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SHORT COMMUNICATIONS

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ENVIRONMENTAL EFFECTS ON THE GROWTH AND PHENOLOGY OF SESAME (*SESAMUM INDICUM* L.)

A. NARAYANAN AND M. RAVINDRA KUMAR
Department of Plant Physiology, Agricultural College, A.P.Agricultural University, Bapatla—522101. Andhra Pradesh.

ABSTRACT

Fifteen genotypes of sesame (*Sesamum indicum* L.) were planted on the first of every month from January to June, 1986 to study the variations in flowering mode, day from bud to first flower and the growth in height at first flowers opening. Flowering was delayed considerably in all genotype when planted during April to June. Which was attributed to the high mean day and night temperatures. Maximum node number appeared to be for first flower was observed in genotype CO-1. Out of six sowings E-8 and CO-1 late in flowering. Considerable changes in number of days for buds to form flower in genotypes were also observed. This was attributed to the temperature differences during the growth period. Again the plant growth in height was also influenced by the dates of planting. Plant height during the first flower to open was again primarily influenced by photoperiod. Genotypes showed marked difference to this response.

Key words : Sesame, Flowering Phenology, Environment.

INTRODUCTION

Sesame (*Sesamum indicum* L.) is one of the important oilseed crops grown during monsoon, post-monsoon and summer seasons either as a sole or inter crop in India (Sharma, 1985). These seasons provide varying aerial environments for the growth and development of this crop. The monsoon crop is generally affected by high rain fall causing waterlogging which lead to pest and disease incidence. The high humidity of this season aggravates these incidences. The post-monsoon crop is mostly subjected to low temperature and short photoperiod, which normally influence the growth and flowering. The summer crop is grown under irrigation. More-over the high temperature and long photoperiod favour the crop to put forth more vegetative growth which in turn provides more fruiting points (Narayan and Narayanan, 1987).

Therefore the growth and development of sesame are highly influenced by environment. Moreover genotype response to varied environments is also possible. In order to investigate the response of genotypes to the cumulative environmental changes the present study was undertaken by planting 15 genotypes of sesame from January to June at monthly interval.

MATERIAL AND METHODS

A field experiment was laid out at the Agricultural College Farm, Bapatla (80°30' E, 15°54' N) with 15 genotypes of sesame. They were Phule Til–1, B–67, CTM–1, Vinayak, Pb Til–1, HT–1, CST–782, Co–1, CST 785, K–white, Kayamkulum, Gujarat

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Til-1, E-8 HT-6 and Madhavi These genotypes were planted from January, 1986 to June, 1986 on the first of every month.

Split plot design was followed with the date of planting as main plot and genotypes as sub-plot. Three replciations were kept. The area of each main plot was 48 m^2 and sub-plot measured 14 m^2 having 7 m length and 2 m width. Each genotype was sown in two lines. The sandy loam soil was fertilized wtth 30 kg N, 20 Kg P2O5 and 20 kg K_2O per ha. The sowing was done in lines by dibbling the seeds. The spacing between lines was 25 cm and between hills 15 cm. Thinning of seedlings and weeding were done 15 days after sowing The crop was irrigated based on the requirement. Plant protection measures were taken by spraying Nuvacron and Rogor @ 1 ml l^{-1} of water.

Five uniform plants in each genotype at random per replication were tagged for taking the non-destructive observations. Number of days for the appearance of flower bud and first flower to open was recorded. In addition to these the node at which first flower arose, and height of the plant when the first flower opened were also observed. From these observations the number of days required for the buds to become a flower was calculated. The data were statistically analysed for split plot design by Analysis of Variance (Snedecor and Cochran, 1967).

RESULTS AND DISCUSSION

Meteorological data :

The monthly average of maximum and minimum temperature, relative humidity and wind speed are given in Table 1. The maximum temperature did not exceed 38.7°C during the experimental period. The lowest temperature recorded was 17.1°C during

TABLE 1. Mean Monthly Meteorological Data

Month 1986	Temperature °C			Relative humidity %	Wind speed Km h^{-1}
	Maximum	Minimum	Mean		
January	28.1	17.1	22.6	76	8.0
February	29.7	19.0	24.4	77	7.5
March	31.9	21.9	26.9	75	9.2
April	33.3	25.6	29.5	73	15.0
May	38.7	28.3	33.5	61	13.5
June	37.6	27.3	32.5	57	13.0
July	35.8	25.9	30.9	63	12.5
August	32.6	25.0	28.8	74	9.5

January, 1986. The mean of the maximum and minimum temperature increased steadily from January to June, 1986 and decreased further. The relative humidity declined from January to June and increased thereon. The speed of the wind was maximum during the month of April and considerably high during May to July as compared with January to March, 1986.

Flowering node :

One of the quantitative methods normally used for determining the time of flowering is simply to count the number of nodes from the base till a flower appears on a particular node. It evidently expresses the earliness or lateness of flowering by a plant.

TABLE 2. Mean node number at which first flower appeared

Genotypes	Dates of sowing						Mean
	Jan.	Feb.	Mar.	Apr.	May.	June	
Phule Til-1	3.8	3.8	3.7	4.8	5.7	5.9	4.6
B-67	4.1	3.8	3.5	4.6	5.5	5.7	4.5
CTM-1	3.8	4 2	3.9	3.5	4.9	5.1	4.2
Vinayak	4.4	3 8	4.0	4.8	6.2	6.3	4.9
Pb Til-1	3.6	4.1	3.9	4.6	4.3	4.8	4.2
HT-1	3.5	3 6	3.7	4.3	5.3	5.3	4.3
CST-782	3.8	3 8	3.8	4.6	5.8	5.3	4.5
Co-1	3.8	4.4	4.4	5.1	5.9	6.5	5.0
CST-785	4.4	3.9	3.4	4.5	5.1	5.4	4.5
K-white	3.7	3.7	3.7	4.4	5.2	4.8	4.3
Kayamkulam	3.8	4.1	3.5	5.0	4.5	6.5	4.6
Gujarat Til-1	3.8	3.8	3.4	5.1	4.0	5.0	4.2
E-8	4.6	3.6	4.5	5.7	4.1	6.7	4.9
HT-6	4.1	3.4	3.7	4.3	3.9	5.5	4.2
Madhavi	4.2	4.2	3.7	5.0	5.7	4.4	4.5
Mean	3.9	3.9	3.8	4.7	5.1	5.5	

	SEm±	LSD(0.05)	C.V(%)
Dates of sowing	0.054	0.169	8.110
Varieties	0.093	0.259	8.805
Dates at fixed level of genotype	0.210	0.662	
Cenotype at fixed or different level of dates	0.225	0.637	

It was observed that sowing during January, February and March, 1986 did not bring about significant changes in mean number of nodes, however from April to June it increased significantly from month to month indicating thereby that the flowering is delayed considerably as the planting is drawn towards June (Table 2). The temperatures (maximum and minimum) during January to March were lower than that of April to May (Table 1). It appears that lower temperature accelerates the flowering whereas high temperature delays this processes. But the effect of photoperiod and temperature on flowering is difficult to separate in the field (Aggarwal and Poehlman, 1977). Since the photoperiod generalty increases from January to June, and so the temperature, it becomes obvious that these two environmental factors play an important role in flowering of sesame. It is also evident that the vegetative growth is promoted by these two factors as a result the plants could put forth more number of non-flower bearing nodes initially.

Genotypes were also showing significant changes. Maximum node number was observed for Co-1 (5.0) followed by Vinayak, E–8, Phule Til-1 and Kayamkulam whereas rest of the genotypes were relatively early in flowering by producing lesser number of nodes.

When the genotypes were planted in January, E–8, Vinayak and CST–785 produced maximum nodes before flowering as compared with others. In February sowing none of these genotypes showed more number of nodes but Co-1 had the maximum node nunber. Again in March, April sowing E–8 and Co–1 showed maximum number of nodes. During May, sowing Vinayak, Co–1, CST–782, Madhavi, Phule Til–1, B–67 and HT–1 produced more number of nodes before flowering, whereas in June sowing E–8, Co–1, Kayamkulam, Vinayak, Phule Til–1 and B. 67 produced maximum number of nodes.

In general, out of six sowings E–8 and Co–1 appear to be late in flowering. The variations observed with genotypes for early or late flowering may be influenced by temperature and Photoperiod. It is possible to infer that genotypic response to flowering depends on environmental factors such as photoperiod and temperature.

Days from bud to first flower :

The number of days for the first flower opening from the date of bud appearance was recorded and given in Table 3. The main effect of genotypes showed a slight decrease in number of days in crops sown in March onwards. In the January and February planted crops the first flower appeared late which may be due to the low temperature. High night temperature was found to promote flower opening in lima bean by Fisher and Weaver (1974). Similar results were also reported for mung bean by Aggarwal and Peohlman (1977).

Genotypes of sesame showed considerable variation in day from bud to first flower. For example B–67, CTM–1, Pb Til–1, Kayamkulam and Madhavi took less than 11 days whereas all others took more than 11 days.

TABLE 3. **Mean number of days for buds to become flowers**

Genotypes	Dates of sowing						Mean
	Jan.	Feb.	Mar.	Apr.	May	June	
Phule Til-1	11.8	11.9	13.0	11.6	7.9	10.6	11.2
B-67	11.8	11.9	9.9	10.7	7.4	10.0	10.3
CTM-1	11.1	12.0	11.1	10.0	8.0	10.4	10.4
Vinayak	11.7	11.9	10.8	11.8	10.4	10.2	11.2
Pb Til-1	12.2	11.5	8.7	12.3	9.4	10.8	10.8
HT-1	11.1	11.8	8.9	11.4	12.6	10.8	11.1
CST-782	11.5	11.9	9.6	10.6	15.7	10.7	11.7
Co-1	11.6	11.8	8.1	11.5	15.2	10.2	11.4
CST-785	11.7	11.8	8.2	12.0	10.1	10.2	11.0
K-white	12.1	11.4	8.5	12.7	12.7	10.1	11.3
Kayamkulam	12.1	11.9	7.4	11.3	8.4	10.6	10.3
Gujarat Til-1	11.9	12.0	10.6	12.8	12.0	11.0	11.7
E-8	11.8	11.7	12.6	10.0	12.3	10.5	11.3
HT-6	12.1	12.0	11.9	12.1	11.9	10.4	11.7
Madhavi	11.9	12.0	11.0	10.8	8.8	9.8	10.7
Mean	11.8	11.9	10.2	11.4	10.9	10.4	

In March sowing Phule Til-1, CTM-1, Vinayak, Gujarat Til-1, E-8, HT-6 and Madhavi produced flower from the buds within 10 days whereas rest of the genotypes were delayed to form flowers. Such an effect was not found in April sowing for which no reason could be attributed. In May planting Phule Til-1, B-67, CTM-1, Pb Til-1, Kayamkulam and Madhavi took less than 10 days. Considerable variations were noticed for other genotypes. Therefore it becomes very difficult to explain the behaviour of individual genotype with respect to date of planting for days from bud to first flower.

Plant height at first flower opening:

Height of a plant measured at a given time indicates the actual growth. The dates of sowing exhibited significant difference in plant growth at the time of first flower opening (Table 4). The maximum height was observed for plants sown in June. There was no significant difference between April and May sowings. However, the difference was marginal among January, February and March sowings. The plants grew only 15.6 cm in height during February sowing as compared to the height of 29.7 cm during the June sowing. It is very difficult to explain the reasons for the available meteorological data. However, it is possible to presume that the long photoperiod during the

TABLE 4. Mean height of plant (cm) at first flower opening

Genotypes	Dates of sowing						Mean
	Jan.	Feb.	Mar.	Apr.	May.	June	
Phule Til-1	14.7	16.5	17.9	21.8	21.2	30.3	20.4
B-67	14.9	13.8	12.5	26.1	23.1	30.4	20.1
CTM-1	16.0	12.8	15.4	24.0	21.7	27.7	19.6
Vinayak	15.0	13.5	17.5	23.1	23.4	32.3	20.8
Pb Til-1	17.3	18.2	18.1	24.4	21.1	30.2	21.6
HT-1	14.5	19.8	17.7	28.2	20.8	28.1	21.5
CST-782	16.9	22.1	16.9	27.4	19.7	28.7	21.9
Co-1	15.8	15.0	19.6	25.9	22.6	26.8	20.9
CST-785	19.1	15.2	18.1	23.6	21.6	30.2	21.3
K-white	18.1	15.4	19.4	25.2	21.4	28.4	21.3
Kayamkulam	16.3	13.5	16.2	26.0	22.3	31.3	20.9
Gujarat Til-1	15.6	14.5	20.4	26.3	21.9	30.2	21.5
E-8	20.0	15.5	18.9	21.4	20.5	30.8	21.2
HT-6	13.5	14.1	17.3	23.9	20.1	30.0	19.8
Madhavi	18.5	14.6	18.4	23.6	22.9	30.5	21.4
Mean	16.4	15.6	17.6	24.7	21.6	29.7	

	SEm±	LSD(0.05)	C.V(%)
1. Dates of sowing	0.337	1.061	10.780
2. Varieties	0.523	1.450	10.592
3. Dates at fixed level of genotypes	1.305	4.111	
4. Genotype at fixed or different level of dates	1.286	3.646	

month of June and July might have influenced the growth of plants. Thus Ghosh (1955) indicated that short photoperiods in sesame reduced the vegetative growth. Similar results were also reported by Thomas (1965). He found that longer photoperiods produced more sturdy and big sesame plants.

More number of leaves were also produced by long photoperiod (Sinha *et al.*, 1973) which was also observed in the present study. The mean number of leaves observed at the first flower appearance in January planting was 10.9 which subsequently increased at every monthly planting and reached the maximum of 16.6 leaves in June planting. This indicates the faster growth of plants in height and leaf production when sown in June.

Genotypic variations in plant height were also observed. CST–782 recorded a maximum height of 21.9 cm whereas CTM–1 showed the minimum height of 19.6 cm. Rest of the genotypes showed marginal variations.

In January sowing E–8 showed the maximum height of 20 cm followed by CST–785 and Madhavi. HT–6 showed the minimum height of 13.5 cm. However, the pattern was altered in February sowing. CST 782 grew to the maximum height of 22.1 cm followed by HT–1 and Pb Til–1. Lowest height of 12.8 cm was observed for CTM–1. Again in March sowing the response of genotypes differed. Gujarat Til–1 had a maximum height of 20.4 cm followed by Co–1 and K–white. B–67 was the shortest (12.5 cm) among the genotypes. In April sowing, the maximum height of 28.2 cm was recorded by HT–1 followed by CST–782. The lowest height of 21.4 cm was observed in E–8. Vinayak showed the highest growth of 23.4 cm followed by B–67 and and Madhavi during the May sowing. CST–782 showed the lowest height of 19.7 cm. Again in June sowing Vinayak grew taller (32.3 cm) where Co–1 showed the lowest height of 26.8 cm. It is evident from these results that the genotypes respond to various months in terms of a combination of environmental factors planting during each month provides varied environments for the genotypes to respond. But it becomes very tedious to separate out the environmental factors in such field studies. However, sesame genotypes differ in their response to the dates of planting in growth measured as plant height upto the first flower to open. As it was discussed earlier that the growth is mainly controlled by the photoperiod, it is obvious that the response of genotypes to photoperiod is found to vary considerably. Some of them do not show variation in growth even though they are planted in months of long photoperiod whereas some do show considerable variations as explained above.

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PHNOTYPIC STABILITY FOR QUANTITATIVE TRAITS OF SESAME UNDER RAINFED CONDITIONS OF ARID ENVIRONMENT

D. KUMAR
Central Arid Zone Research Institute, Jodhpur — 342 003 (Raj.)

ABSTRACT

Phenotypic stability of 5 quantitative traits were studied for sesame by growing 10 genotypes in 8 environments under rainfed conditions. Genotype x environment interactions were present, and large portion of these was accounted for by linear component. Non-linear component was also significant yet magnitude was smaller than the linear component. The strains 4–2 and T–13 were the most stable for seed yield in better environment whereas TC 171 and C6 exhibited maximum stability for yield in poor environment. Top yielder TC 25 with unit regression also rendered considerable stability for yield towards favourable environment.

Key words : Arid environment, agronomic manipulation, better and poor environments, responsiveness, stability.

INTRODUCTION :

Sesame is reckoned as an important *Kharif* oilseed of the arid environment. The crop occupies almost 16% of the national oilseeds acreage, yet the productivity is alarmingly low. The low yield of sesame is characterized mainly to the lack of high yielding drought resistant genotypes. Furthermore, lack of response to better-conditions and the instability in yield of sesame to varying environments are also of great concern. Information on stability of sesame genotypes prior to their recommendation for cultivation is very much necessary, There is no published report in this crop on yield stability in arid environment. Hence, an attempt was made to evaluate 10 sesame strains for stability of seed yield and related traits.

MATERIALS AND METHODS :

Ten genetically diverse genotypes (4–2 ,Guari, Mrug–1, T–13, C–6, Patan–64, Pb–1, TC–171, Pratap and RC–25) of sesame (*Sesamum indicum* L.) were selected for stability studies under light textured loamy sand soils of CAZRI, Jodhpur. The strains were raised in a randomized block design with 3 replications in 8 environments under rainfed conditions during *Kharif* 1985 (137 mm rainfall during cropping period). The environments stated below were created by agronomic manipulations. The two sowing dates were chosen as component of environments to assess the suitablity of genotypes to early and the late onset of monsoon while below and above N doses were used to study their role under normal and below normal rainfall situations. Similarly, higher intra-row spacing (15 cm) was also included as a component of created environment alongwith usual (10 cm) spacing, owing to greater role of lower, plant density under extreme drought situations.

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Environments	Dates of sowing	Nitrogen doses (kg/ha)	Intra-row spacing (cm)
I	17.7.85	20	10
II	17.7.85	40	10
III	17.7.85	20	15
IV	17.7.85	40	15
V	07.8.85	20	10
VI	07.8.85	40	10
VII	07.8.85	20	15
VIII	07.8.85	40	15

Each genotype was sown in 3–m –long single row with inter row spacing of 30. cm. Whole of the required nitrogen (20 and 40 kg/ha) was drilled at the sowing time Intra-row spacings of 10 and 15 cm were maintained by retaining 30 and 20 plants respectively for each entry. No irrigation was applied during cropping period. Observations on 10 randomly selected plants from each row plot were recorded for days to maturity, plant height (cm), number of pods on main shoot, number of plants/plot at maturity (plant stand) and seed yield/plot. Analysis of mean data for stability was done following Eberhart and Russell (1966).

RESULTS AND DISCUSSION :

Mean squares due to genotypes and environments were significant indicating that the genotypes were distinct in their attributes and the environments created were different (Table 1). Significance of genotype × environments and environments + genotypes × environments component was found for the traits excepting plant stand which revealed that the genotypes interacted substantially with the environmental conditions towards the expression of these traits. Both linear, genotype × environment (linear) and non-linear (pooled deviation) compoents fo g × e interactions were present, however, the former contributed greater part to these interactions. Furthermore, significant linear sensitivity and the non-significant non-linear sensitivity for plant stand indicated that the prediction of performance across the environments was feasible for this trait only (Bains and Gupta, 1972).

Data presented in Table 1 indicates that seed yield was minimum in Env. V and increased in order of the Envs. VI, VIII, VII, I, III, II and was maximum (12.64 g) in Env. IV (sowing on July, 17, 40 kg N/ha and 15 cm intrarow spacing). Higher yields in Env. I to IV than in comparison to Envs. V to VIII reflected the suitability of early sowing in higher yield realization. This confirms earlier findings of Yadava and Bhola (1978) that the sowing of sesame by mid of July was quite appropriate in rainfed conditions of arid environment. The response of 40 kg N over 20 kg N/ha observed in the environments with early sowings is obvious, from more precipitation in the root zones confirming earlier results of Daulay *et al.* (1984) in the existing conditions. Across the N doses and the dates of sowing intra-row spacing of 15 cm gave more yields than that of 10 cm.

Seven genotypes viz., 4–2, Mrug–1, T 13, C 6, Pb 1, TC 171 and TC 25 exhibited significant regression coefficient and non-significant S^2di component indicating that the former component accounted for major part of the g × e interaction in these strains. Linear component however, contributed for only a part in rest of the strains. C 6 and TC 171 which have been giving excellent performance in All India Coordinated Sesame Trial under rainfed conditions (Anonymous 1984), characterized with below average response were the most stable strains in poor environments ($S^{-2}di$ = 0.03 and –0.02, respectively). The former being tallest in stature and earliest in maturity (66 days) was also characterized with maximum stability in number of pods on main shoot towards poor environment ($S^{-2}di$ = 0.07). In favourable environments, maximum stability for yield was conferred on 4–2 and T 13. National check TC 25 with maximum yield across the environments was rated third in stability. The former, exhibited maximum stability in respect of number of pods on main shoot in better environment whilest latter was the stable most for this trait in poor environment. Further-more, all the strains but 4–2 were stable to plant stand at maturity towards poor environment and had significant bi component.

To conclude, the sowing of sesame crop around July 7 when fertilized with 40 kg N/ha and the plants adjusted to 15 cm intra-row spacing would be ideal in arid environment. TC 25 with maximum seed yield gave considerably high stability to this trait under better environment, TC 171 on the other was stable most in poor environment.

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TABLE 1. Pooled analysis of variance of stability for 5 quantitative traits in sesame

Source	D.F.	Days to maturity	Plant height	No. pods on main shoot	Plant stand at maturity	Seed yield/plot
Genotypes	9	53.46**	42.63*	2.43*	16.75*	3.12**
Environments	7	41.08**	1686.91**	15.94**	217.19**	104.33**
Genotypes × environments	63	3.18**	19.01*	2.35*	7.97	2.90**
Env. + (genotype × env.)	70	6.97**	185.80**	2.51*	28.90	11.31**
Environment (linear)	1	287.26++	11808.31++	111.57++	1520.34++	730.32++
Genotypes × environments (linear)	9	6.12@	36.79@	2.29++	14.91@	2.51++
Pooled deviation	60	2.43**	14.44**	0.73**	6.14	0.64**
Pooled error	144	1.51	17.53	1.53	30.16	0.98

*P = 0.05. **P = 0.01 against pooled error

@P = 0.05. ++P = 0.01 against pooled deviation.

TABLE 2. Mean seed yield (g/plot) and stability parameters of 10 sesame genotypes grown over 8 environments

Genotypes	Environments								Mean	bi	S^2di
	I	II	III	IV	V	VI	VII	VIII			
4-2	5.10	9.36	5.60	13.00	3.20	3.76	4.76	4.26	6.13	1.01**	0.12
Gauri	6.80	11.16	5.90	10.63	2.86	3.90	4.06	4.06	7.17	0.92**	0.01*
Mrug-1	5.96	8.50	5.76	12.36	3.13	2.70	4.53	3.36	5.79	1.00**	-0.13
T 13	7.60	10.13	6.76	12.76	2.53	2.83	3.93	4.43	6.37	1.11**	0.13
C 6	6.10	8.63	6.56	10.93	2.43	4.10	5.40	4.56	6.09	0.81**	-0.03
Patan 64	4.06	9.93	4.66	15.06	2.20	2.00	3.16	3.60	5.58	1.37**	0.85*
Pb 1	6.96	7.86	8.60	11.56	4.10	4.20	5.63	5.30	6.77	0.74**	0.34
TC 171	6.73	8.03	7.03	12.66	3.83	3.60	5.13	4.80	6.47	0.89**	-0.02
Pratap	5.53	10.66	9.46	14.76	3.66	4.50	5.30	4.60	7.31	1.17**	0.67*
TC 25	8.90	10.43	8.40	12.70	4.50	4.53	5.83	5.00	7.53	0.92**	0.20
Mean	6.37	9.46	6.83	12.64	3.24	3.61	4.77	4.39	6.42	1.00	—
SEm ±	0.86	0.87	1.02	1.01	0.71	0.45	0.88	0.36	0.30	0.09	—
CV (%)	16.63	11.28	18.40	9.84	26.85	15.24	22.67	10.23	15.00	—	—

*P = 0.05, **P = 0.01

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EVALUATION OF 'NAP' CYTOPLASMIC MALE STERILITY IN *BRASSICA NAPUS* L. UNDER INDIAN CONDITIONS

S.S. BANGA, K.S. LABANA AND ALKA SRIVASTAVA
Department of Plant Breeding, Punjab Agricultural University, Ludhiana—141 004.

ABSTRACT

'Nap' cytoplasmic male sterile line of *B. napus* was evaluated for fertility restoration and yield heterosis. All 22 strains used as pollen parents restored fertility either completely or partially. Inheritance of restoration was studied in ten crosses and except for three instances, restoration was due to single dominant gene. In three cases there was a better fit with 13:3 ratio of digenic epistasis. Yied heterosis in 19 F1 hybrids ranged from –52.7 to 42.4 per cent over commercial variety, GSL–1. Hybrid CMS × Sv Nikalas was the top yielder. Breakdown of sterility at high temperatures (22°C) may limit exploitation of this system under Indian conditions.

Key words : *Brassica napus*; Male sterility; Restoration; Genetics; Hybrids.

INTRODUCTION

Cytoplasmic male sterility (C.M.S.) in *Brassica napus* was first reported by Thompson (1972). Male sterile plants had flowers with narrow petals and reduced stamens having very few pollen grains. Later, Shiga and Baba (1973) independently identified male sterility in another intervarietal cross of *B. napus*. Both these systems were later shown to be similar as Thompson's cms line could be maintained by its maintainer, Bronowski as well as by Shiga's maintainers. Isuzunatane and Murasake-natone Shiga's cms was also maintained by Bronowski. Both these cms lines also had common restorers (Shiga *et al.*, 1983). Previously, *B. napus* was not cultivated in India, but during last few years, cultivators have shown lot of interest in this crop due to its higher yield potential and oil content. Availability of cytoplasmic male sterility, coupled with reports of substantial yield heterosis in *B. napus* (Sernyk and Stefansson, 1983; Grant and Beversdorf, 1985) have led to concerted efforts to produce commercial hybrids in this crop of great economic significance. The objectives of the study reported in this communication were to evaluate 23 hybrids based on 'nap' male sterility for fertility restoration and yield heterosis. Inheritance of restoration was also investigated in ten crosses.

