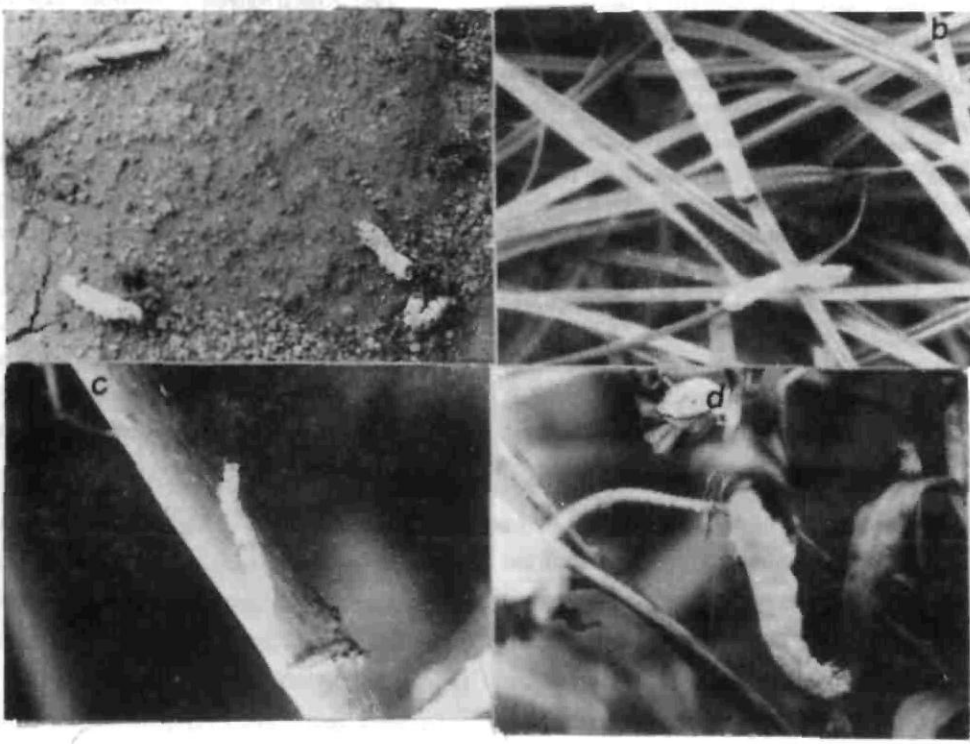
LEGENDS

Fig. 1. a) Fungus infected *Spodoptera litura* on soil, b) grasses, c) castor and d) Fungus infected green semi-looper, *Plusia sp.*, on niger



ISSN 0970-2776

VOLUME 13 NUMBER 1 JUNE 1996

JOURNAL OF OILSEEDS RESEARCH

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

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

Principal ... my)
Director... earch
Rajendra... ad-30.

JOURNAL OF OILSEEDS RESEARCH

CONTENTS

DOR-347

Volume 13 June, 1996 Number 1

Short Communications

J. Oilseeds Res. 13 (1) 1996: 1-6
ISSN 0970-2776

SOYBEAN BASED CROPPING SYSTEMS IN INDIA - A REVIEW

P.S. BHATNAGAR, O.P. JOSHI, V.S. BHATIA, S.D. BILLORE and A. RAMESH
National Research Centre for Soybean Khandwa Road, Indore 452 001 (M.P.)

ABSTRACT

Soybean offers good potential to be introduced into cropping sequences or intercropping systems. It is a short duration (85 to 130 days) leguminous energy rich crop. It is relatively tolerant to drought and excessive moisture. It is a remunerative cash crop too. The other desirable features are that its cultivation does not cause any allelopathic effect on companion/succeeding crops, leaves 45 to 60 Kg residual nitrogen per hectare to the succeeding crop and creates salutary physico-chemical environment in the soil for crop growth. It is also instrumental in sustaining soil organic matter status through substantial recycling of foliage/rhizosphere root mass. Experimental evidences have established that soybean could fit aptly in any of the traditional cropping systems in all the five agroclimatic zones of India specified for soybean. Hence, the inclusion of soybean in any of the existing cropping systems generates much more dividends than any other cropping sequence.

Key words: Cropping sequence; Soybean; Intercropping; Legume

Soybean (Glycine max (L) Merrill) has already emerged as one of the major rainy season cash crops in the central part of the country. Its cultivation is fast spreading to southern India comprising the states of Maharashtra, Karnataka, Tamil Nadu and Andhra Pradesh besides other parts of the country like Uttar Pradesh and Rajasthan adjoining Madhya Pradesh. Madhya Pradesh has distinguished itself as a 'Soya State' on account of 75 per cent of its share in area and production of soybean. During 1993-94, it covered an area of 4.26 million hectares producing 4.62 million tonnes of seeds (DOR., 1995).

During the last one and a half decade, the growth in area, production and productivity has been 752, 1550 and 91 per cent, respectively (Table 1). This trend of fast adoption of the crop by the farmers points out that soybean is going to be the future leading commercial venture in the country. Soybean has a good potential to get involved in the intercropping as well as crop sequences as it is a short duration (85 to 130 days) leguminous crop and shows comparative tolerance to drought (Lawn, 1982) and excessive soil moisture conditions (Hunter *et al.* 1980; Nathanson *et al.* 1984; Wright *et al.* 1988). It offers a number of advantages like better ability to fix nitrogen, low phosphorus requirement, and tolerance to low pH, high level of aluminum, and high moisture content (Tanaka, 1983). Soybean, an edible oil generating legume has been documented to fetch much more price than sorghum and corn resulting in high net returns (Soni *et al.* 1990).

Table 1 : Area, production and productivity of soybean in India

Year	Area (m ha)	Production (m tonnes)	Productivity (kg/ha)
1979-80	0.50	0.28	570
1993-94	4.26	4.62	1089
Percent increase	752	1550	91

From the view point of soybean cultivation in India, five agroclimatic zones (Table 2) viz; Central, Southern, Northern Plain, Northern Hill and North Eastern have been designated (Bhatnagar and Tiwari, 1990). The information presented herein is confined to the zone-wise economic and agricultural viability of soybean based cropping system.

Received for publication March, 1995

Central zone

Wheat is the major rabi crop in the central part of the country. There has been a common myth that the adoption of soybean-wheat sequence for a number of years results in gradual reduction in productivity of soybean as well as wheat. On the contrary, the findings of a long-term experiment conducted at Jabalpur revealed that the yields of both the crops show a steady increase provided the component crops receive a balanced nutrition. The average productivity of wheat was 4.0 and 4.4 tonnes per hectare for the period 1971-89 which increased to 5.2 and 5.8 tonnes per hectare during 1987-89 at optimal (100%) and super-optimal (150%) NPK levels, respectively. The average yields of soybean at 100 per cent NPK level for 1987-89 was 2.7 tonnes per hectare, which also showed an increase in productivity over 1971-89 (2.3 t/ha). It has also been reported that continuous application of sulphur-free fertilizers over years brought down the productivity of both the crops (Anonymous, 1988-89). Response to continuous dressings with sulphur containing fertilizers was obvious with the passage of time (Nambiar and Abrol, 1989). Similarly, the beneficial influence of application of NPK with farm yard manure was observed. The soybean-wheat system also increased the organic carbon content of the soil (Anonymous 1988-89). The study undertaken at National Research Centre for Soybean indicated that recycling of organic matter through leaf litter varied from 0.5 to 2.5 tonnes per hectare depending on the variety of soybean cultivated.

Cultivation of short duration varieties of soybean provides adequate opportunity to grow post-monsoon crops like chickpea and lentil utilizing residual moisture after *kharif* soybean (Krishnamurthy, 1974).

The wheat yields increased when grown after soybean than after any other crop, regardless of level of nitrogen application (Anonymous, 1988-89). The crop sequences involving soybean, green gram, *bajra*, groundnut or pigeonpea in *kharif* followed by rapeseed-mustard or wheat in *rabi* and groundnut or green gram in summer in alluvial soils brings out the possibility of better resource utilization for optimum productivity (Tomar and Tiwari, 1990; Tomar and Namdev, 1988).

Soybean can conveniently be raised as *kharif* crop without disturbing the existing rapeseed/mustard cultivation in Bundelkhand region of Uttar Pradesh and Gird region of northern Madhya Pradesh, thus generating additional returns from unit land. The agricultural feasibility and economic viability of this system has already been demonstrated (Hirve, 1993). Further work on nutrient management is warranted so as to maintain the yield levels of mustard along with the yields of soybean. The soybean varieties suited to this cropping sequence in order of their significance were JS 71-05, Sagar selection, Monetta, Punjab-1, PK 416, JS 81-1498 and JS 73-22. Besides increasing the gross returns by 24 to 61 per cent over growing mustard alone, the cropping system incorporating soybean is likely to improve physical environment of soil by recycling organic matter through leaf litter and rhizosphere parts in these light textured soils. The improvement in fertility thus effected will have a strong bearing on sustainability of agriculture in long run.

Soybean is reported to have replaced less remunerative *kharif* crops such as sorghum, cotton and pigeonpea in Chromusterts of Akola region of Maharashtra. Such replacement of traditional crop cultivation could conveniently be avoided by fitting soybean in as *kharif* crop with added advantage of increased dividend. Bhaskar *et al.* (1992) tested the cropping systems like soybean-safflower or pigeonpea or sorghum and found these to be economically viable. They further suggested that soybean-pigeonpea association either as intercrop in *kharif* or as a *kharif-rabi* sequence is more suitable and rewarding. Sharma and Gupta (1992) reported that the higher and sustainable seed yield

Table 2 : Existing classified zones, regions covered and equivalent agroecological regions for soybean

Classified zone *	Region covered	Agroecological regions **
Central zone	M.P. Bundelkhand region U.P., Southern part of Rajasthan, Gujarat, Northern and Western parts of Maharashtra, & Orissa	2. Western plain, Kachchh and part of Kathiawad peninsula, Hot arid ecoregion with desert and saline soils. Growing less than 90 days.
		4. Northern plain and central high lands including Aravallis hot semiarid ecosystems with alluviam derived soils. Growing period 90 to 150 days.
		5. Cemtral (Malawa) high lands, Gujarat plains, Kathiawad peninsula, hot semi-arid ecoregions with medium and deep black soils. Growing period 90 to 150 days.
		6. Deccan plateaue, hot semiarid ecosystem with shallow and medium (with inclusion of deep) black soils. Growing period 90 to 150 days.
		10. Central high lands (Malawa, Bundelkhand and eastern Satpura), hot subhumid ecoregions with black and red soils. Growing period 150 to 180 days.
		12. Eastern (Chotanagpur) plateau and eastern ghats, hot subhumid ecoregions with red and lateratic soils. Growing period 150 to 180 days (to 210 days)
Southern zone	Southern parts of Maharashtra, A.P., Karnataka, T.N. & Kerala	3. Deccan plateau, hot arid ecoregion with red and black soils. Growing period less than 90 days.
		6. As in central zone.
		7. Deccan (Telengana) plateau and eastern ghats, hot semiarid ecoregion with red and black soils. Growing period 90-150 days).
		8. Eastern ghats, T.N. uplands and deccan (Karnataka) plateau, hot semiarid ecoregion with red loamy soils. Growing period 90 to 150 days.
		19. Western ghats and coastal plains, hot humid per humid ecoregions with red and lateritic and alluvial derived soils. Growing period 210 + days.
North Plain zone	Punjab, Haryana, Delhi & North eastern plains	4. As in central zone
		9. *Northern plain, hot subhumid (dry) ecoregion with alluvium derived soils.* Growing period 150 to 180 days.
North Hill zone	Northern hills of U.P. and H.P.	13. Eastern plains, hot subhumid (moist) ecoregion with alluvium derived soils. Growing period 180 to 210 days.
		14. Western Himalayas, warm subhumid (to humid) with inclusion of per humid ecoregion) with brown forest and podzolic soils. Growing period 180 to 210 + days.
North Eastern zone	Assam, W.B., Bihar & Meghalaya	9. As in North plain zone
		11. Eastern plateau (chattisgarh), hot subhumid ecoregion with red and yellow soils. Growing period 150 to 180 days.
		12. As in central zone
		13. As in north hill zone
		15. Bengal and Assam plains, hot subhumid (moist) to humid (Inclusion of perhumid) ecoregion with alluvium derived soils. Growing period 210 days.
		17. North eastern hills (Purvachal), warm perhumid ecoregion with red and lateritic soils. Growing period 210 + days.

* NRCS Technical Bulletin No. 1.

** NBSS & LUP, Nagpur

with better nutrient recovery and water use efficiency could be achieved by combined application of N, P and S @ 40, 22 and 60, kg/ha, respectively, applied to soybean. The succeeding safflower grown on residual moisture and nutrients not only gave 37% more yield but also 27.7% higher water use efficiency and 46 to 47% increased recovery of N, P, K and S, respectively.

Southern Zone

The most promising cropping pattern in the southern zone comprises of wheat-soybean-fingermillet-bean, oat-cowpea-barley-soybean, soybean-fingermillet-beans and soybean-wheat-groundnut (Trikha, 1985). Srinivasan *et al.* (1991) have reported that corn cultivated after summer soybean is benefited on an average by 15 kg N/ha. The continuous cultivation of rice in rotation with black gram, green gram, cowpea, soybean, sesame or water grass has been demonstrated in Tamil Nadu (Jayakumar and Alagappan, 1990). The intercropping of soybean with cotton following paddy could yield to a tune of 1.2 tonnes per hectare, whereas marginal yield reductions were observed in cotton (Murali Krishnaswamy *et al.* 1990). Gopala Krishnan and Palaniappan (1992) observed that application of farmyard manure and superphosphate plus Mussourie rockphosphate (1:1) well before the first crop of soybean, appears to be a potential phosphate management package for soybean-sunflower cropping system for near neutral soils. An attempt made to introduce soybean (Pb 1) - fcv tobacco at Rajahmundry, although was successful with 32 per cent yield increase over tobacco-fallow, but the performance of tobacco got affected (11% reduction in yield) as it was grown on residual moisture (Chari, 1995-Personal communication).

Northern Plain Zone

The benefit of approximately 60 kg N/ha was reported to the succeeding wheat crop in a soybean-wheat crop sequence (Trikha, 1985) from 279 demonstrations at 20 locations in Uttar Pradesh with soybean-wheat and soybean-potato sequences conducted on farmers' fields. Similarly, in trials from 1974-1982, the yield of soybean realised was 2.0 tonnes per hectare and that of potato 26.8 tonnes per hectare. These trials conducted at locations with varied environments clearly establish that both the crops (wheat and potato) provide viable cropping sequences with soybean. Dwivedi et al. (1989) brought out that in a soybean-wheat sequence on Inceptisols, the use of Mussourie rock phosphate to be superior to single superphosphate with regards to direct and residual effects on yield and phosphorus availability irrespective of liming. At Kanpur, cultivation of wheat following soybean resulted in highest wheat equivalent yield compared to growing cowpea (fodder), pigeonpea/mungbean, mustard or sorghum in place of soybean, indicating its positive contribution in crop rotation (Kushwaha and Ali, 1988). The results of a long-term fertilizer experiment conducted at Almora revealed that the beneficial effect of continuous manuring with farmyard manure was more pronounced than of chemical fertilizers. The chemical fertilizers did not adversely affect the soil physical properties except bulk density in soybean-wheat sequence (Bhatnagar *et al.* 1992).

Northern Hill and North Eastern Zones

Prakash *et al.* (1991) demonstrated successful cultivation of wheat, pea, lentil and *toria* following fingermillet and soybean in Uttar Pradesh hills during *kharif*. It was deduced that soybean-pea and soybean-lentil to be more remunerative cropping sequences. Trikha (1985) reported the contribution of about 45 kg residual nitrogen by soybean to succeeding wheat crop. A long-term trial (14 years) to elucidate the effect of continuous application of potassium in sandy loam soils of Almora to soybean in rotation with wheat revealed that the average response was 15.49 kg seed per kg potassium in soybean and 5.5 kg grains per kg potassium in wheat (Kundu *et al.* 1990). soybean cultivar PK 472 has been reported to be a stable yielder in Shillong, Orai and Ugarkhurd regions by Tiwari *et al.* (1994).

Based on the agronomic feasibility and economic viability, suitable cropping sequences have been arrived at and are presented in Table 3. Although, these sequences have been advocated, further in-depth study on the nutrient management aspects is yet to be taken up with a view to sustaining Indian agriculture.

LITERATURE CITED

Anonymous. 1979-80 to 1992-93. Annual Report, All India Coordinated Research Project on Soybean (ICAR).

Anonymous 1988-89. Annual Report, All India Coordinated Research Project on Long-term Fertilizer Experiments (ICAR).

Bhaskar, K.S., Balkar, S.Y., Pattidar, W. and Thare, D.N. 1992. Efficient soybean based cropping systems for the black cotton soils. *Indian Farming*, 42: 3-6.

Bhatnagar, P.S. and Tiwari, S.P. 1990. Production technology. In Technology for Increasing Soybean Production in India. Eds. Bhatnagar, P.S. and Tiwari, S.P., NRCS Technology Bulletin 1:9-16.

Table 3 :Soybean based crop sequences and suitable varieties of soybean for various zones

Zone	Cropping sequence	Soybean varieties
Central	Soybean-wheat Soybean-potato Soybean-garlic Soybean-rapeseed/mustard Soybean-pigeonpea Soybean-safflower Soybean-linseed Soybean-gram/lentil Soybean-sorghum Soybean-wheat-maize (fodder)	JS 335, JS 80-21 PK 472, Durga, Pb1, JS 71-05, Pusa 16, PK 262, MACS 57, MACS 58, MACS 124, MACS 13
Southern	Wheat-Soybean-Fingermillet-pea Oat - Cowpea-Barley-Soybean Soybean-Fingermillet-Beans Soybean-wheat-Groundnut	KHsb-2, MACS 124, Monetta, PK 472, PK 426, PK 262, JS 235, Hardee, Pusa 16, MACS 58, Co-1, JS 80-21, MACS 13
Northern Plain	Soybean-wheat Soybean-Potato Soybean-gram	PK 472, PK 262, PK 327, PK 416, Pb-1, SL-4, SL-96, VLS 2, Bragg, JS 335, MACS 13
Northern Hill	Soybean-wheat Soybean-pea Soybean-lentil Soybean-Toria	VLS 2, Bragg, JS 335, PK 262, PK 472, PK 416, PK 327, Shivalik
North Eastern	Paddy-Soybean Soybean-Paddy	JS 80-21, PK 262, Bragg, VLS 2, Pb-1, Birsa soya 1, Shivalik, Pusa 16, PK 327, PK 472

Bhatnagar, V.K., Kundu, S. and Ved Prakash. 1992. Effect of long-term manuring and fertilization on soil physical properties under soybean-wheat cropping sequence. *Indian J. Agric. Sci.* 62: 212-214.

Chari, M.S. 1995. Personnel Communication, C.T.R.I., Rajahmundry.

DOR. 1995. Oilseeds situation in India: A statistical overview, Directorate of Oilseeds Research, Hyderabad, pp. 31-34.

Dwivedi, G.K., Dwevedi, M. and Pal, S.S. 1989. Relative efficiency of Mussourie rock phosphate and single superphosphate with lime on yield and phosphorus availability in maize-wheat and soybean-wheat rotation in Inceptisols. *J. Indian Soc. Soil Sci.* 37:61-65.

Gopala Krishnan, B. and Palaniappan, S.P. 1992. Influence of mussourie rock phosphate on available nutrients in a soybean-sunflower cropping system. *J. Indian Soc. Soil Sci.* 40:474-477.

Hirve, C.D. 1993. Personal Communication, Zonal Research Station, (JNKVV, Jabalpur), Morena.

Hunter, M.N., De Jabran, P.L.M. and Byth, D.E. 1980. Response of nine soybean lines to soil moisture condition close to saturation. *Aust. J. Exptl. Animal Husbandry*, 20:339-345.

Jayakumar, K. and Alagappan, R.M. 1990. Studies on rice based cropping systems. *Intl. Rice Res. Newsletter*, 15:31.

Krishnamurthy, Ch. 1974. International Workshop on Cropping Systems, ICRISAT, Hyderabad, India, pp 274-286.

Kundu, S, Bhatnagar, U.K., Prakash, V., Joshi, H.C. and Koranne, K.D. 1990. Yield response of soybean-wheat rotation to K applications in a long-term field experiment. J. Pot. Res. 6:70-78.

Kushwaha, B.L. and Ali, M. 1988. Effect of *Kharif* legumes on production and nitrogen economy of succeeding wheat. *Indian J. Pulses Res.* 1: 12-17.

Lawn, R.J. 1982. Response of four grain legumes to water stress in Southern Queensland. I. Physiological response mechanisms. *Aust. J.Agril. Res.* 33:481-496.

Murali Krishnaswamy, S., Budhar, M.N., Rajendran, R. and Kareem, A.A. 1990. Intercropping following rice. *Intl. Rice Res. Newsletter*, 15:34.

Nambiar, K.K.M. and Abrol, I.P. 1989. Long term fertilizer experiments in India-a review. *Fert. News*, 34. 11-20.

Nathanson, K., Lawn, R.J., De Jabsun, P.L.M. and Byth, D.E. 1984. Growth, nodulation and nitrogen accumulation by soybean in saturated soil culture. *Field Crops Res.* 8: 73-92.

Palaniappan, K. 1985. Soybean cropping system in Tamil Nadu, India. In Soybean in Tropical and Sub-tropical Systems, proceedings of a symposium, Tsukuva, Japan, The Asian Vegetable Research Development Centre, Shanhua, Taiwan, China, pp. 71-72.

Prakash, V., Tandan, J.P. and Sanwal, T.D. 1991. Comparative performance of soybean and finger millet based rotations under rainfed conditions of U.P. Hills. Indian *J. Agric., Res.* 25: 102-106.

Sharma, R.A. and Gupta, R.K. 1992. Response of rainfed soybean-safflower sequence to nitrogen and sulphur fertilization in Vertisols. *Indian J. Agril Sci.* 62: 529-534.

Soni, S., Rajput, A.M. and Goyal, M. 1990. Grow soybean instead of jowar and maize in Indore district. *Indian Farming*, XL: 10.

Srinivisan, K., Santhi, R. and Ramaswamy, M. 1991. Effect of summer pulses on growth and productivity of succeeding maize crop. *Indian J. Pulses Res.* 4:51-55.

Tanaka, A. 1983. The physiology of soybean yield improvement. In Soybean in Tropical and Sub-tropical Systems, proceedings of a Symposium TSUKUVA, Japan, September 26 to October 1, 1983. pp 323-331.

Tiwari, S.P., Bhatnagar, P.S. and Prabhakar. 1994. Identification of suitable soybean varieties for nontraditional regions of India. Indian *J. Agric. Sci.* 64: 872-874.

Tomar, S.S. and Namdev, K.N. 1988. Production potential and economics of multiple cropping systems. *Indian J. Agron.* 33:104-106.

Tomar, S.S. and Tiwari, A.s. 1990. Production potential and economics of different crop sequences. *Indian J. Agron.* 35:30-35.

Trikha, R.N. 1985. The potential of Soybean in Indian cropping systems. In Soybean in Tropical and Sub-tropical Cropping Systems, proceedings of a symposium., Tsukuva, Japan, The Asian Vegetable Research and Development Centre, Shanhua, Taiwan, China, pp 77-80.

Wright, G.C., Smith, C.J. and Nilson, I.B. 1988. Growth and yield of Soybean under wet soil culture and conventional furrow irrigation in South Eastern Australia. *Irri. Sci.* 9: 127-142.

J. Oilseeds Res. 13 (1) 1996: 7-9
ISSN 0970-2776

EFFICACY AND ECONOMICS OF IPRODIONE FOR THE CONTROL OF *ALTERNARIA* BLIGHT IN BROWN *SARSON*

ASHOK KUMAR and H.L. THAKUR
Oilseeds Research Station (HPKV) Kangra - 176001 (H.P.)

ABSTRACT

Alternaria blight caused by *Alternaria brassicae* (Berk.) Sacc. inflicts heavy yield loss in rapeseed - mustard. Six concentrations of Iprodione (Rovral 50 w.p.) were tested under field conditions to find out effective and economic dosage for the control of this disease. All the treatments were effective in lowering the percent disease intensity and increasing the crop yield. Three sprays of Iprodione (0.20%) provided maximum net return and cost benefit ratio.

Keywords : Iprodione; *Alternaria* blight; *sarson*

INTRODUCTION

Alternaria blight is a widespread and serious disease of rapeseed-mustard around the world. Three species of *Alternaria* viz. *A. Brassicae* (Berk.) Sacc., *A. brassicicola* (Schw.) Wiltshire and *A.raphani* Groves and Skolo are known to affect the rapeseed-mustard crop. Of these, *A. brassicae* is most destructive widespread and appears every year resulting in 35-46% yield losses in India (Kolte *et al.*, 1987). *Alternaria* blight poses a great threat to the cultivation and productivity of Brassicas in India. In the absence of stable disease resistant varieties, there is a need to evolve effective and economically viable disease management strategies. Kolte and Tewari (1978), Gupta *et al.* (1977), Kaushik *et al.* (1983), Singh, (1986) and Ansari *et al.* (1990) reported the effectiveness of various fungicides for the control of this disease. The effectiveness of Iprodione (3-(3,5, - dichlorophenyl) - N - isopropyl 2, 4 - Dioxoimidazolidine - 1 carboxamide) against *Alternaria* blight has been proved beyond doubt (Anonymous, 1992). There is lack of information on its effective and economic dosage and hence this investigation.

MATERIALS AND METHODS

A field trial was conducted during *rabi* 1991-92, 1992-93 and 1994-95 at Oilseeds Research Station, Kangra, Himachal Pradesh. The experiment was laid out in Randomised Block Design with three replications. Six concentrations of Iprodione (Rovral 50 w.p.) ranging from 0.05% to 0.3% were tested on the susceptible variety BSH-1 of *Brassica campestris* L. var. *dichotoma* Watt. (brown sarson) during first two years of experimentation. During the third year recommended fungicide against *Alternaria* was included as standard check for comparison with different concentrations of Iprodione. The crop received three foliar sprays at seeding, flowering and late flowering stages with a spray volume of 750 l water/ha. The percent disease intensity was calculated on 0-5 scale as employed by earlier workers (Rai *et al.*, 1976) at the time of maximum disease appearance in the control. The net return and cost benefit ratio were calculated.

RESULTS AND DISCUSSION

Mean data of 1991 and 1992 (Table 1) showed that the percent disease intensity at leaf as well as pod stage was significantly lower with Iprodione spray as compared with unsprayed control. Foliar spray of Iprodione at 0.3% remaining comparable with 0.25% and 0.20% offered grater disease control resulting in reduced disease intensity. 1000 grain weight and yield were significantly higher in all the treatments as compared to control. Maximum 1000 grain weight (3.79g) and yield

Received for publication October, 1993

Table 1 : Efficacy of Iprodione for the control of *Alternaria* blight in brown *sarson*. (mean of 1991-92 and 1992-93).

Treatments	Percent disease intensity				1000 grain Wt. (g)	Seed yield (kg/ha)
	Leaves		Pods			
Iprodione 0.05%	8.23	(17.27)	33.73	(35.26)	3.57	1461
Iprodione 0.1%	6.57	(14.69)	22.63	(27.72)	3.63	1490
Iprodione 0.15%	4.50	(12.14)	20.19	(26.15)	3.62	1613
Iprodione 0.2%	0.67	(3.31)	10.33	(18.59)	3.72	1972
Iprodione 0.25%	0.54	(2.94)	9.99	(18.23)	3.71	1950
Iprodione 0.30%	0.54	(2.94)	9.34	(17.58)	3.79	1976
Control (unsprayed)	44.60	(41.89)	59.27	(50.37)	2.85	1018
CD (0.05)	2.72	3.65	0.31	350		

Figures in parentheses are angular transformed values.

(1976 kg/ha) were recorded with Iprodione 0.3% followed by 0.2% (3.72g, 1972 kg/ha) and 0.25% (3.71 g, 1950 kg/ha). Almost similar trends in disease control and yield were observed during 1994-95 (Table 2). Disease intensity was minimum with Iprodione 0.3% spray followed by 0.25% and 0.2% resulting in corresponding yields of 1666 1640 and 1624 kg/ha. The disease was better controlled even with Iprodione, 0.05% in comparison to Mancozeb, 0.2% offering 1392 and 1296 kg/ha yield, respectively.

Maximum net return was obtained with 0.2% Iprodione spray (Rs.4510/ha) followed by 0.05% spray (Rs.4151.75/ha) as against Rs.3143/ ha obtained in case of Mancozeb 0.2% spray. The cost benefit ratio was highest with Iprodione 0.05% spray (3.26) in comparison to 1.3 in 0.2% and 2.57 with mancozeb 0.2% spray.

Our studies reveal that three sprays of Iprodione at 0.2% offers effective disease control, higher yield and net return in brown sarson than Mancozeb at 0.2%. (Table 2).

LITERATURE CITED

Anonymous, 1992. Annual progress report (AICORPO). Directorate of Oilseeds Research, Rajendranagar, Hyderabad.

Ansari, N.A. Wazid Khan, M. and Muheet, A. 1990. Evaluation of some fungicides for seed treatment and foliar application in management of damping off of seedling and blight of rapeseed caused by *Alternaria brassicae*. *Mycopathologia* 110:163 - 168.

Gupta, I.J. Sharma, B.S. and Dalela, G.G. 1977. Control of white rust and *Alternaria* leaf spot of mustard. *Indian J. Mycol. & Pl. Pathol.* 7 : 163 - 164.

Kaushik, C.D. Kaushik, J.C. and Saharan, G.S. 1983. Field evaluations of fungicides for the control of *Alternaria* leaf blight of raya (*Brassica juncea*). *Indian J. Mycol. & Pl. Pathol* 13: 262 - 264.

Kolte, S.J. and Tewari, A.N. 1978. Efficacy of certain chemicals for the control of *Alternaria* blight of yellow sarson. *Indian Phytopath.* 31:81 - 83.

Kolte, S.J.Awasthi, R.P. and Vishvanath. 1987. Assessment of yield losses due to *Alternaria* blight in rapeseed and mustard. *Indian Phytopath.* 40:209 - 211.

Rai, B., Kolte, S.J. and Tewari, A.N. 1976. Evaluation of Oliferous brassicae germplarm for resistance to *Alternaria* blight. *Indian J.Mycol.& Pl. Pathol.* 6: 76 - 77.

Singh, D.B. 1986. Evaluation of fungicides for control of *Alternaria* brassicae and Drechslera graminea. *Iran J.Plant Pathol.* 22 : 39 - 44.

Table 2 : **Efficacy and economics of Iprodione for the control of *Alternaria* blight in brown *sarson* (1994-95).**

Treatments	Percent disease intensity		1000 grain Wt. (g)	yield (kg/ha)	yield increase over control (kg/ha)	Addl. return over control (Rs./ha).	Treatment cost (Rs./ha)	Net return (Rs./ha)	Benefit: Cost ratio
	Leaves	Pods							
Iprodione 0.05%	9.8 (18.3)	25.6 (30.4)	3.20	1392	493	5423	1271.25	4151.75	3.26
Iprodione 0.1%	9.1 (17.5)	18.9 (25.8)	3.32	1407	508	5588	2002.50	3585.50	1.79
Iprodione 0.15%	5.3 (14.0)	17.6 (24.8)	3.38	1492	593	6523	2733.75	3789.25	1.39
Iprodione 0.20%	2.9 (9.8)	12.8 (21.2)	3.46	1624	725	7975	3465.00	4510.00	1.30
Iprodione 0.25%	1.9 (7.8)	10.7 (19.0)	3.48	1640	741	8151	4196.25	3954.75	0.94
Iprodione 0.30%	1.6 (7.3)	10.7 (19.0)	3.46	1666	767	8437	4927.50	3509.50	0.71
Control (unsprayed)	33.9 (35.6)	47.2 (43.4)	2.76	899	-	-	-	-	-
Mancozeb 0.2%	16.5 (23.9)	32.5 (34.8)	3.22	1296	397	4367	1224.00	3143.00	2.57
CD (0.05)	1.17	4.14	0.18	156	-	-	-	-	-

Figures in parenthesis are angular transformed values.

Cost of: Fungicide : Rs. 650/kg; Labour : Rs. 40/day; Sprayer hire : RS. 5/day ; Sale price of Sarson : Rs. 11/kg.

J. Oilseeds Res. 13 (1) 1996: 10-12
ISSN 0970-2776

EFFECT OF SOWING DATE AND ROW SPACING ON RAINFED MUSTARD UNDER LATE SOWN CONDITIONS

P.C. SARMAH
Regional Agricultural Research Station, Shillongani - 782 001, **Assam**

ABSTRACT

A field experiment was conducted using mustard variety TM 2 during *Rabi* 1992-93 to 1994-95 at Regional Agricultural Research Station, Shillongani to assess the optimum date of sowing and to find out suitable inter-row spacing for rainfed mustard. It was found that sowing on 25 October remaining comparable with 9 November sowing resulted in substantial increase in seed yield as compared with delayed sowing on 24 November and 9 December. Delayed sowing on 24 November and 9 December resulted in 24.8 and 51.6 percent yield reduction in comparison with sowing on 25 October. Sowing the crop at 30 cm spacing offered substantially greater yield and net return than 40 cm spacing.

Key words: Mustard; sowing date; row spacing.

INTRODUCTION

Timely sowing of rainfed mustard depends solely on the occurrence and duration of monsoon. Sowing is usually delayed due to late withdrawal of monsoon and consequent delay in land preparation. Sometimes occupation of land by *Kharif* Paddy also compels the farmers to go in for late sowing. Information on the extent of yield reduction under late sown conditions as well as the effect of row spacing to overcome the effects of late sowing is meagre. Keeping this in view the present experiment was designed to find out suitable combinations of sowing date and inter row spacing.

