individual genotypes and correlations between them for yield and yield attributing traits

Varieties	Plant height			Number of branches per plant			Number of capsules per plant			Days to maturity			Seed yield		
	Mean	b _i	$\bar{S}^2 d_i$	Mean	b _i	$\bar{S}^2 d_i$	Mean	b _i	$\bar{S}^2 d_i$	Mean	b _i	$\bar{S}^2 d_i$	Mean	b _i	$\bar{S}^2 d_i$
Kanke white	107.48	0.93	-34.75	2.09	0.39*	-0.15	24.56	0.41*	-10.50	76.92	1.25	-0.15	275.52	1.66*	3362.26**
OMT 11-6-3	93.34	0.63*	37.88	2.47	1.63*	-0.07	25.67	1.49*	8.69	75.25	0.94	0.07	174.51	1.34*	2782.00**
TC 25	94.12	1.07*	39.11	2.28	0.80	0.02	26.96	1.08	53.20	75.25	0.90	2.11	167.34	1.41*	212.35
OMT 34	98.52	1.11	149.77	2.42	1.41*	-0.05	23.24	1.10	-12.62	75.83	0.84	6.08	158.06	1.32*	432.65
OMT 26	91.36	1.19	-2.73	2.69	0.99	-0.46	26.64	1.61	-7.80	75.91	0.70	2.19	163.46	1.34**	208.12
RT 57	89.93	1.06	-18.64	2.25	0.57*	-0.16	25.78	0.89	-13.10	75.17	0.71	6.04	135.00	1.14	141.06
RT 167	91.00	1.45*	-0.65	2.11	0.78	-0.02	25.39	1.31	7.46	77.00	1.18	-0.32	117.41	1.18*	1450.23**
RC 326	95.83	0.97	-12.41	2.33	0.53*	-0.09	21.72	1.14	-11.91	75.50	1.02	1.25	168.05	0.96	-14.06
RT 55	90.31	0.49	-35.37	2.09	0.58*	-0.09	24.00	1.21	-15.71	73.67	0.72*	3.54	115.57	1.01	990.82**
OMT 10	97.59	1.48*	-18.43	2.65	1.41*	0.15	28.28	1.76*	-7.85	77.58	1.03	3.55	111.57	0.87	471.14**
OMT 11-6-5	94.11	0.58*	118.09	2.53	1.74*	-0.14	27.99	1.04	-11.80	75.75	0.79	-0.46	186.26	0.93	98.87
TC 407	91.08	1.11	-32.66	2.07	0.96	0.03	24.06	1.65*	3.62	75.00	0.82	4.76	146.57	0.77*	2458.03**
OMT 11	90.36	0.76	5.83	2.40	1.10	-0.04	24.94	0.63*	12.53	76.49	0.65*	0.19	101.86	0.66*	272.35
TNAU 28	97.76	0.88	-17.41	3.12	1.56*	-0.01	22.44	0.24*	-9.46	78.58	1.79*	30.08	129.56	0.52*	4569.50**
BT 9-4-1	102.37	1.26*	28.76	1.94	0.78	-0.12	18.50	0.59*	-11.29	77.67	0.93	0.22	106.28	0.45*	437.28*
Krishna	102.06	1.02	5.19	2.38	0.76	-0.17	27.42	-0.16*	40.27	75.25	1.72*	20.59	74.34	0.36*	410.39*
Mean	95.45			2.37			24.86			76.05			141.69		
SEM \pm	3.93	0.22		0.22	0.36		2.37	0.31		1.35	0.33		21.18	0.17	
$r(\bar{X}, b_i)$	0.167			0.169			0.166			0.086			0.193		
$r(\bar{X}, \bar{S}^2 d_i)$	0.058			0.186			0.076			0.196			0.196		
$r(b_i, \bar{S}^2 d_i)$	0.260			0.112			0.179			0.189			0.088		

*, ** Significant at 5 per cent and 1 per cent probability levels respectively.

in respect of number of branches per plant. The most stable genotype is TC 25 ($\bar{S}^2 d_i = 0.02$).

With respect to days to maturity, the b_i values were significant in genotypes OMT 11, TNAU 28 and Krishna, indicating their suitability for favourable environments. Most of the genotypes were stable with average performance and also responding in respect to maturity. The most stable genotype is OMT 11-6-3 ($\bar{S}^2 d_i = 0.07$).

In case of number of capsules per plant, the b_i values were significant for genotypes Kanke white, OMT 11-6-3, OMT 26, OMT 10, TC 407, OMT 11, TNAU 28, BT 9-4-1 and Krishna, showing their ability to do well in favourable environments. The genotypes, TC 25, OMT 34, RT 57, RT 167, RT 55, and OMT 11-6-5 were stable with average performance and also responding to number of capsules per plant. The most stable genotype is RT 167 ($\bar{S}^2 d_i = 7.46$).

Correlation coefficients among the stability parameters, \bar{X} , b_i and $\bar{S}^2 d_i$ indicated that there was no significant association among these parameters (Table 1). It was, therefore, suggested that all the three stability parameters should be taken into account, while breeding for stable varieties of sesame. The use of mean values, as advocated in some crops, for judging the stability of varieties may not be useful in sesame.

TC 25, OMT 11-6-5 and OMT 34 were stable for seed yield, plant height, primary branches per plant, days to maturity and number of capsules per plant. TC 326 was stable for all characters except number of capsules per plant whereas RT 57 was stable for seed yield, number of branches per plant, days to maturity and number of capsules per plant. Labana *et al.*

(1980) in Indian mustard, Singh and Gupta (1984) and Kundu and Khurana (1991) in *toria* and Osman (1994) in sesame also identified stable genotypes for seed yield and days to maturity. Verma *et al.*, (1994) also reported stable genotypes of *toria* for number of secondary branches per plant, number of siliquae per plant, number of seeds per siliqua, days to maturity and seed yield.

LITERATURE CITED

- Eberhart, S.A. and Russell, W.A. 1966. Stability parameters for comparing varieties. *Crop Sci.* 6: 36-40.
- Henery, A. and Daulay, H.S. 1987. Genotypic - environment interactions for seed yield in sesamum. *Indian J. agric. Sci.* 57 (9): 622 - 624.
- Kumar, D. 1988. Phenotypic stability for quantitative traits of sesame under rainfed condition of arid environment. *J. Oilseeds Res.* 5(1): 8-12.
- Kundu, S. and Khurana, S.R. 1988. Stability for seed yield and its components in *toria*. *Indian J. Genet.* 48(3): 389-391.
- Labana, K.S., Badwal, S.S. and Chaurasia, B.D. 1980. Varietal performance and genotype x environment interaction in mustard. *Indian J. Genet.* 40: 57-63.
- Moheim Bohm Faith, A. and Mohmoud, A.M. 1983. Genotypic stability analysis of yield in sesamum (*S. orientale* L.) in the central rainland of Sudan. *More Food From Better Technology*, Holmes, J.C. and Tahir, W.M. (Eds). Food and Agricultural Organisation of the United Nations, Rome, 1983. pp. 841 - 847.
- Rathnaswamy, R. and Jagathesan, D. 1982. Association between stability parameters 'b' of different characters with seed yield in *S. indicum* L. *Madras Agric. J.* 69(9): 612 - 613.
- Singh, D. and Gupta, P.K. 1984. Genetic divergence among 31 genotypes of *toria* (*Brassica campestris* L.) grown in 12 environments. *Theoretical and Appl. Genet.* 69 (2): 129 - 131.
- Verma A.K, Mahto, J.L. and Sinha, P.K. 1994. Stability for seed yield and yield attributes in *toria* (*Brassica rapa* var *napus*) under rainfed condition. *Indian J. agric. Sci.* 64 (1): 59 6-61.

GERMINATION OF SAFFLOWER (*Carthamus tinctorius* L.) SEEDS AS INFLUENCED BY SOIL MOISTURE AND DEPTH OF SOWING

P.G. PATEL and Z.G. PATEL

Department of Agronomy, N.M. College of Agriculture, Gujarat Agricultural University,
NAVSARI - 396 450

ABSTRACT

Field experiment conducted at the N.M. College of Agriculture Farm, Navsari during the *rabi* season of 1992-93 and 1993-94 revealed that safflower seeds sown at 100% ASM (field capacity) with 2.5 to 5.0 cm depth gave higher percentage of germination and field emergence. Decreasing soil moisture below 100% ASM significantly decreased the germination percentage. Germination of seed sown at 40% ASM drastically reduced (13.71%) in clayey soils of south Gujarat.

Keywords : Safflower; Germination percentage; Available soil moisture; Depth of sowing.

INTRODUCTION

Safflower (*Carthamus tinctorius* L.) is a winter annual oilseed crop recently introduced in south Gujarat. The crop suffers in germination because of its hard seed coat. Low yields are reported mainly due to poor germination resulting in inadequate plant population. Soil moisture and depth of seeding are the important factors governing the germination and plant stand for realizing maximum yield potential. Keeping this in view the present experiment was planned to find out appropriate soil moisture content at sowing and suitable seeding depth for optimum germination of safflower seed.

MATERIALS AND METHODS

A micro-plot field investigation on safflower variety 'Bhima' was conducted during the *rabi* seasons of 1992-93 and 1993-94 at the N.M. College of Agriculture Farm, Navsari. The experiment was laid out in a Split Plot Design keeping

four soil moisture regimes 40, 60, 80, and 100 % available soil moisture (ASM) as main plots and three depths of sowing (2.5, 5.0, and 7.5 cm) as sub-plots with four replications. The soil of the experimental plot was clayey in texture having 0.70% organic carbon, 23.17 kg P₂O₅ / ha and 341 kg K₂O/ha with 7.8 pH. The field capacity, permanent wilting point and bulk density of the soil were 32.20%, 18.70% and 1.40 g/cc, respectively. Soil samples were drawn from 0-15 cm depth for soil moisture studies at an interval of 24 hours so that particular moisture regimes could be maintained. Two hundred seeds were sown in each plot (2.5 m x 1.0 m). Emergence counts were recorded after eight days and repeated every day till complete germination and emergence obtained for two consecutive days. The days to emergence and germination rate were calculated by dividing the number of seedlings emerged at each counting by the number of days the seeds remained in soil as suggested by Dahiya *et al.* (1985).

RESULTS AND DISCUSSION

The data on emergence per cent of safflower as influenced by different levels of ASM are presented in Table 1. The emergence per cent was significantly influenced by ASM during both the years and in pooled results. Data further indicated that during 1992-93 100% ASM at the time of sowing gave significantly higher emergence per cent 73.83, 87.00 and 91.25 at 8, 11 and 14 days after sowing, respectively. However, during 1993-94 and in pooled analysis, 100 and 80% ASM remained at par but found significantly superior to 60 and 40% ASM at 11 and 14 days after sowing. Mishra *et al.* (1992) also obtained better emergence of safflower under field capacity conditions. In pooled analysis, it was further observed that with decrease in ASM, the seedling emergence decreased significantly on 8th (72.17 to 3.42 %), 11th (85.88 to 8.58%) and 14th day (91.29 to 13.71 %) after sowing, as the ASM decreased from 100 to 40 per cent. Significantly lowest emergence per cent was recorded with 40 % ASM during both the years as well as in pooled data. The rate of soil water movement would be too slow at low level of soil moisture to supply adequate moisture to the seeds to initiate seed germination as reported by Rao and Gupta (1976). A progressive decrease in seedling emergence with decreasing soil water potential for wheat, gram and safflower was also reported by Singh *et al.* (1985).

The emergence rate was significantly influenced by ASM during both the years and in pooled results. Data presented in Table 2 indicated that during both the years as well as in pooled analysis, 100% ASM at the time of sowing recorded significantly highest emer-

gence rate while the lowest rate was recorded with 40% ASM.

Effect of Depth of Sowing

The results presented in Tables 1 and 2 indicated that emergence per cent and emergence rate of safflower seeds differed significantly due to different depth of sowing during both the years and also in pooled analysis. During the first year, emergence per cent (61.75%) and emergence rate (4.41 %) was maximum at 5.0 cm depth of sowing but it remained at par with 2.5 cm depth. In the second year and in pooled results, significantly highest emergence per cent (65.25 and 63.50%) and emergence rate (4.55 and 4.48) was recorded at 5.0 cm depth of sowing, respectively. The results was in accordance with the findings of Mahapatra *et al.* (1975). Minimum values for these parameters were recorded with 7.5 cm depth of sowing during both the years as well as in pooled results, probably due to poor aeration at deeper layer.

Interaction effect of ASM x Depth of sowing

Interaction between ASM and depth of sowing presented in Table 3 indicated that significantly maximum seedling emergence of 95.88 and 95.38 per cent and emergence rate/day of 6.85 and 6.81 were recorded at 100% ASM with both 5.0 and 2.5 cm depths of sowing, respectively. However, the lowest emergence of 8.38, 14.38 and 18.38 % and emergence rate/day of 0.60, 1.03 and 1.31 were recorded at 40% ASM in combination of 2.5, 5.0 and 7.5 cm depth of sowing, respectively. The seeds could germinate little more at lower depth (7.5 cm) as compared to 2.5 and 5.0 cm depth of sowing at lower soil moisture (40% ASM) probably due

Table 1. Germination per cent of safflower seeds as influenced by available soil moisture at sowing and depth of sowing

Treatments	Germination Percentage								
	1992-93			1993-94			Pooled		
	Days after sowing			Days after sowing			Days after sowing		
	8	11	14	8	11	14	8	11	14
Soil moisture (%) at sowing									
M ₁ = 100% ASM	73.83	87.00	91.25	70.50	84.75	91.33	72.17	85.88	91.29
M ₂ = 80% ASM	68.33	74.50	79.58	66.33	82.42	88.92	67.33	78.46	84.25
M ₃ = 60% ASM	33.58	43.00	51.67	35.00	49.42	57.83	34.29	46.21	54.75
M ₄ = 40% ASM	2.25	8.08	15.25	4.58	9.08	12.17	3.42	8.58	13.71
S.E.m ±	1.34	0.86	1.39	1.05	0.76	0.83	0.85	2.37	2.82
C.D. at 5%	4.27	2.75	4.46	3.35	2.44	2.64	2.52	10.64	12.70
Depth of Sowing									
D ₁ = 2.5 cm	47.88	55.56	59.00	47.38	57.50	62.13	47.63	56.53	60.56
D ₂ = 5.0 cm	44.94	54.44	61.75	47.38	60.19	65.25	46.16	57.31	63.50
D ₃ = 7.5 cm	40.69	49.44	57.56	37.56	51.56	60.31	39.13	50.50	58.94
S.E.m ±	1.21	0.95	1.06	1.32	1.08	0.84	0.90	0.72	0.67
C.D. at 5%	3.53	2.76	3.08	3.86	3.16	2.45	2.55	2.05	1.92
Interaction (MxD)									
S.E.m ±	2.42	1.89	2.11	2.64	2.17	1.68	1.79	1.44	1.35
C.D. at 5%	NS	5.52	6.16	7.71	6.32	4.91	5.10	4.09	3.84

Table 3. Interaction effect of available soil moisture at sowing and depth of sowing on final emergence and emergence rate of safflower (Pooled data of 1992-93 and 1993-94)

soil Moisturee (%)	Emergence per cent			Emergence rate/day		
	Depth of sowing, cm			Depth of sowing, cm		
	2.5	5.0	7.5	2.5	5.0	7.5
100% ASM	95.38	95.88	82.63	6.81	6.85	5.90
80 % ASM	87.25	88.38	77.13	6.23	6.31	5.51
60 % ASM	51.25	55.38	57.63	3.66	3.95	4.12
40 % ASM	8.38	14.38	18.38	0.60	1.03	1.31
S.Em \pm		1.35			0.10	
C.D. at 5%		3.84			0.27	

to early drying of shallow soil surface as compared to deeper layers.

LITERATURE CITED

- Dahiya, B.S., Solanki, I.S. and Ram, K. 1985. Germination rate and its genetics in chickpea. *Int. Chickpea News Let.* 13: 6.
- Mahapatra, I.C., Singh, N.P. and Yusuf, M. 1975. Agronomic practices for safflower. *Indian Fmg* 25 (4) : 3-4.
- Mishra, V.K., Sharma, R.A. and Holkar, S. 1992. Influence of soil water potential on seedling emergence, plumule and radicle growth of wheat, gram, safflower and linseed. *Crop Res.* 5 (3): 407- 411.
- Rao, A.B.G. and Gupta, R.K. 1976. Influence of soil moisture suction and depth of sowing on seed emergence of soybean in a clayey soil. *Seed Res.* 4 (1) : 124-129.
- Singh, B.R., Sharma, R.A. and Gupta, R.K. 1985. Influence of soil water potential on emergence, plumule and radicle growth of wheat, gram and safflower in a clay soil. *Seed Res.* 13 : 186- 191.

ASSESSMENT OF YIELD LOSSES IN YELLOW *Sarson* DUE TO MUSTARD APHID, *Lipaphis erysimi* (KALTENBACH)

C.P.SINGH and G.C. SACHAN

Department of Entomology, College of Agriculture, G.B.Pant University of Agriculture & Technology, Pantnagar 263 145, Nainital (U.P.)

ABSTRACT

Studies on assessment of yield losses of *Brassica campestris* yellow *sarson* var. PYS-6, due to *Lipaphis erysimi* (Kalt.) revealed reduction in seed yield to the extent of 69.61 per cent in the untreated check whereas it was 6.35 to 56.91 per cent when aphids were allowed to feed for the period of 20 to 80 days. Delay in the aphid infestation by one day beyond 45 days of plant age resulted in an increase of 2.245 siliquae and 0.0622 g seed yield per plant and 0.0242 g in 1000 grain weight. On every increase of one day in aphid exposure, the corresponding decrease was 2.134 siliquae and 0.0611 g seeds per plant and 0.0449 g in 1000 grain weight.

Keywords : Aphid exposure; *Lipaphis erysimi*; Yield loss assessment; *Sarson*.

INTRODUCTION

The mustard aphid, *Lipaphis erysimi* (Kalt.) is the most serious pest of rapeseed-mustard in India. The nymphs and adults suck sap from tender leaves, apical shoots, inflorescence and siliquae. In case of severe infestation, plants get withered with poor pod formation resulting in reduction in seed yield. Estimation of losses in seed yield in different varieties of rapeseed and mustard has been reported (Bakhetia, 1984; Brar *et al.*, 1987, Prasad and Phadke, 1984). Singhvi *et al.* (1973) found that mustard aphid caused 65.7 per cent loss in yield of *sarson* (*Brassica campestris*) while Suri *et al.* (1988) estimated 42.1 per cent loss in yield of brown *sarson* due to mustard aphid. Such information on yellow *sarson* is inadequate and hence the present studies were undertaken to assess yield losses due to aphid infestation and to establish the relationship between exposure period to aphid feeding and yield of the rapeseed.

MATERIALS AND METHODS

Three field experiments were conducted at Crop Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar to estimate loss in yield of *sarson* due to the mustard aphid.

The first experiment was laid out in Randomized Block Design with three replications during *rabi* seasons of 1988-89 and 1989-90. The plot size measured 4m x 3m with row to row and plant to plant spacing of 45 cm and 15 cm, respectively. There were nine treatments out of which one was maintained as aphid free (complete protection) and another as unprotected check. In other treatments, the crop was exposed to natural aphid infestation. The aphid infestation started at late vegetative and flower initiation (45 to 50 days after sowing) stages of crop growth during respective years of investigation. The exposure

periods were 20, 30, 40, 50, 60, 70, and 80 days from the time of occurrence of the aphid. Just after the expiry of each exposure period, the aphid population was recorded from 10 cm terminal shoot of 10 plants selected in each plot. Thereafter the plots were kept aphid free by spraying monocrotophos @ 0.04 per cent.

Seed yield was recorded at harvest. The economics (cost:benefit ratio) was calculated based on prevailing charges of inputs and price of output during the years of investigation.

The second experiment was carried out under artificial infestation in Randomized Block Design. The plot size was 4m x 3m with 45 cm row spacing and 15 cm plant spacing. Ten neonate nymphs of *L. erysimi* from laboratory reared culture were released on the central shoot of ten plants in each treatment at 45, 55, 65, 75, 85, 95, 105 and 115 days after sowing. These plants were kept aphid free by the spray of monocrotophos @ 0.04 per cent fifteen days before the release of the aphid. Thereafter the plants were caged with muslin cloth and aphids were allowed to colonize and infect. Each treatment was replicated thrice. A protected check was also maintained by spraying monocrotophos @ 0.04 per cent at regular intervals. The population of aphid was counted after 125 days of sowing by removing the aphids, winged and apterous, in a Petri dish. At harvest, number of siliquae and seed yield per plant and 1000 grain weight were recorded.

In the third experiment, ten neonate nymphs of *L. erysimi* per plant were released after 40 days of sowing. Twenty such plants constituted one treatment and replicated twice. The experiment was conducted in Randomized Block Design. The plants were caged with Muslin sleeves. The exposure periods for aphids were given 10, 20, 30, 40, 50, 60, 70 and

80 days. An aphid free check was also maintained in the trial. The total number of aphids from a plant were counted after required exposure period. The plants were then kept aphid free by spraying monocrotophos @ 0.04 per cent, as and when needed. At harvest, data were taken on number of siliquae and seed yield per plant and 1000 grain weight.

RESULTS AND DISCUSSION

Highest seed yield was obtained from completely protected crop during both the years (Table 1). It was significantly higher than all other treatments and at par with 20 and 30 days and with only 20 days exposure period during first and second year of investigation, respectively. During both the years, the seed yield was lowest in the unprotected check. On an average, the yield loss varied from 6.35 to 56.91 per cent in unprotected check. The maximum cost benefit ratio was obtained at 20 days of aphid exposure and later on progressively decreased at respective exposure periods. The avoidable losses due to mustard aphid in *rai* had been recorded from 57.8 to 80.6 per cent (Bakhetia, 1984) and from 3.37 to 42.10 per cent in brown *sarson* (Suri *et al.*, 1988). The avoidable loss at 20 days of exposure period was minimum (6.35%) with highest cost benefit ratio (1:19.29). Therefore, the most critical age of the crop is 45/50 days after sowing at which spray should be initiated to get maximum gains from the crop.

Under the condition of artificial release of aphid, the maximum number of aphids were recorded when the crop was exposed for 80 days. The aphid infestation significantly reduced the number of siliquae and seed yield per plant and 1000 grain weight (Table 2). Significantly higher number of siliquae (242.27) and seed yield (7.01 g) per plant were obtained

Table 1. Avoidable yield losses due to aphid on *sarson*, PYS-6 under varying natural infestation periods

Aphid exposure periods (days)	Mean ¹ No. of aphids 10 TSL* before spraying	Grain yield (q/ha)			Avoidable losses in grain yield (%)	Cost: benefit ²
		1988-89	1989-90	Mean		
Complete protection	0.8	14.67	15.27	14.97	-	1:13.38
20	219.8	13.67	14.37	14.02	6.35	1:19.29
30	395.3	13.50	12.50	13.00	13.16	1:17.82
40	553.6	12.43	11.83	12.13	18.97	1:16.56
50	594.5	10.93	9.33	10.13	32.33	1:13.66
60	647.3	8.40	9.00	9.00	41.88	1:11.59
70	839.4	7.22	8.05	7.64	48.96	1:10.05
80	998.5	6.87	6.03	6.45	56.91	1:8.33
Untreated check	1019.5	5.01	4.08	4.55	69.61	-
C.D. (P = 0.05)	-	1.79	2.07	-	-	-

*TSL = Terminal Shoot Length. 1,2 = Mean of two years.

from the completely protected plots than that of all other treatments except when exposed for 10 days only. Similarly, maximum 1000 grain weight was obtained from protected check and it was at par with 10 and 20 days exposure period. The maximum reduction in siliquae and yield per plant and 1000 grain weight was found at 80 days of exposure period. Suri *et al.*, (1988) reported on an average 58.84 per cent loss in seed yield with varying levels of exposure period.

A significant inverse relationship between the age of crop plant at which exposure to aphid initiated and yield was recorded during the investigation. It was evident that the delay of one day in the initiation of aphid infestation beyond 45 days of crop age, resulted in corresponding increase of 2.245 siliquae and 0.0622 g of seed yield per plant and 0.0242 g in 1000 grain weight (Table 4). Suri *et al.* (1988) reported that the delay of one day in initiation of aphid infestation in brown *sarson* resulted in

an increase of 2.754 siliquae and 0.077 g of seed yield per plant.

The minimum and maximum number of aphids were recorded when the exposure period was 10 and 80 days respectively (Table 3). Significantly higher number of siliquae (263.6) and seed yield (6.62) per plant and 1000 grain weight (5.79) were recorded in the protected check than that in all other treatments except when exposed for 10 and 20 days. There was lowest reduction in siliquae and seeds per plant and 1000 grain weight when the crop was exposed for 10 days. It increased progressively with increase in the aphid feeding exposures and was maximum at 80 days of exposure period. The present results were in accordance with Suri *et al.* (1988) and Rajvant Singh *et al.* (1984) who reported maximum loss in yield of *B. campestris* and *B. juncea* at 75 and 60 days exposures, respectively.

The studies on correlation revealed that there was a significant and negative relation-

Table 2. Losses due to *L. erysimi* released at different growth stages of crop, sarson var. PYS-6.

Crop age at aphid release (days)	Aphid exposure period (days)	Number of aphid per plant	Number of siliquae per plant	Grain yield per plant	1000 grain weight	Decrease in yield parameters (%)		
						Siliquae	Grain yield	1000 grain weight
45	80	3693.5	60.17	1.77	2.57	75.16	74.75	44.13
55	70	2890.5	93.93	2.53	2.67	61.23	63.91	41.96
65	60	2099.5	139.67	2.67	2.97	42.35	61.91	35.44
75	50	1008.5	166.03	2.73	3.27	31.47	61.06	28.91
85	40	603.5	182.10	2.93	3.33	24.84	58.20	27.61
95	30	405.0	190.67	4.27	3.33	21.30	39.09	27.61
105	20	289.0	225.30	4.32	3.90	7.01	38.37	15.22
115	10	133.5	235.13	6.37	4.17	2.95	9.13	9.35
Protective check	0	0.0	242.27	7.01	4.60	-	-	-
C.D. (P = 0.05)	-	-	14.56	1.93	1.15	-	-	-

Table 3. Losses due to *L. erysimi* at different exposure periods in *erson. var. PYS-6* released at 40 DAS*

Aphid feeding exposure period (days)	Number of aphids/plant after feeding exposure	Number of siliquae plant ⁻¹	Seed yield plant ⁻¹ (g)	1000 grain weight (g)	Reduction in yield parameters (%)	
					Siliquae	Seed yield
10	53.00	254.27	5.93	5.00	3.54	10.42
20	119.0	247.90	5.83	4.63	5.96	11.93
30	217.5	239.67	5.10	4.50	9.08	22.96
40	407.5	185.20	4.13	3.67	29.74	37.61
50	809.0	170.93	3.70	3.17	35.16	45.25
60	1606.0	157.70	3.33	3.10	40.18	49.70
70	2105.0	139.00	2.17	2.30	47.27	6.20
80	3354.0	92.17	1.87	2.17	65.03	71.75
Uninfested check	0.0	263.60	6.62	5.79	-	-
C.D. (P=0.05)	-	15.84	0.99	1.18	-	-

* DAS = Days after sowing

Table 4. Relationship between duration of exposure and yield parameters.

A. Aphid released at different crop age and allowed to feed

	Correlation coefficient	Coefficient of determination	Regression equations	Standard Error
Number of siliquae per plant	-0.975	0.959	$Y = 260.446 - 2.245 X$	0.1951
Seed yield per plant	-0.940	0.883	$Y = 6.332 - 0.0622 X$	0.00856
1000 grain weight	-0.974	0.949	$Y = 4.3926 - 0.0242 X$	0.002115

B. Aphid released at 45 DAS and allowed for varying exposure periods

	Correlation coefficient	Coefficient of determination	Regression equations	Standard Error
Number of siliquae per plant	-0.974	0.949	$Y = 279.871 - 2.134 X$	1.9592
Seed yield per plant	-0.992	0.984	$Y = 6.458 - 0.0611 X$	0.00295
1000 grain weight	-0.989	0.979	$Y = 5.612 - 0.0449 X$	0.00251

DAS = Days after sowing;

ship between the aphid feeding exposures and yield contributing characters. Every increase of one day in exposure period resulted in the corresponding decrease of 2.134 siliqua and 0.0611 g seeds per plant and 0.0449 g in 1000 grain weight (Table 4). Suri *et al.* (1988) found that every increase of one day in exposure period resulted in the corresponding decrease of 3.183 siliquae and 0.081 g seed yield per plant.

LITERATURE CITED

- Bakhetia, D.R.C. 1984. Chemical control of *Lipaphis erysimi* (Kaltenbach) on rapeseed and mustard crops in Punjab. *J. Res. Punjab agric. Univ.*, 21: 63-75.
- Brar, K.S.; Bakhetia, D.R.C. and Sekhon, B.S. 1987. Estimation of losses in yield of rapeseed and mustard due to mustard aphid, *Lipaphis erysimi* (Kaltenbach). *J. Oil Seed Res.*, 4: 261-264.
- Prasad, S.K. and Phadke, K.G. 1984. Yield losses in some improved varieties of rapeseed and mustard by *Lipaphis erysimi* (Kalt.). *Indian J. Ent.* 46: 250-252.
- Rajwant Singh, Balraj Singh and Mahal, M.S., 1984. Assessment of losses in yield of *Brassica juncea* by *Lipaphis erysimi* (Kalt.), III. Timing and duration of infestation *Indian. J. Ecol. lit.* 139-145.
- Singhvi, S.M., Verma, N.D. and Yadav, T.P. 1973. Estimation of losses in rapeseed and mustard due to mustard aphid *Lipaphis erysimi* (Kalt.). *Haryana agric. Univ. H. Res. J.* : 5-7.
- Suri, S.M., Darshan Singh and Brar, K.S. 1988. Estimation of losses in yield of brown sarson due to aphids in Kangra valley. I. Effect of crop growth stage and aphid feeding exposure. *J. Inst. Sci.* 1: 162-167.

INFLUENCE OF INDUCED MUTATION ON HETEROSIS FOR SEED YIELD AND ITS ATTRIBUTES IN SUNFLOWER (*Helianthus annuus* L) *

R.K. SUGOOR, K. GIRIRAJ and P.M. SALIMATH

Oilseeds Project, University of Agricultural Sciences, Dharwad - 580 005.

ABSTRACT

Twenty five mutant lines of RHA-298 isolated in M₂ generation derived from Ethyl Methyl Sulphonate (EMS) treatment at 0.3 per cent and 0.4 per cent concentration were crossed with two cytoplasmic male sterile lines viz., CMS-234A and CMS-851A. The resultant 50 derived F₁'s were evaluated with two control F₁'s as checks along with 28 parents to estimate heterosis. The hybrids involving mutants with CMS-234A recorded higher magnitude of heterosis for seed yield. Head diameter and test weight were responsible for high heterotic effect in seed yield. Two crosses viz., CMS-234A x P₁₅ and CMS-851A x P₁₄ were found to be superior over the check hybrids. The possibility of identifying promising stabilised mutant lines in advanced generations based on the hybrid performance involving m₂ mutants has been pointed out.

Keywords: Heterosis; Induced mutants; *Helianthus annuus* L.; Mutagenesis

INTRODUCTION

Amongst several edible oilseed crops cultivated in the country, Sunflower (*Helianthus annuus* L.) has offered scope for commercial exploitation of heterosis utilising cyto-restorer system. Although several restorer lines are available, one of the restorer lines RHA-298 has been found to be a high yielding vigorous line besides having resistance to rust, downy mildew and verticillium wilt (Fick *et al.*, 1979), but it is late in maturity. The practice of using induced mutation to overcome such defect is well known. In many instances, these mutants have been found to be more heterotic (Dollinger, 1985 and Patil *et al.*, 1991). In the present study an attempt has been made to estimate the magnitude of heterosis for seed yield and com-

ponent characters in the cross combinations involving mutant lines.

MATERIALS AND METHODS

Pre-soaked seeds of a potential restorer RHA-298 of sunflower were subjected to Ethyl Methyl Sulphonate (EMS) treatment at 0.3 per cent and 0.4 per cent doses. Twenty five M₂ plants selected randomly (P₁ to P₁₅ representing 0.3% dose and P₁₆ to P₂₅ representing 0.4% dose) from the treated population were crossed with the two male sterile lines viz., CMS-234A and CMS-851A with a view to assess its potentiality in early generation testing and subsequent use of selected lines which exhibited high heterotic effect in heterosis breeding programme.

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

Received for publication on December 24, 1993.

These 50 derived F_1 's along with the two control F_1 's were evaluated in Randomised Block Design with three replications along with the two control F_1 's obtained by crossing untreated RHA-298 (P_{26}) as male with the same two male sterile lines, which served as checks. Twenty eight parents (25 mutant lines + 1 untreated restorer line + 2 maintainer lines in lieu of two male sterile lines) were also grown in the same manner. Each entry was grown in a single row of 4m length with a spacing of 60 x 20 cm. Observations were recorded on seed yield (g/plant), head diameter (cm), test weight (g), Oil content (%), husk content (%) and volume weight (g) on five random competitive plants in each treatment. Oil content was determined by Nuclear Magnetic Resonance (NMR) on dry seed basis at the Directorate of Oilseeds Research, Hyderabad.

The relative performance of derived F_1 hybrids were measured by estimating its heterosis over check (untreated) F_1 (CF_1) hybrid.

RESULTS AND DISCUSSION

Analysis of variance for seed yield and its attributes indicated significant variation for all

the traits studied (Table 1). The average heterosis, range and number of crosses showing significant heterosis for the characters studied in different groups of derived hybrids over checks are presented in Table 2 and 3.

It is evident from the results (Table 2 and 3) obtained that the degree of heterosis varied considerably for seed yield and its components. In order to discuss the results the mean of derived F_1 's were used for calculating the heterosis over the check F_1 value to compute the general superiority or otherwise of the mutant lines over untreated restorer line. Per cent heterosis was highest for seed yield/plant followed by head diameter, test weight and volume weight in all cross combinations. Oil content showed least heterosis. In a study reported by Ramirez *et al.* (1969) hybrids involving derived mutants gave high yielding hybrid combination. In this study the hybrid combinations of mutants with CMS-234A showed higher magnitude of heterosis compared to their crosses with CMS-851A. Although both the CMS lines have been derived from *Petioalis* source, the differential response of heterotic effect of mutant lines for seed yield may be attributed to different genotypic constitution of two CMS lines.

Table 1. Analysis of variance (mean squares) for different characters of parents and hybrids in sunflower

Sources	df	Seed yield/ plant	Head diameter	Test weight	Oil content	Husk content	Volume weight
Treatment	79	735.56 **	35.83 **	1.52 **	7.92 *	33.43 **	24.28 **
Parents	27	100.29 **	6.28 **	0.44 **	6.47 **	24.69 **	11.19 **
Crosses	51	40.07 **	1.41 **	0.14 **	2.20 **	8.13 **	3.02 *
Parents Vs Crosses	1	48779.88 **	2441.09 **	85.99 **	152.56 **	542.60 **	1163.71 **
Error	158	5.61	2.14	0.04	1.49	3.26	2.08

*P = 0.05 **P = 0.01

Table 2. Heterosis in EMS treated (0.3% of 0.4% dose) mutant lines of RHA-298 crossed with CMS-851A for seed yield and its attributes in sunflower

Characters		Mean heterosis (%)		Range of heterosis (%)		No. of significant heterotic crosses		Best heterotic cross	
		0.3% mutants	0.4% mutants	0.3% mutants	0.4% mutants	0.3% mutants	0.4% mutants	0.3% mutants	0.4% mutant
Seed yield	CF ₁ *	253.27	250.52	6.22- 61.42	-4.58-33.60	4	7	CMS-851A x P ₁₄	CMS-851A x P ₂₀
Head diameter	CF ₁	57.41	66.78	-1.06-16.28	0.00-13.72	4	1	CMS-851A x P ₁₃	CMS-851A x P ₂₅
Test weight	CF ₁	39.13	36.72	11.75-35.00	7.36-21.83	10	7	CMS-851A x P ₁₀	CMS-851A x P ₁₈
Oilcontent	CF ₁	1.13	4.98	-1.89-9.64	3.71-12.20	4	5	CMS-851A x P ₁₂	CMS-851A x P ₂₃
Husk content	CF ₁	8.94	10.36	-1.52-26.30	-19.09-2.04	2	3	CMS-851A x P ₁₄	CMS-851A x P ₁₆
Volume weight	CF ₁	16.09	11.79	13.74-25.56	8.03-19.81	10	8	CMS-851A x P ₄	CMS-851A x P ₁₉

* CF₁ = Check (untreated) F₁

Table 3. Heterosis in EMS treated (0.3% and 0.4% dose) mutant lines of RHA-298 crossed with SMS-234A for yield and its attributes in sunflower

Characters		Mean heterosis (%)		Range of heterosis (%)		No. of significant heterotic crosses		Best heterotic cross	
		0.3% mutants	0.4% mutants	0.3% mutants	0.4% mutants	0.3% mutants	0.4% mutants	0.3% mutants	0.4% mutants
Seed yield	CF ₁ *	266.07	263.83	0.56 - 66.95	-7.58 - 31.36	12	10	CMS-234A x P15	CMS-234A x P23
Head diameter	CF ₁	51.70	56.61	0.18 - 33.48	4.04 - 24.59	13	8	CMS-234A x P11	CMS-234A x P18
Test weight	CF ₁	50.00	40.43	11.75 - 35.00	2.50 - 31.00	15	5	CMS-234A x P8	CMS-234A x P16
Oil content	CF ₁	1.79	0.08	-1.89 - 9.64	-7.97 - 6.97	3	8	CMS-234A x P5	CMS-234A x P24
Husk content	CF ₁	21.74	21.77	-1.52 - (-)26.30	-3.83 - (-)24.54	3	7	CMS-234A x P9	CMS-234A x P20
Volume weight	CF ₁	18.41	10.32	13.74 - 25.56	9.19 - 26.25	8	10	CMS-234A x P5	CMS-234A x P22

* CF₁ = Check (untreated) F₁

Table 4. The mean performance of two best crosses involving mutants of R lines for some economically important characters in sunflower

Hybrids	Seed yield (g/plant)	Head diameter (cm)	Test weight (g)	Oil content (%)	Husk content (%)	Volume weight
CMS-234A x P15	60.37 **	20.70 **	5.27 **	42.46	22.50 **	40.16 **
Check hybrid	36.16	15.86	4.00	40.16	29.50	32.31
Increase over check (%)	66.95	30.52	31.75	5.72	-23.72	25.15
CMS-851A x P14	57.08 **	20.96 *	4.96 **	41.23	20.92 **	38.90 **
Check hybrid	35.36	18.80	3.94	39.33	24.97	33.08
Increase over check (%)	61.43	11.32	25.89	4.84	-16.21	11.04

*P = 0.05 **P = 0.01.

The high heterotic effect for seed yield was reflected in head diameter and test weight thereby confirming the earlier report of Giriraj *et al.* (1986).

In practice, heterosis can be useful only with marked superiority over the check. When compared with check hybrids (untreated) on the basis of *Per se* performance for most of the characters (Table 4), two crosses CMS-234A x P15 and CMS-851A x P14 were found to be superior over the check. As expected the hybrids showing low husk content also showed high oil content indicating negative correlation among these two characters. The cross combinations involving mutant lines derived from 0.3 per cent EMS mutagen treatment in general recorded relatively high heterotic effect for most of the characters. The M₂ generation mutant lines being heterozygous and unstable, the elite mutant lines viz., P₁₄ and P₁₅ which exhibited high heterotic effect for seed yield may be advanced to derive true breeding mutants for further use in heterosis breeding programme.

LITERATURE CITED

- Dollinger, E.J. 1985. Effect of visible recessive alleles on vigour characteristics in a maize hybrid. *Crop Sci.* 25:818-821.
- Fick, G.N., Zimmer, D.E. and Zimmerman, D.C. 1979. Registration of nine sunflower parental lines. *Crop Sci.* 19:423.
- Giriraj, K., Shivaraju, N. and Shantha, R.H. 1986. Studies on heterosis and inbreeding depression in selected cross combination of sunflower. *J. Oilseeds Res.* 3: 67-72.
- Patil, S.S., Pandit, V.V. and Shashidhara, L.S. 1991. Exploitation of induced variability for combining ability in developing new hybrids in sorghum, *In* Abstract Golden Jubilee Symposium on Genetic Research and Education: Current Trends and the Next Fifty years. Indian Society of Genetics and Plant Breeding, IARI, New Delhi, India. pp.668-669
- Ramirez, I.A., Allian, R.E., Konzak, C.F. and Becker, W.A. 1969. Combining ability of Winter Wheat, *In* Induced mutations in plants (Proc. Symp. Pullman, 1969). IAEA, Vienna. pp. 445-458

PERFORMANCE OF SOYBEAN - PIGEONPEA INTERCROPPING SYSTEM IN MALWA PLATEAU OF MADHYA PRADESH

O.P. JOSHI, V.S. BHATIA and V.P.S. BUNDELA

National Research Centre for Soybean, Khandwa Road, Indore 452001, M.P.

ABSTRACT

Experimentation on Vertisols of *Malwa* Plateau established that pigeonpea cv. ICPL 316 can be intercropped with soybean cvs. JS 71-05 and PK 472 with high yield advantage as judged by Land Equivalent Ratio (LER) approaching 1.50. The maximum yield advantage was observed by one row of pigeonpea between two paired rows of soybean at 22.5/90 cm (average LER 1.50) followed by one row of pigeonpea between two paired rows of soybean at 22.5/90 cm (average LER 1.44). The average monetary returns from these intercropping were Rs.24877 and Rs. 23511 as against Rs. 13074 and Rs.19681, respectively for pure stands of soybean and pigeonpea.

Keywords : Intercropping; Soybean; Pigeonpea; LER; Cropping system; Vertisols.

INTRODUCTION

The rapid expansion of acreage under soybean in Madhya Pradesh during last few years has resulted in its monocropping on a sizeable area. The recent estimates for 1993-94 for soybean area in Madhya Pradesh are 3.39 m ha with a production of 3.73 m t. This is about 75 per cent of the total area (4.57 m ha) in the country. Adoption of this system is capable of giving subsistence to small and poorer farmers with additional advantages (Willey, 1979). Rao and Willey (1980) have reported that slow establishing and later-maturing pigeonpea combined well with either cereals or legumes to give a very large yield advantage as measured by LER.

MATERIALS AND METHODS

An intercropping experiment with variable row/space combinations on soybean and pigeonpea was conducted at Research Farm of

National Research Centre for Soybean, Indore during *kharif* 1991 and 1992. The treatments consisted of interplanting one or two rows of pigeonpea between paired rows of soybean at 22.5/90 cm, 22.5/60 cm and one row between soybean planting at 45 cm (Table 1). The soil of the experimental site belonged to fine, montmorillonitic, hyperthermic family of Typic Chromusterts and is very deep, dark greyish brown to very dark greyish brown, clay and slightly alkaline. The analysis revealed that pH 7.86, EC 0.14 mMho/cm, organic carbon 0.35 per cent, available phosphorus 11 kg/ha and available potassium more than 120 kg/ha. The area falls under semi-arid agroclimate with annual mean precipitation of 1050 mm. The rainfall received was only 748.8 mm and 555 mm during 1991 and 1992, respectively.

During *kharif* 1991, the experiment was undertaken with soybean cultivars JS 71-05 (maturity 90-95 days) and PK 472 (maturity

100-105 days) and during *kharif* 1992 only JS 71-05 was used. The pigeonpea cultivar ICPL 316 (maturity 120-125 days) was interplanted during both the years. The experiment was sown on 12th July, 1991 and 22nd July, 1992.

The experiment was conducted in a Randomized Block Design with three replications and the plot size was 6.0 m x 3.6 m. N, P₂ O₅, K₂ O fertilization @ 20:60:20 kg/ha was applied as per recommendations for soybean only (Prabhakar *et al.*, 1992). The fertilizer carriers used for NPK were urea, single superphosphate and muriate of potash, respectively and applied as basal dose.

RESULTS AND DISCUSSION

Pure stand of soybean at normal row spacing of 45 cm resulted in maximum seed yield of 2.00 t/ha recorded by JS 71-05 in 1991 while in 1992 maximum yield of 2.51 t/ha under paired rows of soybean was at 22.5/90 cm spacings. Planting of soybean in paired row configuration of 22.5/60 cm tended to show decrease in yield (1.82 t/ha and 2.14 t/ha for 1991 and 1992, respectively). In case of PK 472, soybean planted in 22.5/60 cm and 22.5/90 cm configuration showed marginal yield advantage with 1.76 and 1.74 t/ha (LER 1.06 and 1.07, respectively) over 1.64 t/ha achieved under normal spacing (45 cm). Although JS 71-05 yielded more than PK 472, the yield differences were non-significant. In general paired row configuration, in general appears to have an edge in yield over normal spacing of soybean. Pure stands of pigeonpea yielded 2.42 t/ha and 2.60 t/ha during 1991 and 1992, respectively.

Association of soybean with pigeonpea in different configuration (Table 1), in general,

resulted reduction in yields of both the component crops than their pure stands irrespective of varieties and the year of cropping. Reduction in soybean yields were statistically not significant over pure stands during 1991. Two rows of pigeonpea intercropped between paired rows of soybean yielded 2.22 t/ha as compared to 2.42 t/ha in pure stand. During 1992 also, the same treatment yielded 0.77 t/ha as compared with 2.60 t/ha of pure stand. During both the years this treatment yielded maximum combined yield of component crops indicating its suitability. During 1991, cultivar PK 472 yielded lower than JS 71-05 which probably indicated better companionship of latter on account of shorter stature and early maturity offering lesser competition with component crop. JS 71-05 has been reported to offer better companionship with higher yield advantage (Holkar *et al.*, 1991).