MATERIAL AND METHODS

The seeds of 'nap' male sterile *Brassica napus* along with the maintainer were obtained from Dr T. Shiga, Chiba Station, Central Agricultural Experimental Station Yatsuiaido, Chiba, Japan. Twenty three strains of spring type *Brassica napus* obtained from different countries were used as pollen parents to develop 23 F_1 hybrids in 1984. F_1 hybrids were evaluated from fertility restoration. Plants were classified as male fertile, partially male sterile and male sterile according to anther size and pollen production. Yield evaluation of F1 hybrids against the commercial check *Gobhi sarson* Ludhiana-1 (GSL–1) was done in a randomized complete block design with three repli-

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cations. Each replication had one row and mean of ten plant was subjected to analysis of variance. In ten F_1 hybrids, plants were selfed to produce F_2 generation. The F_2 progenies were assayed for male fertility/sterility. Chi square analysis was used to test goodness of fit to hypothetical sage gation ratios.

RESULTS AND DISCUSSION

Excepting Bronowski, Pol 15, and Norin 16, all other *B. napus* strains used in this study completely restored the fertility of 'nap' cms line. The fully restored plants had normal anthers with abundant pollen grains and high pollen fertility (> 90 per cent). Seed set on selfing was also very high. Fertility restoration in crosses with Bronowski, Pol 15 and Norin 16 was incomplete. Partially restored plants had medium sized anthers with few fertile pollen grains. Though Bronowski has been reported to carry fertilizing cytoplasm with recessive alleles (rf rf) for pollen sterility (Thompson, 1972; Shiga, 1980), it is not a complete maintainer for 'nap' cytoplasm (Thompson, 1972). Incomplete restoration by Norin 16 is in contradiction to the report of Fan *et al.* (1986) but in accordance with an earlier report (Shiga, 1980). Fan *et al.* (1986) obtained complete restoration with North 16. Inheritance of restoration was studied in ten crosses and excepting cvs. Strape, Diplo and Brutor, chi square test indicated a perfect fit with a ratio (3:1) of monogenic inheritance. In crosses with Strape, Diplo and Brutor, there was a better fit with 13:3 ratio of digenic epistasis. While Thompson (1972) found that restoration was controlled by a single dominant gene, two and more dominant genes have also been implicated in restoration (Sernyk, 1982; Shiga *et al.*, 1983). Such contradictions are expected since the sterility caused by 'nap' cytoplasm is known to break under higher temperatures (Fan and Slefansson, 1986) and thus there is every possibility of overestimating the fertile segregants, especially under Indian conditions. Uunder Ludhiana conditions the 'nap' sterile plants become completely fertile at higher temperatures (> 22°C).

Data for yield heterosis of fully fertile F_1 hybrids are presented in Table 1. Only three F_1 hybrids cms × SV Nikalas, cms × Brutor, and cms × Proto significantly outyielded the best regional variety GSL-1 used as a check parent. In general, commercial heterosis ranged from -52.7 (cms × Tower.) to 42.4 per cent (cms × Nikalas).

CONCLUSIONS

The system has several advantages for exploitation in hybrid seed production programmes. Since majority of cultivars carry restorer gene(s) a large number of pollen parents can be used to produce F_1 hybrids. In addition, this male sterilizing cytoplasm has no advarse effect on any morphological and physiological characters and F_1 hybrids are stable and productive. However, this cytoplasm will have limited potential under Indian conditions as rising temperatures during peak flowering period (February) leads to complete breakdown of sterility. This is a major limitation as the proportion of F_1 seeds drops drastically with increased selfing in female parent. The cytoplasm might play a role especially in cooler areas of the country (Kashmir, Himachal Pradesh). It

TABLE 1. **Male fertility/sterility of F_1 hybrids, heterosis and genetics of fertility restoration in cms line of *B. napus***

S.No.	Pollen parent	Reaction* (F_1)	Observed segregation(F_2)		Chi square		Commercial heterosis
			Fertile	Sterlie	3:1	13:3	
1.	Strape	F	216	56	2.8	0.6	10.9
2.	SV-81-4012	F	197	72	0.4	—	-42.4
3.	Bronowski	PS	—	—	—	—	—
4.	Sv-Nikalas	F	136	51	0.6	—	42.4
5.	Taichung	F	—	—	—	—	-20.0
6.	Yera 33	F	—	—	—	—	12.1
7.	Gullivar	F	239	72	0.4	—	16.3
8.	Regent	F	—	—	—	—	-24.2
9.	Diplo	F	121	32	1.3	0.6	- 5.4
10.	Tower	F	154	59	0.9	—	-52.7
11.	Operal	F	—	—	—	—	0.0
12.	Topas	F	—	—	—	—	-16.9
13.	Proto	F	176	60	0.01	—	24.2
14.	GSL-1501	F	266	96	0.04	—	7.5
15.	Spoke	F	—	—	—	—	-30.3
16.	Willow	F	—	—	—	—	-40.6
17.	Marris-Haploina	F	—	—	—	—	6.6
18.	Brutor	F	158	40	2.2	0.2	26.0
19.	Loras	F	—	—	—	—	18.1
20.	Aburamasari	F	179	52	0.5	—	6.6
21.	Christa	F	—	—	—	—	- 4.2
22.	Pol 15	PS	—	—	—	—	—
23.	Norin 16	PS	—	—	—	—	—

*F — Fertile; S = Sterile; PS = Partially sterile.

may also be worthwhile to develop early maturing cms lines based on the Cytoplasm which complete their flowering within January under North Indian conditions.

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STUDIES ON THE EFFECT OF APPLIED FERTILIZERS AND RESIDUAL EFFECT OF BIOGAS SLURRY ON THE UPTAKE, YIELD AND OIL CONTENT OF MUSTARD

K. Ramalinga Swamy[1] and J.C. Bajaj[2]
Division of Soil Science and Agricultural Chemistry, Indian Agricultural Research Institute, New Delhi.

ABSTRACT

Field experiment was conducted at Indian Agricultural Research Institute, New Delhi to study the effect of applied fertilizers and residual effect of biogas slurry (applied to the previous crop of maize) on the uptake, yield and oil content of mustard. Application of N, P and K fertilizers increased the uptake of N, P and K and sulphur. Residual effect of biogas slurry was noticed upto 40 t/ha (equivalent to FYM on N basis). Maximum response of mustard was noted with 75–50–25 kg fertilizer N, P_2O_5 and K_2O respectively. Steep increase in the seed yield upto 40 t/ha sulrry level was observed under no fertilizer conditions. Depression in yield was noticed beyond 30 t/ha at higher doses of applied fertilizer N, P_2O_5 and K_2O. Beneficial effect of fertilizer N, P, K application and the residual effect of biogas slurry on the oil per cent and oil yield per hectare was observed. Higher 'r' values at higher slurry levels (residual effect) for the uptake of N,P,K with yield and oil per cent indicate favourable residual effect of biogas slurry to the highest level of 40 t/ha. The critical N : S ratio for obtaining the optimum per cent oil was 3.12.

Key words : Biogas Slurry, Mustard

INTRODUCTION

Use of chemical fertilizers to meet the demands of increased production is undisputed. At the present juncture of energy cricis, these fertilizers have to be supplemented by organic resources to achieve higher food production, besides maintaining long term productivity of soils. The biogas slurry coming out of gobar gas plant as a bye-product is fairly well decomposed, rich in nitrogen and other nutrients. The use of biogas sulrry as a organic source is a new matter of interest for the farmers. The organic manures are known to exert residual effect on the subsequent crops. Pandey et al. (1985) suggested that the practice of incorporating organic residues could rightly be preferred in the kharif season due to favourable environmental conditions and the beneficial effects are likely to be carried over to the subsequent rabi season. Mustard is a dependable oilseed crop to meet the oil needs of the country and it is grown mostly as maize-mustard sequence in the Indogangetic plains of the north-western part of the country. Therefore, investigations were carried out at Indian Agricultural Research Institute, New Delhi to study the effect of added fertilizers and residual effect of biogas slurry on the uptake, yield and oil content of mustard.

MATERIAL AND METHODS

Field experiment was laid out in Indian Agricultural Research Institute Farm, New Delhi during 1984-85. The experimental area was divided into four equal strips which received four levels of biogas slurry (equivalent to 0, 10, 20 and 40 tonnes of

1. Part of the Ph.D. Thesis submitted to P.G. School, IARI, New Delhi by the senior author, presently working as Assistant Research Officer, Regional Agril. Research Station, Anakapalle - 531 001.
2. Scientist S-3, Division of Soil Science & Agricultural Chemistry, Indian Agricultural Research Institute New Delhi - 110 012.

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FYM/ha on the basis of nitrogen content). Each strips was sub-divided into 24 subplots to which 21 selected N, P and K combinations, $N_0 P_{25} K_{25}$, $N_{25} P_0 K_0$, $N_{25} P_{25} K_0$, $N_{25}P_{25}K_{25}$, $N_{50}P_0K_0$, $N_{50}P_0K_{25}$, $N_{50}P_{25}K_0$, $N_{50}P_{25}K_{25}$, $N_{50}P_{50}K_0$, $N_{50}P_{50}K_{25}$, $N_{50}P_{50}K_{50}$, $N_{75}P_0K_0$, $N_{75}P_{25}K_{25}$, $N_{75}P_{75}K_0$, $N_{75}P_{75}K_{25}$, $N_{75}P_{75}K_{50}$, $N_{75} P_{50}K_{50}$, $N_{100}P_{50}K_{25}$, $N_{100}P_{50}K_{50}$, $N_{100}P_{75}K_{25}$, $N_{100}P_{75}K_{50}$ and three controls (No NPK) were allotted as per the approved design of STCR (AICRP on STCR., A manual on Statistical Computations, 1985). Maize was grown as first crop. After the harvest of the maize crop, mustard was grown as a test crop to study the residual effect of biogas slurry applied to the previous crop (maize) and direct application of five levels of nitrogen, 0, 25, 50, 75 and 100 kg/ha, four levels of phosphorus 0, 25, 50 and 75 kg P_2O_5/ha and three levels of potassium, 0, 25 and 50 kg K_2O /ha on the yield, uptake and oil content of mustard variety Pusa Barani.

The soil of the experimental field belongs to Holambi series and is classified as Typic Ustochrept. It is sandy loam in texture, dark yellowish brown in colour, moderately well drained, very deep, non-calcareous, slightly alkaline in reaction with low conductivity. It is medium in respect of available N, P and K with sufficient zinc and sulphur. The general physico-chemical characteristics of the soil are presented in Table 1. The soil was analysed for available N (Subbiah & Asija, 1956); P (Olsen et. al. 1954), K (Hanway and Heidel, 1952) and S (Palaskar et al. 1981). The plant samples were analysed for N, P and K (Piper, 1960) and S (Palaskar et al. 1981).

TABLE 1. Physico-chemical characteristics of the experimental soil.

S.No.	Particulars	Value
1	PH (1 : 2 Soil : water)	7.9
2	Electrical conductivity (mmhos/cm)	0.44
3	Available nitrogen (N kg/ha)	232.0
4	Availabe phosphorus (P kg/ha)	14.0
5	Available potassium (K kg/ha)	224.0
6	Available zinc (DTPA extractable) (ppm)	1.0
7	Available suphlur (ppm)	25.0
8	Cation exchange capacity (centimor/kg soil;)	11.8
9	P fixing capacity (%)	59.5
10	K fixing capacity (%)	48.0
11	Mechanical analysis :	
	Sand %	62.5
	Silt %	26.5
	Clay %	11.0

The biogas slurry contained 91% moisture and rich in plant nutrients (1.50, 0.80, 0.46 and 0.34 per cent of total N,P,K and $So_4 = S$ respectively.

In the present study, critical nutrient concept of Cate and Nelson (1965) was utilised to work out the critical N : S ratio in mustard seed for obtaining optimum oil per cent.

RESULTS AND DISCUSSION

Uptake of nutrients :

The effect of different levels of N, P and K fertilizers and the residual effect of biogas slurry (applied to the previous crop of maize) on the uptake of nutrients was given in Table 2. The uptake of N, P, K and sulphur was noted to increase upto 40 t/ha of biogas slurry level and increase was more marked upto 10 t/ha of slurry application. The ranges of uptake of nitrogen in the four slurry strips were 25 to 95, 39 to 115, 44 to 116 and 49 to 123 kg N/ha with corresponding mean values as 57, 69, 77 and 82 kg N/ha. The respective ranges of phosphorus uptake were 4 to 19, 7 to 29, 8 to 24 and 9 to 25kg P/ha and their corresponding mean values were 11, 14, 16 and 16 kg P/ha. The potassium uptake values ranged from 33 to 112, 38 to 121, 43 to 125 and 43 to 138. The mean potassium uptake values in these strips were 64, 73, 77 and 83 kg K/ha. The sulphur uptake ranged from 13 to 46, 18 to 53, 21 to 55 and 22 to 58 kg S/ha with corresponding mean values as 28, 33, 36 and 38 kg S/ha in the strips which received 0, 10, 20 and 40 t/ha of biogas slurry. Thus, increase in the mean uptake of nutrients due to application of nutrients in the form of fertilizers and biogas slurry could be observed. Similar observations were made by Singh and Singh (1984) for toria, Tandon (1984) Rao and Das (1967) for pea and Dubey and Shinde (1986) for groundnut

Grain yield :

The grain yield of mustard as influenced by the residual effect of biogas slurry applied to the previous crop of maize and different levels of fertilizers was presented in Fig. 1. The mustard grain yield was noted to range from 459 to 1253, 834 to 1643, 907 to 1545 and 1057 to 1513 kg/ha and their mean values were 917, 1147, 1289 and 1320 kg/ha in the strips which received 0,10,20 and 40 t/ha of slurry to its preceding crop maize. Thus, the residual effect of slurry could be observed upto highest slurry level of 40 t/ha. Panda (1985) found that biogas slurry applied to maize in kharif had a profound residual effect on potato (rabi) in potato-maize sequence. The response of mustard to fertilizer N increased from 5.4 to 5.67 kg/kg N at the level of 75 kg N/ha and remained more or less same thereafter. The response to phosphorus increased from 3.68 to 5.08 kg/kg P_2O_5 when the fertilizer dose was increased from 25 to 50 kg/ha. Almost the same response was obtained at 75 kg P_2O_5/ha. In case of potassium, the response was maximum i.e. 7.6 kg/kg K_2O at 25 kg K_2O/ha level and at higher dose of 50 kg K_2O, the response had come down to 6.24 kg. It could be due to law of diminishing returns. Thus, maximum response of mustard was noted with 75-50-25 kg of N, P_2O_5 and K_2O respectively. Bishnoi et al. (1984) did not find response beyond 75 kg

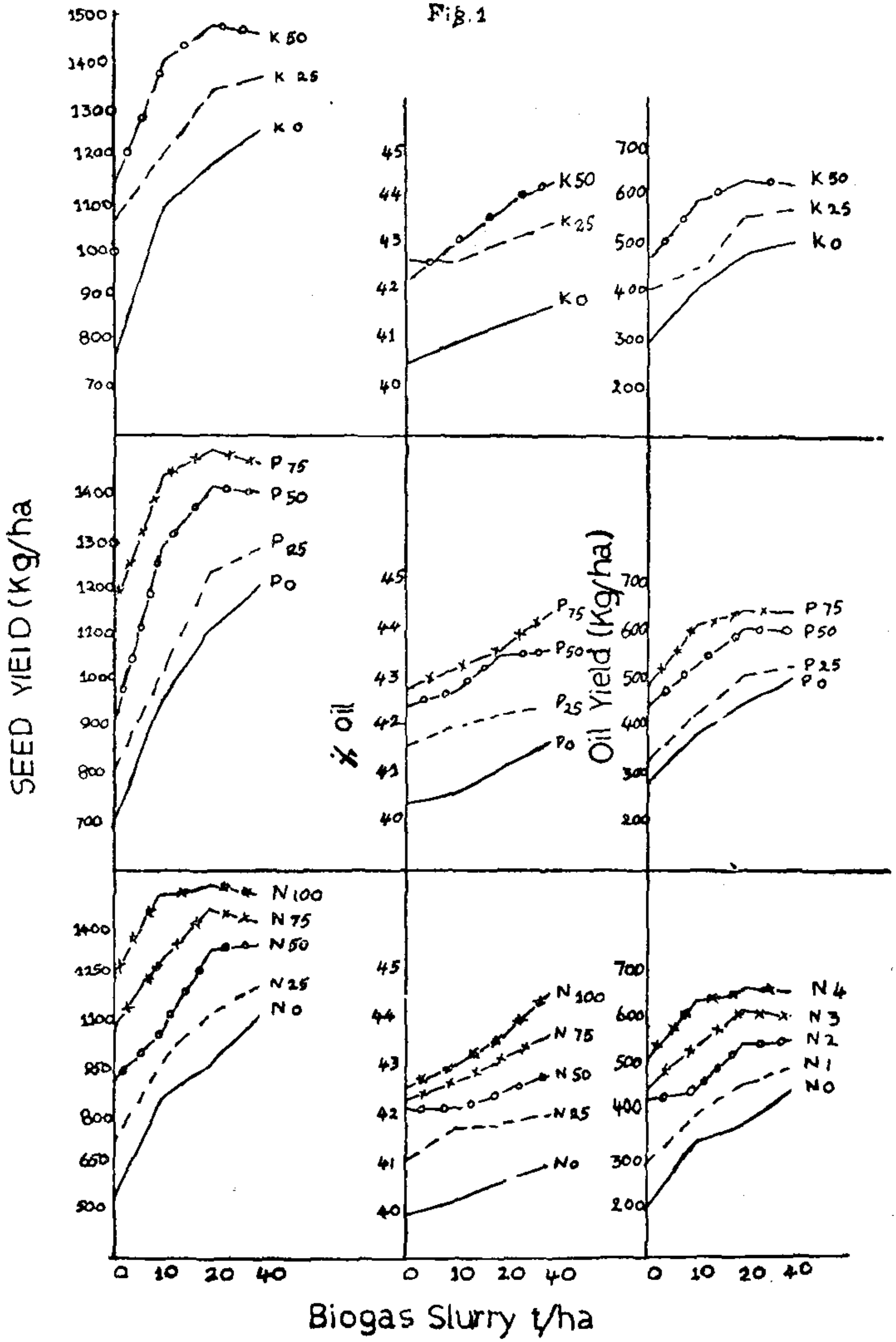
TABLE 2. Effect of fertilizers and residual effect of biogas slurry on the uptake of nutrients.

Level of nutrient kg / ha.	N uptake kg / ha				P uptake kg / ha				K uptake kg / ha				S uptake kg / ha			
	T_0	T_{10}	T_{20}	T_{40}	T_0	T_{10}	T_{20}	T_{40}	T_0	T_{10}	T_{20}	T_{40}	T_0	T_{10}	T_{20}	T_{40}
N_0	28.09	40.51	46.51	52.23	5.28	8.08	9.56	10.46	33.39	41.50	44.85	47.85	14.66	19.82	21.83	24.31
N_1	37.92	49.04	56.52	62.39	7.70	9.89	11.60	12.89	39.37	46.99	52.85	59.10	18.53	23.17	26.13	29.72
N_2	52.74	61.31	72.80	77.58	10.52	12.49	14.66	15.73	58.33	62.92	62.92	68.37	25.75	29.19	34.46	36.93
N_3	72.49	84.14	92.31	94.32	14.36	17.25	19.68	19.68	83.40	92.60	97.56	99.51	34.81	40.61	43.39	45.19
N_4	88.37	105.65	110.73	115.82	17.59	23.47	23.40	23.93	99.72	112.50	117.24	123.61	42.18	49.64	53.00	53.82
P_0	38.98	49.33	57.82	63.31	7.35	9.67	11.52	12.05	43.95	49.28	54.04	59.59	18.76	23.00	26.30	28.80
P_1	49.70	57.75	66.95	71.76	9.29	11.16	13.61	14.65	51.25	59.52	64.53	69.47	22.96	27.52	30.84	34.18
P_2	66.85	72.54	87.80	92.00	13.43	16.19	18.33	19.38	75.68	84.89	90.52	96.78	33.44	39.27	43.37	45.36
P_3	83.07	97.58	102.69	105.33	16.79	21.84	22.26	22.48	95.78	105.09	109.31	113.07	40.47	46.72	48.58	50.49
K_0	43.91	55.28	63.38	68.21	8.85	11.08	13.03	13.62	48.43	55.16	59.98	64.33	21.43	26.00	29.21	31.87
K_1	61.37	72.09	81.08	85.25	12.25	15.52	16.88	17.66	68.88	76.65	81.47	87.13	29.69	34.42	37.76	40.32
K_2	78.46	92.83	99.70	103.83	15.72	17.49	21.01	21.80	91.02	102.32	107.56	113.64	38.11	45.10	48.09	49.93
Mean	57.65	69.38	77.58	82.01	11.43	14.45	16.13	16.84	64.97	73.04	77.95	83.15	28.00	33.13	36.32	38.80

N_0, N_1, N_2, N_3, N_4, = 0, 25 50, 75 and 100 kg N/ha., P_0, P_1, P_2, P_3, = 0, 25, 50, 75 kg P_2 0 /ha
K_0, K_1, K_2, = 0, 25, 50 kg K_2 O/ha., T_0, T_1, T_2, T_3, = Biogas slurry levels 0, 10, 20 and 40 t/ha. (equivalent to FYM on N basis)

EFFECT OF FERTILIZERS AND RESIDUAL EFFECT OF BIOGAS SLURRY ON SEED YIELD, % OIL AND OIL YIELD OF MUSTARD

Fig. 1



N/ha and response to phosphorus application was significant upto 20 kg P_2O_5/ha for mustard.

When the interaction effects of fertilizers and residual effect of biogas slurry are considered, steap increase in the seed yield upto 40 t/ha slurry level could be observed when no fertilizer N, P and K was applied. At lower doses of applied NPK i.e. N_{25}, P_{25} and K_{25} there was steep rise in seed yield upto 30 t/ha of slurry level. Depression in yield was noticed beyond 30 t/ha slurry level at higher doses of applied N, P and K fertilizers (i.e. at N_{50}, N_{75}, $N_{100}P_{50}$, P_{75} and K_{50}). This indicates that under the residual effect of lower doses of biogas slurry, the soil available nutrients alone cannot support plant growth for obtaining higher seed yields. But in case of residual effect due to higher doses of biogas slurry, fertilizer application was not to correct any deficiency but is simply added to the pool of available soil nutrients.

Per cent oil in mustard :

Mustard is an important oil seed crop. The oil production of the country could be improved either by increasing the per cent oil in seed or by increasing the seed yield of the crop. The effect of fertilizer application and the residual effect of biogas slurry on the per cent oil and oil yield per hectare of mustard was given in Fig. 1. The per cent oil in the mustard seed ranged from 38.30 to 43.11, 38.51 to 43.64, 39.86 to 44.64 and 40.23 to 45.18 in the four strips which received slurry at the rate of 0, 10, 20 and 40 t/ha for the preceding crop of maize. The respective mean values were 41.76, 42.06, 42.54 and 42.95% which show that the residual effect of biogas slurry application (to the previous crop) had improved the oil per cent in seed by 0.3 to 1.19. The mean per cent oil at different levels of N were 40.51, 41.71, 42.43, 42.71 and 43.48 for N_0, N_{25}, N_{75}, and N_{100} respectively. The mean oil per cent in mustard seed due to the application of different levels of phosphorus were 41.00, 42.11, 43.10 and 43.57 for P_0,P_{25}, P_{50} and P_{75} respectively. Similarly, the oil per cent at K_0, K_{25} and K_{50} were 41.20, 43.00 and 43.38 respectively. The fertilizer nitrogen, phosphorus and potassium application increased the oil per cent in seed. The residual effect of biogas slurry on oil% could be observed to the highest level of 40 t/ha at different levels of applied N, P and K fertilizers (Fig.1). The increase in the per cent oil due to addition of nutrients either in inorganic or organic form might be due to their beneficial role in the formation of fatty acids. Dubey and shinde (1986) reported that P and K application improved the quality of groundnut. The role of P both in the formation of fatty acids and their esterfication to form oils was stressed by Balan and Gurin (1953). Swami and Yadav (1985) observed that potash promoted the formation of fats by its favourable influence on the carbohydrate metabolism.

Oil yield per hectare :

The oil yield per hectare in different strips ranged from 182 to 527, 330 to 713, 361 to 679 and 425 to 682 kg/ha with respective mean values of 385, 486, 552 and 567 kg/ha. The favourable residual effect of slurry application on the oil yield per hectare was evident from these values and Fig. 1. Fertilizer application was noted to increase the oil yield per hectare due to its favourable influence on both seed yield and per cent oil of mustard. Samui and Bhattacharya (1984) recorded maximum oil yield as well as NPK uptake by sunflower with soil application of N with K.

Relationship between uptake of nutrients and yield and oil content :

Simple correlation coefficients were worked out between the uptake of nitrogen, phosphorus, potassium and sulphur and the grain yield of mustard and the 'r' values are presented in Table 3. Significant positive correlation existed between the uptake of N,P,K and S and grain yield. The overall uptake of N and P recorded comparatively higher 'r' values than K uptake with grain yield. Higher 'r' values for N,P,K uptakes were noted in T_{40} strip when compared to T_0, T_{10} and T_{20} strips indicating better relation of the uptake of NPK (due to the more residual effect in this strip) with the mustard grain yield.