MATERIALS AND METHODS

A field experiment was conducted during three consecutive *Rabi* seasons of 1992-93 to 1994-95 at Regional Agricultural Research Station, Shillongani using mustard variety TM 2 under rainfed late sown conditions. The soil of the experimental field was sandy clay loam in texture with pH 5.5, low in available nitrogen (226 kg/ha), available P_2O_5 (8.5 kg/ha) and high in available K_2O (360 kg/ha). The treatments consisting of four sowing dates viz., 25 October, 9 November, 24 November and 9 December and three row spacings viz., 20, 30 and 40 cm were tested in a split plot design replicated thrice. A common basal dose of 60 kg N, 30 kg P_2O_5 and 30 kg K_2O/ha was applied at the time of sowing. NO top dressing was done thereafter. There was no serious incidence of pests and diseases.

RESULTS AND DISCUSSION

Effect of sowing dates:

The highest seed yield of mustard was obtained from 25 October sowing in all the years which was at par with 9 November except in 1993 (table 1). Plant height, number of branches per plant, number of siliquae per plant, and 1000 seed weight were higher in earlier sowings than later sowings (Table 1). The reproductive phase was comparatively longer for early sown crop which

Received for publication August, 1994

Table 1 : Effect of sowing date and row spacing on growth and yield attributes of mustard CV. TM 2

Treatments	Total number of branches/plant			Number of Siliquae/Plant			1000 seed weight (g)			Seed yield (Kg/ha)		Average		Oil content (%)	Net Return (Rs./ha)
	1992	1993	1994	1992	1993	1994	1992	1993	1994	1992	1993	1994	Mean		
Sowing Date															
25 October	6.1	7.0	6.7	98.3	94.2	89.7	2.3	2.9	2.8	726.9	722.3	794.7	748.0	38.6	3600
9 November	9.0	7.9	7.7	121.4	76.7	81.4	2.3	2.9	2.7	819.9	582.7	734.7	712.4	37.6	3424
24 November	7.5	5.5	6.4	98.7	70.2	72.0	2.1	2.6	2.5	620.3	480.7	587.3	562.8	37.0	1658
9 December	6.2	5.6	5.8	78.8	55.5	56.8	2.0	2.2	2.2	361.8	357.0	368.0	362.3	36.3	-349
S. Em ±	1.2	0.4	0.2	9.6	6.5	2.0	0.03	0.09	0.17	62.9	24.9	26.5	33.9	-	-
C.D. at 5%	NS	1.3	0.6	NS	22.5	7.1	0.09	0.29	NS	217.9	86.3	91.8	117.4	-	-
Row Sppacings (cm)															
20	6.1	6.0	6.1	91.8	65.6	69.0	2.1	2.6	2.5	621.3	580.0	653.3	618.2	38.0	1804
30	7.0	6.5	6.8	100.5	75.9	74.5	2.2	2.7	2.6	642.0	561.8	639.3	614.3	37.3	2300
40	8.5	7.0	7.1	105.6	80.9	81.4	2.3	2.7	2.6	633.4	465.3	571.0	556.6	37.0	2065
S. Em ±	0.6	0.3	0.2	7.5	2.5	3.2	0.05	0.07	0.11	30.1	17.8	16.9	13.4	-	-
C. D. at 5%	1.7	N.S	0.7	N.S	7.6	9.6	N.S	N.S	N.S	N.S	53.3	50.7	40.1	-	-

might be the reason for higher seed yield. Similar results were reported by Jain *et al* (1986), Shastry and Kumar (1981) and Tomar and Mishra (1991). Delay in sowing later than 9 November reduced the seed yield conspicuously. Sowing on 24 November reduced the yield by 24.8 per cent, while 9 December sowing reduced yield by 51.6 per cent, over 25 October sowing (Table 1). Average Oil content in seeds as well as net returns were highest when the crop was sown on 25 October followed by 9 November. The sowing should be completed by 9 November for obtaining more yield.

Effect of row spacing:

Row spacings significantly influenced the seed yield during 1993 and 1994. Significant increase in seed yield was observed with decrease in row spacing from 40 to 30 cm which in turn was at par with 20 cm row spacing. Pooled analysis revealed a similar trend.

An increasing trend in plant height, total number of branches per plant, number of siliquae per plant, and 1000 seed weight was observed at wider spacings in all the years. However, this increase in growth and yield attributes at wider row spacing did not influence the yield probably due to substantially lower number of plants per unit area. Similar results were reported by Singh and Verma (1993). The highest oil content in seeds was observed with 20 cm, while the highest net return of Rs. 2300/ha was obtained with 30 cm row spacing. Thus 30 cm was proved to be optimum spacing.

LITERATURE CITED

Jain, V.K., Chouhan, Y.S., Khandakar, M.P., Jain, P.C., Rathore, D.R. and Rathore, R.N. 1986. Performance of *raya* varieties under late sown condition. *Indian J. Agron.* 31(4) : 374-376

Shastry, A.B. and Kumar, A. 1981. Variation in yield, its attributes and quality of Indian mustard in relation to planting time and level of plant population. *Indian J. Agric. Sci.* 51 : 27-32.

Singh, N.B. and verma, K.K. 1993. Performance of rainfed mustard (*Brassica juncea)* in relation to spacing in *diara* land of Eastern Uttar Pradesh. *Indian J. Agron.* 38(4) : 654-656

Tomar, R.K.S. and Mishra, G.L. 1991. Influence of sowing dates and nitrogen on the yield of mustard (*Brassica juncea* L.) *J. Oilseeds Res.* 8:210-214

J. Oilseeds Res. 13 (1) 1996: 13-17
ISSN 0970-2776

GROWTH, YIELD AND NET RETURNS OF MUSTARD UNDER DIFFERENT LEVELS OF NITROGEN AND SULPHUR APPLICATION ON CLAY LOAM SOILS

R.K.S. TOMAR, S.C. CHOURASIA *, J.S. RAGHU and V.B. SINGH**
Jawaharlal Nehru Krishi Vishwa Vidyalaya Zonal Agricultural Research Station
Tikamgarh - 472 001 (MP)

ABSTRACT

A field experiment was conducted during winter seasons of 1990-91 and 1991-92 to study the effect of nitrogen and sulphur application on growth, yield attributes, seed yield and economics of mustard (*Brassica juncea*, L. Czern & Coss) on caly loam soil. Growth components increased with the advancement of plant growth upto 90 DAS except functional leaves which increased upto 75 DAS. Nitrogen upto 90 kg/ha and sulphur upto 45 kg/ha significantly increased the growth and yield components, seed yield and net return. The highest yield (26.85 q/ha) and net return (Rs. 23,590/-) was obtained from N90 S 45. treatment.

Key Words: Mustard; Nitrogen; Sulphur.

INTRODUCTION

Fertilizer management, especially of nitrogen and sulphur, is one of the most important agronomic factors that affect the growth and yield of mustard (*Brassica juncea* L.). Indian mustard responds to nitrogen and sulphur remarkably on clay loam soils (Tomar and Mishra 1991; Dubey *et al.* 1993 and Khanpara *et al.* 1993). As the information was lacking particularly for Bundelkhand zone, the present study was undertaken to find out the response of mustard to nitrogen and sulphur on a vertisol.

MATERIALS AND METHODS

The field experiment was carried out at ZARS, Tikamgarh (MP) during 1990-91 and 1991-92. The soil was clay loam (vertisol), low in available nitrogen (210.6 kg/ha), sulphur (13.99 kg/ha), phosphorus (12.5 kg/ha) and high in available potash (412.6 kg/ha) with 7.6 pH. Rainfall of 1372 mm and 699 mm was received during 1990-91 and 1991-92 seasons, respectively. The treatments comprising of four rates of nitrogen (0,30,60 and 90 kg/ha) as the main-plot treatments and four rates of sulphur application (0,15,30, and 45 kg/ha) as the sub-plot treatments were laid out in a split-plot design with four replications. Mustard variety Varuna was sown using 5 kg/ha seeds in rows 30 cm apart on 11 November and 28 October during 1990-91 and 1991-92, respectively. A uniform basal dose of 40 kg P_2O_5 and 20 kg K_2O/ha was applied through triple super phosphate and muriate of potash, respectively. Half of the N dose through urea along with full dose of sulphur through gypsum was applied as basal treatment. Remaining half nitrogen was applied just after first irrigation at 25 DAS. One irrigation was given just after sowing and thereafter three irrigations were applied at 25,50 and 75 DAS.

RESULTS AND DISCUSSION

Growth components - The plant height, branches/plant and dry matter production increased to a greater extent with the advancement of plant growth upto 90 days after sowing and functional

* Dept of Botany, Govt. P.G. College, Tikamgarh
** Dept. of Statistics, College of Agriculture, Gwalior.

Received for publication October, 1994

leaves/plant increased upto 75 days after sowing and then declined (*Table 1*). Increasing N from 0 to 90 kg/ha increased growth components significantly at every growth stage, being maximum at 90 kg N/ha. Similar increases were also obtained in growth components by S levels upto 45 kg/ha at every stage of crop growth except plant height and number of leaves/plant at 30 DAS. Khanpara *et al.* (1993) have also reported similar results.

Yield attributes - The number of siliquae, seeds/siliquae, length of siliquae, 1000 seed weight, seed weight/plant, stover yield and harvest index were significantly increased due to each increment in level of N from 0 to 90 kg N/ha. (Table 2). Sulphur fertilization significantly improved the different yield attributes as compared with the control. A significant increase was also recorded upto 45 kg S/ha. The results confirm the findings of Khanpara *et al.* (1993) and Dubey *et al.* (1993).

Seed Yield - Seed yield increased significantly with an increase in N level from 0 to 90 kg/ha in both the seasons (Table - 3). The percent increase in yield over control due to application of 30, 60 and 90 kg N/ha was 54.2, 99.7 and 14.4 and 72.3, 116.3 and 176.6 during 1990-91 and 1991-92, respectively. Joshi *et al.* (1991) also reported response to nitrogen.

Higher levels of sulphur increased the seed yield significantly over no sulphur in both the seasons. Significantly higher seed yield was obtained at 45 kg S/ha and the increase over the control was 16.59% and 29.5%, respectively in 1990-91 and 1991-92. However, the difference between 15 and 30 kg S/ha over no S was not significant during 1990-91. The results confirm the findings of Joshi *et al.* (1991) and Khanpara *et al.* (1993).

Interaction - The interaction effect between N and S was not significant during 1990-91. However, their combined effect was well marked. During 1991-92 consistently higher response to nitrogen was observed in the presence of sulphur. The highest seed yield was obtained at N90 S45 which was significantly higher than rest of N and S combinations (Table - 3).

Net returns - The maximum average net return of Rs. 24680/ha was obtained with 90 kg N/ha which was more than thrice as compared to control. Similarly, highest mean net income (Rs.18800/ha) was obtained at 45 kg S/ha which was higher by 33% over no sulphur. The combined application of N 90 and S45 resulted in the highest net income of Rs. 28090/ha which was higher by 12.3% over N90 S30 and by 34% over N60 S45.

LITERATURE CITED

Dubey, O.P., Sahu, T.R., Garg, D.C. and Khan R.A. 1993. Response of mustard to sulphur and nitrogen under irrigated vertisol condition-II. Effect of S and N on ancillary characters, yield and quality. *J.Oilseeds Res.* 10(1) : 11-15.

Joshi, A.J., Alhawat, R.P.S. and Trivedi, S.J. 1991. Effect of nitrogen and sulphur fertilization on growth and yield of mustard *Indian J.Agron.* 36 (2) : 606-607.

Khanpara, V.D., Prowal, B.L. Sahu, M.P. and Patel, J.C. 1993. Effect of sulphur and nitrogen on yield attributes and seed yield of Indian mustard on vertisol. *Indian J.Agron.* 38(4): 588-592.

Tomar, R.K.S. and Mishra G.L. 1991. Influence of sowing dates and nitrogen on the yield of mustard. *J.Oilseeds Res.* 8 (2): 210-214.

Table 1 : **Growth components of mustard as affected by nitrogen and sulphur (Pooled data)**

Treatments	Plant height (cm) at DAS			Number of functional leaves/ plant					No. of branches/ plant			Dry matter production (g/m²)				
	30	60	90	30	45	60	75	90	60	75	90	30	45	60	75	90
Nitrogen (kg/ha)																
0	16.6	64.7	96.6	6.0	8.5	19.6	23.2	16.6	8.8	13.5	15.9	58	121	256	404	534
30	21.9	73.0	155.5	7.2	10.5	27.5	28.2	20.0	11.4	16.1	19.0	77	158	337	520	657
60	25.6	81.6	168.7	8.1	12.2	32.5	36.8	22.8	15.0	19.1	22.1	100	192	417	649	804
90	28.9	90.0	181.2	9.2	17.2	35.6	42.7	26.2	18.2	23.4	25.4	131	233	492	760	941
C D (0.05)	1.53	1.82	2.02	0.41	0.92	0.91	1.32	1.22	1.32	1.72	1.29	2.43	5.17	3.26	11.06	5.78
Sulphur (kg/ha)	21.4	73.1	156.3	7.2	11.2	25.9	30.5	20.3	12.2	16.8	19.5	82	162	346	538	687
15	22.7	76.4	159.0	7.5	11.8	28.5	31.9	21.0	13.0	17.7	20.3	88	170	357	564	708
30	24.2	78.7	163.0	7.8	12.6	29.3	33.2	21.7	13.8	18.4	21.2	94	184	373	595	745
45	24.5	81.6	167.0	8.0	13.4	30.8	34.9	22.6	14.5	19.6	22.3	101	193	408	626	763
C D (0.05)	NS	1.45	1.46	NS	0.59	0.69	0.70	0.37	0.73	0.80	0.95	2.09	3.56	2.08	4.77	3.92

DAS: Days after Sowing

Table 2 : Yield attributes of mustard as influenced by nitrogen and sulphur (Pooled data)

Treatments	Siliquae/ plant	Seeds/ Siliqua	Siliqua length (cm)	1000 - seed weight (g)	Seed weight/ plant (g)	Stover yield (q/ha)	Harvest index
Nitrogen (kg/ha)							
0	80.6	7.8	4.8	3.06	4.38	54.3	14.3
30	106.3	8.6	5.4	3.24	7.18	65.7	19.4
60	148.4	9.7	6.2	3.47	9.33	74.8	20.3
90	192.8	11.6	7.0	3.81	11.79	86.9	21.3
C D (0.05)	3.5	0.37	0.29	0.03	0.29	1.88	0.75
Sulphur (kg/ha)							
0	118.0	8.9	5.6	3.28	7.38	66.2	18.0
15	127.5	9.3	5.8	3.36	8.35	67.5	18.6
30	136.7	5.6	5.9	3.45	8.62	72.9	18.9
45	146.2	10.1	6.1	3.49	9.18	75.2	19.9
C D (0.05)	2.4	0.21	0.11	0.02	0.23	1.56	0.72

Table 3 : Seed Yield (q/ha) and net returns (Rs/ha) of mustard as influenced by nitrogen and sulphur

Sulphur (kg/ha)	1990-91					1991-92				
	Nitrogen (kg/ha)									
	0	30	60	90	Mean	0	30	60	90	Mean
	Seed yield (q/ha)									
0	7.26	12.74	16.57	19.87	14.16	7.59	14.24	18.82	24.21	16.21
15	7.82	13.38	17.36	20.36	14.73	8.59	16.41	20.40	25.40	17.69
30	8.70	13.38	17.39	20.79	15.06	10.24	17.38	21.15	27.07	18.96
45	10.29	13.74	17.88	23.55	16.51	12.24	18.49	23.15	30.15	21.00
Mean	8.66	13.36	**17.30**	**21.14**	-	9.65	16.63	20.88	26.70	-
					C D (0.05)			C D (0.05)		
Nitrogen (N)					1.27			1.52		
Sulphur (S)					1.30			1.21		
For N at same S level					NS			2.18		
For S at same N level					NS			2.36		
	Net Returns (Rs/ha)									
0	4340	9120	12890	15870	10560	5290	12080	16880	22340	14100
15	4780	9910	13340	16170	11100	6090	1400	1755	2329	1524
30	5520	9820	13430	16700	11130	7890	15210	18290	25010	16600
45	7400	10070	13710	19090	12570	9900	1626	2095	2809	1880
Mean	5510	9740	13390	16960	-	7290	14380	18370	24680	-

J. Oilseeds Res. 13 (1) 1996: 18-21
ISSN 0970-2776

EFFECT OF SOWING TIME ON PRODUCTION POTENTIAL AND INCIDENCE OF *SPODOPTERA LITURA* ON GROUNDNUT CULTIVARS.

R.K. PATIL, G. RAVISHANKAR, I.M. MANNIKERI, K.GIRIRAJ and S.G. RAYAR
Main Research Station, University of Agricultural Sciences, Dharwad - 580 005, Karnataka.

ABSTRACT

Field experiments conducted for three consecutive years (1990 to 1992) during *kharif*, under rainfed condition, to find the effect of sowing time on production potential and incidence of defoliator (*Spodoptera litura* F) on different groundnut cultivars showed that pod yield and incidence of *S.litura* tended to decline with delay in sowing time, irrespective of cultivars. Mean pod yield of 2684 kg/ha was obtained from 15th June sown crop which was 15, 48 and 63 per cent higher than that of 30th June, 15th and 30th July sown crop, respectively. However, lower percent leaf damage due to *S. litura* was noticed in 30th July sown crop (19.2%) as compared with 15th June (51.8%), 30th June (41.3%) and 15th July (31.2%) sown crop.

Key words: Sowing time; Groundnut cultivars; *Spodoptera litura*

INTRODUCTION

Groundnut is an important Oilseed crop grown extensively in Karnataka during *kharif* season under rainfed conditions. However, productivity of the crop in the state has remained around 700 kg / ha for several years. The production potential of groundnut can be improved to a greater extent by adjusting the sowing time, an important non monetary input, to avoid adverse effect of heavy rains, pest and disease infestation and by adopting suitable varieties under such conditions (Purushothaman *et al.* 1974). Hence a study was undertaken to evaluate the effect of different sowing times on yield and incidence of *Spodoptera litura* on different cultivars of groundnut.

MATERIALS AND METHODS

A field experiment was conducted at the Main Research Station, University of Agricultural Sciences, Dharwad, during *kharif* 1990 through 1992 on medium black soils under rainfed conditions to find the effect of sowing time on yield and incidence of *S.litura* on different groundnut cultivars. The soil of the experimental site was low in available N (0.05%), medium in available P_2O_5 (0.002%) and high in available K_2O (0.024%). The soil pH was 7.6. Twelve treatment combinations comprising four sowing dates viz., 15th June, 30th June, 15th July and 30th July and three groundnut cultivars viz., Dh-3-30, JL-24 and TMV-2 were tested in a split-plot design with 3 replications. The crop was sown at a spacing of 30cm x 10 cm. The gross and net plot size was $15M^2$ and $11.52M^2$ respectively. Recommended dose of fertilizer (25:75:25 kg N, P_2O5 and K_2O/ha) was applied at the time of sowing. The total rainfall received during the crop season (June to November) was 553, 846 and 830 mm during 1990, 1991 and 1992, respectively. Observations on pod yield and infestation of *S.litura* on groundnut cultivars were recorded. The percent leaflet damage at 60 days was recorded by counting the damaged and healthy leaflets from five randomly selected plants in each treatment.

RESULTS AND DISCUSSION

During all the three years, crop sown on 15th and 30th June recorded significantly higher pod yields than 15th and 30th July sowings.

Received for publication November, 1994

In general delayed sowings reduced the pod yield considerably. The optimum time for sowing is as close as possible to the onset of the first rain. Conditions at this period will be ideal for crop growth as the soils are well aerated, moist, warm and are benefited from the natural flush of the nitrifying activity of the soil microflora. During 1991 significantly higher pod yield was recorded in 15th June sown crop when compared to other dates of sowing. Lower pod yield obtained in 30th June sown crop during 1991 is mainly due to frequent dry spells that prevailed during sowing time. The reduced pod yield in delayed sowings (15th July and 30th July) could be due to moisture stress during later stages of growth viz., flowering, peg initiation, pod development and pod filling phases. Mean pod yield (average of 3 years) of 2684 kg/ha was recorded in 15th June sown crop, which was 15, 48 and 63 per cent higher than that of 30th June, 15th July and 30th July sown crop, respectively (Table 1). These results are in conformity with the findings of Shantimallaiah *et al.* (1979) Chhonkar and Arvindkumar (1985) and Sandhu and Hundal (1993).

Among groundnut cultivars, JL-24 offered higher mean pod yield of 2121 kg/ha than Dh-3-30 (1855 kg/ha) and TMV-2 (1524 kg/ha), the enhancement being 13 and 28 per cent, respectively.

The incidence of *Spodoptera litura as* influenced by different dates of sowing clearly indicated that the early sown crop (upto 30th June) was more prone to the damage compared to late sown crop (15th July and 30th July sowings) during all the three years. The crop sown on 15th June experienced a leaflet damage of 51.8% as compared with 30th June (41.3%), 15th July (31.2%) and 30th July (19.2%) sown crops (Table 2). Although higher leaflet damage was observed in early sown crop, the yield reduction was least when compared to late sown crop, which was mainly due to better crop growth, recouping/recovery time and intrinsic compensatory mechanism that exists in early sown crop than late sown crops in a specified region. With delay in sowing the growth of crop will be adversely affected due to moisture stress during flowering, peg initiation, pod development and pod filling phase, resulting in lower pod yield.

LITERATURE CITED

Chhonkar, A.K. and Arvind Kumar, 1985. Yield attributes and yield of groundnut varieties as influenced by planting dates in *tarai* region of Uttar Pradesh. *J. Oilseeds* Res. 2: 329-334.

Purushothaman, S., Rangasamy, A., Gopalsamy, N. and Sivasankaran D., 1974. *Time of sowing of groundnut in* the Parambikulam aliyar project tract. *Madras agric. J.* 61:812.

Sandhu, B.S. and Hundal, S.S., 1993. Effect of row spacing and sowing time on production potential of groundnut (*Arachis hypogaea*). *Indian J.Agron.* 38 (3): 422-426.

Shantimallaiah, N.R., Krishnegowda, K.T. and Patil, N.M., 1979. Comparative performance of sunflower and groundnut at different sowing dates. *Mysore J. Sci. 13* (3) : 265-267.

Table 1 : Effect of sowing dates on pod yield of different groundnut cultivars

Sowing dates	Pod yield (kg/ha)												
	1990				1991				1992				
	Dh-3-30	JL-24	TMV-2	Mean	Dh-3-30	JL-24	TMV-2	Mean	Dh-3-30	JL-24	TMV-2	Mean	Mean of 3 years
15th June	2474	2439	1788	2234	2937	3400	2445	2927	2556	3447	2670	2891	2684
30th June	2352	3559	1519	2477	1712	1331	1258	1437	2633	3474	2609	2905	2273
15th July	1927	1510	1640	1692	999	1302	657	984	1543	1516	1380	1480	1385
30th July	946	1007	686	880	853	1012	636	834	1324	1456	1007	1262	992
Mean	1925	2129	1408	1821	1625	1761	1249	1545	2014	2473	1916	2134	
Mean of 3 years	1855	2121	1525										
C D (0.05)													
Date of sowing	418.40				347.0				431.70				
Varieties	361.97				301.0				373.9				

Table 2 : Effect of sowing dates on the incidence of *Spodoptera litura* on different groundnut cultivars

Sowing dates	Per cent leaflet damage due to *Spodoptera litura*												
	1990				1991				1992				
	Dh-3-30	JL-24	TMV-2	Mean	Dh-3-30	JL-24	TMV-2	Mean	Dh-3-30	JL-24	TMV-2	Mean	Mean of 3 years
15th June	52.8	52.5	55.9	53.7	39.2	38.1	35.7	37.7	70.8	61.5	60.1	64.1	51.8
30th June	31.7	36.8	37.2	35.2	30.5	30.6	30.5	30.5	65.8	56.9	52.2	58.3	41.3
15th July	38.5	38.1	45.0	40.8	24.7	26.4	26.7	25.7	28.7	26.9	25.9	27.2	31.2
30th July	26.7	26.5	25.2	29.5	8.5	7.7	8.3	8.2	19.4	19.1	21.7	20.1	19.2
Mean	37.4	38.4	40.8	39.8	25.7	25.7	25.3	25.5	46.1	41.1	39.9	42.4	
Mean of 3 years	36.4	35.1	35.3										
C D (0.05)													
Date of sowing	4.84				3.14				3.79				
Varieties	4.03				NS				3.28				

J. Oilseeds Res. 13 (1) 1996: 22-25
ISSN 0970-2776

EFFECT OF DIFFERENT LEVELS AND SOURCES OF SULPHUR ON YIELD, QUALITY AND UPTAKE OF SULPHUR BY SESAME

N.P.S. YADAV, VINAY SINGH and V.S. MEHTA
Department of Agricultural Chemistry and Soil Science, R.B.S. College, Bichpuri, Agra.

ABSTRACT

The response of sesame to different sources of sulphur applied through ammonium sulphate, gypsum, pyrites and elemental sulphur was studied on an alkaline sandy loam soil. Grain and stalk yields, S uptake and oil content of sesamum increased significantly with increasing levels of sulphur. Amongest the sources of S tested, ammonium sulphate and gypsum were the best followed by pyrites and elemental sulphur in respect of yield, oil content and S uptake.

Key Words: Sources; levels, sulphur; yield; quality, sulphur uptake; sesame

INTRODUCTION

The role of sulphur in oilseed crops from both yield and quality point of view is well established. In Agra region, the soils are alkaline in nature and are deficient in sulphur. The yields of sesame are low when grown on these soils. Therefore, a study was made to find out the optimum dose and source of sulphur for sesame crop raised on an alluvial soil for optimum seed yield and oil production.

MATERIALS AND METHODS

A green house experiment was conducted during *Kharif*, 1992 on a sandy loam soil using sesame as test crop. The soil had pH (1:2.5) 8.0, EC 0.17 dSm^{-1}, organic carbon 0.41% and available S (0.15% $CaCl_2$) 9.0 mg kg^{-1}. Processed soil was filled in earthen pots lined with polythene sheets at the rate of 5 kg pot^{-1}. To these pots, S was added at the rate of 0, 10, 20 and 30 mg kg^{-1} through ammonium sulphate, gypsum, pyrites and elemental sulphur. A basal dose of 25 mg N kg^{-1}, 30 mg $P_2O_5 kg^{-1}$ and 15 mg K_2O kg^{-1} was also applied through urea, triple super phosphate and KCl, respectively. Nitrogen applied through ammonium sulphate was taken into account while applying the basal dose through urea. Different quantities of calcium supplied by gypsum were balanced by the addition of $CaCl_2$. All the treatments were replicated three times in a factorial completely randomized design. Ten seeds of sesame (*Sesame indicum* L. Cv. Pratap) were sown and thinned to four after complete germination. Pots were irrigated with demineralized water as and when required. The crop was harvested at maturity and grain and stalk yields were recorded. The plant samples collected were ground and digested in $HNO_3 + HClO_4$ (5:1) mixture. Sulphur in plant samples was determined turbidimetrically using colorimeter (Chesnin and Yien, 1951). Oil content in the seed was estimated using Soxhlet extraction method.

RESULTS AND DISCUSSION

Increasing doses of sulphur increased the seed and stalk yields of sesame (Table 1) wherein application of 30 mg S kg^{-1} resulted in significantly higher yields of 9.3 and 20.6 g/pot, respectively. In the current study the crop responded to applied S since the soil was deficient in available S as it contained less than 10 ppm $CaCl_2$ extractable S (Mehta *et al.*, 1988). The response of oilseed crops to sulphur was also reported by Mehta and Singh (1988).

Received for publication December, 1994

The effect of different sources of sulphur on the yield of sesame was significant. Application of ammonium sulphate followed by gypsum, pyrites and elemental sulphur offered the highest yields in that order. Superiority of ammonium sulphate could be attributed to its high solubility resulting in adequate S supply to the crop and, thus, increased the yield. Similar observations have been made by Sharma *et al.* (1981). Ammonium sulphate and gypsum were comparable and were superior to pyrites and elemental sulphur in enhancing the yields of sesame. The higher yield with gypsum application may be due to the presence of sulphur in SO_4 form and better calcium supplying capacity of the soil. In addition, gypsum has been known to improve the soil physical condition of saline-alkali soil, resulting in better growth of the crop. Nabi *et al.* (1990) also made similar observations. The poor response to pyrites and elemental S could be due to low oxidation rate of sulphide to form sulphate, which is controlled by soil moisture, temperature and microbial activity. The interaction effect of sources and levels of S was significant. The seed and stalk yields were significantly higher with ammonium sulphate or Gypsum at 30g/pot than the other sources.

The oil content of sesame seed enhanced with increasing levels of sulphur and was highest with 30 mg S kg^{-1} (Pathak and Tripathi, 1979). Sulphur plays a role in formation of glucoside, which on hydrolysis produces higher amount of oil in seeds. Although different sources, did not account for discernible variations in oil content, application of sulphur through gypsum and ammonium sulphate resulted in the highest oil content, while the lowest oil content was observed due to application of S through elemental S (Table 2).

Irrespective of the variation in sources of sulphur, increase in content and uptake of S by sesame seed and stalks was noticed upto 30 mg kg^{-1} sulphur (Table 3). The content and uptake of S were, found to be highest in seed and stalks, respectively. Narwal *et al.* (1991) also reported higher content and up take of S by mustard due to sulphur application. The content and uptake of S by seed and stalks of sesamum differed significantly wherein the highest content and uptake was observed with ammonium sulphate followed by gypsum, Pyrites and elemental sulphur, in tune with the trends observed in the yields of seed and stalk.

LITURATURE CITED

Chesnin, L. and Yien, C.H. 1951. Turbidimetric determination of available sulphate. *Proc. Soil Sci. Soc. Am.* **15**: 149-151.

Mehta, V.S. and Singh, Vinay. 1988. Effect of sulphur and zinc on yield and uptake by mustard. *J. Indian Soc. Soil Sci.*36: 190-191.

Mehta, V.S. Singh, Vinay and Singh, R.B. 1988. Evaluation of some soil test methods for available sulphur in some alluvial soils. *J. Indian Soc. Soil Sci.*36: 743-746.

Nabi, Ghulam, Rahmatullah and Salim, M. 1990. Utilization of added sulpher by groundnut on two Udic Haplustalfs. *J. Indian Soc. Soil Sci.* 38: 70-72.

Narwal, R.P., Gupta, A.P., Karwasra, S.P.S. and Antil, R.S. 1991. Effect of carriers of sulphur on yield and uptake of sulphur by mustard. *J.Indian Soc. Soil Sci.* 39:324-327.

Pathak, R.K. and Tripathi, R.D. 1974. Effect of nitrogen and sulphur on yield and quality of raya (B.juncea Czern coss var. Varuna) *Indian J. Agric. Chem.* 12:152-157.

Sharma, D.N., Khaddar, V.K., Sharma, R.A. and Singh, D.1981. Effect of different doses and sources of sulphur on the quality and yield of mustard. *J.Indian Soc. Soil Sci.* 39: 197-200.

Table 1 : Effect of sources and levels of sulphur on seed and stalk yields of sesame

Sources of S / Levels of S (mg kg^{-1}) (L)	Seed yield (g pot^{-1})					Stalk yield (g pot^{-1})				
	0	10	20	30	Mean	0	10	20	30	Mean
Amm. Sulphate	5.5	7.0	9.0	10.0	7.0	12.0	15.5	20.0	22.5	17.4
Gypsum	5.6	6.8	8.0	10.7	7.8	12.5	15.0	17.5	23.0	17.0
Pyrites	5.6	6.5	7.8	8.2	7.0	12.5	14.7	17.5	18.0	15.7
Elemental Sulphur	5.5	6.2	8.0	8.3	7.0	12.0	13.3	17.5	18.0	15.2
Mean	5.6	6.6	8.2	9.3		12.3	14.5	18.1	20.4	
C D (0.05)	S or L	0.22,	SxL	0.44		S or L	0.37,	SxL	0.74	

Table 2 : Effect of sources and levels of sulphur on oil content in sesame seed

Sources of S / Levels of S (mg kg^{-1}) (L)	Oil content (%)				
	0	10	20	30	Mean
Amm. Sulphate	48.1	48.8	49.5	50.0	49.1
Gypsum	48.0	48.6	49.6	50.2	49.0
Pyrites	48.0	48.5	49.2	49.8	48.8
Elementals Sulphur	48.0	48.4	48.8	48.8	48.3
Mean	48.0	48.6	49.3	49.5	
C D (0.05)	S:NS,	L: 0.26	S x L, :	NS	

Table 3 : Effect of sources and levels of sulphur on content and uptake of S in sesame seed and stalk

Sources of S / Levels of S (mg kg^{-1}) (L)	Seed					Stalk				
	0	10	20	30	Mean	0	10	20	30	Mean
					Sulphur content (%)					
Amm. Sulphate	0.34	0.37	0.41	0.44	0.39	0.19	0.22	0.25	0.28	0.24
Gypsum	0.34	0.36	0.39	0.45	0.38	0.19	0.22	0.24	0.28	0.23
Pyrites	0.34	0.35	0.38	0.40	0.36	0.19	0.21	0.23	0.25	0.22
Elemental Sulphur	0.34	0.36	0.39	0.41	0.37	0.19	0.21	0.22	0.25	0.22
Mean	0.34	0.36	0.39	0.42		0.19	0.22	0.24	0.27	
C D (0.05)	S or L :	0.01	SxL :	0.02		S or L :	0.01	SxL :	NS	
					Sulphur uptake (mg pot^{-1})					
Amm. Sulphate	18.6	25.8	36.8	44.0	31.3	22.8	32.9	49.9	43.0	42.2
Gypsum	19.0	24.4	31.7	48.1	30.7	23.7	33.0	41.9	64.4	40.7
Pyrites	19.0	22.7	29.6	32.7	26.0	23.7	30.8	40.2	44.9	34.9
Elemental Sulphur	18.7	22.3	31.2	34.0	26.5	22.8	27.99	38.5	44.9	35.5
Mean	18.8	23.8	32.2	39.7		23.2	31.2	42.6	53.3	
C D (0.05)	S or L :	0.89	SxL :	1.78		S or L :	1.67	SxL :	3.34	

J. Oilseeds Res. 13 (1) 1996: 26-31
ISSN 0970-2776

RESPONSE OF SUMMER GROUNDNUT VARIETIES TO POTASSIUM AND PLANTING METHOD.

