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SHORT COMMUNICATIONS

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NON-CONVENTIONAL AREA, SEASON, CROP AND TECHNOLOGY APPROACH TO MEET THE VEGETABLE OIL SHORTAGE IN INDIA*

DR. M.V. RAO,
Special Director General, Indian Council of Agricultural Research.

As Crop Scientist I thought that popularising new varieties that are high yielding early maturing, resistant to pests and diseases, among the farmers is the greatest job that one could do as this sort of approach helped us in several other crops. When we gave the new wheat production technology to the farmers, the message was conveyed direct to the farmers and it spread like a wild fire and in a short period of time we could trigger off significant achievements and the wheat revolution in the country. Before the Mexican dwarf wheats were spotted for the first time in India in 1961-62, we have been looking for disease resistant genotypes which are short in stature but with little success. In 1963 Dr. Norman E. Borlaug, the renowned Wheat Scientist who visited different areas in India along with me made four predictions regarding the future wheat production in the country (i) that there is no reason why India's wheat production should not be doubled or tripled in the next few years; (ii) India requires much more fertilizer than what it is producing now and hence the Government should produce more fertilizers to meet the requirements of the new wheat varieties; (iii) the whole irrigation system has to be revamped and reoriented because the dwarf varieties require different pattern of irrigation at crucial physiological stages of the plant; (iv) India might run into storage problems of wheat. All these predictions of Dr. Borlaug came true. Why I am narrating this is just to tell you that besides accumulation and routine analysis of research data, etc. There is a thing like plant breeder's judgement which is very practical, pragmatic and important. The brain of an experienced Breeder works better than a computer and as such he can immediately judge the right variety and the strategy. This kind of faculty of breeders and his robust commonsense which we call as the horse sense is very important. In this context you may also recollect the contribution to sugarcane breeding by Sir T.S. Venkataraman at the Sugarcane Breeding Institute, Coimbatore. We are told that he used to pick up the successful sugarcane varieties more on the basis of his judgement as a practical field worker who understood his material thoroughly than based on statistical data. In the same way the late Shri V.S. Mathur, Wheat Breeder, IARI and also Shri Dhaniram Vasudeva of HAU, though not well qualified on paper, they depended heavily on their thorough knowledge of wheat plant, their commonsense, practical wisdom and dedication. Shri Vasudeva developed the variety Pb.C 306 which was the first Indian wheat variety that was officially released in 1966 and which covers 50% of wheat area even today in north and central India under rainfed conditions. Though nearly 300 scientists are working today at more than 34 research centres in the All India Coordinated Wheat Improvement Programme all over the country, they could not produce better than Pb. C-306 for rainfed conditions. He produced another variety called WH 147. It was highly susceptible to black rust, yellow rust and brown rust. However, we did not

* Presidential Address to the Indian Society of Oilseeds Research at Hyderabad, on 22-4-1988.

come across a variety at that time in the late 70's which could beat the national check Kalyan Sona. It consistently gave 4-5 quintals on an average more yield at most of the trial centres. Since it is very difficult to breed for high yield we thought of taking advantage of this variety for its yield for 2-3 years and rejecting it afterwards to avoid possible rust damage. This variety was released for MP, Haryana and Bundelkhand area of U.P. Now during the last 10 years it has become the most popular variety and in fact, 50 per cent of the area of Haryana and considerable area in MP is under WH-147 Now this agian indicates important of horsesense in plant breeding in sighting a winner in the segregating populations and in early stage of testing. Now we took precautions to control the rust in Nilgiris, Palani Hills and also Himayalays by growing resistant varieties, i.e., we followed the Vanderplanks equation i.e. $X=X_oQRT$ where X= disease intensity at a given period of time; Xo= initial inoculum; Q=the time taken for multiplication; R=the rate of multiplication; T=Time taken for multiplication; e=Constant or a compound interest disease, and saturated the Nilgiris and Palani hills with rust resistant varieties to control XO at the focus of infection and this strategy has helped us a lot. I am giving this example only to tell you that there is something like commonsense in the Plant Breeding and I do not want any one of you to forego that faculty and depend too much on biometries, genetics and cytogenetics for solving practical field problems. With this background, I would now like to turn on the theme of my talk entitled "NON-CONVENTIONAL AREA, SEASON, CROP AND TECHNOLOGY APPROACH TO MEET THE VEGETABLE OIL SHORTAGES IN INDIA".

So far we have been talking about the conventional approach of solving oilseed deficit in the country by exploiting the nine well known annual oilseed crops and perennial coconut. Now let us explore the opportunities and avenues available in the non-traditional sector.

African oil palm is a potential plant that can be exploited for increasing vegetable oil production for adding to the oil pool of the country. Realising its potential a Committee was appointed according to which about 2,50,000 hectares can be brought under oil palm cultivation in Andhra Pradesh /(Krishna, East and West Godavari Districts), 25,000 hectares in Tamil Nadu (Nagarcoil), 2,50,000 hectares in Karnataka (Cauvery, Thungabhadra, Ghattaprabha, Mallparabha area) 10,000 hectares in Orissa (Berhampore, Ganjam, Koraput), and about 5,000 hectares each in Assam, Tripura and other Eastern States. Altogether the Committee identified half a million hectares that could be covered with African oil palm under irrigated conditions. The oil palm has the propensity and capacity to produce large quantities of oil. Even with the best groundnut variety we cannot get more than 2 tons of oil per hectare. But in Malaysia the average yield of oil palm is 6 tons of oil per ha. There are some farmers who are getting even 8-9 tonnes of oil per hectare. In Indonesia also, we are getting about 4-5 tonnes. Our experience in Quilon district of Kerala is that we can get about 2 to 3 tonnes of oil with the young plantations they were started in 1975.

The second approach I could think about is that we should move to non-conventional areas for oilseed cultivation. At present the increase in the production of mus-

tard, soybean, groundnut, etc., are attempted through the conventional approach and in their established areas of cultivation. But during the last two years I have been looking at the possibility of introducing rapeseed-mustard as well as soybean and other crops in the unexploited non-conventional areas. Now the experience in Tamil Nadu and also in Andhra Pradesh, Maharashtra and Karnataka indicate to me that it is possible to push the rapeseed-mustard into these areas. The data collected so far convinced us that it should be possible to introduce rapeseed-mustard in the peninsular India. The yields which ranged anywhere from 10 q to 22q per hectare are very encouraging. Some varieties like Seetha are giving about 15 q per ha. in Tamil Nadu. Now this is one message I would like to convey to you that it is possible to move from the traditional to the non-traditional areas.

Madhya Pradesh and certain parts of UP are considered so far the traditional belt for soybean. However, the crop is very successful in Kota and Udaipur Divisions of Rajasthan, Karnataka, Marathwada and Vidharbha regions of Maharashtra and also in Tamil Nadu, and Guntur and Prakasam districts of AP. I am sure Bihar and Eastern India shall also become potential soybean areas. This non-conventional area approach is one item on which I would like to emphasise during the next few years to increase oilseeds production in the country.

The third approach is to move the oilseed crops to non-conventional seasons. Experience of the last two seasons indicate that it is possible to grow groundnut in the spring/summer seasons in UP besides the Conventional *Kharif* season. In UP, Punjab and Haryana, due to white grub infestation, kharif groundnut area has gone down very drastically in recent years. Remunerative cultivation of groundnut cannot be undertaken as long as white grub is not controlled. The scheme supported by the National oilseeds and Vegetable Oil Development Board (NOVODB) has revealed that 20-25 q/ha can be obtained in the spring/summer groundnut crop in UP as compared to 6-8 q/ha obtained in the kharif season. It is possible to grow good spring/summer groundnut not only in UP, but also in Bihar, West Bengal and other eastern states. The fields vacated by potato, toria etc., could be profitably put under groundnut. Earlier, it was thought that because of the low temparatures the groundnut crop may not grow very well, but now our experience during the last two seasons was quite encoraging. Perhaps, we may have to identify geneotypes with tolerance to low temparatures and at the sametime giving higher yields. Therefore, rabi/summer groundnut production is a very potential area for strengthening. Already we have good experience in Orissa, Andhra Pradesh, Tamil Nadu, Maharashtra, Karnataka, MP and Gujarat where we are harvesting on an average 16 q per ha as compared to 8 q or less obtained during the kharif season. Some farmers are producing even 30 to 35 q/ha in *rabi*. Additionally we are also trying the ICRISAT technology. We expect good prospects and future for rabi/spring groundnut, because the conditions of crop growth are more stable in those seasons, disease and pest incidence and weed problems are manageable and less.

I am convinced that soybean can be a potential crop in the rabi and summer seasons too. Now we have some evidence to show that yield levels of the order of 2

to 2.5 tons per ha can be obtained during rabi/summer season in Karnataka, Tamil Nadu and Maharashtra as compared to conventional Kharif crop yields of 7 quintals per ha.

Exploitation of other hitherto unexploited crops could be the fourth approach to increase vegetable oil production. We have a number of non-traditional crops such as capperis, tumba, salvedore etc., growing wild in Rajasthan which could be exploited to boost oil production. Some species of *Salicornia* a salt loving plant belonging to the family Chenopodiaceae has an oil content of 18-19 per cent. The work done at the Salt and Marine Research Institute of CSIR at Bhavnagar indicated presence of 30 per cent oil. There will be still more such non-traditional unexploited oilseed crops. There is an enormous potential in tree species, like Sal, Mohuva, Karanj, Neem, Kusum, Khakan, Kokun, Undi, Pisa, Dhupa etc., for vegetable oil that could be exploited for extracting oils for industrial or edible purposes. According to the Directorate of Oilseeds Development and the report of the Sub-Committee on Minor Oilseeds (1971) the potential is for 66.7 lakh tonnes of seed which can yield 11.0 lakh tonnes of oil and 55.0 lakh tonnes of deoiled cake. The value of oil is estimated to be of the order of Rs. 1100.00 crores.

The fifth approach is the exploitation of waste lands. We have about 158 million hectares of different categories of wastelands in the country. Out of the 328.29 million hectares of geographical area in India. Out of this about 8m. ha could be of saline and/or alkaline soils. *Brassica carinata* was found to be extremely tolerant to saline and alkali conditions where 15 ot 16 q. per ha were harvested at the IARI. Information is being gathered at the All India level to find out the salt tolerance of the different *Brassica* species particularly of juncea and carinata groups. If they have salt tolerance they could be extensively exploited for getting more oil on lands which are otherwise lying unexploited.

The sixth approach is regarding conversion of the non-edible linseed oil to edible grade oil. In Australia and UK, scientists have shown that they could convert the non-edible lineseed into the edible grade linsed oil. Now we are not doing this sort of basic research. In the All India Coordinated Projects, one of the weaknesses is that we are getting away from the basic researches. All of the Scientists are busy either growing nurseries or conducting trails but very little time is devoted to basic research. Perhaps through basic researches at some of the research centres we may take up work to convert some of the lineseed varieties to produce edible grade oil.

Exploitation of cereals for oils is the seventh appraoch. Corn oil is one of the most important oils in USA and several other countries. About 7-8 million tonnes of corn is produced each year in the country. In Bihar the corn yields in *rabi* are one of the highest. In Karnataka on an average 2.5 tonnes/ha are obtained while 4 to 5 t/ha are also harvested. We may exploit the corn for oil also in some States where production is high. Similarly out of the 60 million tonnes of rice we are producing now we can produce 6-7 lakh tonnes of rice bran oil. We are exploiting at present only half of this potential. Similarly, we can extract the cotton seed oil for edible purposes as

in case of Pakistan, where 70 per cent of the oil production is from the cotton seed oil. We produce annually a little over 30 lakh tonnes of cotton seed which can give 4-5 lakh tonnes of cotton seed oil. By exploiting the available rice, cotton and corn resources of the country we can produce at least 10-11 lakh tonnes of oil.

The other area one could look at is the possibility of introducing Olive cultivation in our country. In the mediterranean countries Olive is an important source of edible oil. We should try different genotypes of oilve in different parts of the country and if we succeed it would be a source of additional oil to meet our future requirements which in any case would be very high because of the ever growing population.

Blending is one potential area through which we can ease pressure on some of the conventional oils like groundnut, sesamum, rapeseed-mustard etc., whose shortages often lead to sky-rocketing of oil prices. Accoring to the NIN we can produce more nutritious and well balanced oil by blending, as no single oil has all the nutritional characters which our body needs . If we can blend oils like soybean, cotton seed oil etc., with groundnut oil, sesamum oil then we can ease presssure on the pure conventional oils. Also we can improve the nutritional standards of our people. However, blending may be misused by unscrupulous elements for adulteration unless some fool-proof packaging system is evolved.

The next opportunity I foresee is the exploitation of inter-cropping vis-a-vis the pure oilseed crop. The information that has been generated in the All India Dry Farming and Agronomic Research Projects show that a number of inter-cropping sequences involving groundnut, soybean, rapeseed-mustard and several other crops are very remunerative to the farmers and also insulate against total failure of single crops. In the normal cereal and non-cereal crops, one can include oilseed as an intercrop to increase oilseeds production. The gobhi sarson and toria intercropping in Punjab has proved to be very remunerative. The farmers are planting gobhi sarson, i.e., *Brassica napus* and also toria in the month of September. While toria comes for harvest in the month of December, the napus is ready for harvesting by April. Through this intercropping they are able to harvest somewhere between 25-30 quintals per ha. This is one classical example by which we can increase oilseeds production by intercropping. Similarly sunflower intercropped with groundnut was found to be very remunerative and risk-free technology in Gujarat.

The other approach worth pursuing is developing or identifying varieties for late sowing . I feel that we can never make the rapeseed-mustard a success unless we identify varieties suitable for late planting conditions like Sonalika of wheat which can be planted in the month of December or even in January. We should identify some mustard varieties which are suitable for late planting. The information so far collected indicate that even varieties like Varuna are suitable for late planting. Some of the exotic varieties like Tobin are also found to be suitable for late planting. Thus, among the existing oilseed crops there might be some varieties suitable for late planting potentiality and this should be exploited. I would request you to kindly look at this potentiality and identify suitable varieties for late planting. I caution that the pest and dis-

ease are fresh problems and should be carefully looked into before recommending late planting to the farmers.

The other possibility is the exploitation of several plant species which can yield oil for industrial purposes. This is necessary because many times it is the shortage of non-edible oils which is creating vegetable oil shortages. For example seeds of tobacco, citrus, *Anona sqamosa*, the sapota, tea, rubber, different shrub species like jojoba, Mango kernel, cashew kernel etc., can yield oil.

I wish to place before you today for your introspection, the case for non-traditional approach to the problem of vegetable oil production in our country, besides the conventional ones, which we usually discuss at our All India Oilseed Workshops. Can we take a detour to the non-conventional areas of the oilseed sector for making an impact on the urgent problem for meeting the vegetable oil requirements of the country by traditional oil seed crops?

I thank at the end the distingushed Vice-Chancellor of RAU, Bihar, for sparing quite a bit of his valuable time, and all of you, ladies and gentlemen, for your patient listening.

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"HETEROSIS AND COMBINING ABILITY STUDIES IN GROUNDNUT (*ARACHIS HYPOGAEA* L.)

H.L. NADAF, A.F. HABIB, SURESH S., PATIL AND SYED SADAQAT
AICRP on Oilseeds, U.A.S., Regional Research Station, Dharwad-580 005

ABSTRCT

Estimates of heterosis and combining ability were made using ten hybrid combinations. The hybrids were produced by crossing five parents viz., JL-24, ICGS-11, ICGS-44, RSHY-4 and ICG-7899 in a diallel fashion (excluding reciprocals), which were evaluated for yield and five yield components along with their parents in a Randomised complete Block Design with three replications at the Regional Research Station, Dharwad during Kharif 1985.

In general, GCA estimates were 3 to 4 times greater in magnitude than SCA effects for most of the characters except for shelling percentage indicating the prodominance of additive gene effects in the inheritance of these traits. Significant heterosis over mid-parent values was recorded for all the traits in some of the crosses. JL-24 and ICG-7899 were found to be the best general combiners which can be extensively used in hybridization programme for improvement of pod yield and its components by pedigree selection or its modified approaches.

The breeding of improved, high yielding peanut cultivars has been hampered by the lack of information on the genetics of yield components (Hammons, 1973). Diallel analysis is one of the methods which is extensively used to evaluate the performance of selected lines and their hybrid combinations through combining ability estimates. The information so obtained on genetic nature and magnitude of gene action of yield and yield components will help in designing appropriate breeding schemes. Such studies on estimates of heterosis and combining ability of peanuts (*Arachis hypogaea* L.) are meager (Hassan and Srivastava, 1986; Wynne *et al*,. 1970, 1975; Garet, 1976; Gibroi *et al*., 1978; Mohinder Singh and Labana, 1980; Habib *et al*., 1985). An attempt has been made in the present investigation to develop and enhance the genetic knowledge of pod yield and its components through heterosis and combining ability estimates.

MATERIALS AND METHODS

Five parents viz., JL-24, IGGS-11, IGGS-44, RSHY-4 (Spanish Bunch) and ICG-7899 (Valencia) were selected and crossed in a diallel fashion excluding the reciprocals. Ten F_1 hybrids so produced were evaluated during *kharif* season of 1985 at Regional Research Station, Dharwad along with their five parents in a 'Randomised Complete Block Design' with three replications. Each entry consisted of three rows of 5m length maintaining the spacing of 30 cm between rows and 20 cm within the row. Five competitive random plants from the middle row were selected for recording the observations. Data were recorded on pod yield per plant (g), number of primary branches and matured pods per plant, 100-kernel weight, shelling percentage and sound matured kernel percentage (SMK %). The progeny means were used in the combining ability analysis following the analysis (method IV model II) given by Griffing (1956).

The procedure as suggested by Hays, Immer and Smith (1955) was used in computing heterosis.

$$\text{SE heterosis over mid-parent} = \frac{\sqrt{(n-1)\sigma e^2}}{\sqrt{n(n+2)}}$$

C.D. at 5% = S.EMP × 't' at 5%

where σe^2 = Error variance

n = Number of parents

RESULTS AND DISCUSSIONS

The estimates of heterosis of ten crosses over their respective mid-parent values for pod yield and other components are presented in Table-1. In general, no particular cross showed more heterosis for all characters. Two crosses viz., IGGS-II × IGGS-44 and ICGS-44 × ICG-7899 showed significant and positive heterosis for pod yield per plant. Thecross ICGS-11×ICGS-44 also showed siginficant and positive heterosis for number of primary branches per plant and shelling percentage. Similarly, the cross, ICGS-11×ICG-7899 exceeded the mid-parent values by larger percentages in positive direction for the characters, number of mature pods per plant, 100-kernel weight and shelling percentage. Maximum heterosis for shelling percentage was obtained in the cross ICGS-11×RSHY-4 but none were significantly superior in heterosis for SMK%. These results from the crosses studied indicate considerable heterosis which depicts the importance of non-additive factors for these traits. However, there is no practical means of utilizing this heterosis at present because of difficulty in obtaining crossed seeds in groundnut.

The mean squares from the analysis of variance (Table 2) revealed that the variation due to the genotypes (parents and F_1s) was highly significant for all the traits studied. The mean squares due to GCA and SCA were also significant for all the traits with the exception of SCA effect of SMK% which was not significant. The estimates of GCA and SCA effects and variance due to additive (σA^2) and non additive (σD^2) factors, indicated the predominance of additive gene efforts for most of traits except shlling percentage which was predominently under the control of non-additive gene effects. Most studies with self pollinated crops where fixed models have been assumed have indicated that GCA is greater than SCA (Hammons, 1973).

GCA effects for the five parents studied are presented in Table-3, which revealed a wide divergence among the parents for general combining ability. No single parent showed better general combining ability for all the traits studied. However, the estimates for GCA for pod yield, 100-kernel weight, shelling percentage and SMK% were highest and significant for the parent JL-24. The parents, RSHY-4 for number of matured pods per plant and ICG-7899 for number of primary branches per plant showed better general combining ability than any other parents. ICG-7899 parent also had good general combining ability for the traits like 100-kernel weight and SMK%. From these results, it is evident that JL-24 parent was the best general combiner for yield and yield components like 100-kernel weight, shelling percentage and SMK%, whereas, the parent ICG-7899 was another good general combiner for vegetative trait (i.e. number of primary branches per plant) and kernel characters (test weight and SMK%). These results confirm the high *per se* performance and rank correlations of

JL-24 (Table-4) for yield and yield components and ICG-7899 for number of primary branches, test weight and SMK%. Thus, *per se* performance and rank correlations of GCA effects can be effectively used to choose the parents for hybridization without carryingout diallel analysis.

The estimates of SCA effects for the crosses involving the five parents for the characters measured are presented in Table-5. The cross, ICGS-11 × ICGS-44 which showed the highest heterosis over mid-parent value for pod yield also had the highest SCA effect for pod yield, number of matured pods and primary branches per plant. SCA component for pod yield was also significant and positive in the cross ICGS-44 × ICG-7899, and the cross RSHY-4 × ICG-7899 had significant and positive SCA effect for number of matured pods per plant. One particular cross i.e. ICGS-11 × RSHY-4 had greater and positive SCA components for all the three fruit characters viz., 100-kernel weight, shelling percentage and SMK%. SCA componentof the cross ICGS-11 × ICG-7899 was highest and positive for the characters 100-kernel weight. Either dominance of genes or geometric gene action may have contributed to the high estimates of SCA (*Wynne et al.*, 1970) indicating the possibility of getting transgressive segregates for these traits in the subsequent generations of selfing. All the crosses involving JL-24 as one of the parent, had negative and significant SCA effects for 100-kernel weight because of its high mean performance for this trait.

It is evident from the above study that more number of favourable genes can be fixed to get maximum genetic gain from the crosses involving better general combiners like JL-24 for pod yield, 100-kernel weight, shelling percentage and sound matured kernel percentage and ICG-7899 for number of primary branches per plant, 100-kernel weight and SMK%. Since, the magnitude of GCA effects were 3-4 times more than the SCA effects for most of the traits except shelling percentage, effecting improvement through additive gene effects by pedigree selection or its modified approaches seems to be feasible. However, some of the specific combinations can also be selected to exploit favourable gene interactions from these crosses as transgressive segregates in future generations.

TABLE 1. Heterosis over mid-parent (in percentage) of the crosses for different characters.

No.	Sl. Name of the cross	Pod yield per plant (g)	Number of matured pods per plant	Number of primary branches per plant	100-kernel weight (g)	Shelling %	Sound matured Kernel %
1.	JL-24 × ICGS-11	—25.07**	+ 3.94	— 5.22	—24.56**	+ 0.37	— 5.47*
2.	,, × ICGS-44	— 9.91	—24.38*	—13.56	—25.09**	— 3.26*	+ 1.28
3.	,, × RSHY-4	— 5.32	—18.33*	+ 1.22	—15.48**	— 1.61	— 5.58*
4.	,, × ICG-7899	— 0.32	— 1.24	—24.98**	—10.08**	— 0.37	+ 1.03
5.	ICGS-11 × ICGS-44	+30.77*	+30.16*	+17.03	— 3.17	+ 3.53*	— 2.59
6.	,, × RSHY-4	+17.60	— 7.83	+10.43	+ 0.15	+19.75**	+ 4.10
7.	,, × ICG-7899	+24.58	+35.31	—23.71**	+ 6.94**	+ 4.34*	— 3.04
8.	ICGS-44 × RSHY-4	— 8.40	— 7.61	+ 2.70	—10.32**	+ 3.02	+ 0.94
9.	ICGS-44 × ICG-7899	+40.19**	+18.43	—14.85*	— 1.95	— 0.32	— 3.79
10.	RSHY-4 × ICG-7899	+23.53	+19.39	—13.09	— 4.00	— 1.90	— 1.40

*, ** *Significant at 0.05 and 0.01 levels of probability.*

TABLE 2. Mean squares for general and specific combining ability for different characters

Source	df	Mean square of					
		Pod yield per plant (g)	No. of matured pods per plant	No. of primary branches per plant	100-kernel weight (g)	Shelling %	Sound matured kernel %
Genotypes	14	22.45**	36.35**	5.28**	82.58**	19.91**	33.04**
Error	28	5.97	9.26	1.22	1.48	2.02	7.73
gca	4	13.3627**	23.507**	3.1382**	60.5107**	4 0739**	25.9828**
sca	10	5.2747*	7.302*	1.0081*	14.9938**	7.7673**	5.1700
Error	28	1.9875	3.085	0.4043	0.4930	0.6711	2.5749
A^2	—	4.785	9.260	1.217	26.010	-2.110	11.893
D^2	—	3.287	4.217	0.604	14.501	7.096	2.596

* ** Significant at 0.05 and 0.01 levels of probability.

TABLE 3. General combining ability (CGA) effects for pod yield and yield components.

Sl. No.	Parents	Pod yield per plant (g)	Number of matured pods per plant	Number of primary branches per plant	100-kernel weight (g)	Shelling %	Sound matured kernel %
1.	JL-24	2.095**	0.655	0.189	4.234**	0.993**	1.118*
2.	ICGS-11	0.167	-0.516	-0.582*	-0.637*	-0.701*	-0.366
3.	ICGS-44	-0.848	0.198	-0.239	-1.708**	0.340	-0.142
4.	RSHY-4	0.024	2.369**	-0.496*	-3.151**	-0.681*	-2.842**
5.	ICG-7899	-1.419**	-2.716**	1.118**	1.291**	0.050	2.236**
	S.En±	0.4766	0.5938	0.2149	0.2374	0.2769	0.5425

*, ** Significant at 0.05 and 0.01 levels of probability.

TABLE 4. **Rank correlations of GCA effects and *per se* performance of parents for pod yield and yield components**

Sl. No.	Parents	Pod yield per plant (g)	No. of matured pods plant	No. of primary branches per plant	100-kernel weight (g)	Shelling %	Sound matured Kernel %	Rank correlation
1.	JL-24	21.4	22.2	9.5	51.1	71.0	94.3	+ 4
2.	ICGS-11	14.1	14.9	7.0	34.8	57.3	91.7	— 3
3.	ICGS-44	11.9	18.5	7.8	34.6	67.0	91.3	— 1
4.	RSHY-4	14.3	24.3	7 0	30.3	59.7	85.3	— 3
5.	ICG-7899	9.5	10.1	12.4	37.2	66.3	95.7	+ 1
	Mean	14.2	18.0	8.7	37.6	64.3	91.7	-

TABLE 5. **Specific combining ability (SCA) effects of the crosses for pod yield and yield components.**

Table 5. Specific combining ability (SCA) effects of the crosses for pod yield and yield components.

Sl. No.	Cross	Pod yield per plant (g)	Number of matured pods per plant	Number of primary branches per plant	100-kernel weight (g)	Shelling %	Sound matured kernel %
1.	JL-24 × ICGS-11	-3.750**	0.925	-0 069	-6.390**	-0.892	-2.980**
2.	,, × ICGS-44	-1.036	-3.689**	-0.712	-5.619**	-1.104	1.823
3.	,, × RSHY-4	-0.007	-2.261	0.444	-1.876**	-1.312*	-3.465**
4.	,, × ICG-7899	-0.006	-0.275	-1.369**	-1.019*	0.616	1.987
5.	ICGS-11 × ICGS-44	2.892**	3.782**	1.158*	0.752	0.171	-1.210
6.	,, × RSHY-4	1.720	-1.989	0.515	1.195	7.102**	3.400**
7.	,, × ICG-7899	1.163	1.897	-1.398**	2.652**	0.671	-1.299
8.	ICGS-44 × RSHY-4	-1.964	-1.003	0.073	-1.233*	0.581	0.815
9.	,, × ICG-7899	2.477*	1.182	-0.541	0.424	0.049	-2.203
10.	RSHY-4 × ICG-7899	1.306	2.611*	-0.486	-0.933	-1.959**	-0.563
	S. Em±	0.9728	1.2120	0.4388	0.4845	0.5653	1.1073

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VARIABILITY AND INTERRELATIONSHIPS AMONG OIL CONTENT, YIELD AND YIELD COMPONENTS IN GROUNDNUT, *ARACHIS HYPOGAEA* L.

T. SWAMY RAO[1], S.P. ANGADI[2] AND S.P. DOSHI[3]
University of Agricultural Sciences Regional Research Station Raichur-584 101.

ABSTRACT

Two hundred and eight accessions of groundnut germplasm were evaluated at Raichur, in the 1978 rainy season, to understand the pattern of variation for pod yield and yield-contributing characters viz. plant height, number of primary branches, number of nodes on first primary branch, leaf length, leaf breadth, number of flo vers, number of pegs, number of mature pods, peg to flower ratio, pod to peg ratio—shelling percentage, hundred seed weight and oil content. Correlations of pod yield with all the yield attributes and also the inter relationships among the yield attributes were worked out. There was considerable amount of variability for all the characters studied. Broad sense heritability estimate was highest for oil content, followed by number of primary branches, number of nodes on first primary branch and number of pegs. Lowest heritability estimate was recorded for pod yield. The characters, number of primary branches, peg number and peg to flower ratio showed high heritability, high GCV values and high expected genetic gain, and thus are important for direct selection to improve yield. Shelling percentage and hundred seed weight with relatively low heritability values and GA as per cent of mean are less suitable for direct selection.

Pod yield was strongly correlated with all the characters except with pod to peg ratio (negatively correlated), hundred seed weight and oil content (no correlation). Associations of oil content with most of the characters were non-significant. Number of primary branches was positively correlated with number of flowers and node number. Number of mature pods was positively associated with peg number, peg to flower ratio and flower number, peg number had a strong positive correlation with flower number, leaf length and peg to flower ratio. Number of primary branches, number of pegs, peg to flower ratio and number of mature pods are suggested as important characters for selection for yield improvement.

Key words : Groundnut, germplasm, variability, pod yield, oil percentage, correlation.

INTRODUCTION

Groundnut, *Arachis hypogaea* (L.) is an important source of edible oil, and is also rich in protein. It occupies the first place for area (7.15 m.ha) and production (6.06 m.tonnes, 1986-87) among the edible oilseed crops grown in India. However, the average yields (847 kg/ha) are low and there is a need and also scope to improve the yield of groundnut cultivars through breeding. As any effective plant breeding programme must operate on existing genetic variability, a quantitative assessment of variation for important yield contributing characters helps to promote ideotype breeding. Though there are reports on variability in groundnut, very limited work has been reported on simultaneous improvement of oil content and yield. Elimination of limit

1. Present Address: Regional Research Station, University of Agricultural Sciences, Gulbarga (Karnataka).

2. Scientist (Plant Breeding), Directorate of Oilseeds Research Rajendranagar, Hyderabad-500 030.

3. Scietist (Agricultural Statistics), IASRI, New Delhi-110 012.

to yield as well as direct selection for yield components are the effective approaches for increasing yield. Selection should be aimed at increasing one or more of the yield components without allowing a compensatory decrease in others. Study/of character associations is important in this direction. Hence, present studies were conducted to assess the genetic variability for important characters and to know associations among them.

MATERIALS AND METHODS

From among the germplasm collection maintained at the Regional Research Station of the University of Agricultural Sciences, Raichur, 208 entries (100 exotic and 108 indigenous) were evaluated during the 1978 rainy season. The accessions were grown in a randomised block design with three replications. Seeds were dibbled in 2 rows of 5 metre length, spaced at 45 cm between rows and 10 cm between plants within the row. Recommended pacage of practices were followed to raise a healthy crop. Observations were recorded from 10 randomly selected plants on plant height, number of primary branches, number of nodes on first primary branch, leaf length, leaf breadth, number of flowers, number of pegs, number of mature pods, peg to flower ratio, pod to peg ratio, shelling percentage, hundred seed weight, oil content and pod yield per plant. Oil content analysis was done by Nuclear Magnetic Resonance (NMR) Method. Standard statistical procedures, were followed by analysing the data.

RESULTS AND DISCUSSION

The accessions studied were of different habit groups belonging to subsp. *hypogaea* and subsp. fastigiate which included all the three botanical varieties viz., var hypogaea (bunch & runner), var *fastigiata* (valencia) and var *vulgaris* (Spanish).

The values of range (Table-1) showed the presence of considerable amount of variability among the genotypes for most of the traits. Pod yield per plant and oil content ranged from 1.85g (CV 2.09) to 11.23g (CV 0.31) and 36.65% (MS-14) to 51.70% (TMV-10), respectively. Estimates of phenotypic coefficients of variation (PCV) were higher than the genotypic coefficients of variation (GCV). Maximum GCV value (29.92) was recorded for number of pegs followed by number of primary branches (28.65) and pegs to flowers ratio (26.66). Pod yield with a low GCV value recorded high PCV suggesting the environmental effect in its variation. Similarly, the variation for number of flowers and number of mature pods were largely influenced by the environment. GCV value for oil content was low and differed least (0.15) from that of PCV, indicating that the trait is least affected by environment.

High values of GCV are reliable, if substantiated by high heritability values, which also provide a measure of genetic variation. A knowledge of the magnitude of heritability gives an idea about the scope for effecting genetic improvement through selection. Broad sense heritability estimates (Table-2) ranged from 13.52% (pod yield) to 94.38% (oil content). Though the oil content recorded maximum heritability, the low GCV value makes it unsuitable for direct selection for improvement. Similarly

TABLE 1. Mean, Range and Coefficients of variation of groundnut

Character	Mean	Range	PCV	GCV	PCV-GCV	CV
1. Plant ht. (cm)	22.23	13.90–32.35	14.42	9.91	4.51	10.47
2. No. of primary branches	6.22	7.70–21.10	34.52	28.65	5.87	19.22
3. No. of nodes on first primary branch	10.71	7.20–23.40	19.04	14.21	4.83	12.66
4. Leaf length (cm)	5.42	4.05– 6.40	9.52	4.04	5.48	8.65
5. Leaf breadth (cm)	2.54	1.85– 3.25	11.80	4.51	7.29	11.13
6. No. of flower	31.96	17.25–77.00	36.24	16.63	19.61	32.33
7. No. of pegs	15.77	5.10–38.80	40.63	29.92	10.71	27.72
8. No. of mature pods per plant	9.66	3.60–16.30	35.24	18.69	16.55	29.88
9. Peg to flower ratio	0.52	0.11– 1.01	38.54	26.66	11.88	—
10. Pod to peg ratio	0.63	0.29– 1.00	31.44	21.96	9.48	—
11. Shelling percentage	74.90	60.75–84.50	6.95	4.01	2.94	5.82
12. 100 Seed wt (g)	34.26	25.90–49.95	15.16	8.10	7.06	1.59
13. Oil content (Percent)	45.06	36.65–51.70	5.12	4.98	0.14	0.31
14. Pod yield/Plant (gm)	6.74	1.85–11.23	35.27	12.97	22.30	2.09

there is little scope for improvement of pod yield by direct selection as both the heritability and GCV values for this trait are low. A high genetic advance expressed as per cent of mean coupled with high heritability offers the most effective condition for selection. Results of the present study indicate that direct selection for number of branches (high GCV, high heritability coupled with high genetic advance as per cent of mean) could be effective in yield improvement. Chauhan and Shukla (1985) also reported high values of GCV, and heritability coupled with high genetic advance as per cent of mean for number of branches. Present investigations confirm their results. Highest GCV was recorded for number of pegs which also had moderately high heritability values coupled with high genetic advance as per cent of mean, suggesting that the charcter can be improved through direct selection. Peg to flower ratio is also important for the above reasons. On the other hand, shelling percentage and 100 seed weight with relatively low values for the three parameters are less suitable for selection. In conclusion it can be said that the characters number of branches, number of pegs and peg to flower ratio are the most reliable indices for selection. High values for these three components suggest the presence of high additive genetic variance (Panse, 1957) and these characters are amenable for improvement through mass selection. On the other hand the charcters shelling percentage, 100 seed weight and pod yield appear to be affected more by the non-genetic sources of variation.

TABLE 2. Heritability, genetic advance and genetic advance expressed as percentage of mean.

Character	Heritability (B.S.) (%)	Genetic Advance (K=2.06)	Genetic Advance as per cent of Mean
1. Plant height (cm)	42.27	3.12	14.03
2. No. of primary branches	68.95	3.05	49.03
3. No. of nodes on first primary branch	55.67	2.34	21.85
4. *Leaf length (cm)*	18.00	0.19	3.50
5. Leaf breadth (cm)	14.58	0.09	3.54
6. No. of flowers	21.07	5.05	15.80
7. Number of pegs	54.20	7.21	45.72
8. Number of mature pods	28.12	1.97	20.39
9. Peg to flower ratio	47.83	0.20	38.46
10. Pod to peg ratio	48.75	0.20	31.75
11. Shelling percentage	33.33	3.57	4.77
12. Hundred weed wt (g)	28.57	3.04	8.87
13. Oil content (Percent)	94.38	4.49	9.96
14. Pod yield/Pl. (g)	13.52	0.66	9.79

Phenotypic, genotypic and environmental correlation coefficients of all the yield attributes studied with oil content and pod yield and their interrelations are presented in Table-3. Genotypic correlations in general were greater than their corresponding phenotypic correlations suggesting that though there was a strong inherent association between various characters the phenotypic expression of the correlations was depressed due to environmental influence. All the characters, except pod to peg ratio, 100 seed weight and oil content showed highly significant, positive, genotypic associations with pod yield. Correlation between leaf breadth and pod yield was 1.0168. As genotypic correlation is an estimated value. 'r' can exceed 1.00. The results are in contrast to those of Rao *et al.* (1983), who reported positive association between pod yield and 100 seed weight and negative correlation of pod yield with number of mature pods and shelling percentage. Kumar and Yadav (1978) reported positive correlation between shelling percentage and pod yield. Positive association of pod yield with 100 seed weight and shelling percentage were also reported by Kataria *et al.* (1984). Number of flowers, number of pegs, leaf length and number of mature pods showed strong association with yield. Non association of 100 seed weight and oil content pod with yield indicates that high values of these three can be esaily combined. Pod to peg ratio had a significantly negative association with pod yield.

Associations of oil content with all the other traits, were of very low magnitude and were significant only in case of leaf length, indicating that all the traits of importance for yield can be improved independently without affecting oil content.

TABLE 3. Phenotypic, Genotypic and Environmental Correlation coefficients(r) for the association of characters in groundnut

	No. of. prim. branches	No. of nodes on first primary branch	Leaf Length	Leaf breadth	No. of flowers	No. of pegs	No. of mature pods	Peg to flower ratio	Pod to peg ratio	Shelling percentage	100 seed weight	Oil content	Pod yield
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1 plant height P	0.1263	0.3706	0.3843	0.3317	0.1454	0.1168	0.1372	-0.0270	0.0873	-0.0843	-0.1031	0.0240	0.1974
G	0.0865	0.3245**	0.9364**	0.8355**	0.3170**	0.0575	0.1639*	0.2104**	0.2053**	-0.1492	0.3000**	0.0474	0.4409**
E	0.1901	0.4223	0.1690	0.1674	0.0703	0.1785	0.1258	-0.1392	-0.0217	0.0423	-0.0117	0.0447	0.1273
2 No. of branches P		0.1688	0.0248	-0.0178	0.3310	-0.0224	-0.0417	-0.2746	0.0889	-0.1833	-0.0027	0.0847	0.1387
G		0.2526**	-0.0439	-0.0299	0.5451**	-0.1893**	0.3899**	-0.5107**	0.1562	0.4892	0.0521	0.3418**	0.3418
E		0.0332	0.0798	-0.0162	0.2489	0.2476	0.2604	0.0464	-0.0040	0.1125	-0.0814	-0.0416	0.0664
3 No. of nodes on first primary branch P			0.1946	0.2243	0.1272	0.0600	0.1553	-0.0861	0.1844	-0.0230	-0.0435	0.0443	0.2395
G			0.2975**	0.4192**	0.1722*	0.0760	0.0732	-0.2026	0.3262**	0.0591	-0.0591	0.0626	0.1993
E			0.1666	0.1705	0.1153	0.2259	0.2238	0.0384	0.0302	0.0045	-0.0196	-0.0034	0.2985
4 Leaf Lenght P				0.5851	0.1284	0.1738	0.2344	0.0566	0.0634	-0.0185	-0.1168	0.0519	0.2580
G				0.9058**	0.4421**	0.2519**	0.4999**	0.1412*	0.0653	-0.1144	-0.1345	0.1539**	0.6863
E				0.5238	0.0526	0.1551	0.1588	0.0232	0.0680	0.0129	-0.1128	-0.0536	0 1792
5 Leaf Breadth P					0.1147	0.1075	0.1819	0.0109	0.0823	0.0143	-0.1468	-0.0089	0.1853
G					-0.1765*	0.1152	0.5642**	0.2967**	0.2616**	0.0346	0.0446	0.0348	1.0168
E					0.1774	0.1201	0.0864	-0.1011	0.1090	0.0089	-0.1996	-0.0995	0.0498
6 No. of Flowers P						0.3847	0.2818	-0.3955	-0.0624	0.0097	-0.0426	0.0644	0.2627
G						0.5775**	0.5815**	0.0497	-0.0418	0.0574	0.1998**	0.1267	0.8506
E						0.3152	0.1862	-0.6410	0.0771	-0.0076	-0.1220	0.0376	0.1441
7 No. of pegs P							0.6771	0.5272	-0.3174	0.0449	-0.1199	-0.0230	0.4033
G							0.9272**	0.8119	-0.5907**	-0.0270	-0.1355	-0.0347	0.6949
E							0.5492	0.2328	-0.0283	-0.1019	-0.1164	0.0113	0.3419
8 No. of mature pods P								0.4150	0.2147	0.0625	-0.1162	-0.0207	0.6534
G								0.7324**	-0.3470**	0.3686**	-0.1306	-0.0374	0.6817
E								0.2391	0.5654	-0.0727	-0.1105	-0.0071	0.6602
9 Peg to flower ratio P									-0.2936	0.0119	-0.0891	-0.0285	0.1935
G									-0.6703**	-0.0160	-0.2162**	-0.0352	0.3902
E									0.0582	0.0310	-0.0150	0.0006	0.1410
10 Pod to peg ratio P										0.0168	0.0719	-0.0452	-0.1625
G										0.1775**	-0.1146	-0.0783	-0.1954
E										-0.0937	-0 0481	0.0469	0.3195
11 Shelling percentage P											0.0277	0.0118	-0.0310
G											0.2884**	0.0153	0.4017
E											-0.0888	0.0166	0.1532
12 Hundred seed weight P												0.0080	0.0158
G												0.0039	0.0545
E												0.0295	0.0066
13 Oil con- P													-0.0088
G													*0.0085*

Intercorrelations among traits may be utilised to enhance the rate of selection response in the primary trait i.e. yield. For selection based on yield components to be effective in increasing yield, it is important that the components are highly heritable and strongly genotypically correlated with yield and genotypic correlations among the components should not be negative (Doku, 1970). In the present study positively significant association of plant height with node number, flower number and pod to peg ratio can be favourably used, for yield improvement. Negatively significant associations of plant height with peg to flower ratio, shelling percentage and hundred seed weight suggest that selecting taller plants might adversely affect these traits. Number of primary branches had strongest correlation with number of flowers followed by node number. These intercorrelations are useful in conjugation with the positive association of branch number with pod yield, for improving yield. In otherwords, selection for higher branch number might indirectly improve the other interrelated traits which show positive association with yield. However, the negatively significant associations of number of pegs and number of mature pods with the number of branches must be kept in view while selecting for branch number. Based on the other important intercorrelations it may be said that hundred kernel weight can be improved by indirect selection for shelling percentage. Indirect selection for number of pegs with high heritability value might improve number of mature pods and thereby the pod yield.

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EVALUATION OF VARIOUS NITROGEN AND PHOSPHORUS AVAILABILITY INDICES FOR RAYA (*BRASSICA JUNCEA* L.) AND TO ESTABLISH THEIR CRITICAL LEVEL IN SOIL

N.S. DHILLON, M.P.S. GILL AND A.C. VIG
Department of Soils, Punjab Agricultural University, Ludhiana-141004.

ABSTRACT

The pot and field experiments were conducted to evaluate availability indices of nitrogen and phosphorus for raya (Brassica Juncea L.). The results showed that organic carbon and $NaHCO_3$ extractable P as indices of available N & P correlated significantly with yield and uptake parameters, indicating their superiority over other methods. The critical levels of organic carbon and available P in soil below which crop will respond to application of N and P fertilizers, were found to be 0.40% (O.C.) and 12.5 kg P/ha, respectively.

(**Key words** : Availabilty indices, soil test methods, available N, available P, critical level.)

INTRODUCTION

In Punjab, raya (Brassica Juncea L.) is a major rabi oilseed crop. It responds well both to applied N and P (Dhillon & Vig 1985). However, little work has been done to evaluate various existing soil test methods for predicting N & P availability to this crop. Under the ICAR sponsored Soil Test Crop Response Correlation Project, experiments were conducted both in green house as well as at cultivator's field to find out a suitable soil test method to predict N & P availability, and to establish their critical level in soil below which crop will respond to applied nutrients.

MATERIALS AND METHODS

(a) *Green house studies:* Surface soil samples (0-15 Cm) were collected from 20 different raya growing sites varying in physico-chemical characteristics (Table 1). Four kg of processed soil (dried & ground to pass through 2mm sieve) was filled in earthern pots (polythene lined).

The fertilizer treatments consisted of 3 treatments viz (i) -N (P+K), (ii) -P (N+K) and (iii) N+P+K. Nitrogen, phosphorus (p_2o_5) and potassium (k_2o) were applied @ 30, 45.8 and 24 ug/g soil through urea, KH_2PO and KCl, respectively. Each treatment was replicated thrice. Crop was harvested after 60 days of growth at initiation of flowering and drymatter production i.e. straw yield of whole plants was recorded potwise. Plant samples from each pot were collected and analysed for total N and P (Jackson, 1967).

(b) *Field Experiments:* Twenty field experiments were conducted at cultivator's fields during rabi seasons for 3 years (1982 to 1985) in various villages of Ludhiana district. The physical and chemical characteristics of the surface soil (0-15 cm depth) collected before sowing crop are given in table 1. The fertilizer treatments consisted of 5 graded levels of N (O, 40,80,120 & 160 kg N/ha as urea alongwith a basal dose of 30 kg P_2O_5/ha as single superphosphpate and 5 graded levels of P (O,15,30,45 & 60 kg P_2O_5/ha as urea). However, in 1982-83, there were only 4 levels of N (O,40,80,&

120 Kg N/ha with and without 40 kg P_2O_5/ha). Each treatment was replicated twice. The experiments were lad out in a randomised block design. Crop was harvested at maturity and both graini & straw yields were recorded plotwise.

The data from control and treated Pots/plots were used to work out relative yield uptake as follows:

$$\text{Per cent Relative yield/ uptake} = \frac{\text{Yield or uptake without nutrient}}{\text{Yield or uptake with adequate nutrient}} \times 100$$

Linear correlation coefficients were computed between soil tests and various yield uptake parameters. Critical levels of N and P in soil were also worked out as per Cate & Nelson (1965) procedure.