The yield advantage of different degree was expressed by the intercropping systems as judged by LER values varying between 1.08 to 1.50. The maximum yield advantage was observed in planting single/paired rows of pigeonpea between paired rows of soybean at 22.5/90 cms (average LER 1.44 and 1.50, respectively). Similarly the maximum average gross monetary returns were obtained in these two treatments amounting to Rs. 23511 and Rs. 24877 respectively. Interplanting two rows of pigeonpea between paired rows of soybean at 22.5/90 cm, thus resulted in a 90 per cent and 26 per cent increase in monetary return compared to sole crops of soybean and pigeonpea, respectively. The above results fall in the category of intercropping wherein the combined yield of intercrops exceed the yield of pure stands of component crops (Willey, 1979). Dubey *et al.*, (1991) reported that intercrop-

Table 1. Seed yield, LER and gross monetary returns under soybean-pigeonpea intercropping (1991 and 1992)

Treatments	Variety	Seed yield (t/ha)				Mean		Mean LER		Mean over years and varieties	
		1991		1992		Soybean	Pigeonpea	Soybean	Pigeonpea	LER	Gross monetary returns (R/ha)
		Soybean	Pigeonpea	Soybean	Pigeonpea						
Soybean at 45 cm	JS 71-05	2.00	-	2.35	-	2.18	-	2.18	-	1.00	13074
	PK 472	1.64	-	-	-	1.64	-	1.64	-	1.00	11501
Soybean, paired rows at 22.5/60 cm	JS 71-50	1.82	-	2.14	-	1.98	-	1.98	-	0.91	12761
	PK 472	1.74	-	-	-	1.74	-	1.74	-	1.06	12180
Soybean, paired rows at 22.5/90 cm	JS 71-05	1.91	-	2.51	-	2.21	-	2.21	-	1.01	13583
	PK 472	1.76	-	-	-	1.76	-	1.76	-	1.07	12320
One row of pigeonpea between two paired rows of soybean at 22.5/90 cm	JS 71-05	1.68	1.67	2.17	0.71	1.93	1.19	1.93	1.19	1.35	23379
	PK 472	1.57	1.41	-	-	1.57	1.41	1.57	1.41	1.52	23644
Two rows of pigeonpea between two paired rows of soybean at 22.5/90 cm	JS 71-05	1.61	2.22	2.26	0.77	1.94	1.50	1.94	1.50	1.49	26248
	PK 472	1.57	1.39	-	-	1.57	1.39	1.57	1.39	1.51	23506
One row of pigeonpea between two rows of soybean at 45 cm	JS 71-05	1.56	1.34	1.97	0.49	1.77	0.91	1.77	0.91	1.17	19984
	PK 472	1.64	1.51	-	-	1.64	1.51	1.64	1.51	1.60	25043
One row of pigeonpea between paired row of soybean at 22.5/60 cm	JS 71-05	-	-	2.26	0.45	2.26	0.45	2.26	0.45	1.22	18770
One row of soybean between two rows of pigeonpea at 60 cm	JS 71-05	-	-	1.97	0.45	1.97	0.45	1.97	0.45	1.08	16622
Pigeonpea at 60 cm	ICPL 316	-	2.42	-	2.60	-	2.51	-	2.51	1.00	19681
CD at 5%		NS	0.70	NS	0.33	-	-	-	-	-	-
Prevailing rates (Rs/t)		7000	9000	6500	8500	-	-	-	-	-	-

ping soybean and pigeon pea formed a more economic association compared to growing blackgram, sesame, niger, kodo millet, kutki or paddy with pigeonpea.

The results from the two years of experimentation revealed that the pigeonpea can successfully be intercropped with soybean in Vertisols of Malwa Plateau of Madhya Pradesh and can fetch higher monetary returns without additional inputs particularly interplanting of two rows of pigeonpea between paired rows of soybean at 22.5/90 cm. The small and marginal farmers can positively respond to this system which is found better than the traditional monocrop pigeonpea.

LITERATURE CITED

- Dubey, O.P., Garg, D.C. and Dixit, K.P. 1991. Intercropping in short duration pigeonpea. *Indian J. Agron.* 36 : 253-254.
- Holkar, S., Jagtap, J.G., Billore, S.D. and Mishra, V.K. 1991. Evaluation of soybean (*Glycine max*) and pigeonpea (*Cajanus cajan*) genotypes grown in intercropping system. *Indian J. Agric. Sci.* 61 : 93-96.
- Prabhakar, Tiwari, S.P. and Bhatnagar, P.S. 1992. Production technologies for augmenting soybean productivity in India. *J. Oilseeds Res.* 9: 1-13.
- Rao, M.R. and Willey, R.W. 1980. Preliminary studies of intercropping combination based on pigeonpea or sorghum. *Exptl. Agric.* 16: 29-39.
- Willey, R.W. 1979. Intercropping- Its importance and research needs. Part 1. Competition and yield advantages. *Field Crop Abstr.* 32: 1-10.

EFFECT OF SULPHUR AND PHOSPHORUS ON GROUNDNUT

S. DIMREE and K.N. DWIVEDI

Department of Soil Science and Agricultural Chemistry, Chandra Shekhar Azad University of
Agriculture and Technology, Kanpur.

ABSTRACT

A field experiment was conducted with Groundnut variety Chitra (MA-10) on Inceptisol of Kanpur during *kharif* seasons of 1988 and 1989. The treatments consisted levels of S and P₂O₅ (0, 15, 30, 45 and 60 kg ha⁻¹ and 0, 20, 40 and 60 kg ha⁻¹), respectively. The kernel and shell yields of groundnut increased significantly with increasing levels upto 45 kg S and 40 kg P₂O₅ ha⁻¹ in both the years. Sulphur application @ 45 kg S ha⁻¹ increased 12.3 and 12.7% protein over control in both the years. Oil content increased significantly upto 45 kg S ha⁻¹ application in both the years and P₂O₅ application also increased oil content considerably upto 60 kg P₂O₅ ha⁻¹.

Keywords : Kernel and shell yield; Groundnut; Effect of S and P.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) being a legume and oilseed crop has greater requirement for sulphur and phosphorus (Kanwar, 1984; Pasricha and Aulakh, 1986). Phosphorus is a constituent of enzymes, phospholipids and proteins, while sulphur is a constituent of S-containing amino acids (methionine, cystine and cysteine) and helps in fatty acid synthesis. Since both elements are essential and perform specific physiological functions of groundnut, lack of one or both might result in retardation of metabolic activity in the plant. Information on responses of S and P fertilization on Groundnut in Udic Ustochrept soils is lacking. The present investigation was carried to study response of S and P fertilization on groundnut at Kanpur.

MATERIAL AND METHODS

A field experiment was conducted with groundnut (*Arachis hypogaea* L.) variety Chitra (MA-10) at Pura farm of C.S. Azad University of Agriculture and Technology, Kanpur during *Kharif* seasons of 1988 and 1989. The experimental soil was having pH 7.8, EC 0.48 dsm⁻¹, organic matter 0.62%, available N 186 kg ha⁻¹, available P 10.8 kg ha⁻¹ and available S 8.0 mg kg⁻¹. Five levels of S comprising (0, 15, 30, 45 and 60 kg) and 4 levels of P₂O₅ (0, 20, 40 and 60 kg ha⁻¹) were applied in combinations through elemental sulphur and Triple SuperPhosphate, respectively. A basal dose of 20 kg ha⁻¹ and 40 kg ha⁻¹ of N and K₂O (as urea and KCl) were applied to each treatment. The experiment was laid out in RBD with four replications. Kernel and shell yields were recorded at harvest.

Nitrogen in kernel samples was determined by Macro Kjeldahl's method (Piper, 1966) and was multiplied by 6.25 factor for protein content. Oil was estimated by soxhlet extraction method (Kanwar and Chopra, 1967).

RESULTS AND DISCUSSION

Kernel and shell yields: It is apparent from the data presented in table 1 that increasing levels of S and P application increased the kernel and shell yields of groundnut significantly upto 45 kg S and 40 kg P₂O₅ ha⁻¹ but non-significant reduction in yields was observed at higher level of P₂O₅ (60 kg ha⁻¹). The increase in yield due to S and P application might be due to response of groundnut and reduction at higher level of S and P might be due to toxic effect. Response of

these two elements are due to that experimental sites were more deficient in P and S. Similar results have also been obtained by Pasricha and Aulakh (1986).

Protein yield: Protein content in kernel was positively and significantly influenced by S and P application during both the years of experimentation (Table 1). The highest protein content was noted at 60 kg P₂O₅ ha⁻¹. Phosphorus plays an important role in energy transformation and participation in fat and protein metabolism. It is a constituent of many vital compounds like nucleotides and most of enzymes. Sulphur plays a very important role in nodulation and protein synthesis especially S-containing amino acids (methionine, cysteine).

Table 1. Effect of S and P on yield (kg ha⁻¹), Protein and Oil content (%) in groundnut

Levels of S/P (kg ha ⁻¹)	Kernel yield (Kg ha ⁻¹)		Shell Yield (Kg ha ⁻¹)		Protein content (%)		Oil content (%)	
	1988	1989	1988	1989	1988	1989	1988	1989
Sulphur								
0	1416	1432	607	619	22.5	22.7	47.6	47.7
15	1514	1561	648	649	23.2	23.4	49.4	48.6
30	1609	1617	689	693	24.2	24.3	52.6	51.8
45	1690	1680	720	732	25.4	25.6	53.5	52.8
60	1634	1644	694	726	25.3	25.1	51.6	51.7
LSD(0.05)	64	37	27	16	0.56	0.72	0.82	0.44
Phosphorus (P₂O₅)								
0	1406	1407	603	610	22.0	22.1	46.5	45.9
20	1466	1465	671	682	23.1	23.2	48.1	47.1
40	1627	1672	698	702	24.0	24.1	50.1	49.8
60	1656	1656	675	692	24.2	24.2	51.0	50.2
LSD(0.05)	58	34	24	14	0.50	0.40	0.74	0.40

and cystine). Rathee and Chahal (1977) also reported similar results.

Oil content: Perusal of data in table 1 also indicates that increasing levels of S significantly increased the oil content of groundnut. This increase was 47.6 to 53.5 per cent in 1988 and 46.7 to 52.8 per cent in 1989 with 45 kg S ha⁻¹. Similarly increasing levels of P₂O₅ also increased the oil content and being highest at 60 kg P₂O₅ ha⁻¹. Increase in oil content due to S application, on an average, was 12.7 per cent over control. The increase in oil content due to S application seems to be due to its key role in biosynthesis of oil in plants (Mudd, 1967).

LITERATURE CITED

- Kanwar, J.S. 1984. *J. Indian Soc. Soil Sci.* 32:595-602.
- Kanwar, J.S. and Chopra, S.L. 1967. Practical Agricultural Chemistry. S. Chand & Co.
- Mudd, J.B. 1967. Fat metabolism in plants. *Ann. Rev. Pl. Physiol.* 18:229-252.
- Pasricha, N.S. and Aulakh, M.S. 1986. Role of sulphur in the nutrition of groundnut. *Fert. News* 31(9): 17-21.
- Piper, C.S. 1966. Soil and Plant Analysis. Published by University of Adelaide, Australia.
- Rathee, O.P. and Chahal, R.S. 1977. Effect of P and S application on the yield and composition of groundnut in Ambala soils. *H.A. U. J. Res.* 7:173-177.

INFLUENCE OF SPECIFIC GRAVITY ON VIGOUR AND VIABILITY OF SUNFLOWER SEEDS

S. RAJENDRA PRASAD, A. SATHYANARAYANA REDDY,

K. SEENAPPA * and T.N. VENKATA REDDY

Seed Technology Research Unit, NSP, UAS, GKVK, Bangalore 560 065.

* Project co-ordinating Unit (Sunflower), GKVK, Bangalore 560 065.

ABSTRACT

To study the influence of specific gravity of seed on viability and vigour of sunflower seed, Morden and EC-68415 varieties were processed and graded into four classes viz., (0.45-0.49), (0.51-0.54), (0.61-0.64) and (0.65-0.69) by using specific gravity separator and ungraded seeds used as control (0.55-0.59). The vigour and viability of sunflower seed in terms of germination percentage, rate of germination, electrical conductivity of seed leachate, dry weight of seedlings in the laboratory and field emergence, seedling dry weight in soil, plant height and yield/plant in field were influenced by the specific gravity of the seed. Seeds with a specific gravity higher than 0.6 were distinctly superior in most of the characteristics measured to those below 0.6 value.

Keywords: Specific gravity; Vigour and viability.

INTRODUCTION

Optimum plant population is a basic requirement to obtain higher yield, response to fertilizers, other inputs for better net returns. Adequate population density largely depends on seed germinability and seedling vigour. Importance of physical properties in relation to viability, seedling vigour and population has been established in many crops. Properties like seed weight or specific gravity of seed is closely associated with viability, seedling vigour, growth and subsequently seed yield (Tseng and Lin 1962; Sung and Delouche 1962; Ashok Kumar *et al.*, 1979). Seeds of same size will differ in germinability and seedling vigour both in laboratory and field because of variability in specific gravity. It is often noticed in sunflower the presence of light seeds, heavy seeds or immature or half filled seeds since processing

is normally based on seed size. The information on influence of specific gravity of seed on viability and vigour in sunflower is scanty and hence the study was under taken to know the influence of specific gravity of seed on vigour, viability and their performance in the field.

MATERIALS AND METHODS

The Morden and EC-68415 varieties of sunflower seeds were processed by using 3.97 and 3.57 (oblong) size screens respectively. The processed seeds were again graded into 4 groups based on specific gravity using Delta type-51 (Denmark make) specific gravity separator in the Seed Processing Unit, NSP, UAS, Bangalore. The specific gravity of each class (group) of seeds and control (SGO-ungraded processed seed) was calculated and given below:

Class	Specific gravity
SG0	0.55-0.59
SG1	0.45-0.49
SG2	0.51-0.54
SG3	0.61-0.64
SG4	0.65-0.69

After grading the seeds based on specific gravity the recovery percentage was worked out on weight basis and 100 seed weight was recorded for each class. Standard germination test was conducted as per the ISTA rules (Anon. 1985). First count was taken on 4th day and final count was taken on 10th day.

Rate of germination was calculated by using the modified formula of Maguire (1962).

Rate of germination =

$$\frac{X_1}{Y_1} + \frac{X_2 - X_1}{Y_2} + \dots + \frac{X_n - (X_n - 1)}{Y_n}$$

where; X_n = Number of seeds germinated at 'n'th count.

Y_n = Number of days from sowing to 'n'th count.

To study the field performance the experiment was taken up with 10 treatment combinations in 4 replicates with a plot size of 3.6 x 2.6 meter each, in Randomized Complete Block Design. The observations on field emergence, seedling dry matter at 20 days after sowing, plant height at 35 days after sowing and yield/plant were recorded. The results of laboratory and field studies were statistically analysed.

Root and shoot length of ten randomly selected normal seedlings from each replication were measured on the day of first count and dry weight was recorded by keeping the same seedlings in oven at $80^\circ \pm 1^\circ\text{C}$ temperature for 24 hours. Seed leachate was collected by soaking 5 grams of seeds in 25 ml. of distilled water for 2 hours. Electrical conductivity was

Table 1. Seed recovery and 100 seed weight of sunflower in various specific gravity classes

Specific gravity (SG)	Seed recovery (%)			100 seed weight (g)		
	Morden	EC-68415	Mean	Morden	EC-68415	Mean
SG0	-	-	-	5.64	5.80	5.72
SG1 (0.45-0.49)	1.55	2.74	2.15	4.38	4.20	4.29
SG2 (0.51-0.54)	36.97	37.60	37.29	5.13	5.00	5.06
SG3 (0.61-0.64)	55.03	54.70	54.87	6.26	6.62	6.44
SG4 (0.65-0.69)	6.45	4.96	5.71	7.18	7.77	7.47
				5.72	5.88	
				S.E.m \pm	CD at 5%.	
			SG	0.06	0.16	
			V	0.04	0.10	
			SG x V	0.08	0.23	

measured in digital conductivity meter and expressed in $\mu\text{mohs/cm}$.

RESULTS AND DISCUSSION

Laboratory studies

The percentage of seed recovery in various specific gravity classes and 100 seed weight are given in Table 1. There was no perceptible difference among the varieties with respect to the proportions of seed in each specific gravity class. About 55 per cent of the seed were having specific gravity between 0.61 to 0.64 while 37 per cent were in between 0.51 to 0.54. Only about 2.15 per cent of the seed had a low specific gravity i.e., between 0.45-0.49 and seeds with high specific gravity (>0.65) was about 5.71 per cent which indicates that seed processed with air screen cleaner based on size will have high percentage of medium specific gravity seeds. The 100 seed weight ranged from 4.29 to 7.47 g in different class of specific gravity and it was significantly increased with increase in specific gravity.

Germination percentage was closely related to specific gravity of the seed (Table 2). In general, germination percentage increased with increasing specific gravity and it was significant at 5 % with lowest of 90 per cent in seeds of specific gravity between 0.45-0.49. Similar results were observed in paddy by Sung and Delouche (1962). There was no significant difference in germination among varieties due to specific gravity and interaction of varieties and specific gravity. The first count as a vigour test had a significant effect due to specific gravity. The low specific gravity seeds (0.45 to 0.54) had significantly recorded low vigour in terms of germination at first count ranging from 76.33 to 79.33 per cent while medium and high specific gravity seeds (0.55 to 0.69) ex-

pressed high vigour by recording increased germination percentage at first count in the range of 85.67 to 89.67 per cent including ungraded seeds (SGO). The rate of germination had a significant difference due to specific gravity (Table 2). High (31.68) rate of germination was observed in high specific gravity seeds (0.65-0.69) followed by all classes of specific gravity seeds except low specific gravity (0.45-0.49) seeds which showed low (28.13) rate of germination thus indicating low in vigour. There was no significant difference in rate of germination between the varieties due to specific gravity.

Electrical conductivity of seed leachate was less ($497 \mu\text{mohs/cm}$) in high specific gravity seeds and it significantly increased with decrease in specific gravity of seeds (Table 2). This may be due to higher leaching of electrolytes because of poor quality and more number of seeds per unit weight. Further, there was not appreciable difference in electrical conductivity of seed leachate between the varieties due to specific gravity. Seedling dry weight significantly increased with increase in specific gravity of seeds (Table 2) although shoot and root length of the seedlings did not differ significantly. The increase in dry weight of seedling may be due to production of healthy and heavy seedlings from high specific gravity classes. Similar observations were made by Sivasubramanian and Ramakrishnan (1977) in sunflower.

Field studies

When the seeds were sown under field conditions, the superiority of the high specific gravity class was more apparent than the laboratory studies. An average of 62 per cent light specific gravity class seeds emerged as compared to a 90 per cent laboratory germination for the

Table 2. Performance of various specific gravity classes of seeds of sunflower in laboratory and field

[illegible]

same class of seed. Field emergence percentage was highly significant due to specific gravity (Table 2) and it increased with increase in specific gravity in the range of 62 to 87 per cent indicating high vigour in high specific gravity seeds. Although, field emergence was less than the germination, the trend was similar. Dry weight of seedling was significantly increased with increase in specific gravity of seeds with the minimum of 290 mg/seedling and maximum of 430 mg/seedling dry weight in low and high specific gravity class seeds, respectively. During growth stage the vigour differences among the specific gravity classes were manifested in plant height (35 days after sowing) with significant increase in height as the specific gravity of seeds increased (Table 2). The plant height varied significantly between varieties within the specific gravity class which may be due to varietal difference.

Although, yield per plant increased with increase in specific gravity of seed, the results were non-significant. This indicates that specific gravity of seed greatly influenced at the beginning of the growth stage and it masked at yield stage with the maximum (56.58 gm) yield per plant in high specific gravity class (SG4). Similar increase in seed yield from the crop raised from large seeds was observed in sunflower by Singh *et al.* 1977 and Varshney and Singh, 1977.

The vigour and viability of sunflower seed in terms of germination percentage, rate of germination, electrical conductivity, dry weight of seedling in laboratory and percent-

age of field emergence, seedling dry weight, plant height and yield per plant in the field was influenced by the specific gravity of the seed. Seeds with a specific gravity higher than 0.60 were distinctly superior in most of the characteristics measured to those less than 0.60 in specific gravity.

LITERATURE CITED

- Anonymous, 1985. International rules for seed testing. *Seed Sci. & Technol.* 13: 299-513.
- Ashok Kumar, T.N., Giriraj, K., Prasad, T.G. and Vidyashankar, T.S. 1979. Influence of test weight on yield and growth parameters in sunflower. *Seed Res.* 7:141-144.
- Maguire, J.D. 1962. Speed of germination - Aid in selection and evaluation of seedling emergence and vigour. *Crop Sci.* 2:176-177.
- Singh, B., Sachan, J.N. and Singh, D. 1977. Variability and correlation in Sunflower (*Helianthus annuus* L.). *Pantnagar J. Res.* 2: 27 - 30.
- Sivasubramanian, S. and Ramakrishnan. 1977. Relationship between seed size and seedling vigour in Sunflower. *Seed Res.* 5: 6-10.
- Sung, T.Y. and James C. Delouche. 1962. Relation of specific gravity to vigour and viability in Rice Seed. *Proc. Assoc. Off. Seed Anal.* 52: 162-167.
- Tseng, S.T. and Lin, C.I. 1962 studies on the physiological quality of pure seed of rice. *Proc. Int. Seed Test. Assoc.* 27: 459- 475.
- Varshney, S.K. and Singh, B. 1977. Correlation and path coefficient analysis in sunflower (*Helianthus annuus* L.) *Pantnagar J. Res.* 2: 147 - 149.

PERFORMANCE OF GROUNDNUT VARIETIES UNDER DIFFERENT DATES OF SOWING DURING *Rabi*/SUMMER SEASON

A.K. GUGGARI, K. MANJAPPA, P.S. DHARMARAJ, Y.B. PALLED and
SATHYANARAYANA RAO.

Regional Research Station, P.B. No.24, Raichur-584 101, Karnataka

ABSTRACT

A field experiment was conducted during *rabi*/summer seasons of 1991-92 and 1992-93 at Regional Research Station, Raichur on red sandy soil to study the performance of groundnut varieties at different dates of sowing during *rabi* summer season. R-8808 gave the best performance among all the varieties tested. The crop sown during 2nd fortnight of November recorded maximum pod yield (2426 kg/ha) followed by 1st fortnight of December (1784 kg/ha) and 2nd fortnight of December (1648 kg/ha) sown crop. The various yield parameters were also higher with November 2nd fortnight sown crop.

Keywords: Groundnut; *Rabi*/summer season; Varieties; Sowing date

INTRODUCTION

Groundnut is one of the important oilseed crops grown in north eastern dry zone of Karnataka. In this region, it is grown largely during *kharif* under rainfed conditions. With the introduction and availability of irrigation water through Tunga Bhadra and Upper Krishna Projects, the area under irrigation during *rabi*/summer season has been increased in the recent years. The farmers are sowing this crop right from the beginning of October to end of January after the harvest of *kharif* crops. The farmers are experiencing reduction in yield in early sown crop due to occurrence of bud necrosis. Though, the yield levels were better with January sown crop, in recent years, the farmers are facing problems in harvesting due to early closure of canal water. In view of the above facts, the present investigation was carried out to test the performance of groundnut

varieties with early sowing during November and December.

MATERIALS AND METHODS

A field experiment was conducted at Regional Research Station, Raichur for two seasons during *rabi*/summer 1991-92 and 1992-93. The soil of the experimental site was red sandy having 156, 42 and 394 kg/ha of available N, P₂O₅ and K₂O, respectively, with 7.7 pH and 0.39 per cent organic carbon. There were nine treatment combinations consisting of three varieties of groundnut (R-8808, ICGS-11 and KRG-1) and three dates of sowing (November 2nd fortnight herein after abbreviated as FN, December 1st FN and December 2nd FN). The experiment was laid out in Randomised Block Design with three replications. The crop was sown on 15-11-91, 30-11-91 and 15-12-91 during 1991-92 and on 20-11-92, 7-12-92 and

21-12-92 during 1992-93. During 1992-93, the sowing was delayed due to cyclonic rain received during November 2nd fortnight. The crop was sown with 30 x 10 cm spacing and fertilized with 25 : 75 : 25 kg/ha NPK in the form of urea, single superphosphate and murate of potash.

RESULTS AND DISCUSSION

The date on effect of groundnut varieties and dates of sowing on yield and yield parameters of groundnut are presented in Table 1 and 2.

Performance of varieties

Groundnut variety R-8808 showed better performance over other varieties in terms of yield and yield attributing characters like number of pods/plant, pod weight/plant and 100 kernel weight. On an average over two years, R-8808 realised significantly higher pod yield (2083 kg/ha) compared to KRG-1 (1823 kg/ha) but on

par with ICGS-11 (1953 kg/ha). The increase in pod yield was mainly due to increase in number of pods and pod weight per plant. The increase in pod yield of R-8808 and ICGS-11 over KRG-1 was to the tune of 14.3 and 7.1 per cent, respectively. The better performance of R-8808 over ICGS-11 and KRG-1 was also reported earlier (Anon., 1993). There was not much difference in oil content of different varieties.

Effect of date of sowing

The pod yield of groundnut differed significantly due to date of sowing during both the years. The crop sown during November 2nd FN recorded significantly higher pod yield (2071 and 2782 kg/ha during 1991-92 and 1992-93, respectively) over that of December 2nd FN sown crop. On an average over two years, the crop sown during November 2nd FN, gave significantly higher pod yield (2426 kg/ha) com-

Table 1. Yield and yield attributes of groundnut as influenced by variety and dates of sowing

Treatments	Number of pods per plant			Pod weight per plant (g)			Pod yield (kg/ha)		
	1991-92	1992-93	Pooled	1991-92	1992-93	Pooled	1991-92	1992-93	Pooled
Varities(V)									
R-8808	19.9	18.9	19.40	12.3	17.9	15.10	1716	2450	2083
ICGS-11	17.5	18.5	18.00	10.5	17.5	14.00	1576	2330	1953
KRG-1	18.2	17.1	17.65	11.8	13.4	12.60	1617	2029	1823
S.Em +	0.90	0.58	0.51	0.85	0.42	0.48	83.2	69.9	58.94
C.D. at 5%	NS	1.75	NS	NS	1.25	1.37	NS	209.5	169.79
Dates of sowing (D)									
November 2nd FN	20.6	19.6	20.10	11.6	18.8	15.20	2071	2782	2426
December 1st FN	17.7	17.8	17.75	12.9	14.3	13.60	1595	1972	1784
December 2nd FN	17.3	17.4	17.35	9.9	15.6	12.75	1243	2054	1648
S.Em +	0.90	0.58	0.51	0.85	0.42	0.48	83.2	69.9	58.94
C.D. at 5%	2.71	1.75	1.47	2.56	1.25	1.37	249.6	209.5	169.79

Table 2. Effect of variety and dates of sowing on 100 kernel weight, shelling percentage and oil content of groundnut

Treatments	100 kernel weight			Shelling percentage			Oil content(%)		
	1991-92	1992-93	Pooled	1991-92	1992-93	Pooled	1991-92	1992-93	Pooled
Varieties(V)									
R-8808	29.3	40.2	34.75	67.9	69.4	68.65	46.4	47.8	47.10
ICGS-11	25.2	43.2	34.20	67.6	70.8	69.20	45.1	49.3	47.20
KRG-1	28.8	33.6	31.20	66.4	67.7	67.05	46.5	48.4	47.45
S.Em \pm	0.88	0.86	0.62	1.09	1.29	0.85	0.47	0.49	0.34
C.D. at 5%	2.66	2.57	1.78	NS	NS	NS	NS	NS	NS
Dates of sowing (D)									
November 2nd FN	29.7	38.1	33.90	67.4	74.7	71.05	44.9	48.4	46.65
December 1st FN	27.6	39.5	33.55	66.3	71.3	68.80	45.3	48.7	47.00
December 2nd FN	26.1	39.3	32.70	68.1	71.8	69.95	47.5	48.4	47.95
S.Em \pm	0.89	0.83	6.62	1.09	1.29	0.85	0.47	0.49	0.34
C.D. at 5%	2.66	NS	NS	NS	NS	2.44	1.43	NS	0.98

pared to December 1st FN (1784 kg/ha) and December 2nd FN (1684 kg/ha) sown crop which were on par with each other. The results are in conformity with the findings of Prasad and Reddy, 1990 and Padma and Madhusudhana Rao, 1992. The increase in pod yield of groundnut sown during November 2nd FN and December 1st FN over that of December 2nd FN was to the extent of 47.2 and 8.3 per cent, respectively.

The effect of date of sowing on number of pods/plant was significant during both the years (Table 1). During 1991-92, the crop sown during November 2nd FN recorded significantly higher number of pods/plant (20.6) over those sown during 1st and 2nd FN of December (17.7 and 17.3), respectively which were on par with each other. The trend was also similar during 1992-93. On an average over two years, the November 2nd FN sown crop also

recorded significantly higher pod yield/plant (15.2 g) over the crops sown during 1st and 2nd FN of December. In contrast, the oil content increased with delay in date of sowing. The increase in oil content may be due to lower temperature prevailed during early stage of crop growth in December 2nd FN sown crop.

LITERATURE CITED

- Anonymous. 1993. Annual Progress Report for 1992-93, 43rd Annual Rabi Oilseed Research Workers Group Meeting of AICORPO, CRIDA, Hyderabad, pp. PB 49.
- Prasad, J.V.L.V. and Reddy, T.R. 1990. Effect of date of sowing on yield and yield components in rabi groundnut varieties. *J. Res.* 18(1): 54-56.
- Padma, V. and Madhusudhana Rao, D.V. 1992. Influence of sowing dates and seasons in growth, development and yield of groundnut (*Arachis hypogaea*). *J. Oil-seeds Res.* 9(1): 33-42.

PROVENANCE EFFECT ON SEED QUALITY OF GROUNDNUT (*Arachis hypogaea* L.) IN KARNATAKA*

S. NARAYANA SWAMY and K.G. SHAMBULINGAPPA

Seed Technology Research Unit, National Seed Project, GKVK, Bangalore - 560 065.

ABSTRACT

Twenty seed samples of two groundnut cultivars were collected from six districts of southern Karnataka viz., Bangalore, Chikkamagalur, Hassan, Kolar, Shimoga and Tumkur during *kharif* 1988 to study the seed quality produced at different provenances. Significant differences were found among provenances with respect to number of kernel per pod, shelling percentage, oil content, electrical conductivity of seed leachate, test weight and germination. Whereas, vigour index was non-significant. Three kernel per pod varied from 3.07 to 11.60 per cent at location-7 and 3 for JL-24, shelling varied from 68.20 to 72.73 per cent for TMV-2, oil content ranged 40.41 to 47.43 per cent and test weight ranged from 25.73 to 34.90 g and 38.20 to 46.50 g for TMV-2 and JL-24 respectively. *Aspergillus flavus*, *Aspergillus niger*, *Penicillium* spp. and *Mucor* spp. were the commonly found fungi which cause considerable reduction in germination with the increased association. Provenances with minimum fungal association may be selected for seed multiplication purposes.

Keywords : Provenance; Kernels; Shelling; Seed leachate; Germination; Vigour; Seed weight; Mycoflora; Oil content.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is one of the important oilseed crops contributing more than 50 per cent to the oilseed production of the country. Variability in seed quality exists among provenances and can be related partly to differences in the habit of growth, reproduction and partly to the adaptability of these genotypes to the environmental factors like temperature, relative humidity, photoperiod, wind velocity, soil type and nutrition (Vanangamudi and Karivaratharaju, 1985). Besides these variations, there are possibilities for variation in the deposition of chemical reserves and seed qualities such as germination, vigour index, test weight, shelling capacity and mycoflora. The information on the seed quality of groundnut produced at different provenan-

ces in Southern Karnataka is not available and hence the study was undertaken.

MATERIALS AND METHODS

Twenty seed samples of JL-24 and TMV-2 groundnut pods were collected from the districts of Bangalore, Chikkamagalore, Hassan, Kolar, Shimoga and Tumkur during *kharif* 1988 to study the quality of seed produced in different provenances (Table 1). It includes breeder, foundation and certified seed lots. The seed samples were uniformly hand graded and the observations were recorded on shelling capacity, number of kernel per pod, germination (Anon. 1985), seedling measurement and field emergence on sixteenth day after sowing (Saha and Dwivedi, 1981). Oil content of the seeds was estimated using Nuclear Magnetic

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

Received for publication on February 26, 1994.

Table 1. Particulars of JL-24 and TMV-2 groundnut pods collected from different provenances produced during *kharif*, 1988

Treatments	Kind of seeds	Provenance of production		
		Village	Taluk	District
L ₁ V ₁	Breeder	Mudigere	Mudigere	Chikamagalur
L ₂ V ₁	Foundation	Kondarahalli	Hosakote	Bangalore
L ₃ V ₁	Foundation	Agatimadaka	Bagepalli	Kolar
L ₄ V ₁	Foundation	Chintamani	Chintamani	Kolar
L ₅ V ₁	Foundation	Hirenagavalli	Chikkaballapura	Kolar
L ₆ V ₁	Foundation	Tolampalli	Bagepalli	Kolar
L ₇ V ₁	Certified	Chelur	Bagepalli	Kolar
L ₈ V ₁	Certified	Tolampalli	Bagepalli	Kolar
L ₁ V ₂	Breeder	GKVKcampus	Bangalore North	Bangalore
L ₂ V ₂	Foundation	Agrahara	Devanahalli	Bangalore
L ₃ V ₂	Certified	Avaregere	Ramanagar	Bangalore
L ₄ V ₂	Certified	Hirehalli	Ramanagar	Bangalore
L ₅ V ₂	Certified	Komaranahalli	Ramanagar	Bangalore
L ₆ V ₂	Breeder	Kandli	Hassan	Hassan
L ₇ V ₂	Foundation	Gudubavanahalli	Chintamani	Kolar
L ₈ V ₂	Certified	Abbuvarapalli	Bagepalli	Kolar
L ₉ V ₂	Breeder	Honnave	Shimoga	Shimoga
L ₁₀ V ₂	Breeder	Kathalgere	Channagiri	Shimoga
L ₁₁ V ₂	Breeder	Navile	Shimoga	Shimoga
L ₁₂ V ₂	Certified	Handikunte	Sira	Tumkur

V₁: JL-24 V₂: TMV-2

Resonance (NMR) spectrometer (Model 20 Pi). Test weight was determined by randomly counting 100 seeds in three replications and weighed in grams, Electrical conductivity of seed leachate was analysed (Mathews and Powell, 1981). For Mycoflora detection, the seeds soaked on wet blotters were incubated at a temperature of $24 \pm 2^\circ \text{C}$ for eight days in an incubator. They were then examined for fungal infection using a compound microscope (Anon., 1985).

The soils of Bangalore, Hassan, Kolar, Shimoga and Tumkur are classified as Red

loamy and Red sandy. These soils are very deep, dark brown to dark red, sandy loam to clay loam on the surface and loam to clay loam and at places gravelly sandy clay in the sub-surface horizon with distinct argillic horizon. These are neutral to weakly acidic in reaction, low in cation exchange capacity, base saturation and medium to high in water holding capacity. The soils are well drained with moderate permeability. The soils of parts of Chikamagalur are laterite. These are deep to very deep. Yellowish red to dark red, reddish brown to brown, clay loam to gravelly sandy on the surface and clay loam to gravelly sandy clay

or clay in the sub-surface horizon. They are acidic in reaction, low in cation exchange base saturation and water holding capacity. These are well drained to excessively drained with moderately rapid permeability.

RESULTS AND DISCUSSION

The percentage of single kernel per pod was found significant with TMV-2 and non-significant with JL-24 (Table 1). While, it was vice-versa for three kernel per pod. Single kernel/pod (Table 2) was the highest (12.40%) at L₂ with TMV-2 and (11.60%) for three kernel per pod with JL-24 at L₃. The number of kernel per pod is basically cultivar dependent, though

it is influenced to some extent by season, location and other factors also. These results also confirm the findings of Seshadri, (1962) and Varisai Muhammed *et al.*, (1973). Single kernel character is not cultivar specific but it may occur in all most all cultivars (Bunting, 1955).

Shelling capacity was found significant among provenances with TMV-2 and non-significant with JL-24. The mean shelling was 74.02% and 71.11% in JL-24 and TMV-2 respectively (Table 2). Varietal differences was observed in addition to the environmental conditions of production and agronomic management of the crop. Oil content and electrical conductivity of seed leachate was found sig-

Table 2. Effect of provenance on production of single and three kernel pods, shelling and electrical conductivity (EC) of seed leachate in groundnut cultivars

Variety Locations	JL-24				TMV-2			
	Kernel/Pod		Shelling (%)	E.C. of seed leachate (dsm ⁻¹)	Kernel/Pod		Shelling (%)	E.C. of seed leachate (dsm ⁻¹)
	Single (%)	Three (%)			Single (%)	Three (%)		
L ₁	6.67	4.53	73.73	0.27	6.53	0.00	72.71	0.58
L ₂	7.47	7.60	74.67	0.28	4.00	0.00	70.67	0.39
L ₃	5.33	11.60	72.27	0.36	0.40	0.00	72.60	0.28
L ₄	8.40	4.53	74.27	0.21	5.47	0.00	72.73	0.29
L ₅	8.67	8.40	75.60	0.27	9.07	0.00	71.93	0.39
L ₆	7.20	7.87	73.60	0.32	3.60	0.27	70.33	0.55
L ₇	8.93	3.07	75.47	0.32	4.67	0.00	69.15	0.25
L ₈	8.03	3.33	72.53	0.20	2.80	0.00	71.33	0.44
L ₉					4.40	0.93	68.20	0.19
L ₁₀					4.67	0.00	69.00	0.35
L ₁₁					7.60	0.27	72.07	0.32
L ₁₂					12.40	0.00	72.60	0.59
Mean	7.59	6.37	74.02	0.28	5.47	0.12	71.11	0.39
S.Em ±	0.96	1.28	0.53	0.05	1.04	1.07	0.35	0.04
C.D (P<0.05)	NS	3.87	NS	NS	3.04	NS	1.01	0.12

NS: Non-Significant; L₁₋₈: JL-24; L₁₋₁₂: TMV-2.

nificantly different among provenances with TMV-2 and non-significant with JL-24 (Fig.1). The mean oil content was 44.77% and 43.79% with JL-24 and TMV-2, respectively. Oil accumulation is temperature sensitive, high temperature favours high oil content. Provenances with high temperature favours high oil content. Provenances with high temperature and also due to agronomic management of crop favoured the oil accumulation as it was reported by Pandey and Thejappa (1975) in cotton. The locational variation causes the variation in oil content of groundnut was also noticed by Dhawan *et al.*, (1981). Both the cultivars differed significantly for test weight of kernel due to provenances (Fig.1). The mean test weight of 41.36 g and 28.47 g was recorded with JL-24 and TMV-2

respectively. This could be attributed to cultivar differences. Further, the differences among locations might be due to environmental changes and agronomic management of the crop (Fig. 1). The above results are in agreement with the findings of Pandey and Thejappa (1975) in cotton.

Germination and hypocotyl length differed significantly among the provenances with JL-24 and non-significant with TMV-2 (Table 3). Vigour index was non-significant in both the cultivars. The mean germination of 82.42% and 80.25% was recorded with JL-24 and TMV- 2 respectively. The germination differences among locations might be due to the variations in growing conditions, harvest and post-harvest conditions of the seed.

Table 3. Effect of provenance on seed quality of groundnut cultivars

Variety Locations	JL-24			TMV-2		
	Laboratory Germination (%)	Hypocotyl length (cm)	Vigour index	Laboratory germination (%)	Hypocotyl length (cm)	Vigour index
L ₁	86.67	8.78	763	76.00	9.70	743
L ₂	94.67	8.23	779	78.67	8.67	679
L ₃	74.67	8.18	614	79.33	9.67	771
L ₄	82.67	7.97	661	80.67	9.10	731
L ₅	80.00	10.35	758	80.00	10.93	879
L ₆	79.33	10.13	803	83.33	9.93	826
L ₇	94.00	9.25	870	80.00	9.62	770
L ₈	81.33	8.78	719	82.00	10.35	845
L ₉				81.33	10.47	852
L ₁₀				82.00	9.67	791
L ₁₁				84.67	10.23	868
L ₁₂				75.00	10.00	749
Mean	84.17	8.96	750	80.25	9.86	792
S.E.m ±	2.98	0.45	60.87	2.25	0.52	54.83
C.D (P < 0.05)	9.04	1.36	NS	NS	NS	NS

NS : Non-Significant; L₁-8: JL-24; L₁-12: TMV-2.

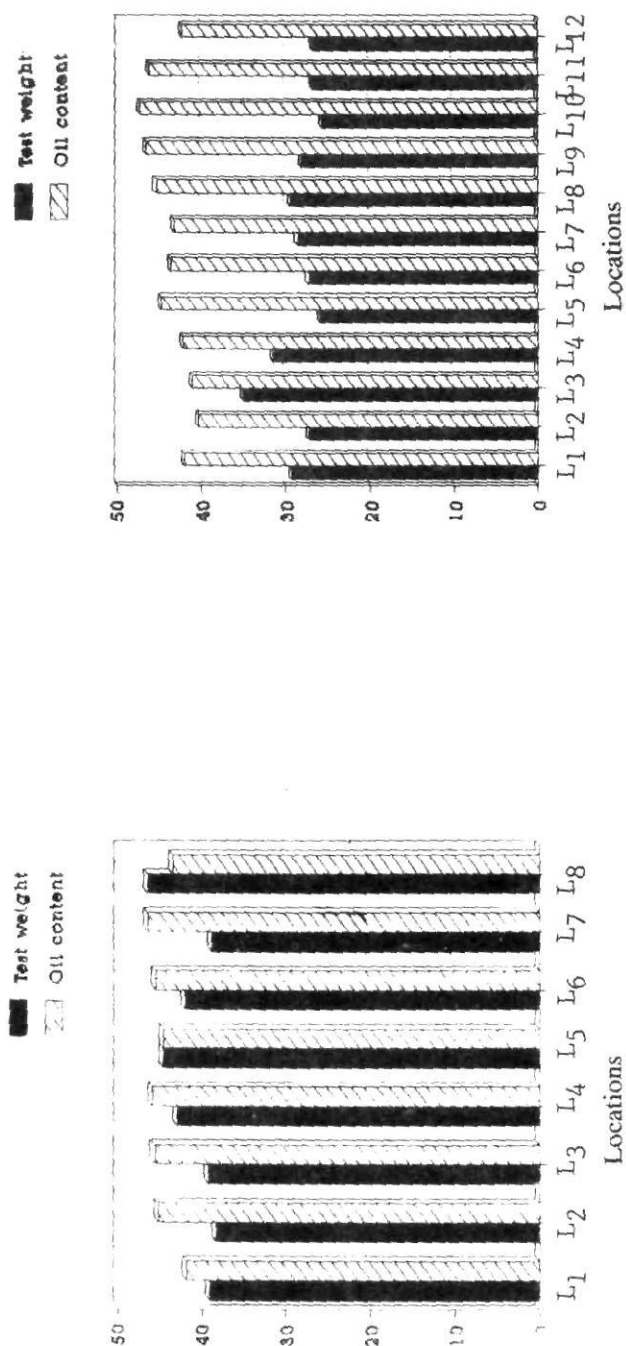


Fig.1. EFFECT OF PROVENANCE ON TEST WEIGHT AND OIL CONTENT FOR GROUNDNUT CULTIVARS.

Fungi belonging to six species of five genera identified on seeds (Table 4) were *Aspergillus flavus*, *Aspergillus niger*, *Macrophomina phaseolina*, *Mucor* spp., *Pencillium* spp. and *Rhizopus* spp. It could be clearly seen that higher (75%) association of fungi had given only 10 per cent germination with JL-24 produced at Mudigere. While TMV-2 produced at Avaregere of Bangalore district had recorded highest (91 per cent) germination with no association of fungi. Similar results were obtained by Srinivasulu *et al.* (1990) from Andhra Pradesh and Gangawane and Jadhav (1992) from Maharashtra who isolated and identified the fungi's association with groundnut seed.

To conclude significant differences were found among provenances with respect to number of kernel per pod, shelling percentage, oil content, electrical conductivity, test weight and germination. Whereas vigour index was non-significant. *Aspergillus flavus*, *Aspergillus niger*, *Pencillium* ssp. and *Mucor* spp. were the commonly found fungi and these causes considerable reduction in germination with increased association. Provenances with minimum fungal association may be selected for seed multiplication purposes.

LITERATURE CITED

- Abdul Baki, A.A. and Anderson, J.D. 1973. Vigour determination in soybean seed by multiple criteria. *Crop Sci.*, 13:630-633.
- Anonymous. 1985. International rules for seed testing. *Seed Sci. and Technol.*, 13:299-335.
- Bunting, A.H. 1955. A classification of cultivated groundnut. *Empire J. Expt.agric.* 23:158-170.
- Dhawan, K., Kumar, P., Yadava, T.P. and Gupta, S.K. 1981. Locational effect on the chemical composition of groundnut *Indian J. Agric. Res.*, 15(2): 123-125.
- Matthews, S. and Powell, A.A. 1981. Electrical conductivity test. In: Hand book of vigour test methods Ed.
- by D.A.Perry pp. 37-42. The International Seed Testing Association, Switzerland.
- Pandey, S.N. and Thejappa, N. 1975. Place and environment effect on seed weight and oil content of cotton seeds. *Mysore J. agric. Sci.*, 9:34-39.
- Saha, S.N. and Dwivedi, R.S. 1981. Seed germination behaviour in groundnut. *Seed Res.*, 9(2): 144-147.
- Sheshadri, C.R., 1962. Groundnut. *The Indian Central Oil Seeds Committee*, Hyderabad, Andhra Pradesh.
- Vanangamubi, K. and Karivaratharaju, T.V. 1985. Seed quality of sorghum as influenced by provenance of production and sowing. *Madras Agric. J.*, 72:226-227.
- Varisai Muhammed, S., Ramanathan, T. and Ramachandran, M. 1973. Variation in morphological characters of (*Arachis hypogaea* L.) *Madras Agric. J.*, 60:1373-1379.