A.K.Patra[1], R.C. Samui And S.K. Tripathy[2]
Department of Agronomy, Faculty of Agriculture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal - 741 252.

ABSTRACT

Field experiments conducted in two summer seasons at Kalyani, revealed that groundnut variety JL 24 was superior to ICGV 86015. Application of 50 kg K_2O/ha significantly increased pod, kernel, oil and haulm yields over no potassium application. Planting in broad bed and furrow (BBF) system gave the highest yield followed by planting in flat bed with earthing up at 25 days after sowing. Planting in BBF system increased pod yield by 14.1% and oil yield by 13.9% and planting in flat bed with earthing up increased pod yield by 7.6% and oil yield by 7.0% over planting in flat bed without earthing up.

Key Words: Groundnut varieties; Potassium; Planting methods.

INTRODUCTION

India ranks first both in area (7.5 m. ha) and production of world groundnut (6.06 m. tons), but productivity wise it is among the lowest (870 kg/ ha). The reasons for such a low yield have been ascribed to growing the crop mostly in rainfed areas and in marginal lands with low inputs, poor plant populations, inadequate and imbalanced fertilization, lack of plant protection, faulty method of planting and also to inefficient post harvest technology. Recent on-farm researchers' managed trials conducted in India indicated that improved genotype contributed 25 - 28% to yield increases, while improved agronomy contributed 30 - 32% (Nageswara Rao, 1992). Trials from various locations showed that planting in broad bed and furrow (BBF) method gave significantly higher pod yields of groundnut over conventional methods (Reddy *et al.*, 1991; Hadvani, *et al*; 1993). Potassium is essential for photosynthesis and pod development in groundnut (Burkhart and Collins, 1941). The present investigation was carried out to study the response of groundnut genotype to potassium and different planting methods in summer under irrigated condition.

MATERIALS AND METHODS

A field experiment was conducted at the University Farm, Kalyani, West Bengal during summer seasons of 1993 and 1994. The soil was a sandy loam, medium in fertility status (0.6% organic carbon, 0.06% total N, 16.5 and 162 kg of available P_2O_5 and K_2O/ha, respectively) and neutral in reaction with pH 7.4. The experiment was laid out in a factorial randomised block design with three replications. The treatments include 2 varieties (JL24 and ICGV 86015), 2 levels of potassium (0 and 50 kg K_2O/ha) and 3 planting methods (flat bed without earthing up, flat bed with earthing up, and broad bed and furrow). The crop was sown in lines 30 cm apart during 1st week of February and was harvested during last week of May. In broad

1. Regional Research Station, OUAT, Chiplima, Orissa - 768 025. 2. Agricultural Research Station, OUAT, Berhampur, Orissa - 761 001.

Received for publication January, 1995

bed and furrow (BBF) method, seed furrows were made 30cm apart and after each 4 furrows 30cm wide and 15cm depression was made. The crop received 20 kg N and 40 kg P_2O_5/ha as basal in the form of urea and single super phosphate. Potassium as per treatment was applied in the form of muriate of potash. Earthing up was done at 25 days after sowing (DAS) according to the treatment requirement. In each plot, second row from both sides of the plot was earmarked for recording biometric observations including destructive sampling and rest of the plot was used for determination of yield and yield components. Oil content in kernel was determined by Soxhlet method.

RESULTS AND DISCUSSION

Growth

Variety JL-24 recorded significantly higher leaf area index (LAI) at 50 DAS than ICGV 86015, but towards the later stages of growth the variation was not significant (Table 1). Similarly, JL 24 recorded significantly higher dry matter production (DMP) at 70, 90 and 110 DAS, net assimilation rate (NAR) at 50-70 DAS as compared to ICGV 86015. Potassium had no significant influence on growth attributes except LAI at 90 DAS, DMP at 70 DAS and NAR at 70-90 DAS. Application of 50 kg K_2O/ha increased LAI by 6.5% at 90 DAS over no potassium application. Planting in BBF method significantly increased plant height, LAI, drymetter over planting in flat bed (FB) with or without earthing up. However, in NAR both planting in BBF and FB with earthing up were similar. Poor growth was noticed in FB without earthing up compared to other two methods of planting. Earthing up creates favourable soil condition and facilitates the uptake of plant nutrients from soil which might have increased the growth of the plant. Better growth in BBF system could be attributed to improved nodulation which probably increased nitrogen supply to plant (Hadvani *et al.* 1993).

Yield Components

The variety JL-24 recorded higher no. of pods/plant, shelling percent and 100-kernel weight than ICGV 86015 (Table 2). Application of potassium had no significant effect on no. of pods/plant in 1993, however, the effect was significant in 1994 and also in pooled analysis. Potassium also increased 100-kernel weight in 1993 and in pooled analysis. Shelling percent was not influenced by potassium. Yakadri *et al.* (1992) also reported positive response for no. of pods/plant and 100-kernel weight but no influence on shelling per cent by application of potassium. Planting in BBF method recorded significantly higher no. of pods/plant and higher 100-kernel weight during both years as compared to other two planting methods, but shelling per cent was not influenced by different planting methods. Reddy *et al.* (1991) and Hadvani *et al.* (1993) also recorded higher no. of pods/ plant and 100-pod weight in BBF than with flatbed method. The oil content of JL24 was more than that of ICGV 86015.

Yield

Genotype JL-24 offered significantly higher pod, kernel, oil and haulm yields than ICGV 86015 (Table 3). The respective enhancement in JL 24 over ICGV 86015 was 12.2, 17.3, 21.4, and 4.6%. This superior performance of JL 24 could be attributed to more no. of pods, higher shelling and 100 kernel weight. The varietal variation in yields might be due to differential genetic make-up. Varietal variation in yield of groundnut was also reported by Padhi (1994). Application of potassium @ 50 kg K_2O/ha significantly increased pod, kernel and oil yields of summer groundnut but had no significant effect on haulm yield. The increase

Table 1 : Effect of variety, potassium and method of planting on growth of Summer groundnut (mean of 1993 and 1994)

	Plant height (Cm)	Leaf area index (LAI)			Dry matter production (g/m^2)				Net assimilation rate ($g/m^2/day$)	
		50 DAS	70 DAS	90 DAS	50 DAS	70 DAS	90 DAS	110 DAS	50-70 DAS	70-90 DAS
Variety										
JL24	63.3	1.40	3.09	3.04	216	436	648	682	7.49	4.75
ICGV 86015	62.6	1.27	2.97	3.02	213	417	622	654	6.91	4.66
S. Em. (±)	0.24	0.02	0.04	0.04	1.8	2.3	2.4	1.8	0.08	0.06
CD (0.05)	NS	0.06	NS	NS	NS	6.4	6.9	5.1	0.23	NS
Potassium level (kg K_2O/ha)										
0	62.7	1.32	3.00	2.93	212	422	633	666	6.99	4.85
50	63.2	1.36	3.07	3.12	217	431	637	670	6.95	4.57
S. Em. (±)	0.24	0.02	0.04	0.04	1.8	2.3	2.4	1.8	0.08	0.06
CD (0.05)	NS	NS	NS	0.12	NS	6.4	NS	NS	NS	0.17
Planting method										
Flat bed (FB)	59.4	1.15	2.75	2.75	196	399	611	642	7.45	5.19
Flat bed with earthing up	63.7	1.38	3.09	3.11	219	436	638	669	6.98	4.43
Broad bed and furrow (BBF)	65.7	1.48	3.25	3.22	228	445	655	693	6.60	4.51
S. Em. (±)	0.29	0.02	0.05	0.05	2.2	2.7	2.9	2.2	0.10	0.07
CD (0.05)	0.84	0.07	0.14	0.14	6.2	7.7	8.5	6.3	0.28	0.20

DAS : Days after sowing

Table 2 : Effect of variety, potassium and method of planting on yield attributes and oil content of summer groundnut

	Number of pods/plant			Shelling percent			100-kernel weight (g)			Oil content in kernel (%)	
	1993	1994	Mean	1993	1994	Mean	1993	1994	Mean	1993	1994
Variety											
JL24	19.2	19.7	19.5	71.6	70.7	71.2	49.2	50.8	50.0	49.62	48.62
ICGV 86015	17.7	18.0	17.9	68.9	67.2	68.1	36.3	36.2	36.3	47.63	47.19
S. Em. (±)	0.38	0.28	0.20	0.21	0.16	0.12	0.18	0.24	0.15		
CD (0.05)	1.11	0.82	0.57	0.60	0.47	0.35	0.53	0.70	0.43		
Potassium level (kg K_2O/ha)											
0	18.4	18.1	18.3	70.2	68.9	69.6	42.3	42.8	48.58	47.90	
50	18.5	19.6	19.1	70.4	69.0	69.7	43.2	43.8	43.5	48.67	47.91
S. Em. (±)	0.38	0.28	0.20	0.21	0.16	0.12	0.18	0.24	0.15		
CD (0.05)	NS	0.82	0.57	NS	NS	NS	0.53	NS	0.43		
Planting method											
Flat bed (FB)	17.4	17.2	17.3	70.3	69.0	69.7	42.3	42.0	42.2	48.68	48.03
Flat bed with earthing up	18.7	19.3	19.0	70.3	69.0	69.7	42.8	43.5	43.2	48.55	47.75
Broad bed and furrow (BBF)	19.3	20.1	19.7	70.2	68.9	69.6	43.3	45.0	44.2	48.65	47.94
S. Em. (±)	0.46	0.34	0.24	0.25	0.19	0.14	0.21	0.29	0.18		
CD (0.05)	1.36	1.00	0.68	NS	NS	NS	0.63	0.84	0.51		

Table 3: Effect of variety, potassium and method of planting on pod, kernel, oil and haulm yield of summer groundnut

	Pod Yield (kg/ha)			Kernel yield (kg/ha)			Oil yield (kg/ha)		
	1993	1994	Mean	1993	1994	Mean	1993	1994	Mean
Variety									
JL24	2606	2679	2643	1866	1894	1880	926	920	923
ICGV 86015	2354	2356	2355	1622	1583	1603	772	747	760
S. Em. ±	13	12	9	14	13	11	5	4	2
CD (0.05)	38	35	26	40	37	32	15	11	6
Potassium level (kg K_2O/ha)									
JL 24									
ICGV 86015									
0	2428	2480	2454	1705	1709	1707	828	819	824
50	2532	2555	2544	1783	1768	1776	869	848	859
S. Em. ±	13	12	9	14	13	11	5	4	2
CD (0.05)	38	35	26	40	37	32	15	11	6
Planting method									
Flat bed (FB)	2334	2328	2331	1642	1610	1626	800	774	787
Flat bed with earthing up	2469	2544	2507	1737	1758	1748	843	840	842
Broad bed and furrow (BBF)	2638	2681	2660	1853	1849	1851	904	887	896
S. Em. ±	16	15	11	16	15	13	6	5	2
CD (0.05)	46	43	32	47	44	38	18	14	7

was due to the fact that K influences the physiological processes that are directly related to symbiotic N fixation, photosynthesis and carbohydrate translocation for pod growth. Higher yields in groundnut were also obtained with the application of potassium by Dubey *et al.* (1986).

The pod, kernel, oil and haulm yields were significantly influenced by various planting methods, Highest yields were recorded with planting in BBF method followed by FB with earthing up. Planting in BBF method increased pod, kernel, oil and haulm yields by 14.1, 13.8, 13.9 and 8.1% respectively; while the corresponding figures for FB with earthing up were 7.6, 7.5, 7.0, and 3.9% respectively over planting in flat bed without earthing up. In BBF method, better and efficient water management might have enhanced the uptake of nutrients by the crop which increased the growth and yield attributes that ultimately enhanced yields. Earthing up at 25 DAS loosened the soil at root zone which facilitated the symbiotic N fixation and aeration and thus positively influencing growth and yield of groundnut. Higher yields of groundnut by earthing up (Agasimani *et al.* 1986 and Garse *et al.* 1986) and planting in BBF method (Reddy *et al.* 1991 and Hadvani *et al.* 1993) were also reported.

Significant interaction between variety and planting method was observed in 1994 and in pooled analysis wherein the variety JL24 offered significantly higher kernel and oil yields when planted in BBF method than the rest of the treatments.

LITERATURE CITED

Agasimani, C.A., Palled, Y.B., Sajjan, S.N. and Katti, H.S. 1986. Effect of earthing up, drum rolling and defoliation on groundnut. Indian J. Agron. 31 (1): 104-105.

Burkhart, L. and Collins, E.R. 1941. Mineral nutrient in peanut plant growth. Proc. Soil Sci. Soc. Am. 6:272-280.

Dubey, S.K., Ray, N. and Sharma, J.K. 1986. Effects of P and K doses on the yield attributes, yield and N content in kernels in groundnut (Arachis hypogaea). Indian Agriculturist. 30 (4): 269-273.

Garse, T.L., Nikam, S.M. and Deokar, A.B. 1986. Effect of drum rolling and earthing up on the yield of *Kharif* groundnut under rainfed conditions. Madras Agric. J. 73 (2): 77-81.

Hadvani, R.G., Ahlawat, R.P.S. and Trivedi, S.J. 1993. Effect of methods of sowing and levels of sulphur on growth and yield of groundnut (*Arachis hypogaea*) Indian J. Agron. 38 (2): 325 - 327.

Nageswara Rao, R.C. 1992. Some crop physiological approaches for groundnut improvement. J. Oilseeds Res. 9 (2): 281-296.

Padhi, A.K. 1994. Response of groundnut (*Arachis hypogaea* L) varieties to time of sowing under rainfed condition. J. Oilseeds Res. 11 (1): 132-133.

Reddy, K.S., Selvam, V.S., Rajan, M.M.S. and Sridhar, V. 1991. Effects of land treatments on the productivity of rainfed spanish groundnut. J. Res., APAU. 19 (1): 1-4.

Yakadri, M., Hussain, M.M. and Satyanarayana, V. 1992. Response of rainfed groundnut (*Arachis hypogaea*) to potassium with varying levels of nitrogen and phosphorus. Indian J. Agron. 37 (1): 202-203.

J. Oilseeds Res. 13 (1) 1996: 32-41
ISSN 0970-2776

EFFECT OF CULTURE MEDIA AND GENOTYPES ON INVITRO RESPONSE OF MATURE EMBRYOS OF LINSEED (*LINUM USITATISSIMUM* L.)*

VIJAY SARATHE and SHARAD TIWARI
Department of Plant Breeding and Genetics,
Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur 482 004

ABSTRACT

Mature embryos of ten linseed genotypes were cultured on MS basal medium with 13 different combinations of growth harmones. Based on their *in vitro* culture response in preliminary trial, four media were selected for the final experiment. The results showed highly significant differences between genotypes, culture media and genotype x media interactions for callus initiation, embryogenic callus formation and plantlet regeneration. The media MS 3DB (3.0 mg l^{-1} 2, 4-D + 0.5 mg l^{-1} BA), MS 2DY (2.0 mg l^{-1} 2, 4-D + 100 mg l^{-1} YE) and MS 2DB (2.0 mg l^{-1} 2, 4-D + 0.5 mg l^{-1} BA) for callus induction and MS 3DB and MS 2DB for embryogenic callus formation and plantlet generation responded best in that order. The highest mean frequencies for callus initiation were observed in genotypes J.23 (94.3%), R.7 (93.5%) and C.3 (91.1%) and for embryogenic callus formation in genotypes C.3 (74.3%), C.2 (69.0%) and R.17 (68.3%). The highest plantlet formation was observed in genotypes R.17 and J.23 which raised as high as 147 plants per 100 embryos of R.17 cultured on MS 2DB.

Key Words: Embryo culture; genotypes; media; callus initiation; plantlet regeneration.

INTRODUCTION

In vitro technologies including embryo culture have drawn considerable attention in recent years for genetic improvement of different crops. For linseed (Flax) also a variety of biotechniques are available now, which are relevant namely, (1) somatic tissue or cell culture for rapid propagation of plants from meristems or calli (Murray *et al.*, 1977; Pretova and Williams, 1986; Kaul and Williams, 1987; Straathof 1989; Zhan *et al.*, 1989); (2) anther-or microspore culture for regeneration of haploid plants (Nichterlein *et al.*, 1991); (3) culture of hybrid embryos out of wide crosses of cultivated species to their wild relatives i.e., interspecific hybridization (Green, 1984), (4) *in vitro* selection for various abiotic factors (McHughen and Swartz, 1984; Jorden and McHughen, 1987), (5) culture and regeneration of hybrid protoplasts by protoplast fusion technique for the development of asexual interspecific and intergeneric hybrids (heterokaryons and 'cybrids') when related species are extremely recalcitrant to hybridization (Barakat and Cocking, 1983, 1985; Ling and Binding, 1987), (6) genetic engineering with isolated protoplasts ('direct gene transfer') and (7) genetic engineering via specific vector system i.e., *Agrobacterium tumefaciens* (Basiran *et al.*, 1987; McHughen, 1989) and *A.rhizogenes* (Zhan *et al.*, 1988).

To implement *in vitro* technologies through embryo culture, it is important to have an efficient and productive culture system. Efficiency of embryo culture is influenced by various genetical and physiological factors such as genotype, nutrient medium and culture conditions.

* Part of M.Sc. thesis submitted by first author to JNKVV, Jabalpur.

Received for publication January, 1995

Embryo culture studies on flax varieties of the same species i.e, *Linum usitatissimum* L. are well documented and discussed (Ibrahim, 1971; Gamborg and Shyluke, 1976; Methewes and Narayanaswamy, 1976). However, similar studies with cultivated varieties of Indian origin of this species where action and interaction of genotypes and culture media on end product are subjected to substantial change, have not been carried out. The present investigation was, therefore, undertaken to findout suitable nutrient medium and genotypes with high regeneration frequencies and to study genotype x culture medium interactions for mature embryo culture of lineseed.

MATERIALS AND METHODS

Experiments were conducted with 10 genotypes of linseed (*Linum usitatissimum* L.) which included six cultivars and four advanced breeding lines obtained from National Agricultural Research Project, JNKVV, Rewa, Madhya Pradesh.

A preliminary experiment was conducted with 13 different combinations of growth harmones supplemented in MS medium (Murashige and Skoog, 1962) in a search for better responding composition of media for embryo culture. For culture purposes, embryos were isolated from randomly selected seeds taken from a mixed seed lot of 10 genotypes. On the basis of culture response, 4 media namely MS 2DB, MS 3DB, MS 2DY and MS 2D were selected for final experiment conducted with mature embryos of same genotypes.

Media were prepared from ready made basal MS medium (Hi Media) supplemented with growth harmones and 30 gl^{-1} sucrose and 7.5 gl^{-1} agar. Media were adjusted to 5.6 pH before adding agar. After sterilization by autoclaving, media were poured into presterilized 100 mm glass petri-dishes for culture.

For excision of mature embryos, mature seeds were surface sterilized for 1 min. in 70% ethyl alcohol and then 15 min. in 10% calcium hypochlorite ($CaOCl_2$) solution, followed by 3 subsequent rinsings with sterilized distilled water. Surface sterilized seeds were imbibed in sterilized distilled water for 24 hr before utilizing for isolation of embryos. In each petri-dish 35-40 embryos were plated. Petri-dishes sealed with parafilm were incubated at 22+2°C under 950 lux of fluroscent light for 12 hr photoperiod.

To search out best medium for plant regeneration, after 35 days, calli obtained from preliminary experiment were transferred to 5 different regeneration media (Table 2). All the media were constituted of MS basal salt and vitamin mixture, 15 gl^{-1} sucrose and 7.5 gl^{-1} agar. Best suited medium for plant regeneration i.e., MS Rg 2 was further used for transferring calli obtained from final experiment. The observations were recorded in final experiment on callus initiation, embryogenic callus formation and plant regeneration.

The experiment was conducted in factorial completely randomized design with 2 replications. Since all the data were recorded in percentage, they were transformed according to Arc-sin transformation.

RESULTS

Analysis of variance revealed the presence of considerable amount of variability for culture response amongst the genotypes, culture media and genotype x culture medium interactions.

Initiation of callus cultures:

Four culture media namely MS 2DB, MS 3DB, MS 2 DY and MS 2D produced quality callus culture in higher frequencies. (Table1) However,

Table 1: Media supplemented with various combinations of growth hormones tested for culture response of mature linseed embryos.

Medium		Growth hormones (mg l^{-1})			Culture response *			
		2, 4-D	BA	Others	Embryo germination	Callus formation	Friable calli	Rhizo-genesis
MS	D	1.0	-	-	-	++	+	-
MS	2D	2.0	-	-	-	+++	+	-
MS	3D	3.0	-	-	-	+++	++	-
MS	2DY	2.0	-	100 YE	-	+++	+	-
MS	DB	1.0	0.5	--	+	+	-	-
MS	2D1B	2.0	1.0	-	+	++	-	-
MS	2DB	2.0	0.5	-	-	+++	+	-
MS	3DB	3.0	0.5	-	-	+++	+	-
MS	2DK	2.0	-	1.0 Kin	+++	+	-	+
MS	2DBK	2.0	0.5	0.5 Kin	+++	++	-	-
MS	2B	-	2.0	-	++	+	-	-
MS	3B	-	3.0	-	++	+	-	-
MS	BN	-	1.0	1.0 NAA	-	++	+	+++

* Comperative culture response: high > 60% (+++), moderate 40-60% (++), low < 40% (+).

Table 2 : Media tested in preliminary experiment for plant regeneration from callus cultures raised from mature linseed embryos

Growth hormones (mg l^{-1})	Media				
	MS Rg1	MS Rg2	MS Rg3	MG Rg4	MG Rg5
BA	-	0.4	1.0	0.4	1.0
IAA	-	0.4	1.0	-	-
NAA	-	-	-	1.0	2.0
Performance (Shoot/Root)	+/+	+++/++	++/++	++/++	++/++

all other media either produced less calli or caused proliferation of friable calli, direct embryo germination and root formation (rhizogenesis).

The first response of cultured embryos was by and large similar after 3-5 days irrespective of genotypes/culture media. At this stage, all the embryos became swollen and no callus proliferation was observed. During second week of culture, callus initiation was observed from embryonic axis. Callus initiating embryos were counted after 5 weeks of culture.

Results presented in Table 3 revealed significant variations among culture media, genotypes and their interaction. On mean basis, maximum callus initiation was recorded with cv. J.23 (94.3%) followed by R.7, C.3, Kiran, J.1, C.2 and R.17 in that order. These genotypes merit to be placed in high callus initiating group (>80%). However, J.23, R.7, C.3, Kiran and J.1 appeared statistically at par. Among the culture media MS 3DB (90.62%)performed best followed by MS 2DY (88.3%) both being significantly superior to MS 2DB and MS 2D. The medium MS 3DB had more than 90 percent embryos of eight genotypes initiating callus (except J.73-25 and C.1). While, MS 2DY and MS 2DB media had similar callus initiation in five same genotypes *i.e.*, R.7, R.17, J.1, C.2, C.3 and Kiran/J.23. Medium MS 2D performed moderately with only one genotype J.23 to reach more than 80 percent mark for callus initiation.

Growth of callus cultures:

After 35 days, callus size was determined as an index of callus growth. Large amount of variation was observed among calli developed from 10 genotypes on different media (Table 4). The genotype C.2 on MS 3DB and MS 2DB and J.17 on MS 3DB could produce large calli (76-100 mm^2) while they generated medium sized calli on other media. Genotype R.7, R.17 and C.3 generated medium sized calli on three culture media namely *MS 2DB, MS 3DB* and *MS 2DY*. The genotypes R.552, J.1, J.23 and C.1 produced small calli (<50 mm^2) on most of the culture media.

Embryogenic callus formation:

During the third week of culture, initiated calli could be distinguished on the basis of their morphological features. The final count on the basis of callus characteristics was made after 5 weeks. Three main type of callus cultures were observed; (a) undifferentiated callus cultures which were often cream in colour and soft friable in texture; (b) highly compact, dark green in colour; and (c) compact, creamish in colour, with one or more green spots of bead like structures, partially covered with a thin layer of pure white loose callus. Some times, such calli were surrounded with friable callus. After 5 weeks 'C' type calli were counted as embryogenic calli.

Significant variations were observed among the genotypes, culture media and genotype x media interactions for their ability to produce embryogenic callus (Table 3). More than 60 percent mature embryos from six of the ten genotypes formed embryogenic calli being significantly maximum in genotype C.3 followed by C.2, R.17, J.23, R.7 and Kiran. Among culture media, MS 3DB and MS 2DB supported nearly 65 per cent of the cultured mature embryos to form embryogenic callus cultures. More than 90 per cent embryogenic callus formation was observed from genotypes Kiran and R.17 on MS 2DB and from C.2 and R.552 on MS 3DB. Very low embryogenic callus formation (<10%) was recorded from J.73-25 and R.552 on MS 2D and from C.1 on MS 2DY.

Table 3 : Callus initiation and embryogenic callus formation from cultured matured embryos of ten linseed genotyped on four different culture media*

Genotype culture medium	Number of callus forming embryos/100 embryo plated					Number of embryogenic calli/100 embryo plated				
	MS 2DB	MS 3DB	MS 2 DY	MS 2D	Mean	MS2DB	MS 3DB	MS 2DY	MS2D	Mean
J.23	86.73 (69.37)	98.28 (84.65)	100.00 (90.00)	92.07 (74.20)	94.27 (79.56)	66.79 (54.82)	86.38 (68.52)	46.29 (42.87)	56.69 (48.90)	64.03 (53.78)
R. 552	87.05 (69.29)	94.00 (79.87)	82.39 (65.42)	15.38 (17.75)	73.55 (58.07)	70.17 (56.94)	90.00 (76.72)	68.07 (55.64)	3.85 (10.92)	58.02 (50.05)
R.7	95.45 (81.23)	100.00 (90.00)	100.00 (90.00)	78.64 (63.88)	93.52 (81.28)	64.78 (83.63)	68.83 (56.05)	63.27 (52.69)	53.87 (47.23)	62.69 (52.40)
R. 17	100.00 (90.00)	98.21 (84.55)	98.45 (84.90)	23.58 (29.00)	80.06 (72.12)	91.29 (73.79)	78.80 (62.68)	86.98 (69.03)	15.97 (23.54)	68.26 (57.27)
J.1	94.40 (80.23)	100.00 (90.00)	98.14 (84.45)	62.96 (52.54)	88.87 (76.80)	64.29 (53.30)	47.82 (43.75)	61.96 (51.64)	43.89 (41.49)	54.49 (47.55)
J. 73-25	65.20 (53.89)	73.46 (59.03)	77.95 (61.99)	26.32 (30.60)	60.73 (51.38)	46.88 (43.20)	20.19 (26.55)	25.17 (30.07)	7.88 (16.08)	25.03 (20.98)
Kiran	98.64 (85.27)	94.67 (76.75)	89.56 (71.19)	77.98 (62.30)	90.23 (73.88)	92.19 (73.78)	67.00 (54.96)	32.84 (34.97)	48.30 (44.02)	60.08 (51.94)
C.1	25.23 (30.00)	47.60 (43.59)	38.39 (28.24)	58.92 (50.19)	42.53 (40.50)	14.18 (22.00)	25.53 (30.34)	8.49 (16.76)	34.09 (35.59)	20.57 (26.17)
C.2	91.02 (73.56)	100.00 (90.00)	100.00 (90.00)	52.26 (46.34)	85.97 (74.98)	66.09 (54.62)	93.00 (75.02)	72.79 (58.86)	44.31 (41.67)	69.04 (57.54)
C.3	96.29 (82.00)	100.00 (90.00)	98.08 (84.35)	70.17 (56.94)	91.14 (78.35)	81.92 (66.84)	83.97 (66.40)	70.98 (57.41)	60.19 (50.89)	74.27 (59.89)
Mean	84.07 (71.50)	90.63 (78.85)	89.19 (76.05)	55.83 (48.38)		65.86 (55.09)	66.16 (55.09)	53.64 (46.99)	36.90 (36.03)	
CD (0.05)										
Genotypes					7.87					5.10
Media					4.98					3.23
Genotype x Medium					15.74					10.20

* Data in parenthesis are transformed values.

Plant regeneration:

After 35 days of culture, all the calli were transferred from 4 induction media to the regeneration medium. Plantlet regeneration took place either via embryoidogenesis or by organogenesis. The embryoid like structure appeared on embryogenic callus cultures as rounded or more irregular in outline and were usually present in clusters. In no case, embryoids developed into bipolar structures resembling a mature embryo with embryonic axis and cotyledons. Plants regenerated via embryogenesis with two thick leaf like structure. Although these were not perfect as *in vivo*, but resembled with cotyledons. Moreover such leaf like structures degenerated after 15-20 days. Plants developed via embryogenesis mostly initiated well developed root system as well.

Shootlets also developed from the meristematic zones arising in the callus. From such calli, root development took place from meristematic zones other than that for shoots (morphogensis or gammo-rhizogenesis). Embryoidogenesis and organogenesis were also observed sometimes on a similar callus. In most of the calli, further culturing on induction media also gave rise to plants. However, transfer to regeneration medium allowed higher plant formation and growth. In case where, there was no root formation, shoots after transferring to rooting media gave rise to roots.

The plantlets, varying in number were obtained from the callus cultures of mature embryos initiated on four different media (Fig.1). In most of the genotypes, maximum plant regeneration was obtained from cultures developed on MS 2DB. However, only 3 genotypes (R.17, J.23 and C.2)

Table 4 : Callus size*, 5 weeks after culturing mature embryos of 10 linseed genotypes on different media

Genotypes	Culture media			
	MS 2DB	MS 3DB	MS 2DY	MS 2D
J. 23	+	+	++	+
R. 552	+	+	++	+
R 7	++	++	++	+
R.17	++	+++	++	++
J.1	+	+	+	+
J.73-25	+	++	++	+
Kiran	++	++	+	+
C.1	+	++	+	+
C.2	+++	+++	++	++
C.3	++	++	++	+

* Callus size (mm^2) denoted by + < 50; ++ 50-75; +++ 76-100

out of ten, produced more plants from cultures developed on MS 3DB. The overall performance of MS 2D and MS 2 DY was lower than MS 2DB and MS 3DB. Maximum of 140 plants per 100 mature embryos of R.17 were obtained on MS 2DB followed by 91 plants on MS 3DB. Cultivar J.23 regenerated more than 80 plants per 100 mature embryos on MS 3DB and MS 2DB. The genotypes C.2 and Kiran on MS 2DB had also considerable amount of plant regeneration.

DISCUSSION

In the present investigation, plant regeneration from embryo callus cultures appeared to be a stepwise process, starting from callus induction, callus proliferation, morphogenesis and finally to plantlet formation. Plants from embryo culture originated by two pathways i.e., organogenesis and somatic embryogenesis. Organogenesis was accomplished by the *de novo* organization of shoot meristems in callus tissues. The shoots were later rooted to obtain complete plants. Somatic embroys formed in callus and directly gave rise to plants.

Regeneration of plants via somatic embryogenesis is preferred to organogenesis because embryoids usually arise from single cell and thus genetic manipulation could be carried through subsequent generations. Bhaskaran and Smith (1990) suggested that there could be a critical ratio of unidentified metabolites that initiate cells to follow one pathway of development in preference to another.

During present investigations, a basic approach in promoting morphogenesis in culture was to manipulate hormonal conditions. For organogenesis, a shift in the total and relative amount of cytokinins and auxins promoted unorganized callus growth, shoot formation and/or root formation. For embryogenesis, growth in a medium with sufficient auxin and some cytokinin appeared essential for the embryonic growth (embryoidogenesis). Kept on such medium, the embryonic cells and proembryos produced additional cells and proembryos. A reduction in growth hormones apparently allowed maturation of somatic embryos leading to plant regeneration.

Many variations for culture response were observed in the present investigation. Different combinations of growth regulators led to morphogenesis from cultured mature embryos, while other generally produce only callus with high or low growth rate. Not all the cells within the callus tissues went on to form organs or embryoids. Also not all the embryos from single genotype responded equally to conditions promoting morphogenesis. This indicates that apart from variations due to culture medium composition, something within an explant is as critical for a given response as its genotype. Genotype differences may be related to variations in endogenous hormone levels (Norstog, 1970). Many of the genotypic differences could be circumvented by growing the source plants under optioned conditions and also by varying nutrients and harmones in the culture medium. In the present investigation, mature embryos for culture were recovered from plants grown under similar field conditions. Embryos isolated from mature seeds of a single plant were distributed evenly to different culture media. It seems reasonable to conclude that the differences obtained resulted from the genetical differences among genotypes.