RESULTS AND DISCUSSION

(a) *Evaluation of Soil Test Methods for Nitrogen:* Among the various soil test methods for available N, organic carbon correlated significantly with grain yield in control pots ($r=0.52^{**}$) (Table 2). Available N estimated by alkaline $KMnO_4$ Oxidisable N failed to correlate with any of the yield or uptake parameters. In field experiments also, organic carbon was closely related to relative yield ($r=0.44^{**}$). The perusal of the data in table 2 also showed that the values of 'r' were of low order in case of $KMno_4$ - N as compared to that of organic carbon. It is, therefore, evident that organic carbon is a better index of N availability to raya crop. Superiority of organic carbon as an index of available N in soils of Punjab have also been reported by Singh and Brar (1973) for maize, Sidhu *et al* (1983) for wheat, and Sidhu and Dev (1985) for Barley under field conditions.

Since organic carbon was found to be a most suitable soil test method for predicting response to applied N in raya, a scatter diagram was prepared according to Cate & Nelson (1965) procedure both for pot and field experiments (Fig.1.). Critical organic carbon content for raya was 0.40% which is the one being used by State Soil Testing Labaratories.

(b) *Evaluation of Soil Test Methods for P :* Simple correlation coefficients were worked out between various parameters of grain yield and P uptake versus available P extracted by various methods (Table 2). The results elucidated that Olsen' P correlated significantly with control yield ($r=0.59^{**}$). relative yield ($r=0.57^{**}$), P uptake in control pots ($r=0.61^{**}$) and relative P uptake ($r=0.61^{**}$) in pot experiments. Other soil test methods for P viz, Bray P1, Bray P2, Datta & Kamath P, Citric acid - P and Acetic acid -P failed to correlate with any of the yield or uptake parameters. In field experiments also, Olsen's extractable P was found to correlate significantly with control yield ($r=0.55^{**}$) and relative yield ($r=0.54)^{**}$, Olsen's P was also found suitable for predicting responses applied P to wheat (Sidhu *et al*, 1984) and harley (Sidhu & Dev' 1985) in these soils.

TABLE 1. Physico-chemical characteristics and availability indicus (N &P) of soils used for pot and field exper ments.

Parameter	Pot experiment	Field experiment	Reference
Soil texture	Loamy sand to loam	Loamy sand to loam	Feel method
pH (1:2 soil water suspension)	8.1 – 8.85	7.9 –8.7	1:2 soil water suspension, pH meter
E.C. (mmos/cm)	0.20– 0.86	0.14–0.50	1:2 soil water suspension, solubridge
O.C. (%)	0.10–0.79	0.09–0.42	
Alkaline $KMno_4$–N (kg/ha)	38 – 163	37 – 162	Subbiah & Asija (1956)
Olsen-P (,,)	5.4–26.3	3.6–32.5	Olsen *et al* (1954)
Bray P- I (,,)	3.6–31.6	—	Bray & Kurtz (1945)
Bray P-II (,,)	16.0–185.0	—	Bray & Kurtz (1945)
Datta & Kamath (,,)	19.0–74.0	—	Datta & Kamath (1959)
Citric acid -P (,,)	20.0–241.0	—	Dyer (1894)
Acetic acid -P (,,)	36.0–263.0	—	William & Stewart (1943)
1N NH_4OAc- K (,,)	—	64–364	Hanway & Heidal (1952)

TABLE 2. Relationship (correlation coefficient) between various indices of soil N and P availability and Yield/up take parameters of raya (pot experiment

Soil test method	Control yield	Relative Yield	Uptake from control plot	Relative uptake
Alkaline $KMnO_4$-N	0.34	0.27	0.39	0.17
Organic Carbon	0.52*(0.42)	0.14(0.44*)	0.41	0.16
Olsen-P	0.59** (0.55**)	0.57**(0.54**)	0.61**	0.61**
Bray P- I	0.40	0.45	0.42	0.42
Bray P II	0.29	0.17	0.28	0.16
Datta & Kamath P	0.05	0.02	0.03	0.10
Citric acid-P	0.16	0.003	0.18	0.002
Acetic acid-P	0.18	0.07	0.22	0.05

* Significant at 5% l vel

** Significant at 1% level

Values in brackets are for field experiments.

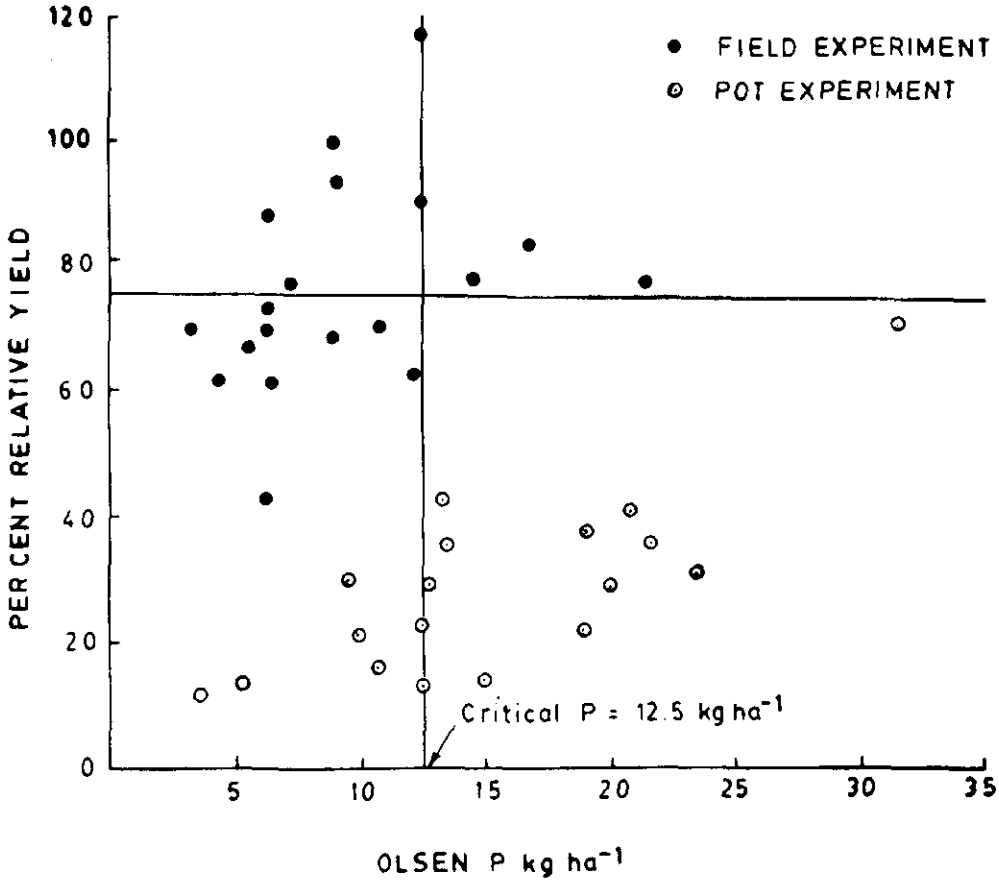

FIG. 2. RELATIONSHIP BETWEEN OLSEN P IN SOIL AND RELATIVE YIELD

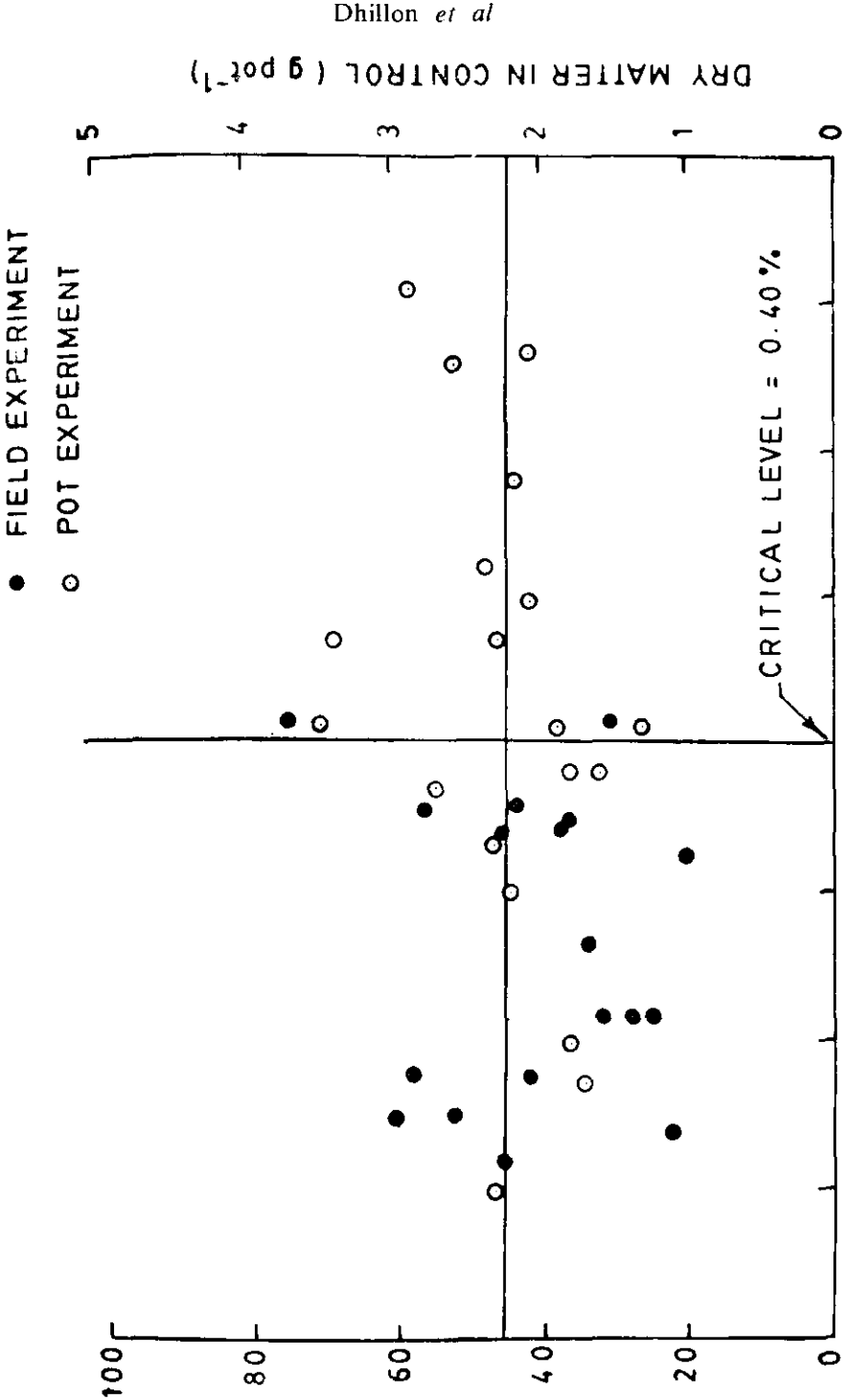

Fig. . : Relationship between organic Carbon in soil Relative yield

The critical level of Olsen- P below which raya will respond to applied P worked out both from pot and field experiments (Fig.2), was found to be 12.5 kg/ha. These values are quite close to that used by soil testing laboratories (12.4 kg/ha) in the state for fertilizer P recommendatoons to various crops.

It is conclusively evident from these results that organic carbon and Olsen' P and their rating limits which are presently used by State's soil Testing Laboratories are suitable for predicting soil N and P availability to raya crop, respectively.

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COMBINING ABILITY ANALYSIS IN *BRASSICA CARINATA* (KARAN RAI)

R.S. MALIK AND MUNSHI SINGH
Division of Genetics Indian Agricultural Research Institute New Delhi-110012.

ABSTRACT

A line × tester (8 × 7) set of crosses made in *Brassica carinata* (Ethiopian mustard) was studied in the parental and F_1 generation, with a view to see the extent of variability produced in the material by hybridization and nature of gene action involved in the improvement of seed yield, it's components and oil per cent. The analysis for heterosis and combining ability clearly showed that cross 4x7 was 51.9% superior in seed yield over the better parent and 27.9% over the highest yielding varieties with highest gca effect (6.81). The improvement of this crop has been suggested through the exploitation of heterosis as well as additive × additive type of gene action.

Key words : Heterosis, combining ability, *Brassica carinata* variability.

INTRODUCTION

A new species of *Brassica* i.e. *B. carinata* has been introduced recently in India which has clearly established it's superiority over conventional species against serious pest like mustard aphid, *Lipaphis erysimi*, and white rust disease caused by *Albugo candida* besides being tolerant to certain abiotic factors (Malik, 1981; Malik and Singh, 1987). Since there is a limited variability in this species, a line x tester programme was initiated to generate genetic variability in the material. The information on the genetic analysis of yield and yield components also is reported in this paper.

MATERIALS AND METHODS

Eight selfed lines and 7 testers of *B. carinata* (Ethiopian mustard) chosen from the germplasm were grown at Indian Agricultural Research Institute, New Delhi in 1982-83. The lines Bcr-210-1, Bcr-2578-11 (yellow seeded), Bcr-2580, Bcr-BRA-929, Bcr-2907, Bcr-2578-6 (brown seeded), Bcr-2578-7 (shinning yellow seeded) and Bcr-BS-26-M (medium in height) were crossed with testers Bcr-2579, Bcr-2607, Bcr-BCID, Bcr-K-1 (Medium in height), Bcr-K-2 (medium in height), Bcr-HC-1 (dwarf) and Bcr-HC-2 (dwarf) in all possible combinations. The strains Bcr-K-1 and K-2 were received from Kanpur and Bcr-HC-1 and HC-2 from Haryana. The F_1 progenies (comprising 56 crosses) were grown in 1983-84 along with their parents in randomised block design with three replications. Each F_1 combination was grown in a single row per replication spaced at 45 and 15 cms between and within the rows respectively with a row length of five metres. Observations were recorded on five randomly selected plants from each cross and their parents, on days to flowering and maturity, plant height (cm), number of primary and secondary branches, length of main shoot (cm), siliqua on main shoot, seeds/siliqua, grain yield per plant (g) and oil content. The data from these experiments were subjected to combining ability analysis following the method given by Kempthorne (1957).

RESULTS AND DISCUSSIONS

The mean performance of the parents and selected F_1s are given in Table 1. For all the characters, the differences in parents and F_1s were significant except for maturity. Among the female parents the highest yielder was number 8 (35.2 g) whereas in males the top yielder was number 3 (36.6 g). There were 18 crosses which gave higher yield than the highest yielding parent (male parent 3) and their yield ranged from 42.0 to 46.8 g/plant (Table 1). The analysis of heterosis of hybrids over the better and highest yielding parents showed 14.0 to 51.9 per cent heterosis over the better and 27.9 over the highest yielding parent (Table 5). This cross also showed the highest positive sca effect (6.81). The heterosis in yield of this cross was primarily due to more number of primary and secondary branches.

The analysis of variance for combining ability indicated significant variances for lines in all the 10 characters and for testers in 9 characters (Table 2). The variance due to hybrids was highly significant for all the characters except yield whereas variance due to interaction between line x tester was highly significant for 50% maturity, plant height, primary and/secondary branches, siliqua on main shoot and oil content. The significance of variance was an indication of variability existing between line x tester in cross combinations for 50% maturity and some of the yield components. Therefore, further analysis in terms of combining ability and degree of heterosis was justified.

The gca effects for both male and female parents are given in Table 3. Among the female parents, numbers 4,6 and 3 were the best general combiners for yield. Parent numbers 2 and 7 were the best general combiners for siliqua on main shoot. For length of main shoot the best general combiners were parents 2,7 and 8. For primary and secondary branches and earliness as indicated by 50% flowering and maturity, female parent 1 was the best general combiner. Among the male parents numbers 6,5 and 3 were best combiners for seed yield, siliqua on main shoot and primary and secondary branches respectively.

The sca effect of the selected cross combinations for various characters are presented in Table 4. The results clearly indicated that none of the cross combinations showed significant sca effect for seed yield. For oil content, significant positive effect was observed in crosses 6 × 4, 3 × 6, 5 × 7 and 7 × 5. Similarly, highly significant positive sca effect was noted for seeds/siliqua in crosses 1 ×6, 4 × 1, 7 × 6 and 8 × 2, siliqua on main shoot in crosses 2 ×7, 6 × 1 and 7 × 7, length of main shoot in crosses 1 × 4, 2 × 3, 2 × 7, 4 × 2, 5 × 2, 5 × 4, 6 × 1, 7 × 5 and 7×7, secondary branches in crosses 1 × 3, 2 × 2, and 8 × 2, primary branches in only 6 × 2 cross and plant height in 2 ×1 and 5 × 5 crosses. Whereas negative sca effects were found with regard to maturity in cross combination 2 × 2.

The possibility of developing high yielding lines through conventional recombination breeding is very good in cross 4 × 7 which showed a heterosis of 51.9 and 27.9% over better and highest yielding parent respectively provided the specific heterosis is due to additive x additive type interactions. This, of course, needs confirmation by

TABLE 1. Mean performance of parents and selected F_1s

Source	Characters									
	Plant yield (g)	Oil content (%)	50% Flowering (days)	50% maturity (days)	Plant height (cm)	Primary branches	Secondary branches	Main shoot length (cm)	Siliqua on main shoot	Seeds/ siliqua
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Female										
1 (Bcr-210-1)	33.5	36.2	114.7	167.4	262.7	14.5	50.5	30.4	18.7	13.9
2 (Bcr-2578-11)	34.7	35.4	115.9	169.9	264.3	15.9	40.5	33.4	24.0	13.9
3 (Bcr-2580)	30.7	35.1	117.2	170.2	253.4	14.7	39.5	34.1	22.7	12.5
4 (Bcr-BRA-929)	30.8	32.4	119.3	169.1	277.5	15.9	38.9	27.3	23.6	13.2
5 (Bcr-2907)	31.3	33.3	123.3	169.8	271.8	16.9	40.9	27.2	18.1	14.7
6 (Bcr-2578-6)	30.0	33.7	125.5	172.9	264.5	17.4	49.4	31.8	21.1	15.4
7 (Bcr-2578-1)	31.0	35.0	117.8	169.4	271.9	13.2	35.4	37.7	25.1	13.6
8 (Bcr-BS-26-N)	35.2	34.5	116.5	169.8	262.2	14.8	41.7	36.2	20.9	15.5
SE.	2.19	0.53	1.03	0.92	2.83	0.51	2.52	0.75	0.72	0.30
Male										
1 (Bcr-2579)	35.6	34.9	119.6	169.6	258.4	15.3	44.4	30.7	20.9	15.6
2 (Bcr-2607)	27.1	34.1	120.2	170.9	255.5	17.0	49.3	23.3	16.9	13.9
3 (Bcr-BC 10)	36.6	35.7	121.0	170.2	274.5	15.7	42.5	34.9	22.0	15.0
4 (Bcr-K-1)	27.1	33.6	119.6	169.4	264.5	16.2	46.5	31.4	20.6	14.9
5 (Bcr-K-2)	32.1	34.1	119.5	170.9	273.9	14.6	44.5	34.3	26.2	14.5
6 (Bcr-HC-1)	30.2	33.6	116.3	168.7	264.5	13.9	39.4	37.3	25.1	14.0
7 (Bcr-HC-2)	27.5	35.1	115.1	169.1	259.2	13.7	40.3	37.7	25.9	15.2
S.E.	2.05	0.50	0.96	0.86	2.65	0.48	2.36	0.70	0.68	0.28

Table 1 Contd.

Source	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1 × 6	41.4	34.4	113.3	171.0	256.1	14.2	36.9	30.0	17.0	14.8
2 × 6	42.8	35.8	116.6	168.6	267.6	14.6	47.8	48.4	33.8	13.7
3 × 2	40.3	33.5	119.0	171.6	251.0	18.2	40.0	27.1	19.0	14.4
3 × 3	43.3	34.5	122.6	170.6	258.9	16.4	41.6	33.4	19.0	15.9
3 × 7	40.2	34.2	116.0	168.3	230.1	11.8	28.4	28.5	26.8	16.2
4 × 6	42.3	31.4	117.3	166.6	287.4	16.2	42.2	34.0	25.8	13.8
4 × 7	46.8	30.7	121.6	170.0	285.7	18.8	48.4	28.0	21.6	16.1
5 × 1	42.0	29.3	126.6	169.3	282.7	16.6	51.6	24.4	15.2	14.9
5 × 2	43.6	33.2	121.6	168.3	245.5	17.2	44.0	22.5	15.8	14.2
5 × 3	42.0	36.5	122.0	170.3	251.0	20.6	51.6	27.1	16.6	16.0
5 × 4	42.6	34.0	128.0	172.0	275.9	16.0	45.6	31.4	20.1	14.5
5 × 5	41.4	29.1	127.3	174.6	307.5	17.3	50.7	33.6	22.8	14.1
6 × 5	42.6	33.7	128.6	177.0	257.9	14.4	59.0	31.0	18.7	16.2
6 × 6	42.9	31.2	121.6	172.3	244.3	12.2	31.9	34.0	25.3	13.1
6 × 7	42.0	36.3	116.0	171.6	248.0	13.0	32.1	30.2	19.7	15.5
7 × 1	40.6	35.6	120.6	165.6	274.8	12.0	32.6	30.8	23.5	14.3
7 × 2	40.4	35.8	122.6	172.0	254.7	12.9	25.5	19.4	16.6	11.4
7 × 6	40.4	30.9	115.6	168.0	273.5	12.8	33.3	43.7	29.7	14.4

TABLE 2. Analysis of variance for combining ability

Source	D.F.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Rep.	2	4.28	14.58	13.18	2.85	147.0	5.86	4.36	21.78	2.35	0.59
Hybrid	55	57.85	16.78**	69.98**	21.37**	812.67**	23.00**	414.18**	238.72**	92.41**	4.97**
Line	7	122.03	31.40	298.73**	47.39**	1223.00**	45.42**	1079.62**	643.43**	273.69**	13.77**
Tester	6	31.66	14.82**	114.50**	17.55**	1200.1**	90.47**	421.34**	737.74**	276.83**	9.54**
L × T	42	50.90	14.63**	25.47**	17.57**	668.9**	9.63	302.25**	99.99**	35.85**	2.86
Error	109	50.79	3.06	11.20	9.03	84.09	2.77	67.11	5.95	5.57	1.01
σ^2Gca		1.15	0.38	8.05	0.66	23.23	2.59	19.92	26.25	10.64	0.39
σ^2Sca		0.03	3.86	4.76	2.85	201.61	2.28	78.38	31.35	10.09	0.62

TABLE 3. Estimates of General Combining ability effects

Source	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Female -1	-3.75**	1.73	-4.09**	-2.39**	-3.10	1.72**	10.54**	-3.07**	-3.83**	-0.86**
2	-2.58	0.96	-2.90**	0.04	-1.44	0.16	7.50	9.94**	5.50**	-0.78*
3	-1.37	0.61	-1.52	0.42	-12.40	-1.16	-5.46*	0.58	0.21	0.75*
4	2.47	2.00*	0.53	-0.72	11.67**	0.17	-6.04**	-6.18**	-1.06**	0.50
5	2.05	-1.18	4.53**	-1.01	5.98*	1.12*	1.92	-6.35**	-4.40**	-0.01
6	1.75	-0.70	8.72**	3.04**	-1.26	1.69**	4.42	-1.75*	-1.46*	0.71*
7	0.73	0.50	-0.99	-0.39	6.10*	-2.53**	-9.60**	4.14**	4.57**	-1.12**
8	-2.04	0.90	-2.28*	-0.01	-5.55*	-0.96	-3.27	2.69**	-1.65*	0.82*
S.E.	2.20	0.54	1.03	0.93	2.83	0.51	2.53	0.75	0.73	0.31
Male -1	-1.74	0.42	0.86	-0.20	2.64	-0.44	-0.57	-2.82**	-1.62**	0.86**
2	-0.19	-0.31	1.45	1.05	-10.25**	2.15**	4.34*	-10.22**	-5.58**	-0.85**
3	-0.71	1.20*	2.28*	0.39	8.69**	2.93**	5.48**	1.39*	-0.53	0.29
4	-0.24	-0.83	0.82	-0.45	-1.25	0.43	1.53	-2.13**	-1.89**	0.14
5	0.78	-0.32	0.70	1.05	8.07**	-1.13	-0.48	5.81**	3.71**	-0.25
6	1.91	-0.86	-2.43**	-1.11	-1.29	-1.89**	-5.59*	3.76**	2.57**	-0.70*
7	0.18	0.69	-3.68**	-0.74	-6.61*	-2.05**	-4.72*	4.21**	3.34**	0.51
S.E.	2.06	0.50	0.97	0.87	2.64	0.48	2.36	0.70	0.68	0.29

TABLE 4. Estimates of specific combining ability effects of selected crosses

Cross	Characters									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1 ×3	0.45	-1.07	-1.99	-2.86	5.95	1.20	21.69**	2.06	0.13	-0.16
1 × 4	0.25	0.99	-2.54	3.36	4.96	1.22	11.70	5.71**	3.42	0.25
1 × 6	5.96	-0.94	1.05	4.64	-5.32	-1.45	-13.04*	-4.25**	-4.24*	1.66**
2 × 1	-6.88	0.78	-0.77	3.96	23.27**	-1.07	- 4.95	-1.21	0.95	-0.54
2 × 2	-4.56	-1.61	-2.02	-4.96**	4.51	2.80*	25.10**	-10.28**	-5.48**	0.24
2 × 3	1.62	-0.32	0.15	1.37	-0.17	-0.64	-1.53	6.51**	3.00	-0.30
2 × 6	6.13	1.30	3.19	-0.12	4.55	0.51	0.88	1.14	3.16	0.49
2 × 7	2.73	0.19	0.44	0.50	-12.39	-1.33	-6.99	9.16**	5.66**	0.61
3 × 3	5.34	-1.75	3.10	-0.01	-3.14	-1.19	-3.44	-2.13	-3.18	0.16
3 × 6	-1.62	3.24**	-0.52	0.16	3.51	1.49	14.37*	3.22	0.72	1.18
4 × 1	0.26	2.48	-6.20	-1.95	-38.05**	-2.02	-4.80	3.37	-2.34	0.26
4 × 2	-0.49	1.25	-2.11	3.14	6.32	-3.07*	-6.45	7.44**	2.62	-0.00
4 × 7	6.81	-2.45	6.01*	1.59	14.82	0.86	6.21	-3.52	-5.37**	-0.40
5 × 2	4.40	0.22	-3.11	-2.58	-16.05*	-1.83	-7.21	5.54**	3.28	0.38
5 × 4	3.51	1.51	3.84	2.59	5.41	-1.38	-2.87	6.32**	3.85**	-0.39
5 × 5	1.30	-3.90**	3.30	3.76	27.68**	1.52	4.28	0.65	0.98	-0.32
5 × 7	-4.57	2.93*	-1.32	-1.45	11.31	0.84	0.52	-4.62	-2.78	0.51
6 × 1	-1.01	1.45	1.95	-1.37	19.23*	1.93	10.88	10.00**	7.38**	-0.43
6 × 2	-0.90	-2.65	1.70	0.57	11.93	5.20*	6.35	3.61	1.74	0.25
6 × 4	-0.18	3.93**	1.32	-1.46	2.86	1.12	1.96	-0.81	-1.69	0.95

Table 4 Codtinued

Cross	Characters									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
7 × 5	-1.51	2.88*	-7.51**	-2.20	-24.17**	-0.97	0.39	5.35**	2.48	-0.29
7 × 6	0.49	-3.24**	0.29	-0.36	2.93	1.40	3.51	2.26	0.02	1.46**
7 × 7	-1.98	0.45	-0.80	0.59	0.58	1.22	12.96*	13.29**	7.21**	-0.25
8 × 2	-1.44	2.95*	0.06	1.09	6.89	-1.01	16.51*	2.10	1.20	1.67**
S.E.	3.82	1.43	2.73	2.45	7.49	1.36	6.69	1.99	1.93	0.62

TABLE 5. Heterosis for seed yield/plant in selecetd crosses

Cross Combination	Mean seed yield (g)			% increase over superior parent	% increase over highest yield or var (36.6g)	Sca
	Cross	Male parent	Female parent			
1×6	41.4	33.5	30.2	23.6	13.1	5.96
2×6	42.8	34.7	30.2	23.3	16.9	6.13
3×2	40.3	30.7	27.1	31.3	10.0	1.81
3×3	43.3	30.7	36.6	18.3	18.3	5.34
3×7	40.2	30.7	27.5	30.9	9.8	1.38
4×6	42.3	30.8	30.2	37.3	15.6	0.61
4×7	46.8	30.8	27.5	51.9	27.9	6.81
5×1	42.0	31.3	35.6	18.0	14.7	4.35
5×2	43.6	31.3	27.1	39.3	19.1	4.40
5×3	42.0	31.3	36.6	19.7	14.7	3.32
5×4	42.6	31.3	27.1	36.1	16.4	3.51
5×5	41.4	31.3	32.1	29.0	13.1	1.30
6×5	42.6	30.0	32.1	32.7	16.4	2.80
6×6	42.9	30.0	30.2	42.0	17.2	1.93
6×7	42.0	30.0	27.5	40.0	14.7	2.73
7×1	40.6	31.0	35.6	14.0	10.9	4.34
7×2	40.4	31.0	27.1	30.3	10.4	2.59
7×6	40.4	31.0	30.2	30.3	10.4	0.49

growing parental F_1 and F_2 generations together and comparing F_1 and F_2 means. If additive x additive epistasis is confirmed then transgressive recombinants for higher yield from F_2 population of this cross can be recovered and advanced through conventional breeding procedures

B. carinata which has certain desirable features like resistance to abiotic and biotic factors over *B. juncea* has low oil content than *B. juncea*. Therefore, to make the *B. carinata* a profitable crop over *B. juncea*, improvement of its oil content along with seed yield will be the goal. Some of the cross combinations showed high seed yield with high oil content like 2 × 6 and 5 × 3 crosses, where seed yield/plant were 42.8 and 42.0 g and oil content 35.8 and 36.5% respectively. Similar results were obtained in *B. juncea* by Asthana et al. (1979), Rawat and Anand (1980) and Trivedi et al. (1983). Seed yield and oil content can be exploited simultaneously in such crosses through conventional breeding methods. The interrelationship between these two characters in segregating population of these crosses will have to be studied at each step of simultaneous improvement programme of yield and oil content.

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ROLE OF AMINO ACIDS IN RELATION TO APHID (*LIPAPHIS ERYSIMI KALT.*) RESISTANCE IN CRUCIFEROUS SPECIES

R.S. MALIK
Division of Genetics, Indian Agricultural Research Institute, New Delhi-110012.

ABSTRACT

The racemes of different species and cultivated varieties of crucifers were analysed for free amino acid content. Significant differences were observed between resistant (13.7 mg/g) and susceptible (20.3 mg/g) groups and also between tolerant (15.3 mg/g) and susceptible (20.3 mg/g) groups with regard to free amino acids. The per cent loss in free amino acid content due to aphid infestation was significantly higher in susceptible (70.9%) than resistant (24.0%) and tolerant (40.5%) groups. The fecundity of aphids was found possitively correlated with free amino acid content of the plants.

Key words : Resistant, tolerant, susceptible, free amino acids, aphid infestation, aphid fecundity.

INTRODUCTION

There may be several factors responsible in determining the host by an insect (Painter, 1951; Horber, 1972) but presence or absence of specific food material in respect of quality or quantity in the host is very important factor for consideration (Kennedy and Booth, 1951). Therefore, to understand the aphid-plant relationship in cruciferous species, the effect of free amino acids on the multiplication rate of aphids was investigated.

MATERIALS AND METHODS

The plant material listed in Tables 1 and 2 was screened for aphid infestation and fecundity for two years under natural aphid infestation. The whole material was classified into three non-overlapping categories i.e. resistant, tolerant and susceptible groups (Malik and Anand, 1984). The plants of these groups were analysed by the method of Lawrence *et al.* (1959) for extraction of total free amino acids and then their content was determined by the Ninhydrin method (Rosen, 1957) and expressed in terms of mg alanine/g of moisture-free and fat-free powdered material.

Plant samples for biochemical analysis were collected at 50% flowering. In order to maintain uniformity in the metabolic processes, samples in all cases were collected between 8.00 and 9.00 A.M. The top six inches of racemes of tertiary branches were plucked and air-dried for analysis as this part is more infested by the aphids. Two such samples were collected from each variety/species from both infested and non-infested racemes. The contents in infested samples were used to find out the percentage loss of free amino acids in comparision to non-infested ones.

The analysis of variance for randomised block design and correlation coefficient were adopted from Steal and Torrie (1960). The mean values were tested for significance using critical difference (C.D.) value.

RESULTS AND DISCUSSION

There was wide variation with regard to aphid fecundity and free amino acid content in non-infested racemes not only between the groups but also within the group of cruciferous species and cultivated varieties of *Brassica* (Table 1 and 2). The range in free amino acids of cruciferous species was observed from 8.6 in amphidiploids (*B. chinensis* × *B. nigra*) to 24.7 mg/g in *B. narinosa*. Significant differences were observed between resistant and susceptible groups and also between tolerant and susceptible groups but not between resistant and tolerant types.

The aphid caused maximum losses in free amino acid content in susceptible (70.9%) and minimum in resistant (24.0%) groups. Highly significant differences were observed in all the three groups in respect of losses caused by the aphids in free amino acid content.

The overall range of free amino acid content in non-infested raceme of cultivated varieties of *Brassica* varied from 12.6 in E.S. 10 variety of *B. juncea* to 29.7 mg/g in C-4 variety of *B. campestris* var yellow *sarson* (Table 2). The highest mean value of free amino acid content was observed in *B. campestris* var yellow *sarson* group (22.9 mg/g) followed by *B. campestris* var *toria* (both were highly susceptible to aphid) and the lowest in *B. juncea* group (16.5 mg/g). All the three groups of *B. campestris* i.e. yellow *sarson*, brown *sarson* and *toria* (highly susceptible to aphid) differed significantly in amino acid content from *B. juncea*, *B. napus* and *B. nigra* except *B. napus* which did not differ from *toria*.

The loss of free amino acid content due to aphid infestation ranged from 6.5 in *B. napus* variety Tower to 60.6 per cent in *B. campestris* var, yellow *sarson* strain C-4. The maximum loss in amino acids was found in yellow *sarson* (43.3%) and minimum in *B. napus* group (19.8%). All the three groups of *B. campestris* differed significantly from *B. juncea*, *B. napus* and *B. nigra* in respect of lose of free amino acids.

The fecundity of aphids was found possitively correlated with free amino acid content ($r=0.48^{**}$) of the plant.

Nutritional requirements of the sucking insects especially aphids have been studied with considerable success by rearing them on chemically defined diets. In the case of *Myzus persicae* and *Acyrthosiphon pisum*, it has been observed that different sucrose and amino acid levels in the diets effect probing and settling, survival and larval growth and development (Mittler and Dadd, 1965 a and b; Dadd and Mittler, 1965 and Auclair, 1965). Pant (1972) reported that *Lipaphis erysimi* could select their food on the basis of nutritional superiority depending upon the quantitative composition of the food stuff. He further observed that the growth (not survival) of *L. erysimi* nymphs was markedly influenced by the total amino acid concentration in the diet.

In the present study also quantitative differences in free amino acid contents observed among different groups of cruciferous varieties/species were apparently the

TABLE 1, **Free amino acid content and their losses due to aphid in the raceme of Cruciferous species**

Species	Aphid* fecundity 5 ×	Free amino acids (mg/g) Not-infested racemes	Insfeted racemes	% loss
Resitant group				
B. integrifolia	172	13.7	12 0	12.4
B. carinata	215	12.1	8.3	31.4
B. alba	225	19.3	12.4	35.7
Eruca sativa, Swedish	117	11.9	9.4	21.0
Crambe abyssinica	135	11.2	9.0	19.6
Mean	173	13.7	10.2	24.0
Tolerant group				
B. japonica	324	10.3	9.4	8.7
B. nigra, Local	357	13.8	10.3	25.4
B. amarifolia	367	20.2	10.1	50.0
B. tournefortii	264	14.2	9.9	30.3
B. napus, Turret	442	17.1	12.9	24.6
B. oleracea, Snow Ball-16	408	9.4	4.7	50.0
B. juncea, Local	387	13.2	7.6	42.4
B. rapa, Pusa Sweti	373	15.3	9.9	35.3
Raphanus sativus, Pusa Deshi	415	9.9	5.6	43.4
(*B. chinensis* × *B. oleracea*)	374	11.2	5.2	53.6
(*B. campestris* × *B. oleracea*)	386	22.8	17.5	23.4
(*B. chinensis* × *B. nigra*)	411	8.6	5.4	37.2
(*B. pekinensis* × *B. nigra*)	477	20.7	8.8	37.5
(*B. narinosa* × *B. nigra*)	461	21.6	10.9	49.5
(*B. japonica* × *B. nigra*)	432	21.7	9.0	58.5
Mean	383	15.3	9.1	40.5
Susceptible group				
B. chinensis	573	18.4	9.5	48.4
B. narinosa	543	24.7	5.4	78.1
B. pekinensis	589	16.2	4.5	72.2
B. campestris var. *toria*	654	19.4	5.8	70.1
B. campestris (Zero erucic)	572	24.7	6.3	74.5
Camelina sativa	651	18.4	3.9	78.8
Mean	597	20.3	5.9	70.9
C.D. (p=0.05%)	113	1.70	0.71	6.77

* Two years mean

TABLE 2. Free amino acid content and their losses due to aphid infestation in the racemes of cultivated varieties/species of *Brassica*.

Species (1)	Aphid fecundity 5 × (2)	Free amino acids (mg/g) Not-infested raceme (3)	Infested raceme (4)	% loss due to aphid (5)
B. juncea				
Appressed mutant	595	14.8	9.4	36.4
E.S. 10	620	12.6	9.9	21.4
T. 59	432	16.2	13.0	19.4
Laha 101	468	18.4	15.3	17.1
R.L. 18	513	20.2	13.5	33.3
Mean	526	16.5	12.2	25.5
B. napus				
72/244/6	397	17.1	14.8	13.1
Tower	319	20.7	19.3	6.5
Zephyre	357	20.2	14.8	26.7
Brownski	405	20.2	18.0	11.1
Oro	368	23.8	13.9	41.5
Mean	369	20.4	16.2	19.8
B. nigra				
Local	322	17.2	15.0	13.0
E.C. 24346	317	15.5	13.0	15.8
I.B. 1861	403	18.0	14.8	17.5
I.B. 1872	368	16.7	12.5	24.7
I.B. 1882	427	16.6	10.2	38.5
Mean	432	16.8	13.1	21.9
B. campestris var. yellow *sarson*				
I.B. 1026	690	23.8	13.9	41.5
I.B. 1054	590	18.4	13.0	29.3
I.B. 1078	568	18.9	13.9	26.3
Y.S. 51	670	20.7	10.8	47.8
Y.S. 144	629	26.6	11.7	54.3
C 4	587	29.7	11.7	60.6
Mean	622	22.9	12.5	43.3

Table 2 continued

(1)	(2)	(3)	(4)	(5)
B. campestris var. brown *sarson*				
Assam Mass Selection	397	15.3	11.1	27.4
Suphala	578	21.6	18.5	51.1
B.S.H. 1	560	21.6	12.5	42.0
Pusa Kalyani	509	18.9	13.4	29.1
D.C. 1	611	21.6	10.9	49.5
Mean	531	19.8	13.3	39.8
B. campestris var *toria*				
I.B. 140	587	19.2	13.8	27.9
I.B. 1098	321	18.8	16.2	18.2
Type 9	716	19.4	10.8	44.5
Type 36	670	21.6	9.1	57.6
Karmaha	645	22.3	12.6	43.4
Mean	588	20.5	12.5	38.3
C.D. (p=0.05%)	94	1.26	0.93	6.77

factors involved in determining resistance or susceptibility to aphid (*L. erysimi*) infestation as amino acid content in suseceptible varieties/species were found significantly higher than in resistant and tolerant types. Similarly, Auclair *et al.* (1957) reported that pea varieties susceptible to *A. pisum* contained comparatively higher (almost twice) concentrations of free amino acids and amides than resistant ones; and the rate of feeding on the later was even less then half than that on the susceptible varieties (Auclair, 1959). These findings are further supported by Srivastava and Auclair (1974). The resistant group of varieties could not attract more aphids and those were feeding on them might not have obtained enough of each essential amino acids per unit of time. Retnakaran and Beck (1968) reported that eleven amino acids were essential for growth and reproduction of *A. pisum*. Thus the aphids could not sustain optimum growth and reproduction on resistant varieties on account of the deficiency of the amino acid content in them. In other words, on resistant species, growth and reproduction of aphids proceeded at a slower rate than on the varieties high in free amino acids thereby contributing to resistance (Auclair, 1957) consequently the total aphid population on resistant species was smaller. On the other hand susceptible group of species, being rich in amino acids provided better nutritional conditions for aphid multiplication due to which a large aphid population was observed on them.

The attraction of more aphids towards the susceptible species with sufficient amount of free amino acids leading to severe-losses in their contents indicated that free amino acids of the plant was phagostimulatory to aphids, *L. erysimi*. Aphids after landing probe the host plant at different sites (Hennig, 1963, and 1966) presumably to get the information about the internal chemical and physical properties of the substrate. With this information the aphids then select their hosts on the basis of nutritional superiority of the foodstuff (Kennedy and Booth, 1951).

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CORRELATION AND PATH-COEFFICIENT ANALYSIS IN SUNFLOWER (*HELIANTHUS ANNUUS* L.)

G.VANISREE, K. ANANTHASAYANA, G.V.S. NAGABHUSHANAM AND C.A. JAGADISH
Department of Genetics and Plant Breeding College of Agriculture, Rajendranagar, Hyderabad-500 030

ABSTRACT

Genotypic and phenotypic correlations among seed yield and nine component characters were studied in 55 genotypes (10 parents and 45 crosses) of sunflower (*Helianthus annus* L.). Pooled analysis of parents and crosses revealed that head diameter, stem diameter, 100 seed weight, number of leaves per plant and plant height had highly significant and positive correlation with yield. Head diameter, stem diameter, 100 seed weight, number of leaves per plant and plant height also had significant and positive intercorrelation among themselves. Stem diameter, head diameter, number of leaves per plant and seed setting per cent influenced the yield directly whereas 100 seed weight and plant height influenced via days to 50% flowering and stem diameter respectively. As such improvement of sunflower crop through yield component traits would be rewarding.

INTRODUCTION

In most of the breeding programmes, yield is ultimate object which has highly variable expression. Yield is determined by the interaction of a number of characters among themselves and with the environment. Thus, a knowledge of association of various characters with yield and among themselves would provide criteria for indirect selection through components for improvemet in yield. Such information in sunflower is very limited. Therefore, genotypic and phenotypic correlations among ten important quantitative characters were analysed. The path-coefficient analysis of Wright (1921) was also undertaken to understand the direct and indirect effects of various traits on yield.

MATERIALS AND METHODS

The material for present study consisted of 55 genotypes comprising ten parents and their fortyfive direct crosses without reciprocals. These were grown during October, 1987 in a randomized block design with three replications. A distance of 60 cm between rows and 30 cm between plants was maintained. Data were collected on five random competitive plants in each genotype for days to 50% flowering, plant height (cm), number of leaves per plant, head diameter (cm), stem diameter (cm), seed filling per cent, husk content (%), 100 seed weight (g), oil per cent and seed yield/plant (g), phenotypic and genotypic correlations were worked out according to Al-jibouri *et al.* (1958) and path analysis according to Dewey and Lu (1959).

RESULTS AND DISCUSSION

Genotypic correlation coefficients (Table 1) were, in general, higher than phenotypic correlation coefficients. Seed yield/plant (g) was significantly and positively correlated with head diameter, stem diameter, 100 seed weight (g), number of leaves per plant and plant height both at phenotypic and genotypic levels. This indicated that

simultaneous selection for these traits might bring an improvement in seed yield. Similar results were also reported by Stoyanova *et al.* (1971), Kovacik and Skaloud (1972, Varsheny and Basudeo Singh (1977), Chandra and Anand (1977), Signh *et al.* (1985). Further plant height was significantly and positively correlated with days to 50% flowering, number of leaves per plant, stem diameter and head diameter. When the duration is longer, the plant grows tall and gives more number of leaves which produce higher amounts of photosynthate for larger heads and seeds. Therefore such correlations are not unexpected. But in sunflower short duration and dwarf varieties are preferred so that they could be fitted in multiple cropping more easily and could withstand lodging. Therefore undesirable association of plant with yield calls for a compromise between selection for high yield, dwarfness and earliness.

As yield is influenced by many factors, selection based on simple correlation without taking into consideration the interaction between the component characters can be misleading. Therefore, the genotypic correlations were partitioned into direct and indirect effects and presented in table 2.

The correlation coefficient between days to 50% flowering and seed yield was positive (0.056). However, this was mainly due to its indirect effect via stem diameter (+0.290) and husk content (%) (+0.103). The high negative direct effect (-0.373) indicated that early flowering varieties could be developed. This was also observed by Varshney and Singh (1977) and Dhadhuk *et al.* (1985).

The direct effect of plant height on yield was high and negative (0-.360). But it had significant positive association with yield (0.157*) which was owing to a indirect contribution through stem diameter (+0.364) and head diameter (+0.183). This indicated that dwarf varieties with enhanced stem and head diameter which indirectly contributed to seed yield could be developed. Similar negative direct effects were reported by Chandra and Anand (1977), Pathak (1983) and Dhaduk *et al.* (1985).

The direct effect of number of leaves per plant (+0.098) on yield was low in magnitude and its indirect effect via stem diameter proved to be chief cause of significant positive genotypic correlation (+0.206**) between the above two charcters. The stem diameter had high direct effect (+0.540) in bulding up the highly significant positive correlation with yield per plant (+0.400**). The indirect effects through other characters were also positive. Chandra and Anand (1977) emphasised this observation, reporting that a higher stem diameter formed a major component for higher seed yield.

The direct effect of head diameter (−0.348) was more or less similar to its total genotypic correlation coefficient (+0.381**) which indicated that the variability for this character is not much influenced by the changes in the variability in other characters. This observation was in agreement with Velkov (1980), Sheriff *et al.* (1984) and Singh *et al.* (1985). The direct effect of seed setting per cent (+0.092) on yield/plant was low in magnitude and its indirect effect through days to 50% flowering and plant height proved to be chief cause of high positive genotypic correlation (0.144**) with yield.

TABLE 1. Phenotypic and genotypic correlation coefficcents among ten characters in parents and crosses

Character	Days to 50% flowering	Plant height	No. of leaves/ plant	Stem diameter	Head diameter	Seed setting per cent	100 seed weight	Husk content per cent	Oil per cent	Yield per plant
Days to 50% flowering		0.434**	0.322**	0.389**	0.205**	-0.160*	-0.466**	-0.439**	-0.547**	0.055
Plant height	0.445**		0.546**	0.471**	0.501**	-0.114	0.015	-0.277**	-0.149*	0.155*
Number of leves per plant	0.354**	0.609**		0.338**	0.272**	0.065	0.036	-0.218**	-0.133	0.186*
Stem diameter	0.537**	0.673**	0.515**		0.329**	-0.044	0.126	-0.237**	0.273**	0.264**
Head diameter	0.204**	0.525**	0.283**	0.394**		0.066	0.244**	-0.290**	0.009	0.350**
Seed setting per cent	-0.165*	-0.118	0.092	-0.091	0.068		0.151*	0.094	0.062	0.137
100 seed weight	-0.491**	0.016	0.029	0.177*	0.269**	0.160*		0.132	0.295**	0.265**
Hulling per cent	0.455**	-0.284**	0.262**	-0.349**	-0.295**	0.093	0.137		0.424**	-0.324**
Oil per cent	-0.618**	-0.164*	-0.144*	-0.353**	0.048	0.067	0.338**	0.489**		-0.138
Yield per plant	0.056	0.157*	0.206**	0.400**	0.381**	0.144*	0.271**	-0.338**	-0.158*	

Phenotypic correlations - above diagonal; Genotypic correlations - below diagonal
* Significant at 5% level; ** Significant at 1% level.