The 'r' values for the uptake of N,P,K and S and per cent oil as well as oil yield in kg/ha were highly significant. The correlation coefficients for oil yield in kg/ha were higher than the per cent oil. A gradual improvement in 'r' value with increase in the level of biogas slurry could be noticed for the per cent oil indicating the beneficial residual effect of biogas slurry to the highest level of 40 t/ha. However, the 'r' values obtained with oil yield per hectare were of the same magnitude. The better uptake of nutrients due to the application of fertilizers and residual effect of biogas slurry might have favourably influenced the photosynthetic activity and formation of the ultimate plant products like oil from the synthesis of the photosynthetic products. Similar observations were made by Petinov and Maly-sheva (1961) for soyabean. Sulphur plays an important role in the oil production from oil seed crops like mustard as evidenced by the presence of sulphur containing amino-acids like methionine. Manual et al. (1976) reported that N and S acted synergistically and increased grain yield by about 210 per cent. When N : S ratio in seed was related with grain yield, per cent oil and oil yield per hectare, the 'r' values were noted to be higher at higher levels of slurry application i.e. in T_{20} and T_{40} strips indicating the favourable residual effect of biogas slurry at higher levels on the yield and quality of mustard.

The critical nutrient technique of Cate and Nelson (1965) was utilized to determine the N : S ratio in the seed for obtaining optimum per cent oil in mustard (Fig.2.). This is important for a farmer as the minimum requirement would be to keep up that level of N : S ratio. From the figure, it could be observed that the critical N : S ratio for obtaining the optimum per cent oil was 3.12. This might be due to the positive interaction of nitrogen and sulphur as reported by Gama (1977).

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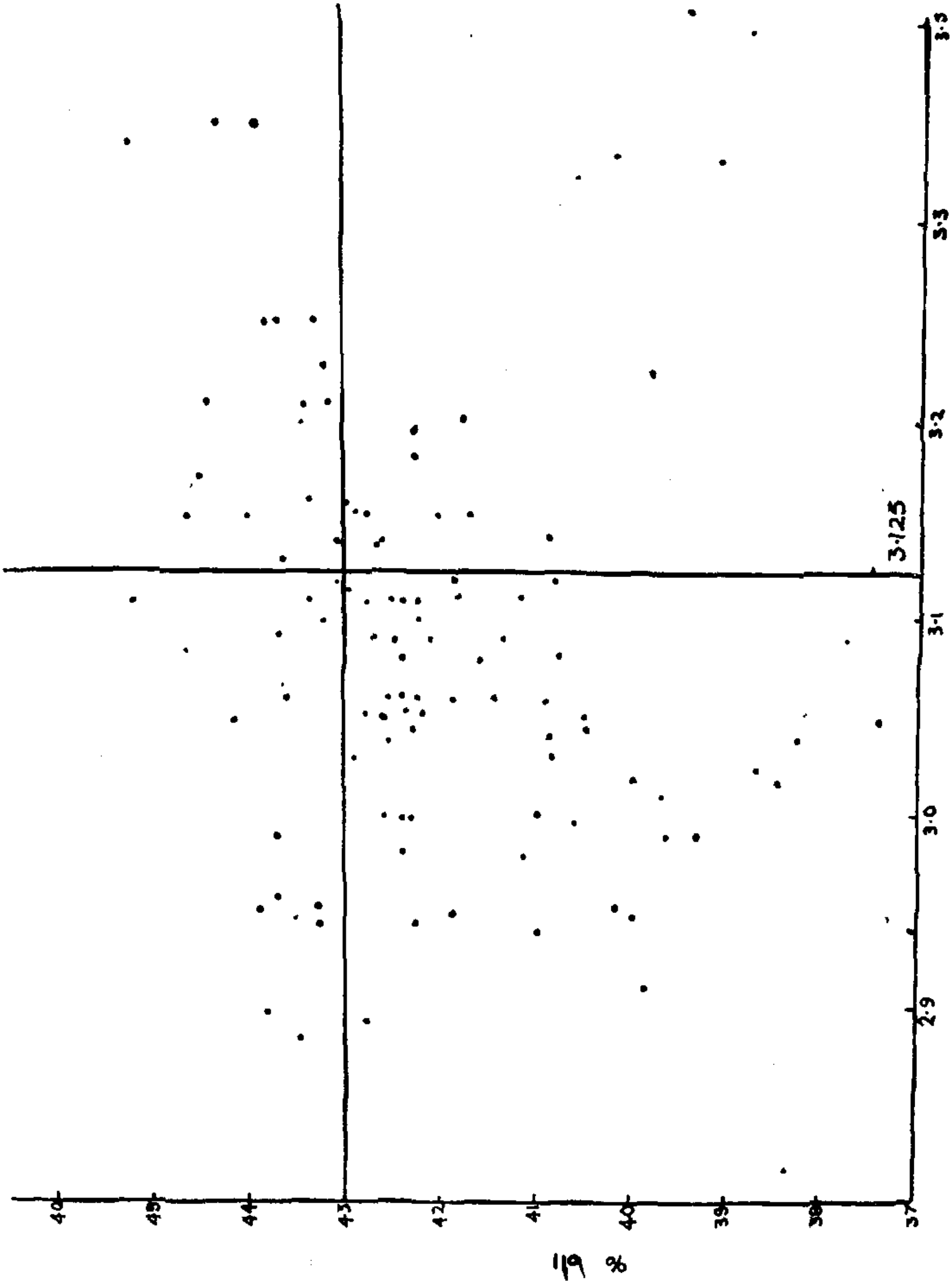
TABLE 3. Simple correlation coefficients (r) between uptake of nutrients, grain yield and per cent oil as well as oil yield (kg/ha) of mustard

Correlation between	Correlation Coefficient at strip				Total
N uptake and grain yield of mustard	0.7393**	0.7594**	0.7724**	0.9780**	0.9302**
P uptake and grain yield of mustard	0.7678**	0.7533**	0.9435**	0.9547**	0.9194**
K uptake and grain yield of mustard	0.7323**	0.8958**	0.3018	0.9616**	0.8418**
S uptake and grain yield of mustard	0.9721**	0.9815**	0.9340**	0.9705**	0.9087**
N uptake and per cent oil	0.6358**	0.7141**	0.7776**	0.8620**	0.7200**
P uptake and per cent oil	0.5770**	0.6909**	0.7903**	0.8596**	0.7691**
K uptake and per cent oil	0.5960**	0.7188**	0.7826**	0.8823**	0.7636**
S uptake and per cent oil	0.6364**	0.7385**	0.7701**	0.8726**	0.7657**
N uptake and oil yield (kg/ha)	0.9753**	0.9863**	0.9617**	0.9723**	0.9271**
P uptake and oil yield (kg/ha)	0.9782**	0.9659**	0.9509**	0.9558**	0.9086**
K uptake and oil yield (kg/ha)	0.9502**	0.9756**	0.9361**	0.9680**	0.8075**
S uptake and oil yield (kg/ha)	0.9684**	0.9830**	0.9447**	0.9696**	0.9260**
N:S ratio and grain yield	0.4677**	0.4491**	0.4816**	0.7286**	0.5482**
N:S ratio and per cent oil	0.2303	0.3265	0.5470**	0.4513**	0.5034**
N:S ratio and oil yield (kg/ha)	0.4530**	0.5009**	0.6669**	0.7138**	0.4990**

** Significant at 1% level

FIG. 8. CRITICAL N : S RATIO ON THE PERCENT OIL IN MUSTARD



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SAGAR MUTHYALU AND APRR—1 TWO IMPROVED AND RUST RESISTANT SELECTIONS OF SAFFLOWER

R. Bener Raj, T. Bhoopal Reddy, G. Raghunatham, V. V. Ranga Rao,
B. Chenchu Reddy, A. F. M. Akbar, D. V. Subba Rao, and Y. V. S. Krishna Murthy
Sub-centre, Safflower, Agricultural Research Institute, Rajendranagar, A.P. Agricultural University, Hyderabad — 500 030, Andhra Pradesh.

ABSTRACT

Two rust resistant selections of Safflower ,Sagar Muthyalu' (APRR. 3) and APRR. 1 suited to the rabi rainfed black soils, were developed by A.P. Agricultural University, Rajendranagar, Andhra Pradesh.

Sagar Muthyalu is a rust resistant selection from an exotic culture SF. 429 (EC. 2725) - Var. Bilor - exotic - Canada. III R-5) and APRR. 1 from SF. 438 (EC. 32017. III R – 10). The rust resistance was established following (i) Hypocotyl reaction test (in green house) (ii) Seedling reaction test (in field nursery) both under natural and artificial conditions and (iii) Adult plant reaction test (in the field) under natural conditions.

Sagar Muthyalu yields 1357 kg/ha against 834 kg/ha of Manjira, the ruling improved variety, giving upto a maximum of 63 per cent increased yield over Manjira. APRR. 1 yields 1302 kg/ha, 56 per cent extra yield over Manjira.

Key words : Rust resistant varieties; Sagar Muthyalu and APRR. 1 Safflower; **High** yielding;

INTRODUCTION

Safflower (*Carthamus tinctorius* Linn.) is cultivated on a large scale in the peninsular states – Maharashtra (Area = 5.42 Lakh ha; Production = 3.24 lakh tonnes) Karnataka (Area = 1.57 lakh ha; Production = 0.8 lakh tonnes) and Andhra Pradesh (Area = 0.43 lakh ha; Production = 0.15 lakh tonnes) which together account for more than 99% of the country's total area of 0.75 million ha under Safflower. Besides, it has gained importance in Uttar Pradesh, Bihar, West Bengal, Madhya Pradesh and Tamil Nadu. In Andhra Pradesh, Safflower is raised, as a rainfed crop, in the rabi season (September/October to March/April) essentially for its oil; mostly in Rayalaseema (Kurnool, Ananthapur and Cuddaph districts) and Telangana (Ranga Reddy, Medak and Mahboobnagar Districts).

Safflower rust (*Puccinia carthami* corda) is a common disease in Andhra Pradesh and causes yield loss from 4–10 per cent depending on the seasonal conditions. Safflower rust is endemic at the Agricultural Research Institute, Rajendranagar, Hyderabad, A.P. and hence is the most ideal place for screening Safflower cultures for rust resistance. Two selections APRR.1 and APRR. 3 were developed which, besides high yield (Mean yield of 13 to 13.5 q/ha as against National average of about 5.5 q/ha), carry genes for resistance to seedling as well as foliar phases of rust (O grade) and hence should be useful not only as potential donors but also to stabilise production in all rust prone areas

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in the country (Ranga Rao, 1984) since all the present day high yielding cultivars are susceptible to the ravages of rust.

MATERIALS AND METHODS

I. Screening of safflower against rust

Screening for rust resistance were done at : (i) Field test under natural conditions, (ii) Hypocotyl reaction test, under green-house and (iii) Seedling reaction test, under artificial conditions in field nursery. The screening safflower cultures for rust resistance started at Rajendranagar in 1968 was founded by the All India Co-ordinated Research Project on Oilseeds (AICORPO) of the ICAR. World germplasm consisting of about 2450 cultures of Safflower were screened from 1968–69 to 1980–81. Cultures SF - 429 and SF. 438 were repeatedly found to be free from rust. After subsequent selection and purification the culture SF - 429 (EC. 2725) - Var. Bilor - exotic - Canada (III.R - 5) was termed APRR - 3 and the culture SF. 438 (EC. 32017. III R - 10) was termed APRR. 1.

The following scale (Table - 1) for recording rust severity developed at Rajendranagar was used in screening the safflower cultures.

TABLE 1. Scale for screening of safflower against rust (*Puccinia carthami*)

Score	Range of intensity of rust percentage	Description	
0	0	Free	: Completely free of rust (no spots or flakes)
1	0.1 – 5.0	Highly Resistant	: Upto 50 pustules on a leaf.
2	5.1 – 10.0	Resistant	: Upto 100 pustules on a leaf.
3	10.1 – 25.0	Moderately Resistant	: Pustules more than 100, upto 25% of leaf area is infected including yellow halo around.
4	25.1 – 50.0	Moderately Susceptible	: Upto 50% of leaf area is infected.
5	50.1 – 75.0	Susceptible	: Up to 75% of leaf area is infected. Bracts are also infected.
6	75.1 –100.0	Highly Susceptible	: More than 75% of leaf area is infected. Infected leaves turn yellow, dry and drop off prematurely.

The diagramatic Rust Intensity score for safflower rust prepared based on USDA scale of Peterson (Peterson *et al.*, 1948), methods of Large (Large, 1966) and Cilve James

(Clive James, 1971) was finalised after repeated field tests. The score ranged from 1 to 6 and the same was broadly classified as Immune (O), Resistant (1and 2), Moderately susceptible (3 and 4) and susceptible (5 and 6) scores.

II. Yield Trials

The grain yield was assessed in three different trials viz., (i) All India Co-ordinated varietal trials (ii) Minikit trials and (iii) District trials.

(i) In the Co-ordinated varietal trial, the crop was sown in half cent plots replicated four times and the yield was assessed in kg/ha. The trial was conducted for four years from 1976-77 to 1979-80.

(ii) The minikit trials were conducted in collaboration with the Department of Agriculture, Govt. of Andhra Pradesh for five years from 1976–77 to 1980–81 in seven districts of Andhra Pradesh.

(iii) The District trials were conducted for five years from 1976–77 to 1980–81, in seven districts of Andhra Pradesh.

III. The Morphological and other characters

The morphological characters of the variety APRR–3 and APRR–1, in respect of plant height, branching, stem, leaves, flowers, fruits and seeds were studied and detailed description is given.

The characters of variety APRR–3 and APRR–1 expressed in the Minikit/District Trials, in respect of Plant height, canopy spread, days to flower, days to maturity, mean yield, oil percentage and oil yield were studied and contrasted with the local ruling variety Manjira.

RESULTS AND DISCUSSION

Safflower selections APRR.3 and APRR.1 remained free of rust (Table 2) under natural infection over years, in the field tests conducted at Rajendranagar whereas the high yielding improved varieties K–1, A–1, S–144, Tara and Manjira which were the ruling varieties in the peninsular states of India had disease severity upto 50 per cent (Anonymous, 1968—1983).

TABLE 2. Field reaction of varieties under test at Rajendranagar

S. No.	Name of variety	Mean disease score 1976–77	1977–78	1978–79	Mean of 3 years	Remarks
1	APRR-3	0.0	0.0	0.0	0.0	R/F
2	APRR-1	0.0	0.0	0.0	0.0	MS
3	K-1	1.7	4.5	3.5	3.2	MS
4	A-1	1.9	4.5	4.5	3.6	MS
5	S-144	1.7	4.3	5.0	3.7	MS
6	Tara	2.2	4.5	5.0	3.9	MS
7	Manjira	2.5	4.5	5.0	4.0	MS

F = Free R = Resistant MS = Moderately susceptible.

Variety APRR.3 and Variety APRR.1 remained rust free in the (i) Hypocotyl reaction test conducted in greenhouse following Zimmer (1962) (ii) Seedling reaction test in the field nursery, both under artificial and natural conditions and also in the (iii) Adult plant reaction test, conducted in the field, under natural conditions (Table 3).

TABLE 3. *Performance of APRR 3 and APRR.1 in Pot culture, Field nursery and Main field at Rajendranagar.*

S.No.	Culture	Hypocotyl reaction	Seedling reaction	Adult plant reaction
1	APRR. 3 (RR-17, SF-429, EC : 2725, III R. 5, APRR. 3)	0	0	0
2	APRR. 1 (RR-23, SF-438, EC:32017, III R—10, APRR. 1)	0	0	0
3	Manjira	S	S	S

0 = Free S = Susceptible

II. Grain yield of APRR.3 and APRR.1

(a) APRR. 3 and APRR. 1 assessed for 4 seasons from 1976 to 1980 showed higher yield (Table 4). APRR. 3 yielded 1357 kg/ha and APRR. 1 1302 kg/ha against the mean yield of 834 kg/ha of Manjira (Check). Selection APRR. 3 gives upto 63% and APRR. 1 upto 56% yield increase over Manjira - the best local check (Anonymous, 1968—1983), and hence these superior genotypes are fit for wider adaptation.

TABLE 4. Safflower coordinated varietal trial, A.R.I., Rajendranagar from 1976 to 1980 (4 seasons).

S.No.	Varieties	1976–77	77–78	78–79	79–80	Mean
1	Manjira (C)	499	997	728	1111	834
2	APRR.1	667	1448	1671	1422	1302
3	APRR.2	556	1015	1509	1534	1154
4	APRR.3	644	1536	1720	1528	1357
5	APRR.4	512	1456	1567	1370	1226
6	APRR.5	521	1184	1411	1421	1134
7	CTS. 7205	588	1398	1278	1452	1179
8	CTS. 7218	578	1459	1229	1360	1156
9	CTS. 7403	536	1550	1286	1627	1250
10	K–1	434	977	1038	1326	949
11	No 83	755	1385	864	1374	1094
12	A–1	625	1245	735	1323	982
13	No 168	738	1331	915	1409	1098
14	S – 144	576	1081	689	1385	933
15	No 673	493	1239	655	1331	930
16	B. 263–2A	533	649	700	869	688
17	87–11	639	615	585	1272	778
18	PI 260 633	660	1286	401	1159	877
19	731	493	566	237	768	521
20	319	393	689	404	1071	639
21	98–9	469	728	657	1150	851
22	Tara	527	760	522	1059	717
	TABLE 4.	**Contd.**				
	Significance	Not	Sig	Sig	Sig	
	S.E.	106	246	177	102	
	C.D.	—	482	234	358	
	G.M.	565	1119	845	1288	
	C.V. (%)	22.9	31.0	17.47	20.04	

(b) The mean increase in yield of APRR. 3 in Andhra Pradesh, ranged upto 21.5 per cent and that of APRR. 1 ranged upto 45.6 per cent over Manjira while the overall increase in yield over Manjira is 8.7 per cent for APRR. 3 and 3.2 per cent for APRR. 1 in the multilocation minikit trials spanning over 5 years and 7 districts. This indicates the inherent high yield potential of selection APRR. 3 and APRR. 1 (Table 5). This observation is further substantiated through the district trials.

TABLE 5. Abstract table showing the mean yields in Minikit Trials conducted in collaboration with the Department of Agriculture, Andhra Pradesh.

District.	Year	Manjira	APRR. 3	% increase of APRR. 3 over Manjira	APRR. 1	% Increase of APRR. 1 over Manjira
Karimnagar.	80–81	408	455	11.5	482	18.1
	79–80	330	387	17.3	480	45.5
	77–78	446	400	—	386	—
	76–77	795	947	19.1	881	11.0
Rangareddi.	80–81	371	397	7.0	476	28.3
	79–80	579	611	5.5	569	—
	78–79	735	764	3.9	678	—
	77–78	742	796	7.3	704	—
	76–77	609	486	—	617	1.3
Kurnool	79–80	338	352	4.1	362	7.1
	77–78	828	877	5.9	906	9.4
	76–77	321	342	6.5	338	5.3
Nizamabad	79–80	765	880	15.0	465	—
	78–79	720	875	21.5	565	—
	76–77	935	1010	8.0	1060	13.4
Ananthapur.	79–80	370	358	—	457	23.5
	76–77	346	337	—	354	1.3
Mahboobnagar.	80–81	259	232	—	218	—
	79–80	655	500	—	560	—
Medak.	76–77	200	700	250.0	550	175.0
Mean		538	585	8.7	555	3.2

TABLE 6. Characters of the varieties included in minikit / District trials.

Variety	Plant height (cm)	Canopy spread (cm)	Days to flower	Days to Maturity	Mean yied (kg/ha)	% increase over Manjira	Oil content (%)	Oil yield (kg/ha)	Per day Oil production (kg/ha)	Remarks
Manjira	90.0	**59.0**	66	122	834	—	33.9	282.7	2.3	Sp. Y/O, RS
APRR. 3	92.0	**46.0**	66	121	1357	63.0	35.7	484.5	4.0	Sp. Y/Y, RR
APRR. 1	97.0	48.0	66	121	1302	56.0	37.2	484.3	4.0	Sp. Y/Y, RR

Sp : Spiny   Y/O : Yellow/Orange florets   Y/Y : Yellow/Yellow florets   RS : Rust sus-ceptible.   RR : Rust Resistant.

The safflower selection APRR. 3 is therefore ideally suited to the *rabi* rainfed black soils of the state in the districts of Rangareddy, Kurnool, Nizamabad, Medak and Karimnagar and APRR. 1 in Rangareddy, Kurnool, Medak, Karimnagar and Ananthapur. It is worth mentioning that APRR. 3 was not significantly superior in the districts of Anathapur and Mahboobnagar vis-a-vis Manjira while APRR. 1 was not superior in Nizamabad and Mahboobnagar.

III. The morphological and other characters of APRR. 3 and APPR. 1

(i) Selection APRR. 3 resembles Manjira in Certain characters however, it differs in flower colour, canopy spread and in yield (Table 6). The florets of APRR. 3 are yellow when fresh and also remain yellow even on drying (y/y) as against Manjira whose florets are yellow when fresh and turn orange on drying (y/o). APRR. 3 has smaller canopy of 46 cm against Manjira with a spread of 59 cm.

APRR. 3 has 63 per cent increased yield over Manjira. Oil yield of APRR. 3 (with 484.5 kg/ha) is superior to Manjira (with 282.7 kg/ha) and is reflected in the per day oil production of APRR. 3 which is 4.0 kg/ha as against 2.3 kg/ha of Manjira - an increase of 1.7 kg/ha per day oil production (Anonymous 1968 — 1983).

(ii) Selection APRR. 1 differs from Manjira in flower colour, plant height, canopy spread, grain yield, oil content and oil yield. APRR. 1 has y/y flower colour and Manjira y/o. APRR. 1 with plant height of 97.00 cm is taller than Manjira (90.0 cm and has a smaller canopy of 48 cm against Manjira (59 cm).

APRR. 1 has 56 per cent increased yield over Manjira. The high quality edible oil content of APRR. 1 (37.2%) is higher than Manjira (33.9%) by about 3.3%. In oil yield, APRR. 1 with 484.3 kg/ha) is superior to Manjira (with 282.7 kg/ha) in giving about 200 kg/ha more oil yield. The per day oil production of APRR. 1 is 4.0 kg/ha as against 2.3 kg/ha of Manjira - an increase of 1.7 kg/ha per day oil production (Anonymous, 1968—1983).

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STUDIES ON CONSUMPTIVE WATER USE, WATER USE EFFICIENCY AND MOISTURE EXTRACTION PATTERN BY MUSTARD AS INFLUENCED BY IRRIGATION AND FERTILIZATION.

B. N. REDDY*, M. N. SINHA and M. R. HEGDE
Division of Agronomy Indian Agricultural Research Institute New Delhi — 110 012.

ABSTRACT

Field experiments were conducted during *rabi* seasons of 1983-84 and 1984-85 at the Indian Agricultural Research Institute, New Delhi on sandy loam soil to study the effect of irrigation, nitrogen and phosphorus fertilization on consumptive water use, yield, water use efficiency and moisture extraction by mustard. Irrigation at 0.6 IW/CPE produced higher seed yield (21.6 q/ha) over no irrigation (18.3 q/ha). Application of nitrogen and phosphorus increased the seed yield upto 80 Kg N and 30 kg P/ha, respectively. The increase in water supply increased the consumptive water use but the water use efficiency was decreased. The consumptive use of water and water use efficiency reached maximum at 80kg N and 30kg P/ha. Moisture use rates were higher from flowering to siliqua development as well as siliqua development to harvest. Moisture extraction from top layer (0-30cm) was more in irrigation at 0.6 IW/CPE *while no irrigation and one irrigation (0.3 IW/CPE) depleted more* moisture from 30-120 cm layer.

Key words : Mustard; Consumptive water use; Water use efficiency; Moisture extraction; Irrigation; Fertilization.

INTRODUCTION

Mustard (*Brassica juncea.* (L) Czern and Coss) is grown both under rainfed and irrigated conditions with variable soil fertility. Wherever the crop is irrigated, it is mostly confined to the areas with limited moisture supply (Prihar *et al*, 1981). Although, response to irrigation was observed by several workers (Bhan, 1979 and Khan and Agarwal, 1985) at different locations, the information on nutritional requirement under differential supply of irrigation water is limited. The response to nitrogen was upto 80 kg N/ha under irrigated conditions and the water use efficiency of the crop greatly lowered at increased moisture regimes under unfertilized conditions. The highest water use efficiency was observed at 0.6 IW/CPE and 80:40:40 fertility status under alluvial sandy loam soils of West Bengal (Roy and Tripathi, 1985). The high yielding varieties have been found to respond well to both nitrogen and phosphorus, but the information on the effect of fertilizer under different water supply on water use, yield and water use efficiency is meagre. The present investigation was, therefore, aimed at studying the effect of levels of irrigation and fertilizers on yield, consumptive water use, water use efficiency and moisture extraction pattern by mustard.

METERIALS AND METHODS

Field experiments were conducted during *rabi* seasons of 1983–84 and 1984–85 at the research farm of the Division of Agronomy, Indian Agricultural Research Insti-

Present address : Scientist (Agronomy), Directorate of Oilseeds Research, Rajendranagar, Hyderabad — 500 030.
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tute, New Delhi. The soil was sandy loam having a pH 7.6, low in organic carbon (0.42%), total nitrogen (0.045%), available phosphorus (7.6 kg/ha) and medium in potash (160 kg/ha). The physical constants of the soil of the experiment are given in Table 1. The depth of ground water table from the soil surface was below two meters during both the years. The soil moisture reserve at 0–120 cm depth at the time of sowing was 178 mm and 181 mm during 1983–84 and 1984–85, respectively.

TABLE 1. Physical constants of the soil of the experimental site.