In tissue culture experiments with lineseed, basal MS medium has been frequently adopted for callus initiation and plantlet regeneration (Ibrahim, 1971; Gamborg and Shyluke, 1976; Methewes

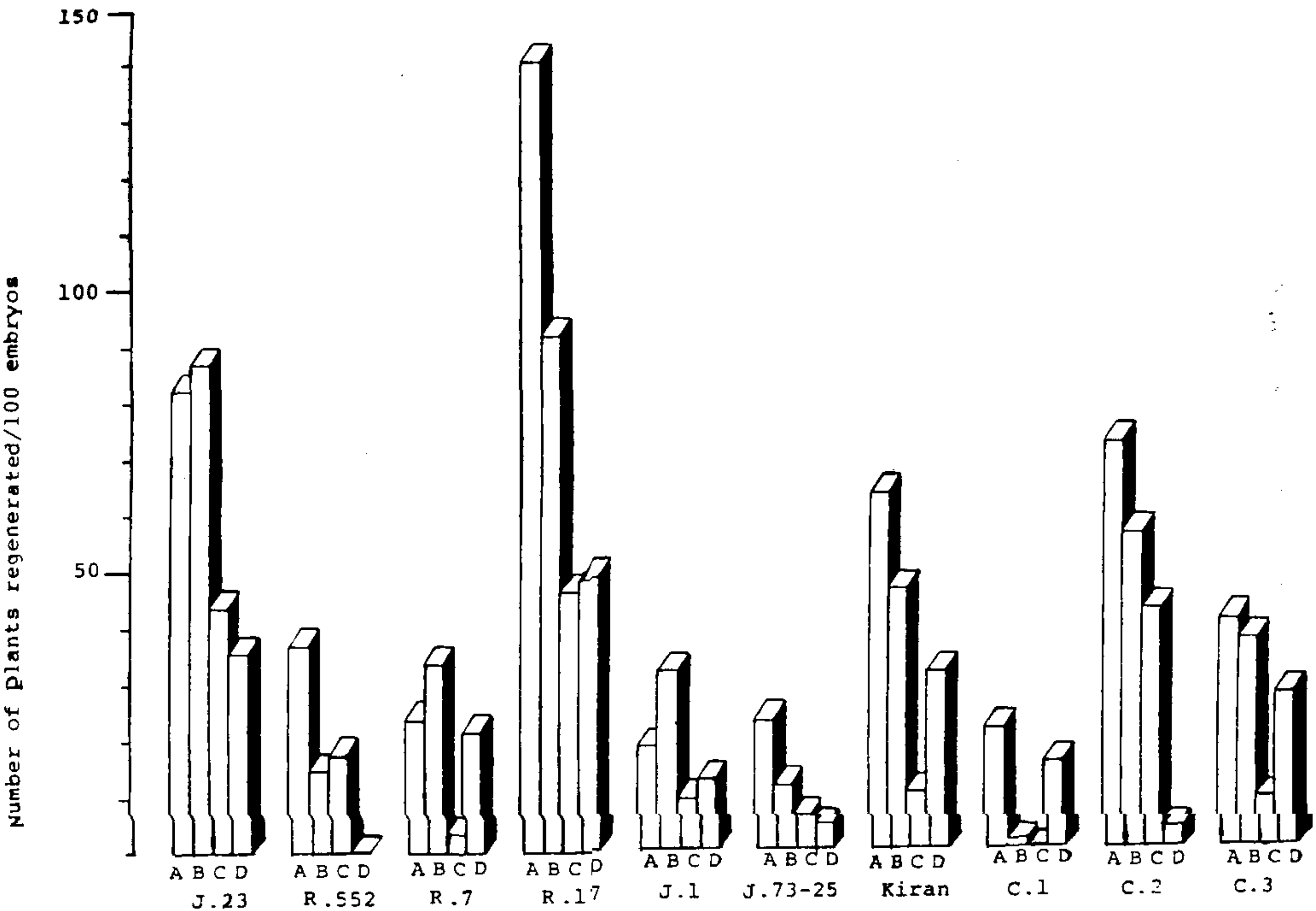


Fig. 1 : Regeneration potential of cultured mature embroys of 10 linseed genotypes on four different media (A-MS2DB); B-MS3DB; C-MS2DY; D-MS2D).

and Narayanaswamy, 1976; Zhan *et al.*, 1989). As per results of preliminary experiment, type and *concentration of growth hormone seem to play* major role for *in vitro* response of embryo culture. Growth hormone 2,4-D in combination with BA facilitated callus initiation. Higher callus initiation in MS 3DB as compared to MS 2DB suggested that auxin is required in higher concentration for this purpose. Much lower frequencies of parameters studied with 2,4-D alone in medium MS 2D as compared to the combination of 2,4-D and BA revealed that an auxin alone was insufficient for higher degree of callus initiation from mature linseed embryos. HOwever, *addition of yeast* extract to 2,4-D produces results as higher as MS 3DB. Interactions of genotypes C.2, R.7, R.17 and J.23 with one or more media except MS 2D *resulted in 100 per cent callus induction from mature embryos.*

Callus quality varied considerably among genotypes. Seven of the 10 genotypes formed more than 50 per cent of embryogenic calli on MS 2DB and MS 3DB. However, the process of embryogenesis was not a perfect prediction of higher plant formation. Two media *i.e.*, MS 2DB and MS 3DB produced overall equal amount of embryogenic calli however, MS 2DB produced more shoot forming calli. The size and growth rate of callus cultures does not seem to effect *in vitro* response. Small size cultures of J.23 produced considerable amount of embryogenic calli compared to medium and large size cultures of R.17 and C.2.

The regeneration of transplantable plants varied among genotypes and initial culture media. It was as high as 140 plants per 100 mature embryos cultured from R.17 on MS 2 DB. For 7 out of 10 genotypes also, MS 2DB initiated more plant regeneration.

The present study demonstrated that under conditions of this experimentation, callus initiation *ability, embryoid formation and plantlet* regeneration ability was under genetic control. Besides genotypic effects, the composition of culture media also influenced all the culture phases. In addition to these two factors, strong genotype x medium interactions suggested that a particular genotype selected for advanced work can be cultured *in the most suitable medium to obtain* maximum response. Also the possibility exists for improvement of *in vitro* efficiency of a particular genotype by further modifying the culture medium.

During the present study, it was shown that under *appropriate culture conditions mature embryos of* lineseed as in a number of other species, gave rise to large number of shoots. Embryos could be cultured as an explant to obtain multiple plants. A system for plant regeneration in linseed is thus available, which has immediate potential for biotechnological studies at the explant level.

ACKNOWLEDGEMENT

Senior author is thankful to Dr. R.P. Singh, Scientist, National Agricultural Research Project, JNKVV Campus, Rewa, M.P. for providing the experimental material.

LITERATURE CITED

Barakat, M.N. and Cocking, E.C. 1983. Plant regeneration from protoplast derived tissues of *Linum usitatissimum* L. (flax). *Plant Cell Reports* 2: 314-317.

Barakat, M.N. and Cocking, E.C. 1985. An assessment of the cultural capabilities of protoplasts of some wild species of *Linum*. *Plant Cell Reports* 4: 164-167.

Basiran, N., Armitage, P., Scott, R.J. and Draper, J.1987. Genetic transformation of flax (*Linum usitatissimum* L.) by *Agrobacterium tumefaciens*: Regeneration of transformed shoots via a callus phase. *Plant Cell Reports* 6: 396-399.

Bhaskaran, S. and Smith, R.H. 1990. Regeneration in tissue culture: a review. *Crop Sci.* 30: 1328-1337.

Gamborg, O.L. and Shyluke, J.P. 1976. Tissue culture, protaplast and morphogenesis in flax. *Bot. Z.* 137: 301-306.

Green, A.G. 1984. The occurance of recinoleic acid in *Linum* seed oil. *JAOCS* 61: 939-947.

Ibrahim, R.K. 1971. Media for growth of flax tissue culture. *Can.J. Bot.* 49:295-298.

Jorden, M.C. and Mc Hughen, A. 1987. Selection for chlorsulfuron resistance in flax (*Linum usitatissimum* L.). *Cell Culture* 131:333-338.

Kaul, V. and Williams, E.G. 1987. Multiple shoot induction *in vitro* from the hypocotyle of germinating embryos of flax (*Linum usitatissimum* L.) *J. Plant Physiol.* 131:441-448.

Ling, Q. and Binding, H. 1987. Plant regeneration from protoplasts in *Linum*. *Plant Breeding* 98: 312-317.

McHughen, A. 1989. *Agrobacterium* mediated transfer of chlorsulfuron resistance to commercial flax cultivars. *Plant Cell Reports* 8:445-449.

McHughen, A. and Swartz, M. 1984. A tissue culture derived salt tolerant line of *Linum usitatissimum* L. *J. Plant Physiol.* 117: 109-117.

Methewes, V.H. and Narayanaswamy, S. 1976. Phytoharmone control of regeneration in cultured tissues of flax. *Z.Pflanzenphysiol* 80:436-442.

Murashige, T. and Skoog, F. 1962. A revised medium for rapid growth and bioassay with tobacco tissue culture. *Physiol. Plant.* 15: 473-497.

Murray, B.E., Handyside, R.J. and Keller, W.A. 1977. *In vitro* regeneration of shoots on stem explants of haploid and poliploid flax (*Linum usitatissimum* L.) *Can. J. Genet. Cytol.* 19: 177-186.

Nichterlein, K., Umbach, H. and Friedt, W. 1991. Genotypic and oxogenous factors affecting shoot regeneration from anther callus of linseed (*Linum usitatissimum* L.) *Euphytica* 58:157-164.

Norstog, K. 1970. Induction of embryo like structures by kinetin in cultured barley embryos. *Dev. Biol.* 23: 665-670.

Pretova, A. and Williams, E.G. 1986. Direct somatic embryogenesis from immature zygotic embryos of flax. *J. Plant Physiol.* 126:95-101.

Straathof, T.P. 1989. Regeneration of somatic cells and induction of androgenesis in flax for the development of an *in vitro* selection system. *Prophyta* 42:127-128.

Zhan, X.C., Hones, D.A. and Kerr, A. 1988. Regeneration of flax Plants transformed by *Agrobacterium rhizogenes*. *Plant Mol. Biol.* 11:551-559.

Zhan, X.C., Jones, D.A. and Kerr, A. 1989. Regeneration of shoots on root explant of flax. *Ann. Bot.* 53: 297-299.

J. Oilseeds Res. 13 (1) 1996: 42-46
ISSN 0970-2776

BIO-ENERGETICS AND ECONOMIC EVALUATION OF CROPPING SYSTEMS UNDER VINDHYAN PLATEAU CONDITIONS

S.D. BILLORE, KALYAN SINGH and MRIDULA BARGALE
R.A.K. College of Agriculture, J.N. Krishi Vishwa Vidyalaya, Sehore 466 001 (M.P.)

ABSTRACT

An experiment was conducted during 1990-91 and 1991-92 to study the bio-energetics and economic feasibility of different cropping systems. The results revealed that the soybean based cropping sequences were more profitable than sorghum and fallow based sequences, though the highest productivity of chickpea was obtained when grown after *kharif* fallow. The sorghum based cropping sequences consumed more energy input. Among the crop sequences, Sorghum-wheat possesses the highest energy input and output, while the maximum energy use efficiency (EUE), energy productivity and least energy intensiveness were noted in fallow-chickpea sequence. The highest energy net returns and net monetary returns (Rs/ha) were associated with soybean-chickpea sequence. The land use efficiency (LUE) was identical when wheat was grown either after sorghum or soybean. The relatively higher land use and production efficiency were found in sorghum based sequences. However, soybean-based cropping systems were energy efficient, productive, remunerative and less energy intensive than sorghum based cropping systems.

Key words: Cropping system; Energy; Land use efficiency (LUE); Production efficiency; Sorghum; Soybean; Chickpea

INTRODUCTION

To feed the expected one billion population of the country in 2000 A.D., a food production target of about 250-275 million tonnes is envisaged (Narang and Gill, 1989). Hence, there is a need to intensity production over time and space. Research on bio-energetics gained momentum through seventies against global fossil fuel crisis. Consumption of energy has been increasing steadily for improving the productivity. However, the energy use efficiency (EUE) has shown a declining trend. Hence, it is essential to explore the possiblity of proper utilization of non-renewable energy sources to sustain farming systems. Thus, the present investigations are undertaken to develop an energy efficient and economically viable intensive cropping system.

MATERIALS AND METHODS

The experiment was conducted at the Research Farm, RAK College of Agriculture, Sehore during 1990-91 and 1991-92 on Vertisols, slightly alkaline (pH 7.5) with available N, P and K of 336, 13 and 575 kg/ha, respectively. The treatments comprised 12 cropping sequences. Viz., soybean, sorghum and fallow, in the *kharif* followed by 4 *rabi* crops namely safflower, chickpea, lineseed and wheat (Table 1). The treatments were replicated thrice in randomized block design. All the crops were grown with recommended package of practices and received recommended fertilizer doses viz., 20:80:20, 10:60:40, 40:40:20, 20:50:0; 60:30:20 and 100:60:40 Kg N:P:K/ha to soybean, sorghum, safflower, chickpea, linseed and wheat, respectively. Sorghum and wheat received N in two split doses i.e., 50% as basal and 50% at 30 and 20 days after sowing. The *Kharif* and *rabi* crops were sown in first week of July and second week of October, respectively during both the seasons.

Energy inputs and outputs were calculated using the equivalents (Table 1) as described by Mittal and Dhawan (1988), while the energy intensiveness was worked out as proposed by Burnett (1982).

1 Present address: Scientist, Agronomy, National Research Centre for Soybean, Khandwa Road, Indore.

Received for publication January, 1995

Table 1 : Energy equivalents for the inputs and outputs

Particulars	Unit	Equivalent energy (MJ)
A. Input		
Adult man	hr	1.96
Diesel including lubricant	L	56.31
B. Chemical fertilizers		
Nitrogen	kg	60.00
Phosphorus	kg	4.85
Potassium	kg	5.56
DAP	kg	15.91
C. Chemicals		
Herbicides insecticides pesticides	kg	120.00
D. Output		
Sorghum/wheat	kg	14.70
Soybean/chick pea/lentil	kg	14.70
Linseed/safflower	kg	25.00
Straw	kg	12.50

Energy intensiveness is a function of yield, price of produce and energy inputs, while the energy productivity is the production per unit energy. Land use efficiency (LUE) values were calculated taking total duration of crops (in individual cropping sequence) divided by 365, and production efficiency values were calculated taking total production in a sequence divided by total duration of crops in sequence. The total gross and net returns (Rs/ha) were calculated on the basis of prevailing market prices of the produce.

RESULTS AND DISCUSSION

Seed yield

Sorghum produced the highest mean yield as compared to soybean in all the crop sequences (Table 2). Similar observations were made by Tomar and Tiwari (1990) who opined that the cereals produced more tonnage than legumes. While all the *rabi* crops produced substantially higher yield when grown after soybean than sorghum; the safflower and chickpea were found the most productive after fallow than soybean and Kharif sorghum. Wheat and linseed were equally productive when grown either after kharif soybean or *Kharif* fallow.

Energy budget

Energy analysis (Table 2) indicated that sorghum-wheat sequence followed by soybean-wheat consumed the maximum energy inputs for their cultivation. In general, sorghum based cropping systems consumed more energy followed by soybean and, fallow based cropping system which consumed the least energy inputs. The lowest energy inputs were required for fallow-chickpea sequences. These differences arised mainly due to the differences in their fertilizer requirements, which constitute major portion of energy input. Moreover, cereal crops require higher quantity of nitrogen than oilseeds and legumes. The energy output was maximum in sorghum-wheat sequence closely followed by soybean-wheat which proved to be superior to rest of the crop sequences. The lowest energy output and net energy return were recorded in fallow-linseed sequence. The average energy output was higher in sorghum than in soybean and fallow based cropping systems. However, the soybean based system turned out to be the most efficient in respect of net energy output. Chickpea grown after any *Kharif* based system proved to be the most energy efficient crop sequence. The same system also proved to be highly energy productive followed by soybean-chickpea. The energy use efficiency was found statistically identical in soybean-chickpea and soybean-safflower sequence. The lowest energy productivity was recorded in fallow-linseed. When the energy intensiveness was compared, just reverse results of the energy use efficiency was observed, indicating lowest values of energy intensiveness

Table 2 : Production potential and energy budget of different cropping systems (pooled data)

Treatment	Seed yield of kharif crop (kg/ha)	Seed yield of rabi crop (kg/ha)	Total energy input (MJ/ha)	Energy output (MJ/HA)	Energy use effi-ciency (EUE)	Energy producti-vity (I/MJ)	Enerty intens-iveness (MJ/Rs)	net return (MJ/ha)
Soybean-safflower	1278	1141	13597	47312	3.48	177.90	0.81	33715
Soybean-chick pea	1344	1663	9175	47143	5.14	349.53	0.42	37968
Soybean-linseed	1147	919	13519	39836	2.95	152.82	0.71	26317
Soybean-wheat	1385	2321	20192	54478	2.70	183.53	0.95	34286
Sorghum-safflower	1695	963	17611	48991	2.78	150.93	1.62	31380
Sorghum-Chick pea	1659	1739	13189	49848	3.80	257.11	0.85	36659
Sorghum-linseed	1478	735	17533	40102	2.29	126.22	1.40	22569
Sorghum-wheat	1688	2025	23805	54581	2.29	155.97	1.67	30776
Fallow-safflower	-	1731	8644	43275	5.00	200.25	0.83	34631
Fallow-chick pea	-	2257	4222	33178	7.85	534.58	0.31	28956
Fallow-linseed	-	911	8567	22775	2.66	106.33	0.85	14208
Fallow-wheat	-	2386	15239	35074	2.30	156.57	1.41	19835
CD (0.05)	49	122	1101	1864	0.26	23.95	0.08	1440

Table 3 : Production potential and economics of various cropping systems (Pooled data)

Treatment	yield of kharif crop (kg/ha)	yield of rabi crop (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	Net returns (Rs/day)	B:C ratio	Land use efficiency (%)	Production efficiency (kg/day/ha)	Total duration of crop sequence (days)
Soybean-safflower	1278	1141	10950	5800	12.68	1.53	64.38	10.29	235
Soybean-chick pea	1344	1863	11000	10594	46.06	1.96	63.00	13.34	230
Soybean-linseed	1147	919	10300	8698	39.53	1.84	60.27	9.39	220
Soybean-wheat	1385	2321	13150	8028	32.11	1.61	68.49	14.82	250
Sorghum-safflower	1695	963	8250	2613	10.88	1.31	65.75	11.07	240
Sorghum-Chick pea	1659	1732	8300	7069	30.08	1.85	64.38	14.43	235
Sorghum-linseed	1478	735	7600	4919	21.86	1.68	61.64	9.83	225
Sorghum-wheat	1688	2025	10450	3726	14.61	1.35	69.86	14.56	253
Fallow-safflower	-	1731	4550	5836	46.68	2.28	34.24	13.85	125
Fallow-chick pea	-	2257	4600	8942	74.51	2.94	32.87	18.81	120
Fallow-linseed	-	911	3900	6121	55.64	2.57	30.13	8.28	110
Fallow-wheat	-	2386	6750	3987	28.48	1.59	38.35	17.04	140
CD (0.05)	49	122	587	473	3.59	0.09	3.07	0.64	-

Sale price of produce (Rs/q): Soybean - 775/-, Sorghum - 300/-, Safflower - 600/-, Chick pea - 600/- lineseed - 1100/-, and Wheat - 450/-

in fallow-chickpea followed by soybean-chickpea. In general, sorghum based cropping system was the most energy intensive than rest of the two cropping systems. These differences in energy intensiveness are a function of yield, price of produce and energy inputs. The aforesaid results are well in confirmity with the findings of Pal *et al.* (1985).

Economics

Economic analysis (Table 3) revealed that the soybean based cropping system registered higher cost of cultivation than sorghum and fallow based systems, while soybean-wheat showed the maximum cost of cultivation than rest of the sequences. When the net returns were compared, soybean based cropping systems were found more remunerative followed by fallow and sorghum, respectively. The highest net returns were obtained when chickpea was grown after soybean followed by fallow-chickpea . However, the fallow based sequences except fallow-wheat offered higher net returns/day and B:C ratio than soybean and sorghum based system, while sorghum based sequences were found to be the least economic with reference to all economical traits. The poorest crop sequence was sorghum-safflower. Similar views were also expressed by Tomar and Tiwari (1990).

Land use and production efficiency

The intensification of time was measured by land use efficiency (LUE) which showed that sorghum-wheat and soybean-wheat induced identical LUE which was substantially higher than rest of the crop sequences. In general, sorghum based cropping systems possessed numerically higher LUE than soybean based cropping systems, because sorghum based sequences occupied the field for longer duration. Mono-seasonal cropping systems performed poorer with respect to LUE, while in case of production efficiency it surpassed double cropping. The lowest production efficiency was observed in soybean based sequences. These results are in agreement with those reported by Tomar and Tiwari (1990).

Thus the results clearly indicated that the soybean-chickpea sequence was more energy efficient and economically viable than sorghum and fallow based cropping systems.

LITERATURE CITED

Burnett, M. 1982. Energy analysis of three agro-ecosystems. In Basic techniques in ecological farming, second Int.conf. held by IFO.AM. Montreal, October 1-5, 1979 eds. Stuart B.Hill, Brikhauses, verlag, pp.183-195

Mittal, J.P and Dhawan, K.C. 1988. *Research manual on energy* requirements in agricultural sector pp. 20-23.

Narang, R.S. and Gill, M.S. 1989. Crop diversification for optimum use of fertilizers to improve crop productivity. FAI(NR) seminar on constraints analysis for optimum use of fertilizers to increase agricultural production in northern India. April 21-22, Shimla.

Pal, M., Singh, K.A., Saxena, J.P. and Singh, H.K. 1985. Energetics of cropping systems. Indian J.Agron.30(2): 1-Lxi.

Tomar, S.S. and Tiwari, A.s. 1990. Production potential and economics of different crop sequences. *Indian J.Agron.* 35 (162):30:35.

J. Oilseeds Res. 13 (1) 1996: 47-52
ISSN 0970-2776

POST - FLOWERING PHYSIOLOGICAL ANALYSIS OF GROWTH AND YIELD IN SAFFLOWER (*CARTHAMUS TINCTORIUS* L.) EXPERIMENTAL HYBRIDS

P. LAKSHMAMMA, C.V. RAGHAVAIAH, K. ANJANI and M.V.R. PRASAD
Directorate of Oilseeds Research Rajendranagar, Hyderabad - 500 030

ABSTRACT

Five promising safflower hybrids viz., DSH-107, DSH-110, DSH-113, DSH-114 and DSH-116 developed at the Directorate of Oilseeds Research, Hyderabad exploiting male sterility systems based on recessive alleles, were evaluated for physiological parameters of growth and yield. These hybrids were compared with two varietal checks i.e., A-1 (national check) and HUS-305 (high oil yielding check). Hybrids were found superior to varietal checks in terms of various growth parameters such as total drymatter, CGR, RGR, NAR, TDM/LA ratio. The number of capitula, the weight of capitula and seed yield per plant besides oil content were more in hybrids than varietal checks. The hybrid DSH-113 was significantly superior to all other hybrids in yield and physiological parameters such as CGR, RGR, NAR and TDM/La ratio.

Key words: Physiological analysis; growth parameters; yield; safflower hybrids.

INTRODUCTION

Safflower is a predominantly self pollinated crop. However, there is a considerable amount of outcrossing in some genotypes. High degree of heterosis for seed yield of safflower was reported by many workers who studied the F_1 hybrids developed by hand emasculation and pollination (Ramachandram and Goud, 1982; Ranga Rao, 1982). Investigations were carried out at DOR to develop hybrids of safflower exploiting male sterility systems based on recessive alleles (Ramachandram and Sujatha, 1991). The hybrids were developed by using these promising male sterile lines. Among the hybrids developed, five promising hybrids were studied with an objective to evaluate their performance in terms of physiological analysis of growth and yield during *rabi* 1993-94.

MATERIALS AND METHODS

Five experimental hybrids were selected along with two check varieties for this study and their pedigree is as follows:

Hybrid		*Pedigree*
DSH-107	-	MS 6 (0) XII-51-1-10
DSH-110	-	MS 107(0) XVI-92-2-4
DSH-113	-	MS 5 (0) X-86-2-2
DSH-114	-	MS 5(0) XII-51-1-10
DSH-116	-	MS 9(0) XVI-92-2-4
A-1	-	National Check
HUS-305	-	High oil yielding check

The crop was sown on 20th October, 1993 and was raised following recommended agronomic practices. The experiment was laid out in a

Received for publication February, 1995

randomised block design with three replications. Observations on growth were recorded at 15 day intervals commencing from 90 days age of the crop. Different growth parameters were calculated following the formulae described by Watson (1952).

RESULTS AND DISCUSSIONS

Dry matter partitioning

The partitioning of dry matter in safflower hybrids and varieties revealed that the post-flowering stem and leaf dry weight of hybrids decreased with age. But, the stem and leaf dry weight of checks increased upto 105 DAS. In A-1 variety the leaf dry weight increased even upto harvest indicating the indeterminate nature of this variety. The capitula dry weight too increased with age. It was found that the reduction in stem and leaf dry weight was not compensated by the increase in capitula dry weight. This shows the contribution of current photosynthates to sink than that of translocation of assimilates from source to sink.

The mean dry weight of leaf, stem, capitula and ultimately the total plant dry weight were higher in hybrids compared with varieties. Among the hybrids, DSH-113 remaining comparable to DSH-110, DSH-107, DSH-114 and A-1 showed significantly higher plant dry weight than DSH-116 and HUS-305 (Table 1).

Growth analysis parameters

The leaf area index (LAI) is one of the important physiological parameters to measure growth. Higher LAI increases the photosynthetic efficiency and inturn can influence crop productivity. In the present study the LAI declined gradually from 90 DAS till harvest in hybrids (Table 2). But, interestingly varieties showed increase in LAI values with crop age. At 90 DAS, the varieties recorded lower LAI values, but with advancement of age they exhibited higher LAI than hybrids. Among the hybrids, DSH-113 showed higher LAI followed by DSH-110. At harvest time, the cultivar A-1 maintained substantially greater LAI than the rest of the test hybrids and HUS-305.

The crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR) were computed from total drymatter and leaf area at different stages of crop growth (Table 2). Generally all the growth parameters presented a declining trend after vegetative stage. But in the present study the hybrids and even the national check A-1 showed higher CGR, RGR and NAR even after vegetative stage. The checks registered higher growth parameters compared to hybrids, but at harvest the growth performance of hybrids was better than checks. The increase in growth characters in safflower with age was probably due to increase in capitula growth and higher LAI. Among the hybrids, DSH-110 recorded significantly higher CGR and RGR upto 105 DAS, while at harvest DSH-113 was significantly superior to other hybrids. Varieties and hybrids did not differ significantly in NAR.

The total drymatter/leaf area (TDM/LA) ratio, an indicator of the photosynthetic efficiency, increased with age of the crop upto harvest. The hybrids DSH-113 and DSH-114 remaining at par with other hybrids showed significantly higher TDM/LA values than check varieties (Table 2).

Yield and Yield components

The safflower hybrids recorded higher capitula number and capitula weight compared with checks. Among the hybrids, DSH-113 displayed significantly higher capitula number (52.83/pl)

Table 1 : Drymatter partitioning of safflower experimental hybrids compared with varieties at different growth stages

Hybrid/ Variety	Stem dry wt. (g/pl)			Leaf dry wt. (g/pl)			Capitula dry wt. (g/pl)			Total plant dry wt. (g/pl)		
	90 DAS	105 DAS	Harvest	90 DAS	105 DAS	Harvest	90 DAS	105 DAS	Harvest	90 DAS	105 DAS	Harvest
DSH-107	34.18	33.88	29.92	14.15	12.35	9.80	52.73	67.05	113.60	96.57	113.28	153.32
DSH-110	40.00	41.90	35.32	18.20	13.05	11.70	33.58	63.20	111.58	91.73	118.15	158.62
DSH-113	52.28	50.37	44.21	16.22	14.25	12.30	44.22	63.83	134.20	112.72	128.45	190.71
DSH-114	32.65	32.63	25.00	12.27	11.62	7.85	43.25	58.93	113.88	88.17	103.02	146.73
DSH-116	36.88	35.57	31.47	12.35	12.22	10.58	51.05	60.53	91.52	100.28	108.32	133.57
Mean	39.20	38.87	33.18	14.64	12.70	10.45	44.97	62.71	112.96	97.89	114.24	156.59
A1	28.02	30.05	25.57	11.77	17.02	17.97	32.42	58.15	101.23	72.21	105.22	144.77
HUS-305	33.55	38.83	30.68	11.53	13.35	12.35	29.78	61.67	84.30	74.87	113.85	127.33
Mean	30.79	34.44	28.13	11.65	15.19	15.16	31.10	59.91	92.77	73.54	109.54	136.05
S. Em. ±	2.76	3.60	1.75	0.96	1.54	1.36	4.84	6.07	14.41	7.35	10.48	14.71
C. D (0.05)	9.55	12.45	6.05	3.32	5.32	4.70	16.74	NS	49.86	25.43	NS	50.90

DAS : Days after sowing

Table 2 : Growth analysis parameters of safflower experimental hybrids compared with varieties at different crop growth stages

Hybrid/ Variety	L A I			CGR ($g\ m^2\ D^{-1}$)		RGR ($g\ g^{-1}\ D^{-1}$)		NAR ($gdm^2\ D^{-1}$)		TDM/LA ratio		
	90 DAS	105 DAS	Harvest	105 DAS	Harvest	105 DAS	Harvest	105 DAS	Harvest	90 DAS	105 DAS	Harvest
DSH-107	3.18	2.77	2.37	12.38	31.02	0.011	0.019	0.04	0.12	3.35	4.58	7.06
DSH-110	4.25	2.97	2.73	19.37	29.67	0.017	0.020	0.06	0.11	2.45	4.38	6.67
DSH-113	3.87	3.27	2.80	11.53	45.65	0.010	0.026	0.03	0.15	3.29	4.40	7.52
DSH-114	2.94	2.64	1.97	10.89	32.06	0.010	0.024	0.04	0.14	3.31	4.29	8.22
DSH-116	2.95	2.81	2.37	5.89	16.85	0.006	0.016	0.02	0.07	3.73	4.30	6.35
Mean	3.44	2.89	2.45	12.01	31.05	0.011	0.021	0.04	0.12	3.23	4.39	7.16
A1	2.55	3.88	3.91	24.17	29.27	0.024	0.020	0.07	0.08	3.12	2.97	4.14
HUS-305	2.68	3.11	2.82	28.59	9.89	0.027	0.007	0.07	0.03	3.09	4.04	4.96
Mean	2.62	3.50	3.37	26.38	19.58	0.026	0.014	0.07	0.05	3.11	3.51	4.55
S. Em. ±	0.23	0.24	0.22	1.78	3.26	0.002	0.003	0.03	0.04	0.27	0.45	0.76
C. D (0.05)	1.02	1.07	0.98	6.16	11.28	0.007	0.010	NS	NS	0.93	1.55	2.63

DAS : Days after sowing

than checks; while in capitula weight it remained comparable to other hybrids and superior to HUS-305. The CGR and RGR of capitula increased substantially upto harvest. Checks were found superior to hybrids upto 105 DAS, but at harvest hybrids recorded higher CGR and RGR than checks. Among the hybrids, DSH-113 and DSH-114 should significantly higher CGR and RGR values. These increased growth rates are represented in increased total CGR, RGR and NAR beyond vegetative stage of crop growth. Though A-1 was following similar trend as that of hybrids, HUS-305 showed declining trends which could be due to the completion of it's major seed filling by 105 DAS (Table 3).

The hybrid DSH-113 offered significantly higher seed yield/plant than the rest of the test hybrids. The 100 seed weight of hybrids barring DSH-114 was significantly lower than varieties. Though hybrids recorded lower test weights, their enhanced seed yields can be traced to more number of capitula/plant and seed number/capitula (Table 3).

Oil content

The oil content of hybrids and varieties was generally lower than that obtained in 1992-93 (Prasad et al, 1993). Even the high oil yielding variety HUS-305 recorded low oil content of 25.26%. This was due to poor endosperm development which was probably due to poor fertility status of the soil besides less duration of cool weather available for the crop growth. Oil content of hybrids was significantly higher than varieties. Among the hybrids, DSH-113 and DSH-116 remaining comparable, recorded significantly higher oil content than the rest.

Thus, the performance of hybrids was found superior to checks. Of the experimental hybrids, DSH-113 was significantly superior to all other test hybrids and varietal checks in terms of growth parameters, physiological efficiency and seed yield (Table 3).

LITERATURE CITED

Prasad, M.V.R., Anjani, K. and Ramachandram, M. 1993. Status paper on "Hybrid Safflower: Historical developments, present status and future perspective in Indian context". National Seminar on Hybrid Research and Development (Dec. 6-8, 1990), IARI, New Delhi.

Ramachandram, M. and Goud, J.V. 1982. Gene action for seed yield and its components in safflower, Ind. J. Genet. & Pl. Breed. 42 : 213-220.

Ramachandram, M. and Sujatha, M. 1991. Development of genetic male sterile lines in safflower. Ind. J. Genet. & Pl. Breed. 51(2): 268-269.

Ranga Rao, V. 1982. Heterosis of agronomic characters in safflower. Ind. J. Genet. & Pl. Breed. 42 : 364-371.

Watson, D.J. 1952. the physiological basis of variation in yield. Adv. agron. 4: 101-145.

Table 3 : Yield and yield components of safflower experimental hybrids compared with varieties

Hybrid/ Variety	Capitula No./Plant	Capitula Wt./Plant (g)	Seed yield/ Plant (g)	100 Seed wt. (g)	Oil content (%)	Capitula CGR		Capitula RGR	
						105 DAS	At harvest	105 DAS	At harvest
DSH-107	32.83	113.60	42.42	4.35	26.20	10.50	34.14	0.017	0.033
DSH-110	35.50	111.58	33.28	3.75	27.68	21.76	35.48	0.042	0.038
DSH-113	52.83	134.20	53.95	4.50	32.50	14.38	51.60	0.028	0.049
DSH-114	34.33	113.88	45.73	5.76	27.80	11.50	40.30	0.020	0.045
DSH-116	36.33	91.52	40.60	4.56	30.84	7.29	22.72	0.011	0.028
Mean	38.36	112.96	43.19	4.58	29.00	13.09	36.85	0.024	0.039
A-1	36.50	101.23	42.12	5.86	22.54	18.87	31.59	0.038	0.039
HUS-305	35.53	84.30	38.87	5.97	25.26	23.38	16.60	0.048	0.020
Mean	35.92	92.77	40.50	5.92	23.90	21.13	24.10	0.043	0.030
S.Em ±	1.71	14.41	0.76	0.17	1.19	1.65	3.81	0.003	0.004
C. D (0.05)	5.92	49.86	2.63	0.59	2.50	5.71	13.18	0.010	0.014

DAS : Days after sowing

J. Oilseeds Res. 13 (1) 1996: 53-55
ISSN 0970-2776

EFFECT OF IRRIGATION METHODS AND LEVELS ON SEED YIELD AND QUALITY OF SAFFLOWER (*CARTHAMUS TINCTORIUS* L.)