TABLE 2. Genotypic Path Coefficients in Parents & Crosses (pooled analysis)

Character	Days to 50% flowering	Plant height	No. of leaves/ plant	Stem diameter	Head diameter	Seed setting per cent	100 seed weight	Husk content per cent	Oil per cent	Correlation with yield 'r'
Days to 50% flowering	–0.373	–0.160	0.035	0.290	0.071	–0.015	0.016	0.103	0.089	0.056
Plant height	–0.166	**–0.360**	0.059	0.364	0.183	–0.011	–0.001	0.064	0.024	0.157*
Number of leaves per plant	–0.132	–0.219	**0.098**	0.273	0.099	0.009	–0.001	0.059	0.021	0.206**
Stem diameter	–0.200	–0.242	0.049	**0.540**	0.137	–0.008	–0.006	0.079	0.051	0.400**
Head diameter	–0.076	–0.189	0.028	0.213	**0.348**	0.006	–0.009	0.067	–0.007	0.381**
Seed setting per cent	0.062	0.042	0.009	–0.049	0.024	**0.092**	–0.005	–0.021	–0.010	0.144*
100 seed Weight	0.183	–0.006	0.003	0.096	0.094	0.015	**–0.033**	–0.031	–0.049	0.271**
Hulling per cent	0.170	0.102	–0.026	–0.189	–0.103	0.009	–0.005	**–0.226**	–0.070	–0.338**
Oil per cent	0.230	0.059	–0.014	–0.191	0.017	0.006	–0.011	–0.111	**–0.144**	–p.158*

The 100 seed weight had significant positive correlation with seed yield, but the path-coefficient analysis revealed a negative direct contribution. The significant postive association (0.271**) of this character with yield was owing to its indirect contribution through days to 50% flowering (+0.183). This is in confirmation with the findings of Velkov (1976).

Husk content (%) and oil per cent had both negative correlation as well as negative direct effects on yield, indicating their limited role in yield improvement, Velkov (1976), Pathak *et al.* (1983) and Sheriff *et al.* (1984) also reported negative effect of oil per cent on yield/plant.

Correlation studies between yield and its components indicated that head diameter, stem diameter, 100 seed weight, number of leaves per plant and plant height had significant positive correlation with yield. But, plant height and 100 seed weight recorded negative direct effects on yield per plant, in which cases the indirect effects contributed more towards the positive correlation. Stem diameter and head diameter had more direct effects as well as indirect effects on yield. Therefore, maximum weightage should be placed on above characters during selection for improvement in seed yield of sunflower.

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STUDIES ON COMBINING ABILITY IN SUNFLOWER (*HELIANTHUS ANNUUS* L.)

G. VANISREEE, K. ANANTHASAYANA, G.V.S. NAGABHUSHANAM AND C.A. JAGADISH
Department of Genetics and Plant Breeding College of Agriculture, Rajendranagar, Hyderabad-500003.

ABSTACT

Combining ability for yield and its components in sunflower (*Helianthus annus* L.) was studied in a diallel set of crosses (without reciprocals) of 10 diverse genotypes. The general and specific combining ability variances indicated the predominance of non-additive gene action for all the characters. The parents, EC 68415, Inbred 303 and EC 68414 were found to be good general combiners for most of the characters. The crosses, Karlic 11-8 × Inbred 303, EC 68415 × Irrago export and Borowski × EC 110763 showed significant positive s.c.a. effects for seed yield/plant.

INTRODUCTION

The analysis of combining ability is used to assess the nicking ability of genotypes and thus helps in identifying parents for use in heterosis breeding. Sunflower hybrids are more stable, highly self-fertile and uniform in maturity (Seetharam, 1979). The information on genetic basis of economic characters is pre-requisite in breeding programmes. The present study has been taken up to assess the combining ability of 10 sunflower genotypes in a diallel cross analysis.

MATERIALS AND METHODS

Ten genotypes of diverse origin, viz., Morden, Borowski, EC 68414, EC 68415, Scaberimus, Karlic 11-8, Inbred 303, EC 110763, Issanka 29-6 and Irrago Export were chosen for diallel analysis. Taking advantage of protandrous nature of the inflorescence hand emasculation was done between 5 A.M. to 6 A.M. using forceps. Pollinations were done between 8 A.M. and 10 A.M. Pollen from the male parents was collected on a glazed paper and applied to the stigmas of the emasculated flowers with the help of a piece of cotton. After pollination the heads were bagged and labelled. The F_1 seed of 45 crosses was collected separately for each cross after physiological maturity. The 45 F_1s together with their 10 parents were evaluated in a randomized block design with 3 replications during rabi season of 1987. Each treatment was grown in 2 rows of 6 m length each adopting a spacing of 60cm × 30 cm. Data on days to 50% flowering, plant height, number of leaves per plant, head diameter, stem diameter, seed filling per cent, 100 seed weight, husk content (%), oil per cent and yield per plant were recorded in each treatment per replication on five random plants. Estimates of general and specific combining ability were computed using Method I and Model II of Griffing (1956). The percentage of seed filling and husk content were calculated by using the following formulae:

$$\text{Seed filling \%} = \frac{\text{Number of filled seeds}}{\text{Total number of filled+unfilled seeds}} \times 100$$

$$\text{Husk content (\%)} = \frac{\text{Weight of kernels}}{\text{Total weight of achenes}} \times 100$$

RESULTS AND DISCUSSION

The parents EC 68415 and Inbred 303 recorded high mean yield per plant. Scaberimus showed high mean oil per cent per plant. Among the hybrids Karlic 11-8 × Inbred 303 and EC 68415 × Irrago Export recorded high mean yield per plant. High mean oil per cent was recorded in Morden × Scaberimus (Tables 1 and 2).

Analysis of variance for combining ability revealed significant differences among parents for all the characters except for stem diameter and 100 seed weight. The hybrids differed significantly for all the characters except for number of leaves per plant, stem diameter, head diameter and 100 seed weight (Table 3).

The estimates of ϵ^2 sca (specific combining ability) and ϵ^2 gca (general combining ability) revealed that the nature of gene action was predominantly non-additive for all the characters (Table 3). These results are in agreement with Setty and Singh (1977), Kadkol *et al.* (1984) and Sheriff *et al.* (1985). Dua and Yadava (1982), Shrinivasa (1982) and Shankara (1983) also recorded the predominance of non-additive gene-action in determining seed yield in sunflower.

Among the parents EC 68415, EC 68414, Karlic 11-8 and Inbred 303 proved to be good general combiners with high g.c.a. effects for seed yield/plant. The significant negative g.c.a. effects observed in Inbred 303 and Morden for plant height and days to 50% flowering is of considerable value for developing dwarf and early flowering hybrids. Karlic 11-8 and EC 68415 were found to be good general combiners for number of leaves per plant. EC 68414 was the best combiner for stem diameter. For head diameter, EC 68415, EC 110763 and EC 68414 showed significant positive g.c.a effects. EC 68415, Morden and Karlic 11-8 had significant positive g.c.a. effects for seed setting per cent. EC 68415 and Inbred 303 were found to be good general combiners for 100 seed wt. Four parents had significant positive g.c.a. effects for husk content, viz., Borowski, Inbred 303, Morden and EC 68414. Scaberimus and Inbred 303 had significant g.c.a. effects for oil percent. Thus, in general, the g.c.a. for yield was related to g.c.a. for one or more yield components (Setty and Singh, 1977) (Table 4).

Data on specific combining ability of some promising crosses (Table 5) suggested that the crosses Karlic 11-8 × Inbred 303, EC 68415 × Irrago Export and Borowski × EC 110763, recorded the highest significant positive s.c.a. effects for seed yield per plant. The crosses involved high × high, high × low and low × low general combiners in that order. This indicated the major role of non-additive gene action in determining the character expression. Three hybrid combinations, viz., Morden × EC 68414, Borowski × Karlic 11-8 and Morden × Scaberimus gave high mean expression and significant positive g.c.a. effects for oil per cent. The gene action was found to be non-additive for oil per cent which was in agreement with Kadkol *et al.* (1984) and Pathak *et al.* (1985).

In general the preponderance of non-additive gene action was evident for all the characters studied.

TABLE 1. Mean values of the parents for ten characters studied

Parents	Days to 50% flowering	Plant height (cm)	Number of leaves per plant	Stem diameter (cm)	Head diameter (cm)	Seed setting per cent	100 seed weight (g)	Husk per cent	Oil per cent	Yield per plant (g)
Morden	55.667	114.200	23.600	1.587	13.867	83.230	3.673	71.933	34.067	30.420
Borowski	57.000	163.733	27.333	1.873	14.200	76.270	4.053	71.733	35.033	28.707
EC 68414	59.333	127.400	28.067	1.960	14.533	87.437	3.640	72.800	34.533	35.633
EC 68415	59.333	157.000	27.533	1.840	16.933	91.390	5.180	71.067	36.600	45.013
Scaberimus	58.333	126.533	29.400	1.553	14.800	79.893	4.007	73.933	42.300	29.573
Karlic 11-8	63.333	137.800	28.667	1.527	12.667	84.070	2.600	70.200	30.700	38.437
Inbred 303	55.667	127.333	27.467	1.667	14.467	82.607	4.447	68.867	36.867	40.680
EC 110763	57.333	146.733	28.733	1.787	17.267	85.813	4.767	69.267	34.600	29.441
Issanka 29-6	63.000	156.967	28.667	1.850	16.400	74.477	3.730	71.267	34.267	35.713
Irrago Export	66.667	166.467	30.000	2.103	15.467	78.423	3.413	66.733	31.533	32.393
Grand Mean	59.567	142.420	27.947	1.775	15.060	82.360	3.951	70.780	35.050	34.600
C.V.	1.797	1.562	3.427	13.083	4.311	1.895	6.078	1.053	5.227	4.603
C.D. at 5%	1.977	4.108	1.769	0.429	1.199	2.883	0.444	1.376	3.384	2.942
C.D. at 1%	2.841	5.903	2.542	0.616	1.723	4.142	0.637	1.977	4.862	4.227

TABLE 2. Mean values of the hybrids for ten characters studied.

Parents	Days to 50% flowering	Plant height (cm)	Number of leaves per plant	Stem diameter (cm)	Head diameter (cm)	Seed setting per cent	100 seed (g) weight	Husk per cent	Oil per cent	Yield per plant
Morden × Borowski	57.333	145.967	28.000	1.680	15.000	86.590	3.487	73.067	34.567	28.500
Morden × EC68414	55.000	146.900	27.733	1.840	15.067	87.990	4.380	73.933	39.633	35.500
Morden × EC68415	59.333	175.876	30.900	1.907	15.533	85.143	3.963	70.867	32.667	34.073
Morden × Scaberimus	55.333	151.933	28.600	1.520	15.667	91.733	4.263	71.533	39.867	35.060
Morden × KARLIC 11-8	56.667	129.433	29.800	1.820	15.800	95.743	4.900	70.467	31.500	44.480
Morden × Inbred 303	52.667	123.333	25.733	1.803	15.200	83.207	5.027	73.133	38.433	35.593
Morden × EC110763	56.667	152.200	28.400	1.740	15.667	81.403	4.507	69.333	35.800	35.873
Morden × Issanka 29-6	55.333	134.233	28.433	1.927	13.467	86.670	4.187	72.733	33.567	33.780
Morden × Irrago Export	57.000	147.233	28.433	1.753	15.033	81.590	3.933	71.933	36.233	30.920
Borowski × EC68414	57.667	149.533	29.500	1.930	15.200	80.690	4.093	74.000	34.833	33.907
Borowski × EC68415	58.000	167.067	28.533	1.787	17.400	85.660	4.453	72.533	36.633	39.843
Borowski × Scaberimus	58.000	150.400	28.867	2.020	14.800	81.273	4.533	72.267	35.000	34.413
Borowski × KARLIC 11-8	56.000	159.933	30.333	1.740	15.467	81.700	4.267	74.000	37.533	32.653
Borowski × Inbred 303	53.000	135.933	27.933	1.800	15.667	84.153	4.280	73.533	38.333	37.093
Borowski × EC 110763	58.667	166.000	29.700	1.867	17.133	85.393	3.660	67.000	35.133	46.180
Borowski × Issanka 29-6	56.333	149.933	29.867	1.847	13.933	89.853	5.067	72.067	38.100	30.233
Borowski × Irrago Exprt	57.333	164.867	29.500	1.913	16.467	87.647	4.760	71.133	33.700	39.847

Table 2. (continued)

Parents	Days to 50% flowering	Plant height cm)	Number of leaves per plant	Stem diameter (cm)	Head diameter (cm)	Seed setting per cent	100 seed weight (g)	Husk per cent	Oil per cent	Yield per plant (g)
EC 68414 × EC 68415	57.667	158.433	29.933	1.967	15.133	84.633	5.187	73.333	36.200	43.173
EC 68414 × Scaberimus	60.667	161.533	29.467	2.113	18.600	83.780	3.827	71.400	35.800	45.033
EC 68414 × KARLIC 11-8	62.667	160.000	30.000	2.373	15.667	80.033	3.293	70.533	34.133	34.680
EC 68144 × *Inbred 303*	54.333	149.067	29.000	1.773	14.400	89.910	4.000	71.400	36.833	37.580
EC 68414 × EC 110763	58.667	158.767	29.267	1.760	17.133	82.870	3.933	71.267	36.233	38.160
EC 68414 × Issanka 29-6	61.000	154.733	29.067	1.600	16.667	80.130	3.887	70.667	32.900	31.780
EC 68414 × Irrago Export	61.333	159.600	29.900	2.290	16.267	82.510	3.607	68.400	34.767	43.700
EC 68415 × *Scaberimus*	60.000	156.700	29.067	1.813	15.533	81.003	5.097	71.200	37.933	38.053
EC 68415 × KARLIC 11-8	59.000	155.400	29.933	1.913	16.067	88.480	4.927	71.933	35.367	36.233
EC 68415 × Inbred 303	57.667	147.800	29.933	2.000	15.800	90.613	5.240	71.800	35.967	35.500
EC 68415 × EC 110763	60.667	165.267	29.400	2.193	16.267	88.090	4.020	70.333	31.900	37.673
EC 68415 × Issanka 29-6	56.667	148.800	28.867	1.720	15.467	86.907	3.920	70.133	37.567	28.653
EC 68415 × Irrago Export	58.667	151.267	30.333	1.947	16.133	78.400	5.277	69.800	32.433	51.500
Scaberimus × KARLIC 11-8	60.667	132.717	27.983	1.810	14.833	83.950	3.200	69.333	25.267	25.973
Scaberimus × Inbred 303	56.667	129.800	28.400	1.560	14.467	83.363	4.287	73.067	34.867	28.427
Scaberimus × EC 110763	58.667	160.533	29.467	1.980	16.533	83.287	3.993	70.600	38.200	30.207
Scaberimus × Issanka 29-6	55.000	159.967	29.500	1.820	15.333	84.537	4.440	71.400	37.900	31.273
Scaberimus × Irrago Export	61.667	144.533	28.667	1.600	14.833	84.567	3.380	71.467	33.733	28.247
KARLIC 11-8 × Inbred 303	55.000	134.833	29.400	1.573	15.000	86.023	3.427	69.600	36.533	56.473
KARLIC 11-8 × EC 110763	61.667	156.000	29.067	2.013	14.667	91.117	3.447	73.400	35.467	34.787
KARLIC 11-8 × Issanka 29-6	57.333	144.333	28.867	1.733	14.600	77.833	3.900	69.400	32.067	32.807
KARLIC 11-8 × *Irrago Export*	63.333	141.400	29.700	1.920	15.600	92.870	3.540	68.667	32.500	36.367
Inbred 303 × EC 110763	53.000	133.200	29.267	1.950	14.800	80.010	5.253	70.267	36.500	36.107
Inbred 303 × Issanka 29-6	53.667	134.267	29.767	1.627	15.400	86.470	4.487	72.533	38.433	29.080
Inbred 303 × Irrago Exprt	54.333	126.933	28.300	1.593	13.667	85.383	3.713	79.600	37.167	26.613
EC 110763 × Irrago Export	58.333	157.367	29.633	1.653	13.433	81.897	3.000	71.533	35.767	24.157
EC 110763 × Issanka 29-6	56.333	150.133	27.467	1.933	15.667	84.070	4.680	73.067	35.600	36.880
Issanka 29-6 × Irrago Export	57.000	143.533	29.167	1.713	17.000	87.500	3.673	71.867	34.933	25.780
Grand mean	57.585	149.500	29.091	1.843	15.499	85 040	4.187	71.590	35.660	35.390
C.V.	1.859	1.488	3.292	12.601	4.189	1.835	5.736	1.041	5.138	4.501
C.D. at 5%	1.713	3.560	1.533	0.372	1.039	2.498	0.384	1.192	2.932	2.549
C.D. at 1%	2.252	4.679	2.015	0.488	1.366	3.283	0.505	1.567	3.854	3.350

TABLE 3. Analysis of Variance for Combining Ability for ten characters in Sunflower

GCA	9–	28.551**	579.074**	2.835**	0.062	2.111*	17.009**	0.924	3.630**	13.050**	69.295**
SCA	45	4.510**	102.981**	1.096	0.028	1.090	18.471**	0.298	4.206**	3.789**	35.444**
Error	108	0.382	1.654	0.306	0.018	0.141	0.813	0.019	0.183	1.119 -	0.845
o^2 gca		2.347	48.118	0.211	0.004	0.164	1.350	0.075	0.287	0.994	5.704
o^2 sca		4.119	101.327	0.790	0.010	0.949	17.658	0.279	4.023	2.670	34.599
$2o^2$ gca/sca		1.140	0.950	0.534	0.730	0.346	0.153	0.541	0.143	0.745	0.330

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

TABLE 4. Estimates of general combining ability effects of ten parents for ten characters studied.

Parents	Days to 50% flowering	Plant height	Number of leaves per	Stem diameter	Head diameter per cent	Seed setting per cent	100 seed weight	Husk content per cent	Oil per cent	Yield per plant
Morden	-1.728**	-7.906**	-1.206**	-0.081	-0.454**	1.373**	0.034	0.417**	-0.050	-1.093**
Borowski	-0.922**	7.227**	-0.068	0.016	0.012	-1.213**	0.094*	0.600**	0.242	-0.638*
EC 68414	0.856**	1.916**	0.191*	0.119*	0.299*	-0.220	-0.175**	0.389**	0.050	2.254**
EC 68415	0.744**	9.186**	0.355*	0.066	0.632**	1.804**	0.572**	-0.150	-0.094	3.916**
Scaberimus	0.439*	-2.432**	0.092	-0.058	0.049	-1.065**	-0.046	0.356*	1.847**	-2.674**
Karlic 11-8	1.800**	-3.393**	0.392*	-0.016	-0.548**	1.319**	-0.457**	-0.678**	-1.603**	1.966**
Inbred 303	-3.033**	-13.378**	-0.420*	-0.085*	-0.523**	0.357	0.252**	0.567**	1.317**	1.341**
EC 110763	-0.006	5.214**	0.199	0.044	0.518**	-0.025	0.037	-0.878**	0.100	-0.751*
Issanka 29-6	-0.061	0.894*	0.232	-0.066	0.126	-1.609**	-0.130**	-0.083	-0.103	-4.064**
Irrago Export	1.911**	2.672**	0.313	0.061	0.166	-0.723*	-0.183**	-0.539**	-1.406**	0.258
S.E. G(I)	0.169*	0.352	0.151	0.037	0.103	0.247	0.038	0.117	0.290	0.252

TABLE 5. Estimates of specific combining ability effects of the 45 crosses for ten characters.

Parents	Days to 50% flowering	Plant height	Number of leaves plant	Stem diameter	Head diameter	Seed setting %	100 Seed weight	Husk Content per cent	Oil per cent	Yield per plant
Morden × Borowski	2.038**	-1.570	0.391	-0.086	0.047**	1.880*	-0.785**	0.608	-1.170	-5.018**
Morden × EC 68414	-2.073**	4.674**	-0.134	-0.029	0.198	2.286**	0.376**	1.685**	4.188**	-0.909
Morden × EC 68415	2.371**	26.371**	2.869**	0.091	-0.064	-2.584**	-0.787**	-0.842*	-2.734**	3.999**
Morden × Scaberimus	1.323**	14.056**	0.831	-0.172	0.652	6.875**	0.131	-0.681	2.524**	3.578**
Morden × Karlic 11-8	-1.351**	-7.483**	1.731**	0.086	1.383**	8.501**	1.179**	-0.715**	-2.393**	8.358**
Morden × Inbred 303	-0.518	-3.598**	-1.523**	0.139	0.758*	-3.074**	0.596**	0.708*	1.612	0.097
Morden × EC 110763	0.455	6.677**	0.605	-0.053	0.183	-4.496**	0.291*	-1.648**	0.405	2.468**
Morden × Issanka 29-6	-0.823	-6.970**	0.524	0.244**	-1.373**	2.356**	0.139	0.958**	-1.826*	3.688**
Borowski × Irrago Export	-1.129*	4.252**	0.444	-0.057	-0.098	-3.611**	-0.062	0.613	2.143*	-2.978**
Borowski × EC 68414	-0.212	7.826**	0.494	-0.036	-0.506	-2.428**	0.030	1.569**	0.904	-2.958**
Borowski × EC 68415	0.232	2.438*	-0.637	-0.126	1.361**	0.518	-0.356**	0.641	0.941	1.316
Borowski × Scaberimus	0.538	-2.611**	-0.041	0.231*	0.656*	-0.999	0.341**	-0.131	-2.634**	2.476**
Borowski × Karlic 11-8	-2.823**	7.884**	1.126*	-0.091	0.608	-2.957**	0.486**	2.635**	3.349**	-3.924**
Borowski × Inbred 303	0.990	-6.132**	-0.462	0.039	0.783*	0.458	-0.210	0.924**	1.230	1.141
Borowski × EC 110763	1.649**	5.343**	0.766	-0.024	1.208**	2.080**	-0.615**	-4.165**	-0.554	12.319**
Borowski × Isanaka 29-6	0.629	-6.404**	0.819	0.066	-1.348**	8.125**	0.959**	0.108	2.416**	-0.314
Borowski × Irrago Export	-1.601**	6.752**	0.372	0.006	0.894*	5.032*	0.705**	-0.370	-0.682	5.494**
EC 68414 × EC 68415	-1.879**	-0.884—	0.505	-0.049	1.217**	-1.502*	0.646**	1.652**	0.799	1.755*
EC 68414 × EC Scaberimus	1.427**	13.834**	0.301	0.221*	2.833**	0.514	-0.097	-0.787*	1.543	10.204**
EC 68414 × Karlic 11-8	2.066**	13.261**	0.534	0.439**	0.497	-5.617**	-0.219	-0.620	0.241	-4.788**
EC 68414 × Inbred 303	-1.434**	12.313**	0.347	0.091	-0.795*	5.222**	-0.221	-0.998**	0.021	-1.263
EC 68414 × EC 110763	-0.129	3.421**	0.074	-0.234**	0.897**	-1.436	0.073	0.313	0.838	1.408
EC 68414 × Issanka 29-6	2.260**	3.707**	-0.239	0.283*	1.074**	-2.592**	0.048	-1.081*	-2.493**	-1.659*
EC 68414 × Irrago Export	0.621	6.796**	0.513	0.279*	0.383	-1.098	-0.180	-2.892**	0.677	6.456**
EC 68415 × Scaberimus	0.871	1.731	-0.263	-0.025	-0.567	-4.287**	0.427**	-0.448	0.635	1.562*

Table 5. *Continued.*

Parents	Days to 50% flowering	Plant height plant	Number of leves	Stem diameter	Head diameter	Seed setting %	100 seed weight	Husk per cent	Oil per cent	Yield per plant
Ec 68415 × Karlic 11-8	-1.490**	1.392	0.304	0.032	0.563	0.806	0.688**	1.319**	1.518	-4 897**
Ec 68415 × Inbred 303	2.010**	3.777**	1.116*	0.189	0.272	3.901**	0.272*	-0.059	-0 801	-5.006**
EC 68415 × EC 110763	1.982**	2.652*	0.044	0.253*	-0.303	1.759*	-0.733**	-0.081	-3.451**	-0.741
EC 68415 × Issanka 29-6	-1.962**	-9.495**	-0.603	-0.110	-0.459	2.161**	-0.666*	-1.076**	2.218*	-6.448**
EC 68415 × Irrago Export	-1.934**	-8.807**	0.783	-0.011	0.084	-7.232**	0.744**	-0.954**	-1.612	12.593**
Scaberimus × Karlic 11-8	0.482	-9.673**	-1.384**	0.053	-0.087	-0.855	-0.441**	-1.787**	-0.523	8.568**
Scaberimus Inbred 303	0.649	-2.605*	-0.155	-0.028	-0.478	-0.480	-0.064	0.702*	-3.843**	-5.489**
Scaberimus × EC 110763	0.288	9.536**	0.373	0.163	0.547	-0.175	-0.142	-0.320	0.907	-1.798*
Scaberimus × Issanka 29-6	3.323**	13.289**	0.293	0.114	-0.009	2.660**	0.472**	-0.315	0.610	2.762**
Scaberimus × Irrago Export	1.371**	-3.922**	-0.621	-0.234*	-0.801**	1.804*	-0.536**	0.208	-2.254**	-4.071**
Karlic 11-8 × Inbred 303	-1.712**	3.389**	0.545	-0.156	0.652*	-0.204	-0.512**	-1.731**	1.274	17.918**
Karlic 11-8 × EC 110763	1.927**	5.964**	-0.327	0.154	-0.723*	5.271**	-0.277*	3.513**	1.624	-1.677*
Karlic 11-8 × Issanka 29-6	-2.351**	-1.383	-0.641	-0.015	-0.145	6.428**	0.343**	-1.281**	1.773*	-0.344
Karlic 11-8 × Irrago Export	1.677**	-6.094**	0.112	0.044	0.563	7.723**	0.036	-1.559**	-0.037	-0.590
Inbred 303 × EC 110763	-1.907**	-6.851**	0.686	0.161	0.614*	-4.874**	0.820**	-0.865*	-0.262	0.268
Inbred 303 × Issanka 29-6	-1.184*	-1.465	1.072*	-0.052	0.630*	3.171**	0.221	0.608	1.674	-3.446**
Inbred 303 × Irrago Export	-2.490**	10.576**	0.476	-0.213	-1.395**	1.198	-0.500**	8.130	1.710*	-9.718**
EC 110763 × Issanka 29-6	0.455	3.043**	0.399	-0.155	-2.378**	-1.021	-1.051	1.052**	0.424	-6.278**
EC 110763 × Irrago Export	-3.518	-5.968**	-1.848**	-0.002	-0.437	0.267	0.682**	3.041**	1.560	2.640**
Issanka 29-6 × Irrago Export	-2.795**	-8.248**	-0.262	-0.112	1.541**	5.281**	0.158	1.046**	0.896	-5.147**
S.E. of (I,J)	1.062	1.062	0.457	0.111	0.301	0.745	0.114	0.353	0.873	0.759

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ANALYSIS OF GROWTH STAGES IN GROUNDNUT GENOTYPES (*ARACHIS HYPOGAEA* L.)

T. SHANTHA KUMARI, B. GOPAL SINGH AND L.M. RAO
Department of Plant Physiology, College of Agriculture, Rajendranagar, Hyderabad-30.

ABSTRACT

Depending upon visual observations, the growth of groundnut crop was mainly grouped into vegetative (VS) (0 - 20 DAS) and reproductive stages (R). The reproductive stage was further sub grouped into a) R_1 - Beginning of bloom (20-30 DAS), b) R_2 - Beginning of peg to beginning of pod development (30 -50 DAS), c) R_3 - Beginning of pod to Full pod development (50 - 70 DAS), d) R_4 - Full pod to full seed development (70 -90 DAS), e) R_5 - Full seed to maturity (90 DAS to maturity). There was a linear increase in dry matter production from R_2 to R_4 stage (30 - 90 DAS) in Spanish and Valencia and upto 110 days in Virginia. In all the genotypes, growth efficiency in terms of relative growth rate, net assimilation rate showed exponential decay law trends. But the crop growth rates increased upto R_3 stage (50-69 DAS) and decreased thereafter. The leaf area ratio (LAR) and thickness of leaf (SLW) also had decreasing trends. Among the cultivars examined, TG-17 (Spanish bunch) had more physiological efficiency and yielded more.

Key words : Groundnut; Total dry matter; Growth stages; Growth analysis; yield analysis.

INTRODUCTION

Description of growth stages in indeterminate crops is very difficult as vegetative and reproductive events go together in the crop's ontogeny. For the last several years, scientists have been trying to describe developmental stages of crop plants. Such studies received good attention in cereals especially rice, sorghum, maize and wheat. Though growth stages have been defined for groundnut (Boote, 1982) their quantification received less attention. The present paper deals some of such aspects to the possible extent.

MATERIALS AND METHODS

The experiment was conducted during the *Kharif* 1986 on a medium deep alfisol. The experiment was laid out following randomized block design with seven cultivars of groundnut viz., Kadiri-2, Kadiri-3 and ICGS-4 (Virginia bunch) TG-17, J-11, and JL-24 (Spanish bunch) and Gangapuri (Valencia), replicated thrice. The crop was seeded at a spacing of 30 × 10 cm in a plot of 5m × 3m. A basal dose of N, P_2O_5 and K_2O was applied @ 20, 40, and 20 kg ha-1. The crop was irrigated three times in a growth period of 90 to 125 days after sowing. Necessary prophylactic measures were taken periodically. To understand the physiological aspects of growth stages, the crop was subjected for destructive and non destructive analysis. To establish growth stages the second sampling was done at 30th day with an interval of 10 days only, whereas the subsequent samplings were taken at an interval of 20 days.

The growth stages were identified as described by Boote (1982) based on visually observable vegetative (v) and reproductive (R) events as follows: 1 vegetative stage (VS) (2) Reproductive stage (R): a) R_1 - Beginning of bloom b) R_2 - Beginning of peg to

beginning of pod. c) R_3 - Beginning of pod to full pod development. d) R_4 - Full pod to full seed development. e) R_5 - Full seed to maturity. For growth analysis studies, mean total accumulated plant weight (biological yield), mean leaf area and mean dry weight of different plant organs (except roots) including weight of economically important parts were obtained at the beginning and at the end of plant growth and was used to compute the crop gorwth rate (CGR), Relative growth rate(RGR), Leaf area ratio (LAR) and Specific leaf weight (SLW) following Watson (1952) and Radford (1967).

To know the varietal difference for chlorophyll content it was estimated at active flowering stage (60 DAS) following Witham *et al.* (1971).

RESULTS

i) Vegetative stage (VS) (0-20 DAS) :

The growth of groundnut crop was quantified in terms of dry matter production. In the vegetative stage, the dry matter production differed among the cultivars. The dry matter production was more in Spanish genotypes followed by Valencia and Virginia bunch (Table-1).

The ratio of leaf area to total plant dry weight (LAR) was more in K_3 (154.8 cm^2 g^{-1}) and the lowest in TG-17 (108.7 cm^2 g^{-1}) (Table-2). But on an average specific leaf weight (SLW) was more in Spanish genotypes. Among the cultivars, the highest values for SLW was recorded in TG-17 (5.84 mg cm^{-2}) and the lowest in K_3 (3.97 mg cm^{-2}) (Table-2).

2) Reproductive stages (R) :

a) R_1 Stage - Beginning bloom (20-30 DAS)

This stage is considered as start of flowering. During this stage, the increase in dry matter was rapid in Gangapuri as compared to Virginia and Spanish bunches (Table-1). Gangapuri recorded significantly more dry matter (4.04 g per plant) followed by ICGS-4 (3.83 g per plant) and JL-24 (3.78 g per plant) representing Valencia, Virginia and Spanish types respectively.

During this stage the dry matter production per unit ground area i.e. crop growth rates ranged from 4.72 to 9.67 g m^{-2} day^{-1} in K_2 (Virginia bunch) and Gangapuri (Valencia) respectively. However CGR in all the varieties showed a similar trend to that of dry matter production (Table-2). In all the varieties RGR was maximum at this stage and the varietal difference was significant (Table-2).

The dry matter production per unit leaf area ranged from 0.877 (K_3) to 1.256 mg cm^{-2} day^{-1} (Gangapuri) (Table-2). The Valencia genotype, Gangapuri showed higher NAR followed by Spanish and Virginia bunches.

Leaf area ratio (LAR) decreased with age of the crop in all the cultivars except TG-17. Hence it was more in Spanish genotypes followed by Virginia bunch and Valencia (Table-2).

Specific leaf weight did not show a definite trend during this stage. The values decreased in ICGS-4, TG-17 and J-11, whereas in K_2, K_3, JL-24 and Gangapuri ,the values increased continuously (Table-2). Among the entries K_2 showed maximum SLW (7.95 mg cm^{-2}).

b) R_2 - *Stage - Beginning of peg to Beginning of pod* (30-50 *DAS*)

Transformation in phenological events is enunciated by the change of flowers into pegs and finally to pods.

During this stage, the production of dry matter was significant among the cultivars (Table-1). Total drymatter production (TDMP) was more in Gangapuri, a Valencia genotype (11.81 g per plant) followed by Virginia and Spanish genotypes.

Crop growth rates increased rapidly during this stage. The values for CGR was highest in K_2 (14.67 g m^{-2} day^{-1}). In early varieties, especially in Gangapuri it showed a peak at this stage. (Table-2).

Irrespective of the varieties, the relative growth showed a declining trend. However on an average, Virginia genotypes maintained relatively higher RGR (0.0641) followed by Spanish (0.0525) and Valencia types (0.0536) (Table-2).

Similar to RGR, net assimilation rate (NAR) also decreased in all the cultivars Table-2). Among the entries the percent decrease was 61.3 in ICGS-4 (Virginia bunch) 55.9 in TG-17 (Spanish) and 43.4 in Gangapuri (Valencia).

In all the cultivars LAR decreased except in K_2. *The percent decrease in LAR* was not pronounced as to that of NAR. The percent decrease was more in Spanish when compared to Valencia and Virginia bunch genotypes (Table-2). Though the trends were definite for CGR, RGR, NAR, and LAR, the values for SLW were inconsistent and significant among the entries (Table-2).

c) R_3 *Stage : Beginning of pod to Full pod development* (50-70 *DAS*) :

Though there were differences in most of the growth attributes, the overall effect *in terms of dry matter production per plant did not differ during this stage* (Table-1).

When dry matter produced per unit land area per unit time is considered (CGR), there were significant differences among the cultivars. CGR reached a peak in case of Virginia and Spanish bunches, whereas Valencias showed a decreasing trend (Table-2) It was interesting to note that lower value of CGR in J-11 during R_2 stage was more than compensated by a sudden increase in its value (15.6 g m^{-2} day 1-).

Though there was a marginal increase in CGR, RGR decreased in all the genotypes. The higher CGR in J-11, was further reflected by higher RGR (0.0344 g g^{-1} day $^{-1}$) (Table-2).

In almost all the cultivars there was a considerable decrease in net assimilation rates. Spanish genotypes maintained relatively higher NAR followed by Virginia bunch and Valencia types (Table-2).

This stage was also characterised by the declining trends of LAR (table-2), causing a concurrent decrease in SLW (Table-2).

As most of the phenological events appear to be active during this stage, the cultivars were analysed for chlorophyll content. The data indicated that cultivars differed significantly for chl 'a' and chl 'b' and total chlorophyll (Table-2). Its content was more in ICGS-4 (Virginia) followed by TG-17 (Spanish) and lowest in Gangapuri (Valencia).

d) R_4 *Stage : Full pod to full seed development* (70-90 *DAS*) :

Most of the phenological events were at lowest ebb at this stage.

The dry matter production when expressed on individual plant basis did not show significant difference, whereas the values on an unit land area bais (m_2) differed significantly among the cultivars and showed increasing trends (Table-1).

The varieties exhibited a significant declining trend of CGR (Table-$_2$). Among Virginia bunches-K_3, Spanish bunches-JL-24 and Valencia - Gangapuri had higher CGR, whereas the relative growth rate did not show significant differences among the entries (Table-2).

Though net assimilation rate was significant among the cultivars, it showed negative values in almost all the Spanish and Valencia genotypes (Table-2). As NAR values decreased rapidly, the values for LAR also decreased progressively (Table-2).

There was no definite trend in SLW among the cultivars (Table-2). In K_2, TG-17, J-11 and Gangapuri SLW increased, whereas in K_3, ICGS-4 and JL-24, SLW showed decreasing trends.

e) R_5 *Stage : Full seed to Maturity* (90 *DAS to maturity*) :

To reach maturity the Spanish and Valencia genotypes took 110 DAS;, whereas Virginia bunches took 125 days.

A significant difference was observed in total dry matter production among the cultivars. But the cultivars of a particular group did not show definite trends. Total dry matter production reached its peak in early varieties viz., JL-24, TG-17 and Gangapuri at 110 DAS (harvestable maturity), whereas in late varieties viz., K_3, K_2 and ICGS-4 it decreased at harvestable maturity (125 DAS) (Table-1).

This stage marks the continuity of late varieties especially Virginia bunches, where crop growth rate, relative growth rate and net assimilation rate followed negative trends (Table-2).

The leafiness in terms of LAR was almost halved while SLW had inconsistent trends (Table-2).

Yield

The varieties differed significantly in their pod yield. Among the cultivars, TG-17 recorded the highest yield (428) which was on par with ICGS-4 (425) and JL-24 and the lowest yield was observed in K_2 (265 g m^{-2}) (Table-1)

DISCUSSION

Dry matter production in Groundnut had a lag phase in the early growth (0-30 DAS), followed by a linear phase during (30 - 90 DAS), and a further such increase from 90 days to maturity. Among the cultivars, the Spanish types had more dry matter accumulation at vegetative stage (0-20 DAS) and from R_2 stage (30-50 DAS) dry matter production was more in Gangapuri as it was ahead by 5 to 10 days in its Physiological events. Thus there was a linear increase in total dry matter production from 30th to 110th day in Virginia (K_2 and ICGS-4) and from 30th to 90th day in Spanish (TG-17, JL-24 and J-11) and Valencia (Gangapuri). A linear increase in dry matter production of groundnut upto peg formation was also observed by Bunting and Anderson (1960), Seshadri (1962), Forestier (1969) and Suraj Bhan (1973).

Growth analysis was used as a tool in describing and quantifying the growth stages. In all the genotypes, growth efficiency in terms of relative growth rate and NAR showed exponential decay law trends. A progressive decrease of RGR in all genotypes of groundnut was also observed by Janmatti (1979). But the crop growth rates incrased upto R_3 stage (50-69 DAS) with a reduction from 70 DAS (R_4 stage). The ratio of leaf area to total dry weight (LAR) and leaf thickness (SLW) had also decreasing trends in all the genotypes. However the values for these growth parameters were more during early stages (upto 30 DAS) in Spanish cultivars and thereafter, the Virginias could record more values. Murthy *et al.*, (1983) also reported higher CGR at early stages in Spanish and Valencia and at later stages in Virginia runner.

Though growth continued, LAR and SLW showed a declining trend indicating that, partitioning of dry matter was more in non-leafy tissues namely stems, flowers, pegs, roots and pods.

The results indicated that Virginias (ICGS-4) had more chlorophyll content as compared to Spanish and Valencias, Bhagsari and Brown (1976) also observed cultivars difference for chlorophyll content in Groundnut.

Yield in groundnut, is the product of pod number, number of kernels per pod and size of individual kernel (Enyi, 1977). As yield is the overall effect of several plant processes occuring at different growth stages of the crop, the yield potential in groundnut genotypes differed accordingly. The low yield in Gangapuri (Valencia) and K_2 (Virginia bunch) when compared to other cultivars would have been due to their, less efficiency in utilizing the fraction of dry matter into the economic component viz., the pods. This is apparent from the data on total dry matter production and economically useful fraction of biological yield i.e. Harvest Index (Table-1 and Table-3.)

TABLE 1. Dry weight of total plant at different stages and yield in groundnut genotypes

Variety	Total plant dry weight														Pod yield (g m^{-2})
	g Plant^{-1}							g m^{-2}							
	Growth stages							Growth stages							
	VS	R_1	R_2	R_3	R_4	R_5 110 DAS	R_5 125 DAS	VS	R_1	R_2	R_3	R_4	R_5 110 DAS	R_5 125 DAS	
K_2	0.96	2.39	11.28	18.59	24.25	31.45	30.01	31.68	78.37	372.24	613.47	800.23	1037.85	990.33	265
K_3	1.09	2.83	10.65	19.35	26.10	24.88	24.71	35.97	93.39	351.45	625.35	861.30	821.04	815.43	307
ICGS-4	1.02	3.83	10.08	19.30	23.75	26.91	26.61	33.66	126.4	332.6	636.90	783.8	888.03	878.1	425
TG-17	0.96	3.70	11.09	18.66	24.59	24.82	—	31.68	122.1	365.9	615.8	811.5	819.1	—	428
J-11	1.12	3.56	9.56	19.01	24.76	24.09	—	36.96	117.5	315.5	627.2	817.1	794.9	—	335
JL-24	1.32	3.78	11.00	18.54	25.06	25.87	—	43.56	124.7	363.0	611.8	826.9	854.04	—	424
Gangapuri	1.11	4.04	11.81	18.01	25.03	27.11	—	36.63	133.3	389.7	592.7	825.9	894.6	—	286
CD at 5%	0.07	0.25	0.60	NS	NS	2.09	1.30	NS	18.50	12.92	11.33	12.02	10.98	19.81	22.37

VS : 0-20 DAS, R_1 : 20-30 DAS R_2 : 30-50 DAS R_3 : 50-70 DAS

R_4 : 70-90 DAS R_5 : 90 DAS to maturity. NS : Not significant.

TABLE 2. Analysis of important growth parameters at different growth stages in groundnut genotype

Variety	CGR (g m^{-2} day^{-1}) Growth Stages						RGR (g g^{-1} day^{-1}) Growth stages						NAR (mg cm^{-2} day^{-1}) Growth stages					
	R_1	R_2	R_3	R_4	R_5 110 DAS	R_5 125 DAS	R_1	R_2	R_3	R_4	R_5 110 DAS	R_5 125 DAS	R_1	R_2	R_3	R_4	R_5 110 DAS	R_5 125 DAS
K_2	4.72	14.67	12.06	9.34	11.89	–2.97	0.0912	0.0776	0.0250	0.0133	0.0130	–0.0029	0.892	0.741	0.240	0.150	–0.217	–0.076
K_3	5.74	12.90	13.70	11.8	–2.01	–0.35	0.0954	0.0663	0.0288	0.0160	–0.0044	–0.0004	0.877	0.761	0.327	0.201	–0.044	–0.011
ICGS-4	9.27	10.31	15.21	7.34	5.21	–0.39	0.1323	0.0484	0.0324	0.0104	0.0062	–0.0004	1.135	0.439	0.387	0.150	–0.123	–0.014
TG-17	9.04	12.19	12.49	9.78	0.38	—	0.1349	0.0548	0.0260	0.0138	0.0005	—	1.140	0.502	0.306	–0.225	–0.013	—
J-11	8.05	9.90	15.59	9.49	–1.10	—	0.1156	0.0494	0.0344	0.0132	–0.0014	—	1.146	0.601	0.443	–0.240	–0.045	—
J-24	8.12	11.91	12.44	10.76	1.34	—	0.1052	0.0534	0.0261	0.0151	0.0016	—	1.081	0.688	0.411	–0.314	–0.057	—
Gangapuri	9.67	12.82	10.23	11.58	3.43	—	0.129	0.0536	0.0211	0.0165	0.0040	—	1.256	0.712	0.263	–0.228	–0.013	—
CD at 5%	0.24	0.16	0.19	0.41	0.23	0.10	0.0012	0.0015	0.0027	NS	0.0013	0.0007	0.028	0.016	0.014	0.015	0.013	0.009

(Contd....)

Table 2. (Contid.....)

Variety	LAR (cm^{-2} g^{-1}) Growth stages							SLW (mg- cm^{-1}) Growth stages							Chlorophyll content (mg- g^{-1} fresh weight) at 60 DAS		
	VS	R_1	R_2	R_3	R_4	R_5 110 DAS	125 DAS	VS	R_1	R_2	R_3	R_4	R_5 110 DAS	125 DAS	Chl.a.	Chl.b.	Total Chl.
K_2	122.39	88.90	115.12	95.35	82.55	55.65	33.68	5.28	7.95	4.97	5.57	6.28	6.15	6.12	1.1050	0.5175	1.6225
K_3	154.77	87.52	86.86	88.98	71.75	53.79	36.25	3.97	6.50	5.72	4.60	4.58	5.23	5.79	1.4106	0.6953	2.1159
ICGS-4	122.29	112.92	108.13	67.36	70.83	50.93	29.71	5.05	5.04	3.95	5.57	4.49	5.02	6.64	1.6101	0.7953	2.4055
TG-17	108.74	124.83	99.16	73.99	51.11	25.08	—	5.84	4.85	4.41	5.19	5.38	6.87	—	1.5780	0.7890	2.3672
J-11	125.47	86.21	79.47	76.15	39.69	22.79	—	5.05	4.85	6.34	5.08	6.11	7.50	—	1.2182	0.6649	1.8834
JL-24	130.18	98.08	67.32	60.51	38.33	19.96	—	4.70	6.07	7.05	6.51	6.19	7.63	—	1.0017	0.4862	1.4879
Gangapuri	127.24	88.78	66.84	92.86	56.44	48.84	—	4.74	5.77	7.98	4.72	5.36	5.50	—	0.9904	0.4879	1.4783
CD at 5%	4.78	2.32	5.44	4.21	3.17	7.05	2.25	0.28	0.32	0.58	0.36	0.41	0.26	0.21	0.1409	0.0530	0.3898

TABLE 3. Comprehensive description of growth stages in 3 typical groundnut genotypes.