	Particulars	Soil depth (cm)				Method employed
		0–30	30–60	60–90	90–120	
1.	Field capacity (%)					
	1983–84	17.61	17.71	17.82	17.84	Field method
	1984–85	17.46	17.64	17.50	17.80	(Dastane, 1972)
2.	Permanent wilting point (%)					
	1983–84	6.65	6.72	6.78	6.65	Pressure membrane
	1984–85	6.54	6.73	6.72	6.74	method (Richards, 1947)
3.	Bulk density (g/cc)					
	1983–84	1.50	1.47	1.44	1.43	Core sampling method
	1984–85	1.51	1.48	1.45	1.43	(Piper, 1950)

The experiment was laid out in split plot design with irrigation and nitrogen allocated in main plot and phosphorus levels in sub-plots. There were three irrigation treatments (no irrigation, irrigation at 0.3 irrigation water depth (IW)/cumulative pan evaporation (CPE) and irrigation at 0.6 IW/CPE), three nitrogen doses (0, 40 and 80 kg N/ha) and three phosphorus levels (0, 15 and 30 kg P/ha). The plot size was 4.05 m × 3.60 m. The mustard seed (Var. Pusa Bold) was sown on October 29 and 20 in 1983 and 1984, respectively in rows 45 cm apart and plant to plant space was maintained 15 cm after final thinning. A basal application of 40 kg K_2O/ha and the entire N and P as per treatment were applied at sowing. Sixty millimeter water was applied at each irrigation. One and three irrigations were applied in treatments 0.3 IW/CPE and 0.6 IW/CPE, respectively. Low temperature accompanied by high humid conditions prevailed during 1983–84 with a meagre rainfall of 10.6 mm. The weather during 1984–85 was fairly dry and rainless while in 1983–84 the crop received 4.2 mm rain at flowering and 6.4 mm rain at siliqua development stages. The maximum and minimum temperatures were approximately 2°C higher with mean evaporation of 3.22 mm per day during 1984–85 as against 2.83 mm per day during the same period in 1983–84. Soil moisture was determined thermogravimetrically from four soil layers (0–30, 30–60, 60–90 and 90–120 cm) at monthly interval as well as before and after each irrigation in one replication. The moisture content values were used to compute consumptive water use and moisture extraction pattern. The consumptive use of water was calculated using the formula as stated by Dastane (1972). The water use efficiency (WUE) was worked out by using the following formula :

$$\text{WUE (kg/ha/mm)} = \frac{\text{Seed yield of mustard (kg/ha)}}{\text{Consumptive water use (mm)}}$$

RESULTS AND DISCUSSION

Seed yield :

In general, the seed yield was higher in 1983–84 than in 1984–85 (Table 2). Irrigation at 0.6 IW/CPE produced significantly higher seed yield (21.6 q/ha) over no irrigation (18.3q/ha), but the differences between the treatments 0.3 IW/CPE and 0.6 IW/CPE or 0.3 IW/CPE and no irrigation were not significant. Irrigation increased the number and size of the siliqua and seed yield per plant. Similar results have been reported by Yusuf (1973). On an average, application of 40 and 80 kg N/ha gave seed yield increases by 49.5 and94. 6 per cent, respectively over no nitrogen as evidenced by pooled data. Similarly, the response to phosphorus was highest seed yield at 30 kg P/ha. Average increases in seed yield due to 15 and 30 kg P/ha were 4.6 and 17.6 per cent, respectively over no phosphorus. Higher seed yield at 80 kg N/ha or 30 kg P/ha was due to higher moisture use by the plant. Similar results have been reported by Bhan (1979) and Khan and Agarwal 1985).

Consumptive water use and water use rate :

In general, the values for consumptive use during 1983–84 were higher than 1984–85 season due to good crop canopy effective rainfall and longer crop duration. The seasonal consumptive use of water increased with an increase in water supply to mustard crop during both years (Table 2). During 1983–84, the per cent increases in favour of 0.3 IW/CPE and 0.6 IW/CPE were 36.0 and 78.6, respectively. The consumptive use of water increased progressively with nitrogen application and was the highest at 80 kg N/ha. There was a clear trend of increase in consumptive use of water with successive increase in the levels of phosphorus in each year. In both the years, the highest consumptive use of water was obtained when phosphorus was applied at 30 kg P/ha.

The data on periodical consumptive water use and water use rate are presented in Table 3. It is clear that the maximum water use took place from flowering to siliqua development although there was increase in moisture use from siliqua development stage to harvest in 1984–85 mainly due to higher evaporative demand in the second year. The water use and daily water use rates were maximum with irrigation at 0.6 IW/CPE at all the stages of growth during both the years, except at flowering to siliqua development stage in 1983–84. Although, there was a progressive increase in the rate of water use with rise in the levels of nitrogen, the magnitude of increases between the successive

TABLE 2. Seed yield (q/ha), consumptive water use (mm) and water use efficiency (kg/ha/mm) of mustard as influenced by irrigation, nitrogen and phosphorus.

Treatments	Seed yield (q/ha)		Pooled	Consumptive water use (mm)		Water use efficiency (kg seed/ha/mm of water)	
	1983–84	1984–85		1983–84	1984–85	1983–84	1984–85
Irrigation levels							
No irrigation	18.3	11.8	15.0	150.1	124.9	12.19	9.45
Irrigation at 0.3/IW/CPE	20.0	12.7	16.4	204.2	171.4	9.79	7.41
Irrigation at 0.6 IW/CPE	21.6	14.2	17.9	168.1	229.3	8.06	6.19
CD (P = 0.05)	2.33	NS	1.98				
Nitrogen levels (kg N/ha)							
0	14.2	8.0	11.1	203.8	154.2	6.96	5.19
40	19.7	13.6	16.6	207.5	174.7	9.49	7.78
80	26.0	17.1	21.6	223.6	196.7	11.63	8.69
CD (P = 0.05)	2.33	2.85	1.98				
Phosphorus levels (kg P/ha)							
0	19.3	11.3	15.3	201.7	159.4	9.57	7.09
15	19.1	12.9	16.0	211.4	178.2	9.04	7.24
30	21.5	14.5	18.0	221.8	188.1	9.69	7.71
CD (P = 0.05)	1.91	0.87	1.01				

TABLE 3. Consumptive water use (mm) and water use rate (mm/day) at different stages of mustard as influenced by irrigation, nitrogen and phosphorus.

Treatments	1983–84				1984–85			
	Sowing to vegetative stage	Vegetative stage to flowering	Flowering to siliqua development	Siliqua development to harvest	Sowing to vegetative stage	Vegetative stage to flowering	Flowering to siliqua development	Siliqua development to harvest
Irrigation levels								
No irrigation	35.14 (0.88)	39.88 (0.80)	38.74 (1.21)	45.86 (1.99)	31.80 (0.66)	28.27 (0.66)	28.12 (0.97)	36.66 (1.59)
Irrigation at 0.3 IW/CPE	36.40 (0.91)	37.88 (0.76)	92.16 (2.88)	47.37 (2.06)	31.01 (0.65)	28.02 (0.65)	59.78 (2.06)	52.63 (2.29)
Irrigation at 0.6 IW/CPE	44.92 (1.12)	64.63 (1.29)	88.00 (2.75)	51.41 (2.23)	42.62 (0.64)	49.51 1.45)	59.98 (2.07)	76.13 (3.31)
Nitrogen levels (kg N/ha)								
0	38.11 (0.95)	48.53 (0.97)	71.31 (2.23)	45.86 (1.99)	23.38 (0.49)	33.63 (0.78)	45.18 (1.56)	52.01 (2.26)
40	38.93 (0.97)	48.04 (0.96)	73.18 (2.29)	47.37 (2.06)	30.48 (0.64)	41.69 (0.97)	49.22 (1.70)	53.28 (2.32)
80	39.09 (0.98)	58.71 (1.17)	74.41 (2.32)	51.41 (2.23)	39.88 (0.83)	43.22 (1.01)	53.50 (1.84)	60.13 (2.61)
Phosphorus levels (kg/Pha)								
0	36.65 (0.92)	47.82 (0.96)	71.75 (2.24)	45.49 (1.98)	26.33 (0.55)	34.43 (0.80)	46.22 (1.59)	52.40 (2.28)
15	39.12 (0.98)	52.39 (1.05)	73.05 (2.28)	46.83 (2.04)	31.41 (0.65)	40.96 (0.95)	50.18 (1.73)	55.60 (2.42)
30	40.36 (1.01)	55.06 (1.12)	74.10 (2.31)	52.32 (2.27)	36.01 (0.75)	43.15 (1.00)	31.49 (1.78)	57.42 (2.50)

Figures in parenthesis indicate water use rate (mm/day)

TABLE 4. Soil moisture extraction pattern (mm) of mustard as influenced by irrigation, nitrogen and phosphorus.

Treatments	1983–84				1984–85			
	Depth of soil (cm)				Depth of soil (cm)			
	0–30	30–60	60–90	90–120	0–30	30–60	60–90	90–120
Irrigation levels								
No irrigation	56.1	35.0	32.4	26.6	33.9	40.3	31.3	19.3
Irrigation at 0.3 IW/CPE	89.9	45.4	36.6	32.3	59.8	47.2	39.7	24.7
Irrigation at 0.6 IW/CPE	143.6	54.4	40.1	30.0	105.2	60.5	38.0	25.6
Nitrogen levels (kg N/ha)								
0	96.2	46.0	35.0	26.6	59.7	42.6	30.0	21.9
40	98.3	42.8	33.5	32.9	64.5	49.8	36.6	23.8
80	107.4	48.1	39.7	28.4	74.5	55.7	42.5	24.0
Phosphorus levels (kg P/ha)								
0	97.3	41.9	35.0	27.5	60.3	45.5	32.8	20.8
15	103.2	46.0	35.1	27.1	65.7	49.1	38.6	24.8
30	101.5	49.1	38.1	33.1	72.8	53.5	37.6	24.2

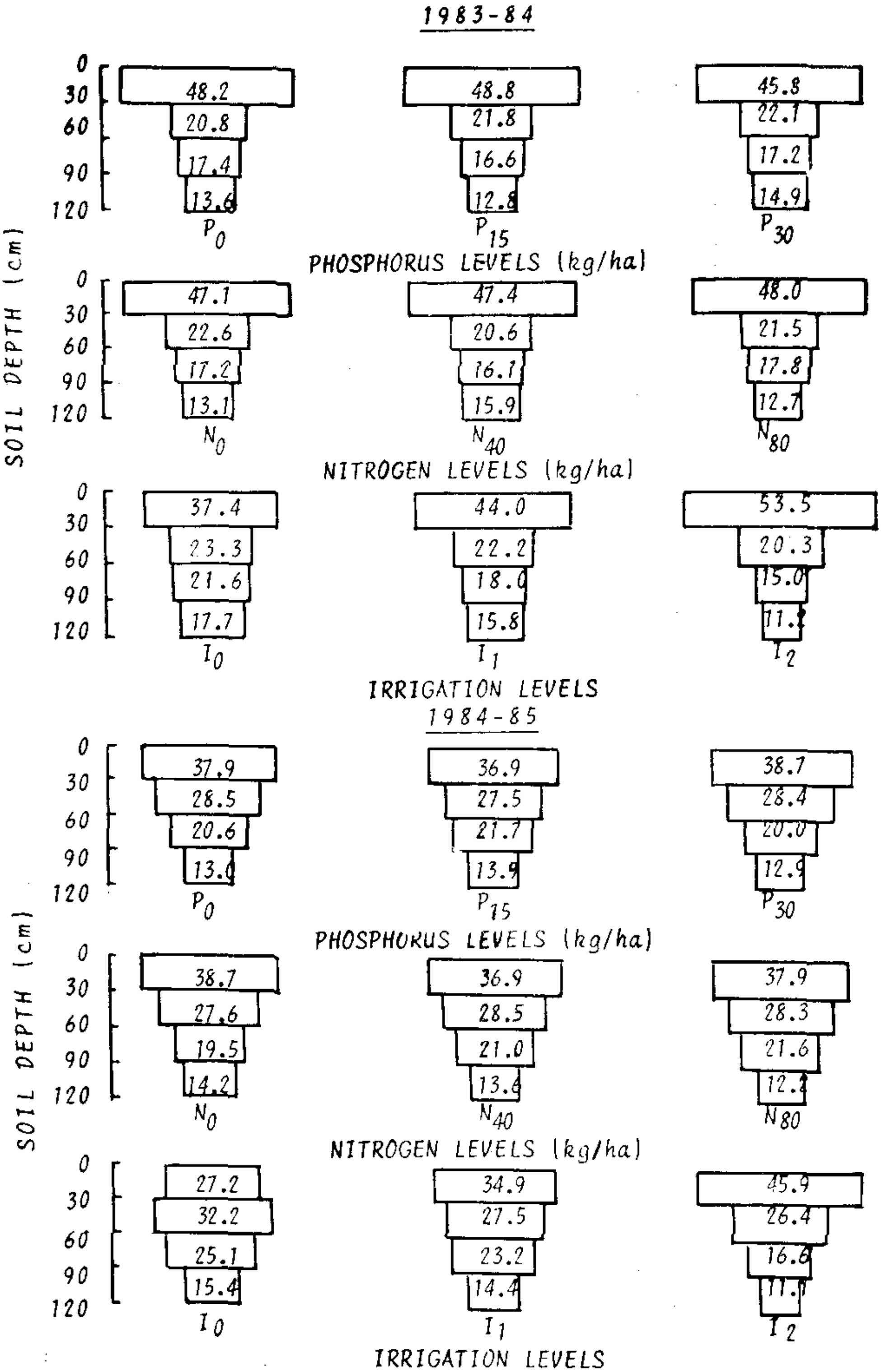

Fig.1 SOIL MOISTURE EXTRACTION (PER CENT) OF MUSTARD AS INLFUENCED BY IRRIGATION, NITROGEN AND PHOSPHORUS

levels varied from stage to stage. During both the years, the maximum water use values were at 80 kg N/ha. The daily consumptive use of water increased by increase in the levels of phosphorus during both the years. The higher water use from flowering to siliqua development stage indicate that water supply is essential at this stage.

Water use efficiency :

The water use efficiency decreased with increase in water supply (Table 1). The lower water use efficiency associated with higher soil moisture status was due to proportionately more increase in evapotranspiration than the increase in seed yield. Appilcation of both nitrogen and phosphorus resulted in increased water use efficiency. The maximum water use efficiency was achieved with application of 80 kg N/ha (11.63 kg/ha/mm in 1983–84 and 8.69 kg/ha mm in 1984–85). Similarly, application of 30 kg P/ha registered higher water use efficiency (9.69 kg/ha/mm and 7.71 kg/ha mm/ in 1983–84 and 1984–85, respectively).

Moisture extraction pattern :

The data on soil moisture extraction pattern by mustard from different soil layers are presented in Table 4, and the per cent extraction pattern is illustrated in Fig. 1. In general, the extraction of soil moisture from top layer of soil (0–30 cm) was the highest closely followed by 30–60 cm layer which declined in lower layer (60–120 cm) indicating there by active root zone of the crop as 0–60 cm from soil moisture point of view. The soil moisture extraction was more in 30–120 cm layer under unirrigated and 0.3 IW/CPE receiving one irrigation. On an average, 67.7 and 60.5 per cent of total water requirement was met from 30–120 cm soil layer in no irrigation and 0.3 IW/CPE treatments, respectively. Mustard being a deep rooted crop would extend its root system to deeper layers under unirrigated and limited supply of irrigation water as a result more depletion was found from lower layers. On the contrary, the soil moisture depletion was maximum in the surface layer (0–30 cm) recording 53.5 and 45.9 per cent in 1983–84 and 1984–85, respectively. Higher moisture extraction from 0–30 cm layer at 0.6 IW/CPE was also reported by Khan and Agarwal (1985) in mustard. The differences in soil moisture depletion between 40 kg N/ha and no nitrogen did not vary much and the highest soil moisture depletion was observed with 80 kg N/ha during both the years. Similarly, application of phosphorus resulted in more depletion of moisture compared to no phosphorus especially from 0–60 cm soil depth.

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EPIDEMIOLOGICAL STUDIES OF SAFFLOWER LEAF SPOT CAUSED BY *RAMULARIA CARTHAMI* ZAPROMETOV UNDER IRRIGATED CONDITIONS*

M. S. PATIL[1] and R. K. HEGDE[2]
Department of Plant Pathology, College of Agriculture, Dharwad — 580 005, Karnataka.

ABSTRACT

The development of leaf spot disease caused by *Ramularia carthami*, was studied on two varieties A-1 and APRR-1 from 1981 to 1983. The temperature has profound effect on the disease development. Temperature of 28°C and above and humid conditions favoured the disease development.

Key words : Safflower, leaf spot.

INTRODUCTION

Ramularia carthami Zaprometov, causing the leaf spot of safflower has established as an important disease. This has been causing extensive damage to the foliage and capsules. Though the disease was recorded from Karnataka (Desai, 1980) and not much information is available despite of Karnataka being the major safflower growing State in the country.

The disease appears as minute brown spots later increase in size to circular, with concentric rings. At the centre of the spots, on the lower side white tufts of conidiophores and conidia emerges. Adjacent spots eventually coalasce to form large irregular spots and the infected leaf totally dries. Infection also occurs on flower bracts, and capsules reducing both the size and number of seeds in the capsule. In the present studies, we had attempted to correlate weather factors with the disease development.

MATERIALS AND METHOD

The role of weather factors on the development of Ramularia leaf spot was assessed by taking observations on disease intensity at seven days intervals, on two commonly cultivated varieties (A-1 and APPR-1) for successively two years 1981-82 and 1982-83 The disease intensity was recorded on the tagged plants, following the 0-5 scale that is given below :

Rating	*Per cent leaf area covered by the disease symptom*
0	<1
1	1-5

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1 Jr. Plant Pathologist, AICRPO (Safflower), Agricultural Research Station, Annigeri — 582 201 Dist. Dharwad.
2 Director of Instructions (PGS), University of Agricultural Sciences, Dharwad — 580 005.

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2	6–20
3	21–40
4	41–70
5	> 71

Per cent disease index (PDI) was calculated by using the formula given by Wheeler (1969).

$$\text{PDI} = \frac{\text{Sum of individual rating}}{\text{Total number of leaves examined}} \times \frac{100}{\text{Maximum grade}}$$

Maximum and minimum temperatures in °C, per cent relative **humidity in the** ***morning*** and *evening* were correlated with the percentage disease index.

TABLE 1. Development of Ramularia leaf spot on A-1 and APPR-1 varieties of safflower in relation to meteorological factors during 1981-82.

Age of the crop (days)	PDI		Temperature °C		Per cent relative humidity	
	A–1	APPR–1	Maximum	Minimum	Morning	Evening
30	—	—	30.2	17.6	93	76
37	—	—	28.9	16.0	89	71
44	—	—	27.9	11.3	79	64
51	—	—	28.8	12.5	83	63
58	0.8	0.03	28.7	14.7	76	68
65	0.92	0.82	27.2	11.6	90	76
72	1.13	0.98	28.9	14.2	76	73
79	1.68	1.12	27.6	12.5	82	64
86	2.26	1.32	28.9	11.6	79	71
93	6.76	1.97	29.8	13.9	79	69
100	16.52	5.74	30.8	13.9	78	65
107	28.80	16.87	29.9	14.3	80	65
114	33.80	26.30	30.8	15.1	83	67
121	48.10	31.90	32.4	15.6	89	66
128	52.20	40.70	33.3	16.0	88	70
135	60.90	49.17	34.4	17.5	83	60
142	72.10	57.21	34.2	17.2	85	70
149	80.57	63.80	34.5	16.7	79	62

RESULTS AND DISCUSSION

From the table 1 and 2, it was evident that the disease development was favoured as the age of the crop advanced and continued to do so till the harvest. This further

TABLE 2. Development of Ramularia leaf spot on A-1 and APPR-1 varieties of safflower in relation to meteorological factors during 1982-83.

Age of the crop(days)	PDI		Temperature °C		Per cent relative humidity	
	A-1	APPR-1	Maximum	Minimum	Morning	Evening
24	—	—	29.1	17.0	97	73
31	—	—	28.4	14.2	96	72
38	—	—	28.8	14.3	91	71
45	0.34	—	28.3	11.3	86	72
52	1.27	0.09	28.4	12.4	91	72
59	2.50	0.18	28.7	11.8	92	72
66	5.33	1.44	28.4	12.1	93	74
73	8.47	2.12	29.4	11.7	85	58
80	12.10	2.74	30.1	12.7	86	70
87	14.83	7.10	29.4	12.5	86	75
94	21.70	13.18	30.6	14.1	80	79
101	37.10	28.90	27.4	13.7	89	71
108	51.23	34.10	30.4	12.5	87	74
115	67.00	56.10	33.4	16.1	88	70
122	78.10	61.90	34.3	14.6	87	65
129	81.30	64.00	33.6	14.4	79	58
136	85.90	67.90	35.0	16.5	86	54
143	88.17	72.00	37.3	19.2	85	51
150	89.30	75.30	36.5	17.7	84	60

substantiates the observations of Rathaiah and Pavgi (1973) and Patil *et al.* (1986). Rapid disease development occurred from February onwards as a result of an increase in the ambient temperature. This validates the observations of Rathaiah and Pavagi (1973). Temperature of 28°C is detrimental to the development of the pathogen and the expression of the disease symptoms. A positive correlation exists between disease incidence and maximum and minimum temperature as has been observed based on 1981-82 and 1982-83 rabi season data (Table 3).

TABLE 3. Correlation between disease incidence and air temperature.

Weather parameters	Variety	'r' value	
		1981–82	1982–83
Maximum temperature(°C)	A–1	*0.9471	*0.9322
	APPR–1	*0.9412	*0.9198
Minimum temperature(°C)	A–1	*0.6513	*0.6643
	APPR–1	*0.6320	*0.7005

* Significant at 5 per cent level.

Based on present studies, it was concluded that the Ramularia leaf spot disease of safflower was favoured by temperature of 28°C and above coupled with high humidity condition.

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NUTRIENT INTERACTIONS IN GROUNDNUT

G. R. PATEL[1] and R. B. PATEL[2]
Department of Agricultural Chemistry & Soil Science Gujarat Agricultural University, Anand Campus Anand—388 110.

ABSTRACT

Results of a field experiment conducted on groundnut varieties (T.G. 17 and J-11) with three levels of P (50, 100 and 150 kg P_2O_5/ha) and two levels of K (O and 60 kg K_2O/ha) improved the nutritional quality by increasing the N content of groundnut kernels. The differences in N content due to K application decreased with the increase in P levels. The antagonism between P and K was noted on their content and uptake by groundnut grown in summer season on soils having sufficient available P and K for normal growth of plant. The decrease in P content in kernels of T.G. 17 due to K application was higher than that in J-11 whereas the trend is reverse for N and K content.

Key words : summer groundnut, nutrient content, antagonism.

INTRODUCTION

Groundnut being a legume requires small quantity of nitrogen, but being rich in protein and oil, it may have relatively higher requirement for phosphorus and other elements like Ca and S. Besides improving the crop quality like colour, flavour and size of pods as well as oil content of groundnut (Satya narayana and Krishna Rao, 1962), potash application has been reported to improve the efficiency of applied phosphorus (Acuna and Sanchez, 1970). N P and K are generally recommended for groundnut cultivation. However, interaction effect of these nutrients on the uptake of other elements has scarcely been studied. The article presents the effect of phosphorus and potash application on yield and content of macro and secondary nutrients by groundnut varieties grown under irrigated condition in summer season on a sandy loam soil.

MATERIALS AND METHODS

The experiment was conducted at the Agronomy farm, Gujarat Agricultural University, Anand Campus, Anand. The soil of the experimental field was neutral in reaction (pH 7.65) and free from salt hazards (EC 0.23 mmhos/cm). The surface soil was low in organic matter (0.27%) and total nitrogen content (0.025%), medium in available phosphate (42.9 kg P_2O_5/ha) and high in available potash (336 kg K_2O/ha).

The field experiment with three levels of phosphate (50, 100 and 150 kg P_2O_5/ha), two levels of potash (0 and 60 kg K_2O/ha) and two groundnut varieties (T.G. 17 and J-11) in combinations was conducted in randomised block design with four replications. Uniform dose of 20 kg N/ha in the form of DAP was applied in each plot which also

Present address :

1. Professor (Biochemistry), College of Agriculture, Junagadh (Gujarat) India.
2. Asstt. Research Scientist (Soil Science), Wheat Research Station, Gujarat, Agricultural University, Vijapur (Dist. Mehsana).

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supplied 50 kg P_2O_5/ha. Single superphosphate and muriate of potash were used as the source of phosphate and potash respectively to supply remainder quantity of phosphate and potash as per the treatment. The fertilizers were drilled (4–5 cm deep) below the seeds. The seeds of the two varieties of groundnut treated with cereson (2.5 g/kg seed) were sown (@ 125 kg kernels/ha), at a distance of 30 cm between rows and 10 cm between plants in the row, the gross plot size being 3.6 m $\times$ 5.0 m. The pod samples were collected randomly at maturity from each treatment after recording the haulm and pod separately. The kernels from the sampled pod were analysed for their content of N, P, K, Ca, Mg and S after oven drying at 70°C and grinding. Wet digestion procedure of Johnson and Ulrich (1960) was employed for preparation of acid extract for determining the nutrients except nitrogen. Nitrogen was determined by Macro-Kejeldhal's method, phosphorus by vanadomolybdo-phosphoric acid yellow colour method and K by flamephotomatic method as described by Jackson (1973). Calcium and magnesium were estimated by versenate titration method of Schwarfenbach and Biedermann (1948) and sulphur by turbidimetic method of Chaudhary and Cornfield (1966).

RESULTS AND DISCUSSION

Yield :

The pod and haulm yield of groundnut were not influenced by P as well as K levels (Table 1). Though not significant, negative trend was observed in pod yield due to P levels, while haulm yield increased with application of 100 kg P_2O_5/ha. But the subsequent increase in P level (150 kg P_3O_5/ha) depressed the haulm yield. The results thus indicated that application of P in soil having madium status (43 kg P_2O_5/ha) of available P will not be beneficial for improving the yield. Similar observations were also noted by Singh and Rana (1979) and Bhatol (1981).