P.G. PATEL [1] and Z.G. PATEL
Department of Agronomy, N.M. College of Agriculture, Gujarat Agricultural University
Navsari-396450.

ABSTRACT

A field experiment conducted during *rabi* seasons of 1992-93 and 1993-94 at the Gujarat Agricultural University, Navsari campus to study the feasibility of mini-sprinkler with different levels of IW/CPE ratio on seed yield and quality of safflower Var. Bhima indicated that irrigation applied through mini-sprinkler produced 15.68 per cent higher seed yield than surface method. The seed yield increased with increasing levels of IW/CPE ratios upto 0.6 under both the systems of irrigation. The oil and protein content in safflower seeds did not differ significantly due to irrigation systems but was influenced by irrigation levels.

Key words: Safflower; irrigation; yield; quality

INTRODUCTION

Irrigation water is a monetary input in crop production and hence its management is very essential for maximizing crop yield. Information with regard to irrigation management for obtaining optimal seed yield and quality of safflower is not available for Gujarat. The present study was therefore conducted with a view to findout the effect of irrigation systems and levels of IW/CPE ratios on seed yield and quality of safflower.

MATERIALS AND METHODS

A field experiment was conducted at the Gujarat Agricultural University, Navsari during *rabi* seasons of 1992-93 and 1993-94 to study the response of safflower to irrigation method and levels in vertisol of South Gujarat. The soil of the experimental plot was clayey in texture. The field capacity and permanent wilting point were 32.2 and 18.7%, respectively with a bulk density of 1.40 g/cc at 0-15cm depth. Two separate experiments were laid out in randomized block design with four irrigation schedules based on IW/CPE ratios Viz., 0.2, 0.4, 0.6 and 0.8 under mini-sprinkler and surface method of irrigation, both replicated six times. Safflower Var. Bhima was sown in the month of October-November and was harvested in February-March. Two common irrigations were applied for establishment of the crop and remaining irrigations each of 50mm depth by mini-sprinkler and 60 mm depth by surface method were applied as per treatments during both the years of experimentation. The quality was measured in terms of oil and protein content and their yield. The oil content was determined using NMR apparatus and N percentage was determined by the micro-Kjeldahl method. The amount of protein content was obtained by multiplying the N with a constant factor of 6.25. The total oil and protein yields were computed on the basis of seed yield obtained and their oil and protein content.

RESULTS AND DISCUSSION

Effect of irrigation levels

The mean data (Table1) indicated that seed yield of safflower significantly increased with increasing levels of irrigation upto 0.6 IW/CPE ratio under

---

1. Gujarat Agricultural University, Sardar Krushinagar - 385 506, Dist. Banaskantha.

Received for publication March, 1995

Table 1. Effect of irrigation methods and levels on seed yield and quality of safflower (Meann of 2 years)

Treatments *	*Seed yield* (kg/ha)	*Oil content* in seed (%)	*Oil yield* (kg/ha)	*Protein Con-* tent in seed (%)	*Protein* Yield (kg/ha)
Mini-sprinkler method					
0.2 IW/CPE ratio	1375.2	31.49	433.0	11.46	157.9
0.4 IW/CPE ratio	1627.2	31.54	513.2	11.36	185.1
0.6 IW/CPE ratio	2114.9	31.69	670.4	11.25	238.4
0.8 IW/CPE ratio	2112.3	31.71	669.8	11.19	236.7
Mean	1807.4	31.61	571.6	11.31	204.5
S. Em. ±	50.3	0.05	16.1	0.05	5.6
C.D. (0.05)	144.9	0.13	46.4	0.14	16.2
Surface method					
0.2 IW/CPE ratio	1177.4	31.38	369.6	11.35	134.6
0.4 IW/CPE ratio	1442.6	31.45	453.8	11.30	162.8
0.6 IW/CPE ratio	1807.7	31.69	572.9	11.19	202.3
0.8 IW/CPE ratio	1821.9	31.77	579.0	11.13	202.0
Mean	1562.4	31.57	493.8	11.24	175.6
S.Em. ±	40.6	0.03	12.7	0.04	5.1
C.D. (0.05)	116.9	0.10	36.6	0.11	13.7
Irrigation systems					
S.Em. ±	22.9	0.02	7.2	0.02	2.6
C.D. (0.05)	64.6	NS	20.5	NS	7.4

both the methods of irrigation. These findings are in conformity with those reported by Anon. (1979) and Phulari *et al.* (1986).

The oil content in safflower seed also increased with increase in irrigation levels upto 0.6 IW/CPE ratio in both the systems of irrigation, which might be due to reduced irrigation intervals enhancing the carbohydrate accumulation leading to increased seed oil percentage. These findings are in conformity with those reported by Ibrahim *et al.* (1991) and Zaman and Das (1991). Consequently the oil yield was significantly higher with 0.6 IW/CPE ratio under both the irrigation systems. This was mainly due to higher seed yield and oil content obtained with this ratio, as oil production is a function of oil content and seed yield. These results are in agreement with the finding of Zaman and Das (1991).

Further, irrigation applied under both the systems significantly influenced the protein content. In general, protein content decreased with increasing levels of irrigation. Similar results were also reported by Haby *et al.* (1982). On the other hand the protein yield of safflower was maximum with 0.6 and 0.8 IW/CPE ratios, while remarkably the lowest protein yield was recorded with 0.2 IW/CPE ratio under both the systems of irrigation. This was mainly due to higher seed yield obtained with 0.6 and 0.8 IW/CPE ratios, as protein yield is a function of protein percentage and seed yield.

Effect of irrigation systems

The pooled data (Table 1) indicated that the seed yield of safflower under mini-sprinkler system was 1807.4 kg/ha which was 15.68 per cent higher than surface method of irrigation. Mini-sprinkler system provided uniform and adequate moisture for plant growth, while keeping the soil structure loose and friable which was conducive for better aeration, ultimately favouring better growth, development and yield of crop. These findings are in line with those of Anon. (1984) and Abrol and Sharma (1990).

The oil content in safflower seed was not significantly influenced by methods of irrigation, but the total oil yield was significantly higher under mini-sprinkler system as compared with surface method. This was mainly due to the fact that mini-sprinkler method offered significantly higher seed yield than surface method.

The protein content in safflower seed was also not influenced significantly due to methods of irrigation. The total protein yield was significantly higher under mini-sprinkler system as compared to surface method, which was mainly due to higher seed yield obtained in the former than with the latter method of irrigation.

LITERATURE CITED

Abrol, I.P. and Sharma, B.R. (1990). Efficient water management is crucial for achieving self-sufficiency in food. Indian Fmg., 40(7): 25-28.

Anonymous (1979). Progress Report of Integrated Project for Research on Water Management and Soil Salinity, Karnal, PP 31-32.

Anonymous (1984). Annual progress Report, Water Management Project, Rahuri.

Haby, V.A.; Black, A.L.; Bergman, J.W. and Larson, R.A. (1982). Nitrogen fertilizer requirements of irrigated safflower in the Northern great plains. Agron. J., *74* (2): 331-335.

Ibrahim, A.F., Sharaan, A.N. and Wakil, A.W. (1991). Water requirements of safflower entries in Middle Egypt. *J. Agron. & Crop Sci.*, *167* (3) : 170-175.

Phulari, D.G.; Bharambe, P.R.; Sondge V.D.; Quadri, S.J. and Rodge, R.P. (1986). Response of Safflower genotypes to irrigation. *J. Maharashtra agric. Univ.*, 11 (1): 99-100.

Zaman, A. and Das, P.K. (1991). Effect of irrigation and nitrogen on yield and quality of safflower. *Indian J. Agron.*, *36* (2): 177-179.

J. Oilseeds Res. 13 (1) 1996: 56-60
ISSN 0970-2776

THE PRE-AND POST-ANTHESIS DRY MATTER CONTRIBUTION TO SEED YIELD IN SUNFLOWER

Y.A. NANJA REDDY, R. UMA SHAANKER, T.G. PRASAD and K. VIRUPAKSHAPPA*
Department of Crop Physiology, *Project Co-ordinating Unit (AICRP-Sunflower), University of Agricultural Sciences, GKVK, Bangalore 560 065.

ABSTRACT

The contribution of pre- and post-anthesis dry matter to the productivity of a few sunflower genotypes was examined following a simple physiological approach. The results suggest that genotypes which translocate dry matter both *from pre-and post-anthesis stages*, on an average yield more than the genotypes in which there is only post-anthesis contribution. In the latter genotypes, the lack of pre-anthesis contribution is more due to non availability of stored dry matter than due to the inability of the genotypes to translocate the resources. Productivity in sunflower can hence be increased by encouraging a higher pre-anthesis storage of dry matter. Therefore the the selection for high pre-anthesis storage dry matter coupled with active current assimilation during seed development could contribute significantly towards the improvement of productivity in sunflower.

Key Words: Sunflower; Pre-anthesis dry matter (PDM); Pre- and Post anthesis DM contribution.

INTRODUCTION

Seed development in any crop is dependent upon the translocation of assimilates contributed by the stored reserves and that from current assimilation. The relative extent to which these two sources contribute to the total biomass accumulated in seed determines the final productivity of the crop. Identification of the relative contribution and developing strategies to improve them could increase the productivity of crops.

In sunflower, a determinate oilseed crop, productivity is generally low. Earlier work in this direction has shown that this could arise due to poor assimilation in this species. In addition, the poor productivity is also attributed to frequent moisture stress that prevails during monsoon season in most parts of India. Sadras *et al.* (1993) showed that under moisture stress, the contribution of pre-anthesis dry matter to the seed development is relatively high. They argued that sunflower adopts an opportunistic strategy to accumulate high dry matter during pre-anthesis period and translocating them to seed particularly under end-season moisture stress.

In this study we have examined the genotypic variation in the contribution of pre and post-anthesis dry matter partitioning to productivity and discuss the possible approaches to improve productivity of sunflower.

MATERIALS AND METHODS

A field experiment was conducted during the rainy season of 1994 at the University of Agricultural Sciences, Bangalore on red loamy soils (pH 6.5). Nine sunflower germplasm lines of similar duration (105 days) were sown in three replicates in completely randomised block design in plots of size 3 x 3m. Crop was raised following all the recommended practices for sunflower cultivation.

Observations on above ground total dry matter (TDM) through its individual components (lamina,

Received for publication May, 1995

stem + petiole and thalamus + seed) were recorded at ray floret stage and at crop maturity. Leaf area at ray floret stage was measured using non-destructive technique (Nanja Reddy *et al.*, 1995).

The contribution of dry matter present in the vegetative parts at pre-anthesis to the capitulum (thalamus + seed) and to seed were computed after modififying the method suggested by Gallagher *et al.* (1976).

(a) The percent pre-anthesis dry matter (PDM) contribution to head (Total):

$$= \frac{\text{L + S at ray floret stage} - \text{L + S at harvest}}{\text{Capitulum weight at harvest} - \text{Capitulum weight at ray floret stage}} \times 100$$

(b) Per cent PDM to seed:

$$= \frac{\text{L + S + C at ray floret stage} - \text{L + S + Thalamus at harvest}}{\text{Seed yield}} \times 100$$

Wherein, L, S and C are leaf, stem and capitulum dry weights, respectively.

(c) Per cent contribution to thalamus:

(a) - (b)

(d) The per cent contribution to seed yield during post-anthesis stage:

100 - (b)

RESULTS AND DISCUSSION

While the total dry matter (TDM) at ray floret stage was positively correlated to seed yield ($r = 0.81$ $P < 0.05$), the post-anthesis TDM was not ($r = 0.23$, $P > 0.05$). This indicates that in sunflower there should be a significant contribution of dry matter from the pre-anthesis reserves. We analysed for this prediction by classifying the genotypes into two groups that is, high and low pre-anthesis dry matter (PDM) types (more and less than the genotypic average of 327 g m^{-2} respectively). Wide variation of nearly four to five fold was seen for all the parameters studied excepting the harvest index (Table 1). Significant genotypic variation existed for all the parameters studied (Table 2). Among the two groups, dry matter (DM) at any given stage and seed yield differed significantly. Seed yield of high PDM types was 43 per cent more compared to low PDM types. The TDM at harvest was also high in high PDM types but, the TDM after anthesis was less by 56 per cent. Harvest index and leaf area did not differ significantly. This clearly indicates that genotypes producing high PDM would yield more.

In studying the contribution of PDM towards seed yield, the high PDM types showed higher contribution (52%) than the low PDM types (Table 3). Similarly, Hall *et al.* (1989) showed that 27 per cent of seed yield in sunflower was contributed from pre-anthesis stored soluble carbohydrates based on carbon labelling study. Seed yield derived from both pre- and post- anthesis DM (in high PDM types) was significantly more compared to the genotypes in which seed yield comes solely from post-anthesis (current photosynthates). This suggests that, pre-anthesis translocation is mainly dependent on the amount of DM accumulated at the time of anthesis.

Correlation analysis within a genotype group showed that, seed yield is significantly and positively related to the DM produced at any given crop growth stage including post-anthesis phase in both high and low PDM types (Table 4). This suggests the importance of contribution of post-anthesis dry matter during seed filling period towards grain yield. Therefore, maintenance of

Table 1. Range and mean for a few growth and yield parameters in sunflower lines

Character	Range			Mean
LAI at ray floret stage	1.65	-	3.74	2.87
TDM at ray floret stage (gm^{-2})	110	-	590	327.00
TDM produced during post-anthesis period (gm^{-2})	60	-	177	117.00
TDM at harvest (gm^{-2})	271	-	661	450
HI	0.20	-	0.31	0.24
Seed yield (gm^{-2})	60	-	148	107.30

Table 2. Seed yield and associated parameters in sunflower genotypes with high and low pre-anthesis (PDM) accumulation capacity.

Genotype	Seed yield (gm^{-2})	TDM (gm^{-2}) at ray floret stage	TDM (gm^{-2}) at Harvest	TDM (gm^{-2}) at post anthesis	Harvest index	LAI at ray floret stage
High PDM types						
Acc 1253	139	415	488	73	0.28	3.12
Acc 1279	112	459	519	60	0.22	3.38
Acc 121	116	399	460	61	0.25	2.85
Acc 1568	148	590	661	71	0.22	3.74
Mean	129	466	532	69	0.24	3.27
Low PDM types						
Acc 1633	93	267	444	177	0.21	3.00
Acc 159	60	110	271	100	0.22	2.01
Acc 1250	67	201	331	130	0.20	1.68
Acc 99	118	224	384	160	0.31	3.21
Acc 1539	113	275	494	220	0.23	2.82
Mean	90	215	385	157	0.23	2.54
CD ($P< 0.05$)						
Genotypes	12.6	54	44	23.3	0.02	0.27
Groups					NS	NS

Table 3. Contribution of pre-anthesis biomass to capitulum and seed weight in sunflower germplasm lines.

Genotype	Pre-anthesis (%)			Post-anthesis (%)
	Thalamus	Seed	Capitulum	Seed
High PDM types				
Acc 1253	8.0	47.5	55.1	52.5
Acc 1279	8.7	37.5	46.2	62.5
Acc 121	5.7	47.4	53.1	52.6
Acc 156[illegible]	4.7	52.0	56.7	48.0
Low PDM types				
Acc 1633	-	-	0	100.00
Acc 159	-	-	0	100.0
Acc 1250	-	-	0	100.0
Acc 99	-	-	0	100.0
Acc 1539	-	-	0	100.0

Table 4. Correlation co-efficients among yield and related parameters in high and low pre-anthesis DM accumulation types of sunflower germplasm lines.

	Seed yield contributed from			
	Pre-anthesis (High PDM)		Post-anthesis (Low PDM)	
Seed yield Vs				
HI	0.29	NS	0.66	**
TDM at ray floret stage	0.66	*	0.63	**
TDM at harvest	0.70	**	0.80	**
TDM after anthesis	0.65	*	0.82	**
LAI and TDM at ray floret stage	0.94	**	0.54	**

higher LAD during seed filling phase should be an important trait for higher productivity. A positive significant relationship between harvest index (HI) and seed yield was observed in low PDM types, but not in high PDM types indicating that, current photosynthates are locked up in vegetative plant parts probably because of low sink demand. Therefore, in general, genotypes should be selected for high DM at anthesis and also for maintenance of higher LAD during post-anthesis period. If, pre-anthesis biomass accumulation is more, it leads to increased sink number. These sinks may draw stored carbohydrates due to high sink demand resulting in high seed yield.

However, the DM at anthesis would certainly be dependent on canopy photosynthesis, which inturn is a function of canopy size and average assimilation rate per unit leaf area (Gimenez *et al.*, 1994). In the present study, the positive significant relationship between LAI and TDM at ray floret stage in both high and low PDM types (Table 4) clearly suggests that, the high LAI types can be selected to obtain high biomass at anthesis. The importance of LAI may be further emphasized since, photosynthetic rate, one of the component of canopy photosynthesis, was found to be already high in sunflower (Connor and Sadrass, 1992). Additionally, LAI is shown to have positive relationship with seed yield also (Steer *et al.*, 1988; Nanja Reddy *et al.*, 1994).

The results show that, genotypes capable of producing high DM during pre-anthesis are probably better yielders. High TDM at anthesis would lead to remobilization of stored carbohydrates from the stem to seed, such a character is most useful during end season stress. Breeding and selection of genotypes with high biomass at anthesis and high post-anthesis LAD would improve the seed yield of sunflower substantially.

LITERATURE CITED

Connor, D.J. and Sadras, V.O. 1992. Physiology of yield expression in sunflower. *Field Crops Research* 30: 333-389.

Hall, A.J., Connor, D.J. and Whitfield, D.M. 1989. Contribution of pre-anthesis assimilates to grain filling in irrigated and water stressed sunflower crops. I. Estimates using labelled carbon. *Field Crops Research*. 20: 95-112.

Gallagher, J.N., Biscoe, P.V. and Hunter, B. 1976. Effects of drought on grain growth. *Nature* 262: 541-542.

Gimenez, C., Connor, D.J. and Rueda, F. 1994. Canopy development, photosynthesis and radiation use efficiency in sunflower in response to nitrogen. *Field Crops Research*. 38: 15-27.

Nanja Reddy, Y.A., Sheshshayee, M.S., Uma Shaanker, R., Virupakshappa, K. and Prasad, T.G. 1994. Selection for high canopy assimilation rate is a good strategy to increase productivity in sunflower. *Helia* 17: 45-52.

Nanja Reddy, Y.A., Keshava Murthy, M.N., Uma Shaanker, R., and Virupakshappa, K.1995. An improved non-destructive method for rapid estimation of leaf area in sunflower genotypes. *J. Agron. Crop Sci.*, (In press)

Sadras, V.O., Connor, D.J. and Whitfield, D.H. 1993. Yield, yield components and source - sink relationships in water stressed sunflower. *Field Crops Research*. 31: 27-39.

Siddaraju, S.R. 1986. Leaf area development, Canopy carbon exchange rate and productivity at varying plant population and nutrient status in sunflower. M.Sc., (Ag). Thesis, Univ. Agric. Sci., Bangalore.

Steer, B.T., Hocking, P.J., and Low, A. 1988. Dry matter, minerals and carbohydrates in the capitulum of sunflower: Effect of competition between seeds, and defoliation. *Field Crops Research*. 18: 71-85.

J. Oilseeds Res. 13 (1) 1996: 61-65
ISSN 0970-2776

USE OF ZINCATED AND BORONATED SUPERPHOSPHATES AND MYCORRHIZAE IN GROUNDNUT GROWN ON A CALCAREOUS SOIL

A.L. SINGH and VIDYA CHAUDHARI
National Research Centre for Groundnut, P.B. NO.5, Evenagar Road, Junagadh - 362 001

ABSTRACT

Pot experiments with calcareous soil have shown that, application of zincated and boronated single superphosphate was more useful than single super phosphate (SSP) and increased the nodule biomass, pod number and pod and haulm yields in groundnut. The zincated SSP was more effective in increasing these parameters than both boronated and ordinary SSP. The plant culture of vesicular-arbuscular mycorrhizae (VAM) fungus *Glomus fasciculatus* when inoculated to groundnut with different doses of P did not influence the growth and yield of groundnut significantly. However, P doses significantly increased the nodule biomass upto 200 kg/ha of P and pod number and pod and haulm yields upto 100 kg P/ha in the calcareous soil.

Keywords: Boronated and zincated single superphosphate; Calcareous soil; Groundnut; Micronutrient; V.A.M.

INTRODUCTION

Groundnut, inspite of its high nutrient requirement, is cultivated mostly on light textured soils deficient in macro- and micro-nutrients (Kanwar *et al.*, 1983; Bell, 1985; Dwivedi, 1988; Singh *et al.*, 1991). The calcareous soils of Saurashtra have marginal available P and crops grown on this soil respond to P application. (Dwivedi, 1988; Singh *et al.*, 1991). Besides, the calcareous nature of soil also causes several other micro-nutrient deficiencies, particularly Zn and B, and yield reduction (Dwivedi, 1988; Singh *et al.*, 1990a, b, 1991, 1993). The P deficiency generally occurs late, on old leaves leaving less scope for its timely amelioration. The Zn and B deficiencies, which occur on young leaves, get intermingled with those of iron and sulphur and result in poor pod bearing and kernel filling. Moreover, by the time these deficiencies are diagnosed in the field, it is too late to rectify them in the standing crop to prevent the yield losses.

Prevention of these deficiencies with soil and foliar applications of P, Zn and B containing fertilizers are the main remedies and field experiments to this affect have been conducted on many soils of India (Kanwar *et al.*, 1983; Dwivedi, 1988; Singh *et al.*, 1990, 1991). However, there is not much information on the use of zincated and boronated single super phosphates and utilization of mycorrhizae in increasing the availability of native and applied P to groundnut in calcareous soils.. Mycorrhizal endophytes of vesicular-arbuscular type are the common root associations of most of the natural flora and crop plants. Of these, *Glomus fasciculatus* has been found to be beneficial to several crops (Suman Bala and Singh, 1983; Singh and Singh, 1988 and Bolan, 1991). As there is meagre information on the beneficial effects of this fungus on groundnut, pot experiments were conducted to understand the effects of zincated and boronated superphosphate and mycorrhizae on yields of groundnut crop.

MATERIALS AND METHODS

Pot experiments were conducted at the National Research Centre for groundnut, Junagadh, during the wet season of 1988 and dry and wet seasons of 1989 on a medium black calcareous (18.5% $CaCO_3$) clayey (58% clay and 12% sand) soil

Received for publication July, 1995

containing 0.9% organic carbon, 0.054% total N, 5.1 mg/kg available P (Olsen P), 0.48 mg/kg DTPA extractable Zn, 0.38 mg/kg available (hot water extractable) B, and pH 7.7. Ten kg of soil was filled in polythene lined earthen pots, on which two experiments were laid-out.

The first experiment was conducted in CRD to test the effectiveness of zincated and boronated single superphosphate (SSP) as against ordinary superphosphate in improving the yield of groundnut. The phosphorus doses were: 0 (P0), 50 (P50) and 100 (P100) kg/ha of P_2O_5. The SSPs used were ordinary SSP, zincated SSP (ZnSSP) grade I containing 0.616% Zn, and boronated SSP (BSSP) containing 0.018% B (5 kg borax per kg P_2O_5). The ZnSSP and BSSP were obtained from Dharamsi Morarji Chemical Co. Ltd., Bombay. Phosphorus through these SSPs was applied to the soil before sowing and mixed well. There were, thus, nine treatments each replicated thrice. Urea at 500 mg N/pot and potassium chloride at 500 mg K/pot were added uniformly to all these pots as basal and mixed well. This experiment was repeated twice during the dry and wet seasons of 1989.

The second experiment was also conducted in CRD to test the effectiveness of mycorrhizae (*Glomus fasciculatus*) with and without P and their interactions. Here the phosphorus doses were: 0, 50, 100 and 200 kg/ha of P_2O_5 and to achieve these SSP at 0, 1.56, 3.12 and 6.24 g/pot (per 10 kg soil), were applied to the soil and mixed well. Two sets of such pots were arranged, and in one set the plant cultures infected with *Glomus fasciculatus* were inoculated. Altogether there were eight treatments each replicated thrice. Urea at 500 mg N/pot and potassium chloride at 500 mg K/pot were added uniformly to all these pots. This experiment was conducted during wet season of 1988, and dry and wet seasons of 1989.

The bunch groundnut variety GG 2 was sown at a rate of three seeds per pot in both the experiments. The pots were irrigated to saturation capacity on the first day after sowing and subsequently irrigated with adequate water on alternate days. The dry season groundnut crop was sown in the first week of February and harvested in the first week of June. The wet season crop was sown in the first week of July and was harvested in the third week of October. At maturity, the plants of each pot were harvested. The nodules, pod and haulm were separated, dried in the sun for about a week and weighed. The pod number of plants from each pot was recorded. The data were analyzed statistically.

RESULTS AND DISCUSSION

Application of P as ordinary SSP increased the nodulation, number of pods, and pod and haulm yields of groundnut. The zincated and boronated SSPs further helped the groundnut to produce more nodules and increase the nodule biomass, pod number per plant, and pod and haulm yields of groundnut during both the seasons (Table 1). The ZnSSP was better than the ordinary SSP as it increased the nodule weight, pod number, pod and haulm yields significantly at both levels of P. Application of BSSP though increased these parameters, none of them were significantly superior to those obtained by using ordinary SSP in either of the seasons at any of the P levels (Table 1). The beneficial effects of ZnSSP over ordinary SSP was mainly due to inclusion of Zn in the SSP as the groundnut responds to Zn in this soil (Singh *et al.*, 1990a, b). Boron application is also beneficial as response of groundnut was observed in this soil earlier (Singh *et al.*, 1990a). The BSSP also increased these parameters, but it could not prove significantly superior to ordinary SSP. This may be due to the effect of P and its antagonistic interaction with B, where the P deficiency increases B content in plant and in presence of excess B, the

Table 1. Influence of zincated and boronated single superphosphates on nodulation, pod number and yields of groundnut

Treatments	Nodule Weight (mg/pot)			Pod no/pot			Yield (g/pot) Pod			Haulm		
	O	Zn	B	O	Zn	B	O	Zn	B	O	Zn	B
						Dry Season						
Phoshporus												
P 0	0.08	0.08	0.10	12	13	11	6	7	5	12	14	13
P 50	0.18	0.19	0.18	16	19	17	10	12	11	18	20	18
P 100	0.21	0.26	0.23	21	26	24	13	15	14	22	28	23
C.D. (0.05)		*0.04*			*4*			*2*			*5*	
						Wet Season						
P 0	0.09	0.10	0.11	10	11	11	6.6	6.3	6.9	15	15	16
P 50	0.20	0.31	0.25	16	18	17	9.5	11.6	10.5	20	18	19
P 100	0.28	0.34	0.31	19	23	21	11.6	13.7	12.6	25	27	25
C.D. (0.05)		0.06			3			2.0			5	

O, Zn and B represent ordinary, zincated and boronated single superphosphates, respectively.

B content is lower in plants receiving adequate or high level of P (Jones *et al.*, 1991). Response of groundnut to P application was well documented in the earlier study (Singh *et al.*, 1991) and similar observations were also made in this study. Both the doses of P were found beneficial and higher dose was seen to be superior to the lower one. Kulkarni *et al.*, (1986), in a field study, reported increase in nodule number and biomass upto 50 kg P/ha against the general recommendation of 30-60 kg P_2O_5/ha (ICAR, 1987). In a well fertilized calcareous soil, inorganic phosphate occurs primarily in different forms of Ca-phosphate of varying solubilities. Since Saurashtra soils are deficient in P, crops respond to P even at higher levels (Singh *et al.*, 1991) as the solubility and availability of P depends both on pH and the Ca concentration. However, this being a pot study, these doses cannot be extrapolated directly to field doses.

The results of the second pot culture experiment are presented in Table 2. It was observed that increasing the P doses increased the nodule biomass, pod number per plant, and pod and haulm yields of groundnut significantly over its lower dose. But the VAM could not increase these characters significantly at any of the P doses during none of the seasons. However, the VAM helped to increase these parameters upto some extent as these data with P plus VAM were superior to P alone (Table 2). The non significant effect of VAM in this study may be attributed to slightly higher pH due to the calcareousness of the soil which might have caused slow establishment of VAM in this soil-plant ecosystem. Besides P, the beneficial effect of VAM is also attributed to its effect in increasing the availabilities of macro - and micro-nutrients which in turn increase the yields, but here several other factors might have played role in this calcareous soil and, hence, the cumulative effects on yields were marginal. Kothari *et al.*, (1990) reported that the mycorrhizal treatment increased the concentrations of P, Zn and Cu in shoots and roots. Suman Bala and Singh (1983) found that the variation in magnitude of the association between leguminous hosts and endophytes can be ascribed to ecological factors,

Table 2. Influence of phosphorus and vesicular-arbuscular mycorrhizae (*Glomus fasciculatus*) on nodulation, pod number and yield of groundnut

Treatments (P doses)	Nodule Weight (mg/pot)		Pod no/pot		Yield (g/pot)			
					Pod		Haulm	
	W	VAM	W	VAM	W	VAM	W	VAM
				Wet Season, 1988				
P 0	0.08	0.09	12	13	6.0	7.5	12	13
P 50	0.20	0.22	16	18	9.0	11.0	16	19
P 100	0.25	0.28	20	23	12.0	12.0	21	23
P 200	0.30	0.33	22	24	13.0	13.5	23	24
C.D. (0.05)	0.05		3.5		2.5		4	
				Dry Season, 1989				
P 0	0.11	0.13	11	14	5.6	6.8	11	14
P 50	0.22	0.25	18	19	10.6	11.6	15	18
P 100	0.28	0.30	22	26	14.2	15.8	19	20
P 200	0.35	0.38	25	27	15.0	16.2	20	22
C.D. (0.05)	0.06		3.8		3.2		4	
				Wet Season, 1989				
P 0	0.08	0.10	12	14	5.0	6.0	12	14
P 50	0.16	0.20	19	21	8.9	10.2	16	19
P 100	0.20	0.25	24	25	10.8	11.3	18	21
P 200	0.25	0.28	26	28	12.2	13.1	19	21
C.D. (0.05)	0.04		3.6		1.5		2	

W and VAM are without VAM and with VAM, respectively

host-specificity and mycorrhizal types. They further noted that the mycorrhizal intensity in groundnut was 78.8% with 47.4 nodules per plant. Joshi *et al.*, (1991) compared six efficient strains of VAM and found that none of them were doing well at pH 8.3 in calcareous soil. However, they reported a positive correlation between percentage of mycorrhizal root infection and nodule number, dry weight of shoot and N and P concentrations.

Thus, from this study, it is concluded that in calcareous soil of Saurashtra, groundnut grower should use zincated superphosphates in place of ordinary SSP to correct the Zn deficiency of groundnut and to increase the production.

LITERATURE CITED

Bell, M.J., 1985. Phosphorus nutrition of peanut (*Arachis hypogeae* L) on cockatoo sandy of the Ord river irrigation area. *Aust. J. of Exptd. Agric.* 25: 649-653.

Bolan, N.S. 1991. A critical-review on the role of mycorrhizal fungi in the uptake of phosphorus by plants. *Plant and Soil* 134: 189-207.

Dwivedi, R.S. 1988. Mineral nutrition of groundnut. Metropolitan Book Co. New Delhi, India, 135 pp.

ICAR. 1987. Fertilizer use in groundnut. *Technologies for Better Crops* 30: ICAR, New Delhi, India, 11 pp.

Jones Jr, J.B., Wolf, B and Mills H. A. 1991. Plant Analysis Handbook. Micro-Macro Publishing Inc. Athens, Georgia, USA, 213 pp.

Joshi, P.K., Bhatt, D.M. and Tomar, R.S. 1991. Effect of inoculation with vesicular-arbuscular mycorrhizal fungi and Rhizobium on crop growth in groundnut (*Arachis hypogeae* L.). pp 113-117, In: Physiological Strategies for Crop Improvement. Eds. Tyagi D. N. *et al. Proceedings of the International Conference on Plant Physiology*. Banaras Hindu University, Varanasi, India.

Kanwar, J.S., Nighawan, H.L. and Raheja, S.K. 1983. Groundnut nutrition and fertilizer response in India. ICAR, New Delhi, India, 185 pp.

Kothari, S.K., Marschner, H. and Romheld, V. 1990. Direct and indirect effects of VA mycorrhizal fungi and rhizosphere microorganisms on acquisition of mineral nutrients by maize (Zea mays L.) in calcareous soil. *New Phytologist* 116: 37-645.

Kulkarni, J.H., Joshi, P.K. and Sojitra, V.K. 1986. Influence of phosphorous and potassium application on nodulation, nitrogen accumulation and pod yield of groundnut. *Legume Res.* 9: 34-38.

Singh, A.L., Chaudhari, Vidya and Koradia, V.G. 1991. Foliar nutrition of nitrogen and phosphorus in groundnut. pp 129-133, In : Physiological strategies for crop improvement. Eds D.N. Tyagi *et al. Proceedings of the International Conference on Plant Physiology*, B.H.U. Varanasi, India.

Singh, A.L., Joshi, Y.C. and Koradia, V.G. 1990a. Effects of micronutrients and sulphur on groundnut (*Arachis hypogeae* L.) in calcareous soil. pp 1236-1240, In: Proceeding of International Congress of Plant Physiology. Eds. S.K. Sinha *et al*, Vol. II. Society for Plant Physiology and Biochemistry, New Delhi, India.

Singh, A.L. Joshi, Y.C., Chaudhari Vidya and Zala, P.V. 1990b. Effect of different sources of iron and sulphur on leaf chlorosis, nutrient uptake and yield of groundnut. *Fert. Res.* 24: 85-96.