Table 4. Seed mycoflora and germination of groundnut cultivars

Locations/ varieties	Germination (%)	Seed rot due to fungi (%)
L ₁ V ₁	10	75
L ₂ V ₁	35	32
L ₃ V ₁	88	10
L ₄ V ₁	86	07
L ₅ V ₁	90	07
L ₆ V ₁	60	40
L ₇ V ₁	89	04
L ₈ V ₁	00	73
L ₁ V ₂	90	10
L ₂ V ₂	86	00
L ₃ V ₂	91	00
L ₄ V ₂	75	29
L ₅ V ₂	65	39
L ₆ V ₂	75	28
L ₇ V ₂	25	14
L ₈ V ₂	35	65
L ₉ V ₂	88	00
L ₁₀ V ₂	82	18
L ₁₁ V ₂	30	59
L ₁₂ V ₂	35	60

L₁₋₈ V₁: JL-24; L₁₋₁₂ V₂: TMV-2

EFFECT OF DATE OF SOWING AND IRRIGATION ON THE DIURNAL VARIATION IN PHYSIOLOGICAL PROCESSES IN THE LEAF OF INDIAN MUSTARD (*Brassica juncea*)

P.K.CHAKRABORTY

Regional Research Sub-station (Red & Laterite Zone). BCKV Sekhampur, Birbhum, W.B.

ABSTRACT

Studies on the effect of date of sowing and irrigation on the diurnal variation in physiological processes in the leaf of two genotypes of Indian mustard reveal that the leaf temperature (LT) at 100% flowering was maximum at 14 h with irrigation in case of early sown crop; unirrigated crop attained the maximum LT at 12 h. Photosynthetic photon flux density (PPFD) was higher under irrigated condition. The highest PPFD was recorded at 12 h in early sown crops. Early sown irrigated crop recorded two peaks of stomatal diffusion resistance (SDR) while under unirrigated condition, SDR increased continually. Leaf transpiration rate (TR) was maximum at 8 h and minimum at 14 or 16 h. The LT, PPFD, SDR and TR varied due to varietal and positional difference of the leaves. Low level of photosynthetic activity might be observed at 12 or 14 h in Indian mustard.

Keywords: Indian mustard; Leaf temperature(LT); Photosynthetic photon flux density; Stomatal diffusion resistance; Transpiration rate.

INTRODUCTION

Physiological processes in leaf are of paramount importance for dry matter accumulation and yield of Indian mustard (*Brassica juncea* (L.) Czern & Coss) Chakraborty *et al.*, 1991. Diurnal variation in leaf temperature and transpiration rate of intact peanut leaves have been reported by Nayyar *et al.* (1990). Little is known about the effects of date of sowing as well as irrigation on diurnal variation in physiological processes in the leaves of Indian mustard. An experiment, therefore, was planned to investigate the effects of date of sowing as well as irrigation on the diurnal variation in the physiological processes in the leaves of Indian mustard.

MATERIALS AND METHODS

A field experiment was conducted with 3 dates of sowing viz. 31 Oct., 15 and 30 Nov., 1990; 2 varieties viz. 'B-85' and 'Varuna' both under irrigated and un-irrigated condition in 3 replicates. Irrigations were applied at branching (26, 22, 21 days after sowing for 3 sowing dates respectively) and at first flowering stage (55, 50 and 47 days after sowing for 3 sowing dates respectively) of the crop. Ten plants were randomly selected from each plot. Leaf temperature (LT), Photosynthetic photon-flux density (PPFD), stomatal diffusion resistance (SDR) and leaf transpiration rate (TR) were measured in 2nd and 6th leaf from apex with the help of LI-1600 steady-state-porometer at

8, 10, 12, 14, and 16 h when the crop attained 100% flowering.

RESULTS AND DISCUSSION

Temperature of the 6th leaf was always higher than the 2nd leaf in all cases (Fig. 1) due to high rate of transpiration in 2nd leaf (Fig. 4) resulting in increased leaf diffusion resistance which led to heating of 6th leaf in the process. When 31st Oct. sown crop attained 100% flowering on 26th Dec., the highest leaf temperature was observed at 14 h with irrigation and at 12 h under unirrigated condition in both the cultivars; however, the leaf temperature of 'B-85' was more than 'Varuna'. Similar pattern was recorded in crops with 100% flowering on 8th January but those flowered on 28th January, recorded highest temperature at 12 h.

The 2nd leaf with better degree of exposure, always recorded higher photosynthetic photon-flux density than 6th leaf of the main stem (Fig.2). Under irrigated situation, both cultivars recorded high photosynthetic photon-flux density. The reflection (higher photon-flux density) under irrigated condition for 2nd leaf may be on account of high reflection (less dullness), which resulted from thin leaf lamina. In contrast, under unirrigated (moisture stress) condition the leaf blade will be thickened, coated with waxy glands (Denna, 1970) and absorb more light. The leaf size under irrigated condition will restrict light penetration to the lower leaf resulting in low photon-flux density as is also evident in Fig.2. The highest photosynthetic photon-flux density was recorded at 12 noon except in late sown and in unirrigated crop. The reason may be the north-south direction of the rows, almost normal incidence of solar radiation at 12 noon and the narrow leaf under the latter situation.

The 6th leaf always recorded higher stomatal diffusion resistance than the 2nd leaf in all cases along with low transpiration rate (Fig.4) and high leaf temperature (Fig.1). In case of early sown crop, both 'B-85' and 'Varuna' showed two peaks at 12 and 16 h under irrigated condition whereas under unirrigated condition, it increased continually up to 16 h. Stomates respond more rapidly to changes in light, temperature, carbon dioxide, water and other environmental factors (Gates, 1981). Under irrigated situation, two peaks were observed due to high leaf temperature (Heath and Orchard, 1957) and low illumination (Ehrler and Van Bavel, 1968). Under unirrigated condition, moisture stress may be the cause of continuous increase in stomatal resistance as Stomates respond through several feed back loops involving carbon dioxide and water vapour (Gates, 1981). Similar pattern was observed in late sown crop (Fig.3) i.e., crop sown on 15 November showed almost a bell-shaped variation. Late-sown crops showed a continuous rise in stomatal diffusion resistance because of higher atmospheric vapour pressure (7.1 mm). High leaf temperature and stomatal diffusion resistance of the 6th leaf could be attributed to high water potential gradient which negatively increases for root to apical leaf and creates a pull transpiration loss from leaf, uptake and movement in xylem system upward. Turner (1974) also observed that the critical water potential was high (less negative) for leaves low in the canopy and low (more negative) for leaves at the top of the canopy of maize, sorghum and tobacco.

The transpiration rate was always high in 2nd leaf (Fig. 4). In the 31st October sown crop, transpiration rate declined from 8 to 12 h because of increase in leaf temperature with the concomitant increase in leaf resistance

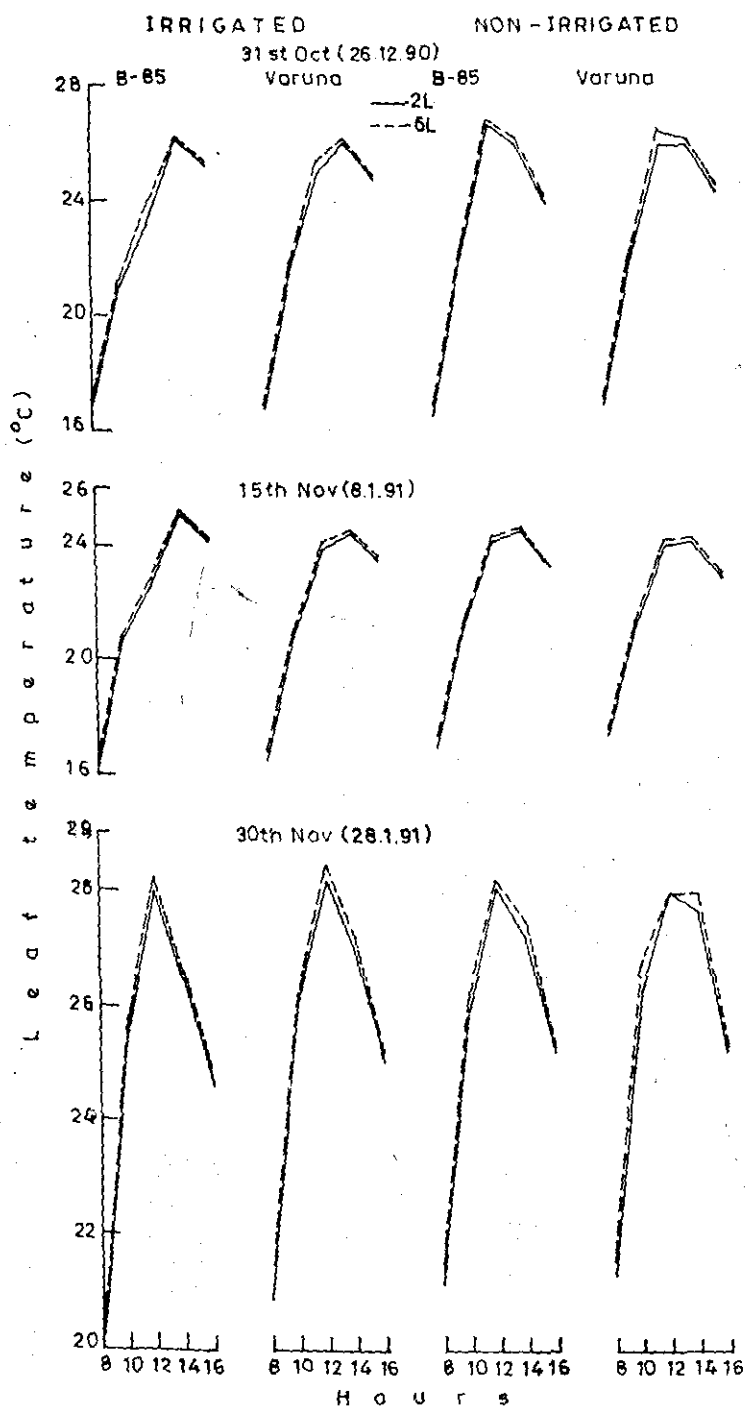


Fig.1: Diurnal variation in leaf temperature at 100% flowering when sown at different dates (Oct 31, Nov 15 & 30) under irrigated and non-irrigated moisture regimes in Indian mustard (*Brassica juncea* L.)

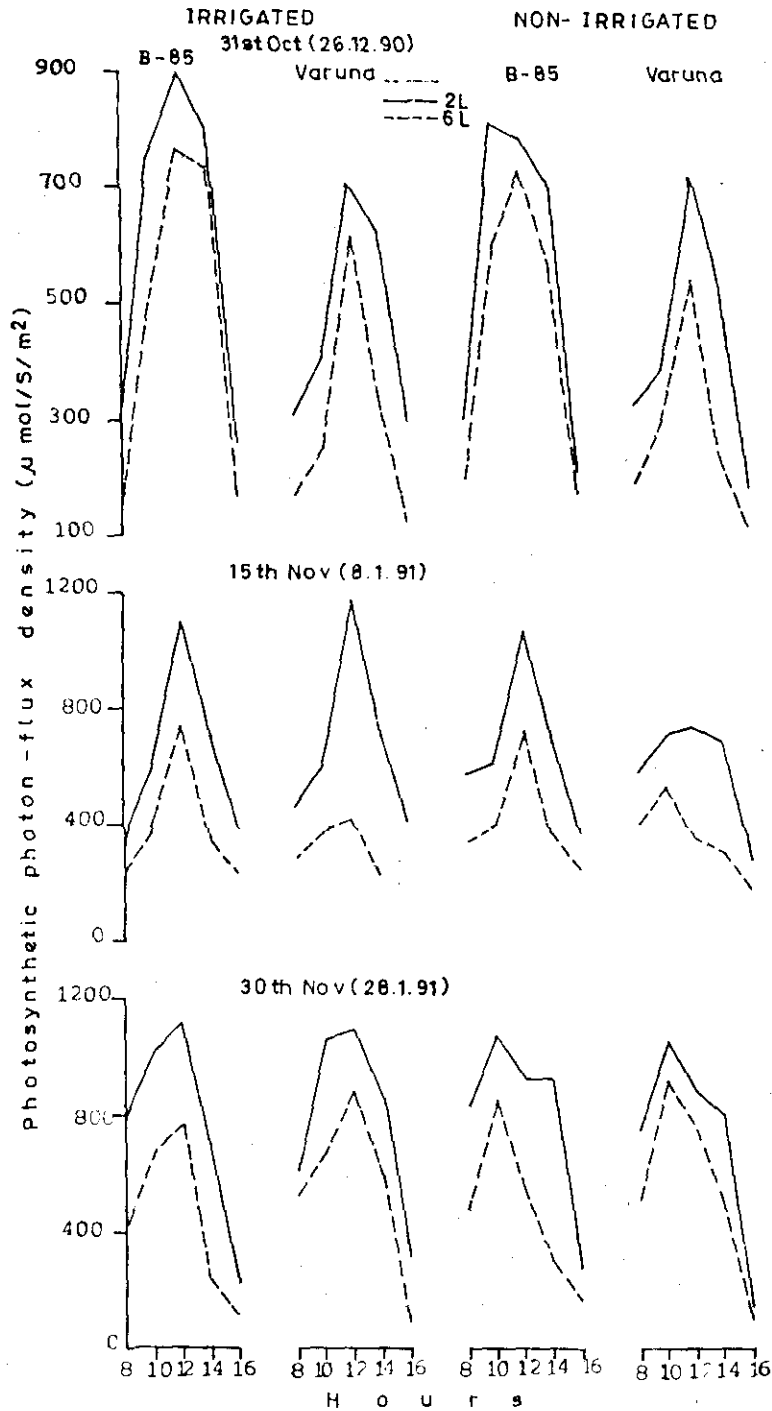


Fig.2: Diurnal variations in photosynthetic photon-flux density at 100% flowering when sown at different dates (Oct 31, Nov 15 & 30) under irrigated and non-irrigated moisture regimes in Indian mustard (*Brassica juncea* L.)

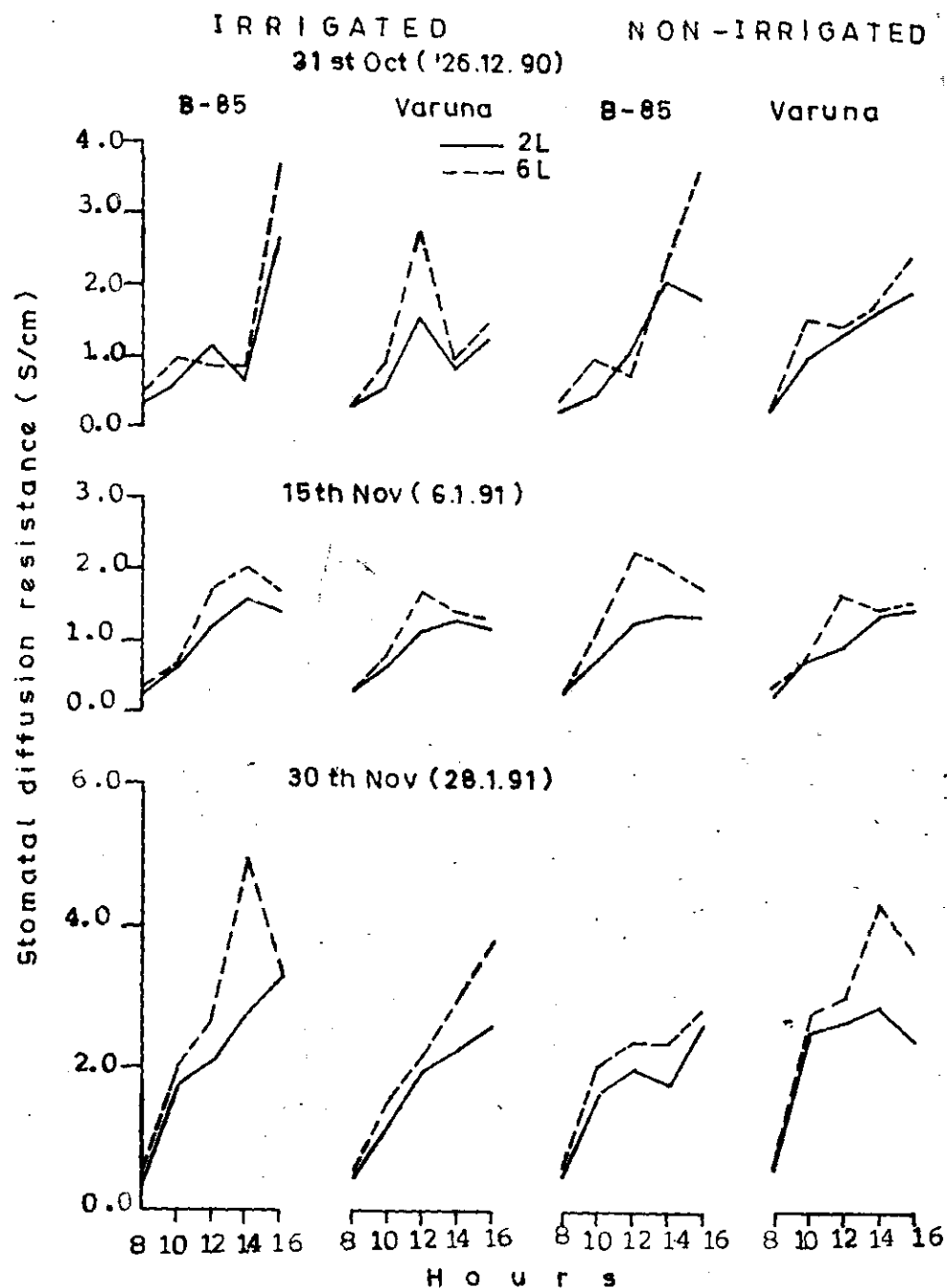


Fig.3: Diurnal variation in stomatal diffusion resistance at 100% flowering when sown at different dates (Oct 31, Nov 15 & 30) under irrigated and non-irrigated moisture regimes in Indian mustard (*Brassica juncea* L)

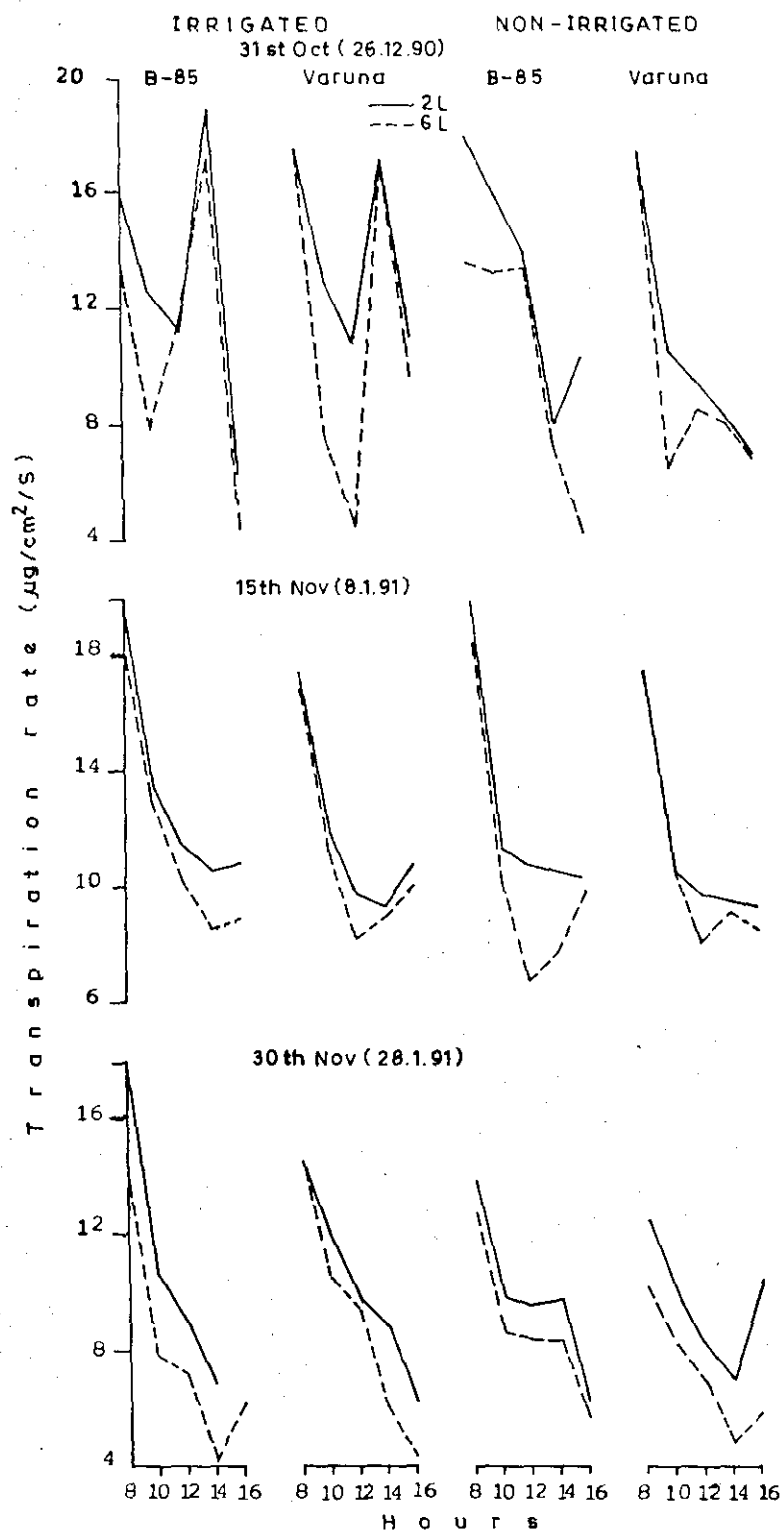


Fig4: Diurnal variations in transpiration rate at 100% flowering when sown at different dates (Oct 31, Nov 15 & 30) under irrigated and non-irrigated moisture regimes in Indian mustard (*Brassica juncea* L.)

which ultimately prevent the rapid desiccation of leaves under the large evaporative stress imposed by high leaf temperature (Wuenschel and Kozlowski, 1971). The Transpiration rate then increased sharply at 14 h and again declined to the lowest value at 16 h under irrigated condition; this also supported high stomatal diffusion resistance recorded at 12 and 16 h respectively. Under un-irrigated condition, highest value was recorded at 8 h which declined with advance of the day up to 16 h. In 15 November sown crop, under irrigated condition the transpiration rate declined up to 12 h and again peaked with opening of stomata due to cooling of weather in the evening solely in response to changed weather. Similar trend was observed under unirrigated situation; the 6th leaf, however, showed a little deviation. Under late sown condition, the transpiration rate was maximum at 8 and minimum at 14 or 16 h in all cases, probably when all the stomates were closed due to internal regulatory mechanism of the plant to restrict recessive loss under very hot/demanding situations.

Nayyar *et al.* (1990) reported that the carbon exchange rate during day-light hours declined under increased photosynthetically active radiation and leaf temperature in intact peanut leaves. The high photosynthetic photon-flux density with high leaf temperature as well as stomatal diffusion resistance at 12 or 14 h showed the probability of low carbon exchange during this period in Indian mustard. It thus indicated a high carbon exchange and photosynthesis during early morning and in late afternoon hours. Pallas and Samish (1974) also recorded similar observation in case of peanut. Application of irrigation increased leaf-sizes and reduced stomatal diffusion resistance and increased leaf transpiration but it did not reduce the leaf temperature to a significant

extent due to its direct exposure to sun light and its interception, recessive heat loss and thus high leaf transpiration failed to countermand the heating significantly. All the same, still the increased leaf size (photosynthetic apparatus area) under irrigated condition was helpful in increasing dry matter accumulation and ultimately the seed yield of the crop.

LITERATURE CITED

- Chakraborty P.K., Majumdar A. and Chatterjee B.N. 1991. Physiological processes in Indian mustard (*Brassica Juncea*) and Yellow sarson (*B. napus* Var. *glauca*) and their agronomic appraisal in mild and short winter prevailing in Gangetic plains of eastern India. *Indian J. of Agric. Sci.* 61: 815-21.
- Denna, D.W. 1970. Leaf wax and transpiration in *Brassica Oleracea* L. *J. Amer. Soc. Hort. Sci.* 95: 30-2.
- Ehrler, W.L. and Van Bavel, C.H.M. 1968. Leaf diffusion resistance, illuminance and transpiration. *Plant Physiol.* 43: 208-14.
- Gates, D.M. 1981. *Biophysical Ecology*, Narosa Publishing, New Delhi. p 331-332
- Heath, O.V.S. and Orchard, B. 1957. Temperature effects on the minimum intercellular space carbon dioxide concentration. *Nature*, London 180: 181-2.
- Nayyar, H., Malik, C.P., Singh, P., Parmar, U., Grewal, M. and Kaur, S. 1990. Diurnal variation in Photosynthetic parameters in peanut. *Photosynthetica* 24: 276-9.
- Pallas, J.E. Jr. and Samish, Y.B. 1974. Photosynthetic response of peanut. *Crop Sci.* 14: 478-82.
- Turner, N.C. 1974. Stomatal behavior and water status of maize, sorghum and tobacco under field conditions. *Plant Physiol.* 53: 360-5.
- Wuenschel, J.E. and Kozlowski, T.T. 1971. The response of transpiration resistance to leaf temperature as a desiccation resistance mechanism in tree seedlings. *Physiologia Plantarum* 24: 254-9

INFLUENCE OF SPATIAL ARRANGEMENT AND NITROGEN LEVELS ON LIGHT UTILIZATION AND PRODUCTIVITY IN MAIZE-SOYBEAN INTERCROPPING SYSTEM

R.S. SHARMA, K.K. AGRAWAL and K.K. JAIN

Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.) 482 004.

ABSTRACT

Field experiments were conducted during *kharif* 1983 and 1984 at research farm, J.N.Krishi Vishwa Vidyalaya, Jabalpur (M.P.) to study the effect of spatial arrangement and nitrogen levels on light utilization and productivity of maize based intercropping with soybean. Base crop maize did not compete for light with soybean as companion crop under intercropping system but light available to soybean was reduced by maize interference. Alternate paired row spatial arrangement provided more light to soybean without declining the desired light utilization for the maize. Increasing rates of N application to maize correspondingly reduced the availability of light to soybean. Maize yield was unaffected by intercropping with soybean. Alternate single row or paired row spatial arrangement did not vary for maize yield but latter given markedly higher yields of soybean. Every incremental dose of 30 kg N from 0 to 120 kg N/ha markedly increased maize yields but results reversed for soybean yields. Paired row spatial arrangement provided better intercropping situation particularly with higher levels of N application.

Keywords: Maize; Soybean; Intercropping system; Nitrogen levels; Light Transmission Ratio.

INTRODUCTION

Intercropping of short growing and shade tolerant crop soybean with maize (tall growing and tolerant to high solar radiation) may provide better crop compatibility because of variable genotypic behaviour and cause their individual growth to experience different micro-environment due to competition for natural resources (Donald, 1963; Trenbath, 1971). Intercropping of soybean with maize can be helpful to economize the nitrogen application in maize. Spatial complementarity can provide more advantages over temporal complementarity in intercropping system as a result of efficient exploitation of resources (Willey, 1979). Pairing of maize rows can provide more inter-row space to accommodate two rows of

soybean without reducing the plant population of maize. Keeping the above views in mind, the present investigation was aimed to maximize the yield of associated soybean without sacrificing the yield of main crop maize in intercropping system.

MATERIALS AND METHODS

The field experiments were carried out during the *kharif* seasons of 1983 and 1984 under rainfed conditions at the research farm, J.N.Krishi Vishwa Vidyalaya, Jabalpur (M.P.). Treatments consisted of two intercropping systems viz., maize + soybean in alternate single and paired rows; and four nitrogen levels to maize viz., 0, 30, 60, and 120 kg N/ha tested in Factorial Randomized Block Design with three

replications. Crop varieties used were "Ganga-5" for maize and "JS-2" for soybean. Uniform plant population of maize in 90 cm x 20 cm spacing was maintained by dibbling two seeds per hill and then thinning to one seedling/hill after 10 days of emergence. Soybean was sown in alternate single or paired row of 15 cm apart. The intra row spacing of 5 cm for soybean was maintained by thinning of plants after 10 days of germination. A uniform dose of 60 kg P₂O₅ and 10 kg K₂O per ha was given to all plots at sowing. Nitrogen was given only to maize crop as per treatments. Half of the total N was given at sowing and remaining half dose was applied as top-dress at 25 day growth stage. Seeds of soybean were inoculated with *rhizobium* culture at the rate of 5 g/kg of seeds. Sowing was done on July 4 and 5 in two consecutive years.

For solar radiation, the crop stand was treated as perfectly diffused reflecting surface. The light intensity on maize canopy surface and the infiltration profiles within the canopy on the middle and ground levels were recorded in lux (Aplab lux meter type-ML 4420) at 25, 50 and 75 days- growth stages. The light transmission ratio (LTR) was computed in crop stands of maize grown with soybean by using the following formula (Golingai and Mabbayard, 1969):

$$LTR = \frac{I}{I_0}$$

where I and I_0 refer the light intensity on the horizontal surface at ground and mid canopy levels, respectively. Foliar absorption coefficient or light extinction coefficient (K) was calculated by formula as suggested by Noble, (1974).

$$\log \frac{I}{I_0} = -K^L$$

Where L is Leaf Area Index (LAI)

RESULTS AND DISCUSSION

Effect of solar radiation

Spatial complementarities did not cause marked variation in LTR to base crop maize at any of the growth stages, though the values were relatively higher under alternate paired rows system than alternate single row system (Table 1). Consequently, light extinction coefficient (K) significantly reduced under paired rows arrangement over alternate single row arrangement. The LTR and K values were maximum at knee high stage (25 DAS) of maize and then both values decreased successively during advanced growth stages i.e. at tasselling (50 DAS) and silking (75 DAS) because of increased LAI values in maize which probably interfered the interception of light. Companion crop soybean being shorter in height than maize did not interfere the light absorption by the maize, but light availability to soybean was curtailed by maize interference. The light interference by maize become more serious with the increasing levels of nitrogen to maize up to 120 kg N/ha which could be gauged from marked reduction in LTR and K values. This may be as a result of increased LAI in maize with higher levels of N application. The LAI did not differ between the two spatial arrangements, but increasing rates of N application significantly increased the LAI at all growth stages. Obviously, the LAI values were higher with lower levels of N (0 and 30 kg N/ha) under alternate single row planting arrangement than alternate paired rows system and the results were vice-versa at higher N levels (60 and 120 kg N/ha). As a consequence, alternate paired row arrangement resulted in higher LTR and lesser K values for maize with lower N dose which could be helpful to provide more light for the as-

Treatment	LTR		K		LAI	
	Knee high (25 DAS)	Tasselling (30 DAS)	Silking (75 DAS)	Knee high (25 DAS)	Tasselling (30 DAS)	Silking (75 DAS)
Spatial arrangement						
Maize + Soybean (A)	0.552	0.430	0.435	0.425	0.262	0.188
Maize + Soybean (P)	0.578	0.472	0.450	0.333	0.197	0.147
CD (P 0.05)	NS	0.032	NS	0.068	0.041	0.034
N - kg/ha						
0 N	0.572	0.471	0.512	0.687	0.407	0.256
30 N	0.601	0.473	0.460	0.282	0.242	0.173
60 N	0.555	0.468	0.427	0.272	0.138	0.112
120 N	0.467	0.391	0.379	0.275	0.133	0.124
CD (P 0.05)	0.088	0.074	0.053	0.117	0.083	0.075
Interaction						
Maize + Soybean (A)						
0 N	0.887	0.444	0.521	0.768	0.465	0.293
30 N	0.543	0.458	0.463	0.319	0.277	0.191
60 N	0.519	0.454	0.417	0.304	0.156	0.118
120 N	0.448	0.364	0.365	0.278	0.150	0.141
Maize + Soybean (P)						
0 N	0.566	0.497	0.513	0.603	0.348	0.218
30 N	0.659	0.487	0.457	0.214	0.206	0.155
60 N	0.591	0.481	0.438	0.239	0.120	0.106
120 N	0.486	0.424	0.392	0.272	0.115	0.107
CD (P 0.05)	NS	0.083	0.092	NS	0.107	0.083

A - Alternate single row, P - Alternate paired rows, N - kg/ha, DAS - days after sowing.

Table 2. Effect of spatial arrangements and nitrogen levels on grain yield in maize + soybean intercropping system

Treatment	Grain yield (q/ha)					
	Maize			Soybean		
	1983	1984	Mean	1983	1984	Mean
Spatial arrangement						
Maize + soybean (A)	23.00	25.87	24.44	9.35	6.80	8.07
Maize + soybean (P)	22.77	26.23	24.50	10.36	8.61	9.48
CD (P 0.05)	NS	NS	NS	0.96	0.63	0.56
N - kg/ha)						
0 N	6.13	8.07	7.10	12.82	9.68	11.25
30 N	16.88	20.59	18.73	11.11	8.21	9.91
60 N	29.78	33.70	31.74	9.02	7.06	8.04
120 N	38.78	41.84	40.31	6.48	5.36	5.92
CD (P - 0.05)	2.35	2.86	2.62	1.52	1.21	0.97
Interactions						
Maize + soybean (A)						
0 N	5.92	8.00	6.96	13.17	9.26	11.34
30 N	17.11	20.81	18.96	10.77	7.48	9.12
60 N	29.74	32.10	30.92	7.45	5.85	6.65
120 N	39.36	42.59	40.92	5.73	4.63	5.18
Maize + soybean (P)						
0 N	6.33	8.15	7.24	12.18	10.11	11.14
30 N	16.66	20.37	18.51	11.45	9.95	10.70
60 N	29.81	35.39	32.55	10.59	8.28	9.43
120 N	38.29	41.10	39.70	7.23	6.09	6.66
CD (P 0.05)	3.06	3.65	3.24	1.84	1.66	1.17

A- Alternate single row, P - alternate paired row, N - kg/ha.

sociated soybean crop particularly at higher levels of nitrogen. These results are in close conformity with the results of Willey (1979).

Effect on the productivity

Grain yield of base crop maize was unaffected due to both spatial arrangements when

soybean was intercropped with it, but alternate paired row intercropping system significantly resulted in higher yield of soybean than alternate single row system because of efficient utilization of light and space (Table 2). Thus, soybean as an intercrop gave additional yield as bonus in intercropping system without influencing the yield of base crop maize. This

indicated that soybean as an intercrop neither caused competition stress to maize for light and space nor helped maize as nitrogen donor to the soil which confirmed the opinions of Ahmed and Gunasena (1979). Every incremental dose of 30 kg N/ha to maize from 0 to 120 kg N/ha significantly increased the maize yield, but soybean yield correspondingly reduced up to the highest level. Singh *et al.* (1983) and Hiremath *et al.* (1983) also reported similar findings. The yield of maize did not vary between the two spatial arrangements but showed linear response to Nitrogen till the highest dose tested. The soybean yields, showed significant differences between the two spatial arrangements but showed negative response to nitrogen at its increased levels. The alternate paired row sowing arrangement for maize-soybean intercropping could be more advantageous particularly when high dose of fertilizers were used for yield maximization. These results also corroborated the findings of Ahmed and Rao (1982).

LITERATURE CITED

- Ahmed, S. and Gunasena, H.P.M. 1979. N-utilization and economics of some intercropped systems in tropical countries. *Top. Agric.* 56(1): 115-118.
- Ahmed, S. and Rao, M.R. 1982. Performance of maize-soybean intercrop combination in the tropics. Results of a multi-location study. *Field Crop Res.* 5: 147-161.
- Donald, C.M. 1963. Competition among crops and pastures. *Adv. Agron.* 15: 1-118; 26: 177-206.
- Golingai, S.A. and Mabbayard B.B. 1969. Plant arrangement and spacing study on C-63 and IR-8 (68) rice varieties. *Philippine agriculturist.* 52: 566-77.
- Hiremath, S.M., Chittapur, B.M. and Hosmani, M.H. 1993. Study on maize based intercropping with soybean. *J. Oilseed Res* 10 (1) : 163-164.
- Nobel, P.S. 1974. Introduction to biological plant physiology. Tokyo, Japan. pp. 194-207.
- Singh, C.M., Modgal, S.C., Sood, B.R. and Thakur, R.C. 1983. Studies on yield and economics of intercropping in rainfed maize under mid-hill valley conditions. *Him J. Agric. Res.* 9(1): 1-4.
- Trenbath, B.R. 1974. Biomass productivity of mixtures, *Adv. Agron.* 26: 177-206.
- Willey, R.W. 1979. Intercropping- its importance and research needs. I. Competition and yield advantages. II. Research approaches. *Field Crop Abstr.* 32: 2-10.

EVALUATION OF PREDICTABILITY OF OIL CONTENT OF GROUNDNUT KERNELS ON THE BASIS OF THEIR SPECIFIC GRAVITY

S.K. YADAV and J.B. MISRA

National Research Centre for Groundnut, Post Bag No. 5, Junagadh-362 001, Gujarat, India.

ABSTRACT

Kernels of twenty-three genotypes with oil content (Oil (S)) ranging from 41-55% were used for evaluating whether specific gravity of cotyledons (SPGR) can be used as an index for predicting oil content of groundnut genotypes. Five genotypes were characterized by their shrivelled testa. One of these genotypes was represented by two samples. Kernels of each sample were split into constituent cotyledons along with testa and collected into two different pools in a manner that each seed was represented in both the pools through its complementary cotyledons. One pool was used for estimation of SPGR while the other for Oil (S). Highly significant and negative correlation was obtained between SPGR and Oil (S) with samples having smooth testa ($r = -0.964^{**}$, $n = 18$). But the value of correlation coefficient decreased slightly when the values of SPGR and Oil (S) of six samples having shrivelled testa were also taken into calculation ($r = -0.882^{**}$, $n = 24$). Predictability of this relationship was also evaluated for comparing subsamples of genotypes. For this SPGR and Oil (S) of pools of complementary cotyledons of six subsamples each of seven genotypes were determined. The correlations were found to be significant only for four genotypes. However, when correlation was estimated between representative values (values representing average of six subsamples) of SPGR and Oil (S) of seven genotypes, it was found to be highly significant ($r = -0.984^{**}$). It was concluded that the specific gravity of groundnut cotyledons can be used for predicting oil content of groundnut genotypes provided the kernels do not have a shrivelled testa and have a constant ($4.6 \pm 1\%$) moisture content.

Keywords: Groundnut cotyledons; Specific gravity; Oil content; Predictability.

INTRODUCTION

Gravimetric procedure of Soxhlet extraction is regarded as the standard method for determining oil and fat content of foods and feeds. Technique of determination of oil content of oilseeds on the basis of their NMR spectrometry has also been developed (Conway and Earle 1963). Use of NMR spectrometry for oil content estimation of groundnut kernels has been standardized (Jambunathan *et al.*, 1985) and is being used widely. Use of nearinfrared spectroscopy

(NIR) has also been demonstrated for predicting oil and some other constituents of oilseeds (Panford *et al.*, 1988). On the basis of properties of floatation of groundnut kernels in brines of different specific gravities, it was earlier suggested that there exists an inverse relationship between the oil content and specific gravity of isolated cotyledons of groundnut (Magne and Beliquez 1963). Recently the functional relationship between the specific gravity of groundnut cotyledons (SPGR) and their oil content as determined by the Soxhlet extrac-

tion procedure [(Oil (S))] has been defined mathematically (Misra *et al.*, 1993) thus:

$$\text{Oil}^{\wedge} (\%) = 239.65 - (176.81 \times \text{SPGR}) \dots \dots \dots A$$

The correlation coefficient (r) has been shown to be -0.946** with a predictability of 89.5%. The relationship has, however, been shown to be valid only for the cotyledons rather than whole kernels. Moreover, this relationship was developed using specific gravities and oil contents of groundnut genotypes varying widely (42 to 55%) in their oil content. The objective of this study was to ascertain whether this inverse relationship would be sensitive enough to detect the marginal differences (say $\pm 1\%$) in the oil content of commercial cultivars which generally ranges between 48 and 51%, and whether it can be used as a reliable method for predicting oil content of groundnut genotypes.

MATERIALS AND METHODS

Seed material

Kernels of 18 groundnut genotypes from the Genetic Resources Section of the National Research Centre for Groundnut (NRCG) and 5 genotypes from the Genetic Resources Unit of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India were obtained. Samples of five genotypes viz. BAU 12, NRCG 2024, NRCG 1014, NRCG 3361 and NRCG 8940 were characterized by their shrivelled testa. The genotypes NRCG 2024 was represented by two samples which were designated as genotypes NRCG 2024a and NRCG 2024b.

Determination of seed moisture content

Seeds, approx. 10 g, were dried in an oven at 105°C to a constant weight and the per cent (w/w) moisture content was calculated.

Determination of Oil (S) and SPGR of complementary cotyledons of seed samples

For each sample approx. 20 g seeds were split into constituent cotyledons along with testa. The two cotyledons of a seed were collected in two different pools in a manner that each seed was represented in both the pools through its complementary cotyledons. One pool was processed for Oil (S) estimation and the other for SPGR determination as described earlier (Misra *et al.*, 1993).

Determination of Oil (S) and SPGR of kernel of groundnut genotypes

Kernels of seven genotypes viz. GG 2, Girnar 1, JL 24, Jyoti, NCAc 17500, TMV 2 and TMV 10 were used. The kernel sample of each genotype was divided into six sub-samples at random. Each sub-sample was further separated into two pools of complementary cotyledons and then processed for determination of Oil(S) and SPGR.

Statistical analysis

Standard statistical procedures as outlined by Canavos (1984) were followed.

RESULTS AND DISCUSSION

The moisture content of the samples ranged from 3.61 (ICGV 88399) to 6.20% (NRCG 8940) (Table 1). The values for mean and standard deviation were 4.65 and 0.68, respectively. The Oil(S) of samples ranged from 41.17 (BAU 12) to 54.61% (NCAc 17500) with the SPGR ranged from 1.0470 (NCAc 17500) to 1.1199 (ICG 799) (Table 1). The values for mean and SD were 47.23 and 3.12, respectively, for oil and 1.0866 and 0.018, respectively, for SPGR.

Table 1. Predictability of oil content on the basis of relationship between Oil(S) and SPGR estimated on complementary cotyledons of groundnut genotypes

Genotype	Moisture %	SPGR	Oil content %				
			Oil(S)	Oil ^ and residuals			
				Equation	B	Equation	C
NCAc 17500	4.37	1.0470	54.61	53.17	1.44	53.48	1.13
TMV 10	3.72	1.0688	49.34	49.89	-0.55	50.25	-0.91
Jyoti	4.28	1.0874	47.03	47.10	-0.07	47.49	-0.46
TMV 3	3.72	1.0603	50.39	51.17	-0.78	51.51	-1.12
Kadiri 3	4.72	1.0746	49.67	49.02	0.65	49.39	0.28
Kadiri 2	4.57	1.0826	48.92	47.82	1.10	48.20	0.72
ICGV 88399	3.61	1.0988	46.05	45.39	0.66	45.79	0.26
S 230	4.82	1.0785	48.46	48.44	0.02	48.81	-0.35
TG 7	4.59	1.0596	50.96	51.27	-0.31	51.61	-0.65
GAUG 10	4.62	1.0804	50.04	48.15	1.89	48.52	1.52
ICG 16	3.75	1.0952	47.14	45.93	1.21	46.33	0.81
ICG 38	4.15	1.1154	43.39	42.90	0.49	43.33	0.06
ICG 508	4.20	1.1070	43.33	44.16	-0.83	44.58	-1.25
ICG 799	4.24	1.1199	42.20	44.22	-2.02	42.66	-0.46
ICG 2411	-	1.0985	45.99	45.44	0.55	45.84	0.15
NRCG 918	5.34	1.0741	49.38	49.10	0.28	49.46	-0.08
NRCG 7276	5.60	1.0945	47.51	46.04	1.47	46.43	1.08
NRCG 8941	5.33	1.0700	49.32	49.71	-0.39	50.07	-0.75
BAU 12*	5.71	1.1060	41.17	44.31	-3.14		
NRCG 2024a*	4.77	1.0889	44.96	46.88	-1.92		
NRCG 2024B*	4.77	1.0937	44.18	46.16	-1.98		
NRCG 1014*	5.16	1.0798	46.84	48.24	-1.40		
NRCG 3361*	4.72	1.1087	47.48	43.91	3.57		
NRCG 8940*	6.20	1.0880	45.07	47.01	-1.94		

*Shrivelled testa

Variability in Oil (S) and SPGR of genotypes

Highest coefficient of variation (%) for Oil (S) (Table 3) was obtained for JL 24 (2.21) followed by TMV 10 (1.38), GG 2 (1.09), Girnar 1 (1.05), TMV 2 (0.83), NCAc 17500 (0.74), and Jyoti (0.59). For specific gravity the highest coefficient of variation (%) was obtained for JL

24 (0.59) followed by NCAc 17500 (0.48), Jyoti (0.38), Girnar 1 (0.32), TMV 10 (0.26), TMV 2 (0.22), and GG 2 (0.21). When the SPGR values of the six sub-samples of each of the seven genotypes were converted into oil content using equation A, the magnitudes of residuals ranged from 0.15 to 1.02 in GG 2, 0.18 to 0.76 in Girnar 1, 0.23 to 1.50 in JL 24, 0.25 to

Table 2. Correlation coefficients (r) for relationship between various sets of Oil(S) and SPGR

Particulars of set	n	r
Across genotypes (complementary cotyledons of a single sub-sample of each genotype)		
Equation B	24 ^{\$}	-0.882**
Equation C	18	-0.964**
Across genotypes (complementary cotyledons of six sub-samples of seven genotypes)		
Equation D	42	-0.966**
Within a genotype (complementary cotyledons of six sub-samples of each genotype)		
GG 2	6	-0.813*
Girnar 1	6	-0.842*
JL 24	6	-0.902*
Jyoti	6	NS
NCAc 17500	6	-0.812*
TMV 2	6	NS
TMV 10	6	NS
Across genotypes (taking average values of six sub samples)		
Equation A	7	-0.984**
Equation E	7	-0.984**

^{\$} includes genotypes with shrivelled testa

* and ** significant at 5 and 1% levels, respectively

1.91 in Jyoti, 0.07 to 2.22 in NCAc 17500, 0.09 to 1.11 in TMV 2 and 0.22 to 2.14 in TMV 10.