The surface soil contained adequate available K for normal growth of plant and hence application did not improve the yield of groundnut the variety T.G. 17 which gave significantly higher pod yield than J-11. The latter yielded higher quantity of haulm. This deviation could be attributed to genetic makeup of the varieties. The results are in agreement with those reported by Panchpute (1981).

Nutrient content :

The content of macro and secondary nutrients in groundnut kernels was significantly affected by P and K application (Table 1). The increase in P levels, in general, increased linearly all nutrients except K. According to Dalal *et al.* (1963), the N and P content increased due to N and P fertilizers in the treatments and Ca and S content rose because of the super-phosphate used as a source of P at higher P levels as it also contains Ca (20%) and S (12%). The K content declined with increase in the levels of P. This can be attributes to rise in Ca concentration on application of superphosphate. According to lime-potash law (Ehrenberg, 1919), when Ca concentration is relatively high, plant may not be able to absorb K at an adequate rate.

TABLE 1. Effect of Applied P and K on yield and Macro and Secondary Nutrient Content of groundnut kernels.

Treatments	Yield (t/ha)		Macronutrient content (%)			Secondary nutrient content (%)		
	Kernels	Haulm	N	P	K	Ca	Mg	S
kg P_2O_5 ha^{-1}								
50 (P_1)	2.10	7.01	3.95	0.91	0.84	0.22	0.22	0.23
100 (P_2)	2.04	7.72	4.09	0.90	0.78	0.23	0.23	0.24
150 (P_3)	1.93	7.20	4.36	0.94	0.77	0.25	0.25	0.25
C.D. 0.05	NS	NS	0.06	0.02	0.01	0.01	0.01	0.01
kg K_2O ha^{-1}								
0 (K_0)	2.08	7.31	4.07	0.93	0.75	0.24	0.24	0.24
60 (K_1)	1.98	7.31	4.20	0.90	0.84	0.22	0.22	0.24
C.D. 0.05	NS	NS	0.05	0.01	0.01	0.01	0.01	NS
Varieties								
T.G. 17 (V_1)	2.21	6.51	3.82	0.96	0.80	0.24	0.23	0.24
J - 11 (V_2)	1.84	8.11	4.45	0.88	0.79	0.22	0.24	0.23
C.D. 0.05	0.18	0.56	0.05	0.01	0.01	0.01	0.004	0.002

Application of K significantly decreased P, Ca and Mg content and increased K in groundnut kernels, S content was not influenced by K fertilization. These results are in agreement with those observed by Walker (1973) and Pachpute (1981). Kernels of variety T.G. 17 and significantly low N and Mg content than that of variety J–11. The N content is the reflection of protein content of the kernels. Therefore, as evidenced, variety T.G. 17 is poor from nutritional view point than variety J–11. The former was superior in respect of P, K, Ca and S contents.

The interaction P $\times$ K was significant for N, P and K contents of the kernels (Table 2). Application of P and K, in general, increased N and K content but reduced the P content in the kernels. The difference in N content due to K levels at 50 kg P_2O_5/ha was more (0.24%) than that at 100 (0.14%) and 150 (0.03%) kg P_2O_5/ha. The imbalance in P and K fertilization might be responsible for such negative trend for N content in kernels. Contrarary to N content, just reverse trend was observed in K content due to P $\times$ K interaction but was not significant.

The interaction effect V $\times$ P was significant for N, P and K contents (Table 2). N content in T.G. 17 was significantly low at 100 kg P_2O_5/ha. However, for improving protein content in kernel, application of both P and K is a must under sandy loam soil conditions. The inconsistent differences in P content of kernels of two varieties were

TABLE 2. **Effect of Interaction Between P and K on Macronutrient Contents of Kernels of Different Groundnut Varieties.**

Kg P_2O_5 ha^{-1}	Variety T.G. 17			Variety J-11			Mean	
	kg K_2O ha^{-1}			kg K_2O ha^{-1}			kg K_2O ha^{-1}	
	0	60	Mean	0	60	Mean	0	60
				Nitrogen (%)				
50	3.54	3.91	3.72	4.13	4.22	4.18	3.83	4.07
100	3.53	3.73	3.63	4.50	4.59	4.55	4.02	4.16
150	4.08	4.12	4.10	4.64	4.61	4.63	4.36	4.37
Mean	3.72	3.92	—	4.43	4.47	—	—	—
C.D. 0.05	VxP	and	PxK	– 0.08;	VxK	– 0.06;	VxPxK	– NS
				Phosphorus (%)				
50	0.98	0.95	0.96	0.83	0.89	0.86	0.91	0.92
100	0.97	0.90	0.93	0.89	0.84	0.86	0.93	0.87
150	0.99	0.95	0.97	0.95	0.86	0.91	0.97	0.91
Mean	0.98	0.93	—	0.89	0.86	—	—	—
C.D. 0.05	VxP	and	PxK	– 0.02;	VxK	– 0.02;	VxPxK	– 0.03
				Potassium (%)				
50	0.84	0.92	0.88	0.76	0.85	0.80	0.80	0.88
100	0.71	0.86	0.79	0.75	0.79	0.77	0.73	0.83
150	0.70	0.81	0.75	0.77	0.81	0.79	0.73	0.81
Mean	0.75	0.86	—	0.76	0.82	—	—	—
C.D. 0.05	VxP	– 0.02;	VxK	– 0.01;	PxK	– NS	VxPxK	– 0.03

observed due to P and K levels. The V $\times$ K interaction was significant for N, P and K content. Though J–11 had high N content than T.G. 17, the application of K did not help in increasing N content of kernels of J–11. Application of 60 kg K_2O/ha increased N content in case of T.G. 17. This suggest that groundnut variety J–11 was non-responsive to K application for improving the N content under the conditions of the present study. The decrease in P content in kernels of T.G. 17 due to K addition was higher than that in J–11. But K content increased at high rate in T.G. 17 than J–11 due to K fertilization. The interaction effect VPK was significant for P and K content in kernels. By and large, the results revealed that the P fertilization higher than 50 kg P_2O_5/ha influenced mainly N content, while K application @ 60 kg K_2O/ha increased N and K content without altering the yield of groundnut pods. The increase in N and K contents due to K varied with P levels. The results confirmed the results obtained by Due and Shinde (1986). The secondary nutrients (Ca, Mg and S) content in kernels did not differ significantly due to any of the interaction effect.

From the results it can be concluded that the variety T.G. 17 produced more pods whereas variety J-11 gave more haulm yield. The phosphate and potash application increased nutritional value without altering the pod yield of groundnut. The P and K had antagonistic effect on their contents in kernels of groundnut grown in summer season on soils having medium status of available P and high K content.

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CROSSABILITY IN RELATION TO SELF-INCOMPATIBILITY LEVELS AND GENETIC DIFFERENCES BETWEEN VARIETAL FORMS IN *BRASSICA CAMPESTRIS L.*

RAM BHAJAN * and BASUDEO SINGH
Department of Plant Breeding, G.B. Pant University of Agriculture and Technology,
Pantnagar—263 145, Distt. Nainital (U.P.).

ABSTRACT

Effect of impairment between yellow *sarson* (A') and toria (A) genomes and of varying self-incompatibility levels on success of intervarietal hybridization was studied in 11 generations of two crosses involving yellow *sarson* (PYS–6) and *toria* (M 3 and PT 303) parents. Self-incompatibility, being dominant, affected adversely siliquae set in F_2 and B_2S generations while it increased in B_1S and F_3 generations, perhaps due to uncovering of recessive self-compatibility alleles. The siliquae set was 10 per cent higher in generations having expected genomic contribution of *toria* of around 75 per cent. Seed yield and its component traits expressed favourably in generations where contribution of yellow *sarson* and *toria* was around 25:75.

Key words : Self-incompatibility, yellow *sarson, toria,* genomes, generations.

INTRODUCTION

Brassica campestris L. includes *toria,* yellow *sarson* and brown sarson. Of these *toria* is cross pollinated, yellow *sarson* is self-pollinated and brown *sarson* includes both cross and self-pollinated forms. Genetic self-incompatibility (SI), a major out breeding device, is dominant over self-compatibility (Rajan, 1958). Yellow *sarson* carries A' genome (Fukushima and Iwase, 1966) where as other *campestris* varieties carry A genome. Thus, it would be worth investigating the effect of impairment between A and A' genomes and varying degree of incompatibility on crossability because recombinants are feasible in intervarietal hybridization (Amirthadevarathinam *et al.*, 1976). Present paper deals with the results of intervarietal hybridization between yellow *sarson* and *toria.*

MATERIALS AND METHODS

Eleven generations F_1, F_2, F_3, B_1 (BC_1), B_2 (BC_2), B_1S (BC_1 self), B_2S (BC_2 self), B_{11} ($BC_1 \times P_1$), B_{12} ($BC_1 \times P_2$), B_{21} ($BC_2 \times P_1$) and B_{22} ($BC_2 \times$ (P_2) of PYS–6 × M 3 (C–I) and PYS–6 × PT 303 (C–II) were produced by hand emasculation and pollination of large number of healthy flower buds on 20 to 25 plants. Among parents, PYS–6 belongs to yellow *sarson* group and other two belong to *toria* group. At maturity, per cent siliquae set was recorded in each generation. Seeds of all the generations were sown in compact family block design in three replications at standard spacing. Observations were recorded on 30 (F_1), 90 (F_2) and 75 (F_3 and other generations) randomly selected plants for primary branches/plant, secondary branches/plant, siliquae/plant and seed yield/ plant (g).

* *Present address :* Daepartment of Genetics and Plant Breeding, N.D. University of Agricultur nd Technology, Narendra Nagar (Kumarganj), Faizabad, U.P.

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RESULTS AND DISCUSSION

Effect of SI alleles :

SI being dominant appeared to have an adverse effect on the success of selfing to produce F_2 and B_2S generations, in proportion to the expected expression of SI allele in these generations (Table 1). Success of selfing to produce B_1S and F_3 generations increased substantially perhaps due to effective expression of recessive self-compatibility alleles. The difference in siliquae set between B_1S and B_2S was greater in C–I (17.88%) than the C–II (5.13%), indicating the excess of modifier genes in M 3 than the PT 303 which have exerted more influence on the expression of SI alleles in M 3. With double dose of *toria* parent in B_2S, probably modifiers accumulated more in it than B_1S generation. This also substantiated the earlier observation of Doloi (1977) that the level of SI in different varieties of *toria* is a variable entity.

Effect of A genome :

The effect of yellow *sarson* genome (A') was ascertainable from the success of crossing in Set–I (B_1, B_{11}, and B_{21}) and Set–II (B_2, B_{12}, and B_{22}) generations derived from back crosses. The set–I has expected proportion of A' genome > 50%, the average being 75%. Contrary to this, in set–II expected contribution of A' genome was on the average 25% which caused 10% less siliquae formation in set–I than that of set–II.

Incidently the generations (B_2, B_{12} and B_{22}) showing higher siliquae set were those in which *toria* was used as pollen parent. Thus, a reduction of > 10% in siliquae set in generations of Set–I than set–II could be attributed partly to the use of yellow *sarson* as pollen parent and rest to the cryptic structural differences in the genomes of the two forms. Such an effect of yellow *sarson* as male and female parents in crosses with *toria* was earlier noted by Arunachalam and Amirthadevarathinam (1978). The present finding showed that despite differences at genetic level the hybridization between yellow *sarson* and *toria* at large scale to augment the genetic variability for favourable selection could be successful.

Mean performance of inter varietal hybrids :

Analysis of variance for the design showed significant differences among generations for all the traits. The mean performance of four quantitative tratis in different generations is given in Table 2. Seed yield showed a remarkable depression in F_2 as compared to F_1. A scrutiny of the generations having on the average 75 per cent contribution of *toria* (Set–II) revealed a definite superiority for all the traits over Set–II having about 25 per cent contribution from *toria*. This suggests that maximum expression of desirable attributes in intervarietal hybrids takes place when yellow *sarson* and *toria* have genomic contribution approximately 25 : 75. Amirthadevarathinam *et al.* (1976) had advocated the production of a synthetic complex using many good combining genotypes of the botanical varieties. Thus, in a bid to boost yield at a higher level, a synthetic complex with several judiciously chosen parental genotypes of yellow

TABLE 1. **Success of hybridization (%) in crosses between yellow *sarson* (PYS-6) and *toria* (M 3 and PT 303) measured in different generations.**

Generations	Expected genomic contribution A' : A (%)	PYS-6 × M3			PYS-6 × PT 303		
		No. of buds pollinated	No. of siliquae formed	Per cent siliquae set	No. of buds pollinated	No. of siliquae formed	Per cent siliquae set
F_1	50:50	432	336	77.8	526	395	75.1
F_2	50:50	748	545	72.9	815	648	79.5
F_3	50:50	1103	968	87.8	1364	1125	82.5
B_1S	75:25	788	667	85.9	679	558	82.0
B_2S	25:75	569	355	62.4	1065	815	76.9
Mean	50:50	—	—	—	—	—	—
Set–I							
B_1	75:25	402	270	67.2	444	334	75.2
B_{11}	87.5:12.5	457	354	77.5	460	323	70.2
B_{21}	62.5:37.5	564	403	71.5	472	341	72.2
Mean	75:25	474	346	72.9	459	333	72.5
Set–II							
B_2	25:75	336	251	74.7	330	292	88.5
B_{12}	37.5:62.5	423	364	86.1	341	311	91.2
B_{22}	12.5:87.5	367	320	87.2	447	349	78.1
Mean	25:75	375	312	83.0	373	317	85.1

TABLE 2. Mean performance of yield and its components in different generations.

Generations	PYS-6 × M 3				PYS-6 × PT 303			
	Primary branches/plant	Secondary branches/plant	No. of *siliquae/plant*	Seed yield/ *plant (g)*	Primary *branches/plant*	Secondary *branches/plant*	No. of *siliquae/plant*	Seed yield/ plant (g)
P_1	5.9	1.9	159.9	4.6	5.9	1.9	159.9	4.6
P_2	6.7	1.8	270.5	5.1	7.4	9.0	281.9	5.4
F_1	8.2	6.4	281.6	6.2	10.1	8.4	368.8	8.3
F_2	7.8	9.2	321.1	5.9	7.4	9.0	310.6	4.6
F_3	8.8	9.2	352.5	4.6	9.0	8.1	348.0	4.5
B_1S	7.8	6.9	283.1	4.8	8.7	8.9	338.6	4.6
B_2S	6.8	9.6	255.7	4.9	8.0	8.5	308.1	7.7
Set–I								
B_1	8.1	6.2	284.7	5.0	7.6	6.6	295.8	4.4
B_{11}	6.8	6.8	371.4	5.8	8.9	6.2	476.9	5.9
B_{21}	8.0	4.2	280.6	4.4	7.8	3.3	277.0	6.6
Menx	7.6	5.8	312.2	5.1	8.1	5.4	349.9	5.6
Set–II								
B_2	8.5	10.3	308.1	6.9	9.2	10.7	326.7	6.2
B_{12}	8.8	8.1	232.7	4.4	8.8	9.6	294.7	5.1
B_{22}	7.1	8.1	267.4	5.2	10.1	8.9	455.0	9.8
Mean	8.1	8.8	269.4	5.5	9.4	9.7	358.8	7.0
S.Em	0.5	1.4	31.9	0.7	0.6	1.2	38.6	0.7
C.D. (at 5%)	1.6	4.1	92.3	2.0	1.6	3.6	111.9	2.0

sarson and *toria* may be tried in such a way that the contribution of yellow *sarson* and *toria* reach around 25 : 75.

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EFFECT OF IRRIGATION AND PHOSPHORUS ON POD YIELD OF SUMMER GROUNDNUT

R. K. KATRE, B. S. CHANDRAKAR, R. K. BAJPAI, K. K. SAHU and K. K. CHOUDHARY.
Indira Gandhi Krishi Vishwa Vidyalaya, Regional Agricultural Research Station, Sarkanda, Bilaspur — 495 001.

ABSTRACT

In the summer season of 1983 and 1984 a field experiment was conducted on sandy-clay-loam soil of Bilaspur to determine the best irrigation schedule and phosphorus dose for higher yields of groundnut. A similar trend on pod yield was recorded during both the years. Pod yield of 22.92 q/ha was obtained under I_1 (IW/CPE = 0.6) and it increased by 4.97 q/ha (19.2%) and 10.53 q/ha (42.3%) under I_2 (IW/CPE = 0.9) and I_3 (IW/CPE = 1.2) respectively. Total water required, including the effective rainfall, under I_1, I_2 and I_3 was 56.7, 67.2 and 88.2 cm respectively. The total number of irrigations of 7.0 cm depth varied during both the years slightly due to effective seasonal rainfall and its distribution affecting the irrigation interval. The average number of irrigations under 0.6, 0.9 and 1.2 IW/CPE including two common irrigations, one as post sowing and another at crop emergence were 7–8, 9 and 1_2 respectively. The field water use efficiency was same under 0.6 and 0.9 IW/CPE (4.04 and 4.07 kg/ha - mm) but it reduced under 1.2 IW/CPE (3.70 kg/ha -mm). Irrigation interval under 0.6, 0.9 and 1.2 IW/CPE varied during the season such that they were 16, 13 and 10 days in March, 13, 10 and 8 days in April and 10, 7 and 5 days in May respectively. Higher profit (Rs/ha) and benefit - cost relation (Rs/ Rs. investment) was obtained due to high frequency irrigations on the order of 1.2 IW/CPE 0.9 IW/CPE 0.6 IW/CPE. In medium phosphorus status soil no phosphorus response was obtained and irrigation × phosphorus interaction was also not significant.

Key words : Summer Groundnut, irrigation, Phosphorous.

INTRODUCTION

Irrigation potential is increasing in eastern part of Madhya Pradesh as many irrigation projects namely Mahanadi, Hasdeo Bango, Upper Wainganga and Pairi with irrigation potential 7.49 lakh hectares are either completed or nearing completion. Suitable rice based cropping sequences are already evolved (Katre et al, 1986). Groundnut fits well in a rice based crop sequence during rabi/summer season and is grown in about 3–5 thousand hectares. At present the productivity of groundnut is low due to unscientific and improper irrigation scheduling in the command area.

MATERIALS AND METHODS

A field experiment was conducted in summer season (January to May) of 1983 and 1984 at R.A.R.S., Bilaspur. The soil is deep (about 1.5 m) and sandy-clay-loam in texture with 6.7 to 7.1 pH. The average soil moisture content at field capacity and permanent wilting point on volume basis is 32.15 and 18.32 cm^3/cm^3 respectively of different soil layers up to 1 m depth. The soil available N, P_2O_5 and K_2O was 150, 45 and 405 kg/ha respectively. The soil was rich in iron but very low in $CaCO_3$ content. Soil hardening was a common characteristic with depletion of soil moisture. The test variety was AK–12–24, a bunch groundnut. Prior to imposing irrigation levels, two common irrigation (as post sowing and at crop emergence were scheduled.

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Three irrigation levels at 0.6, 0.9 and 1.2 IW/CPE (I_1, I_2 & I_3 respectively) and three phosphorus levels of 0, 40 and 80 kg P_2O_5/ha P_0, P_1 and P_2 respectively) were tested in randomised block design with factorial concept and replicated four times.

Urea, single superphosphate and muriate of potash were applied to supply 20 N, P_2O_5 as per treatments and 20 K_2O kg/ha respectively, all as basal by placement. Groundnut seed, treated with rhizobium and fungicide was sown by dibbling in small furrows opened manually with a spacing of 40 × 10 cm. The gross and net plot size were 4.5 × 4.0 m and 3.6 × 3.0 m respectively. The plots were irrigated by check basin method with measured quantity of irrigation water (7.0 cm) through parshall flume. Buffer channels were constructed in between the plots to minimise the effect of seepage at the time of irrigation. Hand weeding was done twice, 20 and 40–45 days after sowing. A total of 3.6 and 4.8 cm rainfall was received in 4 and 10 rainy days during 1983 and 1984 crop season respectively. The total water expense was calculated by adding effective rainfall and depth of irrigation water.

RESULTS AND DISCUSSION

Pod yield and yield attributes

Irrigation schedules significantly influenced pod yield of groundnut in both years (Table-1). Maximum pod yield (32.63 q/ha) was obtained under 1.2 IW/CPE. The increase in pod yield over 0.6 IW/CPE (22.0 q/ha) was 4.9 q/ha (19.2%) and 10.53 q/ha (42.3%) in 0.9 and 1.2 IW/CPE respectively. Higher pod yield of rabi/summer groundnut in sandy-loam soil was reported by Chiplima Centre in Orissa at 1.2 IW/CPE (Anonymous 1983–85) and in clay-loam soil in Raipur, M.P. at 1.0 IW/CPE (Jaggi & Bisen, 1986). Irrigation schedules significantly increased total pod and their weight per plant in both years (Table-1). Similarly, filled pods per plant, though not affected significantly due to different water regimes, but showed an increasing trend. Higher shelling percentage was recorded in 1.2 IE/CPE only. Thus, except shelling percentage all yield attributes increased on order of 1.2 IW/CPE 0.9 IW/CPE 0.6 IW/CPE, corroborating with the pod yield/ha in both years. As the initial soil nutrient status in respect of available P_2O_5 was medium, there was no significant response of added phosphorus and also the interaction effect of irrigation × phosphorus neither for pod yield nor for yield attributes.

Number of irrigations and total quantity of water applied.

Including two common irrigation, the total number of irrigations in 1983 and 1984 varied under 0.6 and 0.9 IW/CPE but remained same under 1.2 IW/CPE (Table-2). During the crop season groundnut required 8 & 10 irrigation under 0.6 and 0.9 IW/CPE respectively in 1983. But the number was 7 and 8 under the same treatments in 1984. The difference in number of irrigation by 1 or 2 was mainly due to change in weather conditions which differed in both the years during the crop season. The crop received 3.6 cm rain in 4 rainy days and 4.6 cm rain in 10 rainy days in 1983 and 1984 respectively. Such a variation in effective rainfall affected accordingly the time interval to

TABLE 1. Effect of irrigation and phosphorus levels on pod yield and yield attributes of groundnut.

Treatments	Pod yield (q/ha)			Yield attributing character								Mean			
				1983				1984							
	1983	1984	Mean	No.of pods/ plant	No. of filled pods/ plant	Wt. of pods/ plant (g)	Shell-ing %	No. of pods/ plant	No. of filled pods/ plant	Wt. of pods/ plant (g)	Shell-ing %	No. of pods/ plant	No. of filled pods/ plant	Wt. of pods/ plant (g)	Shelling %
IW/CPE ratio of															
0.6 (I_1)	23.74	22.10	22.92	30.20	24.05	18.00	65.23	27.00	26.75	20.00	64.57	28.60	25.40	19.00	64.90
0.9 (I_2)	27.59	27.07	27.33	32.20	29.30	23.00	64.46	32 00	27.70	21.50	64.54	32.10	28.50	22.25	64.50
1.2 (I_3)	34.27	31.00	32.63	36.50	30.25	23.44	66.01	37.10	29.25	22.90	67.59	36.80	30.00	23.17	66.80
CD at 5 %	6.32	4.34	—	4.20	NS	3.71	NS	5.04	NS	2.45	NS	—	—	—	—
Phosphorus, P_2O_5 kg/ha															
0 (P_0)	28.09	26.99	27.54	32.6	29.10	23.75	67.92	31.40	27.70	21.25	65.92	32.0	28.4	22.50	66.50
40 (P_1)	27.78	26.88	27.33	34.0	29.20	22.16	66.35	33.00	28.40	21.50	65.25	33.5	28.8	21.83	65.80
80 (P_2)	29.75	27.04	28.39	30.0	27.10	23.16	68.23	32.00	26.50	21.00	65.97	31.0	26.8	22.08	67.10
CD at 5 %	NS	NS	—	NS	NS	NS	NS	NS	NS	NS	NS	—	—	—	—

TABLE 2. ***Record of irrigations, water requirement and field water use efficiency.***

Parameters	1983			1984			Mean (Years)		
	I_1	I_2	I_3	I_1	I_2	I_3	I_1	I_2	I_3
No. of *irrigations*	8	10	12	7	8	12	7–8	9	12
Depth of irrigation water (cm)	56.0	70.0	84.0	49.0	56.0	84.0	52.5	63.0	84.0
Effective rainfall (cm)	3.6	3.6	3.6	4.8	4.8	4.8	4.2	4.2	4.2
Total water required (cm)	59.6	73.6	87.6	53.8	60.8	88.8	56.7	67.2	88.2
Seasonal open pan evaporation (cm)	735.4	735.4	735.4	954.0	954.0	954.0	84.4	84.4	84.4
FWUE kg / ha -mm	3.98	3.75	3.91	4.12	4.45	3.49	4.04	4.07	3.70

TABLE 3. Economics of Groundnut.