Singh, A.L. Chaudhari, Vidya and Koradia V.G. 1993. Spray schedule of multimicronutrients to overcome chlorosis in groundnut. *Ind. J. Pl. Physiol.* 36: 35-39.

Singh, O.S. and Singh, R.S. 1986. Effects of phosphorus and Glomus fasciculatus inoculation on nitrogen fixation, P uptake and yield of lentil (*Lens culinaris medic.*) grown on an unsterilized sandy soil. *Environmental and Experimental Botany* 26: 185-190.

Suman Bala and Singh, O.S. 1983. Endomycorrhizal associations of legume and pulses in Punjab. *Ind. J. Ecol.* 10: 242-247.

J. Oilseeds Res. 13 (1) 1996: 66-69
ISSN 0970-2776

STUDIES ON SOYBEAN CULTIVATION DURING NON-TRADITIONAL *RABI*/SUMMER UNDER IRRIGATED CONDITIONS

H.B. BABALAD, B.S. LINGARAJU and G.D. RADDER
AICRP on Soybean, University of Agricultural Sciences, Dharwad-580 005, Karnataka.

ABSTRACT

Field experiments carriedout during 1992-94 to assess the productivity of soybean varieties in relation to seeding time during non-traditional season (Rabi/summer) under irrigated conditions revealed that sowing during first fortnight to second fortnight of January offered significantly higher seed yield than early sowing in November or December. Plant height, number of branches and number of pods per plant were significantly higher with January sowing as compared to November and December sowings. The soybean variety Pusa-40 was found superior in terms of grain yield and yield components to the recommended *Kharif* varieties like JS-335, Monetta and KHSb-2. The studies indicate that Soybean can be profitably grown during *rabi* summer under irrigated conditions by sowing Pusa-40 variety in the month of January.

Key Words: Soybean; Non-traditional; Irrigation; Sowing time; Varieties.

INTRODUCTION

The phenomenal expansion of area and production of Soybean has earned a prominent position in oilseed industry of India. In fact it proved to be a fortune crop in terms of edible oil, export earnings and rural prosperity. It is extensively grown during *Kharif* with relatively large yield levels. However the current production of 4.6 million tonnes is in adequate to meet the installed crushing capacity of 13 million tonnes per annum, implying a need to increase the production through enhanced area and productivity. The first priority would be to raise the productivity of soybean in traditional areas during *Kharif* season. The other way is to extend its cultivation to non-traditional season mainly during summer, as several varieties of divergent genetic make up have been identified for summer. Amongst the various management practices, sowing time is an important factor. Optimum time of sowing for *Kharif* has been established and was reported by several workers (Shantha Veerbhadraiah *et al.*, 1986, AICRP on Soybean, 1992). However information on the productivity of soybean varieties in relation to seeding time during non-traditional *rabi*/summer season is limited, which prompted the present study.

MATERIALS AND METHODS

The experiment was carriedout on shallow red sandy loam soils during 1992-93 and on medium black clay loam during 1993-94. Six dates of sowing at fifteen days interval as main-plots with eight varieties as sub-plots (Table-1) were laidout in split-plot design with three replications. Irrigation was scheduled at weekly interval during 1992-93 and at twelve days interval during 1993-94. All the recommended package of practices were followed to raise a good crop. As the yield levels were very low during 1992-93 due to shallow depth and poor fertility status of the soil, the experiment was shifted to medium deep black soils during 1993-94. Yield per hectare was calculated based on net plot yield and other observations were recorded at harvest by selecting five plants randomly.

Received for publication July, 1995

RESULTS AND DISCUSSION

Effect of sowing time:

It was found that sowing during January first fortnight was optimum and has recorded significantly higher yield followed by January second fortnight and December Second fortnight during 1992-93. Sowing during *rabi*/summer with rise in temperature has favourable effect on growth and development of soybean. The better growth and development with January sowing was evidenced by significantly higher plant height (47.6 cm), number of branches per plant (2.53) and pods per plant (21.70). The increase in yield with January first fortnight sowing was 175, 133, 73 and 5 per cent as compared to November first fortnight, November second fortnight, December first fortnight and December second fortnight, respectively.

Sowing the crop during January Second fortnight offered significantly higher yield than the other dates of sowing during 1993-94. The yield increased substantially with delay in sowing from November to January at fortnight interval, barring December first fortnight. Early sowing in November drastically affected the seed yield. The increase in seed yield with January second fortnight sowing was 84 per cent as compared with sowing in November first fortnight. The plant height, and number of branches and pods per plant were significantly higher with January second fortnight sowing as compared with November and December sowings. Studies conducted at Pune have shown that December sowing was optimum for *rabi*/ summer Soybean (Halwanker, *et. al.,* 1989).

Varieties:

It was observed that, Soybean variety Pusa-40 performed well and recorded significantly higher yield (805 and 1688 kg/ha) than the rest of the varieties. (Table-1). This was followed by PK-472 during 1992-93 and MACS-124 during 1993-94, which were significantly superior to other varieties studied. The varieties recommended for *Kharif* viz KHSb-2, Monetta and JS-335 failed to perform well during rabi/summer. The increase in yield with Pusa-40 was 40 and 52 per cent over ruling *Kharif* season variety JS-335 during 1992-93 and 1993-94, respectively. The higher yield with Pusa-40 could be attributed to better plant height, higher number of branches and pods per plant recorded during both the years of study (Table-2).

Significant interaction between varieties and sowing date was observed. Variety Pusa-40 when sown in January second fortnight provided significantly higher yield (2254 kg/ha) than other varieties and date of sowing combinations during 1993-94. The study indicates that soybean can be grown during non conventional season with profitability comparable to traditional cultivation during *Kharif.* Besides this also helps in seed multiplication during summer and forms a source of good quality seeds for the ensuing *Kharif* season.

LITERATURE CITED

AICRP, 1992, Annual Progress Report, 1992-93, All India Co-ordinated Research Project on Soybean (ICAR), Indore, M.P.

Halawankar, G.B., Raut, V.M. and Patil, V.P. 1989. Effect of sowing dates on growth and yield of Soybean. *J. Maharashtra Agric.Univ. 14*(1): 120-121.

Shanthaveera Bhadraiah, S.M., Patil, M.P. and Rajappa, M.G. 1986. Influence of sowing dates and Plant population on Sovbean varieties. *Mysore J.Agric. Sci. 20*:19-22.

Table 1 : Yield (kg/ha) of soybean varieties in relation to sowing time during rabi/summer

	1992-93							1993-94							
Varieties	Nov I FN	Nov II FN	Dec I FN	Dec II FN	Jan I FN	Jan II FN	Mean	Nov I FN	Nov II FN	Dec I FN	Dec II FN	Jan I FN	Jan II FN	Mean	2 year Mean
KHsb-2	309	376	539	747	768	637	563	1018	1307	1295	1541	1783	1842	1464	1014
Monetta	387	402	468	890	935	802	639	695	860	908	1014	1086	1183	957	798
MACS-58	273	332	514	923	982	947	662	873	1044	1014	1246	1371	1485	1173	918
JS-335	326	399	517	668	778	918	601	775	987	947	1121	1338	1490	1110	856
MACS-124	372	416	626	1018	1023	1001	742	936	1168	1080	1373	1645	1779	1330	1036
PK-472	393	454	570	961	1057	1134	762	903	1096	1021	1390	1511	1751	1279	1021
NRC-2	263	287	412	767	721	680	521	-	-	-	-	-	-	-	-
PUSA-40	421	498	636	1081	1131	1066	805	1147	1488	1453	1787	2002	2254	1688	1247
MACS-57	-	-	-	-	-	-	-	880	1019	991	1331	1416	1541	1196	1196
Mean	336	396	535	882	925	885		904	1121	1088	1350	1519	1665		

	CD (0.05) 1992-93	CD (0.05) 1993-94
Sowing time (S)	33.33	34.5
Vatieties (V)	33.0	25.0
Between two 'S' levels at Same or different levels of 'V'	82.8	85.7

The F1 seeds obtained from crosses made during winter 1989-90 were used for advancing the generation in an off-season nursery (May to September, 1990) at Ranichauri, Hill campus of G.B. Pant University of Agriculture and Technology. F1 crosses were grown along with their parents in three replications. Each entry was sown in a single row of 3 m length and the spacing was 45 cm x 10 cm. At maturity seed from each F1 plant was harvested separately. For each cross there were about 90 plants over three replications.

Pollen sterility study

The flower buds collected from both field grown (off-season nursery) and pot grown plants were studied for pollen sterility/fertility using acetocarmine as stain under compound microscope. The number of fertile and sterile pollens were counted using five random microscopic fields.

The F2 generation of 12 crosses was raised on a plant to row basis at IARI (Indian Agricultural Research Institute)l New Delhi during winter, 1990-91. Parents were also grown alongside their F2. Apparently productive plants were selected and labelled at pod development stage. The F2 populations of inter-specific crosses were small consequently, the sample size was also small. While, the populations of intra-specific crosses were large enough to select adequately large number of plants. A stepwise multiple regression was employed following Draper and Smith (1966) to construct an index for ranking the F2 plants. Seed yield was used as the dependent variable and the rest as independent variables.

The expected value based on the regression equation was calculated for each F2 plant. The F2 plants were ranked in the ascending order based on those expected values. The distribution of F2 plants was divided into four equal portions and the frequency of F2 plants occurring in the top 25% (T1); 26 to 50% (T2); 51 to 75% (T3) and 76 to 100% (T4) were obtained in each set.

Productive recombinants were identified for seed yield and three other important traits namely, number of primary branches (PB), number of secondary branches (SB) and harvest index (HI). '*productive recombinants*' were defined as those *which showed positive deviation from the mean of* the F2 plants, taken as floor value. Productive segregants for one and more than one character were identified in each cross and in each stratum of ranked F2 distribution (RFD).

RESULTS AND DISCUSSION

F1 cross compatibility

Twelve intra-(*jn* x *jn*) and inter-specific (*jn* x *np*) crosses using *B. juncea* as female were made in this study. Number of pollinations made and number of pods set in each cross were noted (Table 1).

Table 1. Percentage success in hybridization (100x number of pods set/number of pollinations made)

Tester / Line (*jn*)	*jn* BD	*jn* JN	*jn* Mean	*np* BO	*np* BN	*np* Mean
YN	51.7	83.1	67.4	100	96.6	98.3
DR	91.0	77.4	84.2	93.4	86.2	89.8
PR	58.0	97.7	77.8	68.4	92.7	80.5
Mean	66.9	86.1		87.3	91.8	

jn = B juncea; np = B napus.

Success in making inter-specific crosses (*jn* x *np*) was as high as in intra-specific (*jn* x *jn*) crosses. Roy (1980b) observed 73% seed set in a *B. juncea* x *B.Napus* cross. He also noted that there was marked difference in percent seed set (5.1%) in the reciprocal cross. Wahiduzzaman (1987) also reported that *B. Juncea* x *B. napus* crosses gave good hybrid seed set. We obtained as high as 89.5% success by using *B. napus* parents as male. It was slightly higher than the percent success when *B.juncea* was used as male (*jn* x *jn*). This could be attributed to the low success of hybridization with BDSM 7 (BD) as male.

F1 sterility and F2 population size

It is apparent that (Table 2) the F2 population size in each of the *B.juncea* x *B. napus* inter-specific crosses was considerably small compared to intra-specific crosses (*jn* x *jn*). This was because the fertility in inter-specific cross F1's was very low. Roy (1980b) too observed low fertility (2 to 12 seeds per plant) in some *B. juncea* x *B. napus* crosses and moderate (20 to 30 seeds/plant) in some others. Consequently, the size of the F2 population of such crosses was proportionately small. Further, relatively high sterility did not affect F2 population size drastically. For example, the cross YNBN with 92% sterility has given 132 F2 plants which was slightly higher than (114 plants) PRBN with 69% sterility. Thus, it would seem possible to obtain reasonably large F2 populations even with relatively more sterile inter-specific crosses.

Table 2. F1 sterility and F2 population size in intra- and inter-specific crosses

Cross	PS	nF2	Cross*	nF2
YNBO	77.3	132	YNBD	1509
YNBN	91.8	132	YNJN	1840
DRBO	89.3	84	DRBD	1554
DRBN	78.0	135	DRJN	1246
PRBO	81.8	135	PRBD	1774
PRBN	68.8	114	PRJN	945

PS : Mean pollen sterility (%);
nF2 : F2 population size;
* : No pollen sterility

Roy (1980b) reported that in the F2 of a *B. juncea* x *B. napus* cross, plants with very high yield (41 to 58 g) were absent, but in the F3 there were 4% plants with very high yield. Similarly, there were 15% plants with high yield (8 to 40 g) in F2 and 64% in F3.

Taking the above results into proper perspective, it may not be an exaggeration to observe that so long as selecting a super productive recombinant in F2 is not the only goal, one can obtain adequate F2 plants in inter-specific crosses in general, for breeding for higher productivity.

Inter-specific hybridization

Intra-specific hybridization has been the essential pre-requisite and usually attempted by breeders to recombine desirable genes (attributes) from divergent parents of a species into a commercial variety.

Inter-specific hybridization on the other hand, is one of the most promising and at the same time frustrating tools available to the plant breeder (Stephens, 1961). Recombination in the progeny of inter-specific hybrids can generate staggering wealth of variability, but usually a majority of the segregants can be ill adapted and considerably inferior to the parental forms. These ill effects would be apparent whether they result from reshuffling of whole chromosomes or as a consequence of apparently normal crossing over. The advantage of increased crossing over may be more than off set by the disruption of genetic architecture of the species (Harland, 1936), where two differently organized complexes are reduced to random recombinations of their component parts.

Roy (1980b) observed that the F2 populations of inter-specific crosses were highly variable and gave transgressive segregation for fertility and plant type. In some crosses he recovered fertile or partially fertile F2 progeny. In one cross low fertility got improved by inter-crossing or by backcrossing to the compatible parent. In our studies we sought to inquire whether seed yield in inter-specific F2 is comparable to that in intra-specific F2 and whether such F2 could be used as the base material for selection for higher seed yield.

The mean F2 seed yield in the top two strata (T1 and T2) of inter-specific crosses (*jn* x *np*) was as high as that in intra-specific crosses (Table 3). In the other strata, the mean seed yield of inter-specific crosses was relatively low. Nevertheless, it was comparable with that of intra-specific crosses. Roy (1980b) reported that there were 0% plants in F2 with very high yield (41 to 58 g); 15% with high yield (8 to 40 g); 44% with moderate yield (2 to 7 g); 41% with low yield (0.1 to 1.0 g). In this classification, we found nearly 25% with very high yield (Top stratum, T1); 50% with high yield (T2 and T3) and 25% with moderate yield

Table 3. Mean seed yield (g) of intra- and inter-specific crosses in various strata of RFD

Strata	*jn* x *jn* (1)	*jn* x *np* (2)	se (1-2)
T 1	49.7 a	46.2 a	3.56
T 2	33.7 b	28.4 b	2.81
T 3	25.3	15.5	2.4
T 4	17.9	7.3	0.92
se (T 1- T 2)	0.87	4.44	
se (T 2-T3)	0.45	3.66	
se (T 3-T 4)	0.4	2.54	

Means with identical letters are not significant.

(T4). The results pointed to the possibility for initiating breeding programmes to improve yield using inter-specific F2 particularly of *B.juncea* x *B. napus*.

Roy (1984) selected partially fertile and intermediate plant types in F2 progenies from an inter-specific cross between *B.juncea* (black leg resistant) and *B. napus* (susceptible) grown in a disease nursery. In a preliminary yield trial conducted under normal disease situation, 96 single plant selections showed high yield potential at F7. Five selections gave 30-50% higher yield than a check. A number of selections were not only high yielding but also much earlier to mature compared to the check variety. In this context, it would be useful to examine whether response to selection for yield would be accompanied by a correlated response in traits like primary branches (PB), secondary branches (SB) and harvest index (HI) and whether selection responses from intra - and inter-specific crosses were comparable. Answers to these points were attempted by comparing the frequency of productive F2 segregants for seed yield (SY) and other traits.

In order to elicit meaningful information, the data on percentage productive recombinants were pooled over respective males of intra- and inter-specific crosses. It is apparent that (Table 4) the percentage productive recombinants was higher in intra-specific crosses particularly when four characters are considered together, while it was relatively high in inter-specific crosses when less number of characters were considered. However, the percentage productive recombinants in inter-specific crosses (*jn* x *np*) was in general, comparable to that in intra-specific crosses. Of the six inter-specific crosses (*jn* x *np*) only two (DRBN; PRBN) had productive recombinants for one and more than one character. While, the cross YNBO showed productive recombinants for two and more than two characters but not for one character.

Table 4. Percentage of productive recombinants (PR) in the F2 of intra- and inter-specific crosses

Female	Number of characters	*np*			*jn*		
(*jn*)		BO	BN	BO + BN	BD	JN	BD + JN
YN	4	16.7	0	16.7	9.2	15.3	24.5
	3	25.0	16.7	41.7	19.9	14.8	34.7
	2	41.7	50	91.7	20.7	25.7	46.4
	1	0	16.7	16.7	28.3	24.9	53.2
DR	4	0	16.7	16.7	15.7	17.2	32.9
	3	16.7	16.7	33.4	11.9	14.7	26.6
	2	50	16.7	66.7	20.9	25.1	46
	1	33.3	16.7	50	16.1	22.1	38.2
PR	4	0	7.7	7.7	15.2	15.1	30.3
	3	0	15.4	15.4	16.2	17.3	33.5
	2	25	7.7	32.7	30.5	26.6	57.1
	1	25	23.1	48.1	19	23	42

Suggestions

* Hybridization efforts should be intense to get adequate F1 seeds. Our studies do show that sterility is not a serious problem to tackle and that mere increase in the frequency of emasculation - pollination would overcome the limitations in seed set.

* Depending on the F1 heterogeneity (which inturn, is a function of parental heterozygosity), F2 should be obtained by *intermating*. Such a process will sustain usable genetic variability, produce desirable linkages and restore fertility.

* What is still more important is to continue to advance the material to F3 and further generations by mass intermating without conscious elimination of low genotypes (Dutta *et al*, 1986). In every generation, selection for desirable recombinants should be made particularly in the top stratum, where it has been shown that F3 families derived from F2 plants of T1 (top stratum) were found to provide higher frequency of selections for yield (Bandyopadhyay *et al*, 1985). Intermating has been advocated for promoting recombination with favourable potential physiological complementation (Wallace *et al*, 1972).

LITERATURE CITED

Bajaj, Y.P.S. Mahajan, S.K. and Labana, K.S. 1986. Inter-specific hybridization of *Brassica napus* and *Brassica juncea* through ovary, ovule and embryo culture. Euphytica, 35: 103-109.

Bandyopadhyay, A. Arunachalam, V. and Venkaiah, K. 1985. Efficient selection intensity in early generation index selection in groundnut (*Arachis hypogaea* L.). Theoretical and Applied Genetics, 71:300-304.

Draper, N.R. and Smith, H. 1966. Selecting the best regression equation. In: Applied regression analysis. John Wiley and Sons, Inc., New York, 163-195.

Dutta, M. Arunachalam, V., Bandyopadhyay, A and Vinod Prabhu, K. 1986. Early generation intermating for yield improvement in groundnut (Arachis hypogaea L.) Theoretical and Applied Genet., 71: 662-666.

Harland, S.C. 1936. The genetical conception of the species. Cambridge Biological Review, 2: 83-112.

Namai, H, Sarashima, M. and Hosoda, T. 1980. Inter-specific and intergeneric hybridization breeding in Japan. pp. 191-203. In: Brassica crops and wild allies. Eds. S. Tsunoda, K. Hinata and C. Gomez-campo.

Rai, B. 1989. Brassicas. pp. 159-170. In: Plant Breeding Ed. V.L. Chopra. Oxford-IBH. Publications, New Delhi.

Roy, N.N. 1977. Inter-specific cross compatibility and F1 sterility in Oilseed Brassica. In: Proc. 3rd Int. SABRAO Congress, Canberra, 2: 31-33.

Roy, N.N. 1980a. A study of inter-specific crosses for the improvement of Oilseed rape and mustard. The Journal *of the Australian Institute of Agricultural Science, 66-*67.

Roy, N.N. 1980b. Species crossability and early generation plant fertility in inter-specific crosses of Brassica. SABRAO Journal, 12: 43-54.

Roy, N.N. 1984. Inter-specific transfer of Brassica juncea type black leg resistance to Brassica napus. Euphytica, 33: 295-303.

Stephens, S.G. 1961. Species differentiation in relation to crop improvement. Crop Sci., 1(1): 1-4.

Wahiduzzaman, M.D. 1987. Potentials for species introgression in Brassica napus with special reference to earliness and seed colour. Thesis. Sveriges Lantbruksuniversitet, Uppsala, Sweden, Wallace, D.H., Ozbun, J.L. and Munger, H.M. 1972. Physiological genetics of crop yield. Advances in Agronomy, 24: 97-146.

J. Oilseeds Res. 13 (1) 1996: 80-83
ISSN 0970-2776

GENETIC POTENTIAL OF ARTIFICIALLY SYNTHESIZED *BRASSICA JUNCEA* FOR YIELD IMPROVEMENT

C.H.M. VIJAYA KUMAR, V. ARUNACHALAM,
S.K. CHAKRABARTY and P.S. KESAVA RAO
Genetics Division, Indian Agricultural Research Institute (IARI), New Delhi - **110 012.**

ABSTRACT

A study was made to compare the potential of artificially synthesized *Brassica juncea* strains in inter-varietal crosses for basal branching characters and seed yield. Sixty four F3 families of synthetic x synthetic, synthetic x cultivar, and cultivar x cultivar crosses were studied and from among them thirty two superior F3 families were selected and advanced to F4 generation. Artificially synthesized materials generate more useful variability than those by usual inter-varietal crosses.

Keywords: Artificial *Brassica juncea*, **basal branching, inter-varietal crosses, variability.**

INTRODUCTION

Breeding for basal branching, non-lodging, compact plant type with high yield potential for improved agronomic situations has been suggested by several workers (Jain, 1984; Labana, 1984). However, in Indian Mustard, *Brassica juncea*, the genetic variability is limited for several characters (Rai, 1989), and particularly for seed yield (Uddin *et al*, 1983). Lack of physiologically efficient plant type in mustard has been one of the limiting factors in the productivity advance (Singh and Chauhan, 1984). Nevertheless, both the diploid parents of this amphlidiploid species exhibit enormous variability in morphology and physiology. A major advance was made by Prakash (1973a) when a large number of amphidiploids were synthesized for their practical utilization in the improvement of this crop.

Preliminary studies with resynthesized *B.juncea* (Olsson, 1960a; Frandson, 1943) showed that the direct products of such interspecific hybrids represented no improvement. However, the lodging resistance was better and there was greater variation for seed size and the seeds of artificial *B.juncea* were larger than those of natural species. The report of the Prakash (1973b) in *B.juncea* and the release of cultivar 'Norde' in *B.napus* (Olsson and Ellerstrom, 1980) demonstrated how successful was an appropriate introduction of resynthesized material.

Our investigations were designed to study the variability for basal branching and yield in F3 and F4 generations of three types of crosses; cultivar x cultivar, cultivar x synthetic and synthetic x synthetic.

MATERIALS AND METHODS

In the F2 of nine crosses listed below, 64 individual plants were selected on the visual basis for basal branching and other yield components.

Received for publication September, 1995.

List of crosses and their pedigree

Cross	No.of Plants	Expanded pedigree
PBRN	10	PB = Pusa Bold
PBNN	6	RN = Synthetic *B. juncea*
PBYS	7	(*B. Campestris* ssp. *rapifera*
JNRN	6	x *B. nigra*)
JNNN	4	NN = Synthetic *B. juncea*
RNJN	8	(*B. campestris* ssp. narinossa
RNYS	8	x *B. nigra*)
NNRN	8	YS = Yellow seed *B. juncea* An accession from Poland
RNNN	6	JN = Synthetic *B. juncea* (*B. campestris* ssp. *japonica* x *B. nigra*)

The F3 of those selected individuals was raised during rabi 1989-90 on plant to progeny basis. Each F3 family was sown in four rows of 3m length with a row to row spacing of 75 cm and 10 cm between plants. Data were collected on seven traits. The traits defining basal branching were number of primary (PBI) and secondary branches (SBI) attributable to 30 cm height of plant from the ground level. Other traits measured were plant height (HT), seed yield (SY) and harvest index (HI) on per plant basis. Any entry with two third of the selected plants possessing basal branching within 30 cm from the ground were termed as basal branching entries, while others non-basal branching.

Data collected on five randomly selected plants was analysed using CRD on individual plant basis. Using the method suggested by Arunachalam and Bandyopadhyay (1984), the relative order of importance of 64 F3 families was obtained using all the seven traits. Based on the mean and standard deviation of the final scores 32 families were selected. The F4 progeny of the selects was raised during rabi 1990-91 in a RBD, where each family was sown in a single row of 5m length in two replications with a row to row spacing of 75 cm and 10 cm between plants. The seed yield (grammes) per plot of each family was noted.

RESULTS AND DISCUSSION

The ANOVA for seven traits studied is presented in Table 1. The differences between families were significant for all the traits. The variability for seven traits in the F3 of three types of crosses is presented in Table 2. It is seen from the table that the range of variability increases when cultivar is replaced by synthetic. For instance, the range and mean of synthetic x synthetic crosses was most desirable for almost all traits including seed yield. It was followed by cultivar x synthetic and cultivar x cultivar crosses in that order.

Table 1. Percentage success in hybridization (100 x number of pods set/number of pollinations made)

Tester Line (*jn*)	*jn*			*np*		
	BD	JN	MEAN	BO	BN	MEAN
YN	51.7	83.1	67.4	100	96.6	98.3
DR	91.0	77.4	84.2	93.4	86.2	89.8
PR	58.0	97.7	77.8	68.4	92.7	80.5
MEAN	66.9	86.1		87.3	91.8	

Jn = *B juncea*; *np* = *B napus*.

Table 2. Mean (M) and range (R) of seven traits in 64 F3 families of three crosses

Cross	Mean Range	Plant height (cm)	No. of primary branches	No. of secondary branches	Seed yield seed yield (g/plant)	Seed yield (g/plot)	Harvest Index (per plant basis)	Harvest index (per plant basis)
CC	M	210	0.8	2.3	1.1	17.1	0.8	14.8
	R	188-229	0-2.4	0-6.8	0-4.5	10-23	0-3.7	9-19.5
	Sd	14.1	1.9	2.5	1.5	4.8	1.2	3.6
CS	M	224	0.7	2.2	1.1	18.1	0.7	13.7
	R	190-264	0-2.6	0-8.8	0-5.5	11-27	0-2.4	8.8-19
	Sd	17.9	0.7	2.6	1.6	4.9	0.9	2.7
SS	M	217	0.8	2.4	1.3	16.6	0.8	13.8
	R	172-247	0-3	0-10.4	0-7.3	6.2-34	0-3.7	7.5-24.1
	Sd	18.0	1.0	3.1	1.7	6.7	1.1	3.8

Sd : Standard deviation

The variability for seed yield in the F3 and F4 of 32 selected families of three types of crosses is presented in Table 3. In the F3, the mean seed yield was similar in all crosses, however the variability in synthetic x synthetic crosses was most desirable followed by cultivar x synthetic and cultivar x cultivar. While, in the F4, the range of variation was low in cultivar x cultivar crosses and it increases when cultivar is replaced by synthetic strain. Interestingly, the mean seed yield of those families increased from 277g in cultivar x cultivar crosses to 364g in synthetic x synthetic crosses.

The potential of artificially synthesized material *has been noted by many Brassica workers*. Robbelen (1979) for example, observed that heterosis in synthetic x cultivar combinations was far higher than in cultivar x cultivar crosses. It is a general openion among the *Brassica* breeders dealing with inter-specific crosses at manogenomic level that synthetic populations provide good genetic stocks to breed better cultivars.

Our studies with F3 and F4 generations of three types of crosses clearly showed that intervarietal crosses made using artificially synthesized material generate useful variability for various traits including those of plant type and seed yield.

LITERATURE CITED

Arunachalam, V. and Bandyopadhyay, A. 1984. A method to make decisions jointly on a number of dependent characters. The Indian Journal of Genetics and Plant Breeding. 44(3): 419-424.

Frandson, K.J. 1943. The experimental formation of Brassica juncea Czern and coss. Dansk. Bot. Arkiv. 11:1-17.

Jain, H.K. 1984. Improvement of oilseed crops: Objectives, concepts and methods. pp 3-8. In: Research and

Table 3. Variability for seed yield (g) in F3 and F4 of 32 families of three crosses

Cross	Mean per plant (F3)			Mean per plot (F4)		
	Mean	Range	Standard error	Mean	Range	Standard error
Cultivar x Cultivar	20.4	16.5-23.0	1.45	277.4	191.1-399	44.25
Cultivar x Synthetic	21.2	14.9-27.5	1.39	313.5	183.6-441	27.53
Synthetic x Synthetic	20.2	10.3-34.0	1.67	363.7	196.1-739	37.86

development strategies for oilseed production in India. Eds. P.L. Jaiswal and R.S. Gupta, I.C.A.R., New Delhi.

Labana, K.S. 1984. Breeding strategy for developing high yielding varieties of Indian mustard pp: 118-122. *In: Research* and development strategies for oilseed production in India. Eds. P.L. Jaiswal and R.S. Gupta, I.C.A.R., New Delhi.

Olsson, G. 1960. Species crosses within the genus *Brassica* I. Artificial *B.juncea* coss. Hereditas. 46:171-223.

Olsson, G and Ellerstrom, J. 1980. Polyploidy breeding in Europe. pp 167-190. In: *Brassica* crops and wild allies. Eds. S. Tsunoda, K. Hinata and C. Gomez-campo. Japan Scientific Societies Press, Tokyo.

Prakash, S. 1973a. Artificial synthesis of *Brassica juncea*. coss. Genetica 44: 249-263.

Prakash, S. 1973b. Non-homologous meiotic pairing in the A and B genomes of *Brassica*: its breeding significance in the production of variable amphidiploids. Genet. Res. Camb. 21: 133-137.

Rai, B. 1989. *Brassicas*. pp. 159-170. In: Plant Breeding. Eds. V.L. Chopra, Oxford - IBH, New Delhi.

Robbelen, G. 1979. Transfer of quantitative characters from wild and primitive forms. pp: 249-255. In: Proc. Conf. Broadening Genetic Base Crops. Pudoc, Wegeningen, 1978.

Singh, H.G. and Chauhan, Y.S. 1984. Factors limiting rapeseed mustard production in north eastern part of India. pp: 17-84. In: Research and development strategies for oilseed production in India. Eds. P.L. Jaiswal and R.S. Gupta, I.C.A.R., New Delhi.

Uddin, M.M., Samad, A., Khan, M.R., and Salam, M.A. 1983. Estimates of genetic parameters, correlations and path coefficients of some quantitative characters in mustard (*Brassica juncea* L.) and rapeseed (*B.campestris* L.). Bangladesh Journal of Botany 12:132-138.

J. Oilseeds Res. 13 (1) 1996: 84-87
ISSN 0970-2776

GENETIC ANALYSIS AND COMBINING ABILITY FOR SEED YIELD AND YIELD COMPONENTS IN TORIA (*BRASSICA CAMPESTRIS* L. VAR. *TORIA*)

I.S. YADAV* and T.P. YADAVA
Department of Plant Breeding, CCS Haryana Agricultural University, Hisar - 125 004.

ABSTRACT

In a study of 8 x 8 diallel analysis (excluding reciprocals), it was found that both additive and dominance genetic components were important for seed yield and yield components in toria (*Brassica campestris* L. var. *toria*). But the magnitude of dominance component was larger than the additive component for all the traits. Heritability estimates were higher for days to maturity and 1000-seed weight. Parent 'Sangam' was the best general combiner for seed yield, primary branches, secondary branches, siliquae per plant and seeds per siliqua. Another parent 'T-9' was also a good combiner for seed yield, earliness, 1000-seed weight and seeds per siliqua.

Key words: Combining ability; Toria; Yield

INTRODUCTION

Toria is an important oilseed crop taken as a catch crop in between *Kharif* and *Rabi* seasons in northern and eastern parts of the country. The knowledge of gene effects and type of genetic variance present in the population play an important role in devising suitable breeding approaches in the crop improvement programme. The analysis of combining ability is used to assess the nicking ability of genotypes and thus, helps in identifying parents which are likely to be useful to get desirable segregants in a hybridization programme. Very little work has however, been done to understand the nature of gene effects and the inheritance of yield and yield components in toria. The present study was therefore, undertaken to understand the inheritance of yield and yield components in toria (*Brassica campestris* L. var. *toria*).

MATERIALS AND METHODS

Eight inbreds maintained by 3 subsequent selfing (bud pollination) namely, Sangam, ITSA, TH-68, T-9, TH-78, TH-86, PT-303 and TL-15 were crossed in all possible combinations, excluding reciprocals. The 28 F1 crosses alongwith their 8 parents were grown in a randomized block design with 3 replications at Haryana Agricultural University, Hisar. Each genotype was represented by a single row of 5m. length sown 30 cm apart with a plant to plant distance of 10 cm. The data were recorded on 10 competitive plants selected at random for days to maturity, plant height (cm), number of primary branches per plant, number of secondary branches per plant, number of siliqua per plant, number of seeds per siliqua, 1000-seed weight (g) and seed yield per plant (g). The analysis of combining ability was carried out by Griffing (1956) method 2 model 1, and genetic components of variance were calculated according to Hayman (1954).

RESULTS AND DISCUSSION

The analysis of variance indicated that the inbreds studied were significantly different from each other with respect to all the traits under study. The mean sum of squares due to both general and specific combining ability (Table 1) were

* Present Address: Scientist (Plant Breeding), Cotton Research Station, Sirsa.