Character	Genotype	VS	Growth stages R_1	R_2	R_3	R_4	R_5 110 DAS	125 DAS
Total plant dry matter production (g plant^{-1})	Vir. B.	1.02	3.02	10.67	19.08	24.70	28.75	27.11
	SB	1.13	3.68	10.55	18.73	24.80	25.26	—
	Val.	1.11	4.04	11.81	18.01	25.03	27.11	—
CGR (gm^{-2} day^{-1})	Vir. B.	—	6.58	12.63	13.66	9.49	8.25	-1.24
	SB	—	8.40	11.33	13.51	10.01	0.57	—
	Val	—	9.67	12.82	10.23	11.58	3.43	—
RGR (g g^{-1} day^{-1})	Vir. B.	—	0.106	0.064	0.028	0 013	0.005	-0.001
	SB	—	0.120	0.053	0.029	0 014	0.002	—
	Val.	—	0.129	0.054	0.021	0.016	0.004	—
NAR (mg cm^{-2} day^{-1})	Vir.B.	—	0.968	0.647	0.318	0.167	-0.128	-0.034
	SB	—	1.122	0.597	0.387	-0.260	-0.038	—
	Val.	—	1.256	0.712	0.263	-0.228	-0.013	—
LAR (cm^2 g^{-1})	Vir. B.	133.15	96.45	103.40	83.90	75.04	53.12	30.77
	SB	121.46	103.04	81.98	70.22	43.04	22.61	—
	Val.	127.24	88.78	66.84	92.86	56.44	48.84	—
SLW (mg cm^{-2})	Vir. B.	4.77	6.51	4.88	5.25	5.12	5.47	6.18
	SB	5.20	5.26	5.93	5.59	5.89	7 40	—
	Val.	4.74	5.77	7.98	4.72	5.36	5.50	—
Total chlorophyll (mg g^{-1} fresh wt.)	Vir. B.	—	—	—	2.0480	—	—	—
	SB	—	—	—	1.9128	—	—	—
	Val.	—	—	—	1.4783	—	—	—

	Pod yield (g m^{-2})	*Harvest Index*
Vir. B.	332.33	0.34
SB.	395.66	0.40
Val.	286.00	0.35

Vir.B Virginia Bunch. SB Spanish Bunch. Val Valencia.

Variation in yield potential of peanut cultivars due to variation in partitioning of assimilates was also observed by Duncan *et al.* (1978). Finally it can be concluded that some of the physiological aspects of growth observed in the present study was maximum in all the early varieties (Spanish and Valencia) during R_3 stage (50-70 DAS) and it was as at R_4 stage (70-90 DAS) in late varieties (Virginia). Such information will be useful for designing a blue print of the target yield and examining the defects of a given crop if a comparision is made with a crop that has already achieved a good yield under a similar environment. Thus identification, description and quantification of growth stages become meaningful technique in Agricultural Research and Education.

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PROSPECTS AND CONSTRAINTS IN THE CULTIVATION OF SOYBEAN IN INDIA

H.C. GAUTAM* AND K.S. LABANA**
Ministry of Agriculture, Government of India, Krishi Bhavan, New Delhi

INTRODUCTION

Soybean (*Glycine Max* (L.) Merrill) crop, according to Morse (1950), has been under cultivation in China since 2838 B.C. (Caldwell, 1973). Since then, it has been an important part of Chinese diet. Its cultivation in the Western countries, however, has been traced to the beginning of 20th century. The cultivation of soybean in India is not exactly known. Nevertheless, the black-seeded soybean with various local names has been grown for centuries by the people in the Northern hills, North-eastern hills and Central parts of India.

Although soybean contains 18 to 22% oil and 38 to 42% protein, its importance could be realised more during the World War-II as a source of edible oil and also as a compact form of nutritious food for armed forces. Since then, area has grown over ten times and now soybean stands first in the world in contribution of edible oils. According to FAO estimate for 1986-87, 198 million tonnes of oilseeds including cotton seed was produced in the world. Of this, crop-wise production (million tonnes in parenthesis) of major oilseeds were: soybean (98), cotton seed (29), groundnut (22), rapeseed and mustard (20), sunflower (19) etc. The major soybean producing countries in the world in 1985-86 (with their percentage share of world production) were: USA (58), Brazil (18.3), China (9.2), Argentina (6.5), India (0.9) and rest (7). According to an ad-hoc estimation in 1958, about 17,200 ha was under soybean in India which produced about 6000 tonnes of soybean. The area under soybean started moving up after the introduction of yellow-seeded varieties from USA, establishment of All-India Co-ordinated Research Project (AICRP) on Soybean and Intensive Soybean Development Programme during seventies. The area which was about 32.3 thousand hectares in 1970-71 rose to 1392 thousand hectares in 1986-87. The corresponding production values were 13.1 and 835.3 thousand tonnes, respectively with the maximum production of 1024 thousand tonnes in 1985-86. Though, it is grown in many states of the country, Madhya Pradesh alone is producing about 80% of total production of the country, which is followed by Uttar Pradesh (about 15%), Rajasthan (about 2.5%) and remaining 2.5% of production is made by other states.

Although, it showed tremendous expansion in area, the yield level is still very low in India as compared to many other countries of the world. The average yield (Q/ha) in 1985-86 was 23 for USA, 18.1 for Brazil, 7.6 for India, 12.7 for Asia and 19 for world. The policies have to be changed and constraints removed so that yield

* Director (Soybean)

** Head & Prof., Deptt. of Plant Breeding, PAU, Ludhiana.

level is increased as this crop has great potential in India. It is because that this crop known as "gold of the soil" has many advantages such as easy cultivation, higher cost-benefit ratio, less requirement of nitrogenous fertilisers and labour, beneficial effect on following crop, soil conservation, relatively better suitability for black-soils etc.

The present paper, therefore, analyses certain constraints, which need to be overcome in order to boost soybean production. Before this, a brief highlight on the prospects of area expansion in coming years under soybean have been discussed.

PROSPECTS OF AREA EXPANSION :

Soybean has shown tremendous growth during the last fifteen years particularly in the black-soils of the central India. Besides, area is also increasing in the eastern region of the country. Also, soybean researchers have shown the possibilities of soybean cultivation during *rabi* and summer seasons particularly in the southern India. It is, therefore, important to figure out, atleast roughly, the area that might come under soybean in the coming years. The potential area for soybean in varoius parts of country has been given briefly below:

1. Use of fallow-lands :

The experience of area expansion in the black-soils in Madhya Pradesh, which earlier remained fallow, indicated that success story of Madhya Pradesh can be reported in the black-soils of other states as well which mostly remains fallow in *kharif* season. There are no data available as to how much *kharif* fallow-land is available in the black-soils. The senior author made some approximation for the year 1983-84 (a very good rainfall year) of the suitable soybean districts having black-soils. He estimated that about 7-11 million hectare of *kharif* fallow-land in the various states (fallow area in lakh ha in parenthesis) are: Andhra Pradesh (8), Gujarat (3), Karnataka (16), Madhya Pradesh (34), Maharashtra (29), Rajasthan (3), Tamil Nadu (5), Uttar Pradesh (10) etc. Besides, approximately 8-12 lakh ha of up-land kharif-fallow suitable for soybean are available in Bihar and north-eastern states.

Since the black-soils are suitable for soybean, much of fallow lands in this category can be diverted to soybean. In the high rainfall areas of eastern regions, soybean in upland fallow is among the crops giving profitable return, where as upland-paddy gives very poor yield. With allocation of 30% of such fallow land for soybean, an additional 30 lakha area can be added to the present area under soybean.

The soybean can also be grown in *rabi*/summer seasons. Some data indicate that it can be grown in *rabi*/summer in the southern India, eastern parts of India and even during spring in north India. The cultivation in *rabi*/summer, however, depends on the availability of water for irrigation. The vast fallow-lands after the harvest of kharif paddy are available in southern and eastern parts of country. The area that could be diverted to soybean is difficult to assess at this stage, when cultivation of soy-

bean during *rabi*/summer is at the initial stage and, perhaps, it may not exceed 10 lakh ha. This also includes area in north India, where soybean, groundnut and sunflower can be grown in spring season in the land vacated by *toria*, potato, sugarcane etc.

2. Replacement of low-yielding/remunarative crops

Various crops in rainfed as well as inadequately irrigated areas show poor yield or are less profitable. Soybean, as compared to some crops in one or another zone appears to be promising under above situations. In the low-to-medium rainfall regions the rainfed crops such as paddy in Madhya Pradesh, Gujarat, Uttar Pradesh, Maharashtra and Rajasthan; cotton in Madhya Pradesh, Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu & Gujarat and some pulses in Andhra Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Tamil Nadu, Uttar Pradesh and Rajasthan can be replaced by soybean.

In the high rainfall zones, the low-yielding rainfed crops such as paddy, small millets, pulses etc. in the parts of Orissa, West Bengal, Bihar, Himachal Pradesh, hilly and Eastern Uttar Pradesh and north-eastern states can be replaced by Soybean. Areas with water stagnation for some days, where Soybean has relatively more tolerance than maize, sorghum etc. or areas with inadequate water supply for water-intensive crops like paddy, sugarcane etc., can be switched over to soybean. These are present in Haryana, Rajasthan, Uttar Pradesh, Bihar, West Bengal, Orissa, Madhya Pradesh, Tamil Nadu, and Karnataka.

The total area that can be replaced by soybean is difficult to assess but it might range between 20-30 lakh ha in future in various parts of the country.

3. Area expansion through inter-cropping

Intercropping, in general, has been proved more beneficial than raising pure crop against erratic rainfall conditions. According to the reports of AICRP on Soybean, it can be inter-cropped with many crops with a increased return. The areas west of 80°E longitude (line running through Madras-Jabalpur-Kanpur) show usually erratic rainfall and inter-cropping of soybean in these areas can be popularised with other crops such as maize, tur, sugarcane, cotton, millets, horticultural crops etc. It has also proved useful when intercropped with irrigated sugarcane. In the case of sugarcane, cotton, tur, etc., which before could develop into dense foliage, the early maturing soybean intercropped reaches into advance stage of growth. In the widely spaced plantation/horticultural crops, the inter-plant space can be effectively used for the cultivation of soybean.

Some of the crops, for the purpose of illustration, that could be suitably intercropped with soybean in some of low-to-mid rainfall area are : Maize in Himachal Pradesh; maize, ragi, tur, sorghum sugarcane in Uttar Pradesh; maize, tur, cotton in Rajasthan; tur, cotton, castor in Gujarat; tur, cotton, sorghum, sugarcane in Maharashtra; tur cotton, ragi, sorghum, sugarcane in Karnataka; cotton, sugarcane, banana

coconut tapioca in Tamil Nadu; cotton, sorghum, sugarcane, coconut in Andhra Pradesh; and maize, tur, cotton, sorghum, small millets in Madhya Pradesh etc. Provisionally, it can be guessed that about effective area of 10 lakh ha can be brought under soybean in the states mentioned above.

4. Total potential

Based on a broad estimate by the senior author, about 80 to 100 lakh ha could be brought under soybean in the future, which could produce as much as 120 to 200 lakh tonnes of soybean. Bhatnagar (1987), however estimated that about 60 lakh hectares could be brought under soybean in future. This would help the nation to a considerable extent in the task of supplying oil and protein for its population in required quantities through indigenous production. Also soybean gets favourable market price and all support from the Government.

CONSTRAINTS

As mentioned earlier that productivity of soybean in India is very low, which could be due to various reasons including poor plant-stand, low-input application to erratic rainfall. The failure to expand the area under soybean in some regions of the country could be mainly due to lack of marketing facilities. Such constraints are required to be analysed and removed through research and developmental efforts so that not only area under soybean can be enhanced rapidly, but also to generate good income to the growers through increased productivity. Some of the constraints faced presently are presented below:

1. High seed cost

Unlike other oilseeds except groundnut, seed-rate in soybean is high due to large seed size, low viability etc. The seed rate of 75 to 100 kg per hectare is a heavy initial input for the farmers particularly when yield per hectare is low. Consequently farmers are either using low seed-rate or are reluctant to buy expensive quality seeds. This is one of the important factors for poor plant stand in the field which leads to low yield.

The following lines of work may be useful in this regard:

a) Reducing seed-size.

b) Increasing seed-viability.

c) Changing the plant-type in order to increase spacing.

d) Developing storage techniques and facilities so that viability can be maintained during storage.

e) Multiplying soybean for seed purpose during rabi season in Southern India and during kharif in the hills of Northern India.

2. Varieties

(i) *Number of varieties*

About 23 varieties have been released during the last two decades i.e. on an average one variety has been released every year. Many are old, absolete and have become susceptible to diseases. Thus, there are very few good varieties available for varying climatic regions of India. Though, there is always need of high-yielding varieties with resistance to diseases, drought etc., the state Governments have great responsibilities for the popularisation and adequate supply of seeds of improved varities. It has been noticed that some states are giving indent for breeder seeds of varieties which are either low yielders or have become highly susceptible to one or another pathogen. In this context, it is important that information on diseases & pests, pre-planned seed production programme of improved varieties in right quantities, use of specific variety in the specific climate must be followed scrupulously in order to increase yield, reduced cost on disease/pest control, slow-down the spread of disease/pests etc.

(ii) *Diseases and pests*

There is considerable damage in some years or zones by diseases, mainly mosaic, leaf blights, bacterial pustule, etc, and pests like girdle beetle, stem fly, Bihar-hairy catter-pillar, leaf miner etc. For many diseases, seeds are carrier, which cause seedling mortality. It has been observed that mostly farmers do not control diseases and pests and seldom practice seed treatment. The reasons could be many including lack of purchasing power of farmers to buy pesticides. In the long-term basis, the breeding of varieties resistant to diseases and pests appears to be the best choice. The present day varieties are often susceptible to one or other disease. Germ-plasm collection, careful use of diverse and many genes for resistance, proper deployment of genes or their combination in different regions etc, are needed in order to slow-down disease development and its spread.

The losses by diseases and pests can be reduced by concerted efforts under developmental programmes through increased awareness for seed treatment, quick diagnosis of diseases/pests and their control at the very begining, timely & adequate supply of quality chemicals etc.

(iii) *Germination and plant stand*

Soybean is mostly grown under rainfed conditions in the uncertain rainfall areas of the country. The fluctuation in yield level over years and wide gap between yields under rainfed and irrigated conditions may indicate that the level of drought resistance is low in the present varieties and needs to be incorporated. Soybean shows poor emergence whenever there is heavy rainfall immediately after sowing particularly in black soils. Also under such soils, it is difficult to sow following heavy rainfall. The requirement that seeds should be 3-5cm deep in the soil, poses a problem i.e., sowing after light rain is again risky as the soil moisture during hot days of June/July at upper 3-5 cm may dry up before seed germinates and result in poor plant stand.

(iv) *Early maturity*

Many of the present-day varities mature between 100-130 days. In major soybean growing areas of the country. 80-90% of annual rainfall occurs before the end of August and the long duration varieties usually face moisture-stress during the seed-filling stage (very sensitive stage to moisture-stress). Though, few early maturing varieties are available for some zones, more concerted efforts are needed for the breeding of early maturing but high yielding varieties to fit in as a pure crop, inter-crop, & seqence crop. Such varieties are also required in the farming situation where after taking soybean, farmers would like to conserve residual moisture for the sowing of *rabi* crop. Thus, the development of varieties with the maturity of 80-90 days will accelerate the area expansion.

3. Inter-cropping

Soybean has been advocated for intercropping with other crops particularly in low-to-medium rainfall areas as described earlier in this paper. Besides additional returns, soybean adds nitrogen to soil (i.e. to companion and following crops), checks soils erosion, supresses weed growth etc. Inspite of various advantages, inter-cropping is not popular and reasons for its slow or negligible adoption needs to be studied, and analysed.

4. Date of sowing

Generally soybean is sown between 15th June to 15th July. In the Eastern India there is heavy rain in July and the farmer may like to sow it in June or towards end of May. Also, the onset of monsoon in some regions or years may not be in time, as happened during the last three years in one or other part of country. Farmers are not sure as to which variety is recommended for such situations. Thus, it is suggested that besides complete package of practices for the released/identified varieties, the categorisation of varieties for early, normal and late sown conditions for each zone, will be of great help for realising maximum benefit from the varieties.

5. Increase in the number of soybean zones

At present the area under soybean cultivation has been divided into 4 agro-climatic zones viz. Northern Hills, Northern plains, Central and Southern. Looking at varying climatical conditions under which soybean is grown in India, the above four zones may not be sufficient for the realisation of optimum yield. It is known that soybean varieties show high environment-varietal interaction. A review on this aspect is needed. A tentative soybean zones could be as below:

(i *Northern Hills*

The Hills of Himachal Pradesh, U.P. and J&K.

ii) *The North Eastern states*

The states of Assam, Sikkim, hills of West Bengal, Meghalaya, Arunachal Pradesh, Manipur, Nagaland, Mizoram and Tripura.

iii) *Northern Plains*

Punjab, Haryana, parts of J&K, U.P. (except hills and Bundelkhand area), Northern Rajasthan.

iv) *Eastern plains*

Bihar, West-Bengal (except hills), Orissa, Eastern M.P.

v) *Central*

Bundelkhand area of U.P., M.P. (except Eastern area), Eastern Rajasthan Vidharba, & Marthwada region of Maharashtra.

vi) *Western*

Rajashthan (except northern and eastern area) and Gujarat.

vii) *Southern*

Andhra Pradesh, Karnataka, Tamil Nadu, Kerala, Kolapur region of Maharashtra.

6. Technology for home-utilisation

Though recipies are available for the preparation of multitude of soybean products, the awareness among people about the utility of soybean and the methods for its consumption at home etc. are lacking. Lately, about 5-7 lakh tonnes of soya meal is exported, which though is the highest foreign-exchange earner among oilseed meals, is a big drain of valuable protein. It could have been used for crores of people with mal-nutrition, particularly when prices of pulses are going up. The creation of such indigeneous demand of soybean and its products, will accerlerate its development.

7. Technology adoption by the farmers

Some studies in the M.P. (Anonymous 1987) for example showed that most of the farmers do not control diseases. Very few are applying fertilisers or rhizobium culture and many do not apply the required seed rate. This kind of district or zone-wise studies to know the real problems faced by the farmers in the adoption of new technology are important in order to make suitable strategies for the faster development of soybean in the country.

9. Marketing

Soybean is not consumed locally except by few people in the hills. Thus, most produce has to be marketted. Though, marketing facilities through the establishment of processing plants have been the one among main factors for the development in some states, but the lack of such infrastructure in other potential area have been

hinderance for its growth. The processing plants are needed, for instance, in north-eastern, northern Karnataka regions of the country.

10. Extension & input service

Agricultural extension is an important medium in transfering technology to the farmers. Though it is good in some states, adequate in others while very poor in remaining. This needs strengthening so that maximum yield can be obtained from the crop. Some years or places, production suffers due to inadequate and or poor quality of seed, pesticides, fertilisers, rhizobium etc. The improvement in these services including credit supply will increase area and yield of soybean.

SUMMARY

In this paper, the need to accelerate research and developmental efforts on important field problems encountered in the cultivation of soybean in India is discussed. A brief account on the prospects of soybean cultivation in India is highlighted. Emphasis is given on the issue or reducing seed rate, increasing seed viability, development of varieties resistance to diseases, pests, drought etc. Views are expressed for the creation of more agro-climatic zones for soybean to utilise technologies to their best. Also stress is laid on the creation of indigenous demand for soybean and its product, indepth study of farmers problems and improvement in extension and input service to the farmers.

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IDENTITY AND CULTURAL CHARACTERS OF THE PATHOGEN CAUSING ALTERNARIA BLIGHT OF RAPESEED AND MUSTARD

NISAR A. ANSARI, M. WAJID KHAN AND A. MUHEET*
Plant Pathology and Plant Nematology Laboratories, Department of Botany, Aligarh Muslim University, Aligarh-202002, India.

ABSTRACT

The present study establishes the identity of the pathogen causing Alternaria blight of rapeseed and mustard in the state of Uttar Pradesh, in India as *Alternaria brassicae* (Berk.) Sacc. The pathogen caused damping-off of seedlings as well as blight of the leaves, stems and pods on the grown up plants in fields. Lower leaves were attacked first and gradually all the leaves became infected. Then stems and pods were attacked.

The pathogen grew and sporulated well on a wide range of media. Variation in colony characters were observed on different solid media. Potato dextrose agar medium was found as best for its growth and sporulation. Morphological characters of the pathogen were similar to those described for the species by earlier workers.

INTRODUCTION

Alternaria blight regularly appears on rapeseed and mustard during the cropping season and has assumed great importance in recent years in the state of Uttar Pradesh. The disease is known to be caused by three different species of *Alternaria* viz., *Alternaria brassicae*, *A. brassicicola* and *A. raphani*. In the present paper, we report the results of the studies on the identity of the species causing the disease in the region and its cultural characters.

MATERIALS AND METHODS

Fields in large area in and around Kanpur (Uttar Pradesh) sown with rapeseed (*Brassica campestris L.*) and mustard (*Brassica juncea* (L.) Czern. and Coss.) were observed for the appearance of the disease at seedling stage as well as the plants in different stages of growth till flowering and fruiting. The naturally infected specimens collected from the fields were closely examined for symptoms on different parts of the plants and characteristics were noted. Spots were measured. The pathogen was isolated in pure culture from a large number of representative samples of seedlings, leaves, stems and pods collected from different areas on potato dextrose agar (PDA) in aseptic condition. The purified cultures of the pathogen were used for various tests.

The pathogenicity of the fungus was tested following Koch's postulates on potted plants of rapeseed, *B. campestris* var yellow *sarson* (cv. K-88) by inoculating leaves. Leaves of seedlings as well as of one-month-old plants grown in 30 cm clay pots filled

* Section of Economic Botanist (oilsedd), C.S.A. University of Agriculture & Technology, Kanpur-208002, India.

with sterilized field soil were inoculated by spraying spore suspension prepared in sterilized water with the help of an atomizer. Plants were then covered with polythene bags for 72 h and sprayed occasionally with sterilized water to maintain maximum humidity. A separate set of control was maintained using only sterilized water for spraying. There after the pots were shifted to greenhouse (temp. 23-25°C) and were regularly examined for the appearance of the symptoms.

In another experiment, in order to test the pathogenicity in causing seedling damping-off, pots filled with autoclaved soil were inoculated with the pathogen and surface sterilized seeds of rapeseed (cv. K-88) were sown. Another set of pots without the inoculum of the pathogen served as control. Emergence of seedlings was observed for a week.

Different cultural and morphological characters of the pathogen were studied by growing it on 12 solid and 12 liquid media (Table 1). A week-old-culture of the pathogen was used as inoculum. Inoculated petri-plates or flasks were incubated at 23°C and observations were recorded after 10 days of incubation. Growth was observed on the basis of dry mycelial weight or linear growth and colony characters of the pathogen growing on different solid media were also examined and noted.

The degree of sporulation was graded in the following five categories on the basis of spore count as given below:-

Sporulation grade	No. of spores/microscopic field
— (Nil)	No sporulation
+ (Poor)	1 to 5
++ (Fair)	6 to 10
+++ (Good)	11 to 15
++++ (Excellent)	Above 15

RESULTS

Damping-off symptoms of seedlings in the field plots became visible at the time of emergence of seedlings and was observed occasionally in the field (Fig.1). Healthy seedlings that emerged and survived became infected later. Lower leaves were infected first. Symptoms appeared on the upper leaves later. Symptoms were observed on stems and pods also. On the leaves spots were circular, zonate, light brown to dark brown measuing 0.5-12.0 mm in diam. with concentric rings, some times coalescing with each other. The spots were oblong or linear and shrunken on midrib of the leaves whereas they were in the form of lesions, circular, dark brown and black on the pods. As the disease progressed, several lesions coalesced and tended to cover large areas of leaves and pods, resulting in their eventual death. Several elongated lesions were also observed on stems which developed black sooty colour as they enlarged.

A number of isolations of the pathogen in pure form were made from diseased seedlings, leaves, stems and pods of rapeseed and mustard. The isolates of the patho-

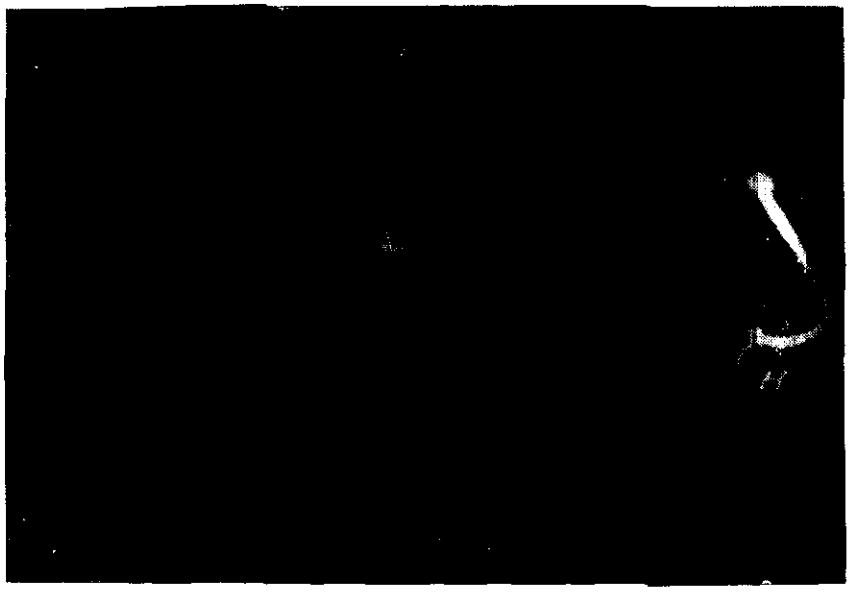

Fig. 1. Healthy and diseased seedlings of *Brassica campetris* var. yellow *sarson* (cv. K-88)
H = Healthy
D = Diseased, showing damping-off symptoms.

gen obtained from different areas and different parts of rapeseed and mustard were invariably found to be morphologically similar.

In pathogenicity tests, characteristic symptoms of the disease as observed in the field appeared on the inoculated plants of rapeseed. Re-isolations of the pathogen from artificially inoculated plants yielded the pathogen with same morphological characters. Damping-off of seedlings showed characteristics of both pre-and post-emergence damping-off symptoms. Reisolate was similar to the original isolate used in inoculation. Thus the pathogenicity was confirmed according to the Koch's postulates.

Table 1 shows that all the liquid media varied significantly in their effect on growth of the pathogen. Kirchoff's medium was found to be significantly superior to all the media tried in supporting mycelial growth, which was followed by Richard's medium. Growth of the pathogen was also good on mustard leaf extract, Sabouraud's Czapek's, Brown's starch, potato dextrose asparagine, malt extract and potato dextrose media in descending order. There was poor fungal growth on cornmeal and Asthana and Hawker's media. The least growth was recorded on oat-meal.

Sporulation was excellent on Kirchoff's, Richard's, mustard leaf extract, potato dextrose asparagine, malt extract and potato dextrose; and good on sabouraud's, Czapeck's and Asthana and Hawker's and fair on Brown's strach, corn-meal and oat-meal media (Table 1).

In solid media highest growth was obtained on potato dextrose agar followed by Richard's agar medium. Good growth was also noticed on Kirchoff's agar, mustard leaf extract agar; Sabouraud's agar; malt extract agar and potato dextrose asparagine agar. In the other media, growth was not good. Least growth was recorded on corn-meal agar.

Sporulation was excellent on potato dextrose agar, Richard's agar, Kirchoff's agar, mustard leaf extract agar, malt extract agar and potato dextrose asparagine agar media; good on Sabouraud's agar, Czapek's agar and Asthana and Hawker's agar media and fair on Brown's starch agar and con-meal agar. There was no sporulation on oat-meal agar (Table 1).

The cultural characters demonstrated that potato dextrose agar had the best colony development followed by Richard's agar and Kirchoff's agar media. In general, the aerial mycelium was loose, colonies were cob-web like, sub-merged with radiate to curly growth in most of the media. The shape of the colonies was usually circular, compact very rarely irregular and thin. The colour varied from colourless to deep greyish olive to dark olive (Table 2). Morphological characters of the pathogen cultured on PDA were examined which were as follows:

Mycelium-septate, branched, thin and smooth, hyaline to olive buff, deep olive buff to dark olive buff; hyphae-3.6-6.5 μ wide; conidiophores simple, septate (0-7), amphigenous with slightly swollen base and rounded apices, unbranched, erect, geniculate with a prominent scar at each geniculation, 35.6-171.5 μ in length, olive brown, formed singly either as side branch or terminally on the hyphae; conidia with great morphological variability, obclavate to obpyriform with ovate oultline, elongated, long beaked, olive buff with a smooth surface 75-350 × 10-43 μ with beak about 1/3 to 1/2μ of the length of the spore body and 4-8 μ in width, mostly 11-15 cross septa and 0-3 vertical septs, constricted at septa.

On host, conidia were formed singly but in culture in chains of mostly two, rarely three. The beaks measured 8-14.5 × 4-8 μ. Conidia were provided with 0-8 transverse septa and sometimes with 1-2 scars. On the basis of morphological characters, the pathogen causing the disease - Alternaria blight in the region was identified as *Alternaria brassicae* (Berk.) Sacc.

DISCUSSION

In fields the disease was found both on seedlings and on the fully grown plants. Affected seedlings damped-off while grown up plants exhibited numerous spots on leaves, stems and pods. These symptoms resembled well to those described earlier for Alternaria blight of crucifers by Dey (1948) McDonald (1959), Changsri and Weber (1963) and Ellis (1971).

Three species of *Alternaria* are known to be pathogenic on oleiferous species of *Brassica* and are distinguished on their morphological features especially by their spore

TABLE 1. Growth and sporulation of *Alternaria brassicae* on different liquid and solid media

Liquid medium	Dry Mecelial weight (mg)	Sporulation	Solid medium	Diameter of colonies (mm)	Sporulation
Kirchoff's	342.00	++++	Potato dextrose agar	70.75	++++
Richard's	332.22	++++	Richard's agar	65.75	++++
Mustard leaf extract	306.11	++++	Kirchoff's agar	57.00	++++
Sabouraud's	299.45	+++	Mustard leaf extract agar	55.25	++++
Czapek's	265.60	+++	Sabouraud's sagar	48.25	+++
Brown's starch	241.56	++	Malt extract agar	45.00	++++
Potato dextrose asparagine	227.82	++++	Potato dextrose asparagine agar	43.00	++++
Malt extract	219.25	++++	Oat-meal agar	41.25	—
Potato dextrose	203.32	++++	Czapek's agar	35.25	+++
Corn-meal	193.29	++	Brown's starch agar	31.00	++
Asthana and Hawker's	157.78	+++	Asthana and Hawker's agar	29.00	+++
Oat-meal	109.72	++	Corn-meal agar	25.50	++
L.S.D. (P=0.05)	4.52		L.S.D. (P=0.05)	3.20	
L.S.D. (P=0.01)	6.07		L.S.D. (P=0.01)	4.30	

TABLE 2. **Measurement of conidiophores, conidia and colony characters of *Alternaria brassicae* on different solid media**

Medium	Conidiophore (μ)	Conidium (μ)	Colony characters
Potato dextrose agar	35.6–171.5	75 – 350 ×10 – 43	Colony circular, growth very thick and compact, aerial mycelium loose, cottony, cob-web like, brown colour with rings of thick conidial patches, curly submerged mycelium, reverse brown.
Richard's agar	53.4–167.8	25.8–350.6 ×10.3– 43.2	Colony circular, raised and profused, mycelial growth with concentric rings, colony dark olivaceous on surface, reverse iron-grey.
Kirchoff's agar	40.2–158.6	70.7–372.4 ×15.3– 35.6	Colony circular, growth compact, aerial mycelium usually loose sometimes dense, cottony with thick rings of conidial patches, light olive grey to dark olive grey, reverse dark brown.
Mustard leaf extract agar	73.6–161.7	66.2–315.7 ×20.5– 38.6	Colony circular, loose, cottony, mycelial growth with rings of conidial patches, curly submerged, mycelium colourless to pale smoke grey to pale drab grey, reverse olive grey.
Sabouraud's agar	40.6–129.3	77.4–221.5 × 9.4– 30.5	Colony circular, thin growth with creeping hyphae, wihtish in the centre without zonation, deep olive to dark olive grey, reverse olive grey.
Malt extract agar	30.6–128.5	40.7–275.8 ×11.6– 38.9	Colony circular, growth compact, aerial mycelium loose, cottony, cob-web like, with rings of conidial patches, submerged mycelium radiate to curly in growth, deep greyish olive to dark olive, reverse dark brown
Potato dextrose asaparagine agar	58.8–195.5	100.2–285.6 ×13.3– 32.5	Colony irregular, mycelial growth compact, without zonations dark olive grey to olivaceous black at surface, reverse matal brown

TABLE 2. (Continued)

Medium	Conidiophore (μ)	Conidium (μ)	Colony characters
Oat-meal agar	46.8–155.6	58.2–247.0 × 9.7– 35.2	Colony circular, growth poor, cottony without zonations, surface dark neutral grey, reverse state grey.
Czapek's agar	28.9–145.6	67.8–295.5 ×11.0– 32.5	Colony circular, thin creeping mycelial growth, fluffy to dense cottony with zonations, olivaceous in colour, reverse brown.
Brown's starch agar	46.8–152.3	60.3–250.6 × 9.7– 33.0	Colony circular, thin superficial growth with scanty mycelium, concentric annulation of the conidial growth pronounced, olivaceous grey in colour, reverse sorghum brown.
Asthana and Hawker's agar	15.6–135.2	56.7–346.6 ×16.7– 36.4	Colony circular, growth compact, aerial mycelium loose, cottony colourless with patches of conidia and scattered over the culture no zonation, deep olive to dark olive grey, reverse neutral grey.
Corn-meal agar	52.4–146.0	45.7–275.5 ×12.7– 25.5	Colony circular, growth very poor mycelium superficial and scanty without zonation. Surface whitish brown, reverse dark brown.

size and symptoms they cause. The morphological characters of the isolates of the pathogen in the present study were similar to that of *A. brassicae* studied by Groves and Skolko (1944), Neergaard (1945), Wiltshire (1947) and Joly (1965). The pathogen was therefore, identified as *Alternaria brassicae* (Brek) Sacc. causing blight of plants and damping-off of seedlings of rapeseed and mustard in the state of Uttar Pradesh. The species is reported from other states in India like Bihar (Mason, 1928), Rajasthan (Prasad *et al.* 1970; Gupta *et al.*, 1972) and Punjab (Chohan, 1978).

The pathogen could grow well on a wide range of media and sporulated sufficiently but there was no definite trend in the preference of the pathogen for synthetic and natural media. Some natural media supported sufficient growth but some corn-meal and oat-meal fared rather poorly. Sporulation of the pathogen was excellent not only in media which supported excellent growth but also in media in which moderate growth occurred. In some media growth was poor but sporulation was good. On the other hand, in some media both growth and sporulation were poor. Performance of the media differed to some extent with a change of their forms, as there was no correlation between dry weight of the fungus and its linear growth.

A considerable variation was noted in the colony characters of *A. brassicae* on various media. The mycelium was usually light brown to brownish grey. Conidia were brown, mostly born singly with long beaks or sparingly in chains of two and sometime three. Elliot (1917), Changsri and Weber (1963) and Prasada *et al.* (1970) also observed similar colony characters of the fungus. These characteristics of the colony further lend support to the identity of the pathogen involved. The present study establishes *A. brassicae* responsible for the blight which is presently prevalent on oilseed crucifers especially of rapeseed and mustard in the state of Uttar Pradesh. As the pathogen has no specific nutritional requirements, it is expected that it can grow and sporulate on a wide range of substrates which can be regarded as an attribute for its chances of survival and initiation of disease cycle.

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INFLUENCE OF CARRIERS, ISOLATES AND INOCULATION METHODS OF *RHIZOBIUM* ON GROUNDNUT IN VERTISOLS

V.T. JADHAV, S.S. KORE AND C.D. MAYEE
Department of Plant Pathology, Marahtwada Agricultural University, Parbhani, Maharashtra.

ABSTRACT

Effect of different carrier materials, *Rhizobium* isolates and inoculation methods on groundnut was studied in screen house experiments. Soil and FYM mixture proved to be good carrier material next to lignite. Inoculation of different *Rhizobium* isolates observed to influence the nodulation and dry matter accumulation by groundnut, differentially. Amongst the nineteen isolates tested, local isolate Rh-1, proved to be superior in nitrogen fixation. Of the three different methods of *Rhizobium* inoculation tested, liquid inoculation below the seed was observed to be superior in increasing the nodulation in groundnut.

Key words : Groundnut *Rhizobium*; carrier material: *Rhizobium* isolates: methods of inoculation.

INTRODUCTION

Rhizobium inoculation to leguminous host is highly useful in many ways. Effectiveness of the strains, however, to benefit the legume host through symbiotic nitrogen fixation differs substantially. Weaver (1974) observed variation in effectiveness of groundnut rhizobia collected in Texas, U.S.A. Only effective strain increased the groundnut yield (Burton, 1975). Similarly, the methods of inoculation and the carriers used for inoculants, also greatly influence the nitrogen fixation and yield (Anonymous, 1985). Peat and lignite are commonly used carriers for *Rhizobium* inoculant preparation. The sources are not commonly accessible. Groundnut seed coat being delicate, the usual method of inoculation may harm the germination. Several workers have tried alternate methods for *Rhizobium* inoculation. This includes use of liquid inoculants, solid inoculant mixture, inoculation of preceding cereal crop etc. (Nambiar *et al.* 1981). The present investigation is therefore, planned to study these aspects under Marathwada conditions.

MATERIAL AND METHODS

Feasibility of lignite, soil, F.Y.M. and soil-FYM mixture as carrier material was studied in an screen house experiment. Forty ml. culture broth was mixed throughly in 100g of well ground carrier material. After recording the initial rhizobial count, inoculants were packed in polythene bags and stored in laboratory for 10 weeks. Feasibility of carriers was assessed by viable cell count and nodulation on host plant.

To study the effect of *Rhizobium* isolates on host, a pot culture experiment was conducted using 19 isolates of groundnut *Rhizobium* and groundnut cv. SB-XI. Pots were filled with sterilized soil. One ml. of rhizobial suspension was added to surface sterilized seeds while sowing. Plants were depotted on 50th day after sowing and

observations were recorded on leaf colour (Scale 1 to 3 with 1-yellow, 2-light green, 3-dark green, by visual observation), number of nodules and plant dry weight.

Influence of different methods of inoculation was assessed in pots using groundnut cv. SB-*XI* and local groundnut *Rhizobium* isolate Rh-1. The plants were depotted on 50th day after sowing and observations were recorded on nodule number.

RESULTS AND DISCUSSION

The results on rhizobial survival and nodulation influenced by different carrier material are given in Table 1. Lignite supported maximum rhizobial population during

TABLE 1. Effect of different carriers on survival of *Rhizobium* and nodulation in groundnut.

Sr. No.	Carrier material	Initial rhizobial countper g of carrier	Rhizobial count per g of carrier after 10 weeks of storage	Average nodules per plant
1.	Lignite	10^8	8.8×10^7	26.2
2.	Soil	10^8	2.1×10^4	17.6
3.	F.Y.M.	10^8	4.3×10^5	21.4
4.	Soil + F.Y.M. (1:1)	10^8	8.3×10^7	22.6
			S.E. ±	0.64
			C.D. at 5%	1.94

the storage period. This was obvious since lignite has been proved to be suitable carrier and being used successfully for inoculant preparations. However soil and F.Y.M. mixture also supported substantial number of *Rhizobium* cells. Field soil (vertisol) proved to be poor in supporting rhizobial population. Nodulation test revealed the similar pattern, where maximum nodulation was observed in the plant inoculated with the inoculant where lignite was the carrier material. This was followed by soil + FYM mixture and FYM alone, however, the differences between these two were non-significant. These results have practical significance since soil and F.Y.M. are locally available material and cheaper compared to lignite. Soil-FYM mixture can be used in inoculant preparation without much reduction in viability of *Rhizobium*.

The data on evaluation of different *Rhizobium* isolates are given in Table 2. Variability in effectiveness of different isolates has been observed in the screen house test. Amongst the isolates tested, the isolate Rh-1, isolated at Parbhani, was proved to be the most effective in improving different parameters of nitrogen fixation. The isolates did not differ significantly in respect of the plant colour. However, significant difference occured in nodule number and plant dry weight due to inoculation of different isolates. Inoculation of Parbhani isolate Rh-1, increased nodule number and plant dry weight over other eighteen isolates, and the increase being statiscally significant. Similar

variations in different nitrogen fixing traits has been reported in past (Elkan, *et al* 1981). The Parbhani isolate Rh-1 dominated over other isolates in nitrogen fixation, probably because of its adaptability to the host genotype and environment.

TABLE 2. Evaluation of different *Rhizobiusm* isolates of groundnut

Sr. No.	Isolate number	Plant colour (Average of 6 plants)i	Nodules/plant	Dry wt./plant (g)
1.	Rh-1	2.167	24.83	2.02
2.	Rh-2	1.667	20.17	1.81
3.	Rh-3	2.000	18.33	1.64
4.	Rh-4	1.833	16.83	1.73
5.	Rh-5	1.667	14.83	1.78
6.	Rh-6	2.000	15.17	1.69
7.	Rh-7	2.000	17.67	1.51
8.	Rh-8	1.833	14.83	1.70
9.	Rh-9	2.000	16.66	1.76
10.	Rh-10	2.168	20.00	1.89
11.	Rh-11	1.833	17.33	1.80
12.	Rh-12	2.000	18.00	1.78
13.	Rh-13	1.833	19.00	1.80
14.	Rh-14	1.833	19.67	1.93
15.	Rh-15	2.000	67.17	1.74
16.	Rh-16	2.000	18.67	1.61
17.	Rh-17	1.833	17.67	1.82
18.	Rh-18	2.000	17.50	1.79
19.	Rh-19	2.000	19.33	1.87
	S.E. ±	0.2	1.112	0.069
	C.D. at 5%	N.S.	3.177	0.197

The results from the experiment, where effect of different methods of inoculation on nodulation (Table 3) was studied, clearly indicated that application of *Rhizobium* broth just below the seed is the best method for obtaining maximum nodulation. Similar beneficial effects of liquid inoculants have been reported (Nambiar *et al* 1981). Another beneficial effect of this method, though not looked in the present experiment, is that no adverse effect on germination of groundnut occur since the seeds are not hand-

TABLE 3. Nodule production on groundnut as influenced by method of inoculation

Sr. No.	Treatment	Nodule number/plant (Average of 10 plants)
1.	*Rhizobium* broth inoculation with lime pelleting	45.4
2.	Rhizobium broth inoculation only	33.3
3.	*Rhizobium* broth applied below the seed	60.4
4.	No *Rhizobium* inoculation	22.8
	S.E. ±	0.764
	C.D. at 5 %	2.182

led for inoculation. Seed inoculation with lime pelleting also proved to be a good practice for obtaining improved nodulation.

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GENETIC VARIABILITY IN INDIGENOUS SOYBEAN (*GLYCINE MAX* (L.) *MERRILL*) OF NORTH EASTERN HILLS REGION OF INDIA

B.K. SARMA AND M.J. ABRAHAM
Division of Plant Breeding, ICAR Research Complex for NEH Region, Shillong-793004

ABSTRACT

Thirty one indigenous genotypes of soybean (*Glycine max* (L.) Merrill) with three check varieties were screened for a few morphological and nine quantitative characters. Much variation was observed in morphological characters with regard to flower colour, pubescence, stem type, leaf type, pod and seed colour. MGSB 77-1 was the earliest to followers. IC 15959 had the highest number of primary branches plant, maximum nodes in the main stem, and the highest number of pods but had the smallest seed size. IC 25760 was the earliest to mature as well as had the biggest seed size. MGSB series, in general, had less number of seeds per pod. IC 9471 was the highest yielder among the local germplasm. All the Mizoram collections were late maturing. A wide range of variability was observed in days to 50% flowering, days to maturity, plant height, pods per plant, 100 seed weight and seed yield per plant. Primary branches per plant, nodes on the main stem and seeds per pod had intermediate range of variation. Seed yield per plant, number of pods per plant, number of seeds per pod and plant height had high phenotypic and genotypic coefficient of variability. Characters with high heritability were, seed yield per plant, days to 50 percent flowering, number of pods per plant, days to maturity and plant height. Genetic advance was very high for seed yield per plant and number of pods per plant. Individual plant selection for characters viz. seed yield ,pods per plant and seeds per pod would be effective as they have high heritability coupled with high genetic advance.

Key words : *Glycine max*, genotypic coefficient of variability, heritability, genetic advance

INTRODUCTION

The seeds of soybean (*Glycine max* L.) have been used for centuries as food in China, Japan and Korea substituting rice diet (Bhatia *et al*, 1983). In India, black soybean has been grown for ages in Kumaun and Garhwal regions of U.P., in some scattered pockets of Central India and to a limited extent in north eastern hills. Inspite of its importance as a source of oil and protein, the crop has not yet become popular in India. Recently, however, the area under soybean is rapidly increasing and Madhya Pradesh alone has accounted for more than 80% of the total area of the country. In North Eastern hills, the area under soybean is 6,200 ha with a production of 5,900 tonnes as estimated in 1984-85 (Anon, 1985). In this region, it is taken as a pulse crop and most of the local varieties are black or brown seeded. For any crop improvement programme, knowledge of the nature and magnitude of genetic variability in respect of various yield contributing characters is essential. Therefore, an attempt was made in the present investigation to estimate the phenotypic and genotypic co-efficient of variability, heritability and genetic advance in thirty four soybean germplasm including thirty one indigenus collections from North Eastern Hills region.

MATERIALS AND METHODS

The materials consisted of thirty four soybean genotypes including three check

varieties sown in Randomised Block Design with 3 replications during *kharif* 1985 at ICAR Research Complex Farm at Barapani (1000 m, msl, 25.4°N and 91.5°E), in Meghalaya. Each plot consisted of 5 rows of 3 m length spaced 45 cm between rows and 15 cm between plants. Standard cultural practices were followed. Observations were recorded on five randomly selected competitive plants from the middle rows of each plot. The characters studied were days to 50% flowering, days to maturity, plant height, nodes/plant in the main stem, primary branches/plant, number of pods/ plant, number of seeds/pod, 100 seed weight and seed yield/plant. Phenotypic coefficient of variability (PCV) and genotypic co-efficient of variability (GCV), heritability in broad sense and genetic advance were computed as per methods suggested by Burton (1952), Burton and de Vane (1953) and Johnson *et al* (1955) respectively.

RESULTS AND DISCUSSIONS

Variation in morphological characters

Much variation was observed for morphological characters in the collections of different states. Flower colour in the collections from Arunachal Pradesh, Manipur, Meghalaya and Sikkim was white and purple whereas it was only purple in Mizoram and Nagaland collections. The pubescence varied from appressed brown white (Sikkim and Nagaland) to appressed grey, brown erect etc. (Arunachal Pradesh, Manipur, Megha laya, Mizoram). The stem varied from ridged and round determinate to indeterminate type and branching varied from short erect to long erect. Pod colour of Sikkim collections was brown but collections from other states showed variation such as yellow, brown and straw. Seed colour of Mizoram and Nagaland collections was yellow while those from other states was brown, black and yellow.