Treatments	Cost of production/g (Rs)			Net profit (Rs/ha)			Benefit cost relation (Rs / Rs investment)		
	1983	1984	Mean	1983	1984	Mean	1983	1984	Mean
IW/CPE ratio of									
0.6 (I_1)	154.13	165.56	159.80	7125.00	6386.00	6755.50	1.95	1.74	1.84
0.9 (I_2)	133.43	135.94	134.70	8831.00	8601.50	8716.00	2.40	2.34	2.37
1.2 (I_3)	107.82	119.19	113.50	11826.50	10355.00	11090.70	3.21	2.80	3.00
CD at 5 %	—	—	—	418.47	538.73	—	—	—	—
Phosphorus, P_2O_5 kg/ha									
0 (P_0)	122.02	127.01	124.54	9308.00	8817.50	9062.75	2.71	2.57	2.64
40 (P_1)	132.44	136.83	134.63	8918.50	8518.00	8718.25	2.42	2.31	2.36
80 (P_2)	132.08	145.27	138.67	9555.00	8304.00	8929.50	2.43	2.11	2.27
CD at 5 %	NS	NS	—	NS	NS	—	—	—	—

obtain the desired CPE value as required under different irrigation schedule based on IW/CPE criteria. Number of irrigations, averaged over two years, were maximum under 1.2 IW/CPE (12 irrigations) followed by 0.9 IW/CPE (8–10 irrigations) and 0.6 IW/CPE (7–8 irrigations). The number of irrigations required for higher yield of groundnut have been reported by different workers (Annonymous, 1983–85; Jaggi and Bisen, 1986; Reddy, 1982; and Reddy et al., 1985) and their number ranged inbetween 8–12. The irrigation interval changed periodically due to change in evaporative demand conditions. Accordnigly, such an interval in the month of March was 16, 13 and 10 days in April 13, 10 and 8 days and in May 10, 7 and 5 days under 0.6, 0.9 and 1.2 IW/CPE respectively. Higher frequency of irrigation was thus maintained under higher IW/CPE which helped in maintaining sufficient moisture in the root zone during sentitive growth stages of groundnut at flowering, pegging and pod development resulting into higher pod yield. Reddy et al., (1980) reported higher pod yield of groundnut under higher frequency irrigations. Goldberg et al. (1971) and Black (1969) claimed that increasing the irrigation frequency increased the availability of irrigation water and nutrients through the establishment of relatively moist conditions in the root zone through out the crop period. These results find similarily with the results obtained in the present study.

The total water required under 0.6, 0.9 and 1.2 IW/CPE was 56.7, 67.2 and 88.2 cm respectively (Table–2) while the seasonal open pan evaporation amounted to 94.4 cm. Field water use efficiency was maintained same under 0.6 and 0.9 IW/CPE but decreased slightly under 1.2 IW/CPE. This indicates that by keeping depth per irrigation 7.0 cm and increasing the frequency of irrigation, the sandy-clay-loam soil could not retain entire water at each irrigation, resulting into deep percolation losses beyond root zone depth of the crop. The study thus indicates that good yield of groundnut can be obtained under 0.6 IW/CPE with 7–8 irrigations. But, if irrigation water is not limiting, significantly higher yield can be obtained by increasing number of irrigations up to .12 by increasing irrigation frequency.

Economics of irrigation groundnut —

Net profit (Rs/ha) and benefit cost relation ship (Rs/Rs investment) increased due to different water regimes on the order of 1.2 IW/CPE > 0.9 IW/CPE > 0.6 IW/CPE but there was no significant change in these parameters due to different levels of phosphorus (Table–3). The net profit increased significantly by Rs. 1961 = 00 (29.0%) and Rs. 4337 = 20 (64.2%) and by investing one rupee, Rs. 0.53 and Rs. 1.16 more was obtained under 0.9 and 1.2 IW/CPE over 0.6 IW/CPE. Cost of production reduced from Rs. 159.88/q under 0.6 IW/CPE to Rs. 113.50/q under 1.2 IW/CPE.

Results of present study revealed that summer groundnut cultivation in eastern part of Madhya Pradesh has great potential after late paddy in a paddy based crop sequence and it can be a good substitute for summer paddy.

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Short Communication

ESTIMATION OF LEAF AREA CONSTANTS FOR GROUNDNUT CULTIVARS

V. B. SHELKE, V. S. SHINDE, D.N. ARTHAMWAR and V. V. DAHIPHALE.
Department of Agronomy, Marathwada Agricultural University, Parbhani — 431 402, India.

Leaves are the important organs in groundnut crop as they are centres of photosynthesis and transpiration. The leaf area of the groundnut plant is the best measure of photosynthetic size or photosynthetic efficiency and the most appropriate measure of leaf area for crop whose yield is expressed per unit area of land, is the leaf area per unit area, the leaf area index (Watson, 1952).

As such there is a need of scientists engaged in crop science research to determine accurate leaf area quickly for various purposes. At present, the leaf area of the plant is determined using either planimeters or graph papers which necessarily demands the detachment of leaves from plant. These methods are tedious and time consuming. It also induces variations in leaf area estimation due to higher sampling errors.

The leaf area estimation of standing plants without detaching the leaves through linear measurement is possible as reported by Montogomery (1911) in maize, Bhan and Pandey (1966) in rice and Stickler *et al.* (1961) in Sorghum.

In the present paper, efforts are made to evolve suitable methods of leaf area estimation for groundnut Cv. ICGS-11 and JL-24 based on linear measurement of intact leaves using appropriate regression analysis.

Two cultivars of groundnut (ICGS-11 and JL-24) representing a varying range of plant types were grown on medium clay soil during pre-monsoon season of 1986. Sixty one leaves from each plant types were randomly selected, detached, dipped in water for one hour and the leaves were dried by filter paper.

The extreme linear measurements i.e. maximum length and maximum breadth, were recorded. The leaf area determined with the help of automatic leaf area meter model AAM-7 (Tokyo, Japan) was considered as true leaf area and denoted by 'A'. The leaf area determined by taking the product of linear measurement was termed as apparent leaf area and was denoted by 'Y'.

As there are more chances for greater errors in linear measurements, the apparent leaf area variables were regressed upon least error variables (i.e. actual leaf area). The examination of the data indicated that there occured wide differences in these variables at their higher magnitudes. This led to believe that some systems of weightage was

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necessary. Following Kemp (1960), the data were subjected to weighed regression analysis. The following methods were adopted.

Model I : Unweighed = (W = 1)

Model II : Weights inversely proportional to 'A' = (W = 1/A)

Model III : Weights inversely proportional to A2 = ($W = 1/A^2$).

The regression coefficients were computed from weighed regression coefficient model.

bi : AT/ A^2

bii : Y/ A

biii : 1/N × (Y/A)

These coefficients were subjected to analysis of variance. The standard errors (SE) and fiducial limits (b ± t 5% sb). The least standard error of regression coefficient (sb) was taken as a criteria for selecting the appropriate model. The inverse of regression coefficients of selected model were chosen as leaf area constants. The data on test statistics are presented in Table 1.

TABLE 1. Test statistics of regression coefficients.

Cultivars	Model	Constants				% Accuracy	Fiducial limits at 95% confidence
		b	sb	t	f(1/b)		
ICGS-11	W = 1	1.222	0.076	16.079	0.8183	98.60	1.2220 ± 0.1490
	W = 1/A	1.205	0.018	66.944	0.8298	99.95	1.2050 ± 0.0353
	$W = 1/A^2$	1.80	0.022	53.636	0.8474	97.90	1.1800 ± 0.0431
JL-24	W = 1	1.1654	0.0435	26.7908	0.8580	98.39	1.1654 ± 0.0853
	W = 1/A	1.1468	0.0157	73.0446	0.8720	99.99	1.1468 ± 0.0308
	$W = 1/A^2$	1.1151	0.0224	49.7813	0.8967	97.17	1.1151 ± 0.0439

The test statistics presented in Table 1 indicated that, the apparent (Y) and actual (A) leaf area were having positive significant correlations in both the groundnut cultivars. The Model II (W = 1/A) has yielded the least standard error for different regression coefficients followed by Model III (W = 1/A2) and Model I (W = 1) in both the groundnut plant types. Similarly, the fiducial limits were the smallest in Model II followed by Model III and Model I. The accuracy percentage was 99.95 and 99.99 in Model II for groundnut cultivars ICGS–11 and JL–24 respectively.

These results indicate that the Model II provides the best estimation of leaf area. The weighed regression coefficients (b) in this model are 1.2050 and 1.1468 for ICGS–11 and JL–24 respectively. As in Model II, the weights given are the inverse of actual leaf area (A), the respective leaf area constants would be the reciprocal of corresponding weighed regression coefficients.

The constants are 0.8298 and 0.8720 for groundnut cultivars ICGS–11 and JL–24 respectively. Finally, the estimation equation for actual leaf area (A) is recommended as follows :

$$A = \text{Maximum length} \times \text{Maximum breadth} \times F$$

where,

F = Inverse of respective appropriate regression coefficients i.e. 0.8298 for ICGS–11 and 0.8720 for JL–24.

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PRELIMINARY STUDIES ON AUTOGAMY IN SUNFLOWER POPULATIONS, HYBRIDS AND INBRED LINES

N. SHIVARAJU, K. GIRIRAJ and SHANTA R. HIREMATH
Sunflower Scheme, University of Agricultural Sciences, Bangalore — 560 065.

Poor seed set is one of the important constraints limiting productivity in sunflower populations. Although interaction of physiological, genetic, nutritional and environmental factors decide seed filling, it was concluded that final seed set is decided to a large extent by the population of pollinators in the vicinity, as sunflower is essentially a cross pollinated crop (Seetharam, 1982). One of the means to alleviate this problem is by identifying self-fertile lines and thus increase seed set and productivity. In the present study, open-pollinated varieties of sunflower, hybrids and their parental lines were evaluated for their autogamy.

A set of 14 genotypes comprising three populations (viz., EC. 68415, CGP-1 and Morden) six hybrids and their parental lines (five inbred lines) were raised in a single row each of 5 m length during summer 1985. Before anthesis, five heads at random, in each genotype were covered with cloth bag. Autogamy percentages were determined from the seed set under bagged heads divided by the mean seed set of the exposed heads and expressed in percentage (Robinson, 1980). The results obtained are given in Table 1.

The per cent seed set under open pollination ranged from 74.58 to 89.70 and as such did not vary appreciably either for populations, hybrids or the parental lines of hybrids. However, the mean values of per cent seed set under bagged condition and autogamy percentage calculated for populations, hybrids and their parents (inbreds) revealed wide variation. The highest autogamy per cent was for hybrid cultivars (52.46 per cent) followed by inbred lines (45.70 per cent) and open pollinated varieties (7.09 per cent). Amongst the three populations, Morden, which is presently widely cultivated in the country, is comparatively more self-fertile than CGP-1 and EC. 68415 (Armavirskii-3497). Amongst hybrids, CMS. 234×RHA 801 combination had the highest autogamy per cent closely followed by BSH-1 with 68.65 autogamy per cent value. In the other experimental hybrids the autogamy per cent ranged from 40.53 to 48.69. In a similar study, Robinson (1980) also observed very low autogamy for populations and high autogamy for hybrids (41 to 46 per cent) over two seasons.

Although a genotype is considered as self fertile based on its seed production under bagged condition, George *et al.* (1980) pointed out that this procedure fails to ensure the potential self-pollination in some genotypes that can be achieved by manual self-pollination and hence this should be included in self-compatibility estimations. Besides, environmental factors influence self-compatibility in sunflower (Pinthus, 1959; Vranceanu *et al.*, 1978; George *et al.*, 1980). These factors will be considered in future studies. The present study has brought out the importance of developing self-fertile

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TABLE 1. Per cent seed set under bagged condition, open pollination and autogamy in sunflower genotypes.

Genotype	% seed set under		Autogamy (%)
	Bagged condition	Open pollination	
Open pollinated varieties			
EC. 68415	0.07	85.62	0.08
CGP-1	4.29	83.05	5.17
Morden	13.65	85.18	16.02
Mean	6.00	84.62	7.09
Parental lines (Inbreds)			
234 B	39.71	74.58	53.24
302 B	22.85	82.37	27.74
308 B	42.89	78.51	54.63
RHA. 274	35.97	88.39	40.70
RHA. 801	46.80	89.70	52.17
Mean	37.64	82.71	45.70
Hybrids			
234 × 274 (BSH-1)	55.28	80.53	68.65
234 × 801	59.34	85.54	69.37
302 × RHA. 274	39.61	81.35	48.69
302 × RHA. 801	35.61	87.86	40.53
308 × RHA. 274	36.07	83.37	43.27
308 × RHA. 801	36.72	82.95	44.27
Mean	43.77	83.60	52.46
Overall Mean	33.49	83.50	40.33
S.D.	17.52	4.04	21.23

populations/hybrids for areas where natural pollinating agents are limited. Besides, when peak rainy period coincides with the flowering phase, the transfer of pollen is not effective either manually or through bee activity. Under such situations the use of high self-fertile lines assume great importance. In cross pollinated plants continuous autogamy may lead to inbreeding depression. But in sunflower hybrids and inbreds self-fertility is not obligatory but facultative. In other words, in the absence of cross pollination, self pollination or autogamy comes into operation and thus enhance seed set and yield. In areas of low bee activity, commercial cultivation of hybrid sunflower is suggested to alleviate the poor seed-set problem as hybrids in general are more self-compatible.

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ESTIMATES OF GENE EFFECTS WITH RESPECT TO YIELD AND ITS COMPONENT TRAITS IN INDIAN MUSTARD

PARKASH KUMAR, T. P. YADAVA, A. K. YADAV and S. K. THAKRAL
Department of Plant Breeding, Haryana Agricultural University, Hisar — 125 004 Haryana (INDIA)

In Indian mustard, very limited information, is available regarding the relative magnitude of gene effects (Hayman, 1958) of a particular cross combination. Therefore, an attempt has been made in the present study to determine the relative magnitude of gene effects and to identify the suitable cross combination which could give promising segregants with respect to yield and its component traits in Indian mustard.

The experimental material included 6 F_1 crosses (Prakash × RL-18, RL-18 × RH-30, RH-30 × Rai B/85, T-59 × Rai B-85 Dwarf mutant (D.M.) × Rai B/85 and T-59 × Laha 101), their parents (i.e., P_1 and P_2), F_2's, BC_1's, and BC_2's that were grown at the farm of Haryana Agricultural University, Hisar. The parents, F_1's, BC_2's and BC_2's included a single row whereas the F_2 population included 5 rows plot that were 4.5 meter long The spacing of 30 × 15 cm was maintained between and within rows for each population. Data for seed yield, days to maturity, plant height, primary branches, siliqua length, and 1000 seed weight were recorded on 5 plants in parents, F_1'S, BCIs, BC_2's and for 20 plants in the F_2 populations. Scaling tests as suggested by Mather (1949), were conducted. The six components of generation means (i.e., m,d,h,i,j and l representing the mean, additive, dominance, additive × additive, additive × dominance and dominance × dominance components respectively were estimated from the population means of P_1, P_2, F_1, F_2, BC_1 and BC_2 generatinons based on the method suggested by Hayman (1958).

The scaling tests indicated the presence of epistasis for all the characters under study and, therefore, it was considered to be desirable to use the model that included epistatic effects. The mean effects (m) were significant in all the crosses for all characters except for seed yield in two crosses (RL-18 × RH-30 and RH-30 × Rai B/85). The magnitude of the mean effects was greater than the corresponding additive and dominance components in all the crosses for all the characters except for total siliquae where, in some of the crosses the magnitude of dominance component was greater. The additive genetic components was significant for all the traits in all the crosses except T-59 × Rai B/85 for seed yield, days to flowering and primary branches; RH-30 × Rai B/85 for days to flowering, seeds per siliqua and 1000 seed weight; Prakash × RL-18 for days to flowering, plant height and siliqua length; RL-18 × RH-30 for seeds per siliqua and 1000 seed weight and D.M. × Rai B/85 for siliqua length and seeds per siliqua. The dominance component was also significant with respect to characters under study for all the crosses except RL-18 × RH-30 for days to flowering, primary branches and seeds per siliqua; D.M. × Rai B/85 for plant height and siliqua length; T-59 × Rai B/85 for plant height and siliqua length; T-59 × Rai B/85 for primary branches and total siliquae; Prakash × RL-18 for siliqua length and 1000 seed weight. The magni-

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tude of dominance component was generally higher compared to the corresponding additive genetic components for all the traits in all the crosses with the exception of few crosses; D.M. × Rai B/85 and T-59 × Laha-101 for seed yield and plant height; Prakash × RL-18 for seeds per siliqua, 1000 seed weight; and RH-30 × Rai B/85 for 1000 seed weight. Regarding epistatic effects, it was observed that all crosses exhibited significant epistatic effects for one or more of the three types of estimates (additive × additive, additive × dominance, and dominance × dominance) with respect to all the characters.

The results have clearly indicated the presence of additive, dominance, and epistatic interactions for the inheritance of yield and its components in Indian mustard. Under the situations, as prevailing in the present study, the breeders job become very difficult to simply because of the complicated genetic make up. Further, it is possible to exploit either the fixable portion (i.e., additive genetic component) or non-fisable portion (i.e., dominance genetic component) or both the fixable and non-fixable portions by adopting suitable breeding methodologies, provided the characters under improvement are not influenced by the epistatic effects.

The selection of a suitable breeding strategy for the improvement of different traits would have to be different for different crosses. This would depend on the relative magnitude of genetic components in a particular cross. The presence of higher magnitude of additive genetic components in some crosses for some traits suggests that these could be fixed in the population by resorting to appropriate selection procedures. On the other hand, to exploit the dominance variance, heterosis breeding may be fruitful provided some genetic machanism is available for the production of hybrid seed economically. But, unfortunately, no such mechanism is available in Indian mustard for producing the large quantities of F_1 seed commercially. The presence of both additive and dominance components in some of the crosses would certainly require a breeding strategy that would select for desirable alleles and at the same time, maintain sufficient heterozy-gosity for the exploitation of dominance gene effects in the population. Intermating of the selects in the early segregating generations would be most appropriate to exploit simultaneously the additive and dominance components. It may also break the undesirable linkages and subsequently results in the establishment of rare desirable recombinants. The genetic mechanisms like self incompatibility (Singh, 1959) or protogynous condition (Singh, 1961) may facilitate the recombinations. The use of mass selection with concurrent random mating as suggested by Redden and Jensen (1974), could be another possibility for population improvement.

TABLE 1. Showing the effects with respect to yield and its component trials in Indian mustard

	Seed yield						Days to flowering	
	m	d	h	i	j	l	m	d
Prakash × RL-18	26.50*	15.06*	49.96*	46.67*	28.46*	–109.13*	45.33*	– 0.67
RL-18 × RH-30	23.43	10.77*	19.87*	17.93*	19.13*	– 50.27*	45.33*	7.67*
RH-30 × Rai B/85	23.06*	6.67*	36.40*	25.20*	2.13*	– 62.40*	43.00*	–1.00
T-59 × Rai B/85	25.50	– 0.76	0.13*	– 6.73	–6.73*	– 28.93*	43.67*	0.33
D.M. × Rai B/185	26.23*	17.67*	3.63*	–2.67*	27.53*	– 35.93*	41.33*	2.67*
T-59 × Laha 101	30.03*	6.97*	–2.83*	10.07*	19.60*	– 1.93*	44.00*	4.66*
	Primary branches						Secondary branches	
	m	d	h	i	j	l	m	d
Prakash × RL-18	5.36*	1.03*	2.53*	2.86*	3.00*	–2.26*	19.13*	2.73*
RL-18 × RH-30	5.50*	1.43*	2.36	1.00	0.26	1.00*	13.16*	5.13*
RH-30 × Rai B/85	5.16*	–1.10*	3.60*	2.46*	2.40*	–5.46*	13.36*	0.62*
T-59 × Rai/B/85	5.93*	0.03	–1.15	–2.06*	0.70*	1.76*	16.16*	3.73*
D.M. × Rai B/85	7.03*	0.39*	–5.18*	–6.28*	1.44*	6.10*	23.46*	3.97*
T-59 × Laha-101	6.30*	–0.33	–2.86*	–3.33*	0.26	1.33*	18.53*	–0.93*
	Seeds per siliqua						Total siliquae	
	m	d	h	i	j	l	m	d
Prakash × RL-18	14.16*	0.96*	0.41	–1.13*	2.96*	0.10	576.30*	174.23*
RL-18 × RH-30	14.00*	0.10	1.09	0.14	–10.70*	3.92*	447.20*	103.76*
RH-30 × Rai B/85	14.76*	0.22	–0.91*	–2.20*	–0.26	–1.09*	549.20*	37.53*
T-59 × Rai B/85	13.30*	–1.21*	6.26*	5.76*	0.24	–5.96*	589.00*	–95.60*
D.M. × Rai B/85	13.53*	–0.26*	–0.73*	–0.63*	0.47	8.00*	668.70*	190.86*
T-59 × Laha-101	11.90*	–1.48*	4.62*	4.77*	0.62	–2.18*	750.86*	9.69

* denotes significance at P = 0.05.

						Plant height			
h	i	j	l	m	d	h	i	j	l
21.83*	20.00*	-0.33	-15.67*	221.40*	-0.16	22.86*	24.88*	11.80*	4.40
18.33	12.67*	8.67*	-4.67	215.10*	24.70*	48.86*	44.46*	28.46*	-14.39*
0.67*	6.00	1.33	-4.00*	225.06*	-22.16*	73.70*	-46.06*	-22 80*	6.86*
-6.33*	-10.00*	-10.00*	15.33*	198.76*	9.93*	16.90*	0.13	-30.60*	-35.53*
9.67*	5.33*	-7.33*	-0.67*	193.10*	12.07*	10.16	-20.30*	-9.50*	-16.33*
-7.50*	-10.67*	0.33*	11.00*	207.76*	22.76*	-3.46	-15.53*	-19.20*	-20.26*

						Siliqua langth			
h	i	j	l	m	d	h	i	j	l
4.11*	3.60*	3.23*	21.30	3.86*	-0.01	-0.94	-0.99*	0.13	0.95*
5.98*	7.73*	7.83*	-19.56*	8.80*	-0.90*	-0.63*	0.82*	-0.07*	0.50*
3.98*	2.45*	6.45*	-5.17*	4.00*	-0.15*	0.10	-0.04	-0.40*	-0.60*
-4.01*	-8.40*	9.23*	4.16*	3.76*	-0.20*	1.27*	0.80*	-0.27*	0.28*
-33.83*	36.93*	8.84*	31.40	4.43*	-0.07	-1.99*	-2.38*	0.34*	2.52*
-1.85*	-3.46*	-1.96*	3.03	3.93*	0.77*	-1.30	-1.10*	0.27*	2.33*

						1000 seed weight			
h	i	j	l	m	d	h	i	j	l
792.89*	856.99*	166.53*	102.01	3.76	-0.36*	0.01	0.06	-0.63*	-0.70*
412.30*	394.73*	94.80*	11.62	4.03	-1.00	1.76*	2.53*	-0.33	-4.60*
269.00*	-318.66*	7.86	750–80*	4.33*	0.20	-0.28	-0.26*	-0.50*	1.23*
-102.61*	-337.20*	-494.36*	526.56*	3.60*	1.20*	-1.10*	-0.53*	0.66*	1.13*
-347.81*	-464.80*	250.56*	-116.23*	3.26*	-0.06	0.05	0.13	-0.23	-0.36
-857.95*	92.36	5.42	1099.64*	4.10*	0.96*	1.26*	1.26*	-0.20	-1.73*

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CHARACTERISATION OF OIL AND PROTEIN DYNAMICS IN DEVELOPING SUNFLOWER (*HELIANTHUS ANNUUS* L.) SEEDS

S. P. SINGH, V. SINGH and P. P. SINGH.
Department of Agronomy, G.B. Pant University of Agril. Tech., Pantnagar, (Nainital)

Sunflower is a good source of high quality of edible oil. One of the major limiting factor to achieve the potential production is poor grain filling. Therefore, the under standing of the assimilated photosynthates translocation pattern and knowledge of its various distribution within the plant has a considerable significance in plant development and grain yield.

A pot culture experiment with sunflower variety paredovic (EC68414) was conducted during spring 1976 at Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, to study the oil and protein accumulation pattern in the seeds of different reproductive growth stages (3rd to 48 days after anthesis). The experiment was laid out in complete randomized block design with three replications. The plastic pots were filled with 2kg silt loam soil and were fertilised @ 80 N; 60 P_2O_5; 40 K_2/ha respectively. Three seeds per pot were placed at 5 cm depth and were thinned to one plant per pot after two weeks. Pots were watered whenever required. At bud initiartion stage, plants were exposed for one hour to $^{14}CO_2$ ($^{14}CO_2$ was produced by reacting $NaCO_3$ of 0.06 mei activity with lactic acid) in assimilation chamber. After the exposure to $^{14}CO_2$, pots were removed from the assimilation chamber and allowed to grow under normal condition. With the anthesis initiation a daily account of all the bloomed rows in the disc floret was kept till complete anthesis of head. To get the seeds of different age groups, 5 plants were harvested at each stage. Collected seeds of different age groups were grounded separately by wiley mill. For protein counts - 40 mg ground material was kept in test tube and poured 10 ml of 5% TCA upto 15minutes under shaken condition. The solution was filtered and then residue was transferred to planchet and counts were recorded through G.M. counter upto 20 seconds. For oil counts the finally ground samples were used for oil extraction. The oil was determined by soxhlet extraction method using petroleum ether as the solvent (Anon. 1974). A 40 mg oil was taken in planchet and recorded counts through G.M. counter upto 20 seconds.

The radioactivity in protein increased with the age upto 15 days after anthesis and thereafter, a marginal reduction in counts was observed. The seeds of different age groups differed significantly among themselves with respect to their counts in protein (Table 1). The maximum counts (5.325×10^4 cpm g^{-1}) recorded at 15 days after anthesis which were on par with 18, 21, 24, 27, 30, 33, 36, 39, 42, 45 and 48 days after

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Present address : Scientist S-2 (Agronomy), Directorate of Rice Research, Rajendranagar, Hyderabad — 500 030.

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TABLE 1. Radioactivity in protein and oil of seeds collected on different days after anthesis

Days after anthesis	Protein (C p m × 10^4 per gm)	Oil (C p m × 10^4 per ml)
3	3.525	2.100
6	3.920	2.380
9	4.205	2.725
12	4.720	3.065
15	5.325	3.405
18	5.280	5.860
21	5.225	4.315
24	5.230	4.655
27	5.220	5.905
30	5.170	6.300
33	5.110	7.265
36	5.050	7.155
39	5.115	7.095
42	5.055	6.985
45	5.055	6.955
48	5.110	6.945
S.Em ±	0.101	0.102
C.D (p=0.05)	0.301	0.366

anthesis and all these stages had significantly higher counts than the counts of 3, 6, 9, and 12 days after anthesis. However, a consistent and significant increase in counts was recorded upto 15 days after anthesis. Kumar *et al.* (1976) also reported that the seeds of the outer zone of sunflower head received more radioactivity than inner zone seeds because inner seeds were relatively functionally poor sink.