Correlation coefficients and regression equations

The correlation coefficients (r) for various sets of values of Oil(S) and SPGR are given in Table 2. The regression equation based on Oil (S) and SPGR of 24 genotypes "B" and that based on only 18 genotypes "C" (excluding genotypes with shrivelled testa), respectively, were:

$$\text{Oil}^{\wedge} (\%) = 210.29 - (150.08 \times \text{SPGR}) \dots\dots\dots \text{B}$$

$$\text{Oil}^{\wedge} (\%) = 208.65 - (176.81 \times \text{SPGR}) \dots\dots\dots \text{C}$$

The Oil[^] calculated on the basis of equations B (24 genotypes) and C (18 genotypes) alongwith corresponding residuals are given in Table 1. The minimum and maximum magnitudes of residuals for B and C equation were 0.02 and 3.57, 0.06 and 1.52, respectively. The regression equation obtained on the basis of values of SPGR and Oil (S) of 42 sets of complementary cotyledons (6 sub-samples each of the 7 genotypes, data not shown) was:

$$\text{Oil}^{\wedge} (\%) = 237.76 - (174.95 \times \text{SPGR}) \dots\dots\dots \text{D}$$

Within the seven genotypes tested, the correlation coefficients for Oil(S) and SPGR (of complementary cotyledons derived from six

Table 3. Representative (average of six determinations) SPGR and Oil(S) of seven groundnut genotypes and their Oil[^]

Genotype	Specific gravity	Oil(S) %	Oil [^] and residual %			
			Equation	E	Equation	A
GG 2	1.0776	49.61	49.24	0.37	49.12	0.49
Girnar 1	1.0621	51.42	52.01	-0.59	51.87	-0.45
JL 24	1.1020	43.93	44.87	-0.94	44.81	-0.88
Jyoti	1.0908	47.66	46.85	0.81	46.79	0.87
NCAc 17500	1.0526	53.20	53.72	-0.52	53.54	-0.34
TMV 2	1.0001	45.39	45.21	0.18	45.14	0.25
TMV 10	1.0570	53.61	52.93	0.68	52.76	0.85

sub-samples) were significant only for four genotypes viz. GG 2, Girnar 1, JL 24 and NCAc 17500 (Table 2). The regression equation obtained on the basis of average values of six determinations of Oil (S) and SPGR of seven genotypes was:

$$\text{Oil } \hat{(\%)} = 242.26 - (179.13 \times \text{SPGR}) \dots\dots\dots \text{E}$$

For both the equations A and E, when correlation was estimated between the representative values (average values of six sub-samples) of Oil (S) of seven genotypes and corresponding Oil $\hat{}$ values (obtained by using representative SPGR) the correlation coefficient was found to be highly significant ($r = -0.984^{**}$) with a predictability of 97%. The values of Oil $\hat{}$ calculated on the basis of equation A and E and the corresponding residuals for the seven genotypes are shown in Table 3. In case of equation A, a maximum magnitude of residual was 0.88 for genotype JL 24 and the minimum was 0.25 for genotype TMV 2. Among the residuals obtained on the basis of equation E, a maximum magnitude of 0.94 was for genotype JL-24, and a minimum of 0.18 for genotype TMV 2.

The highest predictability was for equation E (97%), followed by equation D and C (93% each), and the lowest for equation B (78%).

Discussion

In earlier study Misra *et al.*, (1993), used separate sub-samples for Oil (S) and SPGR determinations and the predictability of the regression equation concerned (equation A) was estimated to be 89.5% ($n = 32$) with magnitudes of residuals ranging from 0.06 to 1.78%. Since the oil content of a genotype varies from seed to seed (Dwivedi *et al.*, 1990), and also there is some error in the methods of

determination of Oil(S) (Jambunathan *et al.*, 1985) and SPGR (Misra *et al.*, 1993), the oil content of a sub-sample determined by Soxhlet method will differ from the value predicted on the basis of specific gravity of another sub-sample even if the relationship between Oil(S) and SPGR were a perfect one. With a view to overcoming dilutions of residuals on account of seed to seed variations, sets of complementary cotyledons of a sub-sample were used in this study so that all the seeds were equally represented in the materials used for the determination of Oil(S) and corresponding SPGR. This exercise gave an improved predictability of 93% ($n = 18$) with a value of residuals ranging from 0.06 to 1.52.

Jambunathan *et al.*, (1985) estimated standard error (SE) of Soxhlet method (by using 5 sub-samples of groundnut meal) to be 0.21 to 0.31% (corresponding to SD of 0.48 to 0.70% of oil). Similarly, for sub-samples of kernels the SE ranged from 0.42 to 0.65 (corresponding to SD of 0.96 to 1.47% of oil). The values of the SD in the present investigations ranged from 0.28 (Jyoti) to 0.97% (JL 24) of oil, which is of the same order as reported by Jambunathan *et al.* (1985). For determining SPGR Misra *et al.* (1993) have estimated the SD of weight of volumetric flask visually filled to 100 ml mark with kerosene to be 0.0086 g. This value corresponded to SDs of ± 0.00012 and $\pm 0.02\%$ for specific gravity and oil content, respectively. Hence the method of determining specific gravity is more precise than that of determining oil content by Soxhlet extraction procedure. Looking to the precision of Oil(S) and SPGR, a value of $2(0.70 + 0.02) = 1.44$ in the residuals can be ascribed to the errors of Soxhlet and SPGR methods, even if the two samples have the same oil content. But in this experiment residuals up to 2.22% have been obtained in case of NCAc 17500 (see

results), which suggests that the relationship between the Oil(S) and SPGR of cotyledons is not a perfect one and that there are factors other than oil which also determine the specific gravity of groundnut cotyledons. Groundnut oil, which comprises about 50% of the kernel weight is fairly homogeneous and thus its specific gravity remains rather constant across the genotypes. Whereas rest of the 50% mass of the kernel is quite heterogeneous in the sense that it comprises several components namely proteins, carbohydrates, minerals, fibre, moisture etc. all varying in their respective specific gravities. Hence any change in the relative properties of the other than oil constituents of the kernels within or across the genotypes will effect a corresponding change in the overall specific gravity of kernels. And this will introduce residuals of varying magnitudes between the actual values and predicted values of oil contents.

Besides the chemical composition, a morphological factor that was identified in this study was the shrivelled nature of testa with irregular air spaces between the testa and cotyledons. When the Oil(S) and SPGR of the complementary cotyledons of six samples with shrivelled testa were included for estimating the predictability, the predictability was only 78% (equation B) compared to that of 93% (equation C) estimated after excluding the genotypes with shrivelled testa. The cotyledons with shrivelled testa showed a low specific gravity and consequently a high Oil[^] with residuals as large as 3.57 %. Though among the cultivated types only a few genotypes are there with a characteristic of shrivelled testa, kernels with varying degrees of shrivelling can be seen in the samples of any genotype, which emanate from the immature pods. Another factor which is likely to interfere with the SPGR determination is variability in the moisture content of

kernel samples, because, water has a specific gravity lower than that of other than oil portion of the kernel and hence a sample having a high moisture content would show a lower specific gravity and consequently a high Oil[^] and vice versa.

Hence, it is possible that the variation in the shrivelling of testa (not discernible to the naked eye) and moisture content of kernels interfere with the estimation of SPGR and thus sometimes render the relationship between Oil(S) and SPGR incomplete and produce dilated residuals.

It has been shown through NMR imaging that the complementary cotyledons of a groundnut seed may not necessarily have same oil content (Lakshminarayana *et al.*, 1992). Besides, groundnut genotypes have been reported to show a highly significant positive correlation between seed mass (size) and oil content of kernels (Dwivedi *et al.*, 1990).

It can thus be summarised that the additive effect of interference by the variability in seed mass, shrivelling of testa and uneven distribution of oil in the complementary cotyledons coupled with a low precision of Soxhlet method and a low degree of freedom (i.e. 4 in the present case) sometimes renders the relationship between the Oil(S) and SPGR insignificant for the subsamples of a given genotype. This may explain the insignificant relationship between the SPGR and Oil(S) of six subsamples of Jyoti, TMV 2 and TMV 10. Hence, it may sometimes not be possible to perceive the narrow differences in Oil(S) of the subsamples of a genotype through their SPGR.

Both the precision of Soxhlet method and the extent of innate variability in the oil content of groundnut genotypes stress the necessity to obtain average of several analysis

for arriving at a representative value of oil content of a particular genotype or sample and the same holds good for arriving at a representative value of SPGR. The results of the present investigations indicate that when correlation between Oil(S) and SPGR is estimated on the basis of representative values (average of six determinations) a highly significant relationship between SPGR and Oil(S) is obtained with a very high predictability even with as low a degree of freedom as 5.

Conclusion

It is concluded that for comparing oil content of a large number of genotypes, the representative values (average of several determinations) of SPGR of isolated groundnut cotyledons can be used for predicting oil content provided that the samples do not exhibit visible shrivelling of testa and have a constant ($4.6 \pm 1\%$) moisture content. The equation A or E can be used for predicting the oil content of genotypes from their representative SPGR.

There, however, exists a scope for further refining the regression equation A on the basis of representative values of Oil(S) and SPGR of a larger number of genotypes (say 50) with a wider range of oil content (say 40 to 56%).

LITERATURE CITED

- Canavos, G.C. 1984. Applied probability and statistical methods. Little, Brown and Company. Boston, Toronto.
- Conway, T.F. and Earle, F.R. 1963. Nuclear magnetic resonance for determining oil content of seeds. *J. Am. Oil Chem. Soc.* 40: 265-268.
- Dwivedi, S.L., Jambunathan, R., Nigam, S.N., Raghunath, K., Ravi Shankar, K. and Nagabhushanam, G.V.S. 1990. Relationship of seed mass to oil and protein content in peanut (*Arachis hypogaea* L.). *Peanut Sci.* 17: 48-52.
- Jambunathan, R., Raju, S.M. and Badre, S.P. 1985. Analysis of oil content of groundnuts by nuclear magnetic resonance spectrometry. *J. Sci. Food Agric.* 36: 162-166.
- Lakshminarayana, M.R., Joshi, S., Gowda, G.A.N. and Khetrapal, C.L. 1992. Spatial distribution of oil in groundnut and sunflower seeds by nuclear magnetic resonance imaging. *J. Biosci.* 17: 87-93.
- Misra J.B., Yadav, S.K. and Chauhan, S. 1993. Inverse relationship between oil content and specific gravity of groundnut kernels. *J. Sci. Food Agric.* 61: 231-234.
- Magne, C. and Beliquet, A.F. 1963. Une methode simple et rapide d'apprécier la richesse en huile des graines d'arachide utilisable selection vegetale. *Oleagineux* 18: 571-574.
- Panford, J.A., Williams, P.C. and deMan, J.M. 1988. Analysis of oilseeds for protein, oil, fibre and moisture by nearinfrared reflectance spectroscopy. *J. Am. Oil Chem. Soc.* 65: 1627-1634.

Acknowledgements

The authors wish to express their gratitude to Dr. A.K. Singh of the ICRISAT for supplying seeds of groundnut genotypes and to Dr. P.S.Reddy, Director, NRCG, Junagadh for providing facilities and encouragement. The authors also wish to express their thanks to Ms. Sheela Chauhan, Technicians for providing excellent technical assistance. The authors are also grateful to Prof. S.K. Dixit, Head, Department of Agricultural Statistics, Gujarat Agricultural University, Junagadh for guidance in statistical analysis and interpretations.

EVALUATION OF GERMPLASM COLLECTIONS OF SAFFLOWER (*Carthamus tinctorius* Linn.) IN INDIA FOR MORPHOLOGICAL CHARACTERS AND ITS ASSOCIATION WITH REACTION TO APHID INFESTATION

R.BALAKRISHNAN, K.VENKATESWARA RAO¹, R.V.DATHKHELE², and R.C.PATIL³

Directorate of Oilseeds Research, Rajendranagar, Hyderabad 500 030, A.P.

ABSTRACT

Morphological characters of safflower were significantly associated with reaction to safflower aphid (*Dactynotus carthami* H.R.L.) infestation. Bushy and cone shaped plant types were showing more degree of tolerance than appressed and erect plant types. Plant types with many or intermediate number of spines on upper stem leaves and outer involucre bracts (OIB) showed better tolerance to aphids than those with no spines or only a few spines. Long and moderate length of spines on OIB were associated with better tolerance to aphid infestation than those of short spines or no spines on OIB. Plant types with fleshy upper leaves were more susceptible than those with normal and leathery leaves. Susceptible reaction to infestation of aphids resulted in reduction in number of capitula per plant and yield per plant. Early physiological maturity was closely associated with tolerance to aphid infestation.

Keywords : Safflower; Germplasm; Safflower aphid; Morphological characters

INTRODUCTION

Safflower (*Carthamus tinctorius* Linn) is an important annual oilseed crop grown in many parts of the world, India having the largest crop area. The crop is infested by a number of pests and as many as 14 different species of aphids have been reported on this crop. *Dactynotus carthami* (H.R.L) is one of the major aphids causing considerable damage to the crop (Parlekar, 1987). The safflower aphid is widely distributed in India and it is polyphagous (Narayanan, 1961; Bindhra and Rathore, 1967). In order to exploit the potentials of the rich source of genetic material of this crop available in India, evaluation of a number of

economically important characters are being carried out systematically on the germplasm material at the Germplasm Management Unit, Mahatma Phule Agricultural University, Solapur. The present study analyses the results of evaluation of a set of 1136 accessions during 1987-88 *rabi* season for their reaction to the safflower aphid and its association with morphological characters of importance.

MATERIALS AND METHODS

The germplasm material was raised in GM Unit, Solapur (Longitude - 17° 14' N; Latitude - 75° 56' E and Elevation 483.6 m MSL), in single rows of 6 m length spaced at 45 cm

1. Project Coordinating Unit (Safflower), Solapur, Maharashtra 413 002

2. MPKV, Agril. Resh. Station, Rahuri, Maharashtra

3. MPKV, Agril. Resh. Station, Digraj, Maharashtra

Received for publication on September 5, 1994.

between row and 35 cm within rows using augmented block design with 13 standard checks of Indian origin. Reaction to aphid infestation was scored on a 1-5 scale, a score of 1 indicating 'highly tolerant' (0-20% drying); a score of 2 indicating 'tolerant' (21-40% drying); 3 indicating 'moderately tolerant' (41-60% drying); 4 indicating 'susceptible' (61-80% drying) and 5 indicating 'highly susceptible' (more than 80% drying). Details of other morphological characters are provided in a catalogue of the germplasm material (Ghorpade *et al.*, 1991). Relevant combinations of the pest and a morphological character were taken and two-way contingency tables were prepared to study the character association. In case of some quantitative characters like seed yield, number of capitula and days to maturity, one-way analysis of variance was performed to study the effect of the aphid infestation on these characters.

RESULTS AND DISCUSSION

The frequencies of aphid reaction scores for some of the source countries is given in Table 1. None of the entries were found to be 'highly tolerant' (0-20% drying). However, 67 entries were found to be 'tolerant' (21-40% drying) to the pest. More than 50% of accessions were found to be moderately tolerant (41-60% drying).

The four plant types or growth habits showed different types of reaction to the aphids (Table 2). Appressed and erect plant types were more susceptible (a score of 4-5) to the pest as compared to bushy and cone shaped ones. The latter two types had a large proportion of moderately tolerant plants compared to the former two types. Combining the first three scores (tolerant types), it was seen that bushy and cone shaped plant types were more tolerant than appressed and erect shaped (the

Table 1. Reaction of safflower germplasm entries to aphid infestation

Source country	No. of entries	Frequency (as per cent)				
		1	2	3	4	5
India	546	0.0	8.4	71.4	19.8	0.4
U.S.A	144	0.0	2.8	47.2	49.3	0.7
Turkey	64	0.0	6.2	40.6	51.6	1.6
Pakistan	53	0.0	0.0	52.8	45.3	1.9
Iran	51	0.0	3.9	33.3	62.8	0.0
Egypt	27	0.0	0.0	44.4	51.9	3.7
Portugal	20	0.0	5.0	15.0	70.0	10.0
Australia	18	0.0	11.1	55.6	33.3	0.0
Israel	18	0.0	0.0	100.0	0.0	0.0
Total frequency	*1136	0	67	645	410	14

Columns labelled 1-5 are classifications of reaction to aphid infestation (drying percentage), i.e. 0-20%, 21-40%, 41-60%, 61-80% and more than 80% drying respectively.

*- including other countries each with a smaller number of accessions

Table 2. Morphological types and their association with reaction to safflower aphid infestation.

Descriptors	Tolerant group	Moderate group	Susceptible group	Total	χ^2 Value
	Drying (%)				
	$\leq 40\%$	40-60%	$> 60\%$		
Growth habit					
Bushy	13.9	67.3	18.8	202	137.7**
Cone shaped	5.6	67.1	27.3	374	
Appressed	0.0	21.7	78.3	83	
Erect	3.8	50.3	45.9	477	
Spines on Upper Stem Leaves					
No spines	0.0	22.0	78.0	50	74.1**
Few spines	1.5	46.2	52.3	197	
Intermediate/many	6.5	60.4	33.1	724	
Spines OIB					
No spines	0.0	27.0	73.0	37	56.0**
Few spines	1.5	46.2	52.3	197	
Intermediate	6.5	60.4	33.1	724	
Many spines	9.6	60.1	30.13	178	
Length of spines on OIB					
No spines	0.0	22.9	77.1	35	56.0**
Short	3.6	33.7	62.7	255	
Intermediate	5.4	63.8	30.8	665	
Long	12.1	70.2	17.7	181	
Texture of Upper Leaves					
Fleshy	1.7	40.0	58.3	60	26.0**
Normal	5.9	54.7	39.4	768	
Leathery	6.8	65.2	28.0	308	
Seed size					
Bold	8.4	63.2	28.4	321	24.1**
Intermediate	4.7	58.9	36.4	365	
Small	5.1	50.4	44.4	450	

The cell frequencies are expressed as percentage of corresponding row totals

** Contingency χ^2 significant at 1% level

ratios being 81:19, 73: 27, 22: 78 and 54: 46 respectively of tolerant to susceptible). The differences in the reaction of these plant types were statistically significant.

Spines on upper stem leaves also exhibited statistically varying patterns of reaction to the aphids. Plant types with more number of spines on upper stem leaves were less susceptible to the pest than those with few or no

spines. The former type had more proportion of moderately tolerant plants than the latter two plant types and the ratio of tolerant to susceptible in many/intermediate spiny types was 70:30 as compared to 22:78 in non-spiny ones and 51:49 in few-spined types (combining the first two columns in Table 2). Bhumannavar and Thontadarya (1979a) also reported that the infestation by the aphid was higher on spineless than in spiny varieties because of more succulent nature of spineless varieties.

Spines on outer involucral bracts (OIB) and length of spines on OIB also showed varying patterns with regard to reaction to the pest. The differences were statistically significant. Plant types with no spines on OIB were the most susceptible (73% entries showing more than 60% drying), followed by the ones with few spines (52% entries being susceptible). Plant types with intermediate or many spines on OIB had about 30-33% susceptible entries. The latter types had also more proportion of tolerant and moderately tolerant lines. Long and moderately long spines on OIB resulted in better tolerant plant types than those with no spines or short spines. Plant types with long spines were least susceptible (18%) followed by intermediate spine length (31%); while short spined types resulted in 63% susceptible entries and those with no spines had 77% susceptible entries among them. There were also larger proportion of moderately tolerant

entries among those types with long or moderately long spines on OIB.

Plant types with fleshy upper leaves had 58.3% susceptible entries whereas those with normal leaves had 39.4% and those with leathery leaves had 28.0% susceptible entries among them. The latter two types also had more tolerant entries. Accessions with small seeds had 44.4% susceptible entries among them, followed by those of intermediate seeds (36.4%) and bold seeded ones (28.4%). The bold seeded accessions had maximum proportion of tolerant entries (8.4%) and moderately tolerant entries (63.2%). This is in contrast to the results of Karve (1980) who reported that small seeded lines possessed maximum aphid resistance. However, the present study involved a larger number of accessions from a wider range of world collections.

Apart from studying the relationships between the morphological character and the reaction to safflower aphids, one-way analysis of variance was done to study the effect of the degree of reaction to the pest on seed yield per plant, number of capitula per plant and days to physiological maturity (Table 3). The mean values were significantly different. The mean seed yield was 16.1 g for tolerant types followed by 13.0 g for the moderately tolerant types. The mean seed yield for the susceptible and highly susceptible (Combined) was 9.8 g. The mean

Table 3. Effect of aphid infestation on some quantitative characters in safflower

Drying per cent	Seed yield (gms) ± SE	Capitula/Plant ± SE	Days to maturity ± SE	No. of cases
20-40 %	16.1 ± 1.14	35 ± 2.2	126 ± 0.9	67
41-60%	13.0 ± 0.37	32 ± 0.7	127 ± 0.3	645
> 60%	9.8 ± 0.45	28 ± 0.9	132 ± 0.4	424

The differences were statistically significant at 1% level. Drying per cent > 80% has been combined with 61-80% as there were only 14 entries in the former case.

number of capitula for the plant types with a score 1-2 (tolerant) was 35.4, whereas for moderately tolerant ones, the mean was 31.6. Accessions for which the pest reaction were graded as susceptible or highly susceptible, had an average of 28.4 capitula per plant. Yield losses due to the aphids had been reported to varying levels of 20% to more than 60% at different locations in India (Karve *et al.*, 1978; Bhumannavar and Thontadarya, 1979 b; Basavana *et al.*, 1981; AICORPO, 1985; and Parlekar, 1987). The above results confirm the yield losses reported to be caused by the aphids and that the levels of yield loss were in accordance with the reaction to the pest. With regard to days to maturity, the mean values were 126, 126, 132 and 131 for the four grades of reaction to the pest (tolerant, moderately tolerant, susceptible and highly susceptible) respectively. The most critical phase of damage due to the aphids is at flowering and post-flowering stages (Parlekar, 1987). The aphid is active during November - February in peninsular India. Low temperature and high humidity favours a high built-up of the aphid population on the crop (Upadhyaya *et al.*, 1980 and Rathore, 1983). Sowing of safflower in early September exposes the crop to lesser aphid infestation during flowering stage. More and Nikam (1987) reported that aphid population on 10 cm apical twig per plant for 1st and 2nd fortnight of October, was respectively 398 and 507. As the low temperatures in November/ December are very congenial to aphid multiplication, the early sown crop becomes woody and hardy by that time and hence the attack by aphids is lessened. Nevertheless it is subjected to exposure of *Alternaria* leaf spot infection and hence there is risk of yield reduction (AICORPO, 1985). Karve (1980) observed that the local Indian varieties being better adopted to growing under short duration, tend to flower early

and mature early. The exotic varieties on the other hand planted at the same time are slow in growth and remain succulent when the maximum aphid infestation occur in nature. A detailed analysis of days to maturity of the accessions investigated under the present study revealed that Indian accessions matured on the average in 117 days, whereas exotic accessions matured beyond 126 days (Ghorpade *et al.*, 1991). A factor analysis study on the germplasm data base (Balakrishnan *et al.*, 1993) including fourteen morphological characters revealed that plant types with tolerant and moderately tolerant reaction to aphids had low maturity factor (factor comprising days to first flowering, days to 50% flowering, days to primary branch initiation, days to bud initiation, and days to maturity) indicating that they were early types. The results of the present study only confirm that early maturing plant types tend to escape the pest where as, the late maturing types tend to be vulnerable to the pest.

Out of 67 accessions that showed tolerant reaction to the aphids (score of 1-2), 62.7% entries had days to maturity of ≤ 126 days and out of 424 accessions that were graded susceptible (score 4-5), 62.0% entries had days to maturity of ≥ 130 . Hence while analyzing the tolerance mechanism vis-a-vis days to physiological maturity, the average days to maturity were computed for the morphological classes that were found to have varying reactions to the aphid infestation. The results are presented in Table 4. Bushy and cone shaped plant types matured earlier than appressed and erect plant types. The former two plant types were found to be less susceptible than the latter two types as per the earlier results (Table 2). Plant types with many or intermediate number of spines on upper stem leaves matured on

average in 127 days compared to non-spiny ones (137 days) and few-spiny ones (130 days). The spiny types were more tolerant than the other two types. Likewise plant types with many, intermediate, few and no spines on OIB matured in 128, 127, 130 and 138 days respectively and the earlier results indicated that spiny ones were more tolerant in their reaction to aphids than the few-spiny or non-spiny ones. Plant types with longer spines on OIB matured in 126-127 days as compared to short-spined ones (132) and non-spiny ones (138). Again,

Table 4. Average days to physiological maturity for different morphological types

Morphological types	Mean days to maturity ± SE
Growth Habit	
Bushy	125 ± 0.5
Cone Shaped	126 ± 0.4
Appressed	135 ± 0.8
Erect	130 ± 0.3
Spines on Upper Stem Leaves	
Non-spiny	137 ± 1.0
Few	130 ± 0.4
Intermediate/many	127 ± 0.3
Spines on OIB	
Non-spiny	138 ± 1.2
Few	130 ± 0.5
Intermediate	127 ± 0.3
Many	128 ± 0.6
Texture of Upper Leaves	
Fleshy	136 ± 1.0
Normal	127 ± 0.4
Leathery	128 ± 0.3
Seed size	
Bold	126 ± 0.4
Intermediate	127 ± 0.4
Small	130 ± 0.3

Note : The differences are statistically significant at 1% level.

the earlier results showed that long and moderately long spines on OIB were associated with better tolerance to the aphids. Plant types with fleshy upper leaves were found to be more susceptible to the aphids and they matured on an average in 136 days, whereas those with normal and leathery upper leaves which were found to be less susceptible, matured in 127-128 days. Plant types with bold seeds which showed lesser susceptibility to the pest matured in 126 days as compared to the small seeded ones, which matured in 130 days. The above results clearly brought out that days to maturity has a very clear role in the varying levels of reaction to aphid infestation and that earliness is desirable. Further evaluation of lines with the morphological classes that were indicative of tolerance to the aphids and which mature early may have to be undertaken for successful breeding of resistant or tolerant safflower material.

Three check varieties, namely, Bhima, A-1 and S-144 were evaluated as tolerant with regard to reaction to aphid infestation (drying 21 - 40%). The evaluation of these cultivars with regard to important morphological descriptors are given in Table 5. It is clearly seen that these cultivars have all the desirable morphological traits which classifies them as tolerant to aphids in the light of the foregoing analysis. In case of days to maturity, though Bhima and A-1 recorded a mean of 130 - 132 days in 1987-88 evaluation trial, their duration for physiological maturity was quite low in 1988-89 and 1989-90 evaluation trials, indicating the potential of these cultivars in their tolerance to aphid infestation.

Thus the present investigation revealed that morphological types were significantly associated with reaction to safflower aphids. Ap-

Table 5. Morphological traits of safflower cultivars showing tolerant reaction to aphid infestation

Descriptor	Bhima	A-1	S-144
Growth habit	Bushy	Bushy	Bushy
Spines on upper stem leaves	Intermediate	Intermediate	Intermediate
Spines on OIB	Intermediate	Many	Many
Length of spines on OIB	Long	Intermediate	Intermediate
Texture of upper leaves	Leathery	Normal	Normal
Seed size	Bold	Bold	Bold
Mean days to maturity:			
1987-88	132	130	115
1988-89	125	121	125
1989-90	121	111	107

pressed and erect plant types were showing more degree of susceptibility than bushy and cone shaped plant types. Spines on upper stem leaves and OIB were significantly associated with better tolerance to the pest. Plant types with leathery or normal upper leaves were less susceptible than fleshy leaf types. Plant types with more tolerance had higher mean seed yield and capitula per plant than the less tolerant ones and susceptible ones. Plant types maturing early showed better tolerance to the aphid infestation than the late maturing types.

LITERATURE CITED

- Narayanan, E.S. 1961. Insect pests of safflower and methods of their control. In: Niger and safflower, Ed. Chavan, V.M. Indian Central Oilseeds Comm, Hyderabad.
- Bhindra O.S. and Rathore, V.S. 1967. Investigations on the biology and control of safflower aphid at Jabalpur, JNKVV Res. J. 1: 60-63
- Karve, A.D., Murugkar, V.K. and Quadri, S.M. 1978. assessment of yield loss (reduction) due to aphid infestation. Report on resistance of safflower (*C. tinctorius* L.) to insects and diseases. Nimbkar Agric. Res. Int. Phaltan. pp 58-60.
- Bhumannavar, B.S. and Thontadarya, T.S. 1979 a. Varietal response of safflower (*C. tinctorius* L.) to aphid *D. compositae* Theobald (Hemiptera: Aphididae) on safflower in Karnataka. *Pesticides* 13(9): 28-30.
- Bhumannavar, B.S. and Thontadarya, T.S. 1979b. Estimation of the safflower crop losses due to the aphid *D. carthami* Theobald (Hemiptera: Aphididae) on safflower in Karnataka. *Pesticides* 13(9): 28-30.
- Upadhy, V.R., Kaul, C.L. and Talati, G.M. 1980. Seasonal incidence of aphid *D. carthami* H.R.L. and Coccinellids in relation to weather conditions. *Ind. J. Plant Prot.* 8: 117-121
- Karve, A.D. 1980. Resistance of safflower (*C. tinctorius*) to insects and diseases. Final Tech. Report. N.A.R.I. Phaltan (Annual Linseed and Safflower Research Workers' Group meeting held at Ranchi, Sept 16-20, 1980.
- Basavana, G.K., Kulkarni, K.A. and Thontadarya, T.S. 1981. Residues of insecticides in safflower seeds. *Pesticides* 15(3): 12-13.
- Rthore, V.S. 1983. Bionomics and management of safflower aphids. *Indian Famg.* 5: 35.
- AICORPO, 1985. All India Coordinated Project on Oilseeds, Annual Progress Report, Safflower 1984-85. Directorate of Oilseeds Research, Hyderabad, India.

- More, S.M. and Nikam, S.M. 1987. Safflower Agronomy. In: P.S.Patil (Ed.). Safflower- All India Coordinated Project on Oilseeds (Safflower), Mahatma Phule Agri. University, Solapur (India).
- Parlekar, G.Y. 1987. Pests of Safflower. In: P.S. patil (Ed.). All India Coordinated Project on Oilseeds (Safflower), Mahatma Phule Agri. University, Solapur (India).
- Ghorpade, D.S., Patil, R.C., Balakrishnan, R., Venkateswara Rao, K., Shende, V.D. and Deolankar, K.P. 1991. Safflower Genetic Resources: Evaluation and Analysis (1987-88, 1988-89 & 1989-90). Germplasm Mnagement Unit and Project Coordinating Unit (Safflower), M.P.A.U, Solapur and Directorate of Oilseeds Research, Hyderabad, India
- Balakrishnan, R., Venkateswara Rao, K. and Patil, R.C. A factor analysis of some qunantitative chaaracters in safflower (*Carthamus tinctorius* L.)

PHENOTYPIC STABILITY ANALYSIS OF SOYBEAN VARIETIES IN *KHARIF* AND SUMMER SEASONS

S.P. TAWARE, V.M. RAUT, G.B. HALVANKAR and V.P. PATIL

Agharkar Research Institute, Agharkar Road, Pune 411 004.

ABSTRACT

Eighteen promising varieties of soybean were grown in two successive *kharif* and summer seasons. Mean squares for varieties and seasons were highly significant for days to flower, days to maturity, plant height, pods/plant, 100-seed weight, oil content and seed yield. Varieties x seasons interaction was significant for days to flower and pods/plant. Stability parameters indicated MACS-63 and MACS-57 as the most stable varieties for *kharif* and summer seasons. *Kharif* was indicated as the most favourable season for soybean and MACS-124 as the most suitable variety for *kharif* sowings.

Keywords : Stability analysis; Phenotypic stability; Yield

INTRODUCTION

Soybean (*Glycine max* (L.) Merrill) has become an important *kharif* crop in Maharashtra state. In *kharif* season of 1993, it was grown on an area of around 0.5 million hectares with a total production of around 0.65 million tonnes. To increase the area and production of soybean crop, besides trying its cultivation in non-conventional areas, it is also necessary to develop varieties for *rabi* and summer seasons. Earlier research on cultivation of soybean in *kharif* and *rabi* and summer seasons suggest the need for the identification of widely adapted varieties with stable performance (Sharma *et al.*, 1980; Konwar and Talukdar, 1986; Patil *et al.*, 1989; Raut *et al.*, 1990.; Taware *et al.*, 1991; Raut *et al.*, 1992). The present study is an effort in this direction.

MATERIALS AND METHODS

Eighteen promising soybean varieties were planted in Randomised Block Design with three replications on 14.7.91, 7.2.92, 30.7.92

and 4.2.93 at the Research farm, Agharkar Research Institute, Hol (Tal. Baramati Dist. Pune). Each variety was sown in two rows of 5 m length with 45 cm distance between rows. Seed yield was recorded on net plot basis (net plot size : 4 m x 0.9m). Data were also collected on other characters, viz., days to flower, days to maturity, plant height, number of pods/plant, 100-seed weight and oil content. Data were analysed for stability as per procedure given by Eberhart and Russell (1966).

RESULTS AND DISCUSSION

Analysis of variance of the data pooled over four seasons (Table 1) indicated highly significant differences among the varieties and seasons for all the characters. However, interaction between varieties and season was significant only for days to flower and number of pods/plants.

The varieties MACS-63 and MACS-57 recorded significantly higher mean seed yield than MACS-124 and other varieties (Table 2).

Table 1. Analysis of variance.

Source	d.f.	Characters						
		Day to flower	Days to maturity	Plant height	Pods/plot	Seed yield	100-seed weight	Oil content
Varieties	17	25702.54**	88.05**	849.26**	204.49**	104696.34**	4.29**	6.00**
Environment + (Varieties x environment)	54	31.03	28.12	123.43	170.15	82453.64	2.07	0.47
Environment (Linear)	1	327.25**	1216.49**	4439.02**	6490.01**	3621674.40**	69.92**	10.45
Varieties x Environment (Linear)	17	73.58**	6.22	34.11	105.54**	238469.68	0.91	0.38
Pooled deviation	36	0.68	5.46	45.73	25.10	592352.67	0.74	0.23
Pooled error	144	1.17	2.19	23.02	60.84	693001.70	0.35	0.05

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

Table 3. Mean yield (kg/ha) and environmental indices for different seasons

Sr No.	Variety	Seasons				Average	Rank
		Kharif 91	Summer 92	Kharif 92	Summer 93		
1.	MACS-57	3579	3083	3183	2383	3057	2
2.	MACS-63	3458	2972	3447	2455	3083	1
3.	MACS-209	2928	2457	2961	1449	2449	11
4.	MACS-227	4198	2032	2311	2018	2640	7
5.	MACS-241	3644	2189	2851	2077	2690	6
6.	MACS-242	3356	1678	1956	1473	2116	14
7.	MACS-286	3765	2262	2856	1901	2696	5
8.	MACS-308	3081	1662	2473	1764	2245	13
9.	MACS-212	3271	2495	2569	1219	2389	12
10.	MACS-13	3404	2213	2731	1904	2563	9
11.	PK-472	3258	2094	2762	1990	2526	10
12.	AGS 19	3333	1025	2006	1165	1882	16
13.	G-76	3180	919	1036	1000	1534	18
14.	PK-564	2545	1106	1219	1353	1556	17
15.	NRC-1	3338	2352	1816	934	2110	15
16.	JS-335	3534	2322	2653	1829	2585	8
17.	Punjab-1	3494	2722	2690	2263	2792	4
18.	MACS-124	3752	2192	3523	1770	2809	3
	IJ	348	-199	26	-255	-	-
	SE \pm	215	233	181	115	74	-
	CD (P=0.05)	618	670	519	330	241	-

Table 2. Stability parameters for different characters in soybean

Variety	Days to flower			Days to maturity			Plant height		
	\bar{X}	bi	S^2_{di}	\bar{X}	bi	S^2_{di}	\bar{X}	bi	S^2_{di}
MACS 57	45.00	0.72	2.89*	88.50	0.66	2.36	51.33	1.25	-8.93
MACS 63	44.67	0.85	0.46*	89.09	0.51	0.61	55.67	1.05	13.13
MACS 209	47.92	1.12	0.96	99.92	0.99	-0.39	69.39	0.28	19.50
MACS 227	46.34	0.82	-0.76	98.00	1.42	-0.09	69.94	0.57	-4.21
MACS 241	43.75	0.99	0.90	98.17	1.12	1.25	73.42	0.73	4.63
MACS 242	45.33	1.03	-0.62	96.50	1.57	4.10	67.20	1.39	-8.10
MACS 286	44.25	0.85	2.64*	95.42	0.64	18.03**	56.15	1.19	40.37
MACS 308	47.42	1.02	5.31**	95.67	1.39	-0.71	43.85	1.23	-15.07
MACS 212	44.92	0.98	0.98	96.00	1.16	6.22*	77.28	1.36	134.80**
MACS 13	49.00	1.22*	-0.72	102.59	1.20	10.76**	49.94	0.67	-8.18
PK 472	44.92	1.23*	-0.74	94.67	1.18	-0.30	31.98	0.69	-2.43
AGS 19	41.75	1.35*	-0.39	88.58	1.23	7.21*	51.07	0.39	55.50*
G 76	42.92	1.21	5.21**	92.00	0.93	11.46**	51.88	1.03	-20.85
PK 564	41.25	0.94	-0.89	90.25	0.69**	-1.95	34.60	1.03	-2.31
NRC 1	46.42	1.65	10.58**	93.42	1.01	-0.04	45.42	1.44	-14.12
JS 335	40.00	0.87	2.23	86.17	0.78	0.58	34.08	0.99	33.64
Punjab 1	45.25	0.42**	-1.16	88.33	0.78	0.63	53.80	1.58	9.89
MACS 124	47.08	0.72	0.82	98.58	0.74	-0.83	78.00	1.13	181.44**
Mean	48.30			93.99			55.28		
S.E. \pm	0.48			1.35			3.90		
C.D. ($P=0.05$)	1.55			4.39			12.70		

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

Table 2 contd...

Variety	Pods/plant			Seed yield (kg/ha)			100-seed weight (g)			Oil content(%)		
	\bar{X}	b_i	S^2_{di}	\bar{X}	b_i	S^2_{di}	\bar{X}	b_i	S^2_{di}	\bar{X}	b_i	S^2_{di}
MACS 57	49.07	0.41	-40.78	3057.17	0.63	2981.21	12.06	0.62	-0.15	18.74	1.34	0.01
MACS 63	50.30	0.61	-16.04	3083.11	0.56	7549.20	12.29	1.33	0.19	18.56	1.74	0.04
MACS 209	62.22	1.42	85.89	2448.86	0.78	30994.82**	12.53	1.58**	-0.31	18.11	0.06	0.22**
MACS 227	59.95	1.78**	-56.48	2639.81	1.37	20176.19**	14.19	1.41	-0.08	20.48	0.01	0.03
MACS 241	51.29	0.98	-40.66	2690.50	0.99	-1823.23	13.47	1.12	1.93**	20.42	0.37	0.11*
MACS 242	49.69	1.31	-17.11	2115.75	1.15	2316.29	13.87	0.97	2.56**	20.58	-0.23	0.32**
MACS 286	46.44	0.87	-58.47	2695.83	1.13	-4154.08	12.44	0.86	-0.09	20.28	0.93	0.16*
MACS 308	47.37	0.12**	-55.78	2244.92	0.88	3804.77	12.02	1.72	1.68**	19.78	0.06	0.16**
MACS 212	58.02	2.08**	-51.24	2388.89	1.07	21953.07**	12.18	0.78*	-0.33	20.30	0.33	0.19**
MACS 13	45.97	0.52	-33.76	2562.72	0.91	-3886.74	13.85	1.24	-1.26*	18.28	1.48**	-0.05
PK 472	41.03	0.48**	-56.69	2526.17	0.80	-788.72	15.06	-0.45**	-0.08	19.08	1.83	0.17*
AGS 19	42.29	1.21	-40.17	1882.17	1.42	10844.03*	14.15	1.00	0.06	21.98	0.59	0.07
G 76	43.58	1.13	-55.90	1533.81	1.38	39237.45**	14.13	1.34	-0.23	22.21	0.76	-0.02
PK 564	34.80	0.66**	-59.58	1555.78	0.79	19184.66**	13.37	0.81	0.38	20.26	1.27	0.02
NRC 1	51.97	1.82**	-59.11	2109.97	1.24	38019.68**	11.29	1.05	-0.06	20.01	1.20	0.28**
JS 335	37.72	1.05	-59.22	2584.50	1.00	-4357.15	12.40	1.08	-0.26	19.84	2.52	0.66**
Punjab 1	49.33	0.47	-9.91	2792.36	0.69	-1497.51	12.54	1.08	-0.05	18.82	1.45	0.04
MACS 124	48.38	1.10	-18.24	2809.25	1.23	28997.18**	14.27	0.46	0.53	17.92	2.30	0.79**
Mean	48.30			2428.98			13.11			19.76		
S.E. \pm	2.89			74.06			0.50			0.05		
C.D. ($P=0.05$)	9.41			240.89			1.61			0.14		

Both the varieties were more or less at par for seed yield. Non-significant values for regression coefficients and deviations from regression for these varieties indicated their high stable nature over seasons.

Perusal of stability parameters (x , b_1 and s^2_{di}) for different varieties indicated that MACS-63 and MACS-57 possessed more than average stability for all the characters studied. Earlier work (Patil et al., 1989; Raut et al., 1990, 1992) indicated highly stable nature of MACS-57 over seasons as also locations. This variety (a derivative of JS-2 x Improved Pelican) is released for general cultivation in *kharif* and summer seasons in Maharashtra State. Present studies indicated that MACS-63, a derivative of Punjab-1 x Improved Pelican, is also promising for cultivation in both the seasons would help in broadening the genetic base of the available cultivars. Angeles (1987) reported 'Improved Pelican' as the most stable variety. Bhatnagar and Tiwari (1989) found MACS-58, a derivative of cross JS-2 x 'Improved Pelican', to be the most stable variety at different locations. In the present studies also MACS-63 and MACS-57 have 'Improved Pelican' as one of the parents.

Mean seed yield and environmental indices for different seasons (Table 3) indicated *kharif* as the most favourable season for soybean production in Maharashtra. However, MACS-63 and MACS-57 also performed well in summer season compared to other varieties. In *kharif* season, MACS-124 (a released variety for Maharashtra, Karnataka, Tamil Nadu and Andhra Pradesh) was the highest yielder followed by MACS-63, MACS-57, MACS-286 and MACS-227. Hence, the present study revealed MACS-124 as the most suitable variety for *kharif* while MACS-63 and MACS-

57 could be cultivated in both *kharif* and summer seasons in Maharashtra state.

LITERATURE CITED

- Angeles, J.B. 1987. Phenotypic stability of soybean in Peru. *Soybean Genet. Newsl.* 14:120-124.
- Bhatnagar, P.S., and Tiwari, S.P. 1989. Phenotypic stability analysis of yield in soybean (*Glycine max* (L.) Merrill) *Biovigyanam* 15(2) : 90-93.
- Eberhart, S.A. and Russell, W.A. 1966. Stability parameters for comparing varieties. *Crop Sci.* 6 : 36-40.
- Konwar, B.K. and Talukdar, P. 1986. Stability analysis of yield and its components in soybean. *Crop Improvement* 13 : 172-175.
- Patil, V.P., Raut, V.M., Halvankar, G.B. and Taware, S.P. 1989. Stability analysis for seed yield and its components in soybean. Proceedings of World Soybean Res. Conf. IV, held at Buenos Aires, Argentina, during 5-9 March, 1989, vol. 2, pp. 1042-47.
- Raut, V.M., Patil, V.P., Taware, S.P. and Halvankar, G.B. 1990. Stability of soybean varieties for different seasons. *Biol. Ind.* 1(1) : 21-26.
- Raut, V.M., Halvankar, G.B., Taware, S.P. and Patil, V.P. 1992. Stability analysis of soybean varieties in non-conventional summer seasons. *Biovigyanam* 18(2) : 67-69.
- Sharma, S.M., Jain, K.K., Rai, R.C. and Singh, N. 1980. Evaluation of yield and stability performance of soybean genotypes. *Indian J. Agric. Sci.* 50 : 650-54.
- Taware, S.P., Halvankar, G.B., Raut, V.M. and Patil, V.P. 1991. Analysis of phenotypic stability in soybean (*Glycine max*). *Indian J. Agric. Sci.* 61 : 933-36.

Acknowledgements

The authors are grateful to Dr. A.D. Agate, Director, A.R.I., for facilities. This work has been carried out under All India Coordinated Research Project on Soybean sponsored by Indian Council of Agricultural Research, New Delhi.