Varietal performance

The analysis of variance revealed the presence of significant differences among the entries for all the characters (Table 1). MGSB 77-1 (Meghalaya) was the earliest to flower (42 days), IC 15959 (Meghalaya) had the highest number of primary branches per plant (8.0) maximum nodes on the main stem (17.5) and the highest number of pods per plant (81.2) but had the smallest seed size (7.2 g). IC 25760 (Arunachal Pradesh) was the earliest to mature (110 days) and possessed the biggest seed size (25.1 g). IC 10678 (Arunachal Pradesh) had attained maximum plant height (83.9 cm). MGSB series (Meghalaya), in general, had less number of seeds per pod (0.6-2.0). Among the local genotypes, IC 9471 (Sikkim) was the highest yielder (56.2 g/plant) followed by MG 77-3 (Meghalaya) with 51.5 g per plant. However, the check variety Alankar (68.2 g/plant) significantly out yielded all the other varieties although the other two check varieties viz. Bragg and Lee yielded significantly less than IC 9471 and MGSB 77-3. Mizoram collections were late in flowering and maturity. IC 9456 (Sikkim) had the lowest number of primary branches and nodes/plant and MGBS 75-2 was the lowest yielder (4.0 g per plant).

TABLE 1. Mean values of 9 characters in 34 local soybean germplasm

Genotypes	Source	DF	DM	PH	PBP	PP	SP	100 SW	NP	YP
IC 15959	Meghalaya	46	117	83.5	8.0	81.2	2.0	7.2	17.5	**15.0**
MGSB 75-1	,,	53	121	55.9	3.9	25.0	2.7	18.3	11.5	**31.1**
MGSB 77-1	,,	42	118	28.7	4.0	39.2	2.0	18.2	**9.9**	**13.5**
MGSB 77-3	,,	49	124	31.9	4.2	31.9	2.3	15.0	**7.2**	**51.5**
MGSB 75-2	,,	60	129	41.9	6.3	11.3	0.6	19.0	10.3	**4.0**
MGSB 77-2	,,	56	123	47.3	5.6	12.1	0.9	20.0	10.9	**8.7**
MGSB 78-1	,,	62	128	52.3	4.9	11.3	0.8	24.1	11.2	**6.7**
MGSB 78-2	,,	62	128	48.6	5.3	17.1	1.0	19.7	11.4	**9.0**
MGSB 78-3	,,	61	128	46.6	6.0	12.7	1.0	16.0	10.9	**7.0**
MGSB 78-4	,,	61	130	52.2	5.9	12.1	0.9	15.6	9.7	6.7
MGSB 78-5	,,	62	130	45.7	5.5	19.3	1.1	18.6	10.4	**10.0**
MGSB 78-6	,,	62	128	43.9	5.6	10.2	0.8	18.5	9.9	5.7
MGSB 78-7	,,	54	125	42.9	3.9	10.9	0.8	22.3	9 9	8.7
MGSB 78-8	,,	56	124	40.1	4.7	12.5	0.9	22.3	10.1	**9.7**
MGSB 78-9	,,	56	124	43.0	4.6	11.7	0.7	22.9	10.1	**7.0**
MGSB 78-10	,,	56	126	43.5	4.5	9.8	0.7	24.0	9.5	7.7
MGSB 78-11	,,	51	124	44.3	4.5	14.7	1.1	23.7	10.5	12.0
MGSB 78-12	,,	48	140	68.1	6.1	20.5	1.9	13.5	12.7	**13.0**
IC 25760	Arunachal	48	110	30.3	5.0	31.0	2.0	25.1	6.8	**10.9**
IC 10678	,,	48	120	83.9	4.4	45.3	2.2	7.4	9.1	**27.9**
IC 10684	,,	51	119	28.7	6.2	52.3	2.6	19.1	8.0	**20.5**

TABLE 1. (Continued)

Genotypes	Source	DF	DM	PH	PBP	PP	SP	100 SW	NP	YP
IC 9456	Sikkim	58	117	26.2	3.1	32.5	2.3	20.8	6.1	24.9
IC 94771	,,	60	121	45.6	3.1	38.0	2.0	21.5	6.9	56.2
Sikkim local	,,	49	125	43.3	4.2	25.8	2.3	14.5	15.4	18.5
Mizoram 1	Mizoram	82	161	77.4	5.3	22.7	3.0	6.5	13.2	8.0
Mizoram 3	,,	82	163	48.0	5.0	28.7	3.0	17.7	7.1	23.0
Bekang	,,	89	150	57.0	4.2	28.4	2.7	15.4	6.2	10.8
Manipur 1	Manipur	65	122	67.0	5.4	25.4	2.7	11.0	6.5	34.7
Manipur 2	,,	63	127	51.7	5.2	31.0	2.0	13.4	7.5	25.8
Manipur 4	,,	62	113	43.5	4.4	34.3	3.0	13.1	6.8	31.9
NL 81-1	,,	59	130	64.5	4.5	29.7	3.0	14.5	11.5	21.8
NL 81-2	Nagaland	68	128	57.3	4.5	31.9	2.5	15.9	6.2	19.8
NL 81-8	,,	62	130	42.3	7.2	38.2	2.2	18.6	10.1	18.5
Bragg	USA	42	128	41.2	5.0	22.0	2.7	24.4	9.1	37.5
Lee	USA	45	115	28.5	3.7	61.0	2.3	17.1	7.3	31.1
Alankar	Pantnagar	46	117	45.9	4.9	53.6	2.4	17.3	8.9	68.2
CD at 1%		4.7**	6.7**	8.9**	1.8**	9.5**	0.7**	7.7**	3.6**	6.5**

DF : Days to 50% flowering; DM : Days to maturity; PH : Plant height (cm); PBP : Primary branches/plant; NP : Nodes on main stem/plant; PP: Pods/plant; SP : Seeds/pod; 100 SW: 100 seed weight (g); YP : Yield/plant (g)

TABLE 2. Range of variability and genetic parameters for 9 characters of 34 soybean germplasm

Parameters	Days to 50% flowering	Days to maturity	Plant height	Primary branches/ plant	Nodes/ plant in mainstem	No. of pods/ plant	No. of sedes/ pod	100-seed weight (g)	Yield plant (g)
Range	42.89	110–163	26.2–83.9	3.1–8.0	6.1–17.5	9.8–81.2.	0.6–3.0	6.5–25.1	4.0–68.2
Mean	57.62	126.86	48.49	4.99	9.70	28.98	1.88	17.40	19.58
SEm ±	1.28	1.83	2.46	0.50	0.99	2.60	0.20	2.12	1.79
'F' value	67.39**	37.26**	33.16**	4.41**	6.97**	47.21**	10.96**	4.85**	70.66*
Genotypic variance	109.55	121.05	195.08	0.84	5.85	312.43	0.61	17.30	224.40
Phenotypic variance	114.51	131.06	213.28	1.58	8.78	332.71	0.73	30.82	234.06
GCV	18.16	8.67	28.80	18.37	24.93	60.99	41.54	23.91	76.51
PCV	18.57	9.02	30.12	25.21	30.55	62.94	45.39	31.90	78.14
Broad sense Heritability (%)	95.67	92.36	91.47	53.16	66.63	93.90	83.56	56.13	97.91
Genetic Advance (GA)	21.16	21.70	27.38	1.37	4.09	35.32	1.48	6.40	30.26
GA as % of mean	36.73	17.10	56.46	27.50	42.16	121.88	78.64	36.81	154.52

** P = 0.01

Disease and pest resistance

The geotnypes MGSB-75-2;-75-1;-77-1;-77-3;-75-2; Sikkim local; Bekang; Manipur-2; NL-81-1 were found to be moderately resistant to soybean rust (*Phakopsora pachyrhizi* Syd.) which is a serious problem in the north eastern hills region. MGSB-77-1; 77-3; and 75-2 also posessed moderate resistance to frog eye leaf spot disease (*Cercospora sojini*) which is also a serious constraint in soybean production in this region (Chandra *et al*, 1987 and Kumar *et al*, 1987). It was also found that NL-81-1; MGSB-77-3 and Sikkim local were least prefered by leaf roller, bean leaf bettle and stem fly.

Genetic variability

The range, mean, standard error, genotypic variance, phenotypic variance, GCV, PCV, heritability and genetic advance of all characters are given in Table 2. A wide range of variability was recorded for days to 50% flowering (42-89), days to maturity (110-163), plant height (26.2-83.9 cm), pods per plant (9.8-81.2), 100 seed weight (6.5-25.1 g) and seed yield per plant (4.0-68.2 g), Primary branches per plant, nodes on the main stem and seeds/pod had intermediate range of variation. Bhatia *et al* (1983) and Asthana *et al* (1984) also reported wide variability for these agronomic characters of the indigenous soybean genotypes of NE India. The variances were observed to be high for seed yield per plant, number of pods per plant and number of seeds per pod. Genotypic coefficient of variation ranged from 8.67 tp 76.51 and phenotypic coefficient of variation ranged from 9.02 to 78.14 . The characters with high GCV and PCV were seed yield per plant, pods per plant and seeds per pod and these characters are amenable to improvement through selection. Characters like days to maturity, days to 50% flowering and primary branches per plant had low genotypic and phenotypic coefficient of variation. However, GCV itself would not be a correct measure to know the heritable variations present and therefore, GCV should be considered together with heritability estimates to get the best picture of the amount of the advance to be expected from the selections (Burton, 1952).

Heritability estimates were high for most characters, except primary branches/plant and 100-seed weight. Heritability ranged from 53.10% (Primary branches/plant) to 97.91% (seed yield/plant). Characters having high heritability values such as days to maturity (92.36%), plant height (91.47%), Pods/plant (93.90%), seeds/pod (83.56%), seed yield/plant (97.91%) could be improved directly through selection since these characters are relatively less influenced by environment and there would be greater correspondence between phenotypic and breeding values. Characters with low GCV such as 50% flowering and days to maturity, showed high heritability estimates indicating that the heritable portion of the variability in these characters is higher. These results are in conformity with the findings of Mahmud and Kramer (1951), Johnson *et al* (1955), Anand and Torrie (1963) and Lal and Haque (1972) on soybean. This high heritability estimates would be helpful for breeding superior genotypes on the basis of phenotypic performance of quantitative character. However, Johnson *et al* (1955) reported that heritability estimates alongwith genetic gain were more useful in soybean than that the

heritability values alone for selecting the best individual. Ramanujam and Tirumalachar (1967) reported in red pepper that heritability estimate in the broad sense will be more meaningful if accompanied by a genetic advance. Days to maturity, which had a high heritability showed the lowest gentic advance as percentage of mean (17.10). The highest genetic advance as percentage of mean was obtained for seed yield (154.52) followed by pods/plant (121.88) and seeds/pod (78.64). The three characters had high genetic advance together with high heritability values. The high heritability obtained for characters in such cases is probably due to additive gene action as opined by Panse (1957), and Gandhi *et al* (1964) suggested that a high genetic advance alongwith high heritability would be the most effective for selection. Characters like days to 50% flowering and days to maturity had high heritability but low genetic advance, probably due to the non-additive (dominance and epistasis) gene effects (Panse, 1957) for these characters.

The rust and frog eye leaf spot resistant genotypes viz. MGSB-77-3; 75-1 and Manipur-1; early maturing bold seeded genotype IC-25760; high yielding genotypes Alankar and IC-9471 and genotype with highest pod number IC-15959 would be useful parental lines for the improvement of soybean in the north eastern hills region. The study of various genetic parameters indicated that individual plant selection, for the improvement of seed yield per plant, pods per plant and seeds per pod would be effective, from indigenous soybean genotypes of the north eastern hill region.

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INHERITANCE OF PERIOD FROM SEEDLING EMERGENCE TO FIRST FLOWERING IN PEANUT (*ARACHIS HYPOGAEAL*)

S.N. NIGAM, S.L. DWIVEDI, G.V.S. NAGABHUSHANAM, AND R.W. GIBBONS
International Crops Research Institute for the Semi-Arid Tropics ((ICRISAT) Patancheru P.O.,Andhra Pradesh 502 324, India.

ABSTRACT

F_1 progenies of peanut (*Arachis hypogaeal*. L.) from a 6×6 diallel. including reciprocals and their parents, were evaluated for the number of days from seedlings emergence to first flower appearance during the 1981 and 1982 rainy seasons at ICRISAT Centre, Patancheru, India. Genetic analysis indicated the predominant role of additive genetic variance in the expression of this character. Genotype 91176 had the best general combining ability for early flowering and has the potential for use in breeding programs. Variety M 13 had the best general combining ability for late flowering.

Key words : Peanut, combining ability, genetic variance, flowering

INTRODUCTION

The period from seedling emergence to first flowering in peanut (*Arachis hypo gaea* L.) is one of the important traits that determines maturity of variety. This trait is potentially useful in formulating an effective breeding strategy in programs where crop duration is of prime concern. There have been very few genetic studies on this character in peanut (Gibori *et al.*, 1978, Parker *et al.*, 1970, and Wynne *et al.*, 1970). The present study was, therefore, undertaken to characterize the nature and magnitude of genetic variance associated with the period from seedling emergence to first flowering in peanut.

MATERIALS AND METHODS

Six peanut genotypes, Chico, 91176 and Dh 3-20 (subsps. *fastigiata* var *vulgaris*), Gangapuri (subsps. *fastigiata* var *fastigiata*), and Robut 33-1 and M 13 (subsps. *hypogaea* var. *hypogaea*), were chosen for this study. Chico, 91176 and Gangapuri flower at the same time but Gangapuri takes a little longer to reach maturity than the other two genotypes. Dh-3-20 flowers later than Chico and 91176 but is similar to Gangapuri in maturity. In the subsps. *hypogaea* group ,the variety Robut 33-1 flowers and matures earlier than M 13 which takes about a month to flower and has a longer maturity period.

The genotypes were crossed in a diallel mating system that included reciprocals. Thirty F_1's and six parents were sown in a randomized block design with two replications in the rainy seasons (June-October) of 1981 and 1982 at ICRISAT Research Cente Patancheru, India. Each plot had a signle row of ten plants spaced 15 cm apart on 75 cm ridges. Five competitive plants within a row were randomly selected and used to record observations on days to first flowering.

Data were analyzed on a plot mean basis following combining ability analysis, method 1, model 1 (Griffing ,1956) and the graphical and component analyses of Hayman (1954) and Jinks and Hayman (1953).

RESULTS AND DISCUSSION

In both years significant genotypic differences for the period from seedling emergence to first flower production were observed among the parents and the crosses (Table 1). Mean squares due to general combining ability (GCA), specific combining ability (SCA), and reciprocal effects (REC) were highly significant for this character in both years (Table 2). The estimated variance due to GCA was twice the variance of SCA in 1981, and five times greater in 1982. Although the magnitude of the variance component of combining ability varied with years, possibly due to genotype × environment interactions, the predominance of GCA variance was evident in both years. Variance dueto REC, though significant, was small compared to GCA variance. Component analysis also revealed the predominance of additive genetic variance in both years. However, the variance estimates of the additive effect of genes (D) varied over years, being higher in 1982 (Table 3). Earlier reports on combining ability studies for days to flower in F_1 progenies of a 6×6 diallel cross in peanut, evaluated under phytotron and field conditions, also revealed the predominance of additive genetic variance (Parker *et al.*, 1970 and Wynne *et al.*, 1970).

The best general combiner for early flowering in both years was the genotype 91176, followed by Gangapuri, Chico, the earliest flowering genotype, was third (Table 4). Chico has been used extensively in breeding programs as a source of earliness, but its combining ability has not been determined previously. Genoytpe 91176, with a similar flowering period to Chico, and with better combining ability has been used little in breeding programs. Similarly, M 13, followed by Robut 33-1, was the best general combiner for late flowering and could be used to develop high yielding, late maturing peanut varieties. Highly significant positive correlation (r=0.94 in 1981 and 0.97 in 1982) between the *per se* performance of the parents and their crosses indicates that cross performance can be predicted based on the performance of parents involved in a cross. Genotype 91176, although early in flowering, has a low yield potential and small seeds, whereas M 13 is a late flowering, large seeded variety with a high yield potential. Transgressive segregants combining early flowering and large seed type with high yield potential might be recovered from an F_2 populations of a cross between these two genotypes.

The nonsignificant t^2 value in both years (1.18 in 1981 and 0.06 in 1982) indicated the fulfilment of the assumptions of the diallel analysis. The regression of covariance (Wr) on variance (Vr) also did not deviate significantly from unity, which further proved the adequacy of the additive dominant model in this material. The regression line intercepts the Wr axis above the origin, indicating partial dominance in both years. The distribution of array points revealed that both early flowering genotypes, Chico and 91176, possessed an excess of recessive alleles. However, Gibori *et al.*, (1987) reported an excess of dominant alleles in Chico for this trait in the F_2 generation. Dominant and recessive alleles controlling late flowering in M 13 were observed to be of a differential nature; with an excess of recessive alleles in 1981 and of dominant alleles in 1982. This particular observation is similar to those on oil content in flax reported

by Yermanos and Allard (1961) indicating that identical genotypes can exhibit different typese of gene action when grown in different environments.

These results and those reported earlier indicate the importance of additive genetic variance in controlling the flowering period from seedling emergence to first flower production in peanut. Genotype 91176 and M 13 were the best general combiners for early and late flowering periods, respectively.

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TABLE 1. Analysis of variance of parents and F_1 progenies for days to first flowering from seedling emergence in peanut, rainy seasons 1981 and 1982 ICRISAT Center.

Sources	df.	Mean sum of squares	
		1981	1982
Replications	1	0.01	1.61
Treatments	35	330.73**	356.28**
Parents	5	1269.54**	1336.29**
Crosses	29	3.24**	10.98**
Parents vs. Crosses	1	5134.00**	5469.80**
Error	35	0.34	0.69

** Significant at 0.01 probability level.

* *Parents* P1 = *Chico*; P2 = 91176; P3 = Dh 3-20; P4 = Gangapuri; P5 = Robut 33-1; P6 = M 13

TABLE 2. Analysis of variance for components of combining ability for days to first flowering from seedling emergence in peanut, rainy seasons 1981 and 1982 ICRISAT Centre.

Sources	df	Mean sum of squares	
		1981	1982
GCA	5	13.61**	38.88**
SCA	15	0.77**	0.97**
REC	15	0.54*	0.95**
Error	35	0.17	0.34
Var (GCA)		1.12	3.21
Var (SCA)		0.60	0.63
Var (REC)		0.18	0.30

** Significant at 0.01 probability level

GCA — General combining ability;

SCA — Specific combining ability;

REC — Reciprocal effects;

Var (GCA) — Variance due to general combining ability;

Var (SCA) — Variance due to specific combining ability;

Var (REC) — Variance due to reciprocal effects.

TABLE 3. Components of genetic variance for days to first flowering from seedling emergence in peanut rainy seasons 1981 and 1982 ICRISAT Centre.

Components	1981		1982	
D	7.89**	+ 0.62	11.73**	+ 0.25
H_1	2.57	+ 1.68	-1.29	+ 0.63
H_2	1.18	+ 1.52	-1.22	+ 0.68
h^2	0.05	+ 1.02	0.57	+ 0.41
E	0.17	+ 0.23	0.35	+ 0.01

** Significant at 0.01 probability level

D — Additive genetic variance;

H_1 — Nonadditive genetic variance due to dominance effects of genes;

H_2 — Proportion of nonadditive variance due to positive and negative effects of genes;

h^2 — Net dominance effects;

E — Variance due to environmental effect.

TABLE 4. ***Per se*** **performance of the parents and general combining ability effects for days to first flowering from seedling emergence in peanut, rainy seasons 1981 and 1982 ICRISAT Centre.**

Parents	1981		1982	
	Per se performance	GCA Effects	*Per se* performance	GCA Effects
91176	20	-1.14*	20	-1.54**
Gangapuri	20	-0.94*	21	-1.23**
Chico	20	-0.32*	20	-0.98**
Dh 3-20	23	-0.09	22	-0.51*
Robut 33-1	24	0.89*	26	1.18**
M 13	27	1.60*	29	3.10**
SE gi		0.11		0.15
SE gi-gj		0.17		0.24

* and ** Significant at 0.05 and 0.01 probability level, respectively.

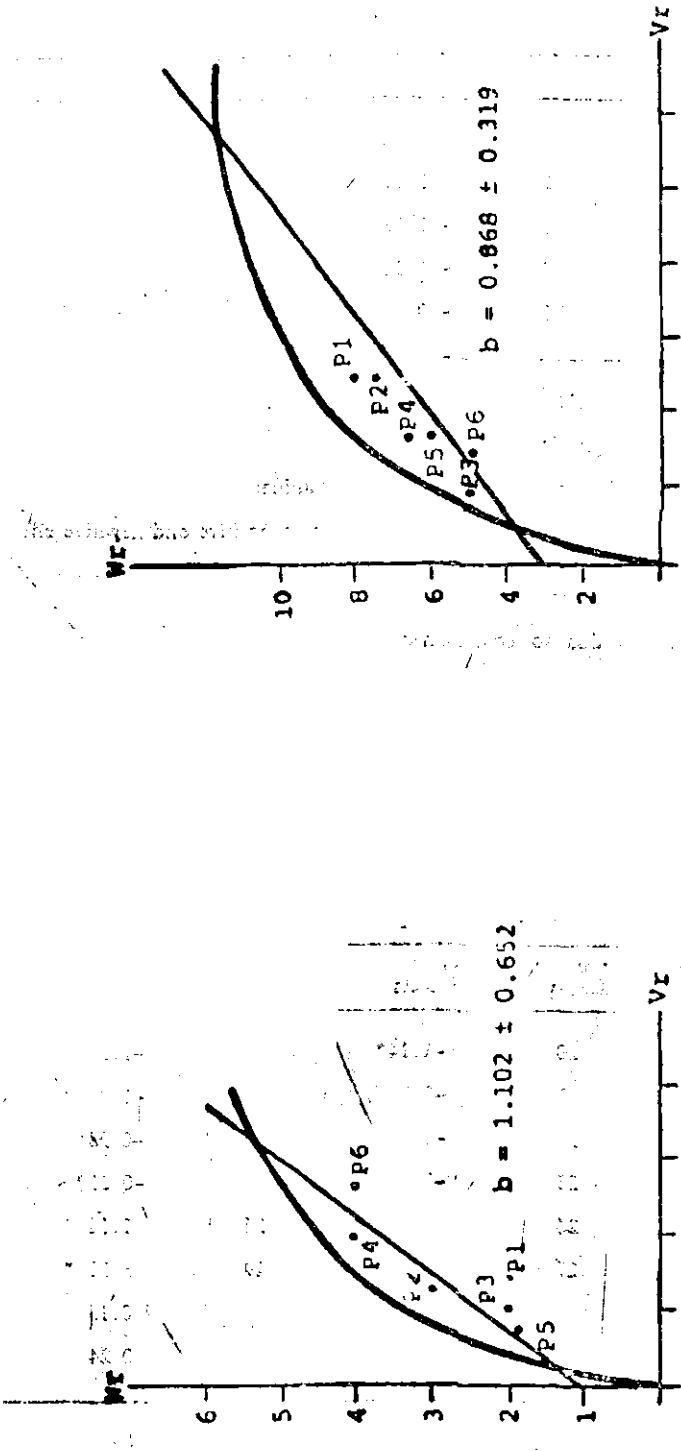

Fig. 1: Covariance (Wr), Variance (Vr) graph for days to first flowering from seedling emergence, rainy seasons 1981 and 1982.

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YIELD GAPS AND CONSTRAINTS ANALYSIS IN GROUNDNUT PRODUCTION IN WARANGAL DISTRICT OF ANDHRA PRADESH

G.P. SUNANDINI, T.D.J. NAGABHUSHANAM AND J. KRISHNAIAH
Department of Agricultural Economics, College of Agriculture, A.P.A.U., Rajendranagar, Hyderabad 500 030.

ABSTRACT

The present study is undertaken to assess the yield gaps on groundnut farms separately for Kharif and rabi seasons and to identitfy the technological and socio-economic constraints responsible for these yield gaps in Warangal district of Andhra Pradesh.

The concepts of yield gaps used are:

Gap I : Between Research Station and Demonstration farms.
Gap II : Between demonstration farms and progressive farms.
Gap III : Between Research Station farm and progressive farms.
Gap IV : Between progressive farms and average sampled farms.
Gap V : Between Research Station and the Average yield realised by farmers.

The data relates to the year 1985-86 and covers 148 farms of different sizes namely small, medium and large besides 26 demonstration plots and 27 progressive farms.

The exponential function of Cobb-Douglas type is employed to measure the contribution of Bullock labour, seed Cost, Pesticide cost, Nitrogen, Phosphorus and Technology index to yield gap. The yield gaps are conspicuous in Kharif season in relative terms, while they are more conspicuous in rabi absolute terms. It is observed that Technology, Seed, Pesticides, Bullock Labour, Nitrogen and Phosphorus are the most important factors explaining yield gap in the order of mention.

The regression coefficient of technology index is negative implying that the increased adoption of improved technology reduces the yield gap.

The reasons attributed by the farmers for the yield gaps are incidence of pests and diseases, lack of own funds, high cost of inputs, lack of timely supply of these inputs and rainfall. It is suggested that more demonstrations, subsidised supply of inputs, timely supply of inputs, credit facilities, technical know how and marketing facilities help in reducing this gap.

Key words Yield gap, Cobb-Douglas function, Technology Index, Socio-economic constraints, Regression Coefficient, Demonstration farm, Research Station Farm, Progressive farm, pooled farm, large farms, medium farms, small farms.

INTRODUCTION

There is a saying that research efforts are to be concentrated on identifying the farmers who are left behind, providing explanation for their lagging behind and setting forth what should be done to help them. Any attempt to understand the basic problems in the adoption of recommended technology package assumes special significance. This step needs a scientific evaluation of the extent of yield gap, the causes and constraints thereof. The present study is undertaken to assess yield gaps on groundnut farms when compared to those of research stations, demonstration plots and progressive farms and identify technological as well as socio-economic constraints responsible for yield gap in groundnut in Warangal district in Andhra Pradesh.

MATERIALS AND METHODS

Groundnut which occupies about 25 per cent of total cultivated area in Warangal district (1985-86) is grown in Torrur and Wardhannapet mandals in both the seasons. Four villages namely Torrur, Hariparala, Ellendu, and Wardhannapet are selected from these two mandals based on the probability proportional to area under the crop. A stratified random sample of 148 farmers comprising of 52 farmers for Kharif season and 96 farmers for rabi season was drawn from the selected villages. Out of 52 farms in Kharif, there are 21 small farms (less than 2 hectares), 17 medium farms (2 to 4 hectares) and 14 large farms (More than 4 hectares). 39 small farms, 35 medium farms and 22 large farms are selected for study during rabi season. Besides, 13 demonstration plots in each season, 13 progressive farm in Kharif and 14 in rabi are also considered. The data required is collected for the period 1985-86, through a pre-tested questionnaire using survey method. Yield gaps were studied earlier by employing three gap model (Swaminathan, 1977; International Rice Agro-economic Net work, 1978 and four gap model (Venkateswarlu, 1978; Suryanarayana, 1980). The present study employs five gap model. The following concepts of yield gaps are used in the study.

Gap I : The difference between the yields obtained in Research Station Farm and Demonstration Farms.

Gap II : The difference between yield obtained on demonstration plots and that obtained on progressive farms.

Gap III : The difference in yield obtained on Research Station and that obtained on progressive farms.

Gap IV : The difference between yield obtained by the progressive farms and average yield realised by sample farms.

Gap V : The difference in the yield on Research Station and the average yield realised by the farms.

The yield gap is the cumulative effect of biological and Socio-economic factors. Because of the data limitations in socio-economic factors, the functional analysis was restricted to examine the contribution of only biological factors to the yield gap.

The model specified is as follows:

$$Y = a\ B^{b1}\ S^{b2}\ P^{b3}\ N^{b4}\ PS^{b5}\ TI^{b6}\ u$$

Y = Yield gap in Kilograms

B = Gap in bullock labour in pair days

S = Gap in seed cost in Rupees.

P = Gap in Pesticide cost in Rupees.

N = Gap in nitrogen in Kilograms.

PS = Gap in Phosphorus in Kilograms.

TI = Technology Index

a = Intercept

$b_1 \ldots b_6$ = are partial regression coefficients

u = Error term.

The constraint analysis was based on the opinion survey of the farmers.

RESULTS AND DISCUSSION

It is observed that the yield obtained in Rabi season was more than double the yield in Kharif season. The yields per unit area obtained on different farms in both the seasons are presented in Table 1. From a comparison of the yields, it is inferred that small farms recorded the lowest and the research station farm at Warangal recorded the highest in both the seasons.

TABLE I. Yields obtained on different farms in kharif and rabi seasons (1985-86)

Sl. No.	Farm	Kharif Qts/ha	Rabi Qts/ha
1.	Research Station Farm at Warangal	12.00	29.50
2.	Demonstration Plots	7.25	25.00
3.	Progressive Farms	6.00	21.50
4.	Small farms	3.50	13.50
5.	Medium Farms	4.00	16.50
6.	Large farms	5.50	18.50
	Pooled Farms	4.33	16.17

The yield gaps between different farms are presented in Table II. It can be inferred that the gaps were more conspicuous in rabi season compared to that of Kharif. The yield gaps range from 0.50 to 8.50 quintals per hectare in Kharif and 3.50 to 16.00

quintals per hectare in rabi season. The maxima and minima occur in Gap IV and Gap V in Kharif and Gap III and Gap V in Rabi.

TABLE II. Yield gaps between different farms in kharif and rabi (1985-86)

Sl. No.	Yield gaps	Kharif Qts/ha	Rabi Qts/ha
1.	*GAP I*		
	Research Station vs Demonstration Plots	4.75	4.50
2.	*GAP II*		
	Demonstration Plots vs Progressive Farms	1.25	3.50
3.	*GAP III*		
	Research Station Farm vs Progressive Farms	6.00	8.00
4.	*GAP IV*		
	a) Progressive Farms vs Large Farms	0.50	3.00
	b) Progressive Farms vs Medium Farms	2.00	5.00
	c) Progressive Farms vs Small Farms	2.50	8.00
	d) Progressive Farms vs Pooled Farms	1.67	5.33
5.	*GAP V*		
	a) Research Station Farm vs Large Farms	6.50	11.00
	b) Research Station Farm vs Medium Farms	8.00	13.00
	c) Research Station Farm vs Small Farms	8.50	16.00
	d) Research Station Farm vs Pooled Farms	7.67	13.33

Functional analysis was employed to know the factors contributing to the gap in yield. It may be mentioned here that the functional analysis is not complementary to the tabular analysis. As pointed out earlier, the functional analysis was restricted to examine the contribution of only biological factors. The estimated functions for different yield gaps in kharif and rabi seasons are presented in Table III.

TABLE III. Estimated functions for different yield gaps in kharif and rabi seasons

Particulars			Estimated function						
						KHARIF SEASON			
Gap I			Y =4.6431 R^2 =0.6528	B0.2457 n = 13	S0.3289	P0.5836*	N0.2286	PS0.2634	T-0.6473*
Gap II			Y =5.6216 R^2 =0.4875	B0.1384 n = 13	S0.8126	P0.0089	N0.0326	PS0.0636	T-0.0784
Gap III			Y =5.8347 R^2 =0.6286	B0.2383 n = 13	S0.2953	P0.6576***	N0.2471	PS0.3246	T-0.6687***
Gap IV	a)	Small farms	Y =5.0862 R^2 =0.6436	B0.4607*** n = 21	S0.5278***	P0.0026	N0.1176	PS0.1483	T-0.1736
	b)	Medium farms	Y =2.1860 R^2 =0.5634	B0.3829 n = 17	S0.5982***	P0.0082	N0.1128	PS0.1236	T-0.1364
	c)	Large farms	Y =2.6937 R^2 =0.5634	B0.1826 n = 17	S0.4926	P0.0062	N0.2086	PS0.2534	T-0.1426
	d)	Pooled farms	Y =5.5049 R^2 =0.6762	B0.3357** n = 54	S0.4981***	P0.0006	N0.2629	PS0.0746	T-0.1577
Gap V	a)	Small farms	Y =1.8987 R2 =0.8891	B0.4662* n = 21	S0.6284***	P0.8123***	N0.0157	PS0.0862	T-0.8939***
	b)	Medium farms	T =0.4896 R2 =0.6559	B0.2267 n = 17	S0.5409**	P0.6436***	N0.1678	PS0.1678	T-0.6529***
	c)	Large farms	Y =3.6672 R2 =0.7467	B0.1918 n = 14	S0.3325*	P0.6672***	N0.1431	PS0.2628	T-0.5801***
	d)	Pooled farms	Y = 6263 R2 =0.9681	B0.2646* n = 52	S0.3989**	P0.5969**	N0.0113	PS0.3672**	T-0.6278***
						RABI SEASON			
Gap I			Y =4.9198 R2 =0.5716	B0.1508 n = 13	S0.3934***	P0.1433	N0.0946	PS0.1509	T-0.0463
Gap II			Y =3.8589 R2 =0.4975	B0.8121 n = 14	S0.2623	P0.3439*	N0.1785	PS0.1613	T-0.2648
Gap III			Y =0.8508 R2 =0.5946	B0.1805 n = 14	S0.3935***	P0.3187*	N0.1605	PS0.1909	T-0.2678
Gap IV	a)	Small farms	Y =0.9263 R2 =0.7826	B0.0986 n = 39	S0.3683**	P0.4234	N0.0486	PS0.3326**	T-0.1386
	b)	Medium farms	Y =1.8274 R2 =0.6286	B0.0367 n = 35	S0.4986***	P0.5635***	N0.0144	PS0.1227	T-0.1286
	c)	Large farms	Y =1.5445 R2 =0.6135	B0.0732 n = 22	S0.0732	P0.3126*	N0.0227	PS0.1246	T-0.1182
	d)	Pooled farms	Y =0.5407 R2 =0.7798	B0.2389*** n = 96	S0.2736***	P0.3189***	N0.0386	PS0.2436***	T-0.1126
Gap V	a)	Small farms	Y =0.2643 R2 =0.9749	B0.2978* n = 39	S0.4826**	P0.5984***	N0.0262	PS0.3426*	T-0.6183***

Particulars		Estimated function						
b)	Medium farms	Y =2.3002 R2 =0.6936	B0.1262 n= 35	S0.6096*** —	P0.6128***	N0.0974	PS0.2316	T-0.5639***
c)	Large farms	Y =5.1670 R2 =0.7134	B0.1059 n = 22	S0.4386**	P0.5123***	N0.0856	PS0.2323	T-0.3731***
d)	Pooled farms	Y =0.7885 R2 =0.7628	B0.2136** n = 96	S0.2986***	P0.3189***	N0.2286***	PS0.2686***	T-0.3086***

Note : * indicates significance at 10 per cent level

** indicates significance at 5 per cent level

*** indicates significance at 1 per cent level

Kharif Season:

The functional analysis reveals that bullock labour (Gap V Small and Pooled farms), Seed (Gap II, Gap IV and Gap V), Pesticides (Gap I, Gap III and Gap IV) and Technology (Gap I, Gap III and Gap IV) are the most important factors influencing yield gap in kharif season. Nitrogen and Phosphorus applications have not contributed to the yield gaps. Technology has a negative effect on yield gap implying that the yield gap will be reduced with the increased adoption of technology on all farming situations. But, in case of Gap IV, it was not statistically significant which means that the level of technology adopted by progressive and average farms are same. The results reveal that one per cent increase in bullock labour in pair result in 0.38 per cent and 0.34 per cent increase in yield gap on small and pooled farms respectively in case of Gap IV while it results in 0.47 per cent and 0.26 per cent increase in yield gap on small and pooled farms respectively in case of Gap V. One per cent change in seed cost is accompanied by 0.33 to 0.81 per cent change in yield gap on different category of farms (Gap II, Gap IV and Gap V). One per cent change in Pesticide use is accompanied by 0.58 to 0.81 per cent change in yield gap (Gap I, Gap III, IV and V) while this range varies from 0.65 to 0.89 in case of technology.

Rabi Season:

By and large, similar trend is observed here also. One per cent increase in bullock labour results in 0.21 to 0.30 per cent increase in yield gap, while the gap ranges from 0.28 to 0.64 per cent due to one per cent increase in seed. Similarly, one per cent increase in pesticides result in an increase of 0.32 to 0.61 per cent increase in yield gap. Nitrogen explains variation in yield gap significantly only in case of Gap V and pooled farms to a tune of about 0.32 per cent for every one per cent increase in it. Phosphorus explains variation in yield gap on small and pooled farms only (Gap IV and Gap V). As expected technology has a negative sign implying that the adoption of improved technology reduces the yield gap. It explains the variation in yields significantly only in case of Gap V. This implies that the average farmer does not apply all the recommended package of practices in case of rabi groundnut.

Thus, technology, seed, pesticides, bullock labour, nitrogen and phosphorus explain variation in yield of groundnut on different farms when compared to research station and progressive farms in the order of mention.

It may be mentioned that the technology index is negatively correlated with other independent variables also. The simple correlation coefficients between the independent variables indicated the presence of multicollinearity, that they are not serious enough to alter the results presented. Due to limitation of space, they are not being reported.

CONSTRAINT ANALYSIS IN THE PRODUCTION OF GROUNDNUT ON FARMERS FIELD

The opinion survey formed the basis for the constraint analysis. Thus, the generalizations are the feedback of the farmers engaged in groundnut farming in the region.

1) Adoption of High Yielding Varieties

It is seen that only six farmers are using high yielding varieties out of 96 sampled farms. The reasons for non-adoption of high yielding varieties are presented in Table IV

In kharif season about 56% of the farmers explained the major reason for non-adoption of high yielding varieties as continued crop failure. Kharif groundnut was mainly rainfed. Due to continuous drought conditions during the last four years there was no encouragement for the farmers to take up high yielding varieties. Risk proneness indicated by about 21 per cent of sampled farms and non-availability in proper time by about 23 per cent of sampled farms are the other reasons expressed for non-adoption of improved varieties. In rabi groundnut the major reasons attributed by farmers are non-availability in time (expressed by 30 per cent of samples farms) and risk proneness (expressed by 29 per cent of sampled farms). The other reasons are lack of awareness, low price for the produce and high cost of seed.

2) Adoption of fertilizer schedules

In case of Kharif, 69 per cent did not want to apply due to continuous crop failure, as kharif crop is always being hit by drought while 31 per cent did not have proper knowledge about adoption of fertilizer schedule.

In rabi season, the major constraint explained by the farmers is non-availability in time (expressed by 33 per cent of sampled farms). While 17 per cent expressed lack of awareness about fertilizer schedule, about 13 per cent expressed shortage of own capital. High cost of seed (expressed by 10 per cent of samples farms), lack of credit facilities (expressed by 10 per cent of sampled farms) risk proneness and lack of local availability (expressed by about 8 per cent of sampled farms) are other reasons

In case of small farmers the main reasons are lack of knowledge, continuous

TABLE IV. Reasons for non adoption of high yielding varieties

Sl. No.	Reasons	Kharif				Rabi			
		Small	Medium	Large	Pooled	Small	Medium	Large	Pooled
1.	Lack of awareness	—	—	—	—	12	6	—	18 (18.75)
2.	High cost of seed	—	—	—	—	—	5	—	5 (5.21)
3.	Risk proneness	6	3	2	11 (21.15)	20	6	2	28 (29.17)
4.	Non-availability time	—	4	8	12 (23.07)	7	10	12	29 (30.21)
5.	Susceptible to pests and diseases	—	—	—	—	—	—	—	—
6.	Continued crop failure	15	10	4	29 (55.77)	—	—	—	—
7.	Low price	—	—	—	—	—	8	8	16 (16.67)

(*Note* : Figures in parentheses indicate percentage to total)

crop failure, shortage of own funds and lack of availability in time in the order mentioned. The major constraint attributed by large farmers is lack of availability in time. The reasons expressed by medium farmers are lack of knowledge, continuous crop failure, high prices of fertilizers and non-availability in time.

3) Adoption of Plant Protection Measures:

In case of Kharif, the main reason is that most of the farmers do not want to take risk due to continuous failure of crop 34 farmers (65.38%) attributed risk proneness, while 18 farmers (34.62–%) indicated lack of awareness.

In rabi season 22 farmers (22.92%) attributed the reason being lack of awareness and high cost of pesticide, about 15 farmers (16%) to lack of own funds about 8 farmers (8%) expressed traditional belief and lack of technical guidance and about 6 farmers (6–%) expressed lack of availability locally.

The major constraints for small, medium and large farmers were lack of awareness and risk proneness.

Thus, the reasons attributed by farmers for yield gap are summarised in Table V.

In case of kharif, the major reason for yield gap is the amount of rainfall received. The constraint analysis revealed that 22 farmers (42.31%) felt inadequate rainfall, 15 farmers (28.35%) expressed incidence of pests and 8 farmers (15.38%) felt high cost of inputs as the reasons for the yield gaps.

In case of rabi the major reason for yield gap is incidence of pests. The results revealed that 20 farmers (20.83%) attributed the yield gap to incidence of pests, 15 farmers (15.63%) to high cost of inputs, 12 farmers (12.5%) expressed non-availability of inputs in time, 10 farmers (10.42%) expressed lack of own funds 12 farmers (12.5%) indicated non-availability locally and 10 farmers (10.42%) opined lack of credit facilities.

Sankar Reddy and Adivi Reddy (1979) identified the input constraints in groundnut production such as improved varieties, seed selection, seed treatments, increasing seed rate, application of fertilizers and adoption of plant protection measures for the low yield in groundnut crop in Mahaboobnagar, Guntur and Srikakulam districts of Andhra Pradesh.

SUGGESTIONS FOR REDUCING THE GAP

The suggestions reported here are based on the opinion survey of farmers. A good majority of the farmers want subsidised supply of inputs as it is the first suggestion by about 72 per cent of sampled farmers. This impression is more in case of small farmers. The inputs like seed, fertilizers and pesticides etc., are essential in agricultural production which are not adequately available. Besides, the prices are high in

TABLE V. Reasons identiffed by the selected farmers for the yield gap

Sl. No.	Reasons/constraints	Kharif	Rabi
I.	BIOLOGICAL		
	a) Variety	—	—
	b) Weed infestation	—	—
	c) Incidence of pests	15 (28.85)	20 (20.83)
	d) Incidence of diseases	3 (5.77)	6 (6.25)
	e) Irrigation water management	—	—
	f) Amount of rainfall received	22 (42.31)	—
	g) Soil fertility variation	—	2 (2.08)
II.	SOCIO ECONOMIC AND TECHNICAL CONSTRAINTS		
	a) Lack of own funds	4 (7.69)	10 (10.42)
	b) Lack of credit facilities	—	10 (10.42)
	c) Traditional belief	—	3 (3.13)
	d) High cost of inputs	8 (15.38)	15 (15.63)
	e) Lack of knowledge about technology	—	6 (6.25)
	f) Non-availability of inputs in time	—	12 (12.5)
	g) Non-availability locally	—	12 (12.5)

(*Note :* Figures in parentheses indicate percentage to the total number of respondents).

input markets. Thus, many farmers are not applying fertilizers and pesticides to ground nut crop.

Availability of credit is next in importance suggested by about 70 per cent of the sampled farmers. The feeling is more in case of small farmers. Short term credit is very essential especially to small and medium farmers to adopt the latest technology like application of adequate fertilizers and adopting suitable plant protection measures.

Timely supply of inputs is another issue suggested by about 64 per cent of sam-

TABLE VI. Suggestions for reducing the gap

Sl. No.	Suggestions	Number of farmers			
		Small	Medium	Large	Pooled
1.	More demonstrations	15 (25.00)	27 (51.92)	30 (83.30)	**72** (48.65)
2.	Subsidised supply of inputs like seeds fertilizers and pesticides	47 (78.33)	34 (65.38)	25 (69.44)	106 (71.62)
3.	Timely supply of inputs	33 (55.00)	32 (61.53)	29 (80.55)	94 (63.51)
4.	Availability of crop production and marketing credit	54 (90.00)	**36** (69.23)	20 (55.55)	**104** (70.27)
5.	Availability of technical help in greater degree.	33 (55.00)	30 (57.69)	21 (58.33)	84 (56.76)
6.	Organisation of the marketing the produce	28 (46.66)	16 (30.77)	9 (25.00)	53 (35.81)

(*Note* : Figures in parentheses are percentages to total number of respondents in each category).

pled farmers. This feeling is more with large farmers. The delay in availability of inputs causes delay in agricultural operations which in turn reduces the yield.

It also suggested that strengthening and streamlining the existing extension services helps in achieving higher productivity. There is an extension gap contributing to the existing yield gap. Adequate extension staff at field level to make farmers more aware of latest technology is another suggestion put forth by 57 per cent of sampled farmers.

More demonstartions is suggested by about 49 per cent of sampled farmers since there are hardly any demonstrations in the area. If more demonstrations are organised on scientific lines more farmers will be convinced to adopt the latest technology which is a pre-requisite for higher productivity.

The produce must be marketed to assure a remunerative price to farmers. Organising the marketing of produce is another suggestion putforth by about 36 per cent of sampled farmers and there is a need to eradicate the present irregularities in marketing system.

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SHORT COMMUNICATION

A NOTE ON GERMPLASM COLLECTIONS IN SUNFLOWER

K. VIRUPAKSHAPPA AND S.S. SINDAGI
Project Co-ordinating unit (sunflower) U.A.S., GKVK, Bangalore-560 065

The importance of germplasm collections in breeding of sunflower (*Helianthus annuus L.*) needs no emphasis. The work on collection, evaluation and maintenance of sunflower germplasm is taken up in the Project Co-ordinating Unit (Sunflower) at GKVK, UAS, Bangalore.

At present, 657 collections are maintained at this centre. These collections include 602 populations, 14 CMS lines, 14 maintainer lines, 11 restorers and 13 wild species and 3 wild types.

During 1984 highest number of collections (88) were obtained through FAO, Rome. Other countries from where the populations were received are Hungary, Turkey, USA, USSR, Israel, Netherlands and East Germany. The CMS lines have been obtained from USA (12) and Canada (2). The restorers were received from USA (8) and Canada (2) and also one was from India. Twelve wild species were obtained from USA and one was from India. Two wild types were collected in India (North India) and one was from East Germany (*Helianthus annuus* ssp *lenticularis*). These wild species have useful attributes which can be incorporated into the cultivated forms (Dragan Scoric, 1981).

Maintenance and Evaluation of Collections

A total of 538 collections were sown during *kharif* 1984 in a **Randomised Complete** Block Design with two replications under rainfed conditions.

The populations were maintained by sib mating. About 15-20 plants were bagged in each line and sib pollinated at the time of flowering. The plants used for sib mating were excluded from recording the data.

Data were recorded on yield, yield components and oil content. The germplasm was also scored for resistance to rust (*Puccinia helianthi*) and leaf spot (*Alternaria helianthi*). Screening was done on a scale of 0 to 5. The plants without any infection were given 'O' and those with maximum infestation were assigned 5.

Mean and Variance

The range, mean, variance and coefficient of variation were computed using the the data. The range with respect to height was 50.0 to 187.0 cm with a mean of 121.7 cm. For head diameter the range was 5.30 to 15.38 cm with a mean of 9.82 cm. There was a wide variability for seed yield ranging from 4.15 to 40.63 g/plant. The mean for

100 seed weight was 4.15 g with a range of 2.50 to 6.64 g. Oil content in the collections ranged from 23.8 to 42.4 with a mean of 32.74 percent. The low oil content in the collections may be due to drought spell during seed filling.