The radioactivity in oil increased upto 33 days after anthesis and thereafter, a marginal reduction in counts was recorded (Table 1). A consistent and significant increase in counts were recorded upto 33 days after anthesis and thereafter the differences were not significant. The maximum counts (7.26 × 10^4 cmpg^{-1}) recorded at 33 days after anthesis which were on par with 36, 39, 42, 45 and 48 days after anthesis and all these six stages had significantly higher counts than those recorded at 3, 6, 9, 12, 15, 18, 21, 24, 27, and 30 days after anthesis. Ivanow (1912) also reported a sharp increase in oil in first few weeks after blooming and slow down towards the end of ripening.

From these findings, it can be concluded that protein accumulation reaches maximum level earlier and then oil formation starts with the highest level reaching around 33 days after anthesis. It could be due to the fact that photosynthates were being utilised for protein synthesis in the early stages of seed development and subsequently for oil synthesis.

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INHERITANCE OF OIL AND PROTEIN CONTENT IN SESAME

I. S. YADAV and S. K. GUPTA.
Department of Plant Breeding, Haryana Agricultural Univeristy, Hisar — 125 004 (INDIA)

Sesame (*Sesamum indicum* L.) is one of the major oil yielding crops in India. Sesame seed is not only rich in oil but also in proteins with relatively high proportion of essential amino acid, methionine (Dhindsa and Gupta, 1973). Information on the nature of gene action governing the various agronomic and chemical characters of crop plants is of crucial importance to breeders for the improvement of the crop. While efforts to increase the seed yield in sesame had been attempted, the work to improve oil content through breeding manipulation is limited. Hence a study was conducted to understand the genetic control of oil and protein content for adopting suitable breeding methodology for high oil and protein content in sesame.

With ten diverse lines of sesame diallel crosses without reciprocals were raised. The 10 parents and their 45 hybrids were planted in a randomized complete block design with 3 replications at Haryana Agricultural University, Regional Research Station Bawal in Kharif 1983. In each replication, parents as well as hybrids were alloted a single plot each. Each plot comprised a single row of 5m length with a spacing of 30cm between rows and 15 cm between plants in a row. The percentage of oil was determined from the bulk sample of 10 plants by NMR technique. The percentage of crude protein was estimated by multiplying the total per cent of nitrogen of the seed by the factor 6.25. The total percent nitrogen was determined by micro-Kjeldahl procedure. The components of variation were estimated according to the procedure of Hayman. (1954). Heritability in the narrow sense was worked out according to Crumpacker and Allard (1962).

The analysis of variance revealed highly significant difference among the genotypes for oil and protein content. The genetic components of variation and their standard errors estimated from the diallel analysis together with the ratios of the genetic components, heritability and t^2 (F) tests are given in Table-1. Non-significant t^2 (F) value indicated the fulfilment of assumptions concerning the diallel cross analysis. The D component which measures additive variation was highly significant for both oil and protein content. The H_1 component which measures the dominance variation was also highly significant and larger in magnitude than the D component for both the characters. This suggested that dominance component had a predominant role in the inheritance of oil and protein content. Murty and Hashin (1973) also reported the importance of both additive and dominance components for the inheritance of oil and protein content in sesame. Narkhede (1986) also reported the importance of both additive and non-additive components for protein but on the contrary he reported that oil content in sesame was governed by non-additive gene action. The H_2 component of both the characters were significant and were different in magnitude. From their

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TABLE 1. Components of variation for oil and protein content in sesame.

Components of variation	Mean squares	
	Oil	Protein
D	7.56** ± 1.37	7.49** ± 22.37
F	11.21** ± 3.16	20.60** ± 10.94
H_1	20.01** ± 2.92	92.59** ± 20.19
H_2	13.48** ± 2.48	72.51** ± 17.16
h'	7.45** ± 1.66	7.45** ± 2.67
E	0.05 ± 0.41	0.12 ± 0.71
$(H_1/D)^{\frac{1}{2}}$	1.62	3.51
$H_2/4H_1$	0.41	0.19
KD : KR	2.67	2.28
h^2/H_2	0.55	0.10
Heritability (%)	15.67	9.36
t^2	0.03	0.87

respective magnitudes of H_2 indicating asymmatry of gene distribution in parents which was confirmed from $H_2/4H_1$ estimates.

The estimates of F which measures the covariance of additive and dominance effects was positive and significant, indicating an excess of dominant alleles in the parents for percentage of oil and protein content. The h^2, which measures the net dominance effect expressed as an algebric sum over all loci at the heterozygous phase, indicating thereby that the mean direction of dominance was positive for both oil and protein content. The ratio $(H_1/D)^{\frac{1}{2}}$ was more than unity for both the characters and was in the range of over dominance. The KD : KR ratio which provides an estimate of the proportion of the total number of dominant and recessive genes in the parents, suggested that for every recessive gene there were at least two dominant genes or gene groups. The ratio of h^2/H_2, reflecting the number of gene groups controlling a character, were small and are known to be under estimated unless the 'h' effects of all the genes are equal in size and sign, and the distribution of the genes uncorrelated. The narrow sense heritability estimates were rather low for oil and protein. The predominant role of dominance component and low heritability estimate suggested that progress for selection of oil and protein content would rather be slow. Hence recurrent selection might be adopted for improvement or elevation of additive variability for oil and protein content in the genotypes of sesame.

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IRRIGATION TIMING AND LEAF AREA SURVIVAL IN SUNFLOWER

M. R. HEGDE,
Department of Agronomy, University of Agricultural Sciences, College of Agriculture, Bangalore — 560 065.

Sunflower is used as drought indicator plant as it shows the moisture stress symptoms earliest than many of the crop plants. Some of the reasons for this nature being hypersensitive stomata, where stomata close early sensing stress and open early after its alleviaticn. Crop also found to put forth rapid ramification of secondary/tertiary roots immediately after moisture alleviation thereby depleting the soil moisture quickly. Its short duration nature, adaptability to varied soil and climatic conditions drought tolerance nature and photo insensitiveness have made this crop a ideal one for rainfed situations. Lindstorm *et al* (1982) reported that Sunflower's capacity to yield well under water stress was due to a drought escape mechanism rather than lower water requirements. Sunflower has been reported to be more sensitive to moisture stress during flowering stage. Roblein (1967) concluded that 20 days before and 20 days after flowering as the most sensitive period for moisture. There are indications that Sunflower can tolerate the moisture stress during early stages of crop growth. Rawson and Turner (1982) had shown that crop has the capacity to recoup the loss in reduction of earlier leaf area due to moisture stress once it is alleviated. This study was undertaken to know the effect of moisture stress during different growth stages on growth and yield of Sunflower with particular reference to leaf area survival.

Experiment was conducted during 1985 crop season at Main Research Station, University of Agricultural Sciences, Bangalore. Treatments included (i) No Stress (ii) Moisture stress during vegetative state (0–21 days after sowing) (iii) Moisture stress during early flowering (22 to 43 days after sowing) (iv) Moisture stress during late flowering (44 to 65 days after sowing) (v) Moisture stress during seed filling (66 DAS to harvest). In case of no stress treatment, whenever cumulative pan evaporation (CPE) totalled to 50mm, 5cm depth of irrigation was given. In case of moisture stress treatments irrigation was given only when soil moisture content in the top 0–30 cm layer reached permanent wilting point (4.80 per cent). Experiment was laid out in randomised block design with four replications.

Data (Table 1) indicated that moisture stress during different growth stages of the crop affected the yield, yield parameter, leaf area index and leaf area duration considerably. Late flowering followed by seed filling stages of Sunflower found to be most critical in respect of moisture. Yield reduction due to moisture stress at vegetative phase, early flowering, late flowering and seed filling stages was to the extent of 16.4 14.0, 27.3 and 23.5 per cents respectively over no stress. Yield parameters like seed

Present address : Scientist S-1 (Agronomy), Directorate of Oilseeds Research, Rajendranagar, Hyderabad — 500 030.

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TABLE 1. Effect of Moisture Stress during different growth stages on yield, yield parameters, Leaf area index and leaf area duration of Sunflower.

Treatments	Yield kg/ha	Seed yield g/plant	Per cent seed filling	Leaf Area Index				Leaf Area duration Days			
				I	II	III	IV	I	II	III	IV
No stress	1708	18.79	89.8	0.91	1.98	3.05	1.49	19.1	31.6	55.0	54.2
Moisture Stress at vegetative stage	1429	16.41	88.0	0.68	1.60	2.72	1.44	14.3	23.8	47.1	49.3
MS at Early flowering	1469	16.93	88.2	0.90	1.42	2.79	1.47	18.9	25.5	47.4	49.7
MS at late flowering	1242	14.00	82.2	0.90	1.95	2.19	1.19	18.9	31.2	45.3	40.9
MS at seed filling	1307	15.12	84.4	0.90	1.94	3.01	1.32	18.9	31.2	54.3	52.0
CD at 5 %	74.5	1.45	0.91	0.019	0.019	0.027	0.016	0.27	0.33	0.42	0.71

I — Vegetative State (21 days after sowing)
II — Early flowering (43 days after sowing)
III — Late flowering (65 days after sowing)
IV — At Maturity.

yield per plant and per cent seed filling found to contribute to these variations in seed yields. Where seed yield per plant and per cent seed filling recorded was significantly lower due to moisture stress during late flowering followed by seed filling.

In Sunflower leaf area index and leaf area duration at flowering have been positively correlated with seed yield. Rawson and Turner (1983) revealed that there isa close relationship between total area of green leaf carried by the crop at anthesis and crop seed yield. In the present study it was observed that at flowering stage significantly lower LAI was noted with moisture stress during late flowering (2.19) and at harvest it was significantly lower due to moisture stress during seed filling stage (1.19). At the end of late flowering LAD recorded was significantly lower (45.3 days) over no stress (55.0 days) due to with holding water from 43 to 65 days after sowing. LAD recorded for 65 DAS to harvest period also was significantly inferior due to moisture stress during late flowering stage (40.9 days) as compared to no stress (54.2 days).

It was observed that Sunflower can tolerate the moisture stress experienced during early period of growth by improving the lost leaf area once it is alleviated. Close perusal of LAI data clearly demonstrates this behaviour of the crop. Moisture stress during vegetative stage recorded LAI of 0.68 as compared to 0.90 with no stress. By the end of early flowering stage (43 DAS) the LAI recorded with moisture stress during vegetative stage was 1.60 as compaied to 1.98 observed with no stress. By the time of late flowering (65 DAS) there was further improvement i.e., LAI recorded was 2.72 with moisture stress during vegetative stage as against 3.06 with no stress. Similar improvement in leaf area after moisture stress during early flowering once it is alleviated was also noticed. The improvement in leaf area after moisture stress at vegetative stage (0–21 DAS) by the time crop reached flowering stage was more (75 %) than that observed due to no stress treatment (71 %) for the same period. It was observed in this study that increase in leaf area after moisture stress alleviation was more conspicuous in early formed leaves than one which have late emerged. The results of the investigation clearly demonstrate that late flowering and seed filling stages are critical periods in respect of moisture. Sunflower has the capacity to revive the lost leaf area due to moisture stress during early part of the crop growth once it is favourably alleviated later.

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EFFECT OF VARIETIES, NITROGEN LEVELS AND SPA ON SEED YIELD OF NIGER *(GUIZOTIA ABYSSINIC.*

P. K. SAHU, R. C. MISRA and S. V. RAO,
Regional Research Station, Semiliguda, Post Box No-10, Sunabeda — 763 002, K

Niger is the third important Oilseed crop of Orissa and is cultiv of 159,294 hectares. It is generaly cultivated in slopy lands of the hi state, mostly in Koraput, Phulbani, Keonjhar and Mayurbhanja dis mostly cultivated by the tribals, improper crop husbandry is the most of low productivity of the crop in the state. Information on crop hu ed varieties of niger is quite limited. So the present investigation determine the optimum nitrogen and spacing requirement of the niger for increasing the productivity of the crop.

The experiments were conducted at Niger Improvement Project, Semiliguda (at an altitude of 884 m) during Kharif, 1985 and 1986, in split Split plot design with 3 replications with varieties (N–71 and IGP–72) in main-plots, Nitrogen levels (0. 15, 30 and 45Kg/ha) in sub-plots and spacings (30 cm × 8cm 30cm × 10 cm and 30 cm × 15 cm) in sub-subplots. Nitrogen, as per treatments, was applied in form of urea in two equal splits, one before sowing and other 21 days after germination. 20 Kg P_2O_5 (S.S.P)/ha was applied as basal. Net plot size were 11.2 and 10.8 sqm. during 1985 and 1986. Seed yield data were recorded and analysed individual year wise and both years pooled.

Analysis of yield data indicated similar results during both the years, except for difference between varieties was significant during 1985 and not significant during 1986 (Table-1). Pooled analysis results of both years indicated significant difference among varieties (V), levels of nitrogen (N) and spacings (S). However, all the first order interactions (VXN, VXS and N × S) and second order interaction (VXNXS) were not significant during both the years. During 1985 and 1986 highest yields of 538 and 426 Kg/ha respectively were recorded for the variety N 71 with 45 Kg N/ha and 30 × 15cm spacing.

VARIETIES

During 1985 the differences between varieties were significant with N–71 giving higher yield, while in 1986 they were at par. The pooled analysis indicated significant difference between the varieties, with N–71 producing an average yield of 338 Kg/ha against 319 Kg/ha for IGP–72.

NITROGEN

Both year wise and pooled analyses indicated significant differences in yield at different levels of nitrogen epplication. Regression of yield on nitrogen levels indicated

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TABLE 1. Yield (kg/ha) of Niger, as influenced by varieties, nitrogen levels and spacings.

Treatments	1985	1986	Pooled
Varieties			
N-71	434.0	242.4	338.2
IGP-72	393.1	244.3	318.7
C.D. (5%)	33.3	N.S.	11.2
Nitrogen levels (Kg)			
0	282.7	91.3	187.0
15	409.2	169.8	289.5
30	424.1	286.8	355.5
45	538.2	425.7	482.0
C.D. (5%)	52.1	20.5	36.2
Spacings			
30cm × 8cm	392.5	215.1	303.8
30cm × 10cm	394.4	244.0	319.2
30cm × 15cm	453.9	271.0	362.5
C.D. (5%)	45.4	15.5	23.9

that both the varieties showed linear increase in yield with increase in nitrogen levels. However, the variety N-71 showed slightly better response to nitrogen application with b-value of 7.01 against 5.67 for IGP-72. Pooled analysis of response to nitrogen showed b-value of 6.34 which indicated that there was an average increase of 6.34 Kg of seed yield with each Kg of Nitrogen applied. Considering cost of seed yield and Nitrogen, it was observed that application of nitrogen is quite economical upto 45 Kg/ha. Jaipurker and Puri (1985) in a study with niger reported similar increase in seed yield and Oil production with increased levels of nitrogen upto 60 Kg N/ha and observed that 45 Kg N/ha was optimum and most economical for niger.

SPACING :

Significant difference among yield levels at different spacings were observed during both years of study and increase in yield was observed with wider spacing. Pooled analysis did not show significant difference in yield of 30 × 8 cm and 30 × 10 cms spacings, which may be due to very high plant population. However 30 × 15 cm spacing gave a significantly higher average yield of 362.5 Kg/ha. It was due to the fact that the improved varieties under the study have better vigour, proper growth and branching producing more and larger capitula with wider spacing, there by increase in yield.

Thus, summing up all aspects of the study it was observed that variety N-71 has a potentiality of higher yield than IGP-72. Both the varieties responded well to nitrogen application and nitrogen application was economical upto 45 Kg / N/ha. Moreover, optimum spacing for the improved varieties under fertilizer application was 30cm × 15cm i.e.a population density of about 2.2 lakh/ha.

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LEAF AREA ESTIMATION IN MUSTARD BY SHORT CU. METHOD

B. N. REDDY[1] and M. PRABHAKAR[2]
Division of Agronomy, Indian Agricultural Research Institute, New Delhi — 110 012.

Leaf area determination in mustard (*Brassica Juncea* (L) czern & coss) is of paramount importance as it gives an expression of growth of leaves which are the sources of photosynthetic material. The variation in leaf area under the influence of environmental factors, edaphic factors and plant density has been observed by many workers. But studies on easy method of leaf area estimation in mustard are negligible. Since leaf area has shown a fairly good relationship with some easily measurable characters like length and breadth and dry weight etc., (Sheshadri and Shanmugham, 1983 and Singh *et al*, 1984), the present study was made to find out the relationship with easily measurable characters.

Investigations were carried out during *rabi* season of 1984-85 at Indian Agricultural Research Institute, New Delhi. Ten plants of mustard crop (variety Pusa bold) grown under varied fertility conditions were selected randomly and all the leaves were used for leaf area estimation at flowering and pod development stages. The exact leaf area was determined by Automatic Leaf Area Meter (LI-COR Area Meter-Model LI-3100), in Addition length, breadth and dry weight were also recorded for respective leaves.

Studies of correlation and regression between leaf area and dry weight, leaf area and product of length and breadth were made separately at two stages of crop growth.

The correlation coefficients between leaf area and other characters were found to highly significant (Table 1). On overall basis, the highest correlation was obtained between leaf area and dry weight ($r = 0.954$) followed by leaf area and length $\times$ breadth ($r = 0.930$). The highest correlation coefficient was obtained between leaf area and dry weight at pod development stage ($r = 0.969$) closely followed by flowering stage ($r = 0.967$). The correlations between leaf area and length $\times$ breadth were also highly significant but the correlation coefficient was the highest at flowering state ($r = 0.899$) The flowering stage seems to be better indication of leaf area of plant than later stages.

The linear equation was a better fit than quandratic. High value of correlation coefficient ($r = 0.954$) between leaf area and dry weight leads to infer that estimation of leaf area can be accurately made from dry weight.

Observations on each character and estimates of area obtained from regression equations between leaf area and length $\times$ breadth and leaf area and dry weight are

Present address : 1. Scientist (Agronomy), Directorate of Oilseeds Research, Rajendranagar, Hyderabad — 500 030.
2. Scientist (Agronomy), Central Tuber Crops Research Institute, Trivandram.

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TABLE 1. Correlation and regression between leaf area (Y) and other characters (X)

Character (X)	Correlation between Y & X	Regression equation
I. *Dry weight at*		
Flowering	0.967**	Y = 109.08 + 164.79 X
Pod development	0.969**	Y = 294.16 + 123.29 X
Over all	0.954**	Y = 166.51 + 151.5 X
II. *Length × breadth (Sq.cm) at*		
Flowering	0.949**	Y = 100.27 + 0.561 X
Pod development	0.899**	Y = 41.14 + 0.539 X
Over all	0.939**	Y = 61.16 + 0.508 X

TABLE 2. Leaf measurements and leaf area obtained from regression equations

Sample No.	Dry wt. (g)	Length × breadth (cm^2)	Actual	Leaf area (cm^2) Estimated I	II
		Flowering			
1	7.8	2699	1407	1414	1394.4
2	1.3	838	280	369	323.3
3	6.7	2156	1263	1109	1213.2
4	7.4	2920	1562	1538	1328.5
5	8.7	2765	1418	1451	1542.7
6	9.0	2657	1459	1390	1592.1
7	9.3	2975	1731	1569	1641.6
8	4.0	1408	795	690	768.2
9	5.3	1704	872	856	892.5
10	7.0	2878	1207	1514	1262.6
		Pod development			
1	4.8	1618	815	913	885.9
2	5.1	1998	1055	1118	922.9
3	4.3	1294	784	739	824.3
4	9.4	2367	1428	1317	1453.1
5	5.0	1370	878	780	910.6
6	9.6	2719	1492	1507	1477.7
7	7.9	2081	1225	1163	1268.1
8	8.5	2383	1335	1326	1342.1
9	4.6	1616	811	912	861.3
10	4.9	1817	926	1021	898.3

I — Using regression equation of length × breadth

II — Using regression equation of dry weight.

presented in Table 2. It is clearly seen that the actual measurement of leaf area and estimates of leaf area agree closely each other except in few cases. Thus, it can be inferred that it is possible to estimate the leaf area by length × breadth product method more precisely as dry weight differs for each genotype due to difference in leaf thickness.

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POD SHATTERING OF SOYBEAN IN INDIA

S. P. Tiwari and P. S. Bhatnagar
National Research Centre for Soybean Khandwa Road Indore — 452 001 India.

Extent of yield loss due to pod shattering in soybean (*Glycine max* (L.) Merill) ranges from negligible to as high as 90% depending upon time of harvestng, environmentul conditions and genetic endowment of the variety. Rainy season crop of 1987 at NRCS Indore provided good opportunity to screen large number of genotypes for tolerance against pod-shattering as the untimely rain at the maturity, followed by hot and dry weather provided favourable conditions for pod-shattering. This note attempts to categorise different soybean varieties for the degree of pod-shattering.

Twenty five varieties grown in randomised block design with four replications were screened for pod-shattering. Rating for shattering behaviour was followed as adopted by IITA, Ibadan, Nigeria. The varieties were grouped into 5 categories.

1. No pod-shattering, i.e., shattering resistant
2. <25% pod-shattering, i.e., shattering tolerant
3. 26 to 50% pod-shattering i.e., moderately shattering
4. 51 to 75% pod-shattering, i.e., highly shattering
5. > 75% pod-shattering, i.e., very highly shattering.

The varieties studied represented a wide range of variability with score of pod-shattering from 1 (no shattering) to 5 (very high shattering). The scores for pod-shattering for a single variety were found to be more or less consistent in all the replications. Mean value of pod-shattering score for the population was 3.02 ± 1.26.

Out of 25 varieties studied, only two, namely Bragg and Himso 1520 were found to be resistant and 8 varieties were observed to be tolerant to pod-shattering (Table 1).

TABLE 1. Categorization of soybean varieties according to extent of pod shattering

Score *	Category	Soybean varieties
1	Shatterinng resistant	Bragg, Himso 1520
2	Shattering tolerant	JS-81-714, PK-472, DS-2, PBN-104 JS-79-277, AKSS-65, JS 71-05, PK-416
3	Moderately shattering	MACS-13, MACS-58, Gaurav, AKSS-34, JS-79-81, JS-79-291, Durga, PK-262
4	Highly shattering	JS-81-303, JS-8 -21
5	Very highly shattering	JS-2, Lee, Co-1, Punjab-1, Kalitur

After IITA, Ibadan, Nigeria

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Elight other narieites showed pod-shattering of a moderate rating. Two varieties viz. JS 81–303 and JS 80–21 exhibited high pod-shattering. Five varieties viz. JS–2, Lee, Co–1, Punjab–1 and Kalitur showed very high pod-shattering. The present study has identified Bragg and Himso 1520 as ıesistant to pod-shattering which can be used as donor parents in breeding programmes. The results also warn about the vulnerability of some popular varieties viz. Punjab–1, JS–2 and Kalitur and to some extent of Gaurav and Durga also to pod-shattering. It is suggested that in the Central Zone, area under Gaurav and Punjab–1 should be diverted to the variety PK–472 which is recommended for the Central Zone and was found to be shatte-ing-tolerant as yield erosion in this variety was comparatively much less.

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METHODS OF VEGETATIVE MULTIPLICATION IN GROUND-NUT

P. SEN, K. JOHNSON GEORGE and T. G. K. MURTHY,
National Research Centre for Groundnut (ICAR) Junagadh — 362 015.

Adequate population in F_2 generation is a prerequisite for any breeding programme in order to recover useful segregants. Hybridization is difficult in groundnut due to its complex floral structure and position and sufficient number of F_1 hybrids are often not recovered. Multiplication of F_1 hybrids through vegetative means will be an aid to breeding programmes as it can increase the size of F_2 population and facilitate recovery of more useful segregants and recombinants. Stem cutting method of vegetative multiplication was attempted by different workers (Harvey and Shultz, 1943; Ashri and Goldin, 1964), but feasibility of the method under field conditions of semi-arid tropics of India was not investigated thoroughly.

In the present study, eight cultivars representing different habit groups and conspecific *Arachis monticola* Karp. et Rig. which were grown in Rabi and summer were used as stock plants at maturity and three different methods of vegetative multiplication viz. stem cutting with and without hormone (0.2% indole-3 butyric acid in talc) treatment and mature plant quartet (MPQ) (Tiwari *et al.*, 1987) were employed. The propagates were transplanted in a well prepared land in the rainy season after the onset of monsoon employing two methods of planting viz. flat bed and ridges. The plots were irrigated when needed to keep up sufficient soil moisture. The survival percentage was calculated after two months of planting. The experiment was conducted for two consecutive years – 1985 and 1986 and the pooled data were subjected to analysis.

In all the genotypes studied, the mean survival percentage of MPQ was significantly higher than that of stem cutting with and without hormone treatment (Table 1). Genotypes were found to differ in their response to the MPQ method. It was highest in case of MH-2 (55.5) followed by Punjab-1 (50.0), JL-24 (43.3) and GAUG-10 (42.1). The differential response of the genotypes may be due to differential ability to recover from the transplantation shock (Zade *et al.*, 1983). No relationship was observed between growth habit of the stock plants and survival percentage. Genotypic differences were also observed in response to hormone treatment of stem cutting. Three genotypes viz. JL-24, MH-2 and *A. monticola* showed significantly higher response to hormone treatment while others did not. The overall response of genotype MH-2 was significantly more than others in all the multiplication methods which may be attributed to its compact plant type with short internodal length. Highest survival percentage obtained in case of MPQ method was due to the fact that the intact roots help in the absorption of water and nutrients instantaneously (Tiwari *et al.*, 1987).