SEED AND OIL QUALITY OF SAFFLOWER GENOTYPES

G. NAGARAJ

Directorate of Oilseeds Research Rajendranagar, Hyderabad - 500 030

ABSTRACT

Twenty four safflower genotypes were analysed for oil, protein and fatty acid composition. The oil content of these genotypes varied from 25.1 to 34.1%, while protein content varied from 8.6 to 16.2%. The major fatty acid was linoleic acid (72-80%) followed by oleic acid (11-19%). Palmitic and stearic acids were the other two fatty acids present in safflower. In general safflower genotypes had lower oil stability values (0.14 - 0.25) while the nutritional quality indices were higher (7.7 - 10.3). BLY 652, HUS-305, 86-93-20A, NIRA, JSFI, CTV 196, CTV 102 and CTV 107 had higher oil (more than 30%) and higher linoleic acid levels (more than 75%).

Key words : Safflower oil; Linoleic acid; Oleic acid; Oil stability; Nutritional quality.

INTRODUCTION

Safflower (*Carthamus tinctorius*) is an important crop valued for its highly nutritious edible oil. The oil extracted from the seed was initially popular for its use in the preparation of paints, varnishes and surface coatings. It has recently gained importance as a healthy oil because of its higher content of linoleic acid, an essential fatty acid. Many varieties of safflower are grown in different parts of the country (Ramachandram, 1991). In addition, some promising breeding lines are available with good characteristics. In the present paper, the cultivars as well as some advanced breeding lines were analysed for their seed composition and oil quality and the results discussed.

MATERIAL AND METHODS

Safflower genotypes (24) grown during Rabi 1991-92 at Sholapur were collected and analysed for total oil by the NMR method (Jambunathan *et al.*, 1985) and protein by the

biuret method (David and Peck, 1988) after extracting the seeds with phosphate buffer. Fatty acid profile was obtained after separation of the fatty acid methyl esters (Paquot and Hautfenne, 1987) on a DEGS column by gas chromatography (Nagaraj, 1986). The iodine value, (Mazingo and Steele, 1982) and the quality ratios (Carpenter *et al.*, 1976) namely oleic/linoleic acids - oil stability index and linoleic/saturated fatty acids (SFA) - nutritional quality index (NQI) were calculated from the fatty acid profile.

RESULTS AND DISCUSSION

The oil content of the genotypes varied from 25.1 (N7) to 34.7 (CTV 196). The varieties A1, Sharda, A 300, Manjira, SL44, HUS- 3182, N7, Bhima, T 65, K-1, Co-1, JSLF 113, JSLF 118 and Tara had less than 30% oil while others had more than 30% oil (Table 1). The protein content ranged from 8.6 to 16.2%. Only Sharda and CTV-107 had protein contents of less than 10% (9.4 and 8.6%) respectively. HUS-3159-3

had highest protein content of 16.2% followed by Nira with 14.8%, JSF1 with 14.5% and T-65 with 14.4%. Other genotypes had 10-14% levels of protein.

The major fatty acids in safflower genotypes were linoleic (73- 80%) and oleic acids (11-19%). The other two fatty acids were palmitic (5.6 - 7.7%) and stearic (1.4 - 3.2%)

acids, JSF 1 had highest linoleic acid (79.7%) and lowest oleic acid (11.3%). In general HUS-305, Sharda, S144, HUS-3182, Manjira, Bhima, T-65, Tara, 86-93-16A, Co-1, A-300, 86-93-20A, Nira, JSF1, CTV 196, CTV 102, CTV 107, had linoleic acid levels above 75% while other genotypes had 73-75% levels. A1 variety had the lowest level of linoleic acid (72.6%) with an oleic acid level of 17.7%. N-7 had the highest

Table 1. Seed composition and quality of safflower genotypes

Genotypes	Oil (%)	Protein	16:0	18:0	18:1	18:2	18:1 18:2	18:2 SFA	I.V.
Released Varieties									
A 1	26.5	12.0	6.6	2.3	17.7	72.6	0.24	8.2	125.8
A 300	28.1	12.3	5.6	2.4	14.7	77.2	0.19	9.7	133.7
Bhima	29.7	13.8	6.6	2.2	15.4	76.3	0.20	8.7	132.2
BLY 652	33.5	13.9	6.5	2.6	16.1	74.7	0.22	8.2	129.4
Co-1	29.1	12.9	6.1	1.6	12.5	79.6	0.16	10.3	137.9
HUS-305	32.7	12.9	6.6	2.4	12.7	78.1	0.16	8.7	135.3
JSF-1	32.1	14.5	6.4	2.3	11.3	79.7	0.14	9.2	138.0
K-1	27.2	12.5	6.3	1.9	16.6	73.7	0.23	9.0	127.7
MANJIRA	28.2	13.2	6.5	2.1	17.3	75.6	0.23	8.8	130.9
N-7	25.1	12.3	5.6	2.0	18.7	73.7	0.25	9.7	127.6
NIRA	30.6	14.8	5.6	2.6	16.0	75.8	0.21	9.2	131.3
S 144	29.5	12.6	6.0	2.2	15.0	76.9	0.20	9.2	133.2
SHARDA	26.3	9.4	6.5	2.4	13.8	77.3	0.18	8.7	133.9
T-65	26.5	14.4	6.1	1.6	14.8	77.5	0.18	10.1	134.4
TARA	29.1	14.1	6.7	3.2	13.5	76.5	0.18	7.7	132.5
Breeding lines									
CTV 102	33.4	12.0	7.7	2.1	13.7	76.3	0.18	7.8	132.2
CTV 107	31.9	8.6	6.8	2.7	13.1	77.3	0.17	8.1	133.9
CTV 196	34.1	10.9	7.3	2.3	12.5	77.9	0.16	8.1	134.9
HUS-3182	28.3	10.8	6.2	2.4	16.3	75.1	0.22	8.7	130.1
HUS-3159-3	33.9	16.2	6.3	2.1	18.0	73.5	0.24	8.8	127.3
JLSF-113	28.0	12.8	6.2	1.4	17.5	74.6	0.23	9.8	129.2
JLSF-188	25.3	10.7	6.0	2.2	17.5	74.3	0.24	9.1	128.7
86-93-16A	32.5	11.7	6.8	1.9	13.9	77.3	0.18	8.9	133.9
86-93-20A	31.5	12.4	6.6	2.1	14.8	76.6	0.19	8.8	132.7

level of (18.7%) oleic acid with linoleic acid level of 73.7%. The genotypes with 15% and above levels of oleic acid were A1, S144, HUS-3182, HUS-3159-3, N-7, Manjira, Bhima, K-7, BLY-652, Nira, JSLF-113 and JSLF-118. The fatty acid composition presented here is in agreement with those reported earlier (Doulatabad, 1982, Muralidharudu *et al.*, 1976, Nagaraj, 1993 a).

In general the oil stability index (18:1/18:2) values were lower for all the genotypes of safflower (Carpenter *et al.*, 1976). This was because of its higher levels of linoleic acid. The values varied from 0.14 (JSF1) to 0.25 (N-7). Only a few genotypes namely, A1, S144, HUS-3182, HUS-3159-3, N-7, Manjira, Bhima, K-1, BLY-652, Nira, JSLF-113 and JSLF-118 had oil stability values above 0.2 in the range of 0.2 - 0.25. Despite lower oil stability values, safflower oil may be considered stable because of the presence of Vitamin E, which acts as an auto-oxidative stabilizing agent (Salunkhe *et al.*, 1991).

The nutritional quality index values, on the contrary were higher for all the safflower genotypes (7.7 - 10.3). S144, N-7, T-65, K-1, Co-1, A 300, Nira, JSF1, JSLF-113 and JSLF-118 had values above 9. Because of its higher nutritional quality, safflower is considered a premium oil (Nagaraj, 1993 b).

The iodine values of all the genotypes were also higher (126-138) again because of the higher linoleic levels in the safflower oil.

In general HUS-305, HUS-3159-3, 86-93-16A, 86-93-20A, BLY-652, Nira, JSF1, CTV-196, CTV-102, were better with higher oil protein and linoleic acids and will be useful for cultivation and in the breeding programmes to develop suitable genotypes.

LITERATURE CITED

- Anonymous, 1991: Annual Rabi Oilseeds Research Workers' Group Meeting, Annual Progress Report 1990-91. D.O.R., Hyderabad, Mimeographed Report pp 90-109.
- Carpenter, D.L., Lehman, J., Manon, D.S. and Slover, H.T. 1976: Lipid Composition of selected Vegetable oils. *J. Amer Oil Chem Soc.* 53: 713-718.
- David, J.H. and Peck, H. 1988: Analytical Biochemistry. Longmans Scientific and Technical, London, pp. 393-394.
- Doulatabad, C.D., Ankalgi, R.T., Vijaya Kumar, S. and Habib, A.F. 1982: Fatty acid composition of important safflower varieties. *Karnataka Oilseeds J.* 12: 29-32.
- Jambunathan, R., Raju, S.M. and Badre, S.P. 1985: Analysis of oil content of groundnut by nuclear magnetic resonance spectrometry. *J. Science of Food and Agriculture* 36: 162-166.
- Mazingo, R.W. and Steele, J.L. 1982: Fatty acid composition of peanut genotypes in Virginia-carolina production area. *Proc. APRES* 14: 29-35.
- Muralidharudu, Y., Nagaraj, G. and Mev Singh. 1989: Effect of location and genotype on safflower oil and its quality. *Ann. Plant Physiol.* 3(2): 132-136.
- Nagaraj, G. 1986 a: Fatty acid composition of some released Indian groundnut varieties. Symp. Newer Technologies for augmenting and utilization of oilseed and derived products. Hyderabad, Feb. 1986.
- Nagaraj, G. 1993 a. Seed Composition and fatty acid profile of some Indian Safflower Cultivars. Proceedings of III Int. Safflower Conference, Beijing, China, June 14-18 pp 241-249.
- Nagaraj, G 1993. b. Safflower, the superior oilseed: *Farmer and Parliament*. 28: p 28.
- Paquot, C and Hautfenne, A. 1987: Standard methods for the analysis of oils, fats and derivatives. Blackwell Scientific Publishers, Oxford pp 73-77.
- Ramachandram, M. 1991: Current varietal situations of safflower in India. Lecture notes for SMS Workshop cum Seminar on Rabi Oilseeds organised by NCTCO, DOR, Hyderabad Oct. 3-10, 1991
- Salunkhe, D.K., Chavan, J.K., Adsule, R.N. and Kadam, S.S. 1991. World Oilseeds Chemistry Technology and Utilization An Avi Book.

POTENTIALS OF IMPROVED OILSEED CROP PRODUCTION TECHNOLOGIES IN INDIA - AN ASSESSMENT THROUGH FRONTLINE DEMONSTRATIONS

V. KIRESUR and M.V.R. PRASAD

Directorate of Oilseeds Research (ICAR), Rajendranagar, Hyderabad - 500 030.

ABSTRACT

The present study analyses the economics of latest improved oilseeds crop production technologies, their contribution to anticipated additional production of oilseeds as well as their adoption pattern. The results indicate that the improved technology could register, under real farm situations, an yield advantage ranging from 12 to 108 per cent across different oilseeds over the prevailing farmers' practices, mean additional net returns to the tune of Rs. 470/ha to Rs. 10531/ha and an incremental benefit cost ratio of 1.37 to 13.40. The commercially realizable but unexploited yield potential of the improved technologies was of the order of 688 kg/ha. Irrespective of the crop, the technology adoption was higher with respect to seed, spacing/seed rate and fertilizer. The technology adoption index was highest in the case of safflower followed by sunflower, sesame, rapeseed-mustard and groundnut.

Keywords : Improved technology; Farmers' practice; Frontline demonstrations; Adoption index; Economics

INTRODUCTION

India reached near to self sufficiency in oilseed production soon after the set up of Technology Mission with an all time record of 20 m. tonnes during 1992-93. However, the oil seed production suffers due to a high degree of variation in the annual production owing to their predominant cultivation under conditions of low and uncertain rainfall and input starvation with poor management. Sustainability of the enhanced oilseeds production is as important as enhancing the production itself (Kiresur *et al.*, 1993). Given the current level of technology there exists a wide commercially untapped yield reservoir in almost all the oilseed crops. The productivity potentials of the currently available improved oilseeds production technologies that could be exploited under real farm situations are considerably higher than

that of the corresponding state or district average. The weak technology transfer system in the country is the crux of the problem. It is in this context that the Project on Frontline Demonstrations in Oilseed Crops (FDO) sponsored by the Department of Agriculture and Cooperation, Ministry of Agriculture, Govt. of India was introduced in the year 1990-91 as an extension of the earlier research project entitled "On-Farm Researches on Annual Oilseed Crops" initiated during 1988-89. The main objective of the project has been to demonstrate under real farm situations the superior production potentials and benefits of the latest improved technologies recommended for different regions and agro-ecological and crop growing situations vis-a-vis prevailing farming practices (Anonymous, 1994). The demonstrations conducted on

farmers' fields belong to three different categories: (i) Whole (complete) package demonstrations, (ii) Cropping systems oriented demonstrations and (iii) Adaptive trials of component technology, e.g., improved variety/hybrid seed, fertilizer, irrigation, etc. Each demonstration was conducted in an area of 0.4 hectare and for each of the demonstration plots the adjoining plot of the same farmer with prevailing cultivation practices served as local check/control plot. Wherever demonstrations pertained to specific inter/sequential cropping systems involving oilseed crops, the currently existing popular cropping systems in the specific region formed the check for the purpose of comparison of their economic feasibilities. The present study attempts to analyse the economics of improved oilseeds production technologies, the existing levels of adoption of different technology components and also the anticipated additional production of oilseeds through enhancement in technology adoption.

MATERIALS AND METHODS

The study is based on primary data collected from 4237 demonstrations conducted on farmers' fields by the scientists of various AICORPO centres (Table 1) in eight oilseed crops, namely, groundnut, rapeseed-mustard, sesame, sunflower, linseed, safflower, castor and niger during the period of five years from 1988-89 to 1992-93. The economics of improved technology (IT) and prevailing farmers' practices (FP) were studied taking into consideration the prevailing costs of inputs and prices of output in respective years and areas. The cost of cultivation was worked out based on variable costs including family labour; however, it excludes depreciation on capital, land rent and interest on working capital. The supe-

riority of IT over FP was assessed mainly in terms of yield increments, additional net returns from IT over FP (ANR) and incremental benefit cost ratio (IBCR). The IBCR was computed as follows:

$$IBCR = \frac{\text{Additional gross returns obtained from IT over FP}}{\text{Additional costs incurred towards IT over FP}}$$

Hence the IBCR indicates the average additional gross income obtained for every additional one rupee invested in IT over and above what is invested in FP.

The technology adoption pattern was studied using the primary data pertaining to the year 1991-92 collected from 416 farmers through a separate survey conducted after the withdrawal of the facilities offered to frontline demonstrations. The 'Technology Adoption Index' (TAI) was computed for each of the oilseed crops as below :

$$TAI = \frac{A_i}{M_i} \times 100$$

where A_i = Average adoption score registered by the farmers for i^{th} crop, and

M_i = maximum adoption score for i^{th} crop.

RESULTS AND DISCUSSION

Whole package technologies

There exists a vast untapped yield potential of the oilseed crops even with the currently available oilseed crop production technologies as suggested by the valuable data available from more than 4200 demonstrations conducted in the country in diverse oilseed growing areas/agroecological situations/ regions and in different seasons (namely, *kharif* and *rabi* / sum-

Table 1. Crop-wise and State-wise AICORPO centres under FDO programme

Crop	State	Centres	Crop	State	Centres
Groundnut	Andhra Pradesh	Jagtial, Kadiri	Rapeseed-mustard	Assam	Shillongani
	Gujarat	Amreli, Anand, Junagadh		Bihar	Dholi
	Karnataka	Chintamani, Dharwad, Raichur		Gujarat	Junagadh, S.K. Nagar
	Madhya Pradesh	Khargaon		Haryana	Bawal, Hissar
	Maharashtra	Jalgaon, Latur, Rahuri		Himachal Pradesh	Kangra
	Orissa	Chiplima		Madhya Pradesh	Morena
	Rajasthan	Durgapura, Sriganaganagar		Orissa	Bhubaneswar
	Tamil Nadu	Ahiarnagar, Bhavanisagar, Vridhachalam		Punjab	Bhatinda, Ludhiana
				Rajasthan	Jobner, Navgaon, Sriganaganagar
				Uttar Pradesh	Faizabad, Kanpur, Pantnagar
Sesame	Bihar	Dholi	Safflower	West Bengal	Berhampore
	Gujarat	Amreli		Andhra Pradesh	Tandur
	Kerala	Kayamkulam		Karnataka	Annigeri
	Maharashtra	Jalgaon, Nagpur		Maharashtra	Jalgaon, Solapur
	Madhya Pradesh	Tikamgarh	Linseed	Madhya Pradesh	Indore
	Orissa	Bhubaneswar		Bihar	Kanke
	Punjab	Gurdaspur		Himachal Pradesh	Kangra
	Rajasthan	Mandore		Maharashtra	Nagpur
	Tamil Nadu	Vridhachalam		Madhya Pradesh	Raipur, Sagar
	Uttar Pradesh	Mauranipur		Punjab	Gurdaspur
Sunflower	West Bengal	Berhampore		Rajasthan	Kota
	Karnataka	Dharwad, Raichur		Uttar Pradesh	Faizabad, Kanpur, Mauranipur
	Maharashtra	Akola, Latur	Castor	West Bengal	Berhampore
	Tamil Nadu	Coimbatore		Andhra Pradesh	Palem
	Uttar Pradesh	Kanpur		Gujarat	Junagadh, S.K. Nagar
Niger	Punjab	Ludhiana		Karnataka	Raichur
	Bihar	Kanke		Orissa	Semiliguda
	Karnataka	Raichur		Rajasthan	Mandore
	Maharashtra	Dindori, Igatpuri		Tamil Nadu	Tindivanam
	Madhya Pradesh	Chindwara			
	Orissa	Semiliguda			

mer) over the period of 5 years (1988- 89 to 1992-93).

With the adoption of latest improved (whole package) oilseed crop production technologies recommended from time to time the increase in yield ranged from 21 per cent (in irrigated *kharif* sunflower) to as high as 108% (in irrigated niger) over the prevailing farmers' practices across various crop-season situations (Table 2). Thus on the yield front, IT was found to be highly remunerative. In terms of IBCR also, the superiority of IT over FP could be well established as the parameter value was greater than unity in all the crop-season situations in general. It ranged from 1.37 (in irrigated niger) to 13.4 (in rainfed mustard). The favourable yield increments, additional incomes and higher IBCR attributable to the adoption of improved oilseed crop production technology are largely due to low cost nature of the recommended technology which mainly exploits non-monetary and low cash inputs contrary to the wide spread belief that improved technologies are input intensive and require huge initial investment. The mean additional cost of IT incurred over and above FP was of the order of Rs. 216/ha to Rs.1604/ha while the mean additional gross returns ranged from RS.1619/ha to Rs. 6161/ha, thus resulting in encouraging additional net returns to the tune of Rs. 475/ha, to Rs. 4835/ha across various crop-season situations.

Cropping systems technologies

The annual oilseed crops, by virtue of their diversity of plant type, growth and developmental rhythm and adaptability to varying crop growing situations and areas, admirably fit in to a multitude of cropping systems in drylands as well as areas with favourable rainfall and moisture. Recent researches have unfolded a

whole range of new opportunities for expanding the frontiers of oilseeds cultivation in traditional as well as non-traditional areas of their cultivation and increasing per hectare yields and incomes from rainfed and irrigated areas through their exploitation as intercrops either *inter se* or with other cereals, grain legumes, etc. and as sequence/relay crops before or after other crops taking advantage of the new varieties/hybrids in different crops and the availability of efficient soil-water-crop management techniques. Cropping systems approach not only enhances yields and incomes of farmers from diverse crop growing situations and resource levels, but also brings about the much needed stability (Rao, 1991).

A number of profitable and viable cropping systems involving oilseeds as sequential and intercrops either *inter se* or with other traditional crops have been identified under the AICORPO network in recent years. The promising cropping systems have been tested under real farm situations to a limited extent in various oilseed producing states. The most popular and economically viable intercropping systems widely followed in various agro-ecological situations under *kharif* (rainfed) situation are: (i) groundnut + pigeonpea in 5:1 row proportion at Chintamani, Dharwad and Raichur in Karnataka (ANR : Rs.4476/ha and IBCR : 3.23), (ii) sesame + blackgram (6:2) at Tikamgarh in Madhya Pradesh and Mandor in Rajasthan (ANR:Rs. 1210/ha, IBCR : 1.87), and (iii) sunflower + groundnut (2:6) at Akola in Maharashtra (ANR : Rs.2363/ha, IBCR:2.11) (Table 3).

Similarly, the performance of proven intercropping systems involving oilseed crops during *rabi* season is promising. In the case of rapeseed-mustard, the ANR obtained with the

Table 2. Economics of improved technologies in oilseeds production in relation to prevailing farmers' practices (1988-89 to 1992-93)

Crop	Season RF/I/LI	No. of demonstra- tions	Mean yield (kg/ha)		% increase over FP	Mean cost of cultivation (Rs/ha)		Mean addl. cost over FP (Rs/ha)	Mean addl. returns over FP (Rs/ha)	Mean addl. net returns over FP (Rs/ha)	Incremental benefit cost ratio(BCR)
			IT	FP		IT	FP				
Groundnut	K,RF	368	1340	960	39.58	5666	4383	1283	3480	2197	2.71
	K,I	189	1932	1352	42.90	7355	5751	1604	5718	4114	3.56
	R/S,I	567	2341	1741	34.46	7991	6665	1326	6161	4835	4.65
Mustard	R,RF	92	964	615	36.75	3458	3242	216	2895	2679	13.40
	R,I	664	1806	1320	36.82	4419	3537	882	4148	3266	4.70
	R,RF	44	778	422	84.36	3054	1932	1122	3099	1977	2.76
Sesame	RI	91	1418	977	45.14	3405	2622	783	3504	2721	4.48
	K,RF	342	554	345	60.58	2764	1880	884	2559	1675	2.89
	K,I	39	860	564	52.48	4029	2690	1339	2961	1622	2.21
Sunflower	R/S,RF	24	544	277	96.39	4146	2703	1443	4325	2882	3.00
	R/S,I	164	826	549	50.46	3773	2795	978	3020	2042	3.09
	K,RF	36	1401	1044	34.20	5047	4523	524	2952	2428	5.63
Safflower	K,I	15	1453	1198	21.28	4725	4247	478	3333	2855	6.97
	R/S,I	175	1312	923	42.15	4995	4001	994	3105	2111	3.12
	SPR	39	1528	1165	31.16	5983	5027	956	3110	2154	3.25
Niger	R,RF	79	973	606	60.56	2496	1681	815	2715	1900	3.33
	R,I	10	1157	830	39.39	1776	1454	322	3539	3217	10.99
	R,I	30	1835	1344	36.53	4699	3861	838	3876	3038	4.63
Castor	K,RF	242	409	230	77.83	1792	1011	781	1619	838	2.07
	K,I	14	475	229	107.42	2527	1230	1297	1772	475	1.37
	K,RF	88	1281	837	53.05	3071	2129	942	2533	1591	2.69
Linseed	K,I	131	2628	1999	31.47	5431	4844	587	4093	3506	6.97
	R,RF	304	607	348	74.43	2304	1407	897	2721	1824	3.03
	R,I	289	967	536	80.41	3292	1942	1350	4279	2929	3.17

* K = Kharif; R = Rabi; R/S = Rabi/summer; SPR = Spring; RF = Rainfed; I = Irrigated; LI = Limited Irrigation

Table 3. Productivity potential and economics of intercropping systems in oilseeds (1988-89 to 1992-93)

Crop/system	Season (R/F/I)	No. of Demos.	Mean yield (kg/ha)		Cost of cultivation (Rs/ha)		Addl. cost over FP (Rs/ha)	Net returns (Rs/ha)		Addl. net returns over FP (Rs/ha)	IBCR
			IT	FP	IT	FP		IT	FP		
Groundnut:											
Groundnut + Pigeon pea (5:1)	K(RF)	34	1159 257	816 --	6128	4123	2005	8008	3532	4476	3.23
Sesame:											
Sesame + Blackgram (6:2)	K(RF)	12	296 188	176 125	2832	1444	1388	2719	1518	1210	1.87
Sunflower:											
Sunflower + Groundnut (2:6)	K(RF)	3	200 1000	750 --	5217	3080	2137	6783	4420	2363	2.11
Safflower:											
Gram + Safflower (3:1)	R(RF)	35	798 541	1026 --	3420	2714	706	6589	4653	1936	3.74
Coriander + Safflower (3:1)	R(I)	7	820 654	1328 --	2923	2288	635	11677	9795	1882	3.96
Wheat + safflower (3:1)	R(RF)	22	646 447	848 --	2892	1847	1045	3464	2652	812	1.78
Rapeseed-mustard:											
Wheat + Mustard (9:1)	R(I)	11	4189 339	2741 187	5210	4063	1147	9327	5354	3973	4.46
Gram + Mustard (3:1)	R(RF)	5	2250 520	1150 198	3979	2720	1259	19451	8920	10531	9.36
Toria + Gobhi sarson (1:1)	R(I)	5	663 1420	-- 1575	4121	3260	861	11427	9346	2081	3.42
Toria + Gobhi sarson (1:1)	R(RF)	4	1060 1119	647 803	5596	4801	795	11367	7112	4255	6.35
Toria + Gobhi sarson (1:1)	R(I)	10	1255 975	1533 (Mustard)	7141	5170	1971	11565	6814	4751	3.41
Linseed:											
Linseed + Gram (3:1) vs. (1:3)	R(I)	5	1232 930	472 1634	3307	2873	434	11501	7239	4262	10.82

* K = Kharif; R = Rabi; RF = Rainfed; I = Irrigated.

Note: Figures in parentheses indicate row proportions of respective intercropping systems

adoption of various viable intercropping systems ranged from Rs.2081/ha to as high as Rs. 10531/ha in different agro-climatic zones while the IBCR varied from 3.41 to 9.36. The economically viable intercropping systems involving rapeseed-mustard are wheat + mustard (9:1), gram + mustard (3:1) and toria + gobhi sarson (1:1). In linseed, the most viable intercropping system has been linseed + gram (3:1) as against the prevailing farmers' practice of linseed + gram but in 1:3 row proportion at Kanpur and Mauraipur in Uttar Pradesh. This improved practice has registered an ANR of Rs. 4262/ha over the prevailing FP and an IBCR as high as 10.82. The proven profitable intercropping systems in safflower have been gram + safflower (3:1) at Jalgaon and Solapur in Maharashtra, Annigeri in Karnataka and Tandur in Andhra Pradesh, coriander + safflower (3:1) at Jalgaon and Tandur and wheat + safflower (3:1) at Annigeri. These systems fetched an ANR ranging from Rs. 812/ha to Rs. 1936/ha with an IBCR varying from 1.78 to 3.96.

In all, irrespective of the crop and season, the ANR that could be obtained from the intercropping systems involving oilseeds varied from Rs. 812/ha to Rs. 10531/ha and the additional monetary returns realized ranged from about 2 to 11 times the additional cost incurred.

As regards cropping sequence trials, toria-wheat and blackgram-mustard cropping sequences have been economically evaluated at one of the AICORPO centres, namely, Morena (MP). The results indicate that farmers realised an additional net returns of Rs.6568/ha and Rs.3771/ha respectively from the cultivation of toria followed by wheat and

blackgram followed by mustard adopting all recommended improved package of practices over and above what they obtained from fallow-mustard system (Table 4). Apart from higher incomes, farmers also reaped an income of about Rs.2.25 to Rs.2.50 per every additional rupee invested on these sequential systems.

Component technologies

In addition to whole package and cropping systems technologies, the adaptive trials of component technologies involving newly developed high yielding varieties/hybrids and recommended technologies with respect to fertilizer, irrigation, plant protection chemicals, etc. have been evaluated against the existing popular practices in the region. While testing the yield potential of an individual component of the technology package, all the components other than the one under evaluation were held constant between improved and farmers' plots. The results presented in Table 5 clearly indicate that the new variety/hybrid alone could contribute to the yield increase to the tune of 33 per cent in groundnut at Khar-gaon (MP) and 35 to 38 per cent at Bhavanisagar (Tamil Nadu), 39 per cent in sesame at Jalgaon (Maharashtra), 12 to 24 per cent in sunflower at Akola (Maharashtra), 12 to 22 per cent in safflower at Tandur (AP) and 14 per cent at Annigeri (Karnataka) and 20 to 35 per cent in linseed at Kangra (HP). The additional net returns accrued due to the adoption of these new varieties/hybrids ranges from Rs. 2782 to Rs. 7438/ha in groundnut, Rs. 470 to Rs. 2251/ha in sunflower, Rs. 1833 to Rs. 2090/ha in linseed and Rs. 768 to Rs. 1150/ha in safflower. The same with respect to sesame was of the order of Rs. 1369/ha.

Table 4. Productivity potentials and economics of sequential cropping systems in rapeseed-mustard (1988-89 to 1992-93)

Crop/System	RF/I*	No. of demon.	Mean yield (kg/ha)		Cost of cultivation (Rs/ha)		Addl. cost over FP (Rs/ha)	Net returns (Rs/ha)		Addl. net returns over FP (Rs/ha)	IBCR
			IT	FP	IT	FP		IT	FP		
Toria- Wheat	I	4	1475	1325** (Mustard)	8125	3520	4605	15330	8762	6568	2.43
Blackgram- Mustard	I	7	2650	822** (Mustard)	6884	3873	3011	7561	3790	3771	2.25
			605								
			1039								

* RF = Rainfed; I = Irrigated. ** Sole mustard in the FP plot.

Table 5. Productivity potentials and economics of varietal trials in oilseeds (1990-91 to 1992-93)

Crop/Centre	RF/I	No. of demon- strations	Mean Yield (kg/ha)		Per cent increase in yield over FP	Cost of cultivation (Rs/ha)		Net returns (Rs/ha)		Addl. net returns over FP (Rs/ha)
			IT	FP		IT	FP	IT	FP	
Groundnut:										
Khargaoon	RF	1	1000 (KGN-3)	750 (AK-12-24)	33	8070	7352	5930	3148	2782
Bhavanisagar	I	1	3375 (ICGS-11)	2500 (TMV-2)	35	10868	10868	17820	10382	7438
	I	1	2750 (ICGS-11)	2000 (VRI)	38	11118	11118	12257	5882	6375
Sunflower:										
Akola	I	4	1245 (BSH-1)	1005 (EC-68414)	24	3830	3615	9390	7139	2251
	I	2	739 (MSFH-17)	629 (EC-68414)	17	4900	4275	1881	1411	470
	RF	6	900 (AKSF-9)	790 (Morden)	14	2955	2955	4545	3628	917
		I	4	1491 (PKVSH-27)	1329 (BSH-1)	12	4519	4576	7610	6218
Sesame:										
Jalagaon	RF	6	531 (JLT-26)	381 (HAWARI)	39	3820	3035	3612	2243	1369
Safflower:										
Annigeri	RF	1	1000 (343-12-10)	875 (A1)	14	4317	4317	4883	3733	1150
Tandur	RF	2	1188 (Manjira)	1063 (Local)	12	2615	2508	5698	4930	768
	RF	1	1125 (Bhima)	925 (Local)	22	2615	2250	5260	4225	1035
Linseed:										
Kangra	I	6	1085 (KL-1)	902 (Himalini)	20	3936	3936	6914	5081	1833
	RF	2	808 (RLC-29)	599 (Local)	35	4500	4500	3580	1490	2090

* RF = Rainfed; I = Irrigated.

Note : Names of the crop varieties/hybrids are given in the parentheses under the column "Mean Yield".

Anticipated additional production

Thus with the adoption of currently available oilseeds production technology, be it whole package, cropping systems or component technologies, farmers could realize an additional yield ranging from 12 to 108 per cent over the prevailing farmers' practices, mean additional net returns varying from Rs. 470/ha to Rs. 10531/ha resulting in the higher IBCR ranging from 1.37 to 13.40 under a wide range of agro-ecological and crop growing situations. This wide commercially untapped yield reservoir would be much larger if one compares the realizable yield levels of improved technologies with the district/state/national average yield levels and more so if one considers the highest yields recorded from demonstration plots. An attempt has been made to estimate the anticipated additional production of oilseeds possible through tapping the yield gap by complete or partial adoption of the improved technologies.

The results indicate that the productivity of oilseeds realizable under farmers' field conditions is of the order of 1437 kg/ha while the national average yield stands at as low as 749 kg/ha (Table 6). Thus there exists realizable yield gap of 688 kg/ha which means an additional production of the order of 14.61 million tonnes otherwise would have been available. Even with a conservative expectation of 25% to 50% of the mean unrealized yield reservoir to be commercially tapped through the adoption of improved technologies, our country should be able to add another 3.7 to 7.3 million tonnes to the oilseeds production from out of the existing area under oilseeds and under the existing price support policies. Much of the anticipated additional production comes from

groundnut (15.63 to 31.25 lakh tonnes), rapeseed-mustard (10.21 to 20.43 lakh tonnes), castor (2.34 to 4.67 lakh tonnes) and sesame (2.23 to 4.46 lakh tonnes) in that order.

Pattern of adoption of technology components

The extent of adoption of individual technological components was measured in terms of percentage of sample farmers adopting the particular component completely or partially. The results indicate that even after the withdrawal of the facilities offered to frontline demonstrations the adoption was higher in respect of improved variety/hybrid seed (range: 78 to 100%, weighted mean: 91.6%) followed by spacing/seed rate (range: 73 to 100%, weighted mean: 86.3%) and fertilizer application (range: 16 to 100%, weighted mean: 61.0%) in that order across different oilseed crops in general (Table 7).

A moderate level of adoption was observed in the case of weed management (46.9%), seed treatment (41.8%), irrigation (38.7%) and plant protection (35.3%). Although seed treatment is a low cost practice, about 38 per cent of the oilseed farmers did not adopt this technology. In the case of plant protection, adoption was more a partial (36.1%) one than complete (35.3%) and about 29% of the farmers did not adopt this technology.

By and large, majority of the sample farmers raising various oilseed crops have adopted recommended variety/hybrid and spacing/seed rate, while the adoption with respect to nutrient management and plant protection including weed control was either complete or partial.

Table 6. Anticipated additional production of oilseeds through adoption of improved technology

Crop	Mean realizable yield with IT (kg/ha)	Quadrennial* national average yield (kg/ha)	Realizable yield gap (kg/ha)	Quadrennial* national average area (Lakh ha)	Quadrennial* national average production (Lakh tonnes)	Additional production (in lakh tonnes) possible with realization of exploitable yield gaps under real farm situations by			
						100%	75%	50%	25%
Groundnut									
Kharif	1541	827	714	71.18	58.90	50.82	38.12	25.41	12.71
Rabi/summer	2341	1528	813	14.37	21.95	11.68	8.76	5.84	2.92
Sesame	653	295	358	24.90	7.34	8.91	6.68	4.46	2.23
Niger	413	289	124	6.20	1.79	0.77	0.58	0.38	0.19
Sunflower									
Kharif	1416	416	1000	7.26	3.02	7.26	5.45	3.63	1.82
Rabi/summer	1351	593	758	7.81	4.63	5.92	4.44	2.96	1.48
Castor	2087	778	1309	7.14	5.56	9.35	7.01	4.67	2.34
Rapeseed-mustard	1629	888	741	55.13	48.93	40.85	30.64	20.43	10.21
Safflower	1206	488	718	7.43	3.62	5.33	4.00	2.67	1.33
Linseed	782	304	478	10.84	3.29	5.18	3.89	2.59	1.30
Total (8 oilseeds)	1437	749	688	212.26	159.03	146.07	109.55	73.04	36.52

* Average of quadrennium ending 1991-92.

Table 7. Adoption of different components of oilseeds crop production technologies (1991-92)

Technology adopted	Extent of adoption	Groundnut	Sesame	Sunflower	Niger	Safflower	Rapeseed-Mustard	Linseed	All oilseeds
Variety	C	90.0	89.2	100.0	100.0	92.9	95.5	78.3	91.6
	P	-	10.8	-	-	7.1	4.5	21.7	6.7
	N	10.0	-	-	-	-	-	-	1.7
Seed treatment	C	77.2	47.1	3.3	4.4	67.9	19.4	39.1	41.8
	P	21.4	12.7	-	60.0	17.8	9.0	28.3	20.2
	N	1.4	40.2	96.7	35.6	14.3	71.6	32.6	38.0
Spacing/seed rate	C	77.1	97.1	100.0	73.3	94.6	83.6	73.9	86.3
	P	10.0	2.9	-	26.7	5.4	16.4	26.1	11.5
	N	12.9	-	-	-	-	-	-	2.2
Fertilizers	C	24.3	73.5	100.0	15.6	96.4	79.1	39.1	61.0
	P	71.4	25.5	-	84.4	3.6	20.9	60.9	38.0
	N	4.3	1.0	-	-	-	-	-	1.0
Weed management	C	38.6	65.7	53.3	4.4	85.7	28.4	34.8	46.9
	P	55.7	31.4	46.7	62.3	14.3	50.7	13.0	38.7
	N	5.7	2.9	-	33.3	-	20.9	52.2	14.4
Irrigation	C	48.6	11.8	100.0	-	46.4	70.1	26.1	38.7
	P	27.1	6.8	-	-	21.4	22.4	60.9	19.5
	N	24.3	81.4	-	100.0	32.2	7.5	13.0	41.8
Plant protection	C	27.1	36.3	50.0	-	75.0	35.8	21.7	35.3
	P	72.9	41.2	3.3	2.2	25.0	38.8	32.6	36.1
	N	-	22.5	46.7	97.8	-	25.4	45.7	28.6

Note : C = Complete adoption; P = Partial adoption; N = Non-adoption.

Technology Adoption Index (TAI)

A composite score for adoption of various technology components was worked out for each of the oilseed crops to understand the overall adoption of improved technology across different oilseeds. The maximum number of technology components considered for this analysis is 7 for all the crops except in the case of niger wherein it is 6 due to non-inclusion of irrigation component in the recommendation domain as niger is mainly grown as a rainfed crop.

The results reveal that the average number of technology components completely adopted varies from 1.98 in niger to as high as 5.59 in safflower (Table 8). The TAI was highest in the case of safflower (80%) followed by sunflower (72%) and sesame (60%), while rapeseed-mustard and groundnut had moderate level of adoption (59% and 55% respectively). However, the TAI was less than 50% in the case of linseed and niger. Thus there exists a wide extension gap in the adoption of improved technology in the case of niger and

linseed and to some extent in groundnut and rapeseed-mustard. Therefore, in order to enhance productivity and profitability of these crops, extension efforts have to be strengthened and more concentrated particularly towards the technology components of plant protection, weed management and seed treatment in that order of priority.

CONCLUSION

The present study reveals that there exists a vast commercially untapped yield potential of the oilseed crops even with the currently available technologies. The improved oilseeds crop production technology could register, under real farm situations, an additional yield ranging from 12 to 108 per cent over the prevailing farmers' practices, mean additional net returns to the tune of Rs. 470/ha to Rs. 10531/ha resulting in higher incremental benefit cost ratio varying from 1.37 to 13.40 under a wide range of agro-ecological and crop growing situations. The realizable yield gap is of the order of 688 kg/ha which means an additional production of 14.61 million tonnes which otherwise would

Table 8. Technology adoption indices for component technologies of oilseeds production

Crop	No. of Farmers	Average adoption score registered by farmers			Technology adoption index (TAI) (per cent)		
		C	P	N	C	P	N
Groundnut	70	3.83	2.59	0.58	54.71	37.00	8.29
Sesame	102	4.21	1.31	1.48	60.14	18.72	21.14
Sunflower	30	5.07	0.50	1.43	72.43	7.14	20.43
Niger	45	1.98	2.35	1.67	33.00	39.17	27.83
Safflower	56	5.59	0.95	0.46	79.86	13.57	6.57
Rapeseed-mustard	67	4.12	1.63	1.25	58.86	23.28	17.86
Linseed	46	3.13	2.44	1.43	44.71	34.86	20.43
Total	416						

Note : C = Complete adoption; P = Partial adoption; N = Non-adoption

have been available to the country with the existing level of area under oilseeds cultivation. Even after the withdrawal of the facilities offered to the frontline demonstrations, the adoption was higher in respect of improved variety/hybrid seed, spacing/seed rate and fertilizer in general, while it was moderate in the case of weed management, seed treatment, irrigation and plant protection, in that order. The adoption of technology components (of the technology adoption index) was highest in the case of safflower followed by sunflower, sesame, rapeseed-mustard and groundnut, while it was low in the case of linseed and niger. Therefore, in order to enhance the productivity and profitability of these crops, the extension efforts have to be essentially strengthened based on the technology adoption index and more concentrated, particularly towards plant protection, weed management and seed treatment.

LITERATURE CITED

- Food and Agriculture Organization of the United Nations (FAO). 1991. FAO Production Yearbook. Rome.
- Kiresur, V., B.N. Reddy and M.V.R. Prasad. 1993. Low Cost Technologies for sustainable oilseeds production. In Prasad, M.V.R. et al. (Ed) 1994. Sustainability in Oilseeds. Indian Society of Oilseeds Research, Hyderabad pp. 441-447.
- Anonymous, 1994. Frontline Demonstrations in Oilseed Crops, Annual Report 1992-93, Directorate of Oilseeds Research, Hyderabad.
- Ranga Rao, V. 1990. Self Reliance in Vegetable Oils - A Myth or Reality. *Journal of Oilseeds Research*, 7(2) : 58-64.
- Ranga Rao, V. 1991. Improved Technologies in Oilseeds : Performance and Promise under Real Farm Situations. Directorate of Oilseeds Research (ICAR), Hyderabad.

PROSPECTS FOR UTILIZATION OF GENOTYPIC VARIABILITY FOR YIELD IMPROVEMENT IN GROUNDNUT*

R.C. NAGESWARA RAO, A.K. SINGH, L.J. REDDY, and S.N. NIGAM
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT),
Patancheru 502 324, (A.P), India.

ABSTRACT

During the past decade, significant progress has been made in identifying resistance sources and developing groundnut cultivars with resistance to major biotic constraints. However, very little progress has been made in identification and exploitation of genetic traits contributing improvement of yield potential and adaptation.

An understanding of physiological factors influencing yield components and the development of simple screening techniques to select for traits contributing to yield is central to the development of appropriate genotypes. Recent research on groundnut physiology at ICRISAT Asia center has indicated substantial variation among genotypes for desirable traits like water-use efficiency (WUE), partitioning of dry matter to pods (p) and efficient root systems etc. However, measurement of these traits is complex and laborious. Significant correlations amongst WUE, carbon isotope discrimination in leaf and specific leaf area (SLA), suggested that SLA can be used as a surrogate for carbon isotope discrimination to identify genotypes with high WUE.

The adaptation of improved genotypes to varied environments is one of the major problems in groundnut improvement program. Although significant genotype \times environment interactions have been noted, there is little emphasis on understanding and exploiting variability for specific adaptation. There seems to be scope for yield improvement in groundnut by selecting for physiological attribute(s) contributing to yield advantage in a given environment and combining them to enable further identification of genotypes with desirable combinations of traits. Scope also exists to enhance productivity of groundnut by sacrificing wider adaptation and instead developing varieties with specific traits to match certain special agro-climatic requirements.

Keywords: Groundnut; Yield improvement; Physiological traits; Adaptation.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is an important oilseed and cash crop in India, where it is grown over 7.4 million hectares, predominantly under rainfed conditions. Although India is the

world's largest producer (6.4 million tonnes per year), the national average productivity was 0.7-0.9 t ha⁻¹ during the past decade, compared to the world's average of about 1.1 t ha⁻¹ (Fletcher *et al.*, 1992). The gap between Indian and the world productivity has been consistent

* Invited paper presented at the National Seminar on "Oilseeds Research and Development in India: Status and Strategies" 2-5 Aug. 1993, Hyderabad. Indian Society of Oilseeds Research, Hyderabad.

Received for publication on December 23, 1994.

over last decade. A marginal increase in groundnut production during the past 5 years (9%) is attributable to 12% increase in area and 6% increase in productivity (AICORPO, 1993). The on-farm average yields in India (ca. 0.8 t ha^{-1}) are much lower than in the developed countries (2.5 t ha^{-1}). There is an urgent need to enhance yields, both in terms of quantity and quality, if India is to compete in international groundnut trade.

In Zimbabwe, on-farm yields of about 9.6 t ha^{-1} was reported (Hilderbrand, 1980). Sun Yanhas and Wang Caibin (1990), reported pod yields of 11.2 t ha^{-1} in a 0.1 ha plot and 9.6 t ha^{-1} from 14 ha plot in Shandong province in China. At ICRISAT Asia Center (IAC), yields up to 7 t ha^{-1} have been achieved on small plots and up to 5 t ha^{-1} larger plots. On-farm trials conducted under an ICAR-ICRISAT collaborative project during 1988-90 have shown that yields of groundnut up to 5 t ha^{-1} could be obtained on large plots (0.2 ha) when improved technologies were adopted. These studies also showed that improved genotypes contributed 25-28% and improved management contributed 30-32% to the observed increase in yield. However, appropriate combination of improved genotype and crop management resulted in a synergistic improvement in yield ranging from 50 to 150% (Nene, 1993). Obviously, the logical approach to increase yield in groundnut calls for an appropriate combination of crop improvement and management.