The coefficient of variation was highest for seed yield (39.13%) followed by height (16.56%), 100 seed weight (15.89%), head diameter (14.67%) and oil content (10.17%).

Promising germplasm for different characters and disease resistance

Based on the evaluation of the collections during *Kharif* 1984, the promising ones have been identified for different characters (Table 1). It is observed that in the germplasm there are collections resistant to rust and they include populations, CMS lines, restorers and wild types. However, studies are underway to screen these accessions under artificial inoculation. For *Alternaria helianthi* only tolerant types are available. For yield *per se*, No. 64, 135, 144 and 113 are promising. The types with high oil content are No.88B, 95, 190, 309, 391 and 516. The earliest types are Co-1 (65-70 days) and S-55 (75 days).

Concerted efforts are being made to augment the germplasm collections.

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TABLE 1 Promising Germplasm for Different Characters

Character	Lines	Value/Score
1. **Resistance**		
a) Rust	No. 512, 602, 603, 414, CMS 207, CMS 338, RHA-273, 274, 298, 299, 265, 586, Inbred No.3 and 29	0 (No infection)
b) *Alternaria*	No.414, 512, CMS 291, RHA-299	1.0–2.0
2. **Height**		
a) Dwarf	No.414 (50 cm), 454 (80 cm), 453 (85 cm)	50–85 cm
b) Tall	No.282, 336, 341, 423, 427	150–187 cm
3. Earliness	Co–1, S-55	65–80 days
4. Oil content (%)	No. 88B, 95, 190, 309, 391, 516	39.7–42.4
5. Yield (g/plant)	No.64, 135, 144, 113	30–40 g

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MULTIVARIATE ANALYSIS OF DIVERGENCE, ITS RELATION WITH HETEROSIS IN INDIAN MUSTARD

H.L. THAKUR, N.D. RANA AND O.P. SOOD
Oilseeds Research Station, Kangra-176 001 (H.P.)

ABSTRACT

Brassica juncea L. (Czern and Coss) from eight states were subjected to multivariate analysis to assess the magnitude of genetic divergence. Based on 10 characteters, the 44 varieties were grouped into 11 clusters. The distribution of genotypes in different groups from various regions did not follow any consistent patterns in relation to geographic diversity. Secondary branches/plant, pods/plant and 100-seed weight were the major components in differentiation among the genotypes. Heterosis of greater magnitude was shown by the crosses among the genotypes of low genetic distance and low inter-cluster genetic divergence, but higher cluster means for seed yield. There was no correspondance between the divergence of parents in crosses, divergence between clusters to which the parents belonged and the heterosis exhibited by hybrid combinations.

Key words Genetic divergence; Heterosis; Indian mustard; *Brassica juncea*

INTRODUCTION

The importance of genetic diversity has long been appreciated by breeders. Several workers (Miller and Masani, 1963; Peter and Rai, 1976; Narsinghani *et al.*, 1978) heve successfully made use of genetic divergence for selection of parents in different crop species. During the present times when varieties are exchanged more frequently from one part of the country to the other, the actual geographic origin may not be known to the breeder concerned. Even if the geographic diversity known it is not always the indicator of genetic diversity. The present investigation was aimed at assesing the genetic divergence, its relationship with heterosis among 44 varieties of Indian mustard.

MATERIAL AND METHODS

Forty four varieties of Indian mustard (*Brassica juncea L.* Czern and Coss) were selected on the basis of yield and other agronomic attributes from eight states of India, viz., Punjab, Haryana, Himachal Pradesh, Delhi, U.P., M.P. Bihar and West Bengal. These were grown in a randomized block design with three replications during 1983-84. The plot size consisted of 5 rows of 5 m length spaced 30 cm apart. Data were recorded on randomly selected 5 competent plants in each plot in respect of seed yield/plot (g), seed yield/plant (g), days to maturity, plant height (cm), primary branches/plant, secondary branches/plant, pods/plant, seeds/pod, 100-seed weight (g) and oil content (%). The data were subjected to D^2 and canonical analysis as suggested by Rao (1952).

Intra-and inter-cluster crosses were attempted the following year taking parents with higher yield *per se*. Twenty four crosses and the parents were raised in a complete randomised block design with three replications. The plot size was a single row of 3 m length spaced 30 cm apart and plant to plant distance within the row as 10 cm. Single

plant yield (g) based on randomly selected 5 competent plants was recorded. Heterosis over the mid and better parent values was computed to see its relationship with genetic divergence.

RESULTS AND DISCUSSIONS

The analysis of variance revealed significant differences among the genotypes for all the characters under study (Table 1). Wilk's criterion also revealed significant differences among varieties for aggregate of all characters indicationg that genotypes also differed significantly from each other when all the characters were considered simultaneously.

D^2 values computed for all possible pairs of varieties ranged from 5.33 (28.29) to 696.10 (3.6). All the entries could be grouped into eleven clusters (Table 2). Of 44 genotypes, 14 were grouped in cluster I, 12 in cluster II, three each in cluster III, IV and V, 2 each in cluster VI, VII, and VIII and one each in cluster IX, X and XI. The group constellation obtained and by D^2 analysis could also be confirmed by canonical analysis. The little discrepancy in the relative disposition of genotypes in the chart as compared to D^2 analysis, could possibly be due to the fact that first two canonical roots accounted for only 78% of total variation. In order to get clear cut two dimentional representation, contribution of first two roots should be more than 95 percent.

No regular geographical demarcation was discerncable from the clustering pattern of the genotypes (Table 2). Varieties belonging to the same state were found to be distributed in more than one cluster and *vice-versa*. Genotypes from Uttar Pradesh have fallen in five different clusters and cluster I consisted of varieties from five states. It may, therefore, be concluded that varieties from the same state of geographic region might have different genetic background as well as wide divergence in features and adaptability. These results are also in agreement with the findings of Bhatt (1970), who concluded that genetic drift and selection could cause greater diversity than genographic distances. Therefore, selection of parents for crossing programme should be based on genetic diversity rather than geographic diversity. Substantial genetic diversity may be found at a location specially when conditions differ widely and specific genotypes are for specific conditions. Clausen and Hiesey (1958) observed that even a single environmental component could cause diffrrences between and within the races. The material for the present study. included highly selected strains from different eco-geographical regions. The nature of selection forces operating under one eco-geographical regions were grouped in different clusters indicating the presence of sufficient genetic variability within themselves. The results thus showed that geographic diversity need not be related to genetic diversity (Murthy and Arunachalam, 1966; Murty and Quadry, 1966)

The magintude of intra- and inter-cluster D^2 values, except for a few combinations, are not very high, indicating intermediate genetic variability in the material (Table 3). This could possibly be due to the fact that raya cultivation in India is not very old and forces of natural and human selection have not yet played enough role in altering the genetic architecture of the prevalent genotypes. The magnitude of intra-cluster

TABLE 1 Analysis of variance involving 44 genotypes for ten characters.

Source	D.F.	Mean squares									
		Seed yield/ plot	Seed yield/ plant	Days to maturity	Plant height	Primary branches plant	Secondary branches/ plant	Pods/ plant	Seeds/ pod	100-seed weight	Oil ancontent
Genotypes	43	52.07**	0.77*	19.11**	251.35**	13.08**	13.99**	1995.4**	3.91**	1.35**	2.27**
Error	86	28.45	0.39	2.70	89.02	0.42	0.95	141.7	1.06	0.14	0.32

* Significant at P = 0.005

** Significant at P = 0.01

TABLE 2 Distribution of 44 genotypes of Indian mutsard in different clusters

Cluster No.	No. of genotypes/ cluster	Name of genotype	Geographic orgin
I	14	Bharatpur-1, Ferozpur-2, RLM-39, RLM-78, RLM-269, RC-530, R 71-2, R 75-2, RH-73, RL-18, RL-70, RNS-1, RNS-14, F 29/22	Uttar Pradesh, Punjab, Madhya Pradesh Delhi, Bihar, Haryana.
II	12	Kesari-4, Hodel-2, Gonda-3, Raya-10, RC-4, RK-10, RLM-134, RS-18, RNS-5, No. 751-62, IB 499-1.	Uttar Pradesh, Him.chal Pradesh, Punjab, Bihar gelhi.
III	3	Varuna, Karanti, pant-18	Uttar Pradesh
IV	3	RC 14-1, RC 15-2, RC 7-4	Himachal Pradesh
V	3	Fer9zpur Tripa-1, RH 75-1, RLM-193	Punjab, Haryana
VI	2	RH-29, No. 5506	Punjab, Haryana
VII	2	Kanpur-2, No. 5422	Uttar Pradesh, Punjab
VIII	2	Gonda-8, RC-12	Uttar Pradesh, Haryana
IX	1	Berhampore	West Bengal
X	1	RH-761	Haryana
XI	1	RLM-198	Punjab

TABLE 3 Intra-and Inter-cluster average D2 value among 11 clusters comprising 44 varieties of *Brassica juncea* L.

Cluster	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
I	31.26	78.49	104.49	82.45	46.03	150.25	73.25	195.16	292.44	95.46	58.46
II		30.08	281.60	141.31	144.11	62.44	45.71	69.44	121.42	73.19	143.49
III			19.44	136.92	67.52	409.76	258.55	513.05	640.55	288.08	79.54
IV				33.54	123.41	264.11	193.75	277.64	390.12	109.63	51.66
					33.82	248.98	106.99	305.32	437.47	152.73	89.75
						22.16	74.93	80.11	48.11	168.88	246.95
							35.06	98.61	156.59	110.12	168.28
								30.37	85.70	111.49	324.92
										298.75	392.70
										—	196.36

D^2 values, ranging from 0.00 (cluster X and XI) to 35.0 (cluster VII), is suggestive of the extent of genetic diversity among cultivars of the same cluster. The minimum inter-cluster distance was observed between cluster II and III (45.71), the remaining cluster combinations having intermediate to high divergence.

The dispersion matrix used for D^2 analysis was also used for canonical analysis. The first canonical root (X_2) accounted for 64.8% and second root (X_2) for 13.15% of the total variation (Table 4). The coefficient of first two canonical vectors Z_1 and Z_2 indicated that secondary branches/plant, pods/plant, 100-seed weight, oil content (%) and seeds/pod constituted the major axis of differentiation. Days to maturity, plant height and seed yield/plant constituted the second axis of differentiation and appear to have contributed towards total genetic divergence through natural and human selection.

TABLE 4 Canonical analysis of differentiation in 44 varieties of Indian mustard

Characters	Vectors	
	Z1	Z2
Seed yield/plot	0.021	0.095
Seed yield/plant	-0.017	0.149
Days to maturity	-0.040	0.017
Plant height	-0.099	0.017
Prinam branches/plant	-0.041	0.021
Secondary branches/plant	-0.045	0.736
Pods/plant	-0.011	0.605
Seeds/pod	0.007	0.061
1,000-seed weight	0.988	0.015
Oil content	0.091	0.204

Firts four canonical roots. 1=64.85%
2=13.15%
3= 8.44%
4= 5.32%

Total =91.76%

The mean performance of each cluster for all the characters is presented in Table 5. The genotypes of cluster VIII showed the highest mean values for seed yield/plant, days to maturity and primary branches/plant and cluster X was characterised by the highest values for secondary branches/plant and oil content but had the lowest plot yield. Similarly RLM 198 of cluster XI had the highest mean values for seeds/pod and

TABLE 5 Mean values of eleven clusters for ten characters in *B. juncea* L.

Cluster No.	No. of entries/ cluster	Seed yield/ plot (g)	Seed yield/ plant (g)	Days to maturity	Plant height (cm)	Primary branches/ plant	Secondary branches plant	Pods/ plant	Seeds/ pod	1000-seed weight (g)	Oil content (%)
I	14	40.71	3.27	153.99	177.78	4.67	7.92	160.48	12.88	3.71	41.30
II	12	40.05	3 42	154.86	182.38	4.98	8.23	172.42	12.92	2.92	41.69
III	3	41.73	3.50	151.55	155.67	3.90*	6.98	148.00	13.43	4.69**	41.50
IV	3	46.34**	3.76	152.89	172.91	4.62	11.44	223.11**	3.89	13.92	41 9'
V	3	38.45	2.70	157.33	173.13	4.34	5.61	143.33	11.33	4.02	42.18
VI	2	37.65	3.00	150.60*	183.03	4.30	6.27	161.16	14.10	2.56	45.98*
VII	2	41.78	2.53*	157.17	185.57	4.90	6.18	138.83*	12.05	3.00	41.75
VIII	2	43.80	4.17**	157.50**	178.38	5.46**	10.78	169.00	13.22	2.22	41.68
IX	1	38.47	3.40	151.00	184.47	4.07	5.30*	178.00	12.00	8 91*	40.67
X	1	34.40*	4.00	152.67	167.73	4.87	12.70**	171.33	11.20*	3.21	43.70
XI	1	44.67	3.50	153.33	180.60	5.13	6.50	215.33	13.20**	4.06	41.53

*= Minumum value
**= Maximum value

TABLE 6 Hetrosis (mid and better parent) and genetic divergence with respect to hybrid for seed yield.

Cross	Clusters	Heterosis over		D2 value	
		Mid parent	Better parent	Between cluster	Between parent
I. Intercluster crosses					
(*a*) *Between low divergent clusters*					
RLM 198 × RC 7-4	XI and IV	57.4	46.6	51.7	64.0
RLM 198 × RNS-14	XI and I	51.2	–46.6	58.5	96.4
Ferozpur-1 × Ferozpur Tripa-I	I and V	–10.6	–21.6	46.0	48.9
RC 530 × RH 75-I	I and V	–57.9	–22.6	46.0	35.5
(*b*) *Between medium divergent clusters*					
RH 761 × RC 15-2	X and IV	10.5	4.8	109.6	123.0
Berhampore × Kanpur-3	IX and VII	36.6	7.3	156.6	158.5
Varuna × Kanpur-2	III and VII	66.3	28.0	258.5	294.1
Pant 18 × Kanpur-2	III and VII	43.2	18.5	258.5	316.9
(*c*) *Between highly divergent clusters*					

	Varuna × Berhampore	III and IX	1.0	−5.8	640.5	583.3
	Varuna × RC-12	III and VIII	42.2	21.9	513 0	408.6
	Karanti × RC-12	III and VIII	−1.8	−12.5	513.0	412.7
	Pant 18 × Gonda 8	IX and VIII	−25.7	−40.6	513.0	643.8
	Berhampore × RLM 198	IX and XI	53.0	36.6	424.9	392.7
II.	**Intracluster crosses**					
	RC 530 × F 29/22	I	16.3	14.4	—	**19.7**
	RH 73 × RL 70	I	−2.8	−11.3	—	**14.3**
	Gonda × RNSS	II	−8.4	−13.3	—	**26.8**
	RK 10 × RS 21	II	13.7	−18.1	—	**10.4**
	Raya 10 × No. 751-62	II −29.0	−36.9	—	—	**49.1**
	Varuna × Karanti	III	18.7	17.4	—	**12.8**
	RC 14-1 × RC 15-2	IV	17.8	−1.9	—	**33.6**
	RH 75-1 × RLM-198	V	69.4	29.7	—	**16.2**
	RH 29 × No. 5506	VI	31.9	27.6	—	**22.2**
	Kanpur 2 × No. 5422	VII	60.6	51.0	—	**35.6**
	Gonda-8 × RC-12	VIII	−40.4	−47.3	—	**30.4**

Berhampore of cluster IX had lowest seed index for test weight and secondary branches. The genotypes group in cluster IV had maximum mean values for pods/plant and plot yield, But these genotypes exhibited inter cluster divergence. Theoratically speaking the maximum heterosis will be manifested in the cross combinations involving parents from the most divergent cluster. Howeve:, the objectives of the practical plant breeder is not only to achieve high heterosis but also to get positive transgression in the subsequent generations. The transgression or F_1 heterosis does not always occur when divergent lines are crossed. (Cress, 1966; Matzinger and Wernsman, 1967, Basbice and Rawlings, 1974).

On the basis of divergence (Table 6) maximum heterosis is expected from crosses among parents of cluster III with those of cluster IV exhibiting highest inter-cluster genetic divergence (640.6). However, the cross between Varuna (Cluster III) and Berhampore (Cluster IX) showed only 1% average heterosis and performed poorer than the better parent (–5.8%). Four other crosses *viz.*, Varuna X RC 12, Karanti, RC 12, Pant 18 X Gonda 8 and Berhampore X RLM 198, involving parents from highly divergent cluster, also failed to show adequate amount of heterosis over the best parent except the last one which exhibited a nominal amount of heterosis (36.6%). In general, it was observed that crosses with higher heterosis values did not necessarily possess more genetic distance. Similar results were reported by Singh and Ramanujam (1981), Anand and Murthy (1968), and Yadav *et al.* (1985).

The frequency of heterotic crosses and magnitude of heterosis for yield and its components in groundnut were found higher in crosses between parents of intermediate divergence rather than extreme ones (Arunacchalam *et al.* 1979). In contrast to this crosses involving the parents from intermediately divergent clusters failed to exhibit high heterosis over the mid and better parent except a cross Varuna X Kanpur-2 (58.8%) However, the results were similar to those of Arunachalam *et al.* (1979) for crosses among the parents of low inter-cluster and parental divergence. Lack of association between parental as well as inter-cluster divergence with heterosis exhibited by hybrids may be attributed to the lack of optimum environmental conditions for the expression of heterosis, internal cancellation of the component of heterosis and cancellation due to varied response of the components of multiple characters. Sometimes, even more genetic divergence might itself result in non-realization of expected performance of the hybrids (Yadav *et al.*, 1985). The crosses among the genotypes of cluster IV,VIII and XI, having higher cluster means for seed yield and low inter-cluster/parental divergence, actually exhibited adequate amount of heterosis such as in the case of RLM 198 (XI) X RC 7-4 (IV) which showed much hybrid vigour (46.6%) over the best parents.

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SEPRATION OF OILSEEDS BY PEDAL-CUM-POWER OPERATED AIR SCREEN CLEANER

RAJINDER P. KACHRU AND K.M. SAHAY
Post Harvest Engineering Division, Central Institute of Agricultural Engineering Nabi Bagh, Berasia Road, Bhopal-462 018.

ABSTRACT

Pedal-cum-power operated air screen cleaner earlier developed by the authors for separation of cereals and pulses was adopted/modified to suit the efficient cleaning grading of sunflower, safflower, linseed and mustard seeds. Based on the determination of some physical properties of the oil seeds, machine and operating parameters were identified for their optimum separation. Testing and economic analysis of the data have given satisfactory results and shown that the adopted cleaner is highly bankable from the user's/processor's point of view.

Key words Cleaning, pedal/power operated cleaner, sunflower, safflower, linseed, mustard

INTRODUCTION

Oilseeds (after threshing) generally contain impurities which have to be removed prior to storage, drying and oil expulsion. For cleaning of oil sceds at farm/processor's level, appropriate, medium capacity and low cost cleaners are not available in the market. Kachru et al. (1987) have designed and developed a Pedal-cum-power operated air screen cleaner which was tested for cleaning/grading of major cereals and pulses.

The cleaner consists of two vibrating sieves, a grain hopper and an air blowing unit. The cleaner can be operated either by a pedal or 0.5 hp electric motor. The cleaner is having a provision for interchangability of screens for separating various types of granular products.

The objectives of the study were

i) adopt the pedal-cum-power operated cleaner for oil seeds,

ii) idenitfy scalping and grading sieves for different oil seeds and

iii) make economic analysis for finding the bankability of using the cleaner.

MATERIALS AND METHODS

Threshed samples of sunflower (Mordon), safflower (JSF-1), linseed (T-59) and mustard (Pusa bold) seed stocks produced at CIAE farm, were procured for separation purpose. The samples were analysed for identification and percentage of each foreign matter present in the sample and for the determination of physical properties, viz; size (length, width, thickness/diameter), specific gravity, moisture content and 1,000 grain weight.

Moisture content of cleaned sunflower, safflower, linseed and mustard seed (three replications) were determined by using hot air oven method maintained at 105C° for 72-96 h (Hall, 1957). 1,000 seed weight (10 replications) was determined with the help of an electronic balance (least count: 0.0001 g).

Eight batches of 10 seeds each from 4 cleaned oilseed lots were randomly chosen and the orthogonal dimensions were measured by using dial caliper of 0.01 mm least count. Length/width of the seed was also obtained by measurement of the total length/ width of 10 seeds (randomly chosen) arranged in a line tip to tip/touching along the width or maximum diameter (Wratten et al; 1969). This was then divided by 10 to obtain an average seed length/width.

Liquid displacement method was used for the determination of specific gravity. Specific gravity bottle and toluene (Carbon tetrachloride) were used for this purpose. The specific gravity was calculated with the help of the following expression (Mohsenin 1970).

$$\text{Specific gravity of particle} = \frac{\text{Sp. gr. of toluene} \times \text{wt. of particle}}{\text{wt. of toluene displaced by the particle}}$$

Based on the basic information thus collected, sieve sizes were determined for 2-screen cleaner to achieve optimum separation for the threshed product.

Purity was determined as fraction of clean seed at clean seed outlet in percent Screen effectiveness (also called cleaning efficiency) was calculated by the following expression (IS:5718:1980).

$$\eta = \frac{100 \times E(F-G)\ (E-F)\ (1-G)}{F(E-G)^2\ (1-F)}$$

where,

η = screen effectiveness, %
E = fraction of clean seed at clean seed outlet, decimal
F = fraction of clean seed in feed, decimal
G = fraction of clean seed at foreign matter outlets (combined), decimal

A medium capacity pedal-cum-power operated air screen cleaner earlier designed developed and tested satisfactorily at the Institute for cleaning/grading of major cereals and pulses (Kachru et al; 1987) was tried for the oil seeds.

The cleaner was tested for one major variety of each of sunflower, safflower, linseed and mustard seed, Necessary modifications in the cleaner design were made to acheive effective separation of oil seeds. Economic analysis was also done for cleaning of the said oil seeds.

RESULTS AND DISCUSSION

The physical properties, viz; size (length, width/diameter, thickness), moisture content, 1,000 grain weight and specific gravity of sunflower, safflower, linseed and mustard seed are presented in Table 1. Table 2 gives the recommended sieve sizes to be used in the 2-screen cleaner for the selected oil seeds.

TABLE 1 Some physical properties of oil seeds

Parameter/ property	Oil seed			
	Sunflower	Safflower	Lineed	Mustard
Variety	Morden	TSF-1	T-59	Pusa bold
Size,				
Length, mm	10.59 (12.35, 9.45)*	9.31 (9.75, 8.80)	5.54 (5.70, 5.30)	—
width/dia; mm	4.19 (6.95, 3.10)	4.20 (5.00, 3.00)	2.61** (2.65, 1.50)	2.30 (2.85, 1.50)
thicknes, mm	2.81 (4.65, 1.60)	3.20 (4.50, 1.80)	1.17** (1.24, 0.74)	—
Moisture content, % (db)	9.24	6.95	6.83	8.01
1,000 seed weight, g	42.18	74.77	9.24	7.10
Specific gravity	0.726	1.003	1.083	1.133

* Figures in parenthesis denote max. and min. values, respectively

** at the middle section of seed

TABLE 2 Recommended sieve sizes for two screen cleaners

Seed	Top sieve (scalper)	Bottom sieve (grader)
Sunflower (Morden)*	8.0 mm	3.0 mm
Safflower (TSF-1)	6.5 mm	2 × 20 mm
Linseed (T-59)	1.6 × 20 mm	2.0 mm
Mustard (Pusa bold)	3.1 mm	1.4 mm

* variety

While testing for the cleaning of oil seeds with the Pedal-cum-power operated air screen cleaner, it was felt necessary to make some modifications in the design and operating conditions of the cleaner for effective separation. They were: reduction in air flow rate of blower, increase in height of fall of oil seeds from the hopper (by providing a mechanism for adjusting the vertical and lateral movement of the hopper from the cleaner frame) and shape of screen box at the outer end. This way, the height of the grain column falling from the hopper to the point of separation where it meets the air stream from the blower and the distance from the blower end could be optimised for effective separation of the oil seeds without losing any seed with lighter foreign matter at the blowing end.

The cleaner adopted and modified to suit the oil seeds separation is shown in Fig.1. The machine is made up of mild steel. Separation takes place on the basis of difference in size and weight. Lighter materials are first carried away by air stream. Then separation with two sieves is achieved by difference in size. The seeds from hoper are dropped to top scalping sieve by gravity and controlled by a feeding mechanism. With the help of a blower, air is blown across the falling grain whereby lighter materials are blown away. Larger impurities are retained over the top screen and the under size is separated by the bottom grading sieve. The cleaned and sound seeds are retained over the bottom screen and delivered outside through a spout.

While testing the cleaner for oil seeds, it was observed that the long slender stems, light chaff and bigger/smaller pieces of hull were turning on end and going through the top screen. This could be avoided if it would be flat and slide over. Thus, a sheet of ordinary cloth with ploycthylene lining underneath was drapped over the top screen (Fig.1). By this, long pieces of stem could not turn up on end to go through the round/oblong holes of top screen but would slide down the screen underneath the smooth polyethylene/rough cloth surface and screened over.

The specifications and test results of the cleaner are given in Table 3.

TABLE 3 Test results of Pedal-cum-power operated cleaner* for separation of oil seeds

Parameter	Sunflower	Safflower	Linseed	Mustard
Pedal operated				
Capacity kg/h	280	274	180	507
Purity of the cleaned seed, %	95.8	98.7	98.6	98.6
Screen effectivencss, %	69.9	77.2	72.4	77.5
Power operated				
Capacity, kg/h	345	315	230	584
Purity o; the cleoned seed, %	98.1	98.5	99.1	99.7
Screen effectiveness, %	72.6	65.4	81.4	91.2

* *Specification of cleaner*

Overall dimensions	:	1,900 mm × 820 mm × 1,035 mm
Total weight	:	111.5 kg (without motor)
Power requirement	:	Manual/0.5 hp electric motor

Other machine and operating specifications of Pedal-cum-power operated air screen cleaner used for oil seeds separation are shown in Tables 4 and 5.

Economic analysis for both the cleaners (Pedal and Power operated) has been done for sunflower, safflower, linseed and mustard seed cleaning. A number of parameters, viz; working capital requirement, cost of operation, break-even-point, net profits, return-on-investment and employment generation per unit of capital investment have been found in order to determine the bankability of the equipment. These economic parameters for the cleaner adopted modified have been determined for four different operational conditions, namely; purely custom-based; 50% custom-based and 50% selling; purely selling and for farmers own use (Kachru et al; 1986). The results for pedal operated and oewr operated air screen cleaner have been resented in Tables 6 and 7, respectively.

TABLE 4 Machine and operating parameters for pedal operated air screen cleaner* for oil seeds

Parameter	Seed			
	Sunflower	Safflower	Linseed	Mustard
Screen pitch degree				
Scalper	3.6	3.1	2.8	2.8
grader	4.7	4.3	3.3	3.9
Hopper capacity, kg	22	32	30	34
Length of stroke of sieve box, mm	20	20	20	20
rpm at eccentric unit	160–180	160–180	160–180	160–180
rpm at blower unit	425–480	425–480	425–480	425–480
Air velocity, m/s at:				
blower outlet	4.13	4.13	4.13	4.13
winnowing section	2.80	2.80	2.80	2.80

* Screen dimensions : 750 mm × 430 mm

TABLE 5 Machine and operating parameters for power operated air screen cleaner* for oil seeds

Parameter	Seed			
	Sunflower	Safflower	Linseed	Mustard
Screen pitch, degree				
Scalper	3.6	3.1	2.8	2.8
grader	4.7	4.3	3.3	3.9
Length of stroke of sieve box, mm	20	20	20	20
rpm at eccentric unit	280	280	280	280
rpm at blower unit	745	745	745	745
Air velocity, m/s at:				
blower outlet	5.13	5.13	5.13	5.13
winnowing section	4.50	4.50	4.50	4.50
Input capacity, q/kWh	15.0	13.7	10.0	25.4

* screen dimensions : 750 mm × 430 mm

TABLE 6 Economic analysis for Pedal operated air screen cleaner* for oil seeds

Economic Parameter	*Operational condition*			
	100% custom hire	50% custom hire and 50% sale	100% sale	Self use
Working capital (weighted), Rs	212	46,252	92,297	212
Cost of operation, Rs/q				
Sunflower	3.95	5.05	6.05	3.95
Safflower	4.05	5.15	6.20	4.05
Linseed	7.75	9.95	11.90	7.75
Mustard	2.15	2.80	3.35	2.15
Break-even-point (weighted), q/y	358	61	43	33
Annual net profits, Rs	1,162	18,605	36,113	n.a**
Return-on-investment, %	38	110	118	n.a
Employment generated, mandays/y/Rs. 10,000 of capital investment	196	36	20	n.a

* Cost of equipment : Rs. 3,000/=

** n.a : not applicable

The test results given in Table 3 shows that purity of clean seed and screen effectiveness as high as 98.7% for safflower and 77.5% for mustard can be achieved, respectively using Pedal operated cleaner. Whileas, using power operated cleaner, purity and screen effectiveness is achieved as high as 99.7% and 92.2% respectively for mustard seed. The input capacity varied between 10/kwh for linsced to 25.498/kwh for mustard seed using power operated cleaner (Table 5).

The cost of operation for pedal operated cleaner was calculated as low as Rs. 2.50/q for mustard at 100% custom hire to a maximum as Rs. 11.90/q at 100% at sale for linseed (Table 6). The annual profit to the user can be as high as Rs. 36,113 with return-on-investment of 118%. Besides, an employment of 20 to 196 mandays/year/Rs 10,000 capital investment can be generated using pedal operated cleaners. With power operated cleaner, cost of operation varied between Rs 2.15/q to Rs. 8.80/q and net profit could be earned as high as Rs 36,773 with return-on-investment of 99% (Table 7).

TABLE 7 Economic analysis for power operated air screen cleaner* for oil seeds

Economic parameter	Operational condition			
	100% custom hire	50% custom and and 50% sale	100% sale	Self use
Working capital (weighted), Rs	248	55,336	1,10,424	248
Cost of operation, Rs/q				
Sunflower	3.70	4.70	5.75	3.70
Safflower	4.05	5.15	6.30	4.05
Linseed	5.65	7.25	8.80	5.65
Mustard	2.15	2.80	3.40	2.15
Break-even-point (weighted,q/y	426	85	61	41
Annual net profit, Rs	1,447	19,090	36,733	n.a**
Return-on-investment, %	36	93	99	n.a
Employment generated, mandays/y/Rs 10,000 of capital investment	147	29	16	n.a

* Cost of equipment : Rs 4,000 (including cost of 0.5 hp electric motor)

** n.a : not applicable

In conclusion, the testing of the cleaner with oil seeds has given satisfactory results for efficient cleaning ease of handling, requiring very little skill and the economic analysis has shown that the cleaner is highly bankable (profitable) from the user's/processor's point of view.

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SHORT COMMUNICATION

EFFECT OF LEVELS OF NITROGEN, PHOSPHOROUS AND POTASSIUM ON GROWTH AND YIELD OF RABI SUNFLOWER

V.B. SHELKE, V.S. SHINDE, V.V. DAHIPHALE AND D.A. CHAVAN
Department of Agronomy, Marathwada Agricultural University, Parbhani 431402, M.S., India.

Sunflower (*Helianthus annuus L.*) is the promising oilseed crop becoming popular in *rabi* season also due to its photo in sensitive nature, it can practically be cultivated in any time of the year. Its cultivation, however, is more accepted during *rabi* season replacing the larger area of wheat due to less cost of cultivation, higher price, minimum risk involvement and availability of additional irrigation facilities in Marathwada region. Moreover, better grain filling is observed during *rabi* as compared to *kharif* season (Kushwa and Sharma, 1973). The most important factor affecting growth and yield of sunflower is the mineral nutrition especially nitrogen, phosphorous and potassium. Crop management and balanced fertilization, therefore, assume importance in sunflower cultivation especially when grown in *rabi* season under irrigation. Literature on fertilizer requirement of sunflower revealed that application of 50 kg N/ha in Konkan region of Maharashtra (Bhosle *et al.*, 1979), 20 kg N and 30 kg P_2O_5/ha at Dharwad in Karnataka (Shivkumar *et al.*, 1973) and 100 kg N, 100 kg P_2O_5 and 50 kg K_2O/ha at Junagadh in Gujarath state (Vijay *et al.*, 1975) was essential for winter sunflower. Therefore, a comprehensive study was made to study the effects of different levels of nitrogen, phosphorous and potassium on yield and yield attributes of sunflower crop during *rabi* season of 1983-84 and 1984-85.

A field experiment during 1983-84 was conducted on the black cotton soil, well drained, clayey in texture, deficient in nitrogen (0.051 % total N), medium in phosphorous (0.014 % total P_2O_5) and high in potassium (0.79 % total K_2O). While during 1984-85, soil was clayey in texture, deficient in nitrogen (0.013 %total N), low in phoshotous (0.041 % total P_2O_5) and high in potassium (0.053 % total K_2O).

The experiment was conducted in 3^3 partially confounded design with two replications. The treatments were having three levels of nitrogen (0, 50 and 100 kg N/ha), phoshorous (0, 40 and 80 kg P_2O_5/ha) and potassium (0,40 and 80 kg K_2O/ha). The fertilizers were drilled in the soil as per treatment combinations. A half of the dose of nitrogen and full dose of phosphorus and potassium were applied at the time of sowing and the remaining half dose of nitrogen was applied in the rows after 30 days of sowing.

Sunflower cv. EC-68414 was dibbled at a spacing of 45×15 cm on 10th and 14th November and were harvested on 12th and 20th March in 1983-84 and 1984-85, respectively. Crop was irrigated as and when required; in all six and five irrigations were given during 1983-84 and 1984-85, respectively. Growth observations namely plant height, number of leaves and dry matter accumulation per plant at 50 per cent flowering

stage of the crop and the test weight and yield data were recorded at the final harvest of crop are reported in Table 1 and 2.

TABLE 1 Growth of sunflower as influenced by levels of nitrogen, phosphorus and potassium.

Treatment	Height (cm)		No. of leaves/plant		Dry matter accumulation/plant (g)	
	83–84	84–85	83–84	84–85	83–84	84–85
Nitrogen (N kg/ha)						
0	171.15	118.21	20.51	19.10	173.36	135.94
50	186.05	157.67	23.09	21.98	179.70	178.50
100	198.88	166.69	25.19	23.38	210.57	192.67
S.E. +	2.65	2.53	0.64	0.47	8.55	5.47
C.D. at 5%	7.79	7.41	1.87	1.38	16.07	16.03
Phosphorus (P_2O_5 kg/ha)						
0	196.28	147.57	22.82	19.82	206.57	153.39
40	186.10	147.96	23.66	22.59	172.15	176.94
80	183.81	148.04	22.60	22.24	183.38	176.78
S.E. +	2.65	2.53	0.64	0.47	8.58	5.47
C.D. at 5%	N.S.	N.S.	N.S.	1.38	N.S.	N.S.
Pottassium (K_2O kg/ha)						
0	187.87	146.58	23.01	21.16	173.53	168.94
40	185.01	148.46	23.37	21.20	186.58	169.00
80	183.14	148.53	22.39	22.10	203.53	169.17
S.E. +	2.65	2.53	0.64	0.47	8.58	5.47
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Mean	185.36	147.77	22.96	21.49	187.71	169.04

Effect of Nitrogen

The response to applied nitrogen was found significant during both the years of experimentation and also for pooled data (Table 2). Increase in the level of nitrogen increased the seed yield and yield attributes of sunflower in a linear manner during both the years and in pooled results. The increase in yield use to nitrogen might have been due to increased plant height, number of leaves, dry matter accumulation per plant and 1000 seed weight. This is in accordance with the findings of Guar *et al.*, (1973)

and Adisehaih et al., (1978). Chowdhary and Upadhyay (1978) reported significant increase in yield due to application of 80 kg N/ha. Bhosle *et al.*, (1979) also reported higher grain yield over no nitrogen due to application of 50 kg N/ha in *rabi* season.

TABLE 2 Test weight, seed yield and cost benefit ratio of sunflower as influenced by levels of nitrogen phosphorous and potassium.

Treatments	Test weight (g)		Seed yield/ha (q)		Pooled mean	C:B ratio
	83–84	84–85	83–84	84–85		
Nitrogen (N kg/ha)						
0	47.43	42.36	10.81	8.30	10.43	0
50	50.65	47.78	12.03	11.36	11.93	1.55
100	53.22	49.38	13.69	13.69	13.60	3.26
S.E. +	0.47	0.86	0.16	0.38	0.26	—
C.D. at 5%	1.75	2.53	0.48	1.12	0.72	—
Phosphorous (P_2O_5 kg/ha)						
0	51.04	45.90	12.10	9.97	11.78	0
40	49.47	47.99	11.90	11.60	11.86	0.20
80	50.78	46.53	12.53	11.16	12.32	0.65
S.E. +	0.47	0.86	0.16	0.38	0.26	—
C.D. at 5%	N.S.	N.S.	N.S.	1.11	N.S.	—
Potassium (K_2O kg/ha)						
0	51.53	45.08	12.13	10.91	11.94	—
40	50.25	46.60	12.94	10.86	12.36	—
80	49.53	47.85	11.66	10.96	11.65	—
S.E. +	0.47	0.86	0.16	0.38	0.26	—
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	—
Mean	50.43	46.51	12.20	10.91	11.98	—

Effect of phoshorus

Response of sunflower to phoshorus was not evident in the year 1983-84. This may be due to presence of sufficient quantity of phoshorus in the soil (0.14 % total P_2O_5 for the growth and development of crop. Similar results were also reported by Vijay kumar *et al.* (1973), Bhosle, *et al.* (1979), Chowdhary and Paturde (1981) and Singhi

and Pacheria (1981). However, phoshorus was also found to increase the number of leaves and dry matter accumulation during second year (1984-85) and in turn increased the seed yield. Application of 40 and 80 kg P_2O_5/ha might be due to significantly higher values of these levels over control in respect of number of leaves and dry matter as accumulation per plant and low native P_2O_5 in soil during the second year of experimentation. These results are in agreement with those observed by Adisehaiah *et al.* (1978) and Tripathi and Karla (1980).

Phoshorus had no effect on seed yield in pooled analysis.

Effect of Potassium

Potassium application to sunflower crop, however, showed no beneficial effects during both the years of experimentation and also in pooled analysis, the reason might be high native soil fertility. Similar results have also been reported by Vijaykumar *et al.* (1973).

The effect of various first and second order interactions were not observed during both the years of experimentation and in the pooled results.

On the basis oI statistical analysis and C:B ratio, it can be concluded that application of 100 kg nitrogen and 40 kg phosphorus/ha is beneficial for improving yield of *rabi* sunflower.

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EFFECT OF DATES OF SOWING ON OIL CONTENT AND FATTY ACID PROFILES OF INDIAN MUSTARD

R.K. GHOSH AND B.N. CHATTERJEE
Department of Agronomy, Faculty of Agriculture Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal, Pin-741235.

The quality of an oil depends upon its fatty acid composition and its cooking and milling quality depends, further, on its isothiocyanate composition. In the present study an attempt was made to find out how different dates of sowing affected the oil content, fatty acid compositions and the isothiocynate compositions of the different varieties of Indian mustard of different growth durations, in the short and mild winter condition of the Gangetic plains of West Bengal.

The experiment was conducted during the winter season of 1980-81 to 1983-84 at the Viswavidyalaya Farm, on a sandy clay loam soil (Entisol) in a split plot design with three dates of sowing (D_1=Third week of October, D_2=First week of November and D_3=Third week of November) in main plots and eight varieties 'TM 4' (early), 'RW 351' (mid-early), 'RW 85-59' (mid-early), 'Varuna' (medium), 'Prakash' (late), 'RLM 198(late), 'B 85' (early) and 'Pusa Bold' (mid-early), in sub-plots, in three replicates. The crop was fertilized at 80 kg N, 40 kg P_2O_5 and 40 kg K_2O/ha protected from diseases and pests and irrigated four times.

Oil content of the seeds was determined by Soxhlet method according to Piper (1966). The fatty acid components were determined from the oil extracted from ground seeds with hexane at the National Institute of Nutrition (Hyderabad) through the courtsey of Dr. I.S. Shenolikar. For isothiocyanate and husk content, chemical analysis was done at the University of East Anglia, Norwich, U.K. through the courtesy of Reckitt and Colman of India Limited, Calcutta. The isothiocyanate (TC) was determined through Gas chromatography using methyl heptanoate in acetone. Husk percentage was determined by weight after separating the kernels from the husk materials by an air classifier fitted with a cyclone separator.

A fortnight delay in sowing (D_1 to D_2) reduced the oil content by 2.9%(Table 1) and a further 1.9% reduction was due to another 15 days delay in sowing (D_2 to D_3). Bishnoi and Singh (1979) also reported that early sowing increased the oil content, due to the effect of high temperature prevailing at the later stages of siliqua development, under late sowing. Most rapid development of oil in seeds takes place within 20 days after fertilization and continues for another 20 days. Delay in sowing reduced the length of reproductive period and ultimately affected the oil content. Similar observation has also been reported by Singh and Singh (1985). Mid-early varieties mainly 'RW 351' recorded maximum oil content than the other varieties. As the mid-early/medium duration varieties could strike a balance between vegetative and reproductive growth stages, unlike the late or early varieties, they appeared to be more suitable in this climatic condition.

TABLE 1 Percentage of oil in seeds

Varieties (V)	Dates of sowing (D) (Mean of 4 years)			Mean
	D_1	D_2	D_3	
TM 4	37.40	34.33	31.88	34.54
RW 351	39.03	35.13	33.15	35.78
RW 85-59	38.28	34.05	33.30	35.21
Varuna	37.30	34.58	32.85	34.91
Prakash	36.97	35.68	32.90	34.80
RLM 198	36.03	33.68	31.85	33.99
B 85	35.05	31.80	29.55	32.13
Pusa Bold	37.20	32.95	30.80	33.67
Mean	37.32	34.42	32.52	

Delay by a month in sowing showed a reduction of 2.67% in erucic acid (Table2). Similar result was also observed in the case of linolenic acid. Early sowing showed 12.9% of linolenic acid but a month's delay showed 10%. But the reverse was true in the case of linoleic acid; there was 2.57% increase from D_1 to D_3 and in Oleic acid 2.33% (9.66 and 12.29% in D_1 and D_3 dates of sowing, respectively). Klassen (1970) held the opinion that there might exist some relationship between the erucic acid level of oil content in different dates of sowing.

High values were recorded in 'Pusa Bold' (mid-early) in palmitic (16:0) and eicosenoic (20:1) acid contents. 'B 85' (early variety) showed high values in oleic (18:1) and linoleic (18:2) acid. 'RW 85-59' (mid-early variety) showed high values in stearic (18:0) and linolenic (18:3) acid. 'RW 351' (mid-early variety) showed high erucic (22:1) and palmitoleic (16:1) acid contents. Highest value of erucic acid was recorded in 'RW 351' (50.7%) and lowest in 'B 85' (42.6%) when the crop was sown in October.

'Varuna' (0.17%) and 'RLM 198' (0.15%) showed higher Allyl ITC content than the other varieties (Table 3). The 3-Butenyl ITC and 1-Methoxy 3-Indoyl-methyl ITC had higher content than the other components of ITC. 'TN 4' and 'Prakash' showed high fixed oil content (38.3%) unlike the 'Varuna' (34.2%) or 'RLM 198' (34.6) though 'Pusa Bold' recorded the maximum (41.4%). High fixed oil and low Allyl ITC are not suitable for good cooking and milling. Perhaps only for this reason Indian varieties are less suitable for milling in comparison to British varieties which contain low fixed oil and high Allyl ITC. In this experiment medium duration variety 'Varuna' thus appeared to have a good milling quality because it contained lowest fixed oil and highest Allyl ITC in comparison to other varieties. 'Varuna' also recorded maximum total ITC value (1.01).

TABLE 2. Fatty acid profiles of the oil samples (expressed as % of total fatty acids) in 1982-83

Treatments	Myristic (14:0)	Palmitic (16:0)	Palmoto-leic (16:1)	Stearic (18:0)	Oleic (18:1)	Linoleic (18:2)	Linolenic (18:3)	Arachidic (20:0)	Eicosaneic (20:0)	Hencico-sanoic (21:0)	Behenic (22:0)	Erucic (22:1)
D_1 (3rd wk of Oct)												
TM 4	TR	2.1	0.3	0.9	8.5	18.5	12.5	TR	6.6	0.8	0.4	49.3
RW 251	TR	2.5	TR	TR	9.8	19.6	12.7	TR	4.7	TR	TR	50.7
RW 85-59	—	—	—	—	—	—	—	—	—	—	—	—
Varuna	TR	2.2	TR	0.9	9.8	18.8	13.3	TR	6.8	TR	TR	48.2
Prakash	TR	—	—	—	—	—	—	—	—	—	—	—
RLM 198	TR	—	—	—	—	—	—	—	—	—	—	—
B 85	TR	2.4	0.7	TR	11.3	22.0	14.5	TR	4.6	1.1	0.7	42.7
Pusa Bold	TR	2.8	0.6	0.8	8.9	17.4	11.6	TR	8.3	1.1	0.5	48.3
Mean	TR	2.40	—	—	9.66	19.26	12.92	TR	6.20	—	—	47.82
D_2 (1st wk of Nov)												
TM 4	TR	1.9	TR	TR	8.4	21.8	11.4	0.4	5.7	TR	TR	50.3
RW 351	TR	3.0	0.3	0.9	9.0	18.8	12.5	TR	6.1	1.0	0.6	47.7
RW 85-59	TR	2.3	TR	1.0	9.3	18.8	13.7	TR	7.3	1.9	0.3	45.3
Varnua	TR	2.5	TR	0.7	10.3	20.6	11.4	TR	6.7	1.5	0.4	45.8
Prakash	—	—	—	—	—	—	—	—	—	—	—	—
RLM 198	TR	2.3	0.2	TR	9.8	19.8	12.6	TR	5.5	TR	TR	49.8
B 85	TR	2.4	TR	TR	10.3	21.2	12.9	TR	5.6	TR	TR	47.5
Pusa Bold	TR	—	—	—	—	—	—	—	—	—	—	—
Mean	TR	2.4	—	—	9.52	20.17	12.42	—	6.15	—	—	47.73

D_3 (3rd wk of Nov)												
TM 4	TR	2.0	0.6	0.6	11.7	22.7	9.0	TR	8.4	0.8	0.5	44.1
RW 351	TR	2.9	0.6	0.6	11.9	23.4	9.1	TR	5.2	TR	TR	46.3
RW 85-59	TR	2.3	0.3	0.7	10.3	18.5	11.9	TR	7.5	0.2	0.8	47.4
Varuna	TR	2.7	TR	0.4	13.3	22.7	9.5	TR	6.5	TR	TR	44.8
Prakash	TR	.6	0.2	TR	11.9	20.1	11.9	TR	7.7	1.9	0.1	43.5
RLM 198	TR	2.7	0.2	0.7	12.6	21.9	10.7	TR	7.7	1.9	0.5	46.9
B 85	TR	2.6	0.5	0.6	13.9	2.40	8.7	TR	0.4	0.9	0.8	47.4
Pusa Bold	TR	2.7	0.5	0.7	12.7	21.3	9.0	TR	7.5	0.3	0.3	44.8
Mean	TR	2.56	—	—	12.29	21.83	9.98	TR	6.34	—	—	45.15

Analysis at N I N, Hyderabad, through the courtesy of Dr. I.S. Shenolikar

TABLE 3. True pungency and isothiocynate (ITC) profiles of mustard seeds (D_2) sowing and its husk content in 1983-84.