Received for publication December, 1995

significant for all the traits. It indicated that both additive and dominance genetic variances were important for all the traits. The results agree with Yadava (1977) in *toria*; Yadav and Yadava (1987) in *taramira*. While Singh and Yadav (1980), Rishi Pal and Singh (1980), Rishipal *et al* (1981) reported the importance of non-additive type of gene effect in *toria*.

The components of variation alongwith the derived genetic ratios for different traits (Table 2) showed that the D and H component which measures additive and dominance variation, respectively were significant for all the traits. This indicated the importance of both additive and dominance components for the inheritance of all the traits in *toria*. However, the magnitude of dominance was larger than the additive component for all the traits which indicated that dominance component had a predominant role in the inheritance of these traits. The positive and negative estimates of h^2 indicated mean direction of dominance and respective genes towards positive and negative sides, respectively. The results showed that six characters viz., days to maturity, plant height, primary branches, seeds/siliqua, 1000-seed weight and seed yield possessed positive effects, indicating the mean direction of dominance as well as importance of excess of dominant genes in the expression of these traits. On the other hand, secondary branches and siliquae/plant exhibited the values in negative direction, showing the excess of recessive genes for these traits.

The estimates of mean degree of dominance, $(H_1/D)^{1/2}$ indicated that all the traits possessed the value of mean degree of dominance greater than one, suggesting the presence of over dominance. The deviation of $H_2/4H_1$ from the theoretical value (0.25) manifested unequal distribution of genes showing positive and negative effects. The estimates of the quantitative proportion of dominant and recessive genes among the parents measured by $(4DH_1)^{1/2} + F/(4DH_1)^{1/2} - F$ showed that for every one recessive gene there were 2 to 3 dominant genes. Heritability in narrow sense was higher for days to maturity and 1000-seed weight. For the remaining traits it ranged low to moderate and very low for seed yield.

The estimates of gca effects revealed that the parent 'Sangam' was the best general combiner for seed yield, siliqua/plant and primary and secondary branches/plant. Another parent T9 was also a good combiner for seed yield, earliness, 1000-seed weight and seeds/siliquae. 'ITSA' showed desirable gca effects for seed yield, primary branches and secondary branches, whereas 'TH-68' exhibited the desirable gca effects for seed yield, earliness, primary and secondary branches. 'TH-68' was good general combiner for seed yield, 1000-seed weight and seeds/ siliquae. The parent 'TH-15' was good combiner for earliness, primary branches and siliqua/plant. The good general combiners could effectively be used in future hybridization programme for developing high yielding varieties (Table 3).

The results obtained from both Griffing and Hayman's analysis indicated the importance of both additive and dominance genetic variances, the latter being more important. To utilize simultaneously both additive and dominance genetic variances, the reciprocal recurrent selection appears to be the best available method to meet the requirement, provided means for natural easy cross pollination and recombinations are available. The early generation intermating, besides accumulating the favourable genes and maintaining the heterozygosity in the population is likely to throw out desirable recombinants.

Table 1 : **Analysis of variance for general and specific combining ability for yield and yield components in Toria.**

Source	d.f.	Days to maturity	Plant height	Primary branches	Secondary branches	Siliquae per plant	Seeds per siliqua	1000-seed weight	Seed yield per plant
gca	7	35.42*	110.85*	7.32*	57.43*	112.54*	2.13*	0.82*	73.34*
sca	28	5.16*	59.47*	3.91*	29.86*	97.13*	1.44*	0.57*	96.92*
Error	70	1.05	32.42	0.95	1.79	5.14	0.34	0.26	3.15

* Significant at 0.05

Table 2 : **Estimates of genetic components of variance for seed yield and yield components in toria.**

Source	Days to maturity	Plant height	Primary branches	Secondary branches	Siliquae per plant	Seeds per siliqua	1000-seed weight	Seed yield per plant
D	11.91*	172.30*	0.48*	1.49*	387.30*	7.56*	7.49*	62.15*
H_1	40.83	288.60*	2.70*	5.58*	1979.00*	20.01*	92.59*	774.60*
H_2	29.27*	235.70*	2.35*	3.30*	1623.0*	13.48*	72.51	667.20*
h_2	2.99	1.88	0.03	-0.55	-41.13	7.45	7.45	11.07
F	21.19	158.40	0.61	1.46	366.70	11.21	20.60	100.00
E	0.72	122.60	0.29	1.26	83.18	0.05	0.12	9.39
$(H_1/D)^{1/2}$	1.85	1.32	2.37	1.94	2.26	1.62	3.51	3.07
$H_2/4H_1$	0.18	0.20	0.22	0.17	0.20	0.41	0.19	0.21
$\frac{(4DH_1)^{1/2} + F}{(4DH_1)^{1/2} - F}$	2.85	2.07	1.73	1.68	1.53	2.67	2.28	1.50
Heritability	56.74	29.18	18.24	10.82	18.70	14.26	60.40	6.91

* Significant at 0.05

Table 3 : Estimates of general combining ability effects for seed yield and yield components in toria

Strain	Days to maturity	Plant height	Primary branches	Secondary branches	Siliquae per plant	Seeds per siliqua	1000-seed weight	Seed yield per plant
Sangam	0.92*	2.43	0.97	2.05*	2.24*	0.02	-0.06*	4.23*
I T SA	2.36*	4.39	0.81*	3.21*	-2.01*	0.008	-0.04*	0.94*
TH - 68	-0.31*	4.17	0.39*	2.47*	1.02	0.45*	0.06*	2.16*
T - 9	-0.42*	-1.01	-0.42*	-0.82*	0.18	0.31*	0.03*	1.44*
TH - 78	1.43*	1.19	0.14	0.09	0.88	0.63*	0.04*	3.47*
TH - 86	-0.42*	-0.18	-0.06	0.86*	0.93*	0.06	0.005	-0.34
TL - 15	-2.17*	-3.67	0.34*	-0.86*	1.84*	-0.05	-0.01*	-0.12
PT - 303	-0.93*	-1.12	0.13	0.07	0.97	0.03	0.07*	-1.16*
SE (gi)	0.05	3.97	0.09	0.11	0.64	0.04	0.01	0.23

LITERATURE CITED

Griffing, B. 1956. Concept of general and specific combining ability in relation to diallel crossing system. Aust. J. Biol. Sci. 9(2): 463-493.

Hayman, B.I. 1954. The theory and analysis of diallel crosses. Genetics, Princeton. 39:789-809.

Rishipal and Singh, H. 1980. Combining ability in rapeseed. Indian J.agric. Sci. 50:-9-13.

Rishipal, Singh, H and Jatasara, D.S. 1981. Genetics of yield and yield components in Indian rapeseed. Indian J.agric. Sci. 51:550-553.

Singh, H. and Yadav, C.K. 1980. Gene action and combining ability for seed yield, flowering and maturity in rapeseed. Indian J.agric. Sci. 50(9): 655-658.

Yadav, I.S. and Yadava, T.P. 1987. Identification of parents for hybridization thorough combining ability analysis in taramira under rainfed conditions. J. Oilseeds Res. 4(1): 82-88.

Yadava T.P. 1977. Genetics of yield and its components in toria. (*Brassica campestris* L. var. toria). HAU, J. Res. 7: 12-16.

J. Oilseeds Res. 13 (1) 1996: 88-92
ISSN 0970-2776

COMBINING ABILITY AND HETEROSIS IN SESAME

A.K. MISHRA and L.N. YADAV
Zonal Agricultural Research Station, (MP), Tikamgarh-472 001

ABSTRACT

The elucidate the extent ofheterosis, nature of gene action and the better general and specific combiners for different traits, a line x tester analysis in sesame with five female and three male parents was employed. Standard heterosis was observed in both the directions for all characters. The crosses TC-289 x Phule-1 and JT-7 x TC-25 showed significant positive heterosis/heterobeltiosis and Standard heterosis for number of capsules/plant, number of seeds/capsule and seed yield/plant. Non additive type gene action played the major role in determining all the characters except test weight. Additive type gene action played the major role for test weight. The combinations TC-289xPhule-1 and JT-7 x TC - 25 were found the best on the basis of sca effect, heterosis and per se performance.

Key Words: Line x tester; Heterobeltiosis; Sesame.

INTRODUCTION

Sesame (*Sesamum indicum* L.) is one of the important oilseed crops grown in the country, since ancient times (watt, 1983). Combining ability studies reveal the nature of gene action and lead to identification of parents with high general combining ability effects and the cross combinations with high specific combining ability effects. This in turn helps in choosing the parents to be included in a hybridization programme. Thus, for effective exploitation of seed yield, some genetic analysis is required. The present study reports the results of Line (5) x tester (3) analysis in sesame.

MATERIALS AND METHODS

Three testers namely, TC-25, Phule-1 and TNAU-10 were crossed with five lines viz., JT-7, N-32, HT-1, TC-289 and Punjab-1 to produce 15 F1 crosses. These 15 F1's alongwith the parents were grown in a randomized block design with three replications at zonal Agricultural Research station, Tikamgarh during kharif 1989. The data recorded for days to maturity, number of capsules/plant, number of seeds/capsule, 1000 seed weight and seed yield/plant from five randomly selected plants in each replication were analysed according to method of Kempthrone (1957).

RESULTS AND DISCUSSION

The analysis of variance indicated that lines, testers and their interactions were significant for all the characters studied. Dominance component of variance was higher for days to maturity, number of capsules/plant, number of seeds/capsule and seed yield/plant. It is suggestive of the fact that there are tremendous possibilities of exploitation of hybrid vigour in sesame. Similar results of non-additive gene for above traits were reported by Goyal and Kumar (1988), Yadav and Mishra (1991) and Mishra *et al.* (1994). For 1000 seed weight the estimates of *gca* was higher than *sca* indicating the predominance of additive gene action for the trait. Chandraprakash (1987), Mishra *et al.* (1994) and Mishra (1994) also reported additive gene action for this trait.

Received for publication December, 1995

Estimation of *gca* effects for the parents showed that HT-1 among lines and Phule-1among testers were found to be good general combiners for most of the yield components and seed yield (Table 1). These parents may be utilised in breeding programmes designed to raise yield levels in sesame. On the basis of specific combining ability effects, the best specific combinations were TC-289 x Phules-1 followed by JT-7 x TC - 25 which recorded significant positive *sca* effects for seed yield and its related characters.

The data on heterosis, heterobeltiosis and standard heterosis (over best local variety phule-1) are presented in Table-2. As can be seen a number of hybrids expressed heterosis for seed yield and its components. The cross combinations HT-1 x TNAU-10, TC - 289 x Phule-1, JT-7 x TC-25 and Punjab 1 x Phide-1 x TNAU-10, Punjab - 1 x TC - 25 Punjab 1 and TC - 289 x TC - 25 gave highest negative values. Significant positive and negative heterosis has already been reported by Dixit (1978), Yadav and Mishra (1991) and Mishra *et al.* (1994). For maturity the cross combination TC-289 x TC - 25, TC - 289 x phule-1 showed considerably high standard heterosis (HT-1 x Phule-1 and JT-7 x Phule-1 exhibited maximum negative heterobeltiosis and standard heterosis indicating the possibility of obtaining early maturing combination as compared to the parent and standard check. Significant negative heterosis for maturity has already been reported by Shrivastava and Singh (1968), Yadav and Mishra (1992) and Mishra *et al.* (1994).

For number of capsules/plant the various cross combinations showed significant positive and negative standard heterosis, the combinations TC -289 x Phule-1, JT-7 x TC - 25, Punjab-1 x TC - 25, HT-1 x TNAU-10, Punjab-1 x Phule-1 and N-32 x TNAU-10 gave maximum positive value, while HT-1 x Phule, JT-7 x Phule-1 and TC - 289 x TNAU-10 gave negative values of higher magnitude. Similar results have been reported by Yermonas and Kotecha (1978) and Mishra *et al.* (1994).

For number of seeds/capsule significant standard heterosis was observed in both positive and negative directions, the combinations giving highest positive standard heterosis were TC-289 x Phule-1 JT-7 x Phule-1 Punjab-1 x Phule-1 and TC 289 x TNAU-10 and those giving negative were JT-7 x TNAU-10 and N-32 x TN AU-10. Significant positive heterobeltiosis in some combinations has been reported by Delgado (1972) and Mishra *et al* (1994). The cross combinations HT-1 x TC-25, JT-7 x TNAU-10 and Punjab-1 x TNAU-10 exhibited maximum positive heterosis, whereas TC-289 x TC-25 and JT-7x Phule-1 showed maximum negative heterosis for 1000 seed weight. Significant positive heterosis in some combinations has been reported by Mishra and Yadav (1994) and Mishra (1994). The cross combination TC-289 x Phule-1 followed by JT-7 x TC-25 showed significant positive heterosis for number of capsules/plant, seeds/capsule, seed yield/plant, and negative for maturity. It is important to note that the better performing crosses usually included good and poor general combiners. Crosses of good x good or poor x poor combiners were poor in performance with respect to heterosis and sca effects.

Based on the present findings it is inferred that the crosses TC-289 x Phule-1 and JT-7 x TC-25 showed highest significant and positive heterosis for different characters. The combination TC-289 x Phule-1 followed by JT-7 x TC-25 was found to be the best on the basis of sca effect, heterosis and per se performance.

Table 1. Estimation of gca and sca effects and their variances for different characters in sesame.

Crosses	Days to maturity	No. of capsules/ plant	No. of seeds/ capsule	1000 seed weight	Seed yield/ plant
Lines					
JT - 7 -1.07**	-12.05**	-0.89	0.211**	-0.49**	
N-32 2.93**	4.65**	-5.30**	0.211**	0.01	
HT-1 -5.85**	-5.65**	-3.67**	0.355**	0.58**	
TC-289-1.96**	-12.09**	7.00**	-0.800**	-0.92**	
Punjab-1	5.93**	5.69**	2.85**	0.022	0.85**
S.E. (gca)	0.262	1.724	0.716	0.0649	0.105
S.E. (gi-gj)	0.371	2.438	1.012	0.091	0.149
Testers					
TC-25 -4.98**	-0.78	-3.35**	-0.175**	0.11	
Phule-1-2.85**	3.02**	4.01**	0.197**	0.19*	
TNAU-10	7.82**	-0.25	-0.65	0.077	0.28**
S.E. (gca)	0.903	1.33	0.550	0.050	0.82
S.E. (gi-gj)	0.287	1.888	0.784	0.071	0.116
Crosses					
JT-7xTC-25	2.87**	31.45**	1.35	-0.287**	4.86**
JT-7xPhule-1	-5.59**	-20.35**	4.69**	-0.258**	-2.47**
JT-7xTNAU-10	3.31**	-11.08**	-6.04**	0.501**	-2.38**
N-32xTC-25	1.54**	-0.88	3.63**	0.03	-0.19
N-32xPhule-1	-0.04	-18.35**	-4.02**	0.50**	-1.58**
N-32xTNAU-10	-1.92**	19.25**	0.400	-0.47**	1.75**
HT-1xTC-25	1.98**	-18.54**	6.33**	0.538	-2.58**
HT-1xPhule-1	-1.81**	-28.01**	-0.09	-0.36**	-3.84**
HT-1xTNAU-10	-0.14	46.59**	-6.36**	-0.14	3.51**
TC-289xTC-25	-4.90**	-28.77**	-10.00**	-0.13	-2.59**
TC-289xPhule-1	-2.30**	47.09**	-6.82**	0.52**	4.48**
TC-289xTNAU-10	2.63**	-18.30**	4.79	-0.35**	-2.22**
Punjab-1xTC-25	-1.46**	16.78**	1.45	-0.06	0.25
Punjab-1xPhule-1	4.74**	19.64**	0.256*	-0.36**	3.42**
Punjab-1xTNAU-10	-3.26**	-36.41**	1.18	0.45**	-3.68**
S.E. (sca)	0.454	2.986	1.240	0.112	0.183
S.E. (Sij-ski)	0.643	4.223	1.753	0.159	0.259
6^2 gca	4.68**	1.08**	1.121**	0.256**	0.509**
6^2 sca	16.29**	80.34**	34.940**	0.031	7.160**
6^2 A	9.38	2.17	2.240	0.512	1.018
6^2 D	16.29	80.63	34.94	0.031	7.160

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

Table 2 : **Heterosis, Heterbeltiosis and standard heterosis in sesame**

Crosses	Days to maturity			No. of capsules/plant			No. of seeds/capsule			1000 seed weight			Seed yield/plant		
	Hetero-sis	Hetero-beltiosis	Standa-red he-terosis	Hetero-sis	Hetero-beltiosis	Standa-red he-terosis	Hetero-sis	Hetero-beltiosis	Standa-red Heterosis	Hetero-sis	Hetero-beltiosis	Standa-red Heterosis	Hetero-sis	Hetero beltiosis	Standa red he-terosis
Jt-7x TC-25	0.52	4.90	-0.38*	88.58**	73.92**	39.80**	-1.87**	-4.16	15.88**	-3.03	-3.47**	-9.2*	143.24**	107.01**	31.75**
JT-7xPhule-1	-15.06**	-17.33**	-7.86**	-24.19**	-28.56**	-19.02**	-11.73**	-11.13**	-34.38**	-22.39**	-3.03**	-3.65**	-4.30	-16.20**	-50.00**
JT-7xTNAU-10	3.93**	-0.33	14.75**	-16.30**	-25.60**	-39.61**	-0.38	-10.76**	-11.90**	8.28**	3.63**	24.91**	-12.00**	-23.81**	-54.27**
N-32xTC-25	-0.75	-10.91**	2.76**	45.97**	26.33	-7.84	-4.69**	-6.73**	2.30	-14.28	-6.11	-18.08**	30.20**	26.54**	-19.48**
N-32xPhule-1	-8.32**	-9.89**	3.94**	2.21	1.06	-26.28**	-6.36**	7.16**	11.81**	12.31*	2.62	5.80	9.00*	9.18	-34.23**
N-32xTNAU-10	-1.18*	-1.36	13.78**	51.14**	43.47**	16.47**	1.81	-8.52**	10.17**	15.62**	-8.29**	13.65**	63.00**	63.22**	-2.02
HT-1xTC-25	1.71*	1.28	-7.08**	-20.02**	-38.36**	-40.78**	16.72**	3.87	18.91**	25.49**	7.39**	51.19**	13.00**	-19.78**	-41.10**
HT-1xPhulle-1	-10.10**	-18.37**	-9.04**	-40.05**	-47.75**	-49.81**	16.63**	2.61	2.84	0.28	-2.69**	19.45**	-29.00**	-36.50**	-53.37**
HT-1TNAU-10	2.48**	-8.21**	-5.51**	53.98**	42.05**	36.47**	10.61**	7.11**	2.80	-19.66**	-2.63	-1.02	153.30**	115.18**	37.99**
TC-289xTC-25	-2.98**	-3.40**	-10.63**	-32.89**	-38.80**	-6.04	-18.62	-4.36	-6.10	-13.21**	-12.54**	-17.06**	-27.11**	-27.62**	-53.37**
TC-289xPhule-1	-1.54*	-9.89**	-8.40**	92.51**	83.53**	50.97**	21.73**	16.94**	38.46**	23.18**	-5.61**	-16.04**	99.09**	91.78**	33.53**
TC-289xTNAU-10	9.30**	-13.36**	13.39**	-27.16**	-35.27**	-47.45**	46.49**	37.63**	20.27**	18.05**	-17.58**	-16.04**	31.15**	-33.56**	-57.20**
Punjab-1xTC-25	7.19**	2.76**	2.76**	79.55**	37.64**	37.64**	9.24**	1.99	17.60**	15.87**	-1.99**	-17.06	-33.47**	-5.06**	-45.60**
Punjab-1xPhule-1	6.52**	1.06	12.60**	67.04**	42.35**	32.35**	21.96**	13.00**	23.18**	24.91**	-6.40**	24.91**	64.73**	31.53**	31.53**
Punjab-1xTNAU-10	7.50**	0.68	15.75**	16.45**	-24.31**	-24.37	29.37**	26.77**	26.77**	34.86**	0.32*	13.93**	-42.25**	-53.82**	-53.82**

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

LITERATURE CITED

Chandraprakash, J. 1987. Gene action and combining ability for oil content, yield and yield components in sesamum (Sesamum indicum L.) Mysore J. Agric. Sci. 21(1): 91.

Delgado, M. 1972. Yield components of sesame (Sesamum indicum L.) under different plant population densities. University of California. Riverside (M.S. thesis) pp.110.

Dixit, R.K. 1978. Combining ability analysis in sesame. Indian J. agric. sci. 48: 362-363.

Goyal, S.N. and Kumar, S. 1988. Heterosis in relation to general and specific combining ability in sesame. Indian J. Genet. 48(2): 251-253.

Kempthorne, O. 1957. An introduction to genetics statistics: John wiley and sons, New York pp. 510.

Mishra, A.K. 1994. Genetic analysis of test weight in sesame. Sesame and safflower news letter (9): 17-21.

Mishra, A.K. and Yadav L.N. 1994. Genetic analysis of test weight in sesame. *Advances in Agril. Res. in India* (1): 202-205.

Mishra, A.K., Yadav, L.N., Tomar, R.K.S. and Raghu, J.S. 1994. Heterosis and combining ability in genetically diverse lines in sesame. *Sesame and safflower news letter* 9:21-29.

Shrivastava, V.P. and Singh, S.N. 1968. Heterosis inn sesame. *J.Indian Bot. soc.* 47: 79-88.

Watt, G. 1983. Dictionary of the economic products in India. Government of India Central printing office, Calcutta - 6.

Yadav, L.N. and Mishra A.K. 1991. Line x tester analysis of heterosis and combining ability in sesame. *Sesame and safflower news letter* (6): 46-54.

Yermanos, D.M. and Kotecha, A. 1978. Diallel analysis in sesame (*Sesamum indicum* L.) (Abs.). *In Agron. Abs. Madison,* U.S.A. Am. soc. Agron. 68.

J. Oilseeds Res. 13 (1) 1996: 93-96
ISSN 0970-2776

FLORAL BIOLOGY OF *SIMAROUBA GLAUCA* DC, AN OIL SEED TREE

SHANTA R.HIREMATH, SYAMASUNDAR JOSHI, K.G. SHAMBULINGAPPA, K.M. CHANNAKRISHNAIAH, CHIKKADEVAIAH, D.P. JAGANNATH and K. SEENAPPA.
University of Agricultural Sciences, Gandhi Krishi Vignana Kendra, Bangalore 560 065.

ABSTRACT

Studies on phenology in *Simarouba glauca* DC., revealed that flowering period is from December to March every year. It is a polygamodioecius plant, with male, male dominant bisexual (andromonoecious) and female flowers on separate trees. Flower bud development in these plants ranges from 35 to 50 days. Diurnal clocking pattern of anthesis was observed. Anther dehiscence started immediately after anthesis. Maximum percentage of pollen germination was observed at 15 per cent sucrose solution with 200 ppm boric acid. Pollen was viable for 6-8 hours. Stigma was receptive for about 10 hours after anthesis.

Key words: Paradise Tree; Floral ontogeny; Biology.

INTRODUCTION

Paradise tree *(Simarouba glauca* DC.), an exotic oilseed tree belongs to the family *Simaroubaceae*. Its common name is aceituno, black olive or tree of paradise. It is a medium sized evergreen tree, a native of Central America, and grown in semi-arid zones, waste lands and marginal lands. It's seeds contain 55-65% edible oil, which can also be used in soap and lubricant industries. As the pressed oil cake has high nitrogen content (7.7%), it can be used in organic farming. Paradise tree is cross pollinated by wind or bees. An understanding of the floral biology of *Simarouba glauca* DC. will help plan its breeding programme and hence the present studies.

MATERIALS AND METHODS

Ten randomly selected panicles from each type of *tree male (M), male dominant bisexual (MDB)* and female (F) were taken for recording the observations on development of flower bud (from bud initiation to full bloom stage) and average number of days required for each bud to pass through various stages of development till anthesis. One hundred fully developed buds per panicle were selected for each type of tree (M, MDB and F) to study the anthesis at hourly intervals for 24 hours. Anther dehiscence and stigma receptivity were studied using a magnifying glass. Stigma was pollinated at hourly intervals to study its receptivity from three hours before anthesis. Ten flowers were selected for pollination for each treatment and the seed set percentage was calculated.

RESULTS AND DISCUSSION

Simarouba glauca DC is polygamodioecious with male (M), male dominant bisexual (MDB) and female (F) flowers produced on different trees. The segregation of male, female and male dominant bisexual plants was in 1:4:5 proportion respectively. It is difficult to identify them morphologically during vegetative period. However, closer observations reveal that the male trees have relatively longer branches with longer internodes (16 mm) than the male dominant bisexual (8 mm) and bisexual (5 mm) trees.

Received for publication December, 1995

However the MDB and F trees cannot be distinguished from each other as they are very much isomorphic.

Panicle development

The appearance of coppery red new flush at the tips of old branches heralds the panicle initiation. The new flush has got coppery foliar primordia which gradually turn dark green. Panicle initiation started first in male dominant bisexual trees in the month of November/December and continued till March, whereas it started at the end of January or first week of February in female trees. Peak period of flowering was during January 15th to February 15th every year. Duration of flowering in general, was more in male dominant bisexual trees (65-75 days) than in female trees (30-35 days). Details of male and male dominant bisexual and female panicles is given in Table 1.

Growth of flower bud and periodicity of flowering

Morphological characters of buds at different stages of their development are as follows:

Stage I: The buds have just appeared, they are tiny, round, completely covered with sepals and are green in colour.

Stage II: The buds attain conical shape due to the elongation of corolla. Corolla is almost twice as long as calyx.

Stage III: Buds attain their full size. They are soft and ready to open the next day. Opening of the flower is manifested by the longitudinal slit at the apex followed by the widening towards the base of the corolla.

Table 1. Description of male (M), male dominant bisexual (MDB) and female (F) panicles.

Characters	Male	Male dominant bisexual	Female
Length of the panicle (Cm)	15 - 20	15 - 20	10 - 12
Secondary branches	20 - 25	25 - 30	7 - 15
Tertiary branches	23 - 55	30 - 60	10 - 35
No. of *flowers* in fascicles	3, 7, 14	3 - 14	3
No. of *flowers* on the *secondary* branches	165 - 486	133 - 366	13 - 63
No. of *flowers* on the tertiary branches	26 - 148	88 - 275	5 - 32
Total No. of flowers per panicle	4125 - 6250	3515 - 5500	250 - 600

Bud length and diameter during these developmental stages range from 1.0 - 5.5 mm and 2.0 - 8.0 mm, respectively.

The plants require about 18-20 days for panicle initiation from the coppery red new flush appearance time (first stage) and 10-15 days for the second stage of bud development in all the three types of plants. However, for the third stage of bud development the female plants require 8-10 days, whereas the other two types of plants (Male and Male dominant bisexual) require about 10-15 days for the corresponding stage. Thus from the appearance of new flush to anthesis the female plants need 35-40 days, whereas the others require 45-50 days.

Anthesis

It is basipetal and biphasic. Anthesis follows a diurnal clocking pattern with one set of buds opening during day and another set opening during night. The first phase started at 9.00 AM. and ended at 11.00 AM, whereas second phase started at 8.00 PM. and ended 11.00 PM. The maximum number of flowers opened at 9.30 AM and 10.00 PM respectively. Each panicle takes 30 to 35 days for complete opening of all the flowers.

Flower description

There are three types of flowers and their structures are as follows:

a) Male flowers: These are found on male plants (M) and male dominant bisexual plants (MDB). The pedicel is 6 mm long. The flowers are pentamerous. Calyx has 5 sepals, fused and valvate. Corolla has 5 petals, 8 mm x 3 mm; greenish white free, twisted. Stamens 10 in number, in two whorls with dorsifixed anthers. Filament is 4.0 mm long and anther 3.0 mm long. The glandular intrastaminal disc is 5 lobed with 2.0 mm diameter. The gynoecium is represented by a pistillode which is almost completely embedded in the intrastaminal disc leaving only the stigmatic surface free. The flower drop started two days after anthesis and it was 100 per cent by 3 days after anthesis. The inflorescence axes remain as bare twigs for some time after the flower drop.

b) Bisexual flowers : These are found at the tips of secondary and tertiary axes on the male dominant bisexual plants (MDB). Except these perfect bisexual flowers, all the remaining ones are male. The perfect flower has 5 mm long pedicel; calyx and corolla are similar to those of male flower. Petals 8 mm x 4 mm; the filament is 4 mm long with dorsifixed 3.0 mm long anthers. The ovary is surrounded by 1 mm wide intrastaminal disc. Stigma is sessile, pentagonal, solid and sticky. Three days after anthesis all the male flowers are dropped whereas fertilized female flowers are retained for further development on MDB plants.

c) Female flowers: Female flowers are borne exclusively on female plants. The pedicels are longer (12 mm) than those of male flowers (6 mm). The flowers are pentamerous, regular, sepals fused, petals free, 8 mm x 3 mm; five rudimentary staminodes are at the base of the ovary; carpels five, free, ovary length is 8 mm with 13.5 mm long externally curved styles and stigma is sticky.

Anther dehiscence

The anther dehiscence is longitudinal and it starts 30 minutes after flower opening in both male and hermaphrodite flowers. All the anthers do not dehisce simultaneously and it takes nearly 60 to 90 minutes for complete dehiscence of 10 anthers. Dehiscence of anther is also biphasic like anthesis, hence the peak period being around 10.00 AM and 9.30 PM respectively.

Pollen studies

a) Morphology: Visually the pollen mass appeared to be bright yellow in colour. The individual pollen grain appeared greenish yellow under light microscope. The pollen grains are smooth, oval in shape with a diameter of 25 u m. The pollen grains are 2 celled at the time of shedding.

b) Pollen germination and pollen viability: Maximum percentage of pollen germination was observed in 15 per cent sucrose solution with 200 ppm boric acid combination. In vitro studies revealed that the pollen tube reached a maximum length of 80 mm in 3-4 hours after the pollen tube initiation. The pollen was viable for 6-8 hours under normal conditions of temperature and humidity.

Receptivity of stigma

The stigma becomes receptive only after the opening of flowers. The stigmatic receptivity was found to last for 10 hours after flower opening. The highest stigmatic receptivity was assessed based on the percentage of fruit set i.e., 90 per cent at 10 AM and 9 PM respectively which gradually reduced to 40% thereby indicating the gradual loss of stigmatic receptivity.

LITERATURE CITED

Armour, R.P. 1959. Investigations on *Simarouba glauca* DC., *Eco.Bot.* 13: 41-66.

Bhagmal, 1994. Minor oil bearing plants: Potentials and germplasm enhancement. *In*: Prasad, M.V.R. *et al* (Ed.), Sustainability of Oilseeds, pp 83-90, Indian Society of Oilseeds Research, Hyderabad 603 pp.

J. Oilseeds Res. 13 (1) 1996: 97-102
ISSN 0970-2776

EFFECT OF DETACHED LEAF AND AGAR LEAFLET DISC TECHNIQUES ON DEVELOPMENT OF GROUNDNUT RUST

SRIKANTA DAS and S.K. RAJ
Department of Plant Pathology, Faculty of Agriculture, P.O. - Krishi Viswavidyalaya, Mohanpur, Dist. - Nadia, West Bengal - 741 252.

ABSTRACT

The effect of cardinal temperatures and relative humidity for quicker development of groundnut rust, (*Puccinia arachidis*) was studied by detached leaf and agar leaflet disc techniques. Detached leaf technique required lower incubation period of 6-7 days for development of chlorotic flecks and 9-10 days for appearance of pustules than the agar leaf let disc technique which required 9-10 days for chlorotic fleck and 11-12 days for pustule appearance at an inoculum load of 6×10^3 ml $^{-1}$. Five day old leaf tissues were most susceptible for disease development than older ones. In both the techniques, optimum temperature for maximum infection was found to be 25°C while the longest IP for infection was at or below 15°C. Pustule development was drastically reduced above 35°C. At 100% relative humidity, IP was 6 and 9 days for chlorotic flecks and pustule appearance in detached leaf technique, where as 9 and 11 days were required in agar leaflet disc techniques respectively. IP increased at 55% RH. Considering the cardinal temperatures and relative humidity, the detached leaf technique was found be the best technique under laboratory conditions.

Keywords: *Groundnut rust; Detatched leaf technique; Agar leaflet disc technique*

INTRODUCTION

Groundnut rust, caused by *Puccinia arachidis* Speg is a well established disease in India. Disease occurs in the field under a wide range of environmental conditions. Incubation period and rate of development of disease are important components for epidemiological studies (Vander plank, 1968; Zadoks and Schein, 1979). The detached leaf culture of *Puccinia sorghi* schw. has been used by Mains (1917) on corn leaves for Physiological study of obligate plant pathogen under laboratory condition. It is well known that inoculum above threshold level is necessary for infection and disease development. Temperature, relative humidity and inoculum density affect the incubation period for symptom expression and disease development. As limited information is available on rust under controlled environmental conditions (Mallaiah and Rao, 1979; Munde and Mayee 1980; Patel and Vaishnav, 1989), the experiment was conducted to assess the cardinal factors for disease development by two techniques under laboratory conditions.

MATERIALS AND METHODS:

Preparation of spore suspension:

Hundred mg of freshly harvested uredospores from 72 hour old pustules were suspended in 100 ml of sterile distilled water. The suspension was centrifuged at 5000 rpm in a Remi centrifuge for 10 min. to eliminate inhibitors (Foudin and Macko, 1974). The supernatent was suspended in sterile distilled water at different dilutions. Number of spores/ml was recorded using a haemocytometer.

Received for publication April, 1994

Evaluation of different techniques for development of rust in laboratory:

Agar leaflet disc technique: (ALT)

Third and fourth leaves from top of the plant (CV. TG-17) were harvested and 2 cm dia discs were cut out from the leaflets with a sterile cork borer. The discs were surface sterilized with 10% sodium hypochlorite and the discs were kept in holes made in 2% water agar in petriplates in such a way that the lower surface (abaxial) of leaflets exposed to inoculum. Spore suspension of different dilutions (0.2 ml each) was applied on the exposed surface of leaf discs with a sterile pipette. The plates were incubated at a temperature of 10, 15, 25, 30, 35 and 40°C in a BOD incubator and at relative humidities of 55, 75, 85, 95 and 100% in humidity cabinet (Winston and Batis, 1960). Five day old leaves from 35 day old plants were used for this experiment. The incubation period required for development of chlorotic flecks, pustules was recorded and number of pustules developed at 14, 21 and 28 days after inoculation (DAI) was recorded following the method of Mayee and Munde (1979).