The dry matter yield of groundnut crop at final harvest can be described as:

$$Y = \text{CGR} \times D \dots\dots\dots (1)$$

Where CGR is the crop growth rate (defined as dry matter produced per unit land area per unit time, usually expressed as g m^{-2}

day^{-1}) and D is the crop duration in days. The pod yield at the final harvest can be described as:

$$Y_p = \text{CGR} \times D \times p \dots\dots\dots (2)$$

Where p is the proportion of the daily assimilates partitioned into pods during the pod filling phase.

If the crop's duration is assumed to be fixed for a given location or cropping system, then CGR and p are the major determinants of the final yield. Both CGR and p are influenced by both genetic and environmental factors. In this paper, we consider some major crop attributes that determine productivity in groundnut, and examine scope for crop improvement by exploiting genetic variability in these attributes.

Radiation interception and Radiation-use efficiency

There is considerable evidence that all crops (including groundnut) accumulate dry matter at a rate proportional to the amount of radiation that the foliage intercepts during the growing period (Mathews *et al.*, 1988 b, Azam-Ali *et al.*, 1989). Any factor that reduces radiation interception below the optimum limit can reduce yield by limiting the photosynthetic area per unit ground area. In groundnut, complete ground cover resulting in >95% radiation interception by foliage is achieved at a leaf area index (LAI) of approximately 3. Once this has occurred, the CGR depends mainly on other limiting factors such as availability of water and crop growth duration. The CGR response to increased leaf area above LAI of 3 is generally small, although there are some reports of 20% more growth at a LAI 6 than at LAI of 3 (Williams, 1979).

Table 1. Yields and RUE of TMV 2 and narrow mutant of TMV 2 (TMV2-NLM) grown under irrigated and water deficit conditions at ICRISAT center.

Genotype	1989-90 postrainy			1990 rainy					
	(Irrigated)			(Irrigated)			Mid-season drought		
	Adj Bio (t ha ⁻¹)	Pwt (t ha ⁻¹)	RUE (g MJ ⁻¹)	Adj Bio (t ha ⁻¹)	Pwt (t ha ⁻¹)	RUE (g MJ ⁻¹)	Adj Bio (t ha ⁻¹)	Pwt (t ha ⁻¹)	RUE (g MJ ⁻¹)
TMV2	11.1	3.3	0.95	6.14	1.3	NA	5.18	0.78	0.59
TMV2-NLM	12.2	3.9	1.16	7.50	1.2	NA	7.20	0.89	0.75
SE	±0.76	±0.31	±0.06	±0.29	±0.04	-	±0.29	±0.04	±0.08
C.V.	13.2	25.2	18.1	4.8	5.1	-	4.8	5.1	21.1

Adj Bio = Adjusted total biomass; Pwt = Pod weight; RUE = Radiation use efficiency

Experiments conducted at IAC and elsewhere indicate genotypic variability in groundnut for radiation-use efficiency (RUE), defined as the dry matter produced per unit amount of radiation intercepted (Mathews *et al.*, 1988b, Nageswara Rao, 1992). There seems to be limited scope for manipulating RUE by altering canopy structure and geometry. In a field study conducted at IAC, we examined the influence of canopy structure on productivity of groundnut using selected mutants with varied leaf size and shape. Results showed that TMV 2-NLM (a mutant of TMV 2 which has narrow leaves but greater number of leaves), produced more total dry matter than TMV 2 (Table 1). One of the main physiological factors responsible for greater dry matter production in TMV 2-NLM was the increased RUE in the former. The narrow leaf morphology in TMV 2-NLM reduced mutual shading by leaves, thus allowing more radiation to penetrate into the canopy. It is possible, however that in addition to a modified canopy structure, TMV 2-NLM may have an altered genetic makeup for other yield attributes. Isogenic lines are needed to accurately quantify the contribution of individual traits to yield. The role of crop canopy

structure in groundnut productivity needs further investigation.

Water use and Water-use efficiency

Many studies have demonstrated a significant positive relationship between dry matter production and the amount of water transpired during the growing period (Ong *et al.*, 1987; Azam-Ali *et al.*, 1989) (Fig.1). This implies that any genetic attribute and/or management practice that enhances transpiration component in the total evapo-transpiration would increase dry matter production.

Recent studies revealed substantial genotypic variation among groundnut germplasm for water-use efficiency (WUE), defined as dry matter produced per unit amount of water transpired (Hubick *et al.*, 1986, Mathews *et al.*, 1988a, Wright *et al.*, 1988, Nageswara Rao *et al.*, 1993). While a higher WUE is potentially useful, WUE is not an easy trait to exploit in a breeding program because of practical difficulties involved in measurement of transpiration and total crop (shoot + root) mass in field experiments. A significant relationship between WUE ¹³C : ¹²C isotope

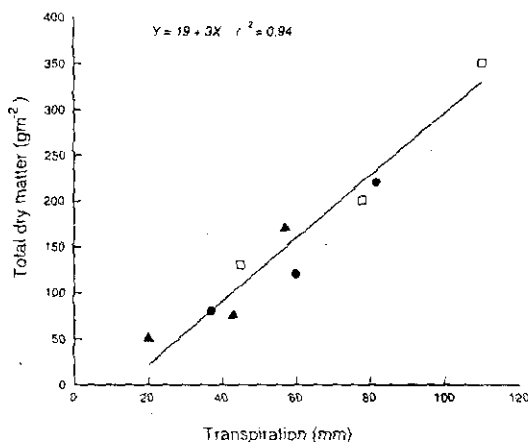


Fig. 1: Relationship between transpiration and total dry matter production in groundnuts grown at three plant spacings (35 x 10 cm ▲ ; 70 x 10 cm ● ; 120 x 10 cm □). Postrainy season 1981-82, ICRISAT Asia Center (from Azam-Ali *et al.* 1989)

discrimination during CO₂ assimilation in leaves has been demonstrated in a range of crops including groundnut (Farquhar and Richards, 1984; Hubick *et al.*, 1986, Wright *et al.*, 1988, Nageswara Rao *et al.*, 1993, Wright *et al.*, 1994). This suggests that carbon discrimination ratio is a potential selection tool to identify groundnut genotypes with high WUE (Fig 2). However, determination of the carbon isotope discrimination ratio requires expensive and sophisticated mass spectrometry facilities which are not easily available in developing countries.

In a recent study, a significant negative relationship was observed between WUE and specific leaf area (SLA) (Wright *et al.*, 1994, Fig 3) SLA, defined as leaf area per unit leaf dry wt (cm² g⁻¹), is an indicator of leaf thickness. Both environment and genotype can significantly influence carbon isotope discrimination ratio and SLA, but the G x E interaction for these parameters appears not to be sig-

nificant (Nageswara Rao and Wright, 1994). This observation implies that SLA, which is a crude but easily measurable parameter, can be used as a rapid and inexpensive selection criterion for high WUE. Screening of groundnut germplasm for SLA indicated significant variability within and between taxonomic groups. It was interesting to note that the genotypes belonging to variety *hypogaea* (virginia bunch and runner), lower mean SLA (Fig 4a), suggesting a likelihood of higher WUE. However, virginia bunch and virginia runner had lower partitioning ability than valencia and spanish types (Fig 4b). There is need to identify genotypes with high WUE and high partitioning for use in groundnut breeding programs.

Partitioning of dry matter to pods

Pod growth rate (PGR), defined as pod dry matter produced per unit land area per unit time, is an important component of CGR and

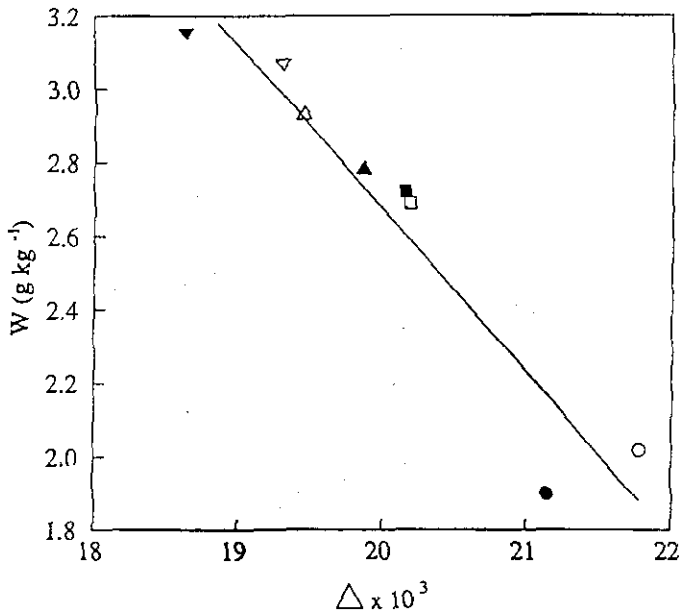


Fig. 2: Relationship between water-use efficiency and carbon isotope discrimination in 4 groundnut genotypes, Chico (O), McCubbin (\square), Shulamit (Δ) and Tifton-8 (∇), grown under intermittent (closed symbols) and continuous (open symbols) drought treatment in 1990-91 season at Kingaroy, Australia (from Wright *et al.* 1994).

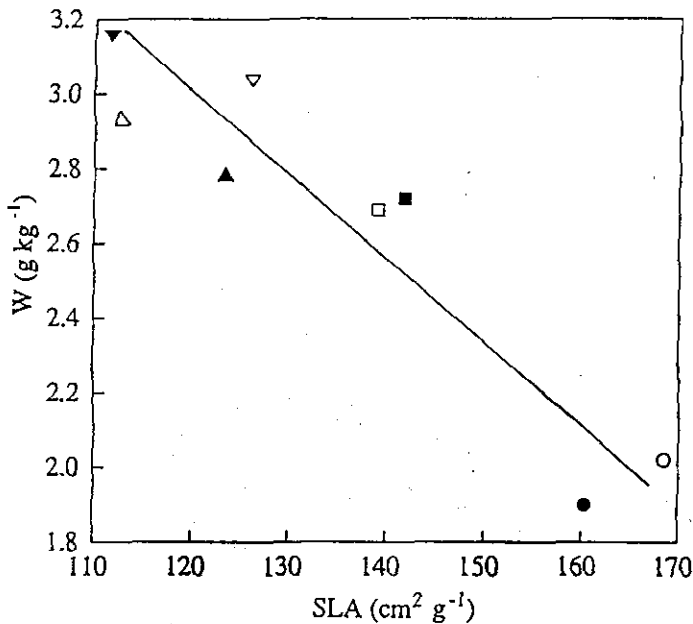


Fig. 3: Relationship between water-use efficiency and specific leaf area in 4 groundnut genotypes, Chico (O), McCubbin (\square), Shulamit (Δ) and Tifton-8 (∇) grown under intermittent (closed symbols) and continuous (open symbols) drought treatments during 1990-91 season at Kingaroy, Australia (from Wright *et al.* 1994).

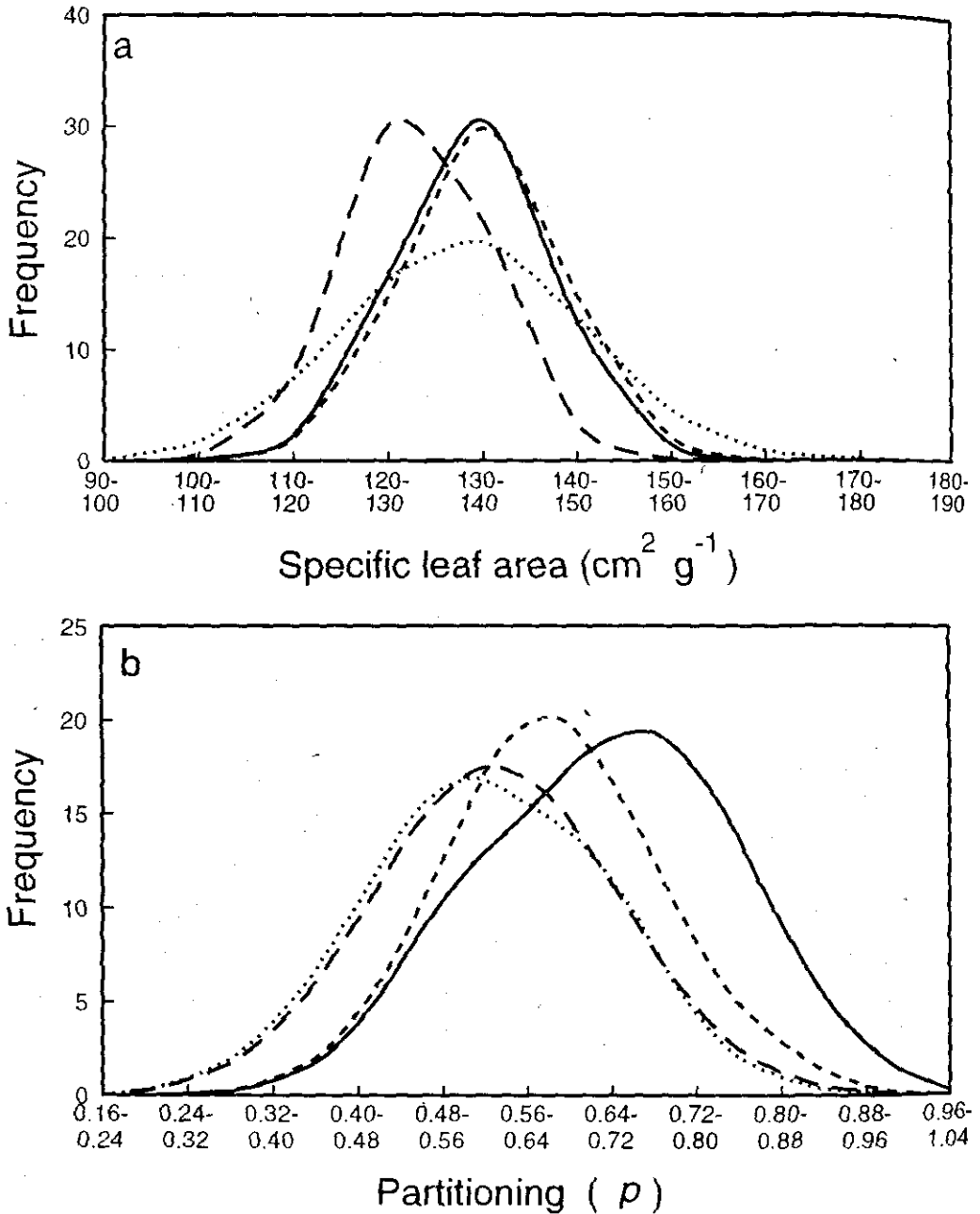


Fig. 4: Specific leaf area (SLA) (a) and partitioning, P (b) in 64 groundnut germplasm accessions of different botanical types. Postrainy season 1992, ICRISAT Asia Center (spanish ---, valencia —, virginia bunch, virginia runner - .-).

determinant of pod yield. In addition to equation (2), pod yield achieved at harvest can be described as:

$$Y_p = PGR \times D \dots\dots\dots (3)$$

Pod growth rate is dependent on both genotype and environment. Although there is considerable variation among genotypes for p (Fig. 4b), conventional methods of determining p are laborious and cumbersome, and are unsuitable when a large number of entries need to be evaluated for this trait. However, simple, non-destructive methods can be effectively used as preliminary screening tools to identify genotypes with efficient partitioning attributes (Williams and Saxena, 1991).

Adaptation to specific environments

Several biotic (diseases, insect pests, etc.) and abiotic factors (photoperiod, soil moisture, soil acidity, nutrient status, etc.) can influence pod growth resulting in significant effect of environment on yield.

Let us, for example, examine the adaptation of improved groundnut genotypes to two types of soils, Alfisols and Vertisols, which are the two major soil types on which groundnut is grown in India. Soil fertility problems, which are likely to be very diverse and location specific, can be overcome to some extent by the use of fertilizers and other amendments. However, inherent physical properties of soil also vary with type (El-Swaify and Caldwell, 1991) and are particularly important because of the subterranean fruiting habit of groundnut. From the crop adaptation point of view, it is important to determine whether high-yielding genotypes developed on one soil type are adapted to other soil types. Several trials conducted at IAC to examine genotype \times soil type

interaction suggested that groundnut growth and yield were superior in Alfisols than Vertisols (Nageswara Rao *et al.*, 1992). A detailed study of genotype \times water deficit interaction conducted on the two soil types at IAC indicated that CGR was 40% greater on the Alfisol than on Vertisol, under adequately irrigated conditions. Although the occurrence of drought significantly affected crop growth on both soils, the effect of time of occurrence of drought on crop growth varied with the soil type. Drought during the pod-filling phase resulted in significant yield reduction on the Alfisols, while on the Vertisol, occurrence of drought during pod set phase appeared to be more detrimental to yield. Partitioning of dry matter to pods (p) was significantly lower on the Vertisol than on the Alfisol.

The CGR on the Alfisol was positively correlated ($r^2 = 0.77^{**}$, $P < 0.01$) with CGR on Vertisol, but there was no such relationship for p ($r^2 = 0.38$) between the two soil types. This suggests that high-yielding genotypes developed on Alfisols may maintain their relative ranking for total dry matter on Vertisols, but not for pod yields (Fig. 5a and 5b). It appears that productivity of groundnut can be improved on Vertisols by developing varieties with specific adaptation.

Concluding remarks

Although genotypic variation exists for putative yield-determining traits like WUE, RUE and p , it is necessary to understand the interactions amongst the traits. At present very little is known about these interactions and their effect on yield.

We believe that sustainable yield improvement can be achieved if the attributes that contribute to yield advantage in a given

Fig 5a

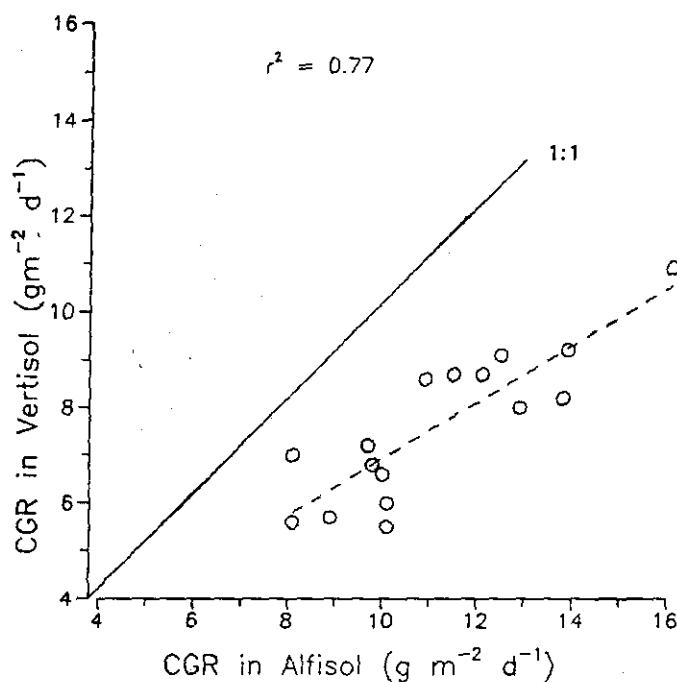


Fig 5b

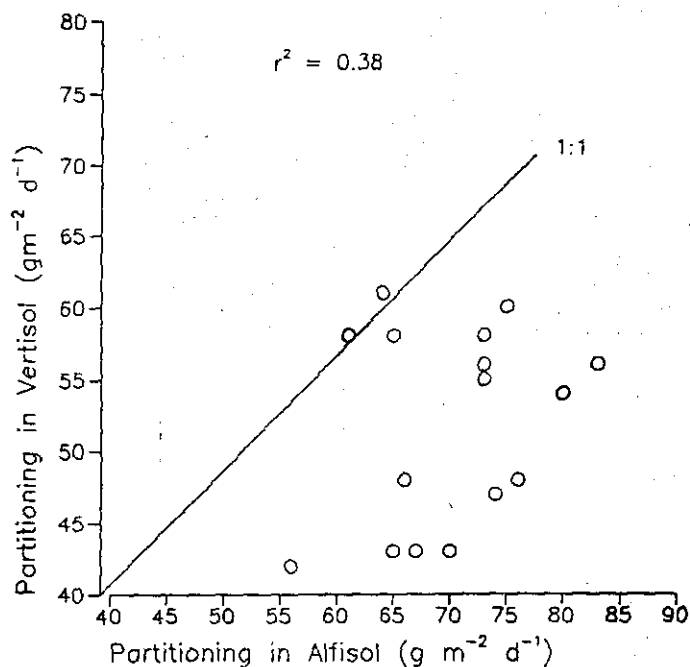


Fig. 5: Comparison of (a) crop growth rate (CGR) and (b) partitioning (p) of 4 groundnut genotypes grown on the Alfisol (a) and Vertisol (b) during postrainy season 1988-89, ICRISAT Asia Center.

environment are identified and used in breeding programs to enable identification of genotypes with desirable combinations of traits. Groundnut productivity can also be improved by sacrificing wider adaptation and developing varieties with specific adaptation to match local agroclimatic requirements.

LITERATURE CITED

- AICORPO, 1993. Annual Progress Report Groundnut. In XXXVIII Annual Kharif Oilseed Research workers Group Meeting, 6-8 May 1991, Gujarat Agricultural University, Junagadh, Gujarat. All India Coordinated Research Project on Oilseeds, Directorate of Oilseeds Research, Rajendranagar, Hyderabad.
- Azam-Ali, S.N., Simmonds, L.P., Nageswara Rao, R.C. and Williams, J.H. 1989. Population, growth and water use of groundnut maintained on stored water. III. Dry matter, water use and light interception. *Expt. Agric.* 25:77-86.
- El-Swaify, S.A. and Caldwell, R.C. 1991. Potential crop productivity of Alfisols and Vertisols in the Semi-arid tropics. pages 3-16 In : Phosphorus nutrition of grain legumes in the semi-arid tropics, Proceedings of an International Workshop, 8-11 Jan. 1990, ICRISAT Center, Patancheru, India (Johansen, C., Lee, K.K. and Sahrawat, K.L. eds.). Patancheru, A.P. 502 324, India : International Crops Research Institute for the Semi-Arid Tropics.
- Farquhar, G.D. and Richards, R.A. 1984. Isotope composition of plant carbon correlates with water-use efficiency of wheat genotypes. *Aust. J. Plant Physiol.* 11: 539-552.
- Fletcher, S.M., Zhang, P. and Carley, D.H. 1992. Groundnut production, utilization and trade in the 1980s. Pages 17-32 In : Groundnut: a global perspective - proceedings of an International Workshop, 25-30 Nov, 1991, ICRISAT Center, India. (Nigam, S.N. ed.) Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.
- Hildebrand, G.L. 1980. Groundnut production, utilization, research problems and further research needs in Zimbabwe. pages 290-296 In Proceedings of an International Workshop, 13-17 Oct. 1980, ICRISAT Center, India. Patancheru, A.P. 502 324, International Crops Research Institute for the Semi-Arid Tropics.
- Hubick, K.T., Farquhar, G.D. and Shorter, R. 1986. Correlation between water-use efficiency and carbon isotope discrimination in diverse peanut (*Arachis hypogaea* L.) germplasm. *Aus. J. Plant Physiol.* 15: 799-813.
- Mathews, R.B., Harris, D., Nageswara Rao, R.C., Williams, J.H. and Wadia, K.D.R. 1988a. The physiological basis for yield differences between groundnut genotypes in response to drought. I Dry matter production and water use. *Expt. Agric.* 24:191-202.
- Mathews, R.B., Harris, D., Williams, J.H., and Nageswara Rao, R.C. 1988b. The physiological basis for yield differences between groundnut genotypes in response to drought. II Solar radiation interception and leaf movement. *Expt. Agric.* 24:203-213.
- Nageswara Rao, R.C. 1992. Some crop physiological approaches from groundnut improvement. *J. Oil Seeds Res.* 9:286-296.
- Nageswara Rao, R.C., Reddy, L.J. and Nigam, S.N. 1992. Influence of soil type on adaptation of groundnut. Pages 15-18 In : Proceedings of the Fifth Regional Groundnut Workshop for Southern Africa, 9-11 March 1992, Lilongwe, Malawi (Nageswara Rao, R.C. and Subrahmanyam, P., eds.). Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.
- Nageswara Rao, R.C., Williams, J.H., Wadia, K.D.R., Hubick, K. and Farquhar, G.D. 1993. Crop growth, water-use efficiency and carbon isotope discrimination in groundnut (*Arachis hypogaea* L.) genotypes under end-of-season drought conditions. *Ann. App. Biol.* 122: 357-367.
- Nageswara Rao, R.C. and Wright, G.C. 1994. Stability of the relationship between specific leaf area and carb-

- on isotope discrimination across environments in peanut. *Crop Sci.* 34:98-103.
- Nene, Y.L. 1993. On-farm adaptive research and technology exchange. pages 7-12 In : *Approaches to on-farm research in Asia: summary proceedings of the Regional Workshop on On-farm Adaptive Research*, 18-20 Feb 1993, Ho Chi Minh City, Vietnam (Gowda, C.L.L., Van Santen, C.E., Johansen, C. and Nigam, S.N. eds). Patancheru 502 324, A.P. India: International Crops Research Institute for the Semi-Arid Tropics.
- Sun Yanhas and Wang Caibin 1990. Factors contributing to high yields of groundnut in Shandong, China. *International Arachis Newsletter* 8:7-8.
- Ong, C.K., Simmonds, L.P. and Mathews, R.B. 1987. Responses to saturation deficit in a stand of groundnut (*Arachis hypogaea* L.). *Ann. Bot.* 59: 121-128.
- Williams, J.H. 1979. Physiology of groundnut (*Arachis hypogaea* L.). 2. Nitrogen accumulation and distribution. *Rhod. J. Agric. Research* 17:49-55.
- Williams, J.H. and Saxena, N.P. 1991. The use of non-destructive and physiological models of yield determination to investigate factors determining differences in seed yield between genotypes of "desi" chickpeas (*Cicer arietinum*). *Ann. Appl. Bio.* 119:105-112.
- Wright, G.C., Hubick, K.T. and Farquhar, G.D. 1988. Discrimination in carbon isotopes of leaves correlates with water-use efficiency of field-grown peanut cultivars. *Aust. J. Plant Physiol.* 15:815-825.
- Wright, G.C., Nageswara Rao, R.C. and Farquhar, G.D. 1994. Water-use efficiency and carbon isotope discrimination in peanut under water deficit conditions. *Crop Sci.* 34: 92-97.

SHORT COMMUNICATIONS

INTERCROPPING OF OILSEED CROPS WITH NIGER IN

Niger is one of the important oilseed crop of the Eastern Ghat Highland of Orissa and is mostly grown as pure crop. Other important oilseed crops grown during *kharif* in the zone are sesame, soybean and sunflower. Earlier studies of Kachapur (1977) and Kachapur *et al.* (1980) have indicated that intercropping of groundnut and sunflower with niger is more profitable than the pure crop. Hence, the present investigation was undertaken to find out a suitable oilseed intercrop with niger under rainfed condition which would boost the total oilseed production and also give higher net return to the farmers.

The niger based intercropping experiment was conducted at Oilseed Research Project, Semiluguda (18° 45'N and 82° 52'E, 884 m MSL) during *kharif*, 1987, 1988 and 1989 under rainfed condition. The soil of the Experimental site was red sandy loam in texture with acidic pH (5.2). Available N, P₂O₅ and K₂O were 210 kg, 8 kg and 280kg/ha, respectively. The trials were laidout in Randomized Block Design with three replications. The treatments comprised intercropping of soybean (Gaurav), sesame (Vinayak) and sunflower (Morden) with niger (IGP-76) in 1:1 and 2:2 row proportions and the pure crops. The fertiliser applied to the pure crops were as per recommended doses for the the respective crops, while the quantities applied to the intercrop treatments were determined on the basis of area occupied by the crops. The trials were sown on 3.7.1987, 13.7.1988 and 4.8.1988. The weather conditions were normal for all the years except the rainfall which showed some

fluctuations. Data on seed yield were recorded and gross monetary returns, niger seed equivalent yield and land equivalent ratios (LER) as influenced by different treatments were estimated and analysed.

Sole crop of soybean showed better performance irrespective of different rainfall pattern during the three crop seasons. Best performance of soybean was recorded during 1987 with an yield of 1000 kg/ha, while performance of other crops during that year of experimentation was poor (Table 1). During all the years of experimentation, niger was second best crop while sesamum and sunflower recorded very poor yields. Average of three years indicated that intercropping of niger and soybean (1:1 row proportion) produced the maximum yields of 436 and 345 kg/ha respectively. Niger and soybean intercropping in the ratio of 1:1 was reported to produce higher yield than sole crop of niger at Chindwara also (Anonymous, 1989). Based on three years average niger seed equivalent yield (Table 1) was maximum with intercropping system of niger and soybean in 1:1 row proportion (666 kg/ha) followed by niger and soybean in 2:2 (587 kg/ha), while that of sole niger and soybean in 2:2 (587 kg/ha), while that of sole niger and soybean treatments were 511 kg and 631 kg respectively.

The gross monetary returns showed significant differences in all the three years (Table 2). During 1987, sole crop of soybean gave the highest gross return of Rs.4000/ha which differed significantly from rest of the treatments.

Table 1. Seed yield (kg/ha) as influenced by different treatments

Treatments	1987		1988		1989		Mean of 3 years		Niger seed equivalent (kg/ha) 3 years av.
	Main crop	Inter crop	Main crop	Inter crop	Main crop	Inter crop	Main crop	Inter crop	
1. Niger sole	242	-	699	-	591	-	511	-	511
2. Soybean sole	1000	-	954	-	884	-	946	-	631
3. Sesamum sole	71	-	33	-	35	-	46	-	46
4. Sunflower sole	105	-	37	-	67	-	70	-	47
5. Niger + soybean (1:1)	183	340	652	366	473	329	436	345	666
6. Niger + Soybean (2:2)	176	314	536	385	386	298	366	232	587
7. Niger + Sesamum (1:1)	181	33	640	17	550	13	457	21	478
8. Niger + Sesamum (2:2)	181	33	536	16	468	13	395	21	416
9. Niger + sunflower (1:1)	203	36	608	17	550	10	454	21	468
10. Niger + sunflower (2:2)	164	36	582	14	411	33	386	28	405

Rate (Rs/kg): Niger = 6.00; Soybean = 4.00; Sesamum = 6.00; Sunflower = 4.00

Treatments	Gross monetary return (Rs/ha)				Land equivalent ratio (LER)			
	1987	1988	1989	Mean	1987	1988	1989	Mean
1. Niger sole	1452	4194	3546	3064	1.00	1.00	1.00	1.00
2. Soybean sole	4000	3816	3536	3784	1.00	1.00	1.00	1.00
3. Sesamum sole	426	198	210	278	1.00	1.00	1.00	1.00
4. Sunflower sole	420	148	268	279	1.00	1.00	1.00	1.00
5. Niger + soybean (1:1)	2458	5376	4154	3996	1.09	1.31	1.17	1.19
6. Niger + soybean (2:2)	2312	4756	3508	3525	1.05	1.17	0.99	1.07
7. Niger + sesamum (1:1)	1284	3942	3378	2868	1.21	1.43	1.30	1.31
8. Niger + sesamum (2:2)	1284	3312	2886	2494	1.21	1.25	1.16	1.21
9. Niger + sunflower (1:1)	1362	3716	3340	2806	1.18	1.32	1.08	1.19
10. Niger + sunflower (2:2)	1128	3548	2598	2425	1.02	1.21	1.18	1.15
S.E.m ±	114	107	156	.				
C.D. (0.05)	340	430	463	.				

Intercropping of soybean with niger was also promising with a gross return of Rs. 2458 and Rs. 2312/ha for 1:1 and 2:2 row proportion, respectively over niger sole (Rs. 1452/ha). During 1988, the highest gross return of Rs. 5376/ha was recorded with intercropping of soybean with niger (1:1) followed by niger + soybean (2:2) with (Rs. 4756/ha). Among sole crops, niger gave higher gross return (Rs. 4194/ha). In 1989 also intercropping of soybean with niger (1:1) gave maximum gross return of Rs. 4154/ha which was significantly superior to other treatments. Among pure crops niger gave higher gross return (Rs. 3546/ha), followed by soybean (Rs. 3536/ha). Sesamum and sunflower did not give considerable return during all the three years of experimentation. In general, intercropping of soybean with niger (1:1) gave highest average gross return of Rs. 3996/ha as compared to sole crop of niger, soybean and other

treatments. Similar results were reported at Chindwara (Anonymous, 1989).

The land equivalent ratio (LER) is an indicator of efficiency of land utilization for intercropping system (Jha and Chandra, 1982). Mean LER was highest (1.31) for niger and sesamum (1:1) intercropping followed by niger and sesamum (2:2). But niger + sesamum in both the row proportions recorded lower gross return in spite of high LER. Similar drawback of LER was also reported by Rehman *et al.* (1982). However, niger and soybean (1:1) showed moderately high LER (1:19) with highest gross return. Based on three years average niger and soybean intercropping in (1:1) row combination produced highest niger equivalent yield, maximum gross monetary return and moderately high LER. Thus intercropping of soybean with niger would boost the total oilseed production and fetch more economic return for the farmers of the zone.

Regional Research Station, Semiliguda,
Post Box-10, Sunabeda-763 002, Orissa.

R.K. PAIKARAY
R.C. MISRA
P.K. SAHU.

LITERATURE CITED

- Anonymous, 1989. Annual Progress Report. XXXVI Annual Kharif Oilseeds Workshop, April 17-20, 1989.
- Jha, K.P. and Chanda, D. 1982. Parallel multiple cropping with rice. *Indian J. Agron.* 27(1): 97-98.
- Kachapur, M.D. 1977. Intercropping of niger with groundnut and sunflower is profitable. *Curr. Res.* 6:130-131.
- Kachapur, M.D., Subbarayappa, A., Prithviraj and Nandagouda, V.B. 1980. Studies on intercropping with niger. *Mysore J. Agric. Sci.* 14:31-33.
- Rehman, A., Sinha, K.P., Singh, Y.P., Rafey, A., Bhagat, A.K. and Singh, R.K. 1982. Effect of intercropping pulses, oilseeds and tuber crops in maize on yield and return. *Indian J. Agron.* 27(1):1-6.

YIELD AND OIL QUALITY OF MUSTARD AS AFFECTED BY RATES OF N AND S IN INCEPTISOLS

Application of N and S have important effects on yield, allylisothiocyanate, iodine value and oil contents in rapeseed-mustard (Bishnoi and Singh 1979). An experiment was planned to examine the influence of N and S on yield and quality of rapeseed. It was conducted on an alluvial soil in the *rabi* seasons of 1981-82 and 1982-83 at the Research Farm, College of Agriculture, Gwalior. The soil was low in organic carbon (0.38%) and available nitrogen (188 kg/ha), medium in available phosphorus (40 kg P_2O_5 /ha), high in available potash (352 kg K_2O /ha) but low to medium in available sulphur as SO_4 8.3 and 16.4 ppm during first and second seasons, respectively with 7.9 pH. The treatments consisted of four doses each of N (0, 30, 60, and 90 kg/ha) and S (0, 20, 40, and 60 kg/ha) were laid out in Randomized Block Design with four replications. 40 kg P_2O_5 and 25 kg K_2O were given as common. Full dose of P, K, S and half dose of N were drilled at sowing through triple super phosphate, muriate of potash, gypsum and urea, respectively. On 20th October 1981 and 19th October 1982 the mustard cv. Varuna was sown in rows 30 cm apart using 5 kg seed/ha. Remaining half of N was broadcasted through two equal splits one month after sowing and at flowering 24 hours after irrigation. The oil and allylisothiocyanate content of mustard seed and iodine number, saponification number and acid value of mustard oil were determined by standard procedure of A.O.A.C (1960).

Each addition of 30 kg/ha in the level of nitrogen up to 90 kg/ha gave a significant increase in seed yield of mustard. The maximum

seed yield of 14.5 q/ha was recorded at 90 kg N/ha and this was 4.9, 2.9 and 0.9 q/ha higher than the yield obtained at 0, 30 and 60 kg/ha. Nayak and Mondal (1985) also got the maximum production of mustard seed at 90 kg N/ha.

Oil content in mustard seed increased significantly up to 30 kg N/ha and further raise caused a reduction. Maximum oil content of 37.7 per cent was recorded at 30 kg N/ha and this was significantly higher than that at 90 kg and 0 kg N/ha. Bhati and Rathore (1982) stated that the apparent decrease in oil content at higher dose of N was due to increase in the proportion of proteinous substance in the seed.

Allylisothiocyanate in Brassica seed increased steadily with every increase in the level of nitrogen and the highest significant content of 4.0 per cent was recorded at 90 kg N/ha in pooled data. Application of N may cause an increase in allylisothiocyanate due to its constituent (Eaton 1942). Similar increase in allylisothiocyanate content due to application of N have also been reported by Bishnoi and Singh (1979).

Iodine number and percentage of acid value of mustard oil increased significantly from 101.5 to 106.6 and 1.3 to 1.7 in mean results with raise of N dose from 0 to 90 kg/ha, respectively. It seems that N dressing to mustard provide sufficient period for polyunsaturating system, which reflected in higher iodine value and synthesis of more free acid content of mustard oil (Khan and Agarwal, 1985). Nitrogen application did not have any effect on saponification number of oil.

Table 1. Effect of N and S on seed yield, seed and oil characteristics of mustard oil (Average of two years)

Treatment	Seed yield (q/ha)	Oil (%)	Allyliso- thiocyanate (%)	Iodine number	Saponification number	Acid value (%)
Nitrogen kg/ha						
0	9.7	36.6	0.34	101.5	174.1	1.5
30	11.5	37.7	0.35	102.9	174.2	1.6
60	13.6	37.6	0.38	104.7	174.3	2.1
90	14.6	36.6	0.40	106.6	174.3	2.1
S.E.m \pm	0.25	0.06	0.003	0.07	0.07	0.02
CD at 5%	0.72	0.18	0.01	0.20	NS	0.05
Sulphur kg/ha						
0	11.4	35.7	0.32	104.8	174.3	1.5
20	11.9	36.9	0.35	104.3	174.3	1.7
40	12.6	37.6	0.39	103.5	174.2	1.8
60	13.4	38.4	0.41	103.0	174.1	2.0
S.E.m \pm	0.25	0.06	0.003	0.07	0.07	0.02
CD at 5%	0.72	0.18	0.01	0.20	NS	0.05

Sulphur

Seed yield of mustard enhanced due to use of sulphur up to 60 kg/ha (Table 1). Application of 60 kg S/ha gave a seed production of 13.4 q/ha and this was higher by 6.2, 12.2 and 18.0 per cent over to 40, 20, and 0 kg S/ha, respectively. These results of present investigation are similar to those of Noellemeyer *et al.* (1981).

Increasing levels of sulphur application were also found to be significantly superior in increasing the oil content in mustard seed. Application of 60 kg S/ha gave 38.4 per cent oil content in comparison to 35.7 per cent of control (Table 1). Application of sulphur to plants enhanced the formation of acetyl Co-enzyme A, a precursor compound for the synthesis of long chain fatty acid (Nightengale *et al.* 1932).

Allylisothiocyanate content in seed varied from 0.32 to 0.41 per cent with the raise of sulphur level from 0 to 60 kg/ha. This may be due to the role of sulphur in increasing the contents of sulphur containing amino-acids which are precursors in the biosynthesis of glucosinolates, (Serif and Schmotzer, 1968). Similar increase due to sulphur application in allylisothiocyanate have also been reported earlier by Freeman and Mossadeghi (1972).

Iodine value of mustard oil significantly decreased with each addition of 20 kg S/ha (104.8 to 103.1). The maximum significant acid value recorded at 60 kg S/ha was 1.96 per cent and this was higher by 30.7, 16.7 and 8.7 per cent over 0, 20 and 40 kg S/ha, respectively.

Table 2. Effect of combined application of different levels of N and S on seed yield, seed and oil characteristics

Treatment	Seed yield (q/ha)	Oil (%)	Allyliso-thiocyanate (%)	Iodine number	Saponification number	Acid value (%)
N ₀ S ₀	9.3	35.6	0.28	102.3	174.2	1.2
N ₀ S ₂₀	9.4	36.4	0.33	101.9	174.2	1.4
N ₀ S ₄₀	9.9	36.9	0.36	101.0	174.1	1.5
N ₀ S ₆₀	10.0	37.3	0.38	100.6	174.1	1.6
N ₃₀ S ₀	10.2	36.4	0.30	104.0	174.3	1.4
N ₃₀ S ₂₀	10.8	37.5	0.34	103.1	174.2	1.5
N ₃₀ S ₄₀	11.7	37.9	0.38	102.6	174.3	1.6
N ₃₀ S ₆₀	13.4	39.1	0.39	102.0	174.2	1.8
N ₆₀ S ₀	12.6	36.2	0.34	105.5	174.3	1.6
N ₆₀ S ₂₀	13.3	37.0	0.37	105.2	174.3	1.7
N ₆₀ S ₄₀	14.1	38.2	0.40	104.4	174.2	1.9
N ₆₀ S ₆₀	14.2	39.2	0.42	103.8	174.2	2.0
N ₉₀ S ₀	13.2	34.6	0.35	107.5	174.4	1.8
N ₉₀ S ₂₀	14.2	36.4	0.38	107.0	174.4	2.1
N ₉₀ S ₄₀	17.7	37.5	0.42	106.0	174.3	2.2
N ₉₀ S ₆₀	15.9	38.1	0.44	105.8	174.2	2.4
S.E.m ±	0.50	0.12	0.007	0.14	0.14	0.03
C.D at 5%	N.S.	0.35	N.S.	N.S.	N.S.	0.09

Interaction

Interaction between various levels of N and S was not found to be significant (Table 2) for seed yield, saponification, iodine and allylthiocyanate content except for oil content and acid value of mustard oil. Maximum oil

content of 38.1 per cent was recorded under N₆₀S₆₀ combination and this was higher by 10.1 and 1.1 per cent over N₀S₀ and N₉₀S₆₀ combination, respectively. But the highest significant acid value 2.4 per cent was recorded under N₉₀S₆₀ treatment combination.

Dept. of Soil Science & Agril. Chemistry
JNKVV Campus, College of Agriculture
Gwalior- 474002, India

ASHA ARORA
VIJAY SINGH
R.R.DAS

- A.O.A.C. 1960. Official methods of analysis of the association of Official Agricultural Chemists. 9th Ed. Washington. D.C.
- Bishnoi, K.C. and Singh, K. 1979. Oil yield and quality parameters of three raya varieties as affected by sowing time and nitrogen levels. *Indian J. Agron.* 24 (3) : 255-63.
- Bhati, T.K. and Rathore, S.S. 1982. Response of Indian mustard to irrigation and nitrogen fertilization. *Indian J. Agron.* 27 (4) : 451-53.
- Eaton, S.V. 1942. Volatile sulphur content of black mustard plants. *Bot. Gaz.* 104 : 82-89.
- Freeman, G.G. and Mossadeghi, N. 1972. Studies on sulphur nutrition, flavour and allylisothiocyanate formation in *Brassica juncea* L. Coss and Czern. (Brown mustard). *J. Sci. Fd. Agric.* 23 : 1335-45.
- Khan, G.M. and Agarwal, S.K. 1985. Effect of moisture stress, sowing methods and nitrogen levels on the quality and oil yield of mustard. *Haryana Agric. Univ. J. Res.* 15 (1) : 82-86.
- Nayak, R.L. and Mondal, S.S. 1985. Nitrogen nutrition of mustard under rainfed conditions of West Bengal. *J. Oilseeds Res.* 2 (1) : 111-14.
- Nightengale, G.T., Schermerhorn, L.G. and Robins, W.R. 1932. Effect of sulphur deficiency on metabolism in tomato. *Plant Physiology.* 7 : 565-95.
- Noellemeyer, E.J., Bettany, J.R. and Henry, J.L. 1981. Sources of sulphur for rapeseed. *Can. J. Soil Sci.* 61(2) : 464-67.
- Serif, G.S. and Schmotzer, L.A. 1968. *Phytochemistry.* 7 : 1151.

FEASIBILITY OF DOUBLE CROPPING WITH OILSEEDS IN RAINFED AREAS OF MADHYA PRADESH

Nearly 80 per cent of cultivable land of Madhya Pradesh are rainfed uplands. Most of these rainfed areas are light soils and receive low rainfall (700-800 mm). Some of the rainfed lands have light to medium textured soils coupled with ill-distributed rainfall of about 1000-1200 mm. As a consequence, monocropping is generally practiced in these areas. Raghu and Choubey (1982) and Choubey *et al.* (1984) emphasized that linseed, safflower and gram can be grown during *rabi* season on residual soil moisture available after the harvest of short duration *kharif* crops. Thus, the present investigation was undertaken to explore the possibilities of successful double cropping system of oilseeds for light soil areas under rainfed conditions.

Field experiments were conducted on sandy loam soils at Jabalpur during the years 1989-90 to 1991-92. The soil had pH 7.2 with 168, 12 and 380 kg/ha available N, P and K contents, respectively. The rainfall was very

low (682.9 mm) and high (1739 mm) in two consecutive years and it was nearly normal (1384.4 mm) in the third year (Table 1). The average field capacity, wilting point and bulk density of the soil were 30.1%, 10.8% and 1.58 g/cc, respectively. Total nine crop rotations consisted of three *kharif* oilseeds viz., sesame (*Sesamum indicum* L.) Cv.N-32, soybean (*Glycine max* (L.) Merrill) Cv.JS 72-280 and niger (*Guizotia abyssinica* Coss) Cv.Ootakamund; and three *rabi* oilseeds viz. mustard (*Brassica juncea* L.Czern and Coss) Cv. Varuna, linseed (*Linum usitatissimum*) Cv.JL-23 and safflower (*Carthamus tinctorius* L.) Cv. JSF-1 were laid out in Randomized Block Design with three replications. During first year of experimentation the combination of niger crop was not included, thus only six crop rotations were studied with four replications. All crops were fertilized with 20:20:0 kg N:P₂O₅:K₂O/ha at sowing except soybean which was given the fertilizers at the rate of 20:60:0 kg N:P₂O₅:K₂O/ha. The seed rates for sesame, soybean, niger, mustard, linseed and safflower were 5, 100, 5, 6, 25, and 20 kg/ha, respectively. *Kharif* crops were sown in first week of July after onset of monsoon every year and *rabi* crops were so tried to take on the availability of soil moisture after *kharif* crops. The average soil moisture contents were 28.4, 32.7 and 27.6% in the three consecutive years.