Varieties (V)	Volatile* oil (%)	Fixed oil (%)	Husk (%)	Isothiocyanate (TIC) profiles					Total of ITC profiles
				Allyl Nitrate	Allyl ITC	3-Butenyl ITC	Unknown ITC	1-Methoxy 3-Indoyl-methyl ITC	
TM 4	0.73	38.3	14.0	0.04	0.11	0.55	0.02	0.17	0.89
RW 351	0.70	37.4	23.0	0.05	0.10	0.50	0.03	0.20	0.88
RW 85-59	0.67	36.3	20.5	0.02	0.02	0.12	0.04	0.71	0.91
Varuna	0.81	34.2	25.4	0.04	17.0	0.57	0.04	0.19	1.01
Prakash	0.73	38.3	20.0	0.06	0.09	0.40	0.04	0.26	0.85
RLM 198	0.80	34.6	22.0	0.04	0.15	0.57	0.02	0.15	0.95
B 85	0.66	36.3	21.5	0.01	0.01	0.13	0.02	0.74	0.91
Pusa Bold	0.55	41.4	19.5	0.03	0.03	0.16	0.08	0.54	0.84
Mean	0.71	37.1	20.8	0.04	0.09	0.38	0.04	0.37	0.91

*Indicate the true pungency of the mustard seeds

Source : University of East Anglia, Norwich, U.K. through Reckitt and Colman of India. Limited,

The husk percentagewas lower (below 20 %) in varieties 'TM 4' and 'Pusa Bold (Table 3) than the others (above 20%).

In this experiment the dates of sowing had a negligible effect on the protein con tent of this seeds. 'RW 351' and 'Varuna' recorded higher protein percentage around 43% as compared to others around 40%.

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CORRELATION STUDIES IN VIRGINIA BUNCH GROUNDNUT (*ARACHIS HYPOGAEA* L. SSP. *HYPOGAEA*)

V. MANOHARAN, R. SETHUPATHI RAMALINGAM AND M.R. SIVARAM
Regional Research Station, Vridhachalam 606 001.

The Virginia Bunch groundnut genotype Robut 33-1 (Probably a corruption of Rehovot 33) was selected from a plot of exotic bunch cultivar (Anon, 1978) introduced into India from Israel in 1964 as an exotic collection (E.C.) 27988. It probably originated as a natural cross (ICRISAT, 1982). This genotype has resistance to bud necrosis disease (Amin, 1985) and promising selections like Kadiri-3, ICGS 1, 4, 11 and 44 have been made from this and are either realeased for general cultivation or entered into national trials. This indicates that the genotype shows considerable variation. Information on the association of important traits is *sine qua non* for the breeder in isolating desirable purelines from this genotype and other Virginia Bunch bulk/segregating populations and the present investigation was undertaken with this objective.

The observations were recorded on 50 random plants of Robut 33-1 grown during summer 1984 at the Regional Research Station, Vridhachalam. Eight yield and yield determining characters namely, pod yield, plant height, number of primaries and secondaries dry matter production, harvest index, number of matured pods, and 10-pod weight per plant were recorded. Correlation Coefficients were worked out as per the procedure outlined by Al Jibouri *et al.* (1958) which is presented in Table 1.

Pod yield was found to be positively and significantly correlated with number of matured pods and secondaries ,dry matter production and harvest index. Positive association between pod yield and number of secondaries and matured pods have also been reported by Sandhu and Khehra (1977) and Baliah *et al.* (1980) in the segregating populations of semi spreading groundnut. Arnon (1975) found that considerable increase in yield of economic product is usually dependent on an increase in dry matter production. Most of the variation in groundnut yield are explained by the length of pod filling period, the rate of pod establishment and especially by the partitioning of the assimilate between vegetative and reproductive parts (Ducan *et al.* 1970). Ball *et al.* (1979) also obtained positive relationship between pod yield and harvest index. The number of secondary branches was also positively related to the number of matured pods which is in confirmity with the findings of Khangura and Sandhu (1972). Though workers like Sangha (1973) and Labana *et al.* (1980) found strong positive association between pod weight and yield, the result obtained in the study is at variance from them. The number of primary branches was also found to be positively correlated to the number of secondaries and dry matter production.

The present investigation revealed that selections made on the basis of number of matured pods and secondaries, dry matter production and harvest index would lead to the isolation of superior purelines in bulk or segregating semispreading populations.

TABLE 1. Correlation Coefficients between yield and its attributes.

	No. of primaries	No. of secondaries	Dry matter production	Harvest Index	No. of pods	100 pod weight	Pod yield
Plant height	–0.144	0.082	0.252	–0.106	0.178	0.111	0.219
No. of Primaries		0.308*	0.331*	–0.194	0.079	0.061	0.087
No. of Secondaries			0.831**	–0.100	0.662**	0.118	0.683**
Dry matter production				–0.201	0.752**	0.081	0.762**
Harvest Index					0.412**	–0.041	0.402**
No. of pods						–0.116	0.963**
100 pod weight							0.131

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

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COMPONENTS OF RESISTANCE IN GROUNDNUT CULTIVARS TO *PUCCINIA ARACHIDIS* Speg+

P. NARAYANA REDDY* AND M.N. KHARE
Jawaharlal Nehru Krishi Vishwa Vidyalaya Department of Plant Pathology, Jabalpur-482 004, M.P.

Groundnut rust disease caused by *Puccinia arachidis* Speg. occupies an imporatnt place among the diseases of groundnut. Yield losses can be severe when the crop is attacked by any one or both rust and *Mycosphaerella* leaf spots. In view of regular heavy losses and high cost of fungicidal control, growing resistant cultivars may be the only easiest, safest and economic way of increaing ysield and production. Since most of the groundnut cultivars are susceptible to rust the present study was undertaken to locate sources of resistance and investigate the components of resistance to *Puccinia arachidis*.

During Kharif 1981 and 1982, two replicates of 96 cultivars were sown in 6m rows, 45cm apart. Every two test cultivars were alternated with a "spreader row" of susceptible cultivar jyoti. All the cultivars were inoculated 40 days after sowing with freshly collected uredospore suspension. Rust severity was measured on ten randomly selected plants in each cultivar following the nine point scale (anon, 1981) and the disease index of the cultivars was rated as immune (0 disease index), highly resistant (0.1-10.0), resistant (10.1-25.0), suceptible (25.1-50.0) and highly susceptible (50.1-100).

To determine the components of resistance six cultivars viz. Jyothi, ICG-1697, ICG-7899, ICG-7882, ICG-7898, and ICG-1697 were sown in pots in a glasshouse. All the cultivars were inoculated 50 days after sowing. To determine the differences in incubation period (days between inoculation and first appearance of visible sypmtoms) plants were observed every day after inoculation with a hand lens for the appearance of rust Pustules. Number of uredia/cm^2 were noted on 30th day of inoculation. The leaves were cleared according to Crossan (1967) and the uredia were measured micrometrically.

Screening of the groundnut cultivars showed that none of them were immune, only two cultivars ICG-1697 and DHT-200 were highly resistant (disease index 9.3) four cultivars moderately resistant, twenty five cultivars susceptible and the remaining 65 highly susceptible. The disease index was 100 in eleven cultivars.

Analysis of the components of resistance in six groundnut cultivars of varying susceptibility to P. *arachidis* revealed (Table-1) that the resistant variety ICG-1697 had longer incubation period (21 days) less number of pustules (21.57), smaller pustules (0.58mm) and less percentage of leaves infected per plant (13.70) compared to the susceptible cultivar Jyothi (10, 100.70, 141mm, and 67.20, respectively). Long incubation period and low pustule density are considered as important components of partial resis-

Present Address : *Assistant Research Officer R.A.R.S. Palem-509 215
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tance (Parlevliet, 1976). Johnson and Wilcoxson (1978) considered long incubation period as a feature of slow rusting. Shaner *et al.* (1978) found larger uredia on fast rusting barely cultivars.

TABLE 1 **Components of partial resistance of groundnut Cultivars to *Puccinia arachidis***

Cultivars	Disease Index	Incubation Period (days)	No. of Pustules Per cm^2 on 30th day of inoculation	Pustule diameter (mm)	Percentage of leaves infected per plant
Jyoti	100.0	10	100.70	1.41	67.20
ICG 2716	67.6	14	7 .40	1.13	37.00
ICG 7899	51.4	16	67.67	1.15	28.00
ICG 7882	48.6	18	40.20	0.83	31.00
ICG 7898	24 4	18	48 .57	0.86	25.00
ICG 1697	9.3	21	21.57	0.58	13.70
S.Ed. (±)			0.13	0.02	0.94
CD 1%			0 4	0.05	2.77

There was positive correlation between incubation period and no. of pustules (r=0.947), pustule diameter (r=0.969) and percentage of leaves infected (r=0.953). So were the no. of pustules and pustule diameter (r=0.995) and percentage of leaves infected per plant (r=0 .907) and between pustule diameter and percentage of leaves infected per plant (r=0.878).

Results show that longer incubation period, fewer pustules per cm^2 and small pustule size appear to be important components that could be used for screening groundnut cutlivars for partial resistance to *Puccinia arachidis*.

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EFFECT OF MORPHO-PHYSIOLOGICAL ATTRIBUTES ON PAR ABSORPTION AND SEED YIELD IN SESAME (*SESAMUM INDICUM* L.)

A.K. YADAV, S.K. THAKRAL, HARI SINGH, PHOOL SINGH* AND T.P. YADAV
Department of Plant Breeding, Haryana Agricultural University, Hisar-125 004.

The reflection of radiation by the Canopy either because of pubescence or presence of wax, bloom may modify Canopy foliage properties and physiological processes through several definable interaction. A change in leaf abosrption will directly effect photosynthesis and leaf energy balance (Ehleringer, 1980 and Bleldocchi *et al.*, 1983). Sesame is the most ancient oilcrop of Indian origin and is adapted to areas of low rainfall but the information on above aspects are not available and hence the present study was conducted to find out the extent of genetic variation for radiation characteristics (PAR 400-700 mm wave length), seed yield and its component characters vis-a-vis their inter-relationship.

The present experiment was conducted during summer, 1986 at H.A.U. Research Area, Hisar (20° 10' 'N latitude and 75° 45' E longitude). Seven genetically diverse genotypes viz., HT-1, HT-6, HT-38, HT-42, RT-49 OMT-11-5-6 and TO-390 were selected based on their different plant types, branching pattern, leaf display and foliage colour. These genotypes were grown under rainfed condition. The soil of the experiment was analysed and was found to be sandy loam, slightly alkaline and medium in fertility. Prior to sowing a basal recommended dose of 40 Kg N/ha was applied. This experiment was laid out in a randomized block design with three replications. Each genotype was grown in a plot size of 2.1 × 5.7 m^2. The inter row spacing was kept at 30 cm while intra row spacing was maintained at 10 cm. Observations were recorded on 10 competitive plants on each genotype in each replication at initiation of capsule formation for seven attributes viz., plant height (cm), number of leaves, leaf area dm2, number of fruiting branches, total capsules, seed husk ratio and seed yield. Photosynthetically active radiation (PAR) absorption was recorded in each plot and in each replication at ten points and their average was calculated. These observations were recorded between 1200 hr. to 1400 hr. The coefficients of PAR were computed by measuring photosynthetic photon flux density with the help of a Radiometer (LICOR, Nebraska, U.S.A.) fixed with a quantum sensor using the following formulae:-

a) Reflection coefficient (r)

$r = \frac{Rr}{\overline{Ro}}$ where, Rr is reflected PAR by crop Canopy and Ro is the incoming PAR above the crop Canopy.

b) Transmission Coefficient (t)

$t = \frac{Rt}{\overline{Ro}}$ Where, Rt is the transmitted PAR through crop Canopy.

* Present Address: Crop Physiologist, NARP, H.A.U., Hisar.

c) Absorption coefficient (A)
$A = 1 - (r+t)$

Correlation coefficients for PAR absorption, yield and its morphophysiological attrbiutes among themselves were worked out following the formula suggested by Al-Jibouri *et al.* (1958)

The *per se* performance of seven divergent genotypes of sesame with respect of eight attributes have been depicted in Table-1. Perusal of the Table indicates significant differences among the genotypes for all these attributes. Coefficient of variation revealed the low influence of environmental conditions for the expression of all the characters except number of leaves and fruiting branches where the manitude of c.v. is slightly higher (11.05 and 12.06%, respectively). On an average, absorptance of PAR was maximum for HT-38 (0.920) and RT-49 (0.918). The minimum value for this attribute was recorded in TC-390 (0.887). This difference was mainly due to lesser transmission of PAR through compact and dark green foliage of the Canopy of HT-38 and RT-49. The range for capsules plant^{-1} was high (38.3 to 39.3). RT-49 possessed maximum capsules followed by genotypes i.e. HT-6 and HT-1 (76.7 and 74.0, respectively). Considerable variability was also observed for number of leaves. HT-36 possessed maximum leaves plant^{-1} (155). This genotype had dark foliage and compact canopy, obviously, had the highest PAR (absorption). The minimum leaves (75.3) were recorded on the genotypes i.e. TO-390 and OMT 11-6-5. The trend of leaf area plant^{-1} was more or less similar to that of number of leaves plant^{-1}. HT-38 had the maximum leaf surface area (78.7 dm^2) while TC-390 possessed the lowest leaf area plant^{-1} (34.17 dm^2). High

TABLE 1 Performance of sesame genotypes w.r.t. PAR absorption, seed yield and its component traits.

Genotypes	PAR absorption	Seed yield plant^{-1} (g)	Seed husk ratio	No. of capsules plant^{-1}	No. of leaves plant^{-1}	Leaf areas plant^{-1} (dm^2)	No. of fruiting branches plant^{-1}	Plant height (cm)
1	2	3	4	5	6	7	8	9
1. HT-1	0.908	5.79	0.640	74.0	166.3	63.67	4.93	174.3
2. HT-6	0.901	4.91	0.644	76.7	130.0	53.61	5.07	151.3
3. HT-38	0.920	5.26	0.467	71.0	155.0	78.70	4.80	176.7
4. HT-42	0.912	4.27	0.626	66.7	146.3	71.98	6.00	174.3
5. RT-49	0.918	7.05	0.585	89.3	95.3	69.16	4.07	151.0
6. OMT 11-6-5	0.901	3.22	0.442	57.0	75.3	51.46	3.80	137.0
7. TO-390	0.887	2.05	0.396	38.3	75.3	34.17	2.93	146.7
C.D. at 5%	0.003	0.67	0.05	13.28	4.78	3.72	1.00	8.73
C.V. %	0.16	7.70	5.410	11.05	2.23	3.46	12.06	3.06

yielding genotypes were generally taller as compared to poor yielders. The range of number of fruiting branches was narrow (3.80 to 6.00). Nevertheless, three genotypes viz. HT-42, HT-6 and HT-1 differed significantly from the genotype having the lowest value of this attribute. For seed yield, there was enough variability ranging from 2.05 to 7.05g. RT-49 a multi-capsuled and branched genotype, had the higher PAR absorption possessed the highest seed yield.

The results presented in Table-2 revealed the impact of PAR absorption at initiation of capsule formation on seed yield and its components characters. This attribute had positive and significant association with seed yield, total capsules and leaf surface area. Obviously, leaf area and total capsules/fruits of dark green and compact canopy had the direct role in increasing the productivity. Similar role in other oil bearing crops has also been reported by Pandya, 1975; Yadav and Singh, 1984 and Chhabra, 1986. Beside this, seed yield was positively and significantly associated with total capsules and leaf area plant-1. Studies of Djigma, 1984; Sharma and Chauhan, 1984 and Krishnadoss and Kadambavanasundaram, 1986 in this crop were adequately corroborative with the present study.

TABLE 2 Relationship among PAR absorption, seed yield and other six morpho-physiological attributes

Characters	PAR absorption	Seed yield	Seed Husk ratio	Total capsules	No. of leaves	Leaf areas	No. of fruiting branches	Plant height
1	2	3	4	5	6	7	8	9
1. PAR absorption	—	0.806*	0.406	0.783*	0.553	0.969**	0.538	0.593
2. Seed yield		—	0.660	0.965**	0.494	0.758*	0.372	0.406
3. Seed husk ratio			—	0.736*	0.628	0.456	0.299	0.430
4. Total capsules			—	—	0.362	0.465	0.724*	0.373
5. No. of leaves.					—	0.688	0.851*	0.921**
6. Leaf area						—	0.647	0.725*
7. No. of fruiting branches.							—	0.790*

* Significant at 5% level

** Significant at 1% level

The findings of the experiment indicated that cultures RT-49, HT-38 and HT-1 performed better with reference to seed yield, leaf area, total capsules and PAR absorption capacity. These genotypes, therefore, showed promise for exploitation directly or could also be the valuable parental material for hybridization programme to evolve better varieties.

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EFFECT OF DIFFERENT LEVELS OF IRRIGATION AND PHOSPHORUS ON YIELD OF SUMMER GROUNDNUT

R.L. THANZUALA and V.V. DAHIPHALE
Department of Agronomy Marathwada Agricultural University, Parbhani - 431 402, M.S.

Groundnut (*Arachis hypogaea* L.) is grown mainly as *kharif* crop under rainfed conditions. Recently in multiple cropping systems, its cultivation has been extended to summer season also. Scheduling of irrigation can satisfactorily be done with the help of evaporimeters which integrate various meterological parameters into a single entity i.e. the evaporation (Dastane and Singh, 1964). Beneficial effect of phosphorus on the yield and yield contributing characters of groundnut has been reported by Dudde et al. 1980. With this background in view, it was considered to take up an experiment to find out the optimum water requirement and phosphorus on groundnut crop variety SB-XI during summer season.

Field experiment was conducted with groundnut variety SB-XI to study the effect of irrigation and phosphorus at the Marathwada Agricultural University farm, Parbhani during summer season of 1986. Treatments under investigation consisted of six levels of irrigations (I_1=critical growth stages viz., crop establishment, vegetative, flowering, yield formation including pod setting. pod filling and pod ripening, I_2=every 10 days intervel, I_3=0.50 IW/CPE ratio, I_4=0.75 IW/CPE ratio, I_5=1.0 IW/CPE ratio and I_6=1.25 IW/CPE ratio) and three levels of phosphorus (P_o=control, P_1=40 kg P_2O_5/ha and P_2=80 kg P_2O_5/ha). The gross and net plot sizes were 6.0×3.6m and 4.2×2.4m, respectively. The treatments were laid out in a randomised block design with three replications. The soil of the experimental plot was clay-loam in texture, low in total nitrogen, medium in available phosphorus and potash and low in organic carbon with a pH of 8.56. The single value physical constants of the experimental soil of 0-45 cm depth were F.C.=32.3%, PWP=14.2% and B.D.=1.32 g/cc. An uniform basal dose of 25 kg N and 50 kg k_2O/ha was given to all the plots and the phosphorus was given as per treatments.

The presowing irrigation was applied on 5th February, 1986. Sowing was done on 8th February, 1986 by dibbling. The common irrigation was applied on 24th February, 1986, to all the plots uniformly. Thereafter, differential irrigations scheduled according to CPE were administered to various plots. The soil samples were drawn from 0-45 cm soil depth before and after irrigations for moisture determination. The source of irrigation water was a well having good quality. The depth of irrigation water applied at every irrigation was 60 mm (1296 l/plot) with the help of water meter.

The important yield contributing characters like plant height, total dry matter weight per plant, number of filled pods per plant, 100 kernel weight and shelling percentage, were favourably affected with irrigations scheduled at 0.75, 1.0 and 1.25 IW/CPE ratios (Table 1). The irrigations scheduled at critical growth stages, every 10 days interval and 0.50 IW/CPE ratio had adversely affected these characters. Similar results were also reported by Shelke and Khuspe (1980) and Mathew (1983).

TABLE 1 Effect of irrigation and phosphorus on yield and yield components of groundnut.

Treatments	Pod yield (q/ha)	Haulm yield (q/ha)	Plant height (cm)	Total dry matter/ plant (g)	No. of filledpods/ plant	100 kernel weight (g)	Shelling percentage
Irrigation:							
I_1 (Critical growth stage)	8.17	39.32	17.96	20.53	8.56	29.96	64.93
I_2 (10 days interval)	16.52	43.71	22.53	25.43	16.10	35.73	71.51
I_3 (0.50 IW/CPE ratio)	17.81	44.24	23.36	26.29	16.44	35.82	72.54
I_4 (0.75 IW/CPE ratio)	26.05	52.35	29.01	32.29	24.70	37.19	74.40
I_5 (1.0 IW/CPE ratio)	26.49	54.50	30.83	33.07	25.33	37.05	74.47
I_6 (1.25 IW/CPE ratio)	24.36	51.50	30.80	32.47	24.19	36.99	73.84
S.E. ±	0.88	1.20	1.50	2.38	0.95	0.39	0.22
C.D. (P=0.05)	2.60	3.45	3.34	6.88	2.73	1.12	0.64
Phosphorus							
P_0 (Control)	15.26	43.71	25.34	26.08	16.33	34.14	70.52
P_1 (40 kg P_2O_5/ha)	22.17	50.47	26.06	30.57	21.29	36.48	72.87
P_2 (80 kg P_2O_5/ha)	22.07	48.63	25.84	30.46	29.67	35.94	72.45
S.E. ±	0.63	0.85	1.06	1.68	0.67	0.29	0.15
C.D. (P=0.05)	1.84	2.44	N.S.	4.36	1.93	0.81	0.45
Interaction (I×P):							
S.E. ±	1.54	2.87	2.60	4.12	1.64	0.69	0.38
C.D. (P=0.05)	4.42	N.S.	N.S.	N.S.	N.S.	N.S.	1.10

The beneficial effect of phosphorus was found on these characters except on plant height. Phosphorus application of 40 kg/ha was most beneficial on these characters, though there was no significant difference between 40 and 80 kg P_2O_5/ha.

The interaction effect of irrigation and phosphorus levels was not significant.

Pod yield was significantly higher in irrigation scheduled at 0.75, 1.0 and 1.25 IW/CPE ratios compared to scheduling of irrigation at critical growth stages or every 10 days or 0.50 IW/CPE ratio. However, the difference in pod yield was not significant between 0.75, 1.0 and 1.25 IW/CPE ratios. Highest pod yield of 26.49 q/ha was obtained with a IW/CPE ratio of 1.0 followed by 26.05 and 24.36 q/ha due to 0.75 and 1.25 IW/CPE ratios, respectively. Similar results were also reported by Shelke and Khuspe (1980). Therefore, it can be advised to schedule irrigation to groundnut crop during

summer at 0.75 IW/CPE ratio i.e total 16 irrigations. Haulm yield was significantly high with irrigation scheduled at 0.75, 1.0 and 1.25 IW/CPE ratios over the rest of the irrigation treatments.

Highest pod yield of 22.17 q/ha was observed with the application of 40 kg P_2O_5 ha, which was at par with 80 kg P_2O_5/ha but found to be significantly superior to control. This indicated that 40 kg P_2O_5/ha seemed to be sufficient for higher pod yield of groundnut. Similar trend was observed on haulm yield also.

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PRELIMINARY SCREENING OF VIRGINIA GROUNDNUT GENOTYPES AGAINST TOBACCO CATERPILLAR, *SPODOPTERA LITURA* (F.)

K. RAJAGOPAL, N. NANDAGOPAL and N.R. BHAGAT
National Research Centre for Groundnut, Junagadh 362 015, Gujarat, India.

In recent years, tobacco caterpillar (*Spodptera litura* (F.) has assumed importance particularly in groundnut growing regions of South India. For the control of this insect pest, chemical and cultural control measures are generally adopted, but cultivation of resistant varieties has been emphasized because it is economical, safe and satisfactory method of pest control. In view of this, screening of sampled Virginia accessions was undertaken to identify sources of resistance with a view to assist resistant breeding programme in the country.

Two forms of Virginia accessions (6 Virginia bunch; 18 Virginia runners) belonging to ssp *hypogaea* var *hypogaea* were selected at random from the germplasm collection The same were sown in 1986 during the main rainy season in randomised block design with 3 replications. Each accession consisted of 3 rows of 3 meter length with 60×10 cm spacing. Recommended agronomic practices were followed but no plant protection measures were adopted. When the damage of tobacco caterpillar was visible in the field 75 days after germination, fully opened apical two leaflets were collected at random from each accession and total leaf area (sq. mm.) was measured. Then these leaf lets of each accessions were arranged in a circular fashion in a petridish (20 cm. diameter), thereby accomodating 8 accessions at regular spacing. 25 first and second instar larvae obtained from isogenic culture were released in the centre of the petridish after 4 hrs of starvation. Petridishes were when kept in a dark chamber. After allowing the insects to feed for 24 hours, the number of larvae on leaflet of each accession were counted, finally followed by leaf area damage. The feeding experiment was repeated thrice and the value was used for further calculation. The accessions were categorised based on the following scale considering the leaf area damaged, Not Preferred - below 1%; Highly Resistant - 1 to 5%; moderately resistant - 5 to 10% Moderately Susceptible. - 11 to 15% and Highly Susceptible - 15 to 30%.

The mean number of larvae oriented was 3.17 and 3.78 in Virginia bunch and Virginia runner habit groups, respectively. The range was narrow in Virginia bunch (1.47 to 4.41) whereas, it was wider in Virginia runner. On the other hand the leaf area damage observed in Virginia bunch was 0.61 to 21.86 and in Virginia runner. 39 to 22.8 with a general mean of 6.41 and 9.14, respectively. There were significant varietal differences both in larval orientation as well as per cent leaf damage in the accessionsl studied. The varieties having less damage could be spotted, which were V-40, Ah 6429 in Virginia bunch and NCA 17840, NFG 79, EC 21989 in Virginia runner (Table 1).

For the biochemical analysis of representative samples from each group the following methods were used. Riitta Julkanen and Titto (1985) for total phenolics, Macro

TABLE 1 Larval orientation, per cent damage in relation to biochemical constituents

Sr. No.	Variety	Type	Origin	Per cent orientation	Per cent damage	Nitrogen %	Phenolics %	Potash Mg/g.	Sodium Mg/g.
	Not Prefered (NP)	VR	USA	.01	0.48	1.87	1.59	2.9	5.4
1.	NCAc 17840								
2.	NFG 79	VR	India	1.47	0.66	1.68	1.41	3.0	5.6
3.	EC 21989	VR	—	0.01	0.39	1.69	1.69	3.2	4.8
4.	V-40	VB	—	1.47	0.61	—	—	—	—
	Highly Resistant (HR)								
5.	C-171	VR	India	2.16	3.92	1.67	1.78	4.1	6.3
6.	Ah 6429	VB	India	4.41	2.86	1.92	0.28	2.6	5.6
7.	M 185-73	VR	Nigeria	4.41	3.31	1.91	1.50	3.3	5.8
8.	NCAc 749	VR	USA	4.41	4.87	1.84	0.72	3.7	6.8
9.	Chetse Hua Seng	VR	China	4.41	1.36	2.17	1.59	4.3	6.0
10.	Dongi	VR	India	4.41	1.99	1.85	0.66	1.0	6.3
11.	Gunajato	VR	—	2.61	4.81	—	—	—	—
12.	C 163	VR	India	3.34	2.16	—	—	—	—
	Moderately Resistant (MR)								
13.	34-2-2	VR	India	5.07	2.16	1.95	1.03	2.6	5.2
14.	EC 24883	VB	Cuba	4.41	7.68	1.88	1.68	.1	5.5
15.	EC 21083	VB	Sudan	2.16	9.22	1.89	1.34	1.2	6.0
16.	64-2	VR	China	2.16	6.99	—	—	—	—
17.	34-3	VR	India	4.41	8.88	—	—	—	—

TABLE 1 (Contd.)

Sr. No.	Variety	Type	Origin	Per cent orientation	Per cent damage	Nitrogen %	Phenolics %	Potash Mg/g.	Sodium Mg/g.
	Moderately Susceptible (MS)								
18.	Punjab 1	VR	India	8.82	13.44	1.69	0.68	2.5	5.9
19.	S/7/4/6.	VB	Sudan	2.16	12.61	1.67	1.38	2.6	5.8
	Highly Susceptible (HS)								
20.	Var. 28-206-27	VR	—	8.82	22.8	1.84	1.69	—	4.9
21.	Sanmelto	VB	S. Africa	4.41	21.86	1.74	1.31	3.3	6.1
22.	Sel. No. 230	VR	—	11.76	18.6	1.88	1.41	2.9	6.5
23.	Ah 6940	VR	India	5.88	15.16	—	—	—	—
24.	GAUG 10	VR	India	3.0	20.28	—	—	—	—
	Per cent orientation	—			0.69**	0.15 NS	.19 NS	0.21 NS	0.5**
	Per cent damage					0.60**	.14 NS	-0.61**	0.07 NS

NS : Not significant

** : Significant at 1%

— : Indicates analysis was not done.

Kjeldahl method using Teecator 1030 auto analyser for nitrogen and potassium and sodium by photometry indicated the absence of significant correlation between any of the four constituents with the leaf area damage. On the other hand, larval orientation indicated significant correlation with nitrogen, sodium and potassium content, the last however showed negative correlation. Similarly the larval orientation and leaf area damage was also significantly correlated (Table 1).

These investigations suggest that there is inherent resistance among the groundnut accessions. This could be further explored by evaluating more number of germplasm lines, and the resistant lines thus obtained can be used in the breeding/crop improvement programme.

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IMPROVEMENT IN OIL CONTENT AND QUALITY BY SOME PHENOLS IN RAYA (*BRASSICA JUNCEA* L. CZERN & COSS)

LAKHVIR SINGH, RAJINDER SHARMA and R.K. RAHEJA*
Department of Botany, Punjab Agricultural University Ludhiana-141004.

Phenolic compounds have been reported to act as analogues of growth hormones (Wain and Taylor, 1965). Recently, an improvement in the yield and oil content has been reported in groundnut by the use of phenolic compunds (Singh and Sharma, 1982). It was, therefore, proposed to study the effect of some phenolic compounds on oil yield and its composition in Raya (*Brassica juncea* L. Czern and Coss).

The crop was raised according to the recommended agronomic practices and sprayed twice with 20 ppm Salicyclic acid (monophenol), 50 ppm Caffeic acid (diphenol) and 50 ppm Tannic acid (polyphenol) at anthesis stage. The oil content in mature seed was analysed by wide-line nuclear magnetic resonance (NMR), Newport Analyser MKIIIA, keeping gate width 1.5 gs. integration time 32 sec and R.F. level 100. Methyl esters prepared according to Luddy *et al.* (1968) were analysed by Nucon (AIMIC) Gas Liquid Chromatographic model series 5700 for oil quality.

An improvement in the oil content was obtained under all the treatments with Tannic acid as the most effective treatment followed by Caffeic acid and Salicylic acid (Table 1). Regarding fatty acids, Oleic acid (18:1) and Erucic acid (22:1) contents were increased by Caffeic acid and Tannic acid whereas Kinoleic acid (18:2) and Linolenic acid (18:3) werr decreased by all the treatments. An increase in the Oleic acid and decrease in linoleic acid has been reported in groundnut (Sharma *et al.* 1987) by the use of Salicycic acid, Caffeic acid and Atonik (an aromatic nitro compound). Ratio of saturated to total unsaturated fatty acids decreased by salicycil acid treatment over control. The increase in Erucic acid and decrease in Linolenic acid are important for commercial purposes and keeping quality respectively. Thus, with the use of phenolic compounds we can obtain mustard oil of better nutritional and commercial value as well as keeping quality.

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* Chemist (Oilseeds), Deptt. of Plant Breeding, Punjab Agricultural University, Ludhiana.

TABLE 1 Effect of some phenolic compounds on oil content and its quality in Raya CV. RLM-198.

Treat-(ment ppm)	Oil conten (%)	Fatty acid (per cent)													
		Lower FA	*16:0	16:1	18:0	18:1	18:2	18:3	20:0	20:1	20:2	22:0	22:1	24:0	Saturated unsaturated ratio
C (0)	38.00	0.44	3.05	0.30	1.01	10.17	15.94	10.25	0.36	7.48	0.69	1.61	47.22	1.22	0.08
SA (20)	39.77	0.14	2.70	0.18	0.95	10.11	14.41	9.04	1.23	8.53	1.02	0.32	50.19	1.09	0.06
CA (50)	40.00	0.83	3.55	0.12	1.28	12.40	9.65	4.06	1.21	9.53	0.39	0.28	56.26	0.50	0.08
TA (50)	40.47	0.72	3.64	0.17	1.23	11.83	10.60	4.73	0.95	8.91	0.52	0.40	55.60	0.68	0.08
C.D. at 5%	1.69	—	—	—	—	—	—	—	—	—	—	—	—	—	—

* 16:0 = Palmitic acid, 16:1 = Palmitaleic acid, 18:0 = Stearic acid, 18:1 Oleic acid 18:2 = Linoleic acid, 18:3 = Linolenic acid, 20:0 = Arachidic acid, 20:1 Eicosenic acid 20:2 = Eicosadienoic acid, 22:0 = Behenic acid, 22:1 = Erucic acid, 29:0 = Lignoceric acid

C = Control, SA = Salicylic acid, CA = Caffeic acid, TA = Tannic acid

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EFFECT OF SOWING DATES AND FERTILITY LEVE THE GRAIN YIELD OF SOYBEAN

R.K.S. RAGHUWANSHI, M.L. NEM, RAJIV UMAT **and H.S. THAKUR**
All India Coordinated Agronomic Cropping System Research **Project, JNKVV College of** Indore 452 001.

Soybean (*Glycine max* L.) is an important legume crop rich in prot *and oil (22%). Since it is a new introduction, the production technology for* yield of soybean under agroclimatic conditions of Malwa plateau is not Hence, the present investigation was taken upto find out the optimum time and fertilizer requirement for the newly released soybean varieties.

A field experiment was conducted during *kharif* seasons of 1983 and Jawaharlal Nehru Agricultural University, Campus CSR Project, Indore. Tl of the area is substropical having temperature range 23°C to 41°C in summe to 29°C in winter season. The amount of rainfall during the cropping pe 987.51 mm in 1983-84 and 863.24 mm in 1984-85. The soil of the experiment medium black cotton soil, having 246.0, 14.0 and 1036 kg/ha of available N, P_2O_5 and K_2O respectively. The experiment was laid out in the split split-plot design with four replications having sowing dates in main plots, four fertility levels in sub plots whereas varieties were assigned to sub-sub plots. Nitrogen,phosphorus and potash were applied through urea, single superphosphate and muriate of potash respectively. Full dose of N, P_2O_5, and K_5O was applied basally.

The results reveal that sowing of soybean in the first week of July produced high grain yield as compared to that sown in the last week of July in both the years of axperimentation. The yield increase in the first date of sowing of soybean was 37.09% end 128.80% higher than the second date of sowing during both the years.

Application of fertilizers @ 10:20:10 of $N:P_2O_5:K_2O$ kg/ha has produced significantly higher yield over control in the year 1983-84. However the optimum dose was found to be 20:40:20 N,P_2O_5 and K_2O kg/ha. Agrawal and Narang (1975) reported that application of 20 kg N with 80 kg P2O5/ha gave maximum average seed yield of soybean. Rehman *et al.* (1978) observed that maximum seed yield of soybean was rcorded from $N40+P_2O_5$ $40+K_2O$ 40 kg/ha. In the year 1983 the varieties JS 72-44 and Punjab-1 were comparable in grain yield, but in 1984 the variety JS 71-05, which was not tested in the previous year gave the highest grain yield of 16.9 q/ha, thus showing its superior performance over the rest.

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TABLE 1 Effect of sowing dates and fertility levels on the grain yield (q/ha) of soybean varieties (1983 84 and 1984-85)

Treatments	Grain yield (q/ha) 1983–84		Grain yield (q/ha) 1984–85
Date of sowing		Date of sowing	
1.7.1983	19.07	3.7.1984	19.45
21.7.1983	13.91	23.7.1984	8.50
CD 5%	2.45		3.07
Fertility levels (kg/ha)			
N_0 P_0 K_0	13.59		11.34
N_{10} P_{20} K_{10}	16.64		13.22
N_{20} P_{40} K_{20}	17.71		15.21
N_{30} P_{60} K_{30}	18.04		16.11
CD 5%	0.70		3.36
Varieties			
JS 72-44	17.36		14.50
JS 72-280	14.77		12.27
Punjab 1	17.33		12.17
JS 71-05	Nil*		16.94
CD 5%	0.71		3.24

*Variety not tested during 1983-84,

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RELATIONSHIP BETWEEN SEED SIZE, OIL AND PROTEIN CONTENTS IN GROUNDNUT

D.M. KALE, J.D. GADIGL and G.S.S. MURTY
Nuclear Agriculture Division, Bhahba Atomic Research Centre Bombay-400 085

Groundnut (*Arachis hypogaea* L.) is an important edible oil crop in India and hence improvement in seed oil content is of interest to the plant bereders and millers. Breeders are often confronted with the problem of preparing a truely representative seed sample from single plant produce for estimating oil percentage (OP). This problem becomes more acute when oil estimations are to be made for genotypes having different range of kernel size. The objective of this study was to find the variation with plant for seed size and observe the relation between seed size based on hundred kernel weight (HKW), with oil and protein percentages among cultivars having genetically small, medium and large kernels, when grown under non-stress conditions.

Groundnut cultivars, Chico and TGE-1 with small (<50g HKW), TG-9 and JL-24 with medium (=50g HKW) and TG-13A and TG-19A with large (> 50g HKW) kernel size were investigated. All cultivars were grown during 1985 rainy season (June-October ber) in three replications. From each cultivar, ten plants per replication were harvested at maturity (ranging between 85 to 130 days). Pods were sun dried for ten days and shelled. Ten largest kernels, uniform in size and shape were picked up and weighed. This procedure was repeated for the rest of the produce each time in every plant. The largest kernels were considered as Grade-1 and subsequent picks as Grades II, III, IV etc. Kernels with wrinkled seed coat were seperately graded and extremely under developed ones were rejected. Frequency curves for HKW in each cultivar were plotted based on 24 plants, eight from each replication. Kernels of remaining two out of ten plants per replication were also bulked to obtain plant bulk and used as control. Using about 5g seeds from each sample, oil extractions were made using Soxhlets and petroleum ether. The defatted seed meal was digested and nitrogen estimations were made using Technicon Auto Analyzer (Industrial Method No. 334-74/W/B of Technicon). Factor 5.46, was used to calculate protein percentage in kernels (KPP).

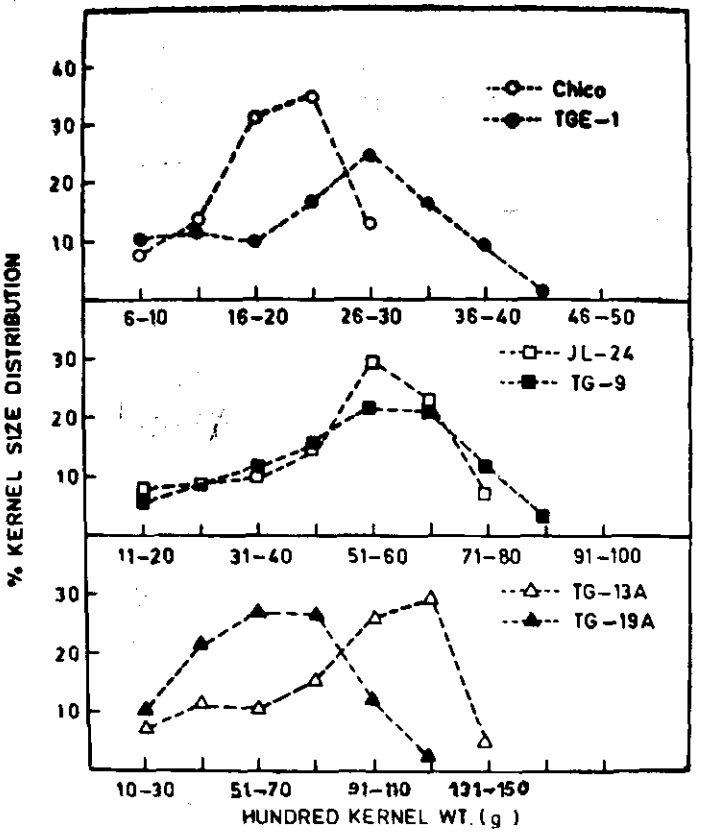
In each of the six cultivars studied, kernels of all grades were significantly different from one another in their HKW (Table 1). The percentage of under developed kernels was less than 20 in all cultivars (Fig.1). Due to higher HKW visual differences for seed size within a variety are more conspicuous in groundnut compared to other oilseeds like sesame, rape, mustard and linseed having small seed size. In general seed size differences are caused by factors like age, water and mineral deficiency, pests, diseases and other stresses. However, under non-stress conditions, the differences in kernel sizes are due to age. In groundnut, pod maturation takes about 10-16 weeks from flowering. During this period, kernel growth depends upon the availability of carbon and nitrogen assimilates. Several developing pods compete for assimilates at a given time. Since, flowering continues for a fairly longer period, kernels of different age groups, starting from under developed to well matured kernels are obtained at harvest.

TABLE 1 Hundred kernel weight, Oil percentage, Oil per kernel and Protein percentage in six cultivars of groundnut

Grade of kernels	Hundred kernel wt. (g)	Oil percentage	Oil/ kernel (mg)	Protein percentage in kernels	Hundred kernel wt. (g)	Oil percentage	Oil/ kernel (mg)	Protein percentage in kernels
	TG-13A				TG-19A			
I	143.1a	50.26b	719a	27.67b,c,d	117.3a	49.52a,b	581a	25.02a,b
II	127.8b	50.95b	651b	26.32d	95.4b	51.02a	487b	24.20b
III	108.1c	52.78a	571.c	27.59b,c,d	82.7c	50.55a,b	418c	24.14b
IV	89.3d	50.09b,c	447d	28.63a,b,c	72.3d	49.77a,b	360d	25.67a,b
V	53.3f	49.03c	261e	29.69a	57.0f	50.21a,b	286f	25.36a,b
VI ±	44.5g	46.29d	206f	29.47a,b	41.1g	43.16c	177g	26.74a
VII ±	30.1h	45.90d	138g	29.78a	28.6h	42.09c	120h	26.11a,b
Bulk	86.2e	51.16b	441d	27.33c,d	68.2e	49.16b	334e	25.98a,b
C.D. 1%	1.0	1.14	8	1.89	0.6	1.54	9	1.98
	TG-9				JL-24			
I	87.8a	51.99d	457a	29.09a	87.3a	47.14c	412a	29.52b,c
II	76.1b	53.56b	407b	26.78b	72.5b	49.28a,b	357b	28.45c,d,e
III	59.4c	54.76a	323c	25.38b	59.4c	49.61a	295c	28.13d,e
IV	48.6e	55.33a	269d	26.40b	48.7d	50.31a	245d	27.34e
V	35.9f	52.41c,d	188e	25.98b	39.9e	47.72b,c	190f	29.32b,c,d
VI ±	31.5g	49.06e	155f	26.78b	38.0f	41.10d	168g	31.50a
VII ±	10.1h	39.14f	39g	26.53b	10.7g	35.64e	38h	30.41a,b
Bulk	51.5d	53.00b,c	272d	26.45b	48.9d	47.77b,c	233e	28.28d,e
C.D. 1%	0.8	0.90	6	1.47	0.5	1.78	9	1.23

	TGE-1				Chico			
I	44.4a	51.28a,b	228a	27.38	30.80a	50.35a	155a	155a 26.13a
II	35.7b	51.52a	184b	27.39	22.97b	50.98a	117b	24.98a,b
III	20.6d	51.72a	105d	27.18	17.70d	51.79a	91d	23.27b
IV ±	13.3e	44.75c	60e	27.30	10.60e	43.51b	46e	26 14a
Bulk	23.4c	50.30b	119c	27.55	19.69c	50.87a	99c	24.60a,b
C.D. 1%	0.7	1.20	4	N.S.	0.35	1.54	3	2.29

Different superscripts within a column of a cultivar, indicate significance at 1% level. ±-indicates Grades with under developed kernels. Plant bulk. N.S.=not significant.



In all cultivars, maximum oil percentage (OP) was observed (Table 1) in medium size kernels (Grade III, in TG-13A, TG-19A, TGE-1 and Chico; Grade IV, in TG-9 and JL-24). These results confirm similar findings of Mishra and Gaur (1982), in large kernel size cv. TG-1. In the present studies, OP differences within a cultivar were not significant for majority of seed grades in small seed types, TGE-1 and Chico, as well as in large seeded TG-19A. However, there were significant differences among the kernel in large seeded TG-19A. The high oil mutant TG-9 (Patil, 1973) had maximum OP (55.33%). It was also superior in OP to the other cultivars in all corresponding samples with similar HKW. Under developed kernels in all cultivars had less OP.

With increase in HKW (Table 1), there was a relative increase in oil per kernel (OPK) as seen in Grade-I samples where OPK was the highest. This indicates that oil continues to accumulate in the kernels upto maturity and apparently appear to be related with the age of kernel.

Protein percentage in kernels (KPP), was higher in the under developed as well as well developed kernels in all cultivars. However, in seven out of eight samples

studied in TG-19A and TG-9 and four of five in Chico, KPP differences were not significant (Table 1). In the case of TGE-1, there was no significant variation for KPP in different grades.

TABLE 2 Correlation coefficients in six groundnut cultivars

	Oil percentage	Oil per kernel	Protein percentage in kernels
TG-13A			
Hundred kernel wt	0.7718**	0.9986**	-0.7589**
Oil percentage		0.8001**	-0.6831**
Oil per kernel			-0.7674**
TG-19A			
Hundred kernel wt	**0.7587****	0.9979**	-0.5532**
Oil percentage		0.7948**	-0.6200**
Oil per kernel			-0.5809**
TG-9			
Hundred kernel wt.	**0.6868****	0.9979**	0.4461*
Oil percentage		0.7212**	-0.0574
Oil per kernel			0.4016
JL-24			
Hundred kernel wt.	**0.7094****	0.9965**	-0.3768
Oil percentage		0.7563**	-0.7802**
Oil per kernel			-0.4404*
TGE-1			
Hundred kernel wt.	0.6470**	0.9990**	0.1027
Oil percentage		0.6763**	0.0035
Oil per kernel			0.1094
Chico			
Hundred kernel wt.	**0.6342***	0.9964**	0.1349
Oil percentage		0.6938**	-0.5403*
Oil per kernel			0.0731

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

Correlation coefficients between HKW, OP, OPK and KPP are shown in Table2. There was significant positive correlation among HKW, OP and OPK in all cultivars. Since, OPK and HKW showed a correlation of 0.99 in all the cultivars, any observed variation in OP within a cultivar could only be due to differences in 'non-oil' components. In the case of large kernel genotypes, the negative relation between HKW and KPP might be due to increased sugar concentration in the kernels (Gadgil and Mitra, 1983). Based on these observations, it can be concluded that in the absence of reduction in OPK the quantity of 'non-oil' components constituting proteins and carbohydrates appear to be primarily responsible for an apparent drop in OP in well developed Grade I and II kernels. Therefore, in genetic experiments more reliable results can be expected if medium size kernels are used while sampling for oil content.