Among the planting methods tested, the flat bed system of planting was found to be superior to ridge planting (Table 2) only in the case of MPQ method but not in

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TABLE 1. Mean survial percentage of groundnut under three different methods of vegetative propagation.

Genotype	MPQ *method*	Stem *cutting*	Stem cutting *+ hormone*	Mean survival *percentage*
JL–24	43.35	2.92	11.65	19.31
J–11	25.80	4.18	3.67	11.21
MH–2	55.50	17.95	34.15	35.87
Gangapuri	31.65	7.92	5.83	15.13
R 33–1	35.82	2.50	8.35	15.55
TMV–10	28.75	1.65	4.58	11.66
GAUG–10	42.07	8.75	5.42	18.74
Punjab–1	50.00	6.70	7.10	21.26
A. monticola	37.91	0.83	7.48	15.40
Mean survival	38.98	5.93	9.80	

C.D. (P = 0.05) method = 6.39; C.D. (P = 0.05) genotype = 11.07

the other methods. The reason may be that the flat bed system of planting assures constant moisture to the propagates during the recovery period.

TABLE 2. Effect of two different planting patterns on the mean survival percentage *under different methods of vegetative propagation.*

Method	Planting pattern		Paired 't' value
	Flat bed	Ridge	
MPQ	45.29	32.67	2.954*
Stem cutting	5.84	6.00	0.304
Stem cutting + hormone	11.67	7.94	1.360

* Significant at 5% level.

It can be concluded from the study that the MPQ method along with flat bed planting system is the most suitable method of vegetative multiplication as compared to stem cutting method under field conditions of semi-arid tropics. This method can be exploited for efficient multiplication of F_1 hybrids, general maintenance of seed sterile genetic stocks and rapid multiplication of elite genotypes.

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HERITABILITY, CORRELATION AND PATH-COEFFICIENT ANALYSIS IN SOYBEAN (*GLYCINE MAX* (L) MERR)

P. K. SAHU and R. C. MISHRA,
Regional Research Station Semiligude P.B. No. 10 Sunabeda — 763 002 Koraput ORISSA.

Yield is a polygenically controlled complex character and is determined by a number of character components which are also quantitatively inherited. A knowledge of heritability and genetic advance of the characters indicates the scope of improvement through selection. Correlation studies provide degree of association of component traits with yield and also amongst them. Path-coefficient analysis brings out the direct and indirect effects of component traits on yield. Though some studies on character association and path-coefficient analysis in soybean have been reported, most of them were based on fewer genotypes and/or limited number of characters. The present investigation based on a large array of diverse genotypes would provide a better understanding about the bearing of the component traits on yield and the scope of yield improvement through selection.

The materials for the study comprised 52 promising varieties/cultures representing diverse eco-geographic and genetic origin. The experiment was conducted at the Regional Research Station, Semiliguda (at an altitude of 884 m) in R.B.D. with three replications. Observations on days to flowering, maturity and 100–seed weight were taken on plot basis, while date on plant height, branches/plant, pods/plant, seeds/pod and seed yield/plant were recorded on ten random plants per plot. Heritability and genetic advance for the characters were estimated following Al–Jibouri *et al.* (1958). Genotypic correlations among characters were estimated after Robinson *et al.* (1951). The direct and indirect effects of component characters on yield were computed by path-coefficient analysis following Deway and Lu(1969).

HERITABILITY AND GENETIC ADVANCE :

Analysis of variance showed highly significant differences among the genotypes for all the characters, except seeds/pods. The heritability estimates were low for seeds/pod, moderate branches/plant and yield/plant and high for rest of the characters (Table-1). The heritability estimates in the investigation are broadly in agreement with reports of Johnson *et al.* (1955), and Lal and Haque (1972).

Johnson *et al.* (1955), in their studies on Soybean, pointed out that heritability alongwith genetic advance would be more effective in predicting resultant effect of selection than heritability alone. The characters pods/plant, 100–seed wt. and plant height showed high heritability as well as high GA indicating presence of additive gene effects for these characters. Thus, these characters would respond to selection with greater efficiency. Similar additive gene effects for seed weight, plant height and pods/plant were observed by Lal and Haque (1972). Days to flowering and maturity showed

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TABLE 1. Estimates of Heritability, genetic advance (% of mean) and genotypic(r_g) correlation among eight characters in Soybean.

	Characters	Heritability h^2(%)	Genetic advance G.A.(%)	Geneotypic correlations (r_g)						
				Days to maturity	Plant ht.	Branches Plant	Pods / Plant	Seeds / pod	100-seed wt.	Yield / plant
1.	Days to flowering	89.63	13.01	0.070	0.433**	0.220	0.341*	0.029	-0.242	0.181
2.	Days to maturity	86.59	9.10		0.364**	0.254	0.274*	-0.265	-0.036	0.291*
3.	Plant height (cm)	83.08	38.25			0.362**	0.630**	0.171	-0.264	0.497**
4.	Branches / plant	77.34	63.81				0.418**	0.111	-0.073	0.487**
5.	Pods / plant	85.62	52.05					0.123	-0.136	0.767**
6.	Seeds / pod	47.46	8.26						0.269	0.429**
7.	100-seeds wt. (g)	94.15	33.26							0.301*
8.	Yield / plant (g)	74.19	53.73							

*, ** — Significant at 5% and 1% levels respectively.

TABLE 1. Direct and indirect effects of component traits on seed yield of soybean.

	Characters	Days to flowering	Days to maturity	Plant height	Branches/ plant	Pods / plant	Seeds / pod	100–Seed weight.	Correlation (r_g) with yield.
1.	Days to flowering	**–0.0362**	0.0100	–0.0192	0.0331	0.2650	0.0080	–0.0794	0.181
2.	Days to maturity	–0.0025	**0.1432**	–0.0161	0.0383	0.2129	–0.0729	–0.0118	0.291
3.	Plant height	–0.0157	0.0521	**–0.0443**	0.0545	0.4896	0.0470	–0.0866	0.497
4.	Branches / plant	–0.0080	0.0364	–0.0160	**0.1506**	0.3171	0.0305	–0.0240	0.487
5.	Pods / plant	–0.0128	0.0392	–0.0315	0.0614	**0.7771**	0.0289	–0.0948	0.767
6.	Seeds / pod	–0.0011	–0.0379	–0.0076	0.0164	0.0950	**0.2751**	0.0883	0.429
7.	100–seed wt.	0.0088	–0.0052	0.0117	–0.0110	–0.1057	0.0740	**0.3281**	0.301

Residual effect = 0.3174

Underlined figures denote direct effects.

high heritability accompanied with low genetic advance (GA) indicating presence of non-additive gene action. The characters yield and branches/plant showed moderate heritability and high GA indicating that the characters are much influenced by environmental factors.

CHARACTER ASSOCIATION :

All the component traits, except days to flowering, showed significant positive genotypic correlation with seed yield (Table-1). Pods/plant showed the highest possitive correlation with yield (0.677), followed by plant height, branches/plant and seed/pod. Similar significant positive association of pods/plant, plant height, branches/plant and days to maturity were reported by Kaw and Menon (1972) and Sharma (1979., In the present investigation, 100-seed weight showed significant positive correlation with yield which is not in agreement with reports of Kaw and Menon (1972) and Malhotra *et al.* (1972).

Both days to flowering and maturity showed significant positive association with plant height and pods/plant which is in conformity with reports of Lal and Haque (1971) and Kaw and Menon (1972). The characters viz., plant height, branches/plant and pods/plant showed highly significant positive association among them, which is in agreement with report of Malhotra *et al* (1972). Seeds/pod showed very low association with all the component traits. The low negative association of 100-seed wt. with all the component traits except seeds/pod is in agreement with reports Lal and Haque (1971) and Kaw and Menon (1972). Thus, the low association among the direct yield components (pods/plant, seeds/pod and seed wt.) and their high positive association with yield indicates that there is scope of yield improvement through selection for these component characters.

PATH—COEFFICENT ANALYSIS :

The cause and effect relationship, as indicated by direct and indirect effects of the component traits on yield were studied by path-coefficient analysis (Table-2). Pods/plant had the highest postitive direct effect (0.7771) on yield. Direct effects of 100-seed wt. and seeds/pod were moderate (0.3281 and 0.2751). The indirect effects of these traits via other traits were very small. Lal and Haque (1971) and Kaw and Menon (1972) have reported high positive direct effects of pods/plant, seeds/pod and 100-seed wt. on yield of Soybean. The direct effects of rest of the characters on yield were small and their correlation with yield was much influenced by indirect effects via pod/plant.

Thus, considering heritability, genetic advance, character association and path-coefficient values of the component traits, it is evident that, yield can be improved upon through selection of genotypes with more pods/plant.

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PHYSIOLOGY OF GROUNDNUT RUST DISEASE : CHANGES IN TOTAL SUGARS, PHENOLS, ASCORBIC ACID, PEROXIDASE AND PHENOL OXIDASE

P. NARAYAN REDDY * and M. N. KHARE,
Department of Plant Pathology Jawaharlal Nehru Krishi Vishwa Vidyalaya Jabalpur—482 004 M.P

Groundnut rust was first reported in India in the year 1971 followed by a number of reports on the occurrence, host range, spread and control but a few on the physiology of rust infected plant (Subramanyam *et al.*, 1976 and Siddaramaiah *et al.*, 1979). While biochemical changes in host metabolism as a result of rust infection have been much elucidiated in cereals and similar studies on non-cereal hosts are few. Therefore the present investigation was designed to study the changes in total contents of soluble sugars, phenols, asocrbic acid, perxoidase and phenoloxidase in susceptible and resistant cultivars during the course of rust development.

Groundnut cultivar Jyothi (highly susceptible) and ICG 1697 (resistant) to rust (*Puccinia arachidis*) were raised in earthen pots (5 plants/pot) in a glass house. Plants were inoculated by spraying with fresh uredospore suspension collected on 50th day of sowing. Leaf samples were collected 2, 4, 6, 8, 10 and 12 days after inoculation for analysis.

Total soluble sugars were estimated following Hodge and Hofreiter (1962) using glucose as standard. Phenols and ascorbic acid was estimated following Bray and Thorpe (1954) and Roe (1954) respectively. Enzymes were extracted using phosphate buffer (6.1). Peroxidase activity was assayed following perur (1962). Peroxidase was expressed as specific activity units. One Unit is defined as the amount of enzyme that causes an increase in A° 470 of 0.01 in one minute at 30°C. Phenoloxidase was determined using catechol as substrate (Mahadevan and srreedhar, 1982) and was expressed as specific activity units. One unit is defined as the amount of enzyme that causes an increase in A°410 of 0.01 in one minute at 30°C.

Healthy plants of susceptible cultivar possessed higher amounts of soluble sugars than the resistant cultivar (Table 1). Inoculation of groundnut cultivars with the rust fungus resulted in an increase of total soluble sugars. In susceptible cultivar Jyoti sugars increased from second day onwards till 12th day of inoculation. However in ICG 1697 the concentration of sugars increased only up to fourth day. The increased susceptibility of groundnut to rust with increased age may be due to the higher levels of soluble sugars in the plant tissues. The extent and duration of changes in soluble sugars in infected tissues depend both on the amount of rust fungus in infected tissues and rapidity of rust development (Inman, 1962). The increase in sugars at low disease intensity in resistant cultivar may be due to enhanced dark fixation of Co_2 at the infection

* Assistant Research Officer R.A.R.S. Palem — 509 215.

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TABLE 1. **Total soluble sugars and phenol content in leaves of healthy and rust inoculated susceptible and resistant groundnut cultivars.**

Days after Inoculation	Total soluble sugars mg/g dry wt				Total phenols mg/g dry wt			
	Jyoti (Susceptible)		ICG-1697 (Resistant)		Yyoti (Susceptible)		ICG-1697 (Resistant)	
	Healthy	Inoculated	Health	Incoulated	Healthy	Inoculated	Healthy	Inoculated
2	36.51	36.54	30.67	30.68	2.65	2.69	2.93	2.98
4	35.75	35.81	31.49	31.58	2.72	2.81	2.91	3.56
6	35.94	37.83	31.46	30.25	2.69	2.92	3.03	4.21
8	36.87	41.85	30.88	30.76	2.69	3.04	3.01	4.99
10	36.85	43.55	32.10	32.00	2.77	3.45	3.02	5.99
12	36.94	39.85	32.04	32.35	2.83	3.95	3.03	3.75

TABLE 2. Ascorbic acid, phenoloxidase and peroxidase in susceptible and resistant cultivars during the course of *P. arachidis* infection.

Days after Inoculation	Ascorbic acid mg / 100 g				phenoloxidase* (A* 410)				Peroxidase* (A* 470)			
	Fresh Jyoti		ICG-1697		Jyoti		ICG-1697		Jyoti		ICG-1697	
	Healthy	Inoculated	Healthy	Inoculated	Healthy	Inoculated	Healthy	Inoculated	Healthy	Inoculated	Healthy	Inoculated
2	24.33	22.86	20.47	18.55	1.8	1.9	1.8	1.9	1.3	1.4	1.0	1.2
4	25.41	28.37	23.60	17.61	1.9	2.1	1.9	2.4	1.6	2.1	1.2	2.9
6	28.37	38.75	22.64	20.51	2.1	2.4	2.3	3.0	1.8	2.6	1.4	3.4
8	29.93	38.33	25.07	22.00	1.7	2.8	2.0	3.4	1.1	2.9	1.3	3.8
10	27.89	40.86	23.30	24.68	2.0	2.6	2.1	2.4	1.4	2.1	1.2	3.2
12	30.31	29.46	23.39	23.55	2.3	3.0	1.9	2.0	1.5	1.8	1.0	1.6

* Specific activity units.

sites (*Zaitlin, 1967*). The decline in total sugars with increase in disease intensity at the later stages of disease development may due to the drastic impairment of photosynthetic activity by formation of necrotic areas. Similar observations were made in bean when infected by *Uromyces Phaseoli* (Livine, 1964).

The amount of total phenols generally increased with the age of the plants in both the cultivars (*Table 1*). The healthy plants of resistant cultivar possed higher amount of phenols than the susceptible cultivar Jyoti. The accumulation-of phenols increased with the advancement of disease development in both the cultivars. However, phenols accumulated at faster rate in the resistant ICG 1697 than in susceptible cultivar Jyoti. It is concluded that there is no clear-cut relation between phenol content and rust resistance of groundnut cultivars. The speed of accumulation is however, related with the rust resistance. Although the final level of phenols were more in the compatible host-pathogen combination, the concentration per cell was higher in the incompatible host-pathogen reaction owing to localization of infection. Further the higher concentrations of the reducing compound, such as ascorbic acid, observed in compatible reaction may keep the phenols in less toxic state there by affecting the resistance.

Diseased leves of susceptible cultivar were characterized by higher amounts of ascorbic acid than the healthy leaves till the tenth day of inoculation, whereas the leaves of inoculated resistant cultivar had significantly lesser amounts of ascorbic acid than those of healthy leaves. Slight increase was observed on the tenth day of inoculation. (Table-2). Similar observations were made by Siddaramaiah *et al.* (1979) in groundnut and by patil and Kulkarni (1977) in sunflower infected with rust fungus.

Peroxidase and phenol oxidase activity of both the cultivars increased with the advancement of disease development (Table-2). Increase in peroxidase activity was seen upto eight day after inoculation and diminished afterwards in both the cultivars The rate of increase in phenol oxidase activity was faster in resistant cultivar than in the susceptible one. The enhanced activity of these enzymes might result in an augmented rate of oxidation of phenol resulting in the formation of more toxie quinones and these substances participate in defense reactions of the host.

The results demonstrate complex defensive biochemical mechanisms operating in the host.

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COMBINING ABILITY AND GENETIC ARCHITECTURE OF SEED YIELD IN SUNFLOWER (*HELIANTHUS ANNUS* L)

N. MOHAMED SHERIFF and R. APPADURI
Tamil Nadu Agricultural University Coimbatore — 641 003 India.

The nature of gene action governing seed yield in sunflower (*Helianthus annuus* L.) was estimated through a diallel analysis, using four well adapted genotypes of sunflower.

Four genetically diverse genotypes of sunflower viz. Tamil Nadu Agricultural University SUF. 3 (Co. 2), TNAU SUF. 4, Morden and Ex. 68414 (inbreds maintained through continuous selfiing) were raised during summer 1984 and crossed in all possible combinations. The diallel experiment consisting of four parents and 12 F_1s were raised in randomised block design, replicated four times in plots of 3 × 1.2 m, adopting a spacing of 60 × 30 cm., during kharif 1984, under irrigated conditions. Ten plants per replication in each of parents and hybrids were observed for grain yield and the mean data were subjected to combining ability and genetic analyses (Hayman, 1954).

The analysis of variance indicated significant differences among the parents and hybrids for grain yield. Five hybrids viz. SUF. 4 × SUF. 3, SUF. 3 × Morden, Ec. 68414 × SUF. 4, Morden × SUF. 4 and Morden × SUF. 3 recorded positive heterosis over the best parent (SUF. 3). The highest grain yield of 1154 kg/ha and the highest heterosis of 29.69 percent over the best parent were recorded in the cross SUF. 4 × SUF. 3.

The Combining ability analysis revealed significant mean squares due to general combining ability and reciprocal effects. The mean squares due to specific combining ability effects were non-significant. Subbaraman (1975) obtained highly significant general and specific combining ability variances for seed yield in sunflower. The t^2 estimate was significant indicating that all the assumptions of diallel set are not satisfied and non-allelic interaction might be present.

The ratio between the variances due to general combining ability (6^2g) and specific combining ability (6^2s) was more than unity (2.65), indicating the predominance of additive gene action for seed yield in sunflower. The estimates of genetic components viz. D, H_1, H_2, h_2, and F and E along with different ratios, however showed the significance of dominance (H_1) and non-significant additive (D) components (Table. 1). The ratio $(H_1/D)1/2$ which measures mean degree of dominance indicated over dominance for this trait. The observations of Subbaraman (1975) also revealed the higher magnitude of dominance (H_1) as compared to additive (D) components indicating over dominance for seed yield in sunflower. The inference drawn from combining ability and genetic analysis did not corroborate each other. Similar observations of non-correspondence between the estimates obtained from genetic and combining ability analyses have also

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TABLE 1. Estimates of genetic components and their ratios for seed yield in sunflower.

		Genetic components	Genetic ratios
D	=	0.0012 ± 0.0055	$(H_1/D)^{\frac{1}{2}}$ — 4.7258
H	=	0.0268* ± 0.0121	$H_2/4H_1$ = 0.2071
H	=	0.0222 ± 0.0146	$\frac{(4DH_1)^{\frac{1}{2}} + F}{(4DH_1)^{\frac{1}{2}} - F}$ = 0.6387
h	=	0.1919** ± 0.0100	h^2/H_2 = 8.6441
F	=	-0.0025 ± 0.0141	Heritability (narrow sense) = 23.04
E	=	0.0023 ± 0.0024	t^2 = 12.40**

* Significant at P = 0.05

** Significant at P = 0.01

been reported by earlier workers (Kanaka and Goud, 1982 and Amirthadevarathinam, 1984). The different authors under such situations suggested the operation of non-allelic interactions in determining the character concerned. The operation of additive and non-additive type of gene action in governing the seed yield in sunflower has been reported (Dua and Yadava, 1982, Gupta and Khanna, 1982 and Subbaraman, 1975).

The estimate 'F' was non-significant. The ratio $(4DH_1)^{\frac{1}{2}} + F$ and $(4DH_1)^{\frac{1}{2}}$ — F was less than unity, indicating more number of receissive genes involved in deciding the seed yield in sunflower. Asymmetrical distribution of positive and negative genes among the parents entering crosses was indicated from the ratio $H_2/4H_1$ (deviating from the theoretical value of 0.25). The ratio h^2/H_2 revealed that eight blocks of genes might be involved in the expression of seed yield. The heritability in the narrow sense was 23.04 percent.

The estimation of combining ability effects revealed significant gca effects in parent SUF. 3 and significant sca effects in the hybrid SUF. 3 × Morden. The *per se* performance of this hybrid was also considerably high.

The present investigation has thus showed the importance of gene interaction besides primary genetic effects in determining the seed yield in sunflower. Intermating of selects in early segregating generations would help to deveiop desirable recombinants for developing high yelding populations.

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STUDIES ON THE GROWING OF *CRAMBE ABYSSINICA* HOCHST IN KASHMIR

A. K. DHAR, R. SAPRU and S. KOUL,
Regional Research Laboratory (Branch) Srinagar — 190 005.

Crambe (*C. abyssinica* Hochst.) is a native of mediterranean region extending from Central Asia to Western Europe and contains 20–53% oil rich in erucic acid (Papathanasiou *et al.*, 1966). Crambe meal, seed residue after extraction of the oil, contains upto 35% proteins (Robison and William, 1966). In view of its great industrial potential and absence of any information on its performance in our country, an attempt was made to introduce the crop and assess feasibility of its cultivation under our agro-climatic conditions.

Three verieties of Crambe *viz*. Prophet, Meyer, and Indy were introduced during 1982 from USA through National Bureau of Plant Genetic Resources, New Delhi and grown at the experimental farm of Regional Research Laboratory, Srinagar. Each variety was grown in 20 m^2 area at regular monthly intervals from February through August during 1982 and 1984. During 1985, variety Meyer was sown in $60m^2$ area in March and in July. Seed from March grown crop was resown to assess its double cropping potential. The seeds were planted 2.5 cm deep, in rows, 25 cm apart. The plants within the rows were 10 cm apart after 10 days of emergence. Nitrogen at 50 kg/ha was applied in two equal doses. One as basal before sowing and the second dose, 10 days after emergence.

Data were recorded on 40 randomly selected plants within each bed, excluding the border plants and analysed in randomised block design wherever necessary. Number of days from sowing to emergence, first flowering, first pod formation and harvesting were recorded for each sowing date and expressed on a mean plot basis. Plant height was measured in centimeters from the ground level to the tip of the plant. Number of pods on the whole plant were counted and weighted in grammes at 7% moisture to express yield per plant. The number of branches at the main axis gave the total branches per plant.

The oil was extracted from the bulked seed from each sowing date, by soxhlet extraction method. The seed meal after petroleum ether extraction was analysed for crude proteins (Kjeldahe Nitrogen × 6. 25).

Crambe in Kashmir behaved as an annual crop. The seedlings emerged 5 days after sowing except in February sowing when it took 23 days for seedlings to appear. It produced small white flowers and took 25 days for the first flower to bloom. Flowers were borne on racemose inflorescence and flowering lasted for 3 weeks. Seed pods are spherical, ivory white and monocarpic. Seed is covered with brown coat with yellow flesh.

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TABLE 1. Oil content (%) in hull intact seeds and crude protein (%) in seed meal of different varieties over various sowing dates.

Varieties	March		April		May		June		July		Variety Mean	
	Oil (%)	protein	Oil (%)	Protein	Oil (%)	Protein	Oil (%)	Protein	Oil (%)	Protein	Oil (%)	Protein
Prophet	14.6	29.0	12.0	—	10.0	20.0	18.0	42.4	14.0	31.4	13.7	30.7
Meyer	24.0	32.2	22.0	33.6	20.0	32.2	28.0	42.4	20.0	40.3	22.8	36.1
Indy	20.0	31.4	18.0	35.0	20.0	32.2	18.0	40.3	18.0	32.2	18.8	34.2
Sowing date mean	19.5	30.8	17.3	34.3	16.7	28.1	21.3	41.7	17.3	34.6	18.4	33.6

Plants were erect, bearing numerous primary and secondary branches. Plant height, branches per plant and seedy yield were significantly effected by sowing dates. There were no statistical differences in morphological characters in the three varieties except Meyer tended to bloom early. Plant height was influenced by temperature as the crop sown in February-March was significantly shorter (35 cm) than that planted in late June or July (108 cm.) Branches per plant and number of seed pods per plant showed a similar pattern. However, the seeds weighted heavier in the early sowing dates (100 seed wt. = 1.00 g) than late July sowing (100 seed wt. = 0.37 g). The later sowings further suffered from uneven maturity.

The oil content (%) in hull intact seeds and crude protein (%) in seed meal showed significant interaction of varieties with sowing dates. Prophet gave a mean oil content of 13.7% as against 22.8% in Meyer. The performance of Indy with respect to oil content was consistent over the sowing dates (Table 1). The crude protein (%) in the seed meal varied similarly. Both oil and crude protein (%) was significantly higher in early June sowing than other sowing dates. More number of days required for seedling emergence and consequent growth for February plantation could be explained to cool soil and atmospheric temperature during that period. Koinov and Stefanov (1972) also reported soil temperatures of above 8°C favourable for growth of Crambe. February sown plants were stunted and gave reduced yield. However, the higher 100–seed weight for these plants could be attributed to plump and well filled seeds. Jablonski (1962) also observed uneven maturity of seeds at low temperature and attributed to increased pod and seed size and proportional decrease in hull weight. The increase in the number of abortive seeds inside the hull, induced by high temperature during flowering and seed formation resulted in lower 100–seed weight for late JULY sowing. In *Brassica napus* L. the winter rape seeds are larger in size compared to summer rape (Loof 1972).

Although the three varieties did not differ in morphological characters over the sowing dates, they gave different oil and crude protein content under varying sowing dates. This interaction is primarily due to differences in oil and protein producing capacity of three varieties which reached its optimum in June sowing for Prophet and Meyer varieties (Table 1).

The possibility of double cropping potential was assesed when seed harvested from the crop sown in March was resown during July, 1985. In the first crop 4.300 kg seed (716 kg/ha) was harvested compared to only 0.400 kg(77 kg kg/ha) in the second crop. This yield was too low, but a few plants from the second crop yielded as high as 5 g per plant. This erratic behaviour calls for indepth agronomic studies for a better harvest. There were a few plants which tolerated a winter temperature of -5°C and produced crop in the next spring. This speaks of sufficient plasticity in the plant and should an interest develop in its cultivation, these attributes could be profitably exploited for the improvement of the crop.

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