All the *kharif* crops were grown successfully every year under rainfed conditions. But the seed yields of soybean depressed in low rainfall season (1989-90) and on early termination of rains in 1990-91 (Table 2). *Rabi* oilseeds viz. mustard, linseed and safflower were grown

Table 1. Rainfall (mm) during crop season

Months	1989-90	1990-91	1991-92
June	125.7	520.1	179.0
July	151.1	394.3	420.2
August	294.4	296.2	704.1
September	111.7	498.1	31.3
October	-	30.3	-
November	-	-	3.8
December	-	-	-
January	-	-	-
February	-	-	-
March	-	-	-
Total	682.9	1739.0	1384.4

Table 2. Production potential and monetary advantages under different crop sequences

Crop sequence	Seed yield (q/ha)								G.M.R. Rs./ha	C:B ratio
	1990-91		1990-91		1991-92		Mean			
	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi		
Sesamum - Mustard	5.82	6.37	2.13	8.56	3.58	6.66	3.74	7.19	10973	1.99
Sesamum - Linseed	5.41	2.15	2.27	7.86	3.64	5.21	3.77	5.07	9971	1.81
Sesamum - Safflower	5.67	1.68	2.03	8.41	3.75	5.42	3.81	5.18	9356	1.70
Soybean - Mustard	8.49	-	13.09	6.87	8.72	-	10.10	6.87	12909	1.72
Soybean - Linseed	9.02	-	13.61	5.68	8.31	-	10.31	5.68	12897	1.72
Soybean - Safflower	8.76	-	13.17	6.35	8.96	-	10.29	6.35	12600	1.68
Niger - Mustard	-	-	5.77	5.61	4.68	-	5.22	5.61	10039	1.82
Niger - Linseed	-	-	5.83	5.39	4.53	-	5.18	5.39	10568	1.92
Niger - safflower	-	-	5.64	6.17	4.61	-	5.12	4.61	10364	1.88

G.M.R. = Gross monetary return, C:B = Cost-benefit

Values of sesamum, soybean, niger, mustard, linseed and safflower were Rs. 1300, 700, 1000, 850, 1000 and 850 per quintal, respectively.

successfully with residual soil moisture contents after sesame in all the three years of experimentation, but the seed yields of linseed and safflower were much low during 1989-90 as a result of quick depletion of soil moisture. Sesame-mustard rotation proved to be superior to the other rotations with regard to success of double cropping. Sesame gave low seed yield during 1990-91 due to poor soil moisture contents at sowing. However, all *rabi* crops were successfully grown during 1990-91. But yields were relatively superior after sesame because it matured earlier than soybean and niger and provided opportunity for timely sowing of succeeding crops. These results are in conformity with the views of Shrivastava and Singh (1979), Warsi *et al.* (1980) and Agasimani *et al.* (1984).

Gross monetary returns per hectare was maximum with soybean-mustard/ linseed/ safflower cropping system, because of high yield potential of soybean. But these cropping sequences were not sustainable. Profitability of these cropping sequences was lower than others because of high cost of production involved in soybean cultivation. Sesame-mustard sequence fetched higher benefit-cost ratio than other crop rotations. This cropping system appeared to be sustainable and economical as well, if family labour is adequate, though the gross monetary benefit was minimum. Similar results were reported by Bhan and Khan (1981). Thus it can be concluded that sesame-mustard double cropping of oilseeds was feasible and economical in sandy loam soils of Jabalpur under rainfed conditions.

Department of Agronomy
J.N.Krishi Vishwa Vidyalaya, Jabalpur (M.P.)

M.L.KEWAT
R.S.SHARMA
K.K.JAIN

- Agasimani, C.A., Palled, Y.B., Naik, H.D. and Habib, A.F. 1984. A note on double cropping studies with *kharif* oilseeds crops. *J.Oilseeds Res.* 1(2): 198-99.
- Bhan, S. and Khan, S.A. 1981. Double cropping under rainfed conditions of central Uttar Pradesh. *Indian J. Agron.* 26(4): 371-76.
- Choubey, S.D., Sharma, R.S. and Rathi, G.S. 1984. To explore the possibilities of double cropping system under "Haveli" conditions of Madhya Pradesh. *JNKVV Res. J.* 18(1-4): 18-24.
- Raghu, G.S. and Choubey, S.D. 1982. Comparison of foliar application of N on wheat, linseed and safflower. *JNKVV Res. J.* 16(2): 182-84.
- Shrivastava, S.T. and Singh, A.P. 1979. Double cropping in dry areas of Udaipur. *Indian Fmg.* 28(1): 31.
- Warsi, A.S., Singh, F. and Singh, S.B. 1980. Feasibility of double cropping in rainfed areas of central Uttar Pradesh. *Indian Agriculturist* 24(1): 49-53.

SEED MYCOFLORA OF CASTOR AND ITS CONTROL

Seed play a vital role for the healthy growth of a crop. They are often known to carry pathogens which cause yield losses. Castorbean (*Ricinus communis* L.) is one of the important oilseed crops in India. Knowing the importance of this crop in Southern Telangana Zone of Andhra Pradesh, an attempt was made to study seed mycoflora of castor and its chemical control.

Seed of castorbean were collected from different parts of Southern Telangana zone of Andhra Pradesh and mixed together to form a composite sample. Two hundred seeds from each sample were plated on moist filter paper. Another two hundred seeds were surface sterilized with 0.1 per cent mercuric chloride solution and washed four times with sterilized water (ISTA, 1976) and placed on moist filter paper. The plates so seeded were incubated at $28^{\circ}\text{C} \pm 1^{\circ}\text{C}$ for 7 days. Percentage of seeds yielding different fungi was recorded.

Six fungicides viz., Aureofungin, Captan, Carbendazim, Copperoxychloride, Mancozeb and Thiram were tested for their efficacy in improving germination and in reducing seed mycoflora.

Fungicidal application was made by dipping the seeds for 30 minutes in 0.3 per cent solution. The treated seeds were plated on moist filter paper.

Castor seeds yielded ten different species of fungi belonging to seven different genera (Table 1). *Cladosporium herbarum* (48%), *Aspergillus flavus* (15%), *Botrytis ricini* (13%) and *Aspergillus niger* (9%) were the most frequent ones. Besides, *Fusarium moniliforme*, *Curvularia lunata* and *Alternaria ricini* were also encountered frequently. *Alternaria tenuis* and *Macrophomina phaseolina* were absent in surface sterilized seeds. The frequency of individual fungi was 2 to 48% in unsterilized seeds, 0 to 23% in surface sterilized seeds. Most of the fungal species detected in this work have been reported earlier as pathogens on castor and affected the germinability of seed (Cook, 1955; Culp *et al.*, 1966; Jain and Patel, 1969; Kanwar and Khanna, 1979; Feliciano *et al.*, 1981; Goodfrey, 1923 & Stevenson, 1945).

Although all six fungicides tested were found quite effective in controlling seed mycoflora of castorbean, maximum control was obtained with carbendazim, followed by captan.

1 Regional Agricultural Research Station
Lam (Guntur)

2 Regional Agricultural Research Station
Palem (A.P)

B. SRINIVASULU¹
P. NARAYANA REDDY²
A. SUDHAKAR RAO²

Table 1. Mycoflora associated with castor seed

Fungus	Incidence of mycoflora (%)							
	Unsterilised	Surface sterilised	Aureofungin	Captan	Carben-dazim	Copper oxychloride	Mancozeb	Thiram
<i>Alternaria ricini</i>	5	2	1	0	2	0	2	2
<i>Alternaria tenuis</i>	4	0	0	0	1	2	2	0
<i>Aspergillus flavus</i>	15	9	9	3	2	12	2	5
<i>Aspergillus niger</i>	9	5	0	0	0	3	0	0
<i>Botrytis ricini</i>	13	8	3	4	3	5	7	6
<i>Cladosporium herbarum</i>	48	23	17	11	8	21	22	18
<i>Curvularia lunata</i>	5	3	0	2	0	1	0	0
<i>Fusarium moniliformae</i>	6	2	0	0	0	1	0	0
<i>Fusarium oxysporum</i>	4	2	0	0	0	0	0	1
<i>Macrophomina phaseolina</i>	2	0	0	0	0	1	1	1
Germination (%)	26	47	67	71	76	57	60	64

Cook, A.A. 1955. Charcoal rot of castorbean in the United States. *Plant Dis. Rep.* 39 : 585-586.

Culp, T.W., Thomas, C.A. and Zimmerman, L.H. 1966. Capsule diseases of castorbeans in Mississippi. *Plant Dis. Rep.* 50 : 35-39.

Feliciano, C., Hepperly, P. and Sotomayor Ros, A. 1981. Characterization of sorghum seed borne mycoflora and its effect on 30 sorghum lines under humid tropical conditions in Puerto Rico. *Phytopathology*. 71 : 169.

Goodfrey, G.H. 1923. Gray mold of castorbean. *J. Agric. Res.* 23 : 679-716.

International Seed Testing Association 1976. International rules for seed testing. Rules and Annexes, *Seed Sci. Tech.* 4:1-156.

Jain, J.P. and Patel, P.N. 1969. Studies on seed mycoflora of castor and its control. *Indian Phytopath.* 22 (2): 209-214.

Kanwar, Z.S. and Khanna, P.K. 1979. Laboratory studies on seed borne fungi of castor in central India. *Phytopath. Z.* 86 (5) : 274-280.

Stevenson, E.C. 1945. *Alternaria ricini* (Yoshii) Hoshstred, the cause of a serious disease of castorbean plant (*Ricinus communis* L.) in United States. *Phytopathology*. 35 : 184-188.

RESPONSE OF GROUNDNUT GENOTYPES TO GRADED LEVELS OF SULPHUR IN ALFISOLS OF SOUTHERN KARNATAKA

An investigation was made during *Kharif* 1991 on red sandy loam soil to study the response of groundnut (*Arachis hypogaea* L.) to sulphur. Six groundnut genotypes (JL-24 (Check), ICGS-1, ICGS-5, ICGS-11, ICGS-37 and ICGS-76) were tested for their relative performance under 3 levels of sulphur (0, 25 and 50 kg/ha). The experiment was conducted at the Agricultural Research Station, Chintamani, Kolar (Dist.), Karnataka. The status of available N, P and K content was 321.64, 13.80 and 144.67 kg/ha respectively. The available sulphur content of soil was 8.5 ppm which was inadequate. The soil was acidic in reaction with pH of 5.9 and low in organic carbon. The experiment consisted of 18 treatments (Table 1). The treatments were replicated three times in a Factorial Randomised Block Design with gross plot size of 4.2 m x 2.5 m. The crop was sown during July with a recommended spacing of 25 cm x 15 cm and was fertilized with 25 kg N, 50 kg P₂O₅ and 25 kg K₂O/ha. Nitrogen and phosphorus were applied in the form of DAP and urea, potash in the form of muriate of potash and other cultivation practices were followed as per the recommended practices. The gypsum obtained from the market was analysed for chemical purity before application to field. The required quantity of sulphur and calcium oxide was incorporated into soil, 40 days after sowing by opening furrows as per the treatment. The percentage of oil was determined by solvent extraction method in soxhlet apparatus with Petroleum ether (BP 40-60°C) as solvent.

The variety ICGS-76 of groundnut yielded significantly higher pod yield compared to JL-24, ICGS-11, ICGS-5, ICGS-37 and ICGS-1 (Table 1). The percentage increase in the yield of ICGS-76 over ICGS-1, ICGS-37, ICGS-5, ICGS-11 and JL-24 was 38.40, 34.20, 15.30 and 7.50 per cent respectively. Higher pod yield of ICGS-76 cultivar was attributed to higher number of mature pods/plant and shelling percentage.

Significant variation in pod yield due to sulphur application was observed in groundnut varieties but the pod yield in JL-24 was significantly lower when compared to ICGS-76. Cultivar JL-24 recorded significantly the higher pod yield at 50 kg S/ha when compared to control. The lower yield in JL-24 as compared to ICGS-76 might be due to lesser number of mature pods. ICGS-1, ICGS-5 and ICGS-37 also had significant variation in pod yield due to graded level of sulphur. However, the yields were low as compared to ICGS-76 and JL-24. The interaction of graded level of sulphur and different groundnut genotypes for pod yield was significant where in ICGS-76 at 50 kgs/ha recorded the maximum yield (Table 2). Similar favourable effect to sulphur has been reported by Manohar and Rathore (1989) in sandy loam soils of semi-arid tract of Rajasthan.

The significant variation in oil content and oil yield were noticed due to groundnut cultivars and graded levels of sulphur, ICGS-76 recorded significantly higher oil content (42.35%) as compared to other cultivars except

Table 1. Yield and yield components of groundnut as influenced by cultivars and sulphur levels

Treatments	Number of mature pods/plant	Shelling percentage	Oil percent	Oil yield (q/ha)	Pod yield (q/ha)	Haulm (q/ha)
Cultivars						
JL-24 (V ₁ -Check)	13.47	71.35	42.53	6.41	21.06	21.22
ICGS -1 (V ₂)	8.64	65.74	40.58	4.36	16.36	14.86
ICGS -5 (V ₃)	10.47	61.91	41.27	4.31	16.89	16.99
ICGS -11 (V ₄)	10.98	66.85	42.53	5.59	19.64	19.09
ICGS 37 (V ₅)	9.58	63.75	41.52	4.36	16.45	15.79
ICGS -76 (V ₆)	17.73	71.64	42.35	6.87	22.64	22.03
S.Em \pm	0.26	0.75	0.40	0.11	0.21	0.38
C.D. at 5%	0.73	2.11	1.10	0.31	0.59	1.06
Sulphur levels (kg/ha)						
O (So - Control)	10.92	63.31	40.44	4.49	17.38	16.50
25 (S ₁)	11.94	68.01	41.78	5.35	18.58	17.50
50 (S ₂)	12.60	68.09	43.19	6.09	20.55	19.40
S.Em \pm	0.19	0.53	0.28	0.08	0.15	0.66
C.D. at 5%	0.52	1.47	0.78	0.22	0.42	1.83

Table 2. Pod yield of groundnut as influenced by cultivars and sulphur levels (q/ha)

Sulphur levels (kg/ha)	Pod yield (q/ha)						Mean
	Cultivars						
	V ₁	V ₂	V ₃	V ₄	V ₅	V ₆	
0	20.12	14.97	15.36	18.00	14.36	21.46	17.38
25	21.17	16.00	15.83	19.77	16.60	22.13	18.58
50	21.89	18.11	19.43	21.15	18.36	24.33	20.55
Mean	21.06	16.36	16.87	19.64	16.44	22.64	
				S.Em ±	CD at 5%		
Varieties (V)				0.21	0.59		
Sulphur levels (S)				0.15	0.42		
Interaction (V x S)				0.37	1.03		
C.V.(%)				3.41			

JL-24 (42.53%) which was on par with ICGS-76. The significant increase in oil yield in cultivar ICGS-76 might be due to higher oil content and Pod yield. This is in conformity with the results reported by Muhammad *et al.* (1973) who concluded that there is a significant variation in oil content among the varieties.

Among the sulphur levels 50 kg S/ha recorded significantly higher oil yield as com-

pared to control and 25 kg S/ha. The increase in oil yield was mainly due to increased oil content. This might be due to sulphur which is essential for synthesis of oil. Narasi Reddy *et al.* (1985) also noticed significantly higher oil content (48.50%) with the application of 60 kg S/ha when compared to control. Thus, it can be inferred that there is genotypic differences for response to sulphur.

Department of Agronomy
University of Agricultural Sciences
GKVK, Bangalore-560 065

S.Y.WALI
B.SHIVARAJ
ANDANI GOWDA

Manohar, S.S. and Rathore, P.S. 1989. Response of soil and foliage applied sulphur. *Haryana J. Agron.*, 5: 160-162.

Muhammad, S.V., Ramanathan, T., Ramachandra, H. and Babu, G.M. 1973. Studies on Asiriya Mwitunde, A

groundnut variety from Tanzania, *Madras Agric. J.*, 60: 207-209.

Narasi Reddy, V., Sreenivasa Raju, V. and Krishnamurthy, V. 1985. Effect of sulphur and molybdenum application on yield protein and oil content of groundnut. *Oilseed J.*, 15: 57-60.

INFLUENCE OF HERBICIDES ON YIELD, QUALITY AND ECONOMICS IN RAINFED GROUNDNUT

Groundnut is extensively grown during *kharif* season under rainfed conditions. The productivity of the crop during *kharif* season is low and not stable due to heavy infestation of weeds. There is a lack of information on economic dose of different herbicides and its effect on pod yield, oil, protein and economics in rainfed groundnut. Therefore, a field experiment was conducted at Main Research Station, University of Agricultural Sciences, Dharwad during the *kharif* season of 1990-91 to study the effect of herbicides on pod yield, protein and oil content and economics of groundnut Cv. Dh-3-30 in medium black soils under rainfed conditions.

The treatments (Table 1) were tested in a Randomized Block Design with three replications. Fluchloralin was sprayed and incorporated into the soil before sowing on 22 June, 1990. The other herbicides viz. alachlor, pendimethalin and metalachlor were sprayed on 28 June 1990 as a pre-emergence spray. The post emergence herbicide Fluazifop-p-butyl was sprayed 15 days after sowing (DAS) The crop received a well distributed total rainfall of 496.60 mm during growing period.

The estimation of oil content was done by Nuclear magnetic resonance (NMR) Spectrometer against a standard reference sample. The nitrogen percentage in groundnut kernels was estimated by modified Kjeldahl's method (Jackson, 1967). The protein percentage was calculated by multiplying the nitrogen percentage with factor 6.25 (Thai and Young 1974). The economics of different treatments

were worked out based on prevailing market prices during 1991.

Hand weeding at 15, 30 DAS in combination with intercultivation at 15, 30, 45 DAS recorded lowest (2.31 q/ha) weed weight and it was on par with alachlor, fluchloralin, pendimethalin along with intercultivations. However, unweeded check recorded significantly highest (50.92 q/ha) weed weight. These findings are in accordance with findings of Yaduraju *et al.* (1980).

Practical way of judging the efficiency of the treatments is comparing the pod yield variation. Hand weeding at 15, 30 DAS along with intercultivations at 15, 30, 45 DAS and fluchloralin in combination with intercultivations at 15, 30, 45 DAS recorded significantly higher pod yield of 28.90 and 28.79 q/ha respectively. (Table 1). This was mainly due to effective weed control. Similar results were also reported by Diwakar (1981).

Pre sowing incorporation of fluchloralin in combination with intercultivation at 15, 30, 45 DAS recorded significantly higher protein content (31.52%) closely followed by 31.23 and 29.81 per cent of protein in case of hand weeding twice followed by intercultivation at 15, 30, 45 DAS and alachlor followed by intercultivation at 15, 30, 45 DAS than rest of the treatments. Higher protein content in these treatments may be due to increased uptake of nitrogen. Gupta *et al.* (1979) and Singh *et al.* (1980) also reported higher protein content with chemical method of weed control. There

Table 1. Effect of different weed control treatments on yield, quality and economics in rainfed groundnut

Treatments	Dose (kg a.i./ha)	Weed weight (g/ha)	Pod yield (g/ha)	Protein content (%)	Oil content (%)	Cost of weed control (Rs/ha)	Net income (Rs/ha)	Net returns/Rs. spent (Rs./ha)
Hand weeding + Intercultivation	15,30 DAS + 15,30,45 DAS	2.31	28.90	31.23	49.66	76.20	24046	4.50
Alachlor	2.00	8.10	17.79	28.19	48.56	420	13197	2.70
Fluchloralin	1.00	6.65	20.13	29.71	48.13	222	15816	3.30
Pendimethalin	1.00	16.20	15.01	28.17	46.20	556	10478	2.00
Metolachlor	1.00	28.21	14.00	28.08	46.56	330	9543	1.80
Alachlor + Intercultivation	2.00 + 15,30,45, DAS	7.23	24.30	29.81	48.26	720	19564	3.70
Fluchloralin + Intercultivation	1.00 + 15,30,45 DAS	4.05	28.79	31.52	49.33	504	24229	4.80
Pendimethalin + Intercultivation	1.00 + 15,30,45 DAS	7.81	23.29	29.20	47.08	838	18534	3.40
Metolachlor + Intercultivation	1.00 + 15,30,45 DAS	18.80	21.55	29.25	47.50	612	16703	3.00
Intercultivations	15,30,45 DAS	34.72	14.12	27.39	46.50	282	10000	2.00
Unweeded check	-	50.92	9.37	22.39	46.50	-	5024	1.10
S.E.m ±		2.57	1.23	0.60	4.89			
C.D. at (5%)		7.50	3.58	1.74	NS			

was no significant difference among the treatments with respect to oil content.

Among the treatments highest net income (Rs. 24,229/ha) was recorded by fluchloralin in combination with intercultivation at 15, 30, 45 DAS followed by hand weeding at 15, 30 DAS along with intercultivation at 15, 30, 45 DAS (Rs. 24046/ha). This was due to higher pod yield in these treatments. Cost of weed control was minimum in fluchloralin (Rs. 222/ha) and was maximum in pendimethalin in combinations with intercultivations at 15, 30, 45 DAS (Rs. 838/ha). Net return per rupee spent was highest (Rs. 4.80) in case of fluchloralin in

combination with intercultivations at 15, 30, 45 DAS. It may be due to low total cost of weed control and higher pod yield. In case of unweeded check lowest (Rs. 1.10) net return per rupee spent was due to lower pod yield. Similar results were reported by Yaduraju *et al.* (1980).

Based on the results obtained it can be inferred that pre-sowing incorporation of fluchloralin @ 1.00 kg a. i./ha followed by three intercultivations at 15, 30, and 45 DAS was found to be more effective in controlling weeds and resulted in higher pod yield, protein content and net income of groundnut.

1 Regional Research Station,
P.B.No.18, Bijapur -586 101.

2 Main Research Station, Dharwad - 580 005

B.G.MURTHY¹
C.A.AGASIMANI²
N.C.PRATHIBHA¹

Diwakar, B.D. 1981. Weed control in groundnut: A review, *Abstract of papers, Annual conference of Indian Weed Sci. Soc., Bangalore. India.*

Gupta, R.K., Singh, S.S. and Ghosh, A.K. 1979. Effect of Planofix (NAA) and 2,4-D on the yield and quality of groundnut. *In: Abstract of papers ISWS/MAU Weed Science Conference, Parabhani.*

Jackson, M.L. 1967. Soil chemical analysis. Prentice Hall of India., New Delhi, P.498.

Singh, B.P., Singh R.P., Kuld Singh, D. and Choudhary, M.S. 1980. Studies on the effect of Alachlor on yield, its attributes and quality of peanut. *Haryana Agricultural University J. Res.* 10: 207-212.

Thai, Y.P. and Young, C.P. 1974. Variation in protein percentage in different portions of peanut cotyledon. *Crop. Sci.* 14: 226- 229.

Yaduraju, N.T., Gita Kulashresta and Mani, V.S. 1980. Herbicide studies in groundnut. *Indian J. Agron.* 25: 447-452.

PERFORMANCE OF SUNFLOWER IN RELATION TO NITROGEN AND PHOSPHORUS IN ACID SOILS OF ORISSA

Sunflower introduced in 1969 to Indian Agriculture, has emerged as an important oilseed crop in recent days. In Orissa, it is grown as a *kharif*, *rabi* and summer oilseed crop in an area of 1.34 thousand hectares with an annual production of 0.74 thousand tonnes. For popularisation of this crop there is a need to evolve agronomic practices. Even though substantial research work has been conducted on the effect of nitrogen and phosphorus on yield, yield attributes and oil content of sunflower elsewhere in the country, information and balanced dose of nitrogen and phosphorus for Orissa is limited. Therefore, the present study was undertaken to determine the response of sunflower to different levels of nitrogen and phosphorus under limited water supply condition.

The experiment was conducted during *rabi* season of 1991-92 at the Central Research Station, Orissa University of Agriculture and Technology, Bhubaneswar, on a sandy loam soil having organic carbon 0.368%, total nitrogen 0.038%, available P 16.5 kg/ha and available K 155.5 kg/ha with pH 5.7. Ten treatment combinations comprising 3 levels of nitrogen (20, 40, and 60 kg/ha) and 3 levels of phosphorus (20, 40, and 60 kg P_2O_5 /ha) and a control with no nitrogen and phosphorus were tested in Randomized Complete Block Design replicated 3 times. Sunflower 'Morden' was sown on December 1, 1991. A uniform dose of 30 kg K_2O /ha alongwith half of N and full dose of P_2O_5 as per the treatments was applied at sowing and the remaining half N was top dressed at 25 days after sowing. The crop received a rainfall of 78.4 mm besides two ir-

rigations applied at bud development and flowering stages.

Application of nitrogen to sunflower resulted in significant increase in the plant height, leaf area index at 60 days after sowing, diameter of the capitulum, weight of capitulum, weight of seeds/capitulum and weight of 1,000 seed (Table 1). The response was significant up to 60 kg N/ha. The favourable effect of nitrogen in increasing the yield components can be attributed to an improvement in vital functions which nitrogen plays in the plant body and this resulted in more weight of seeds/capitulum and weight of 1,000 seed. Similar observations have been made by Khargakharate and Nirwal (1991), Narwal and Malik (1985) and Sarkar (1985).

Total dry matter accumulation per plant, seed and stalk yield were maximum with 60 kg N/ha which offered an yield advantage of 24 and 8.5 per cent over 20 and 40 kg N/ha, respectively. Similar trend was observed for N, P, K uptake and harvest index. Yield is a function of head diameter, weight of seeds/capitulum, fertility per cent and 1,000 seed weight. Beneficial effect of higher dose of N on these yield attributes resulted in higher seed and stalk yield. The result confirms the findings of sarkar (1985). The oil content was the highest (38.2%) at 20 kg N/ha which declined at higher levels of N. Similar adverse effect of N on oil content was also reported earlier by Kalra and Tripathi (1980).

Phosphorus application significantly increased the plant height, leaf area index at 60 days after sowing, head diameter, weight of

Table 1. Growth and yield attributes of sunflower as influenced by nitrogen and phosphorus

Treatments	Plant height (cm)	Leaf area index at 60 DAS	Head diameter (cm)	Weight of capitulum (g)	Weight of seeds/ capitulum (g)	Seed fertility (%)	1000 seed weight (g)
Nitrogen (kg/ha)							
20	124	1.98	10.0	15.2	11.6	42.0	42.4
40	129	2.01	11.1	17.2	13.7	42.7	45.1
60	134	2.04	12.0	18.7	15.2	42.8	47.3
Phosphorus (kg/ha)							
20	127	1.99	10.7	16.2	12.7	42.3	43.9
40	129	2.01	11.1	17.1	13.5	42.7	45.1
60	130	2.02	11.3	17.9	14.2	42.7	45.9
Control	105	1.49	7.3	11.8	8.1	40.7	37.2
C.D for N at 5%	2.05	0.009	0.13	0.33	0.25	0.33	0.36
C.D for P at 5%	2.05	0.009	0.13	0.33	0.25	0.33	0.36

DAS = Days after sowing.

Table 2. Yield and nutrient uptake of sunflower as influenced by nitrogen and phosphorus

Treatments	Dry matter/ plant (g)	Total nutrient uptake (kg/ha) (seed + stalk)			Seed yield (q/ha)	Stalk yield (q/ha)	Harvest index (q/ha)	Oil content (%)
		N	P	K				
Nitrogen (kg/ha)								
20	44.4	46.2	21.3	37.2	7.42	19.3	31.6	38.2
40	47.6	58.4	27.8	47.9	8.48	21.0	32.4	37.8
60	50.3	66.4	30.4	54.7	9.20	22.1	32.9	37.5
Phosphorus (kg/ha)								
20	45.9	55.5	21.7	44.7	7.98	20.3	32.1	37.5
40	47.7	57.2	27.1	46.9	8.41	21.0	32.3	37.8
60	48.8	58.8	30.7	48.1	8.66	21.2	32.4	38.2
Control	31.0	28.5	14.1	26.2	5.07	15.4	29.9	37.1
C.D for N at 5%	0.95	2.82	1.76	3.36	0.17	0.68	0.45	0.18
C.D for P at 5%	0.95	2.82	1.76	3.16	0.17	0.68	NS	0.18

capitulum, weight of seeds/capitulum and weight of 1,000 seed (Table.1), The response was linear up to 60 kg P₂O₅/ha. This might be due to abundance of phosphorus in seeds which stimulated the formation of filled seeds and increase in seed number. Dry matter accumulation per plant, seed and stalk yield were maximum at 60 kg P₂O₅/ha. Seed yield of 8.66 q/ha was recorded at 60 kg P₂O₅/ha which was 8.5 and 3 per cent more than that of 20 and 40 kg P₂O₅/ha, respectively. The response was

higher up to 20 kg than the subsequent higher levels of P₂O₅. Phosphorus application also increased the N, P and K uptake, but the uptake was more conspicuous for P. Similar response of sunflower to P application was also reported by Shelke *et al.* (1988). Phosphorus application did not influence the harvest index of sunflower, but significantly increased the oil yield. Similar results were also reported by Kalra and Tripathi (1980).

Department of Agronomy,
Orissa University of Agriculture &
Technology, Bhubaneswar.

A.MISHRA
P.DAS
R.K.PAIKARAY

Kalra, G.S. and Tripathi, P.N. 1980. Uptake and quality of sunflower as influenced by NPK fertilization. *Indian J. Agron.* 25(4) : 710-716.

Khargakharate, V.G. and Nirwal, B.G. 1991. Growth and yield of sunflower as influenced by inter and intra row spacing and nitrogen. *J. Maharashtra Agric. Univ.* 16(2) : 291-292.

Narwal, S.S. and Malik, D.S. 1985. Response of sunflower cultivars to plant density and nitrogen. *J. Agric. Sci. U.K.* 104(1) : 95-97.

Sarkar, R.K. 1985. Effect of nitrogen levels with and without liming on yield and NPK uptake on lateritic upland. *Indian Agriculturist* 29(1): 59-65.

Shelke, V.B., Shenda, V.S., Dahiphale, V.V. and Chavan, D.A. 1988. Effects of levels of N, P and K on growth and yield of rabi sunflower. *J. Oilseeds Res.* 5.(2): 140-143.

GROUNDNUT SEED PRODUCTION PRACTICES ADOPTED BY THE FARMERS IN SOUTHERN DRY REGION OF KARNATAKA

The seed technology practices like source of seed, seed replacement, seed grading, seed storage, seed rate, seed treatment, use of highly germinable seeds and varieties play a significant role in achieving higher yield at farmers level. A survey was undertaken with an objective of assessing seed technological aspects adopted by the groundnut growers of southern dry region of Karnataka. The taluks of Bagepalli and Chintamani (eastern dry zone) of Kolar district and Pavagada and Madhugiri (central dry zone) of Tumkur district were selected as the groundnut is widely grown in these taluks. A list of one hundred farmers who have grown groundnut has prepared from each taluk with the assistance of staff of the Karnataka State Department of Agriculture and fifty per cent of the farmers were selected randomly for interview from each taluk. The respondents were classified into different groups based on the size of holdings. The respondents were interviewed with a previously administered and tested questionnaire. The data were collected during the month of

June, 1990, before sowing of *kharif*, 1990-91 rainfed crop and analysed.

No farmer used the seeds purchased from known sources like Karnataka State Seed Corporation, National Seeds Corporation, Karnataka State Department of Agriculture and Agricultural University. The major source of seed was savings out of the previous bulk crop constituting 89 per cent followed by "other farmers" with 10 per cent (Table 1). Further from among the farmers who used their own saved seed, 61.80 per cent have confirmed that the original source of seed as "other farmers".

The price of groundnut seeds is more in comparison to other field crops and also due to high seed rate the seed cost component is a major cost item in groundnut production. The normal tendency of small and marginal farmers is to sell the whole produce of groundnut after harvest without keeping for seed purpose. The small and marginal farmers with less purchasing power depend on others for seeds. This study revealed that 25.50 per cent of the

Table 1. Source of seed (percentage of farmers)

Sl. No	Groups	Private seed traders	Own saved seeds	Other farmers	Total
1	I	0.50 (1)	49.50 (99)	6.50 (13)	56.50 (113)
2	II	0.50 (1)	18.00 (36)	1.50 (3)	20.00 (40)
3	III	-(0)	8.00 (16)	0.50 (1)	8.50 (17)
4	IV	-(0)	13.50 (27)	1.50 (3)	15.00 (30)
5	Total	1.00 (2)	89.00 (178)	10.00 (20)	100 (200)

Figures in parenthesis indicate number of respondents

farmers borrowed the seeds before from other farmers and traders on barter system.

It has been observed that the seed replacement is an important factor in achieving higher yields. This study revealed that 41 per cent of the farmers used the seeds beyond six generations (Table 2).

The grading of pods by winnowing was attended by all the farmers, where as further manual grading was attended by only 12.50 per cent of the farmers. The grading of kernels was done by all the sample farmers by using either sieve or through manual grading (Table 3). The sieve size used for grading kernels of TMV-2 and JL-24 were 5.57 and 5.65mm respectively.

Farmers using their own saved seed are required to store the seeds from harvesting till sowing. The containers and method of storage play a significant role in preserving the viability and vigour of the seeds. The selection of the containers and the method of storage largely depends upon the quantity of seeds to be stored, the availability of storage space etc. The present study revealed that 91 per cent of the farmers used gunny bags as storage container, followed by heaping in the room. Incidentally 6 out of 10 farmers who have stored the seeds in heap are the farmers having more than

Table 3. Percentage of farmers adopting grading

Group	Winnowing of pods	Manual grading of pods	Grading of Kernels
I	56.50 (113)	5.50 (11)	56.50 (113)
II	20.00 (40)	2.50 (5)	20.00 (40)
III	8.50 (17)	1.50 (3)	8.50 (17)
IV	15.00 (30)	3.00 (6)	15.00 (30)
Total	100.00 (200)	12.50 (25)	100.00 (200)

Figures in parenthesis indicate number of farms.

15 hectares indicating problem in handling large quantities for seed. However, it was observed that remaining four per cent (Table 4) of the farmers preferred storing in large earthen bins which are available locally at cheaper price.

The influence of plant population on the yield is closely linked with the seed rate. The sample farmers used the average seed rate of 71 kg/hectare. Maximum seed rate (77.12 kg/hectare) was used by farmers having more than 6 ha, where as the small farmers with less than 2 hectares used 69.44 kg/ha. The seed treatment with chemicals and testing for germination prior to sowing was not done. However, 4 per cent of the farmers treated the seeds with *Rhizobium* culture before sowing (Table 5). The seed rate used in JL-24 variety (73.68 kg/ha) is more than TMV-2 (69.88 kg/ha).

Table 4. Method of seed storage (percentage of farmers) and seed rate used

Sl. No	Group	Earthen Pot	Gunny bag	Heap	Total	Average seed rate kg/ha
1	I	3.0 (6)	53.50 (107)	- (0)	56.50 (113)	69.44
2	II	1.0 (2)	17.50 (35)	1.50 (3)	20.00 (40)	69.94
3	III	- (0)	8.0 (16)	0.50 (1)	8.50 (17)	73.52
4	IV	- (0)	12.0 (24)	3.00 (6)	15.00 (30)	77.12
5	Total	4.0 (8)	91.0 (182)	5.00 (10)	100.0 (200)	71.04

Figures in parenthesis indicate number of farmers.

Table 2. Generation of the Seed used (percentage of farmers)

Sl.No	Group	1st year	2nd year	3rd year	4th year	5th year	6th year	7th year	8th year & above	Total
1	I	8.00 (16)	7.00 (14)	4.50 (9)	5.00 (10)	10.50 (21)	5.00 (10)	1.00 (2)	15.50 (31)	56.50 (113)
2	II	2.00 (4)	3.00 (6)	2.50 (5)	0.50 (1)	3.50 (7)	3.00 (6)	- (0)	5.50 (11)	20.00 (40)
3	III	1.00 (2)	1.50 (3)	1.00 (2)	- (0)	1.00 (2)	1.50 (3)	0.50 (1)	2.00 (4)	8.50 (7)
4	IV	1.50 (3)	2.00 (5)	2.50 (5)	1.50 (3)	1.50 (3)	1.50 (3)	0.50 (1)	4.00 (8)	15.00 (30)
5	Total	12.50 (25)	13.50 (27)	10.50 (21)	7.00 (14)	16.50 (33)	11.00 (22)	2.00 (4)	27.00 (54)	100 (200)

Figures in parenthesis indicate number of respondents.

Table 5: Seed treatment given and germination testing done (percentage of farmers)

Seed treatment		Germination testing	
Given	Not given	Done	Not done
2.0 (4)	54.50 (109)	- (0)	56.50 (113)
- (0)	20.00 (40)	- (0)	20.00 (40)
- (0)	8.50 (17)	- (0)	8.50 (17)
2.0 (4)	13.00 (26)	- (0)	15.00 (30)
4.0 (8)	96.00 (192)	- (0)	100.00 (200)

Figures in parenthesis indicated number of farmers.

To achieve higher yields in different agro-climatic region various varieties were recommended and in karnataka the use of improved varieties is moderate with 50 per cent coverage (Rai, 1989). This survey revealed that all the farmers used improved varieties that are recommended to this southern dry region. 69.50 per cent of the respondents had sown TMV-2 and remaining 30.50 per cent JL- 24. The high coverage under the improved varieties in this region may be due to the fact that the survey area is the traditional and major groundnut growing region and also the aware-

ness of the performance of improved varieties in the adjoining Andhra Pradesh

The measures to be taken in the light of this study are as follows. The Karnataka State Department of Agriculture shall take-up extension activities to enlighten the farmers about advantages of using better quality seeds, particularly periodical seed replacement. The Karnataka State Seeds Corporation (KSSC) and Karnataka Oil Seeds Growers Co-operatives Federation (KOF) shall take-up market survey and arrange for certified seed at right time. The financial institutions can plan to include seed as a component in crop loans particularly to small and marginal farmers. Further KSSC and KOF can plan for supplying the foundation seed to the progressive farmers in the locality through which the certified seeds can be channelised by using "barter system" which is already popular in the region. Further research on the reasons for not following certain seed technology practices by farmers will throw much light on the corrective measures to be initiated.

Seed Technology Research Centre,
GKVK, University of Agricultural Sciences,
Bangalore 560 065.

S. RAJENDRA PRASAD
T.N. VENKATA REDDY
N. VIJAYAMOHAN REDDY
G.V. JAGADISH
B. SIDDAPPA

Rai, B. 1989. New groundnut varieties for commercial production programmes. *Seeds & Farms* 15(1): 19-22.

GENOTYPIC VARIATION IN YIELD LOSS DUE TO LEAF MINER, *Chromatomya horticola* Go. INFESTING LINSEED

Chromatomya horticola Go. has been reported to be a minor pest on linseed (Atwal, 1986). However, it mines about 18.4 - 25 per cent leaves and adversely affect the production (Kumar *et al.*, 1992; Jha, 1986; Vishwanath and Agarwal, 1982). The pest generally appears during last week of January and remains till last week of April after attaining peak in the middle of February. The larva tunnels in the epidermis interrupt photosynthetic activity of the plant. The trial for the assessment of yield loss due to the leaf miner was carried out at HPKV, Oilseed Research Station, Kangra, H.P.

A field trial was conducted during the year 1991-92 to assess the yield losses caused by leaf miner in three cultivars of linseed. The cultivars were grown in two sets i.e. protected and unprotected from leaf miner attack. Under the protected set, the cultivars were sprayed with monocrotophos (0.036%) twice at 15 days of intervals starting from the appearance of leaf miner. Yield per plot was recorded at harvest and the data on per cent losses was calculated from the quantitative characters contributing for yield (Table 1).

The persual of data revealed that the maximum loss due to leaf miner was recorded for Jeewan (25.46%) followed by Janki (14.69%) and Himalini (6.60%).

Maximum loss (6.77%) was observed in Jeewan followed by Janki (4.75%) and Himalini (3.56%) in 1000 seed weight. The loss in oil content due to leaf miner infestation was maximum in Jeewan (2.06%) followed by Janki (0.5%) and Himalini (0.19%). The incidence of leaf miner in terms of percentage of leaf infestation was also recorded as 8.18, 11.40 and

Table 1. Per cent loss in yield due to leaf miner in linseed in 1991-92

Varieties	Yield/ Plot	1000 grain wt.	Oil content
Janki	14.69	3.56	0.50
Himalini	6.69	4.75	0.19
Jeewan	25.46	6.77	2.06

17.07 in Himalini, Janki and Jeewan respectively. Thus variety Himalini can be considered as tolerant to leaf miner incidence.

Oilseeds Research Station, HPKV
Kangra 176 001 H.P

AJAI SRIVASTAVA

Atwal, A.S. 1986. Agricultural pests of India and South-East Asia. Kalyani Publishers New Delhi pp. 5 & 9.

Jha, R.C. 1986. Studies on relative resistance of different linseed varieties against major insect-pests under varied condition. Unpublished M.Sc. (Ag.) Thesis CSA Uni. of Agric. and Tech. Kanpur.

Kumar, D., Singh, B., Singh, S.V. and Tuhan, N.C. 1992. Screening of linseed strain against major insect-pests. J. Insect. Sci. 5(2) : 190-192.

Viswanath and Agarwal, R.A. 1982. Insect pests of crops and their control. Bharti Publication, Delhi. pp.139.

NEW RECORD OF *Dolycoris indicus* STAL (Hemiptera : Pentatomidae) AS A MINOR PEST OF LINSEED IN HIMCHAL PRADESH

During April-May 1992, Linseed crop of Kangra district of Himachal Pradesh was found to be infested by the bugs. The nymphs were found sucking the sap from the top shoot of the crop. The adults were also observed to feed on the pods at maturity stage of crop. The nymphs as well as the adults were collected and

got identified from the Natural History Museum, London as *Dolycoris indicus* Stal. A study of literature reveals that this bug has not been recorded earlier, as pest of linseed crop. The authors are thankful to Dr. K.M. Harris, Director, International Institute of Entomology, London for getting this species identified.

Oilseeds Research Station,
Kangra, Himachal Pradesh

AJAI SRIVASTAVA
HIRA LAL THAKUR

WEED MANAGEMENT STUDIES IN KHARIF SUNFLOWER

Sunflower (*Helianthus annuus* L.) is gaining ground in India as an important oilseed crop. Weeds pose serious problem in the cultivation of sunflower if unchecked, weed growth reduce the seed yield significantly to the tune of 26-50% (Kondap *et al.*, 1983). Wet soil conditions do not permit mechanical weeding to create weed free condition. Hence use of herbicides has become necessary to reduce weed menace during early growth stages of sunflower. The present study was conducted to find out the efficacy of two pre-emergence herbicides, one post-emergence herbicide, cultural practices and their combination for controlling weeds in *kharif* sunflower.

A field experiment was conducted at the College Farm, Rajendranagar during *kharif*, 1990 in an Alfisol of medium fertility status. The experiment was laid out in Randomised Block Design. Two pre-emergence herbicides viz., pendimethalin and metolachlor each at 1.5 kg a.i. ha⁻¹ and 2/3 dose of these herbicides followed by post-emergence herbicide fluazifop-p-butyl at the rate of 0.25 kg a.i. ha⁻¹ at 21 DAS or hand weeding at 30 DAS and fluazifop-p-butyl at the rate of 0.25 kg ha⁻¹ at 21 DAS with or without hand weeding at 40 DAS were evaluated with two hand weedings and unweeded control. Sunflower Cv. APSH-11 was used. Weed dry matter per square meter at harvest and weed control efficiency were calculated.

The composition of weed flora in experimental site consisted of four monocots, *Cyperus rotundus*, *Dactyloctenium aegyptium*, *Digitaria sanguinalis* and *Cynodon dactylon* and seven dicots, *Amaranthus viridis*, *Commelina benghalensis*, *Trichodesma indicum*,

Ocimum Cannum, *Euphorbia hirta*, *Acalypha indica* and *Parthenium hysterophorus*. The experimental site was dominated by *Cynodon dactylon*.

There was significant reduction in weed dry matter at harvest and the highest weed control efficiency was recorded with pre-emergence application of metolachlor at the rate of 1.0 kg a.i. ha⁻¹ followed by hand weeding at 30 DAS and fluazifop-p-butyl at the rate of 0.25 kg a.i. ha⁻¹ followed by hand weeding at 40 DAS over all other treatments. The weed control efficiency was higher by 90 to 93 per cent in these treatments compared to unweeded control. Pre-emergence application of metolachlor at the rate of 1.0 kg a.i. ha⁻¹ followed by hand weeding was able to control almost all the dicot weeds and many monocot weeds by inhibiting seed germination, early seed growth and root growth of weeds and inhibition of protein synthesis.