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EFFECT OF DATES OF SOWING AND ROW SPACINGS ON YIELD AND ITS COMPONENTS IN NIGER

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

India is the largest niger growing country with an area of 0.6 million ha. and production of 0.15 million tonnes. But the productivity of the crop is very low (2.5 Q/ha). Its acreage yield in Orissa is 0.16 million ha. and is generally cultivated in marginal and slopy lands in the hilly tracts of the state. As it is mostly cultivated by the tribals, improper crop husbandry is the most important factor limiting the productivity of the crop. Information on ideal sowing time and optimum plant population of niger is quite limited. So the present investigation was undertaken to determine the optimum sowing time and row spacing of niger for increasing the productivity.

Field trials were conducted at Semiligude during Kharif, 1981, 1982 and 1983 in split-plot design with three replications, with dates of sowing in main-plots and row spacings in sub-plots. There were eight dates of sowing (Table 1) starting from onset of monsoon at 10 days intervals and three row spacing 20, 25 and 30 cm. The best variety was IGP-72 and plot size was 5 m × 3 m. A basal dose of 10 kg N and 20 kg P_2O_5/ha was applied and another 10 kg N/ha was applied 21 days after germination. Observations on days to maturity, 1000-seed wt. and seed yield were taken on plot basis and data on plant height, branches/plant, capatula/plant and seeds/capitulum were recorded on ten random plants per plot. Pooled analysis of three years date was done for all the characters.

Analysis of variance of date indicated significant differences among the dates of sowing for all the characters studied (Table-1). Days to maturity was the longest (130.3 days) in D_1 and there was significant reduction in days to maturity with delayed dates of sowing upto 40 days after onset of monsoon (D_5), after which the reduction was very less. Plant height was higest in D_1 and decresed significantly with delayed sowings upto D_8. Number of Branches/plant was highest for D_1, which was at par with D_2 to D_4 and delayed sowing showed significantl reduction in brenches plant due to decrease in growth vigour. Sowing from the on set of monsion (D_1) upto 30 days. after on set of monsoon (D_4) did not show significant difference in capitula/plant and 1000-seed wt., but delayed sowing beyond D_4 (i.e. D_5 - D_8) showed significant decrease in these traits. Seeds/capitulum gradually increased from D_1 to D_4. after which there was a significant reduction. The seeds/capitulum was highest at D_4 (11:39); but was at par with D_3. The lower seed number/capitulum in initial sowing dates (D_1 and D_2) might be due to low seed set owing to continuous heavy rains at peak flowering (15th Aug. to 15th Sept.). The significant decrease in capitula/plant, seeds/capitulum and 1000-seed wt. in sowings beyond 30 days after onset of monsoon (i.e. D_5 to D_8) might be due to moisture stress.

Considering yield of individual years, during 1981 D_3 gave the highest yield of

TABLE 1 Yield and yield component traits of niger under different dates of sowing and row spacings.

Treatments		Pooled over 1981, 1982 and 1983					Seed yield (kh/ha)			
		Days to Maturity	Plant ht. (cm)	Branches/ plant	Capitula/Seeds/ capitulum	1000–seed (grm) wt.	1981	1982	1983	Pooled
Dates of Sowing										
Onset of monsoon	(D 1)	130.3	180.1	12.3	52.7	9.73	3.41	436.1	211.7	448.4	365.4
10 days afterwards	(D 2)	122.3	168.3	10.7	53.3	10.24	3.43	495.8	207.0	454.4	385.7
20 days afterwards	(D 3)	115.7	158.9	10.0	49.3	11.35	3.40	516.6	191.8	494.1	400.8
30 days afterwrds	(D 4)	109.7	149.6	9.8	50.6	11.38	3.39	459.7	224.9	502.0	395.5
40 days afterwards	(D 5)	103.3	132.8	8.6	37.7	9.68	3.27	384.7	99.2	254.0	246.0
50 days afterwards	(D 6)	102.0	101.1	5.8	30.4	9.41	3.21	295.1	68.1	204.4	198.2
60 days afterwatds	(D 7)	98.7	91.4	4.9	23.3	9.28	3.08	154.2	68.1	105.2	109.2
70 days afterwards	(D 8)	97.3	72.1	4.3	18.2	8.97	2.91	44.9	70.1	101.2	72.1
C.D. (5%)		5.8	9.4	2.7	10.2	1.03	0.09	82.7	**48.7**	**18.5**	**19.3**
Row Spacings											
20 Cm.		108.6	148.2	6.1	35.5	9.24	3.22	158.5	137.7	287.2	261.1
25 Cm.		110.9	145.5	8.8	45.2	10.38	3.27	343.8	150.6	354.2	282.9
30 Cm.		110.7	145.6	10.0	50.8	10.40	3.30	352.4	139.9	319.9	270.7
C.D. (5%)		N.S.	N.S.	0.9	3.7	0.47	N.S.	N.S.	N.S.	11.2	N.S.

Dates of onset of monsoon (D 1) were 2.7 1981, 22.6.1982 and 26.6.1983

Average Rainfall pattern during 1981, 1982 and 1983

	June	July	August	September	October	November	December
Rainfall (mm)	196	256	321	222	107	1	5
No. of rainy days	14.0	21.0	26.3	19.	3.77	**0.7**	**0.3**

516.6/kg ha and was at par with D_1, D_2 and D_4. Similarly during 1982, D_4 gave the highest yield of 224.9 kg/ha and was at par with D1, D2 and D3. During 1983, D4 gave the highest yield 502 kg/ha and was at par with D_3, while D_1 and D_2 gave significantly lower yield. During all the years delayed sowings beyond D_4 (i.e. D_5 - D_8- showed significant yield reduction. Pooled analysis of yield data showed that the high) est yield of 400.8 kg/ha was obtained on sowing 20 days after the onset of monsoon (D3) and was at par with D_2 and D_4. Thus sowing from 10 days to 30 days after onset of monsoon gave higher yield. Also, higher seed yield of niger following sowing 10 days and 10-20 days after the onset of monsoon was reported from Chindwara (M.P.) and Kanke (Bihar) respectively (Anonymous, 1984). In this Eastern Ghat High Land Zone, after few pre-monsoon showers in the second and third week of June, heavy rains start in the last week of June. During each year of the study, the onset of monsoon was on the dates 2.7.81, 22.6.82 and 26.6.83; the average date of onset being 27th June. As better yield was obtained from sowing between 10 to 30 days after onset of monsoon (D_2 to D_4), the ideal sowing time for niger in the region is second week to last week of July. The significant yield reduction for D_1 might be due to reduced seeds/capitulum. The drastic and significant yield reduction with delayed sowing beyond 30 days after onset of monsoon (D_5-D_8) might be due to moisture stress, which has resulted in reduction in yield component traits.

The row spacings did not show significant differences in days to maturity, plant height, 1000-seed wt. and seed yield. Though there was significant increase in branches/ plant, capitula/plant and seeds/capitulum with increase in row spacing up to 30 cm, the increase in these traits were not enough to compensate for the decrease in plant population. However, row spacing of 25 cm gave the highest average yield of 282.9 kg/ha, though it was not significantly different from yield at 20 and 30 cm. row spacings.

Thus for higher productivity of niger in the region, best row spacing is 25 to 30 cm. and optimum sowing time is 2nd week to last week of July.

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EFFECT OF N,P AND K FERTILIZERS ON SEED YIELD AND OIL CONTENT OF SAFFLOWER IN DROUGHT PRONE LATERITIC TRACT OF WEST BENGAL

A.ZAMAN
Department of Agronomy Bidhan Chandra Krishi Viswavidhyalaya Kalyani-741 235, West Bengal.

Safflower (*Carthamus tinctorius* L) has acquired the reputation of being drought resistant and suitable crop to be grown in dry areas (Weiss, 1971) due to its partially xerophytic nature in addition to deep and extensive tap root system. As such, it can easily be introduced as annual oilseed crop in semi-arid region of West Bengal under restricted irrigation resources (Zaman, 1986). As the crop is a new introduction in this area, proper manuring of the crop is one of the major factors to evolve a suitable crop management practices.

Field trials were conducted to find out the effect of major nutrients like N, P_2O_5 and K_2O on seed yield and oil content in seed of safflower at the Regional Research Farm of Bidhan Chandra Krishi Viswavidyalaya located at Jhargram (West Bengal) for consecutive two *rabi* seasons of 1983-84 and 1984-85 in the laterite soil of semi-arid region. The research farm was situated under rain shadow area and has got hot humid climate subjected to often drought inspite of 1307 mm mean annual cainfall (average of 50 years) unevenly distributed. Out of total annual rainfall 85 percent was received in 4 months (June to Sptember) and winter rain was meagre to about 8-9 per cent of the total annual rainfall in a year.

The textural classification of the surface soil (0-30 cm depth) was sandy loam with 44, 29 and 27 per cent sand, silt and clay, respectively which was poor in fertility status, light in nature, acidic in reaction, oxisols in order, low in moisture and nutrient retentioh capacity- The dominst type of 9f clay mineral was kaolinite with very low in cation exchange capacity. The important physico-chemical properties of the soil were given in Table 1.

A set of field experiment was conducted with three levels of nitrogen (0, 60 and 120 kg N/ha) in main plots and three levels of phosphorus (0, 40 and 80 kg N/ha) in sub-plots in a split plot design replicated thrice and another set of field experiment was conducted with four levels of potassium (0, 40, 80 and 120 kg K_2O/ha) in a Randomised block design with five replications. An uniform dose of 40 kg K_2O/ha for the former and 120 kg N and 40 kg P2O5/ha for the latter experiment were applied. The nitrogen as urea applied in 2 equal split, one half at sowing as basal and remaining half was top dressed at first irrigation and entire P_2O_5 and K_2O as single super phosphate and muriate of potash, respectively were applied as basal during land preparation.

Safflower (cv A 300) at a seed rate of 20 kg/ha was sown during the mid to last week of October taking full advantages of winter shower of 197 and 58 mm in respective years prior to sowing with a spacing of 50 cm in between rows and 20 cm in between

TABLE 1 Physico-chemical properties of the experimental soil

Particulars	0 - 30 cm soil depth
Field capacity (%) (W/W at 0.3 bar tension)	17.95
Wilting point (%) (W/W at 15.0 bar tension)	7.05
Bulk density (g/cc)	1.54
Soil pH (1:2 soil : water Supension)	5.70
Hydraulic conductivity of undisturbed soil (cm/hr)	0.43
Organic carbon (%)	0.32
Total N (kg/ha)	65 .00
Available P_2O_5 (kg/ha)	31.00
Exchangeable K_2O (kg/ha)	110.00

plants. The crop received three irrigations of 50 mm depth each at branching, flowering and seed development stages occuring at 40, 100 and 130 days after sowing, respecvely in addition to 30.6 and 10.0 mm seasonal rainfall during crop growth period. The crop was harvested during last week of March to first week of April at about 160 days maturity.

The seed yield of saffiower was increased significantly with increased levels of nitrogen fertilisation and maximum seed yield was obtained with 120 kg/ha N during both the years at a maximum increment of 5.87 kg seed/kg of applied N, on an average of two years (Table 2). Singh and Singh (1984) reported the similar response upto 120 kg N/ha to give highest seed yield of safflower under irrigated condition at Chambal Command in Rajasthan. Nitrogen levels increased the oil content per cent significantly upto 60 kg N/ha beyond which it was depressed. Dasgupta *et al.*, (1969) also reported that nitrogen increased oil content in seed of safflower upto certain limit after whcih it has a depressing effect. Nitrogen levels increased the stalk yield of safflower significantly but average values of harvest index decreased appreciably; might be due to proportionate increase in stalk yield in comparission to seed yield at higher levels of N-application (Table-3).

The seed yield of safflower was influenced significantly with increasing levels of phosphorus upto 40 kg P_2O_5/ha which was satistically at par with seed yield obtained at 80 kg P2O5/ha and the maximum increment of 13.05 kg seed—kg of applied P_2O_5 was obtained at the level of 40 kg P_2O_5/ha (Table 2). Phosphate fertilisation under irrigated condition found to be beneficial in augmenting seed yield of safflower as reported by Singh and Kaushal (1974). The per cent oil content in seed was significantly improved with higher levels of P_2O_5 - application upto 80 kg/ha (Table 2). Sharma and Verma (1982) also reported the similar result. The stalk yield of safflower was also

TABLE 2 Seed yield and oil content of safflower as influenced by N, P_2O_5 and K2O-levels

Nutrient level (kg/ha)	Seed yield (q/ha)			Increment (kg-seedl/kg nutrient	Oil content in seed		
	1983–84	1984–85	Pooled		1983–84	1984–85	pooled
N-levels							
0	10.78	11.23	11.00	—	29.26	29.58	29.42
60	13.05	14.12	13.59	4.32	29.53	29.74	29.64
120	16.81	17.41	17.11	5.87	29.41	29.66	29.54
CD (0.05)	0.57	0.20	0.35		0.08	0.11	0.08
P_2O_5 Levels							
0	9.97	10.63	10.30	—	29.07	29.46	29.26
40	15.09	15.95	15.52	13.05	29.44	29.69	29.57
80	15.59	16.18	15.89	0.93	29.69	29.83	29.76
CD (0.05)	0.51	0.25	0.34		0.10	0.13	0.11
K_2O-levels							
0	17.20	19.13	18.17	—	28.66	29.60	29.13
40	20.42	22.00	21.21	7.60	28.90	29.90	29.40
80	20.60	22.17	21.39	0.45	29.12	30.10	29.16
120	20.62	22.37	21.50	0.28	29.26	30.26	29.76
CD (0.05)	0.63	0.82	0.69		NS	NS	NS

NS = not significant

found to increase significantly with higher levels of P_2O_5 but harvest index values progressively declined, might be due to more stalk production at higher levels of P_2O_5 application in comparision to seed yield of safflower (Table 3).

Increased levels of K2O-application increased the seed yield of saffiower significantly upto 40 kg K_2O/ha with a maximum increment of 7.60 kg seed/kg of applied K_2O (Table 2). Prasad and Mahapatra (1970) indicated earlier to have a good response of potassium in red and laterite soil of West Bengal. Zaman (1986) also reported the similar response of safflower to pottassium application under interently poor fertility status of the soil. The response of safflower to K_2O-application to produce stalk was found similar to that of seed yield (Table 3). The harvest index (Table 3) and oil content in seed (Tanle 2) were not affected by levels of K_2O-application.

TABLE 3 Stalk yield and harvest index of safflower as influenced by N,P_2O_5 andK_2O-levels

Nutrient levels (kg/ha)	Stalk yield (q/ha)			Harvest index (%)		
	1983–84	1984–85	Pooled	1983–84	1984–85	Average
N-levels						
0	22.27	22.82	22.55	32.62	32.98	32.80
60	30.05	31.49	30.77	30.28	30.96	30.62
120	41.93	44.02	42.98	28.62	28.34	28.48
CD (0.05)	1.30	1.37	1.11	—	—	—
P_2O_5-levels						
0	20.60	21.87	21.24	32.61	32.71	32.66
40	34.82	36.35	35.59	30.23	30.50	31.37
80	38.87	40.11	39.49	28.63	28.74	28.69
CD (0.05)	1.17	0.79	0.95	—	—	—
K_2O-levels						
0	49.33	56.63	52.88	25.85	25.25	25.55
40	59.00	62.13	60.57	25.71	26.15	25.93
80	59.33	62.30	60.82	25.77	26.25	26.01
120	59.33	62.50	60.92	25.29	26.36	25.83
CD (0.05)	1.99	2.18	1.97	—	—	—

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SIPING BOROK' (*JHUM TIL*) - SOURCE OF SOME VALUABLE GENES

B. SASIKUMAR and S. SARDANA
ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra 799210 West Tripura.

Sesamum is a major oilseed crop of Tripura. Improved sesamum varieties are relatively new to the State. However, some varieties of sesamum locally known as 'Siping borok' (*Jhum* til) have been cultivated by the *Jhum* farmers as well as by the settled cultivators of the State since very old time. The seeds have been used for religious ceremonies besides extracting oil. *Jhum* til is mainly grown in mixture with rice, *mesta*, cotton and vegetables on slopes and tops of the uplands. The present note deals with the agronomic features of this sesamum.

The seeds were collected from different localities and grown during the crop season (July-Nov.) in 1987 at ICAR Research Complex, Tripura Centre alongwith 26 improved sesamum varieties in 2 replications. No variation was observed among the local collections except for the seed colour. Two types of seed colour viz. white and black were observed in the material. The leaves were trilobiate with highly serrated margins. The plants were characterised by very slow growth rate, tall habit and late maturity. Flowering has got 2 or more peaks. There is no lodging. Capsules and seeds were smaller Maturity is nonsynchronous. The branches were confined to the upper portion of the stem which gave an appearance of a broom. The stem was rectangular with ridges. The important Agronomic traits are given in Table 1.

TABLE 1 Agronomic features of '*Jhum* til'

Days to first flower	—	75
Days to 50% flowering	—	85
Plant height (cm)	—	151
No. of branches/plant	—	5
No. of capsules/plant	—	46
Capsule length (cm)	—	2.0
No. of seeds Capsule		36
1000 seed weiget		1.34 g.
single plant yield	—	2 2 g.
Days to maturity		127

It was observed that the plant was resistant/tolerant to *phytophthora* blight and tolerant to leaf curl under field conditions. All the *Jhum* til plants (200) were free from the infection of *phytophthora* while the improved varieties (26) grown alongwith it suffered heavily due to *phytophthora* blight. This might be the main reason for its

wide adoption by the farmers inspite of its poor yield. It could be successfully utilised as source of resistance to these serious diseases of sesamum since other source of resistance to these diseases are limited.

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ROLE OF AMINO ACIDS IN RELATION TO APHID (*LIPAPHIS ERYSIMI KALT.*) RESISTANCE IN CRUCIFEROUS SPECIES

R.S. MALIK
Division of Genetics Indian Agricultural Research Institute, New Delhi-110012.

ABSTRACT

The racemes of different species and cultivated varieties of cultures were analysed for free amino acid content. Significant differences were observed between resistant (13.7 mg/g) vs susceptible (20.3 mg/g) and tolerant (15.3 mg/g) vs susceptible (20.3 mg g) groups with regard to free amino acids. The per cent loss in free amino acid content due to aphid infestation was significantly higher in susceptible (70.9%) than resistant (24.0%) and tolerant (40.5%) groups. The fecundity of aphids was found positively correlated with free amino acid content of the plants.

Key words Resistant, tolerant, susceptible, free amino acids, aphid infestation, aphid fecundity.

INTRODUCTION

There may be several factors responsible in determining the host by an insect (Painter, 1951; Horber, 1972) but presence or absence of specific food material in respect of quality or quantity in the host is very important factor for consideration (Kennedy and Booth, 1951). Therefore, to understand the aphid-plant relationship in cruciferous species, the effect of free amino acids on the multiplication rate of aphids was investigated and the results have been presented in this communication.

MATERIALS AND METHODS

The plant material listed in Table 1 and 2 was screened for aphid infestation and fecundity for two years under natural aphid infestation. The whole material was classified into three non-overlapping categories i.e. resistant, tolerant and susceptible groups (Malik and Anand, 1984). The plants of these groups were analysed by the method of Lawrence *et al.* (1959) for extraction of total free amino acids and then their content was determined by the Ninhydrin method (Rosen, 1957) and expressed in terms of mg alanine/g of moisture-free and fat-free powdered material.

Plant samples for biochemical analysis were collected at 50% flowering. In order to maintain uniformity in the metabolic processes, samples in all cases were collected between 8.00 and 9.00 AM. The top six inches of tertiary branches were plucked and air-dried for analysis as this is the part which is more infested by the aphids. Two such samples were collected from each variety/species from both aphid infested and non-infested racemes. The contents in infested samples were used to find out the percentage loss of free amino acids in comparison to non-infested ones.

The analysis of variance for randomised block design and correlation coefficient was adopted from Steel and Torrie (1960). The mean values were tested for significance using critical difference (C.D.) value.

RESULTS

There was wide variation with regard to aphid fecundity and free amino acid content in non-infested racemes not only between the groups but also within the groups of cruciferous species and cultivated varieties of *Brassica* (Table 1 and 2). The range in free amino acids of cruciferous species was observed from 8.6 in amphidiploids (*B. chinensis* × *B. nigra*) to 24.7 mg/g im B. *narinosa*. Significant differences were observed between resistant vs susceptible and tolerant vs susceptible but not between resistant vs tolerant.

The aphid caused maximum losses in free amino acid content in susceptible (70.9%) and minimum in resistant (24.0%) group. Highly significant differences were observed in all the three groups in respect of losses caused by the aphids in free amino acid content.

The overall range of free amino acid content in non-infested raceme of cultivated varieties of *Brassica* varied from 12.6 in E.S. 10 variety of *B. juncea* to 29.7 mg/g in C-4 variety of *B. campestris* var yellow *sarson* (Table 2). The highest mean value of free amino acid content was observed in *B. campestris* var yellow *sarson* group (22.9 mg/g) followed by *B. campestris* var. *toria* (both were highly susceptible to aphid) and lowest in *B. juncea* group (16.5 mg+g). All the three groups of *B. campestris* i.e. yellow *sarson* brown *sarson* and *toria* (highly susceptible to aphid) differed significantly in amino acid content from *B. juncea, B. napus* and *B. nigra* except *B. napus* which did not differ from *toria*.

The loss of free amino acid content due to aphid infestation ranged from 6.5 in *B. napus* variety Tower to 60.6 per cent in *B. campestris* var. yellow *sarson* strain C-4. The maximum loss in amino acids was found in yellow *sarson* (43.3%) and minimum in *B. napus* group (19.8%). All the three groups *B. campestris* differed significantly from *B. juncea, B. napus* and *B. nigra* in respect of loss of free amino acids.

The fecundity of aphids was found positively correlated with free amino acid content ($r=0.48^{**}$) of the plant.

DISCUSSION

Nutritional requirements of the plant sucking insects especially aphids have been studied with considerable success by rearing them on chemically defined diets. In case of *Myzus persicae* and *Acyrthosiphon pisum*, it has been observed that different sucrose and amino acid levels in the diets effect probing and settling, survival and larval growth and development (Mittler and Dadd, 1965 a and b; Dadd and Mittler, 1965 and Auclair 1956). Pant (1973) reported that *Lipaphis erysimi* could select their food on the basis of nutritional superiority depending on the quantitative composition of the food stuff. He further observed that the growth (not survival) of *L. erysimi* nymphs was markedly influenced by the total amino acid concentration in the diet.

TABLE 1 Free amino acid content and their losses due to aphid in the raceme of Cruciferous species.

Species	Aphid * fecundity 5 ×	Free amino acids (mg/g) Not-infested racemes	Infested racemes	% loss
Resistant group				
B. integrifolia	172	13.7	12.0	12.4
B. carinata	215	12.1	8.3	31.
B. alba	225	19.3	12.4	35.7
Eruca sativa, Swedish	117	11.9	9.4	21.0
Crambe abyssinca	135	11.2	9.0	19.6
Mean	173	13.7	10.2	24.0
Tolerant group				
B. japanica	324	10.3	9.4	8.7
B. nigra, Loca	357	13.8	10.3	25.4
B. amarifolia	367	20.2	10.1	50.0
B. tournefortii	264	14.2	9.9	30.3
B. napus, Turret	442	17.1	12.0	4.
B. oleraca, Snow **Ball-16**	408	9.4	4.7	50.0
B. juncea, Local	387	13.2	7.6	42.4
B .rapa, Pusa Sweti	373	15.3	9.9	35.3
Raphanus sativas, Pusa Deshi	415	9.9	5.6	43.4
(*B. chinensis* × *B. oleracea*)	374	11.2	5.2	53.6
B. campestriss × *B, oleracea*	386	22.8	17.5	23.4
B. chinensis × *B. nigra*)	411	8.6	5.4	37.2
(*B. pekinensis* × *B. nigra*)	477	20.7	8.8	37.5
(*B. narinosa* × *B. nigra*)	461	21.6	10.9	49.5
(*B. japonica* × *B. nigra*)	432	21.7	9.0n	58.5
Mean	383	15.3	9.1	40.5
B. chinensis	573	18.4	9.5	48.4
B, narinsa	543	24.7	5.4	78.1
B. pekinsis	589	16.2	4.5	72.2
B. campestris var. *toria*	654	19.4	5.8	70.1
B. campestriss (Zero erueic)	572	24.7	6.3	74.5
Camelina sativa	651	18.4	3.9	78.8
Mean	597	20.3	5.9	70.9
C.D. (p=0.05%)	113	1.70	0.71	6.77

* Two years mean

TABLE 2 Free amino acid content and their losses due to aphid infestation in the racemes of cultivated varieties/species of *Brassica*

Species (1)	Aphid fecundity 5 × (2)	Free amino acids (mg/g)		% loss due to aphid (5)
		Not-infested raceme (3)	Infested raceme (4)	
B. juncea				
Appressed mutant	595	14.8	9.4	36.4
E.S. 10	620	12.6	9.9	21.4
T. 59	432	16.2	13.0	19.4
Laha 101	468	18.4	15.3	17.1
R.L. 18	513	20.2	13.5	33.3
Mean	526	16.5	12.2	25.5
B. napus				
72/244/6	397	17.1	14.8	13.1
Tower	319	20.7	19.3	6.5
Zephyre	357	20.2	14.8	26.7
Brownski	405	20.2	18.0	11.1
Oro	368	23.8	13.9	41.5
Mean	369	20.4	16.2	19.8
B. nigra				
Local	322	17.2	15.0	13.0
E.C. 24346	317	15.5	13.0	15.8
I.B. 1861	403	18.0	14.8	17.5
I.B. 1872	368	16.7	12.5	24.7
I.B. 1882	427	16.6	10.2	38.5
Mean	432	16.8	13.1	21.9
B. campestris var. yellow *sarson*				
I.B. 1026	690	23.8	13.9	41.5
I.B. 1054	590	18.4	13.0	29.3
I.B. 1078	568	18.9	13.9	26.3
Y.S. 51	670	20.7	10.8	47.8
Y.S. 144	629	26.6	11.7	54.3
C 4	587	29.7	11.7	60.6
Mean	622	22.9	12.5	43.3

TABLE 2 Continued

(1)	(2)	(2)	(4)	(5)
B. campestris var. brown *sarson*				
Assam Mass Selection	397	15.3	11.1	27.4
Suphala	578	21.6	18.5	51.1
B.S.H. 1	560	21.6	12.5	42.0
Pusa Kalyani	509	18.9	13.4	29.1
D.C. 1	611	21.6	10.9	49.5
Mean	531	19.8	13.3	39.8
B. campesrtis var. *toria*				
I.B. 140	587	19.2	13.8	27.9
I.B. 1098	321	18.8	16.0	18.2
Type 9	716	19.4	10.8	44.5
Type 36	670	21.6	9.1	57.6
Karmaha	645	22.3	12.6	43.4
Mean	588	20.5	12.5	38.3
C.D. (p=0.05%)	94	1.26	0.93	6.77

In the present studies also quantitative differences in free amino acid contents observed between different groups of cruciferous varieties/species were appently the factors involved in determining resistance or susceptibility to aphid (*L. erysimi*) infestation as amino acid content in susceptible varieties/species were found significantly higher than resistant and tolerant. Similarly, Auclair *et al.* (1957) reported that pea varieties susceptible to *A. pisum* contained comparatively higher (almost twice) concentrations of free amino acids and amides than resistant ones; and the rate of feeding on the later was even less then half that on the susceptible varieties (Auclair, 1959). These findings are further supported by Srivastava and Auclair (1974). The resistant group of varieties could not attract more aphids and those were feeding on them might have not obtained enough of each essential amino acid per unit of time. Retnakaran and Beck (1968) reported that 11 amino acids were essential for growth and reproduction of *A. pisum*. Thus the aphids could not sustain optimum growth and reproduction on resistant varieties on account of the deficiency of the amino acid content in them. In other words, on resistant species, growth and reproduction of aphids proceeded at a slower rate than the varieties high in free amino acids thereby contributing to resistance (Auclair, 1957) consequently the total aphid population on resistant species was smaller. On the other

hand susceptible group of species, being rich in amino acids provided better nutritional conditions for aphid multiplication due to which a large aphid population was observed on them.

The attraction of more aphids towards the susceptible species which were having sufficient amount of free amino acids and causing severe losses in their contents indicated that free amino acids of the plant was phagostimulatory to aphids, *L. erysimi*. As aphids after landing probe the plants at different sites (Hennig, 1963 and 1966) presumably to get information about the internal chemical and physical properties of the substrate. With this information the aphids then select their hosts on the basis of nutritional superiority of the foodstuff (Kennedy and Booth, 1951).

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UPTAKE OF NUTRIENTS AND QUALITY OF SUMMER SUNFLOWER CULTIVARS INFLUENCED BY SOWING PERIOD

S.D. PATIL, P.S. POL, S.H. SHINDE and N.K. UMRANI
Department of Agronomy, Mahatma Phule Agricultural University, Rahuri-413 722 (M.S)

The wide gap of 10 to 12 lakh tonnes per annum in the production and consumption of edible oils in the country causes a considerable drain on valuable foreign exchange on imports. The present rate of consumption of 8-10 g/capita/day is very low as against 30 g recommended. Sunflower is gaining prominence because it has wider adaptability as compared to groundnut, can be grown in all the seasons and thus can find a place in a wide range of systems (Singh and Singh, 1973). Even though, this crop can be grown all the year round, it responds to the seeding time in a particular season (Hebeebullah et al., 1983). There is very little work carried out in Maharashtra especially for assessing the potential of new cultivars across the dates of seeding in sumer season under irrigation.

A study was, therefore, carried out at Central Campus, Rahuri, in summer, 1984. The trial was conducted in split plot design with five dates of seeding (11th Feb, 3rd March, 25th March, 19th April and 11th May) as main plot treatments and three varieties (EC-58414, Morden and Surya) as sub-plot treatments replicated three times. The soil was clayey in texture, alkaline in reaction (pH 8.33) low in available nitrogen, medium in phosphorus and rich in potash. The sowing was done by dibbling as per treatments at 45×30 cm^2 spacing. The data pertaining to uptake of nutrients, computed by multiplying the concentration of the nutrients in various plant parts and the dry matter of the respective plant parts at harvest. The data are not statistically analysed and the inferences are therefore based on mean values. The protein content in grain was arrived by multiplying N content (%) in grain and a factor of 6.25. Similarly, the protein yield was derived by multiplying the per hectare grain yield and protein content. These data are also not statistically analysed. The oil content and oil yield and seed yield were analysed statistically.

The relevant data in Table 1, indicated that the uptake of nitrogen, phosphorus and potassium nutrients was maximum (90.35, 16.00 and 100.69 kg NPK/ha respectively) when sunflower was sown on 19th April while the values of uptake recorded in 25th March sowing were the minimum (62.23, 10.83 and 61.84 kg NPK/ha respectively). The cultivars tried also differ in uptake of nutrients. Surya utilized the highest levels of NPK with 98.09, 16.72 and 108.35 kg/ha uptake respectively. The Morden ranked the last with uptake values of 70.69, 11.82 and 86.67 kg NPK/ha respectively. The quality as judged by protein content in seed revealed that it reduced progressively with successive delay in sowing while the oil content in seed was the highest when the crop was sown on 19th April (41.20%) which was significantly more than that recorded in rest of the earlier and delayed seedlings. However, the oil yield was the highest (10.39 q/ha) when sown on 11th February which was significantly more than that of 11th May sowing, but was at par with the rate of the seeding times. Surya was the first in pro-

TABLE 1 Uptake of nitrogen, phosphorus and potassium nutrients and quality parameters as influenced by sunflower varieties on various sowing date

Treatments	Uptake of nutrients (kg/ha)			Protein content (%)	Protein yield (q/ha)	Seed yield (q/ha)	Oil content (%)	Oil yield (q/ha)
	Nitrogen	Phosphorus	Potassium					
A. *Sowing dates*								
1. 11th February	82.60	14.93	80.42	18.18	4.73	26.00	40.04	10.39
2. 3rd March	89.76	14.96	92.89	17.53	3.92	22.36	40.49	9.05
3. 25th March	62.23	10.83	61.84	17.52	3.16	18.01	40.58	7.64
4. 10th April	90.35	16.00	100.69	16.90	3.69	21.84	41.20	9.03
5. 11th May	82.13	14.30	79.46	16.94	2.72	16.03	39.66	6.36
S.E. ±	—	—	—	—	—	1.28	0.21	1.28
C.D. at 5%	—	—	—	—	—	4.20	0.67	4.15
B. *Varieties*								
1. ED-68414	87.47	14.22	95.36	18.21	3.74	21.07	41.41	8.66
2. Morden	70.69	11.83	86.67	16.42	2.84	17.89	38.40	6.80
3. Surya	98.09	16.72	108.35	18.40	4.34	24.18	41.36	10.02
S.E. ±	—	—	—	—	—	0.54	0.14	0.55
C.D. at 5%	—	—	—	—	—	1.59	0.45	1.79
C. *Interaction (D × V)*								
S.E. ±	—	—	—	—	—	1.62	0.41	1.22
C.D. at 5%	—	—	—	—	N.S.	N.S.	N.S.	N.S.

tein content as well as in protein yield (18.40% and 4.34 q/ha respectively) while in the case of oil content Surya and EC-68414 were at par and significantly superior over Morden. The oil yield in Surya was the highest (10.02 q/ha) and was significantly more than that recorded in Morden (6.80 q/ha) but was at par with EC-68414 (8.66 q/ha). The seed yield was found to decline significantly with delay in seeding. It was the highest in 11th February seeding (26.00 q/ha) and was the lowest in 11th May seeding (16.3 q/ha). The variety Surya produced the highest and significantly more seed yield (24.18 q/ha) than rest of the cultivars. The EC-68414 (21.07 q/ha) was also significantly superior over Modern (17.89 q/ha) in seed yield. However, the performance of EC-68414 amongst five cultivars at Coimbatore was the best (Premasekar et al., 1977). The interaction effects of seeding dates and entries did not reach the level of significance. Thus, it is desirable to sow summer sunflower in mid February and the choice of the variety may be Surya followed by EC-68414.

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GENE EFFECTS FOR FLOWERING AND MATURITY IN CROSSES BETWEEN YELLOW SARSON AND TORIA

RAM BHAJAN* and BASUDEO SINGH
Department of Plant Breeding, G.B. Pant University of Agriculture and Technology, Pantnagar-263 154, Distt. Nainital (India).

The presence of variable degrees of incompatibility and temporal isolation enforced by changes in flowering and maturity have restricted and narrowed down the variation with in each of the sub-species of *Brassica campestris* L., toria, yellow *sarson* and brown *sarson* (Rajan, 1958). Studies have, however, shown that their desirable traits can be recombined (Devarathinam *et al.*, 1976). Further a knowledge of the nature of gene action for characters related to productivity would aid in the choice of effective and efficient breeding method to accelerate the pace of improvement. This communication deals with the results of generation mean analysis for days to flowering and maturity in two crosses involving yellow *sarson* (PYS 6) and toria (M 3 and PT 303) parents.

The material comprised 15 generations (P_1, P_2, P_3, F_1, F_2, F_3, B_1, B_2, B_{11}, B_{12}, B_{21}, B_{22}, B_1S, B_2S, B_1F_1 and B_2F_1) of PYS 6×M3 (CrossI) and PYS 6×PT 303 (Cross II). Notations for the generations are according to Jinks and Perkins (1969). The material was evaluated in compact family block design with 3 replications during rabi, 1980-81. Depending upon the expected variance of the generations, 3 to 7 rows of 3m length were sown for dieffrent generations keeping a distance of 30 cm between rows and 10 cm between plants with in rows. Data were recorded on 10 randomly selected plants per plot from non-segregating generations, 30 from F_2, 25 from F3, B_1F_1, and B_2F_1, and 15 from rest of the generations.

The joint scaling test suggested by Cavalli (1952) was used to test the adequacy of genetic models as well as for estimating the parameters of the models. Four genetic models viz. additive-dominance, digenic-interaction, trigenic-interaction and linked-digenics were fitted successively according to Jinks and Perkins (1969).

The results of adequacy test of various models presented in Table 1 showed the inadequancy of additive-dominance model for flowering and maturity in both the crosses. Further, the fitting of digenic-interaction model resulted in non-significant value of X^2 ($P > 0.01$) for flowering in both the crosses and for maturity in CrossI indicating its adequacy. For days to maturity in Cross II, all the models tried proved unsatisfactory.

The estimates of gene effects under an adequate model (digenic-interaction model) for flowering in both the crosses and for maturity in Cross I are given in Table 2. For maturity in Cross II, parameters of trigenic-interaction model are given, for which X^2 was lowest ($P=0.007$). Additive effects were highly significant for flowering and maturity in both the crosses. Dominance effects were not important. Among digenic

**Present Address:* Department of Genetics & Plant Breeding, N.D.U.A. & T. Narendra Nagar (Kumarganj) Faizabad (U.P.).

TABLE 1 Chi-square test of goodness-of-fit of various models for days to flowering and maturity in two crosses of *Brassica campestris* L.

Model	No.of para meter	d.f.	Chi-square valur			
			Days to flowering		Days to maturity	
			Cross I	Cross II	Cross I	Cross II
Additive-dominance	3	12	29.4*	36.9**	32.8**	29.1*
Digenic-interaction	6	9	7.3 (0.604)	19.4 (0.023)	15.6 (0.072)	24.3*
Trigenic-interaction	10	5	—	—	—	17.0 (0.007)
Linked digenic	12	3	—	—	—	828.0**

*, ** Significant at 1% and 0.1% respectively.

Figures in parenthesis indicate the probability.

TABLE 2 Estimate of parameters with standard errors under adequate model for days to flowering and maturity in *Brassica campestris* L.

Parameter	Days to flowering		Days to maturity	
	Cross I	Cross II	Cross I	Cross II
(m)	38.9** ± 1.4	35.2** ± 1.3	98.3** ±1.4	92.6** ± 5.4
(d)	4.2** ± 0.6	2.8** ± 0.6	4.6** ± 0.7	16.4** ± 5.0
(h)	-4.3 ± 4.8	7.1 ± 3.8	2.9 ± 5.1	20.1 ± 31.7
(iab/)	-4.2** ± 1.5	-1.0 ± 1.4	-2.7* ± 1.3	3.2 ± 5.4
(ja/b)	-0.9 ± 2.3	1.8 ± 1.8	-0.1 ± 2.9	-48.7* ± 20.2
(1/ab)	-1.4 ± 4.2	-7.8** ± 2.9	-6.7 ± 4.9	-17.1 ±56.3
(iabc/)				-12.7* ± 4.9
(jab/c)				-18.1 ±15.6
(ja/bc)				42.1 ±23.8
(1/abc)				0.2 ±30.8

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

interactions, additive × additive (i_{ab}/) effects were important for both the characters is Cross I.

In Cross II, the importance of non-fixable epistasis in the form of dominance × dominance, ($l/_{ab}$), for flowering and additive × dominance, (ja/b), for maturity emphasizes the need for maintenance of heterozygosity which is quite feasible in yellow *sarson* and t*oria* hybrid populations. Other studies in *B. campestris* with single sub-species, using generation mean analysis, however, showed the importance of both (d) and (h) components (Zuberi *et al.*, 1972; Patnaik and Murty, 1978). Among epistatic effects, they found the larger contribution of $l/_{ab}$).

The presence of substantial amounts of fixable effects in the form of (d) and (i_{ab}/) for both the characters in Cross I and of (d) and $i/_{abc}$) for maturity in Cross II is suggestive for mild selection in early segregating generations (Dickerson, 1963). The presence of such a marked fixable epistasis also suggests that intermating between selects in early generations would allow the desirable epistatic gene combinations to come together and in effect the resulting population will further respond to selection. From the overall results it may be concluded that epistatic effects are likely to be of greater significance in population derived from yellow *sarson* and toria hybrids. Therefore, this component of genetic variation should not be ignored in deciding appropriate breeding programmes.

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CORRELATINN AND PATH COEFFICENT ANALYSIS IN BROWN SARSON

NARESH YADAV, P.R. KUMAR and R.K. BEHL
Haryana Agricultural University, Hisar-125004 (India)

Seed yield in Brassicas is a complex character influenced by several component traits. Selection for component traits has been found effective for improvement in seed yield (Kumar and Yadav, 1978). It is therefore, imperative to know about the nature and magnitude of associations amongest various seed yield contributing characters. Present study deals with such an attempt.

Genetically divergent 39 genotypes of Brown Sarson (*Brassica campestris* var. Brown Sarson) were sown in randomized block design with three replications. Five meter long 5 rows spaced 30 cm apart were allotted to a genotype in each replication. Randomly selected ten plants from each plot were used for recording observations on days to first flowering; plant height (cm) height of main shoot (cm); total pods per plant; pods on main shoot, 1000 seed weight (g); seed yield per plant (g) and oil content. The Phenotypic and genotypic correlation coefficients were computed. Path coefficient analysis was conducted for seed yield and oil content.

Relatively higher magnitude of genotypic correlation coefficients than their phenotypic correlation coefficients indicated a strong inherent association among various characters. Therefore, selection on the basis of phenotype would be effective. Seed yield was found to be significantly positively correlated with days to first flowering (0.35) number of primary branches (0.65) number of pods per plant (0.79) and pods on main shoot (0.38). These characters could be regarded as components of seed yield in this set of pouplation. No morphological character showed any definite association with oil content. Days to first flowering exhibited significant positive association with plant height (0.33) and pods on main shoot (0.35) while plant height recorded positive association with height of main shoot (0.65) and pods per plant (0.37) and pods on main shoot (0.42). Similar observations were recorded by Rawat and Anand (1977) Paul *et al.*, (1979).

Path coefficient analysis revealed that direct effect of most of the characters was low. Pods per plant however, had considerably high direct effect on seed yield (0.76). Also, it had high indirect effects through various characters. Thus, pods per plant figured to be the most important component of seed yield and should be relied upon during selection. Path coefficient analysis for oil content indicated that direct as well as indirect effects of most of the characters were low. It appeared that the components of seed yield are not necessarily the components of oil content.

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A NEW RECORD OF *MELOIDOGYNE GRAMINIS* ON *RAYA* AND OCCURRENCE OF *MELOIDOGYNE* SPP. IN LUDHIANA, PUNJAB, INDIA

V.K. KAUL and H.K. CHHABRA
Department of Plant Pathology, Punjab Agricultural University, Ludhiana

Meloidogyne spp. are of common occurrence on different crop plants throughout the area. A random survey was conducted for the association of root-knot nematode species with various vegetable, oilseed, pulse and horticultural crops at the campus of Punjab Agricultural University, Ludhiana. Fresh roots of 32 host plants were collected, mature females with prominent egg masses were dissected out carefully and observed for general shape, the postion of excretory pore, stylet length and shape of the *parineal patterns*. The egg masses of the respective females were allowed to hatch and the morphological characters of second stage larvae were observed. The exact identity of the nematode species was established with the help of keys (Esser *et al.*, 1976; Taylor and Sasser, 1978; Sasser and Carter, 1985). The data on the occurrence of *Meloidogyne* spp. are presented in Table 1.

TABLE 1 Association of *Meloidogyne* spp. with different host plants in Ludhiana
(+= , — =)

S.No.	Botanical name	Common name	*Meloidogyne incognita*	*M. are naria*	*M. javanica*
	Vegetables				
1.	*Abelmoschus esculentus* (L.) Moench	Okra	+	+	+
2.	*Allium cepa* L.	Onion	+	—	—
3.	*Brassica oleracea* L. var *botrytis*	Cauliflower	+	+	—
4.	*B. oleracea* L. var *capitata*	Cabbage	+	+	—
5.	*Daucus carota* L.	Carrot	+	—	—
6.	*Lycopersicon esculentum* Mill.	Tomato	+	+	+
7.	*Medicago falcata* L.	Methi	—	+	—
8.	*Momordica charantia* L.	Bitter gourd	+	—	—
9.	*Pisum sativum* L.	Pea	+	+	—
10.	*Raphanus sativus* L.	Radish	+	+	—
11.	*Solanum melongena* L.	Brinjal	+	+	+
12.	*S. tuberosum* L.	Potato	+	—	—
	Oilseeds				
13.	*Arachis hypogea* L.	Groundnut	—	+	—
14.	*Brassica campestris* L. var *dichotoma* Watt	Brown sarson	+	+	+

TABLE 1 (contd.)

S.No.	Botanical name	Common name	*Meloidogyne incognita*	*M. arenaria*	*M. javanica*
15.	*B. campestris* L. var *sarson* Prein	Yellow sarson	×	+	+
16.	*B. campestris* L. *toria* Duth	*Toria*	+	—	—
17.	*B. juncea* L.	*Raya*	+	+	+
18.	*Helianthus annus* L.	Sunflower	+	+	—
19.	*Sesamum orientale* L.	*Til*	+	—	—
	Pulses				
20.	*Cajanus cajan* (L.) Millsp.	Arhar	+	—	—
21.	*Cicer arietinum* L.	Gram	+	+	—
22.	*Lens esculanta* Moench	Lentil	+	+	—
23.	*Viona radiata* var. *aureus* Endl.	*Moong*	+	+	—
24.	*V. radiata* var. *mungo* Endl.	*Mash*	+	—	+
	Cereals				
25.	*Pennisetum t-phoides* Pers.	Bajra	+	—	—
26.	*Zea mays* L.	Maize	+	—	—
	Horticultural crops				
27.	*Carica papaya*	Papaya	+	+	+
28.	*Prunus aumygdalus* L.	Almond	+	—	+
29.	*P. communis* L.	Pear	+	—	+
30.	*P. domestica* L.	Plum	+	—	—
31.	*P. persica* L.	Peach	+	—	+
32.	*Psidium quava* L.	Guava	+	—	—

The observations indicated the widespread occurrence of *M. incognita* except on *methi* and groundnut which carried the infestation of *M. arenaria* only. Tomato, brinjal, brown and yellow *sarson, raya* and papaya each carried the infestation of *M. incognita, M. arenaria* and *M. javanica.*

Interestingly *M. graminis* was found infesting *Brassica juncea* (raya) plants though the population was low. The shape of mature female, posterior protuberance, position of excretory pore and perineal pattern along with the morphological characters of second along with the morphological characters of second stage larvae are in confirmity with those of *M. graminis* described by Sledge and Golden (1964). This appears to be the first record of *M. graminis* from India and also *B. juncea* as its host.

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