Yield attributing parameters like head diameter (cm), 1000 seed weight (g), number of filled seeds head⁻¹ were higher with pre-emergence application of metolachlor at 1.0 kg a.i. ha⁻¹ followed by either hand weeding at 30 DAS or post emergence of application of fluazifop-p-butyl at 0.25 kg a.i. ha⁻¹ at 21 DAS (Table 1). All these parameters were significantly decreased in unweeded control. The lowest values of yield components in unweeded control was due to severe weed competition. All other treatments showed significant increase in yield parameters over the unweeded control. Highest seed yield was obtained with pre emergence application of metolachlor at the rate of 1.0 kg a.i. ha⁻¹ followed by either hand weeding at 30 DAS or post-emergence

Table 1. Effect of weed control treatments on weed dry matter, weed control efficiency, yield parameters and yield of sunflower

Treatment	Rate (kg a.i. ha ⁻¹)	Weed dry matter at harvest (g m ⁻²)	Weed control efficiency at harvest (%)	Yield parameters			Seed yield (kg ha ⁻¹)
				Head diameter (cm)	1000 seed weight (g)	Filled seeds per head (No.)	
Pendimethalin	Pre-emr.	1.50	83.9	14.20	41.20	401.00	907
Pendimethalin + fluazifop-p-butyl.	Pre-emr. Post-emr. 21 DAS	1.00 0.25	82.5	14.34	40.10	402.00	840
Pendimethalin + Hand weeding	Pre-emr. 30 DAS	1.00	90.7	14.51	45.04	375.71	973
Metolachlor	Pre-emr.	1.50	89.8	14.53	45.34	404.00	868
Metolachlor + Fluazifop-p-butyl	Pre-emr. Post-emr. 21 DAS	1.00 0.25	86.6	16.10	47.23	491.30	1128
Metolachlor + hand weeding	Pre emr. 30 DAS	1.00	93.7	16.30	47.42	587.30	1148
Fluazifop-p-butyl	Post-emr. 21 DAS	0.25	84.5	13.83	40.56	364.00	819
Fluazifop-p-butyl + hand weeding	Post-emr. 21 DAS 40 DAS	0.25	92.3	14.68	44.40	482.30	892
Hand weeding at 30 and 40 DAS		38.7	89.6	14.31	44.26	344.30	934
Unweeded control		376.5	--	10.36	35.23	169.30	314
S.E.d ±		7.14	1.21	0.35	0.82	19.95	118.83
CD (0.05)		14.57	2.47	0.72	1.68	40.75	242.42

application of fluazifop-p-butyl at the rate of 0.25 kg a.i. ha⁻¹ at 21 DAS (Table 1). This could be due to better weed control and improvement in yield components. Favourable effect of

metolachlor and fluazifop-p-butyl on seed yield of sunflower was also reported at AICRP on Weed Control, Hyderabad (1990).

All India Coordinated Research Programme
on Weed Control, Department of Agronomy
College of Agriculture, Rajendranagar
Hyderabad - 500 030

G. SURESH
N. VENKAT REDDY

Part of M. Sc. Thesis submitted by the first author to Andhra Pradesh Agricultural University, Hyderabad 500 030 A.P.

All India Co-ordinated Research Programme on Weed
control (AICRPWC). 1990. 4th Annual Report
(USDA/PL 480), Hyderabad 64-71.

Kondap, S.M., Narasimha Murthy, Y.V. and Venugopal,
P. 1983. More oilseeds through weed control. *Indian
Fmg.* 33(1) : 24-25.

RESPONSE OF SOYBEAN TO VA MYCORRHIZAL FUNGI AT VARIED LEVELS OF P

Vesicular arbuscular Mycorrhizal (VAM) fungi have been inoculated to crop plants to study the possibility of saving phosphatic fertilizers (Bagyaraj *et al.*, 1979). VAM associations and their beneficial role have been reported in oilseed crops of castor and safflower (Sulochana and Manoharachary, 1989), sunflower (Jones Nirmalnath and Sreenivasa, 1993) and groundnut (Shashidhara *et al.*, 1993). Soybean (*Glycine max* (L.) Merr.) one of the much exploited legume cum oil seed crop of India has higher 'P' requirement (60-80 kg/ha). An earlier pot trial indicated that VA mycorrhiza influenced nodulation and N₂ fixation in soybean (Sreenivasa *et al.*, 1993). Hence, the present field trial was aimed to study the response of soybean to the inoculation of VA mycorrhizal fungi, *Glomus fasciculatum* and *Gigaspora margarita* at different P levels in black clayey soil under field condition.

A field experiment was conducted at Main Research Station, Dharwad (Karnataka) during kharif, 1993 on a black clayey soil with a pH of 7.7. The soil was medium in available P₂O₅ (18.2 kg/ha). The recommended doses of N (20 kg/ha) and K (40 kg/ha) were supplied through urea and muriate of potash respectively. The experiment consisted of seven treatments (Two VAM cultures and three levels of P₂O₅ with a control) with three replications laid out in a Randomised Block Design. Individual plot sizes measured 4 m x 2.1 m. Pot cultures of *Glomus fasciculatum* and *Gigaspora margarita* maintained in rhodes grass (Sreenivasa and Bagyaraj, 1988) with 1900 infective propagules/g inoculum were used @ 250 g/plot as a thin uniform layer in

furrows. Three levels of phosphate through single super phosphate were tested (50, 75 and 100% of recommended dose of 80 kg/ha). Soybean seeds of variety MACS-58 were treated with lignite based *Bradyrhizobium japonicum* with cell density of 1.8×10^8 /g uniformly as per commercial recommendation and sown at a spacing of 30 x 10 cm. Proper comparable uninoculated control plots (without mycorrhizal fungus) were maintained. Per cent root colonization was determined by staining with trypan blue (Phillips and Hayman, 1970), and the mycorrhizal spore count in the rhizosphere soil by wet sieving and decanting technique (Gerdemann and Nicolson, 1963). Shoot P concentration was estimated by Vanadomolybdate Phosphoric yellow colour method (Jackson, 1967).

VA mycorrhizal inoculation, in general, enhanced the growth and seed yield in soybean as compared to corresponding uninoculated control plants. Per cent mycorrhizal root colonization and spore count increased with increase in P level up to 75% of the recommended dose and later decreased at the recommended level of P in both mycorrhizal fungi (Table 1). The plant height, number of branches per plant, number of pods per plant, shoot P concentration and seed yield increased with increase in P level significantly up to 75% of the recommended dose and further increase in these parameters with the increase in P level were not significant in both the mycorrhizal fungi. Inhibition of mycorrhizae by excess P as observed in this study may be associated with membrane mediated root exudates (Graham *et al.*, 1981).

Table 1. Effect of inoculation of *glomus fasciculatum* or *Gigaspora margarita* on per cent root colonization and spore count of VAM and plant height, number of branches and pods per plant, shoot P concentration and seed yield of soybean at different P levels

Treatments	P-level (%) Recommended dose)	Per cent root colonization	Spore count/ 50 g soil	Plant height (cm.)	Number of Branches/plant	Number of pods/plant	Shoot P concentration (%)	Seed yield (kg/ha)
<i>Glomus fasciculatum</i>	100	92	369	79	2.1	26	0.42	1405
	75	93	381	78	1.8	26	0.42	1372
	50	88	343	76	1.7	23	0.36	1184
<i>Gigaspora margarita</i>	100	94	378	79	2.3	27	0.44	1413
	75	95	390	77	2.1	26	0.44	1379
	50	89	354	76	1.7	23	0.37	1203
Un-inoculated control	100	41	82	75	1.7	19	0.37	1356
S.E.m. \pm		1.15	11	1.30	0.14	1.19	0.01	20
C.D. (0.05)		3.8	13.0	NS	0.42	3.67	0.03	63
C.V. (%)		9.7	6.8	12.91	12.47	8.43	0.10	7.28

The principal way in which VA mycorrhizal fungi improve crop growth and yield is through uptake of P, Zn, Cu, Mn, Fe, etc., (Sreenivasa, 1992). In the present experiment also increase in shoot P concentration was recorded with VAM inoculation particularly with 75% and 100% P levels (0.42 to 0.44%) as compared to 50% P level and control (0.36 to 0.37%). Legumes have repeatedly been shown to require higher levels of P for growth and effective nodulation. It is well documented that N₂ fixation by *Bradyrhizobium* has a high phos-

phate requirement and the principal effect of mycorrhiza on nodulation is undoubtedly phosphate mediated. However, nodulation characteristics could not be studied in this experiment as the soil was very hard. However, the study is indicative of the fact that with no improvements in growth and yield of soybean beyond 75% of the recommended dose, there is a possibility of saving 25% of the recommended dose of P when mycorrhizal inoculation is followed.

AICRP on Soybean and
Department of Agril. Microbiology*
U.A.S., Dharwad - 580 005.

B.S. LINGARAJU
M.N. SREENIVASA*
H.B. BABALAD.

-
- Bagyaraj, D.J., Manjunath, A. and Patil, R.B. 1979. Interaction between a vesicular arbuscular Mycorrhiza and *Rhizobium* and their effects on soybean in the field. *New Phytol.* 82 : 141-145.
- Gerdemann, J.W. and Nicolson, T.H. 1963. Spores of mycorrhizal *Endogone* species extracted from soil by wet sieving and decanting. *Trans. Br. Mycol. Soc.* 46 : 235-244.
- Graham, J.H., Leonard, R.J. and Menge, J.A. 1981. Membrane mediated decrease in root exudation responsible for phosphorus inhibition of VA mycorrhizal formation. *Plant Physiol.* 68 : 548-552.
- Jackson, M.L. 1967. Soil Chemical Analysis. Prentice Hall of India, New Delhi. p. 498.
- Jones Nirmalnath, P. and Sreenivasa, M.N. 1993. Response of sunflower to the inoculation of VA mycorrhiza and/or phosphate solubilizing bacteria in black clayey soil. *J. Oilseeds Res.* 10 : 86-92.
- Phillips, J.M. and Hayman, D.S. 1970. Improved procedures for clearing roots and staining parasitic and vesicular arbuscular mycorrhizal fungi for rapid assessment of infection. *Trans. Br. Mycol. Soc.* 55 : 158-161.
- Shashidhara, G.B., Sreenivasa, M.N., Bidari, B.I. and Manjunathaiah, H.M. 1993. Response of groundnut to the inoculation of VAM fungi and/or *Rhizobium* in Vertisols. *J. Maharashtra Agril. Univ.* (In press).
- Sreenivasa, M.N. 1992. Selection of an efficient VA mycorrhizal fungus for chilli. *Scientia Hortic.* 50 : 53-58.
- Sreenivasa, M.N. and Bagyaraj, D.J. 1988. *Chloris gayana* (Rhodes grass) a better host for mass production of *Glomus fasciculatum*. *Plant Soil.* 106 : 289-290.
- Sreenivasa, M.N., Basavaraja, G.T. and Kulkarni, J.H. 1993. Vesicular - arbuscular mycorrhiza assist nodulation and nitrogen fixation in soybean. *J. Maharashtra Agril. Univ.* (In press).
- Sulochana, T. and Manoharachary, C. 1989. Vesicular arbuscular mycorrhizal associations of castor and safflower. *Curr. Sci.* 58 : 459-461.

CLADOSPORIUM HERBARUM ON SUNFLOWER (*Helianthus annuus* L.) HEAD - A NEW RECORD IN INDIA

Dirty white to deep olivaceous brown fluffy growth of fungus on sunflower (*Helianthus annuus* L.) heads having poorly filled/chaffy seeds followed by rotting was observed (Fig.1) in farmers' seed production plots in Adilabad district (variety: NPS 105) and also near Warangal (Hybrid : MEGA-363) in an area of about 5 acres in January, 1994. Fungal growth on both sides with watery ooze spread completely throughout the head was another conspicuous symptom observed (Fig. 2). *Cladosporium herbarum* was isolated from the affected heads. Conidiophores of the fungus were more or less straight, olivaceous brown, smooth, $210 - 220 \mu$ (mean: 216μ) \times 8μ in

size. Conidia were branched in chains, ellipsoidal, olivaceous brown, thick walled, verruculose with warts, protruberant, 0-1 septate and $10-12 \mu$ (mean: 11μ) \times 5μ in size, which corroborate with the original description of *C. herbarum* (Pers.) Link ex S.F.Gray, 1821, Nat. Arr. Br. Pl., 1:556. Although *Cladosporium cladosporioides* (Fres) de Vries causing leaf spots is reported from India (Anil Kumar and Seshadri, 1975), *C. herbarum* causing head rot has been reported only from France (Kuhnoltz - Lordat, 1944). This is the first record of occurrence of *C. herbarum* on sunflower head in India.

Directorate of Oilseeds Research
Rajendranagar, Hyderabad - 500 030, India

S.APPAJI
C.CHATTOPADHYAY

Anil Kumar, T.B. and Seshadri, V.V. 1975. *Cladosporium* leaf spot on sunflower. *Cur. Sci. (India)* 44:722.

Kuhnoltz - Lordat, M. 1944. Notes on Plant Pathology. *Ann. Epiphyt.*, N.S., 10 Fasc. unique : 55-63.

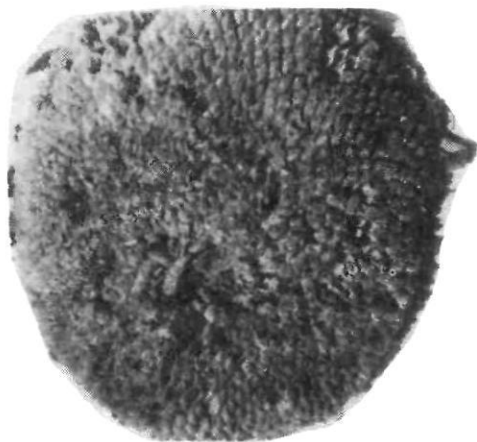


Figure 1.

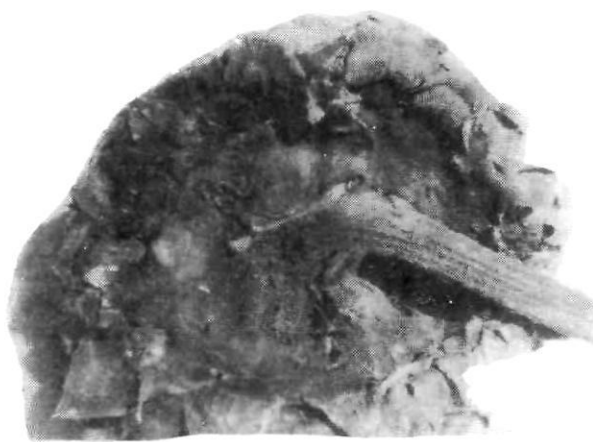


Figure 2.

DEVELOPMENT OF SUITABLE GERMINATION MEDIUM FOR TRINUCLEATE POLLEN GRAINS : AN ILLUSTRATION WITH SUNFLOWER

Sunflower (*Helianthus annuus* L.), introduced to India in the early 1970's, has become an important oilseed crop with rapidly increasing area under its cultivation (Ravishankar *et al.*, 1991). However, much of this area is cultivated under rainfed conditions where the crop experiences intermittent moisture stress leading to poor productivity. Intensive efforts have been recently launched to develop moisture stress tolerant sunflower genotypes by screening germplasm lines for field tolerance (Ravishankar *et al.*, 1991). These approaches, are cumbersome, tedious and expensive. Recently, interest has been generated in the use of an alternate technique involving gamete selection. A pre-requisite for employing such a technique is to culture pollen grains *in vitro* to enable selection of osmotic stress tolerant gametes and to use them in selective fertilization (Uma Shaanker, 1991).

Trinucleate pollen grains such as those of Compositae and Cruciferae have been reported to be difficult to culture *in vitro* (Hoekstra and Bruinsma, 1975; Leduc *et al.*, 1990; Zhang and Croes, 1982). Several earlier workers have proposed a few *in vitro* techniques for culturing these pollen grains. Hoekstra (1973) reported that in *Chrysanthemum*, best germination and pollen tube growth is obtained by pretreating the pollen grains at room temperature (25 to 32°C) and 60 per cent relative humidity (RH) for 30 minutes and culturing them in media containing 1.32 M Saccharose, 100 mg/l Boric acid, 0.002 M Calcium hydroxide. In this paper the development of a suitable media for germina-

tion and tube growth of tri-nucleate pollen grains of sunflower is reported.

Pollen grains of sunflower were brushed on to a petriplate soon after the anther dehiscence (0800-0900 hrs) and incubated in humid chamber (80 % RH and $27 \pm 2^\circ\text{C}$) for 20 minutes. These pollen grains were incubated in cavity slides containing 100 μl of pollen germination medium (PGM) having Sucrose (150g/l), H_3BO_3 (100 mg/l), KNO_3 (200 mg/l), MgSO_4 (200 mg/l), $\text{Ca}(\text{NO}_3)_2$ (200 mg/l) (PGM 1) in the humid chamber. The per cent germination (evident as buds), per cent pollen grains with tubes (where the pollen grains had tubes with length atleast equal to their diameter) and the pollen tube length were assessed after 15 minutes. In this medium, only 28.7 per cent of the pollen grains germinated with none having pollen tubes (Table 1).

An attempt was made to supplement the above medium (PGM 1) with the extracts of stigmatic tissue (PGM 2). Extract of one stigma (obtained from a CMS line) in the above medium increased the pollen grain germination to 61.8 per cent with 10.5 per cent pollen grains with tubes (Table 1). Addition of extracts from more than one stigma did not improve the germination and the growth substantially (data not shown). The enhanced pollen grain germination and growth on addition of stigmatic extract suggests the release of specific nutrients required for the pollen tube growth. Indeed as suggested by Mulcahy and Mulcahy (1988) germination and growth of tri-nucleate pollen which is hetrotrophic, often requires a

Table 1. Media for germination and growth of pollen grains of sunflower

Media	N	Per cent Pollen Germination Mean \pm SD	Per cent Pollen grains with tube Mean \pm SD	Pollen tube length (μ m) Mean \pm SD
PGM 1	36	28.7 \pm 19.6	-	-
PGM 2	33	61.8 \pm 24.5	10.5 \pm 13.2	-
PGM 3	30	92.5 \pm 10.6	76.3 \pm 24.4	10.9 \pm 3.7
PGM 4	21	96.5 \pm 4.5	81.6 \pm 7.7	13.0 \pm 8.3
PGM 5	15	98.0 \pm 3.2	91.5 \pm 6.7	14.4 \pm 3.7

N = Number of replicates; PGM 1 = Sucrose (150 g/l); H_3BO_3 (100 mg/l); KNO_3 (200 mg/l); $MgSO_4$ (200 mg/l); $Ca(NO_3)_2$ (200 mg/l); PGM 2 = PGM 1 + Extract of one Stigma; PGM 3 = PGM 2 + PEG 6000 (296 g/l); PGM 4 = PGM 3 with sucrose increased to 250 g/l; PGM 5 = PGM 4 with boric acid increased to 200 mg/l

complex medium to sustain its growth. It is argued that the second mitotic division which occurs in trinucleate pollen before anthesis deprives them of several nutrient reserves that are essential for pollen grain germination and tube growth (Brewbaker, 1967). The results indicate that the supply of such complex medium can be best brought about by the addition of extracts of stigmatic tissue. The modified medium (PGM 2) as reported here can be readily used for culturing the pollen grains of sunflower.

An attempt was also made to determine the per cent pollen grains with tube and the pollen tube length in the modified medium as a function of osmotic strength by supplementing the PGM 2 with Poly Ethylene Glycol (PEG : 6000 M.W). Significant increase in per cent pollen grain germination and growth was obtained in media containing 296 g/l PEG (PGM 3) compared to the control (Fig.1, Table 1). A few earlier workers have also reported a significant improvement in pollen grain germination and growth on addition of PEG in the

medium in several systems (Leduc *et al.* 1990; Zhang and Croes, 1982). Further improvement in the per cent pollen grains with tube and pollen growth was obtained by increasing the concentration of sucrose and boric acid to 250 g/l (PGM 4) and 200 mg/l (PGM 5) respectively. In PGM 5, all pollen grains germinated with nearly 90 per cent of them developing tubes with a mean pollen length of 14.4 μ m (Table 1).

Therefore, it is suggested that the media containing sucrose (250 g/l), boric acid (200 mg/l), potassium nitrate (200 mg/l), magnesium sulphate (200 mg/l), calcium nitrate (200 mg/l), PEG 6000 (296 g/l) along with the extract of one stigma can be successfully used for *in vitro* germination and growth of pollen grains of sunflower. The above basic medium (PGM 5) could be used in screening pollen grains of sunflower germplasm for tolerance to moisture stress by substituting higher levels of PEG in the medium. For instance, using 405.4 g/l (-1.8 MP a) of PEG in the medium results in over 50 per cent reduction in pollen tube

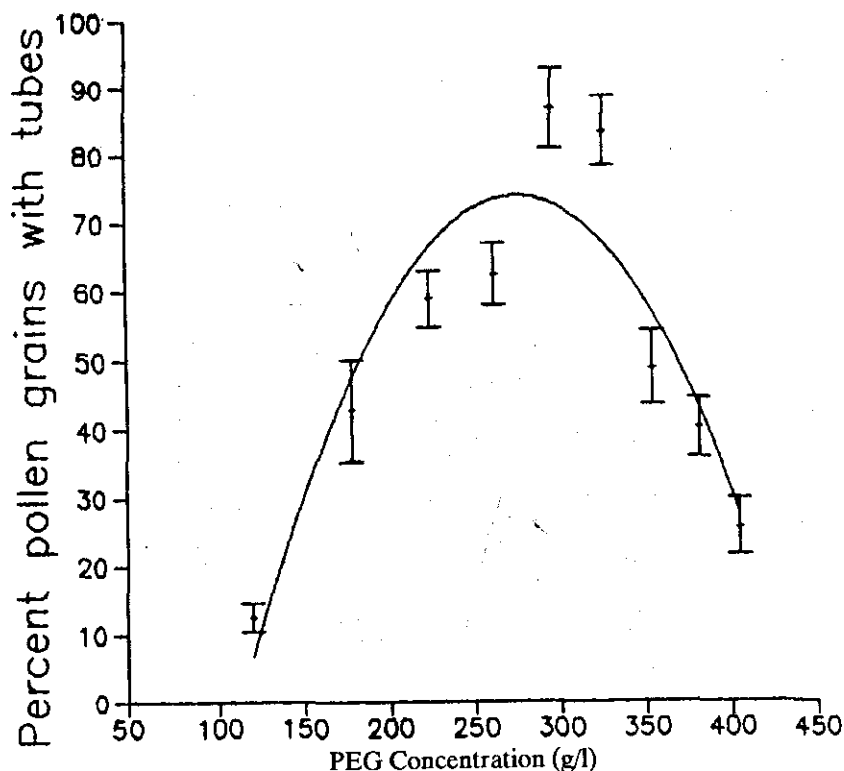


Fig. 1 Effect of PEG on per cent pollen grains with tubes. The vertical lines indicate the standard deviation

$$(Y = -136 + 1.52x - 0.003x^2; R^2 = 0.80)$$

number and growth (Fig.1). Using such restricted medium, a large number of germplasm lines can be screened at the gametic level rapidly. Currently work is in progress to

assess the relationship between the tolerance to osmotic stress at the gamete phase to that at sporophytic phase.

Department of Crop Physiology and
* Project co-ordinating unit (Sunflower),
University of Agricultural Sciences,
GKVK, Bangalore 560 065

M.N. KESHAVA MURTHY
Y.A. NANJA REDDY
K. VIRUPAKSHAPPA*

Brewbaker, J.L. 1967. The distribution and phylogenetic significance of binucleate and trinucleate pollen grains in the angiosperms. *Amer. J. Bot.*, 54: 1069-1083.

Hoekstra, F.A. 1973. *In vitro* germination of compositae pollen. *Incompatibility Newsletter* 3: 46-48.

- Hoekstra, F.A. and Bruinsma, J. 1975. Viability of Compositae pollen : Germination *in vitro* and influence of climatic conditions during dehiscence. *Zeitschrift fur Pflanzenphysiologie*, 76 : 36-43.
- Leduc, N., Monnier, M and Douglas, G.C. 1990. Germination of trinucleate pollen; formulation of a new medium for *Caspella bursa-Pastoris*. *Sex Plant Reprod.*, 3 : 228-235.
- Mulcahy, G.B. and Mulcahy D.L. 1988. The effect of supplemented media on the growth *in vitro* of bi and trinucleate pollen. *Plant Sci*, 55 : 213-216.
- Ravishankar, K.V., Uma Shaanker, R., Udaya Kumar, M. and Prasad. T.G. 1991. Development of drought tolerant sunflower for semiarid tracts of India : Duration of genotypes influence their performance under imposed moisture stress. *Helia*, 14 : 77-86.
- Uma Shaanker, R. 1991. Gametophytic screening technique in identification and development of drought tolerant lines. Proc. of national symposium of recent advances in drought research. Dec. 10-13, 1991, Kottayam, Kerala. p.5.
- Zhang, H.Q. and Croes, A.F. 1982. A new medium for pollen germination *in vitro*. *Acta Bot.Neerl.*, 31 : 113-119.

RESIDUES OF ENDOSULFAN AND LINDANE IN SUNFLOWER (*Helianthus annuus* L.)

Pesticides of chlorinated hydrocarbon group are well known for their accumulation in plant parts more particularly in the component rich in lipids. Although, endosulfan and lindane are known for their efficacies against different pests of sunflower (Bala Subramanian and Chelliah, 1985), the information on their residues in seeds is meagre. The present experiment was conducted to estimate the residues of endosulfan and lindane in the seeds of sunflower.

A field experiment was laid out in a Randomized Block Design with three replications using sunflower variety MSFH-1 sown on July 19, 1992. Endosulfan (Endocel 35% EC) and Lindane (Lintox 20% EC) were used for spraying each at recommended (0.05%) and double the recommended (0.10%) spray concentration by using spray fluid 500 L/ha with hand operated knapsack sprayer. The incidence of *Heliothis* was noticed during 11th week after sowing when the crop was in full bloom. Each insecticide treatment was applied twice at an interval of 20 days by initiating the first spray 80 days after sowing. At 15 days after second application, the seeds from the crop were collected and used for residue analysis. The ground samples were extracted in Soxhlet extractor for 8 hours using hexane. The concentrated extract was further subjected to acetonitrile partitioning using saturated solution of sodium chloride. The extract from samples of endosulfan treatments was treated

with activated charcoal, filtered and residue washed with 9:1 hexane : acetone (3 x 15 ml). The extract was evaporated and finally dissolved in hexane for GC analysis. However, the extract of samples from lindane treatments was subjected to cleanup using concentrated sulphuric acid. The final cleaned extract was used for residue estimation on gas-liquid chromatograph equipped with electron capture detector (Ni-63). The separation was performed on stainless steel column (1.8 m x 3 mm) loaded with 1.5% OV-17 + 1.95% OV-210 on Chromosorb WHP using nitrogen at a flow rate of 60 ml/min. The working temperatures for injector port, column oven and detector were 220, 200 and 300°C, respectively. The sensitivity of the method was 0.01 ppm. The recovery obtained from the samples fortified with endosulfan was 92% and for lindane, 89%.

The levels of residues were 0.029 and 0.048 ppm in respect of seeds harvested from the crop treated with sprays of 0.05% endosulfan and lindane, respectively. Similarly, the values at double the recommended dose (0.1%) were 0.062 and 0.07 ppm, respectively. However, the residue levels in all the treatments recorded less than the maximum residue limits (MRL) of 0.5 and 0.25 ppm for endosulfan and lindane, respectively (Parmar and Dureja, 1990). Spraying of endosulfan or lindane for the control of pests on sunflower can be considered safe as the residues recorded below MRL in seeds at harvest.

Mahatma Phule Agricultural University,
Rahuri 413 722, Dist. Ahmednagar
Maharashtra State

M.D.DETHE
V.D.KALE

Balsubramanian, G. and Chelliah, S. 1985. Chemical control of pests of sunflower. *Pesticides* 19(4) : 21-22.

Parmar, B.S. and Dureja, P. 1990. Minimising environmental hazards of agrochemicals. Indian approach and status. Society of Pesticide Science, India, Publication No. 2, IARI, New Delhi.

CASTOR LEAF MINER *Acrocerops conflua* MEYRICK (*Gracillaridae lepidoptera*) - A NEW RECORD ON *Jatropha* spp. AND CASTOR IN INDIA

In June 1990, symptoms of leaf mining were noticed *Jatropha curcus* L. and *J. glandulifera* in Ranga Reddy District, Andhra Pradesh. The adults of the insect when emerged out were identified to be those of *Acrocerops conflua* Meyrick (*Gracillaridae* : *Lepidoptera*). Few months later infestation of the pest was noticed on castor (*Ricinus communis* Linn.) leaves. Interestingly, it was co-existing with an unknown dipteran leaf miner, which was later reported by Lakshminarayana *et al.*, (1992) as serpentine leaf miner, *Liriomyza trifolii* Burgess. This is the first record of *A. conflua*, attacking *Jatropha* spp., and in India, although it was

previously recorded on Congo jute (Pradhan and Das, 1976), and on sea rush and water pepper in Egypt (Badr *et al.*, 1986), Hill (1987) has included it as *Stomophastis conflua* Meyrick in the list of castor pests occurring in Mozambique.

On *J. curcus* the pest was recorded throughout the year, with the infestation reaching its peak in November, 1990 (19.64 pupae per twig), where as the population was low on castor (2.36 pupae per leaf) in September, 1990. A number of larval parasites were also collected which are awaiting identification.

Department of Entomology,
College of Agriculture,
Rajendranagar, Hyderabad - 500 030.

T.B. GOUR
T.V.K. SINGH
M. SRIRAMULU

Badra, M.A., Usher bah, A.A., Al-Gamal, M.M. and Salem, M.M. 1986. Taxonomy of five species of superfamily Yponomeutoidea in Egypt. *Agr. Res. Reviews* 61(1):257-272.

Hill, D.S. 1987. Agricultural insect pests of the tropics and their control. Cambridge Univ. Press. 746 pp.

Lakshminarayana, M., Basappa, M. and Vijay Singh. 1992. Report on the incidence of hitherto unknown leaf miner, *Liriomyza trifolii* Burgess (Diptera : Agromyzidae) on castor. *J. Oilseeds Res.* 9(1):175-176.

Pradhan, S.K. and Das, L.K. 1976. *Acrocerops* sp. on *Urena lobata* (Congo jute). *Science and Culture* 42(5) : 272-273.

Acknowledgements

The authors wish to express their gratitude to Dr. Swaraj Ghai, Head, Division of Entomology, I.A.R.I, New Delhi, for confirming the identification of the pest species

INDIAN SOCIETY OF OILSEEDS RESEARCH

DIRECTORATE OF OILSEEDS RESEARCH

Rajendranagar, Hyderabad - 500 030

HARDF AWARDS FOR OUTSTANDING OILSEEDS RESEARCH FOR 1993 AND 1994

Background of awards

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

Nature of awards

Cash awards of Rs. 3000/- each and a citation in the following disciplines of oilseeds research

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

rest for sesame, safflower, soybean, castor, linseed and niger.

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

Eligibility for awards

- i) All scientists essentially members of Indian society of Oilseeds Research (for atleast three consecutive years preceding the year of awards) and working in research centres or departments or laboratories of universities, research institutes, directorates and national research centres under ICAR, CSIR, BARC etc., in India.
- ii) Original research work carried out during 5 years preceding the year of award which has bearing on finding solution to any important problem in the disciplines and crops specified.
- iii) Outstanding basic research leading to inventions or discoveries in the disciplines concerned duly supported by publications in journals of repute.
- iv) Results of routine experiments and the research work already submitted or to be submitted for award of any degree or diploma are not considered.

Presentation of awards

- i) Awards will be presented at Annual General Body Meeting of Indian Society of Oilseeds Research.
- ii) Hexamar Agricultural Research and Development Foundation will pay TA

and DA for recipients of awards as per their entitlement.

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

Guidelines for submitting proposals for the awards

- i) Nominations for the award may be made by the Directors of Research Institutes, Vice-chancellor of Agricultural Universities and President of recognised scientific societies. The nominations should invariably be accompanied by eight type written copies of proposals containing:
 - a) Bio-data giving full name, designation, office address, date of birth, academic qualification starting from Bachelor's degree and experience.
 - b) An abstract of research contribution not exceeding 500 words.

- c) Certificate stating the research work submitted for HARDF award is the original contribution of the investigator (s) duly authenticated by the Head of the Institution where it was carried out, and
- d) Detailed technical report as per proforma given below.
- ii) Nominations should reach the General Secretary, Indian Society of Oilseeds Research, Directorate of Oilseeds Research, Rajendranagar, Hyderabad - 500 030 by June 30, 1995.

Judging Committee

- i) Consists of (a) President of Indian Society of Oilseeds Research or his representative from Executive Committee, (b) Director of HARDF or his representative and (c) three experts in each disciplines nominated by the President or Executive Committee of ISOR.
- ii) In all matters relating to the awards, the decision of the Judging Committee is final and no correspondence on this account shall be entertained.

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

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

GUIDELINES FOR AUTHORS

General

Membership in the Indian Society of Oilseeds Research is a pre-requisite for publication of articles in the Journal of Oilseeds Research. The Journal considers for publication 1. Original research papers concerning significant developments of wide interest in any field of oilseeds. 2. Critical review articles indicating gaps in research with suggestions for future lines of work. 3. Short communications on research results not warranting comprehensive treatment and 4. Book reviews. The responsibility for the contents of articles rests with the author (s). Papers must not contain political statements or unsubstantiated assertions.

Submission of Manuscript

Submission of an article implies that it is original and unpublished and not submitted elsewhere for publication.

Papers for consideration should be forwarded to

The Editor,
Journal of Oilseeds Research, Directorate of Oilseeds Research,
Rajendranagar, Hyderabad 500 030, India

Preparation of Manuscript

1. The official language of the Journal is English.
2. Submit your manuscript in triplicate. Enclose the original illustrations and two sets of photo copies (three prints of any photograph).
3. Manuscript should be typewritten in double space, on one side of the bond paper, with two inches margin throughout including abstracts and literature cited. The full papers and reviews should not exceed 15 typed pages and short communications should not exceed 5 typed pages (Two or less than two tables). Every page of the manuscript should be numbered in the upper right hand corner, including title page, literature cited, tables etc. However, in the text no reference should be made to page numbers, if necessary one may refer to sections. Underline words that should be in italics.
4. When corrections are necessary, never follow the same rules as for proof correction.
5. Manuscript should in general be organised in the following order:
Title (avoid long titles); Author(s) name(s); Affiliations(s); Abstract; Keywords; Introduction; Material and Methods; Results and Discussion (Combine together to avoid repetition), Acknowledgement; Literature Cited.

6. Editor reserves the privilege of rejecting the manuscripts and illustrations which do not conform to the guidelines.

Abstracts

An abstract of not more than 400 words should be included in the manuscript. The abstract should be very brief covering the summary of the significant contents of an article.

Keywords: 4-6 keywords should be provided for information search indicating the key areas discussed in the article.

Tables

Each table should be typed on a separate sheet of paper at the end of manuscript. An indication of where the tables are to appear may be made in the text margin. Tables should be numbered according to their sequence in the text. The text should include all tables. Each table should have a brief and self explanatory title. Any explanation essential for understanding the table should be given as a foot note.

Illustrations

1. All illustrations should be given separately, unmounted and unfolded and neatly drawn with Indian ink on butter paper or the original printed with laser printer .
2. Illustrations should be numbered according to their sequence in the text. Reference should be made in the text to each figure.
3. Legends should be in Indian ink or in print. Make sure that the size of the lettering is big enough to allow a reduction of 50% without becoming illegible.
4. Each illustration should have a caption. The caption to all figures should be typed on a separate sheet of the manuscript.
5. Only high contrast photographs are to be included.

Literature Cited

1. All publications cited in the text should be presented in the list of literature cited arranged in alphabetical order with respect to the first author.
2. Use the following system for citing your references:
 - a. For a periodical

Bradbury, J.F. 1970. Isolation and preliminary study of bacteria from plants. *Review of Plant Pathology* 49 : 213-218 (Do not abbreviate the name of the periodical).

Agnihotri, V.P., Sen, C. and Srivastava, S.N. 1975. Role of fungitoxics in the control of Sclerotium root rot of sugarbeet, *Beta vulgaris* L. *Indian Journal of Experimental Biology* 13 : 89-91.

- b. For edited symposia, special issue etc.

Biswell, H.H. 1974. Effects of fire on chaparral. pp 321-365, In: fire and ecosystems Eds. T.T. Kozlowski and D. B. Ahlgrer. Academic press, New York.

- c. For books

Bartik, M. and Piskac, A. 1981. Veterinary toxicology: Developments in animal and veterinary sciences. Elsevier Scientific Publishing Company, Amsterdam/Oxford /New York, 346 pp.

Nomenclature

Authors and editors are by general agreement, obliged to accept the rules governing biological nomenclature as laid down in the International code of Nomenclature of Botanical and the International code of Zoological Nomenclature.

For chemical nomenclature, the conventions of the International Union of Pure and Applied Chemistry and the official recommendations of the IUPAL-IUB combined Commission on Biochemical Nomenclature should be followed.

Indian Society of Oilseeds Research

Publication Announcement

New Book from ISOR SUSTAINABILITY IN OILSEEDS

This publication is the compilation of proceedings of the National Seminar on "Oilseeds Research and Development in India : Status and Strategies" held during 2-5, August, 1993 in Hyderabad, India. The meeting was co-sponsored by eleven prestigious organisations like **ICAR, ICRISAT, NABARD, APSSDC, HARDF, NDDB, APSAIDC, IOPEA, POC, ITC and MAHYCO**. The seminar was organised in five different sessions, and attended by over 500 registrants and special invitees from different sectors within India, added to FAO and ICRISAT. The seminar featured presentations by eminent personalities in oilseeds research, development and allied areas. Also included in the proceedings are around 50 invited presentations, apart from full papers of the 117 poster presentations and session-wise discussions and recommendations.

The material provides the most current thinking about the status and strategies in oilseeds research and development in India. This publication is a treasure of information for personal collection of the scientists, development personnel, processing and nutrition experts concerned with oilseeds, for libraries and institutions since it covers the following varied topics.

- Genetic Enhancement of Oilseed Crops
- Sustainability of Oilseed Production Systems
- Post-harvest Processing Technology
- Vegetable Fat in Human Diet
- Development Scenario and Strategies
- Panel Discussion on Market Intervention & Policy support

The price fixed for the publication is:

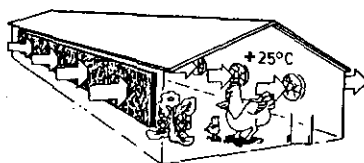
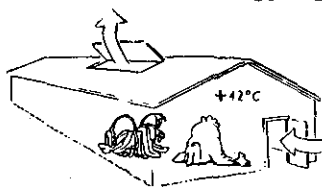
Registered participants	:	Rs. 100/-
Others (in India)	:	Rs. 500/-
Others (Foreign)	:	\$ 50
Postage extra(in India)	:	Rs. 40/-

The publication is available in an attractive paper back form. Please contact the Secretary ISOR, sending the cheque/draft/M.O in favour of Indian Society of Oilseeds Research.

The address :

The Secretary, Indian Society of Oilseeds Research, Directorate of Oilseeds Research, Rajendranagar, Hyderabad - 500030; Fax 91- 0842-245222; Telex 0425-6856 DOR IN

UNI-CELL IN AGRICULTURE



The provision of optimum air conditions is the decisive factor in determining the economy of production in Greenhouses and Livestock Buildings. In tropical and sub-tropical climates similar to India, the world over the production rate of plants and livestock has always suffered from high temperatures.

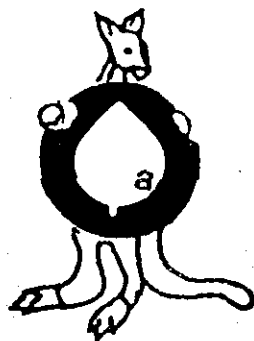
Experience has shown that evaporative cooling based on what is generally referred to as 'Pad and Fan System' to be the most efficient method of increasing production. A temperature between 20 to 28°C and a relative humidity not higher than 75% has generally been found to be optimum climatic conditions for rearing poultry. By installing a cooling system in your poultry houses you will get more production out of your poultry stock.

The same conditions also apply to climate conditions in greenhouses, although this will, of course depend on the type of crop. An evaporative cooling system will cut water consumption by reducing soil evaporation and will also improve working conditions in the greenhouse.



United Engg. Corporation, 147, R.P. Road, Secunderabad 500 003. Ph. 821113

WE BREED BETTER SEED SOW IT AND SEE



Mega - 363
&
Mega - 333

Hybrid Sunflower Seeds

Omega Ag-Seeds (India) Limited
3-6-237, Amrutha Estate, Lingapur-la-Buide Complex,
Flat 12, 6th Floor, Himayatnagar, Hyderabad 500 029,
Phone : 242247; 242324. Telex : 425-6058 MEGA IN.

Indian Society of Oilseeds Research

Directorate of Oilseeds Research,
Rajendranagar, Hyderabad - 500 030.

INDIA

MEMBERSHIP / RENEWAL FORM

Name :

Designation/Status :

Organization :

Mailing Address :

Educational qualification :

Field of Specialisation :

Type of Membership : Patron/Life Member/Corporate member/Ordinary member/Student member

Year of Membership :

Proposed by 1.
(Name & Address)

2.

I enclose payment of Rs. in favour of General Secretary / Treasurer Indian Society of Oilseeds Research by A/c Payee () / Bank Draft () / Money Order (receipt enclosed) () cheque (add Rs.3.00 on outstation cheque in India please) towards my Admission Fee plus membership fee and I agree to abide by the rules and regulations of the Society.

Date

Signature

FOR OFFICE USE

INFORMATION FOR CONTRIBUTORS

Contributions from the members on any aspects of oilseeds research will be considered for publication in Journal of Oilseeds Research. Papers for publication (in triplicate) and book reviews should be addressed to the Editor, Journal of Oilseeds Research, Directorate of Oilseeds Research, Rajendranagar, Hyderabad - 500 030, India.

Manuscript should be prepared strictly according to the "GUIDELINES FOR AUTHORS" published in Volume 2, No. 1 and should not exceed 15 printed pages including tables and figures. Short communications should not exceed four printed pages including tables and figures.

Articles from the Journal of Oilseeds Research are being regularly indexed in AGRINDEX and abstracted in CABI abstracting Journals and Biological Abstracts.

Annual Subscription

India	Abroad
Individual : Rs. 50.00 + Admission fee (Rs.10/-)	U.S. \$ 50.00
Institutions : Rs. 350.00	U.S. \$ 100.00
Students : Rs. 30.00	(Postage extra)

Life membership : Rs. 600.00

For subscription, please contact the General Secretary, Indian Society of Oilseeds Research, Directorate of Oilseeds Research, Rajendranagar, Hyderabad - 500 030, India.

TARRIF FOR ADVERTISEMENTS

Location	2 Issues (Rs.)	1 Issue (Rs.)
Back Cover (Inside)	8000/-	5000/-
Page facing back cover	3000/-	1500/-
Inside full page	2500/-	1500/-
Inside half page	1500/-	750/-

Over all size	:	21.0 cm height (max.) x 14.0 cm width (max.)
Print area	:	1) Back cover & full page : 18.0 cm x 14.0 cm
	:	2) Half page : 9.00 cm x 14.0 cm

Indian Society of Oilseeds Research thankfully acknowledges the financial assistance received from Indian Council of Agricultural Research, New Delhi for Printing of the Journal of Oilseeds Research.

**Edited and Published by the Indian Society of Oilseeds Research
Directorate of Oilseeds Research, Rajendranagar, Hyderabad - 500 030**

Printed at K.S. Latha Photo Offset Printing works, Sultan Bazar, Hyderabad. Phone : 514907

GERMINATION OF SAFFLOWER (*Carthamus tinctorius* L.) SEEDS AS INFLUENCED BY SOIL MOISTURE AND DEPTH OF SOWING

P.G. PATEL and Z.G. PATEL

Department of Agronomy, N.M. College of Agriculture, Gujarat Agricultural University,
NAVSARI - 396 450

ABSTRACT

Field experiment conducted at the N.M. College of Agriculture Farm, Navsari during the *rabi* season of 1992-93 and 1993-94 revealed that safflower seeds sown at 100% ASM (field capacity) with 2.5 to 5.0 cm depth gave higher percentage of germination and field emergence. Decreasing soil moisture below 100% ASM significantly decreased the germination percentage. Germination of seed sown at 40% ASM drastically reduced (13.71%) in clayey soils of south Gujarat.

Keywords : Safflower; Germination percentage; Available soil moisture; Depth of sowing.

INTRODUCTION

Safflower (*Carthamus tinctorius* L.) is a winter annual oilseed crop recently introduced in south Gujarat. The crop suffers in germination because of its hard seed coat. Low yields are reported mainly due to poor germination resulting in inadequate plant population. Soil moisture and depth of seeding are the important factors governing the germination and plant stand for realizing maximum yield potential. Keeping this in view the present experiment was planned to find out appropriate soil moisture content at sowing and suitable seeding depth for optimum germination of safflower seed.

MATERIALS AND METHODS

A micro-plot field investigation on safflower variety 'Bhima' was conducted during the *rabi* seasons of 1992-93 and 1993-94 at the N.M. College of Agriculture Farm, Navsari. The experiment was laid out in a Split Plot Design keeping

four soil moisture regimes 40, 60, 80, and 100 % available soil moisture (ASM) as main plots and three depths of sowing (2.5, 5.0, and 7.5 cm) as sub-plots with four replications. The soil of the experimental plot was clayey in texture having 0.70% organic carbon, 23.17 kg P₂O₅ / ha and 341 kg K₂O/ha with 7.8 pH. The field capacity, permanent wilting point and bulk density of the soil were 32.20%, 18.70% and 1.40 g/cc, respectively. Soil samples were drawn from 0-15 cm depth for soil moisture studies at an interval of 24 hours so that particular moisture regimes could be maintained. Two hundred seeds were sown in each plot (2.5 m x 1.0 m). Emergence counts were recorded after eight days and repeated every day till complete germination and emergence obtained for two consecutive days. The days to emergence and germination rate were calculated by dividing the number of seedlings emerged at each counting by the number of days the seeds remained in soil as suggested by Dahiya *et al.* (1985).