Detached leaf technique: (DLT)

This technique was adopted following Cook (1972) and, Misra and Misra (1975) in groundnuts. Young unfolded 3rd leaf from top with petiole was surface sterilized in 70% ehtanol. The leaves were washed 4-5 times with sterile distilled water and placed on moist filter paper in petriplates in such a way that the lower side of leaflets is exposed and the petiole is dipped in distilled water. Distilled water was sprayed periodically to maintain turgidity of the leaflets. Inoculum load, temperatures and relative humidities were maintained as described under ALT. Data were recorded as stated in ALT.

Effect of host age and incubation period on disease development:

Healthy unfolded leaves of different ages viz. 2 and 5 to 35 days at an interval of 5 days were harvested with petiole from the potted plants raised in a glass house. These were inoculated with a spore suspension of 6 x 10^3/ml concentration, incubated at 25° ± 2°C and 100% RH as described in detached leaf technique. Incubation period for disease development was recorded.

RESULTS AND DISCUSSION:

Numerical Threshold of infection:

Two inoculation methods were tested with different spore concentrations by incubating at 25° ± 2°C temp. for 8 days in a growth chamber at 100% RH. The results showed that 6 x 10^3/ml spore conc. was optimum for initiation of chlorotic flecks and pustule formation at less incubation period (Table 1). Minimum spore load (6 x 10^2 or 5 x 10^2/ml) required longer incubation period, where as increased spore load beyond the optimum (6 x 10^4 or 5 x 10^4/ml) level did not reduce incubation period of the two methods tested. Detached leaf technique required lower incubation period of 7 days for chlorotic flecks and 10 days for pustule appearance at 6 x 10^3/ml conc, where as in agar leaflet disc technique incubation period required 10 days for chlorotic flecks and 12 days for pustule appearance. At all levels of inoculum incubation period was longer in agar leaflet disc technique than detached leaf technique.

Assessment of cardinal temperature on disease development in detached leaf culture:

Two inoculation methods on detached leaves were tested at a temperature ranging 10°-40°C with 5°C intervals. At 10°C, the leaflets suffered from cold injury, had faded black colour and chlorophyll was damaged. At 40°C, leaves shrivelled and dried out quickly. At 15°C, the specks developed at 17 days after inoculation in detached leaf technique (DLT) 19 DAI in agar leaflet disc technique (ALT) whereas pustules appeared at 21 DAI in DLT and 22 DAI in ALT. The number of pustules produced per leaf were 10.2 in DLT and 6.4 in ALT at 28 DAI, where as at 25°C, 178 pustules (DLT) and 100 pustules (ALT) were produced at 28 DAI, and the IP was 10 and 12 DAI at DLT & ALT for pustule appearance. At 35°C, minimum number of pustules appeared per leaf at 28 DAI and IP was 14 days for DLT and 17 days for ALT (Table 2). In detached leal culture below 10°C and above 35°C were unfavourable for disease development. Munde and Mayee (1980) observed that temperatures at 5°C and 42°C are unfavourable for disease development and maximum pustules occurred at 27° in simple detached leaf technique. Prasad *et al.*, (1979) noted that congenial temperature for infection and symptom expression of rust disease of groundnut was 20°-24°C.

Table 1. *Effect of Spore load on development of chlorotic flecks and Pustules in groundnut rust*

Inoculum Conc. / ml.	(A) DLT	(B) DLT	(A) ALT	(B) ALT
6×10^4	9	11	12	14
5×10^4	10	12	13	15
6×10^3	7	10	10	12
5×10^3	8	10	11	12
6×10^2	11	15	14	17
5×10^2	13	17	16	18

	S. Em. ±	CD (0.05)
DLT x ALDT (Techniques)	0.181	0.365
Sporecon/ml	0.315	0.898
Date of appearance of chlorotic lesion x appearance of Pustules	0.181	0.518

DLT = Detached leaf technique ALT = Agar leaf disc technique

A- Appearance of chlorotic lesion (DAI). B - Appearance of Pustules (DAI).

Effect of relative humidity (RH) on disease development in detached leaf culture

In this experiment five different RH levels between 55 - 100% were maintained in humidity chambers. The results (Table 3) showed that increased RH reduced the IP required for chlorotic flecks and pustule appearance. In DLT at 100% RH the IP for chlorotic flecks and pustule appearance was 6 and 9 days, respectively whereas at 55% RH, the IP increased to 18 and 21 days, respectively. In the case of ALT at 100% RH the IP for chlorotic flecks and pustule appearance was 9 and 11 days, where as at 55% RH the IP increased to 21 and 23 days, respectively. In DLT, at 100% RH number of pustules per leaf were 177.4, 196 and 207. at 14, 21 and 28 DAI, where as at 55% RH these were 0.0, 6.8 and 9.3, respectively. In ALT, the number of pustules/leaf were 100.1, 131.0 and 135.0 at 100% RH and 0, 0 and 3.1 at 55% RH at 14, 21 & 28 DAI, respectively. It was also observed that in ALT after 28 days incubation the leaves turned yellow and decayed.

Effect of leaf age and incubation period on development of groundnut rust:

In younger leaves, the incubation period (IP) became less for disease development. As the age of leaf increased, the IP for chlorotic flecks and

Table 2. Effect of temperature and incubation period on development of groundnut rust.

Temp. °C	Incubation period (days)				No. of Pustules/ leaf (days after inoculation)					
	Chlorotic lesion		Pustule appearance		14		21		28	
	DLT	ALT	DLT	ALT	DLT	ALT	DLT	ALT	DLT	ALT
10	-	-	-	-	-	-	-	-	-	-
15	17	19	21	22	0	-	7.3	-	10.2	6.4*
25	7	10	10	12	100.7	48.9	150.9	91.2	178.3	100.0*
30	9	12	10	13	87.3	15.2	108.6	48.1	119.7	51.7*
35	12	14	14	17	16.0	-	19.6	9.8*	25.1	12.1
40	-*	-**	-*	-**	-*	-**	-*	-**	-*	-*

	S.Em ±	CD (0.05)
DLL x ALDT (Technique)	0.139	0.280
Temperatures (°C)	0.241	0.689
IP for CL x IP for PA	0.139	0.398
Temp. x IP	0.342	0.975

CV % = 0.007088

DLT = Detached leaf technique ALT = Agar leaf disc technique

* leaves turned yellow ** leaves turned yellow and dried up

pustule appearance increased. It was found that for disease development a minimum of 5 day leaf was required. Age of the plant was the main factor for maximum pustule appearance and disease intensity. Mallaiah and Rao (1979) reported that maximum number of pustule development on leaflets were higher in 40 to 50 days old Plants. Mckey (1965) also noted that abaxial surface of the leaves had greater susceptibility than adaxial surface.

REFERENCES

Cook, M. 1972. Screening of peanut for resistance to rust in the greenhouse and filed. Plant. Dis. Reporter. *56*: 382-6.

Foudin, A.S. and Macko, V. 1974. Identification of the self inhibitor and some germination characteristics of peanut rust uredospores. Phytopathology: *64* (7): 990-3.

Krishna Prasad, K.S., Siddaramaiah, A.L. and Hegde, R.K. 1979. Development of peanut (grounonut) rust disease in Karnataka State, India. Plant Dis. Reporter. *63*: 692-5.

Mains, F.B. 1917. The relation of some rusts to the Physiology of their hosts. Amer. J. Bot. *4*: 179-220.

Table 3. Effect of relative humidity on incubation period for development of groundnut rust:

Humidity (%)	Incubation period (days)				No. of Pustules/leaf (days after inoculation)					
	Chlorotic lesion		Pustule appearance		14		21		28	
	DLT	ALT	DLT	ALT	DLT	ALT	DLT	ALT	DLT	ALT
55	18	21	21	23	-	-	6.7	-	9.30	3.1*
75	11	17	13	19	53.8	-	59.2	18.8	67.36	28.0*
85	9	12	11	13	93.7	30.8	106.8	51.3	110.11	60.1*
95	8	10	10	11	149.1	59.1	168.7	99.0	189.0	103.1*
100	6	9	9	11	177.4	100.1	196.0	131.0	207.08	135.0*

	S.Em ±	CD (0.05)
DLT x ALT	0.185	0.373
Humidity (%)	0.293	0.840
IP for CL x IP for PA	0.185	0.531
Humidity x IP	0.415	1.189
Techniques x RH (%)	0.262	0.752

CV % = 0.00864

DLT = Detached leaf technique ALT = Agar leaf disc technique

* leaves turned yellow and decay.

Mallaiah, K.V. and Rao, A.S. 1979. Groundnut rust. Factors influencing disease development, sporulation and germination of uredospores. Indian Phytopath *32*: 382-388.

Mayee, C.D. and Munde, P.N. 1979. A modified detached leaf technique for laboratory development of groundnut rust. Indian Phytopath *32*: 467-8.

Mayee, C.D. 1981. Epidemiology of groundnut rust from Marathwada. Third international symposium on plant pathology, New Delhi, 14-18 December, 1981.

McKey, D.V. 1965. Inoculation and development of rust on Peanuts grown in the green house. Plant Dis. Reporter. 49: 191-92.

Misra, A.K. and Misra, A.P. 1975. Groundnut rust in Bihar - varietal reaction. Indian Phytopath *28*(4): 557-559.

Munde, P.N. and Mayee, C.D. 1980. Factors influencing development of groundnut rust in detached leaf inoculation. Indian Phytopath *33* (3): 444-9.

Patel, V.A. and Vaishnav, M.U. 1989. Effects of Temperature and Relative humidity on development of Groundnut rust. J. oilseeds Res.*6*: 375-8.

Winston, P.W. and Batis, D.H. 1960. Saturated solution for the controls of humidity in biological research. Ecology *41*: 232-237.

Vander Plank 1968. Disease Resistance in Plants. Academic Press, New York, 394 pp.

Zaoks, J.C. and Schein, R.D. 1979. Epidemiology and Plant Disease Management. Oxford University Press. New York, 246 pp.

J. Oilseeds Res. 13 (1) 1996: 103-105
ISSN 0970-2776

SYNTHETIC PYRETHROID RESISTANCE IN *HELICOVERPA ARMIGERA* (HUBNER) POPULATIONS COLLECTED FROM GROUNDNUT

P. RAJA SEKHAR, M. VENUGOPAL RAO, B. RAMA RAO and M. VENKATAIAH
Regional Agricultural Research Station, Lamfarm, Guntur - 522 034.

ABSTRACT

Studies were conducted on the insecticide resistance in *Helicoverpa armigera* (Hubner) to the commonly used synthetic pyrethroids viz., cypermethrin, fenvalerate and deltamethrin at the Regional Agricultural Research Station, Lam, Guntur. The resistance was found to be 4.6 - fold to cypermethrin and 7.5 - fold to fenvalerate when compared to the susceptible Reading strain (UK). The *H. armigera* populations also showed a low degree of resistance to deltamethrin. These studies indicated existence of a low level of resistance to synthetic pyrethroids on groundnut.

Key Words: *Helicoverpa*; Synthetic Pyrethroid; groundnut; resistance

INTRODUCTION

In recent years *Helicoverpa armigera* has emerged as a dominant pest of several crops in the Nagarjuna Sagar Project (NSP) area of Andhra Pradesh due to the development of insecticide resistance from 1987 onwards. Acute control problems were experienced with synthetic pyrethroids on cotton resulting in high population pressure and field control failure (Armes *et al.*, 1992b). Subsequently high levels of pyrethroid resistance was detected in the *H. armigera* populations collected from different crops in the NSP area (Venugopal Rao *et al.*, 1994). Groundnut, an important oil seed crop in this region, was also threatened by the polyphagous pest, *H. armigera*. Under such situations the need to monitor resistance has been widely recognised (Dennehy, 1987) as a pre-requisite of developing suitable insecticide resistance management strategies. As a primary step in this direction, monitoring of pyrethroid resistance was initiated in the groundnut tracts of the NSP area from 1994 onwards.

MATERIALS AND METHODS

The eggs of *Helicoverpa armigera* were collected from groundnut fields in the NSP area of Andhra Pradesh. The eggs were brought to the laboratory at Regional Agricultural Research Station, Lam, Guntur and transferred individually to 7.5 - ml cells of 12 - well tissue culture plates containing a chickpea artificial diet (Armes et al., 1992 a). Once the larvae reached 30-40 mg weight they were subjected to topical bioassays. The most commonly used synthetic pyrethroids viz., cypermethrin, fenvalerate and deltamethrin were selected and the technical grade insecticides were used in the topical bio-assays. The serial dilutions of technical grade insecticides in acetone were prepared such that each was one-half of the previous concentration (Mc Caffery et al., 1989). Hamilton microsyringe was utilised to deliver a 1-µl drop to the thoracic dorsum of third instar test insects weighing 30-40 mg. Control insects were treated with acetone alone. Atleast 100 larvae divided amongst four replicates were used in the present

Received for publication July, 1995

study for each treatment group. After treating the larvae they were fed on chickpea artificial diet and mortality was assessed after 6 days. The dose mortality regressions were computed by probit analysis using MLP 3.08 software (Ross, 1987).

RESULTS AND DISCUSSION

The strain of NSP area from groundnut had a higher LD_{50} value (0.092 µg $larva^{-1}$) with technical cypermethrin than the susceptible Reading strain (LD_{50} = 0.02 mg $larva^{-1}$) giving a resistance of 4.6 (Table 1). Even *H. armigera* had a slightly higher LD_{50} of 0.113M $larva^{-1}$ for fenvalerate with resistance factor at 7.5 when compared to the susceptible strain. A moderate resistance to deltamethrin (LD_{50}=0.012 µg $larva^{-1}$) was found in the *H. armigera* but the resistance factor could not be calculated for want of susceptible strain LD_{50}. The examination of the log dose probit lines for all the three chemicals indicated that there was no segregation of phenotypes in the probit analysis and heterogeneity was not significant.

These results indicate that the populations from groundnut have developed resistance only to certain extent when compared to susceptible strain. However, the high degree of resistance in *H.armigera,* occurring in the neighbouring cotton (Venugopal Rao *et al.*, 1994) was due to large number of sprays of synthetic pyrethroids given to

Table 1. Resistance in *Helicoverpa armigera* (Hubner) to synthetic pyrethroids on grountnut

	Chemical	LD_{50} (µg $Larva^{-1}$)	Resistance factor at LD_{50} a	LD_{90} (µg $larva^{-1}$)	Slope (± SE)
A.	NSP Strain Cypermethrin	0.092 (0.063 - 0.134)*	4.6	0.749	1.41 (0.26)
	Fenvalerate	0.113 (0.083 - 0.149)	7.5	0.444	2.15 (0.39)
	Deltamethrin	0.012 (0.008 - 0.016)	--	0.076	1.61 (0.27)
B.	Reading strain Cypermethrin	0.02 (0.017 - 0.024)	–	0.05	1.31 (0.14)
	Fenvalerate	0.015 (0.013 - 0.017)	–	0.03	1.80 (0.20)

* 95% Fiducial limits

a LD_{50} resistant strain/LD_{50} Reading susceptible strain reared on artificial diet cotton than groundnut. This supports the fact that selective survival of resistant larvae and moths accounts for increase in resistance frequency when pyrethroids are applied to field crops (Forrester and Cahill, 1987). Most probably the resistance levels were driven by creating high selection pressure with increased usage of insecticides. Hence, it is essential to reduce the number of insecticidal sprays so that a source of susceptibles were available to dilute the resistance levels. It was already established that immigration of susceptibles from the unsprayed refugia was the most important factor affecting resistance levels. Thus the situation seem to be better in groundnut areas with regard to resistance for pyrethroids. The resistance management strategies like greater control over insecticide application and use should be taken care off, to further lower the resistance in groundnut.

ACKNOWLEDGEMENTS

Authors are thankful to Natural Resources Institute, United Kingdom for funding the project and Dr. N.J. Armes, Principal Entomologist, NRI (UK) for the material assistance.

LITERATURE CITED

Armes, N.J., Bond, G.S. and Cooter, R.J. 1992a. The laboratory culture and development of *Helicoverpa armigera* Hubner. Natural Resources Institute Bulletin 57, Chatham, United Kingdom, NRI.

Armes N.J., Jadhav, D.R., Bond, G.S. and King A.B.S. 1992b. Insecticide resistance in *H.armigera* in South India. Pesticide Science 34: 355-364.

Dennehy, T.J. 1987. Decision - making for managing pest resistance to pesticides pp. 118-126 in Ford, M.G., Holloman, D.W., Khambay, B.P.S. and Sawicki, R.M. (Eds) Combating resistance to Xenobiotics: biological and chemical approaches. Chichester, UK, Ellis Horwood.

Forrester, N.W. and Cahill, M. 1987 - Combating resistance to xenobiotics. Ellis Horwood, Chichester, UK. pp. 127-137.

Mc Caffery, A.R., King, A.B.S., Walker, A.J. and Nayir, H.El. 1989. Resistance to synthetic pyrethroids in the bollworm, *H. armigera* from Andhra Pradesh, India. Pesticide science 27:65-76.

Ross, G.J.S. 1987, Maximum likelihood program. The Numerical Algorithms group, Rothamsted Experimental Station, Harpanden, U.K.

Venugopal Rao, N., Raja Sekhar, P., Venkataiah, M. and Raja Sri, M. 1994. Estimation of insecticide resistance in *H.armigera* in Andhra Pradesh. Indian Journal of Plant Protection, 22:33-37.

J. Oilseeds Res. 13 (1) 1996: 106-108
ISSN 0970-2776

SEED QUALITY AND FATTY ACID COMPOSITION OF NEWLY DEVELOPED SAFFLOWER HYBRIDS AND THEIR PARENTS

G. NAGARAJ and K. ANJANI
Directorate of Oilseeds Research, Rajendranagar, Hyderabad - 500 030.

ABSTRACT

Five newly developed safflower hybrids have been analysed for their seed oil and protein along with fatty acid profile of the oil. The hybrids, in general had higher oil, protein and linoleic acid and lower oleic and saturated fatty acid contents than their parents and local cultivars. Among the five hybrids, DSH 107 and DSH 113 with higher yields also had higher oil, protein and linoleic acid levels than the other hybrids.

Key words: Safflower hybrids; Oil; Protein; Fatty acids.

INTRODUCTION

Safflower (*Carthamus tinctorius*), one of the ancient Indian oilseed crops, is a rich source of the essential fatty acid, namely linoleic acid. Though India is a leading country in the production of safflower (5.8 lakh tonnes during 93-94), its productivity is very low being 733 kg/ha. Attempts to increase the yield have been made through improved agro-production technologies (DOR, 1995a) and also through development of hybrids (Goud, 1995). Five hybrids recently developed at the Directorate of Oilseeds Research have been found to have better yield potentials (DOR, 1995b). These hybrids have been examined for their seed and oil quality, namely fatty acid profile in the present study.

MATERIALS AND METHODS

Seeds of seven parents and five safflower hybrids alongwith two cultivars grown during the post rainy season of 1993-94 at the farm of the Directorate of Oilseeds Research, Rajendranagar, Hyderabad were collected. They were analysed for oil content by NMR method (Jambunathan *et al.*, 1985) and protein by kjeldahl method. Fatty acid composition of the oil was obtained after GLC separation of the methyl esters; (Paquot and Hautfenne, 1987) on a DEGS column. The column was maintained at 190° C with a nitrogen flow of 40 ml/minute and the FID and injector were maintained at 240°C. The analyses were maintained at 240°C. The analyses were carried out in triplicate and the average values are presented in Table-1.

RESULTS AND DISCUSSION

The oil content of parents ranged from 27.6 (GMS 5(0) to 31.1% (II-51-1-10) with an average value of 29.9%. The same for hybrids ranged from 29.4 (DSH-110) to 32.5 (DSH 116) with an average value of 30.7%. The protein content of parents ranged from 14.4 (GMS 6(0) to 17.3% (II 51-1-10) with a mean value of 15.6%, while for hybrids it ranged from 13.2 (DSH 116) to 17.6% (DSH 113) with a mean value of 16.1%. It is thus evident that hybrids had higher oil and protein contents.

Linoleic acid (18:2) was the main fatty acid present in all the samples namely parents, hybrids and cultivars of safflower. It ranged from 77.2 to 80.8% in parents and 79.1 to 80.4% in hybrids with average values of 78.9 and 79.9% respectively. Thus again the major fatty acid levels were higher

Received for publication December, 1995

in hybrids than their parents. These values were higher than those of cultivars, A1 (72.6%) and HUS 305 (78.1%). The oleic acid (18:1) content ranged from 11.1 to 13.8% for the parents and 10.1 to 13.3% for the hybrids with average values of 12.6 and 12.3% respectively. Oleic acid was higher in the cultivars (12.7 to 17.7 average 15.2%). Higher levels of oleic acid are desirable to impart stability to oils during storage and deep fat frying. Safflower oil is more important for its nutritional quality which is due to the higher levels of linoleic acid. In this context, hybrids have the advantage with very high levels of linoleic acid.

Palmitic acid (16:0) ranged from 6.4 to 8.5% in parents with an average value of 7.3% while for the hybrids the range was 6.5 to 7.1% and the average was 6.6%. Stearic acid (18:0) was a minor fatty acid present at around 1-2% in all the samples. Both these are saturated fatty acids and are not desirable for human nutrition. The hybrids have lower levels of both these saturated fatty acids. Thus it is evident that hybrids are richer in the essential fatty acid namely linoleic acid and poorer with respect to the undesirable saturated fatty acids. Hence, they can be considered superior with respect to oil quality. The hybrids had higher yields ranging from 1353 to 1640 kg/ha against 1339 to 1383 kg/ha in the case of cultivars (DOR 1995b). Hybrid DSH 107 had the highest seed yield of 1640 kg/ha followed by DSH 113 with 1605 kg/ha. These hybrids also had higher oil, protein and linoleic acid levels. Hence, these two hybrids need special attention, while in general all the hybrids developed are superior to their parents as well as the cultivars.

ACKNOWLEDGMENTS

The authors wishes to thank Dr. P.S. Reddy, Project Director, DOR for his keen interest and encouragement during the course of the work.

LITERATURE CITED

Directorate of Oilseeds Research (DOR), 1995a. Package of practices for increasing production of safflower, DOR 1995, Hyderabad, India.

Directorate of Oilseeds Research (DOR, Hyderabad, India 1995b. Annual Report 1993-94, DOR, Hyderabad, India, p 13.

Goud, J.V., 1995. Safflower research with special reference to heterosis breeding. Lead paper presented at the Annual *Rabi* Oilseed Research Workers Group meeting of Safflower and Linseed, Punjabrao Krishi Vidyapeeth, Akola, August 28-31, 1995, pp 1-22.

Jambunathan, R., Raju, S.M. and Badre, S.P. 1985. Analysis of oil content of groundnut by Nuclear magnetic Resonance spectrometry, *J. Science Food and Agriculture*, 36: 162-166.

Paquot, C. and Hautfenne, A. 1987. Standard methods for the analysis of oils, fats and derivatives. Blackwell Scientific Publishers, Oxford pp. 73-77.

Table 1. Seed composition and oil quality of safflower hybrids, parents and cultivars

Genotype	Seed oil %	Seed protein %	Fatty acid composition			
			16:0	18:0	18:1	18:2
PARENTS						
86-2-2	30.1	16.9	7.1	1.0	11.1	80.8
VI 92-2-4	30.8	15.3	7.5	1.4	13.8	77.2
II 51-1-10	31.1	17.3	7.7	1.9	13.2	77.2
GMS 5 (0)	27.6	15.5	6.8	0.9	13.5	78.6
GMS 6 (0)	28.7	14.4	6.8	1.1	12.3	79.8
GMS 9 (0)	31.0	14.7	6.4	0.8	12.3	80.3
GMS 107 (7)	30.2	15.2	8.5	0.9	11.9	78.7
Mean	29.9	15.6	7.3	1.1	12.6	78.9
HYBRIDS						
DSH 107 (GMS 6 (0) x II-51-1-10	30.3	16.7	7.1	1.0	10.1	80.4
DSH 110 GMS 17 x VI 92-2-4	29.4	16.8	6.5	0.8	12.6	80.1
DSH 113 GMS 5(0) x 86-2-2	31.3	17.6	6.5	0.6	12.8	80.1
DSH 114 GMS 5 (0) x II 51-1-10	30.2	16.3	6.5	0.6	12.8	80.0
DSH 116 GMS 9(0) x VI 92-2-4	32.5	13.2	6.7	0.8	13.3	79.1
Mean	30.7	16.1	6.6	0.8	12.3	79.9
CULTIVARS						
A1	26.5	12.0	6.6	2.3	17.7	72.6
HUS 305	32.7	12.9	6.6	2.4	12.7	78.1
MEAN	29.6	12.5	6.6	2.4	15.2	75.4

J. Oilseeds Res. 13 (1) 1996: 109-110
ISSN 0970-2776

SHORT COMMUNICATIONS

EFFECT OF GAMMA IRRADIATION ON THE ASSOCIATION OF POLYGENIC TRAITS AND THEIR CONTRIBUTION TO YIELD OF M_2 AND M_3 GENERATIONS IN SOYBEAN

Present investigation was undertaken to understand the nature of character association in M_2 and M_3 generations of gamma irradiated soybean cultivars.

M_2 generation, raised from 197 M_1 plants selected on the basis of physiological injuries caused and stimulating effect of the seed treatment of the varieties MACS-57, MACS-124, MACS-346 and *Monetta* with 10, 20, 30, 40 and 50 kR gamma rays, was screened during rainy season of 1993 and compared with unirradiated control treatments of the respective varieties. Seeds of M_2 selections made on the basis of mean ± 2 SE for respective characters under selection were used to raise M_3 generations during summer, 1993. In all 227 M_3 progenies were raised along with the parental and standard checks in two replications. Data were collected on every plant in both the generations.

From the progeny means, correlation and path coefficients (Dewey and Lu, 1959) were calculated.

M_2 generation: Correlation and path analysis studies revealed that the character 100-grain weight was significantly correlated with grain yield (r=0.478). Branches/plant had a positive correlation with pod/plant (0.579).

M_3 generation: 100-grain weight (r=0.569) exhibited highly significant positive correlation with yield. Further, branches/plant showed highly significant and positive correlation (r=0.417) with 100 grain weight. Pods/plant was positively and significantly correlated with branches/plant (r=0.527) and 100 grain weight (r=0.527). Plant height had highly significant and negative correlation (r=-0.557) with branches/plant. Days to maturity was found to be negatively correlated with branches/plant (r=-0.602), 100 grain weight (r=-0536) and yield (r=-0.753). While days to 50% flowering was positively and significantly correlated with days to maturity (r=0.611) and significantly but negatively correlated with pods/plant (r=-0.430) and yield (r=-0.592). Yield was positively related to 100 grain weight (0.072) and pods/plant (0.030), while branches/plant showed maximum positive indirect effect (0.496) on yield through plant height followed by 100 grain weight (0.442).

Some significant correlations got altered from M_2 to M_3 generations e.g., pods/plant with 100 grain weight (M_2 r=-0.377 and M_3 r = +0.527); branches/plant with 100 grain weight (M_2 r=-0.263 and M_3 r= +0.417) and plant height with 100 grain weight (M_2 r=0.489, M_3 r=-0.349).

Mutation breeding could be resorted to for altering the direction and magnitude of association of polygenic traits (Bhatnagar *et al.*, 1992, a & b) and variance thereof (Rajput, 1987; Conger *et al.*, 1976 and Upadhyay and Singh, 1979) resulting into either disrupted or unusual associations and even breaking of strong negative associations (Bhatnagar *et al.*, 1992, b) in soybean.

Agricultural Botany Section,
College of Agriculture,
Vidyanagar,
Kolhapur - 416 004, M.S.

S.S. MEHETRE
C.R. MAHAJAN
R.B.SHINDE
P.M. DHUMAL

Received for publication April, 1994

Table 1. Genotypic correlation coefficients (r) and path coefficients between yield and other characters in M_2 and M_3 generations of gamma irradiated soybean.

	Generation	Days required to 50% flowering	Days required to Maturity	Plant height	Pods/ plant	Branches/ plant	100-grain weight (g)	Correlation coefficient with yield (r)
Correlation coefficents 'r'								
Days to	M_2	-	0.416	-0.351	-0.354	-0.093	-0.252	-0.290
50% flowering	M_3	-	0.611**	-0.336	-0.430*	-0.107	-0.264	-0.592**
Days to	M_2	-		0.088	-0.364	0.095	0.215	-0.051
Maturity	M_3	-		0.309	-0.210	-0.602**	-0.536**	-0.953**
Plant height	M_2	-			-0.350	-0.321	0.489*	0.044
(cm)	M_3	-			-0.136	-0.557**	-0.349	-0.181
Pods/	M_2	-				0.579**	-0.377	-0.022
Plant	M_3	-				0.527**	0.527**	0.294
Branches/	M_2	-					-0.263	0.387
Plant	M_3	-					0.417**	0.382
100 grain	M_2	-						0.478*
weight (g)	M_3	-						0.569**
Path coefficients								
Days to	M_2	-0.341	0.016	0.100	0.135	-0.058	-0.141	-0.290
50% flowering	M_3	-0.015	-0.503	-0.080	0.085	-0.018	-0.061	-0.592**
Days to	M_2	0.038	-0.142	-0.025	0.138	0.060	-0.120	0.051
Maturity	M_3	-0.824	-0.009	0.067	0.040	-0.103	-0.124	-0.953**
Plant	M_2	-0.285	0.120	0.003	0.133	-0.202	0.274	0.044
height (cm)	M_3	0.217	0.005	-0.255	0.027	-0.096	-0.080	-0.181
Pods/	M_2	-0.380	0.121	-0.014	0.100	0.363	-0.212	0.022
Plant	M_3	0.198	0.006	0.166	0.030	0.228	0.121	0.294
Branches/	M_2	0.627	0.032	0.004	0.092	-0.220	-0.147	0.387
Plant	M_3	0.172	0.002	0.496	-0.121	-0.263	0.096	0.382
100 grain	M_2	0.561	0.086	-0.008	-0.139	0.143	-0.165	0.478*
weight (gm)	M_3	0.231	0.004	0.442	-0.076	-0.104	0.072	0.569**
Residual								0.397
effect								0.107

*, ** Significant at 5 and 1% level respectively. Underlined figures = Direct effect.

Bhatnagar, P.S., Tiwari, S.P. and Singh, C. 1992a. Differential dose response of soybean genotypes to mutagenesis with gamma rays. *Biovigyanam, 18 (2): 108-110.*

Bhatnagar, P.S., Tiwari, S.P. and Singh, C. 1992, b. Disrupting the negative association between oil and protein content in soybean seeds through mutagenesis. *Mutation Breeding Newsletter, 39*:7.

Conger, B.V., Skinner, L.W. and Skold, L.N. 1976. Variability for components of yield induced in soybeans by seed treatment with gamma radiation, fission neutrons and ethylmethane sulfonate. *Crop Science, 16*: 233-236.

Dewey, R.D. and K.H. Lu. 1959. Correlation and Path coefficient analysis of components of crested wheat grass seed production. *Agronomy Journal, 51*: 515-518.

Rajput, M.A. 1987. Induced polygenic variance in soybean. *Soybean Genetics Newsletter, 14*: 112-119.

Upadhayaya, H.D. and Singh, B.B. 1979. Induced variability in soybean. *Indian Journal of Genetics & Plant Breeding*, 39: 207-209.

J. Oilseeds Res. 13 (1) 1996: 111-112
ISSN 0970-2776

R-8808 - A HIGH YIELDING PEANUT BUD NECROSIS TOLERANT GROUNDNUT VARIETY

Peanut bud necrosis disease (PBND) caused by peanut bud necrosis virus (PBNV) is one of the important groundnut virus diseases during *kharif* and *Rabi*/summer in parts of Karnataka, Andhra Pradesh, Maharastra, Tamil Nadu and Uttar Pradesh. In Northern Karnataka, Tungabhadra project (TBP) and Upper Krishna Project (UKP) command areas are considered as hot spots for PBND. Groundnut produced during Rabi/summer season in these areas often encounter moisture stress suggesting the need for an early duration variety. Keeping this in view trials were conducted during 1990-1993 at different locations to identify a high yielding, short duration and PBND resistant tolerant variety.

The genotype R-8808 is a derivative of ICGS-11 and Chico, a short duration Russian variety. One of its parents ICGS-11, because of its long duration (>130 days) is vulnerable to end season drought. The short duration (110-120 days) variety R-8808 fits into the limited water availability period of these command areas, especially during *rabi*/summer season.

Variety R-8808 recorded an average yield of 18.2 q/ha in kharif and 35.2 q/ha in rabi/summer over eight seasons (1990-1993) at different locations of Northern Karnataka, accounting for 50 per cent increase in yield over KRG-1 and 11.6 per cent over JL-24 during kharif and 44.5 and 19.2 per cent over KRG-1 and ICGS-11 respectively during rabi/summer (Table-1).

The variety R-8808 had lesser incidence of peanut bud necrosis disease (1.23-2.40%) in both the seasons (1990-1993) than KRG-1 (20.80-49.35%), JL-24 (41.27-42.00%) and ICGS-11 (9.10%), indicating its resistance / tolerance to PBND. This variety also recorded 70-73 per cent shelling, 88-90 per cent sound mature kernels and 48-50 per cent oil content. The kernels are attractive with dark tan colour, medium in size with a 100 seed weight of 38.0g. Thus, R-8808 could be grown successfully in hot spots of PBND for realising higher yields.

AICRP On Groundnut,
Regional Research Station,
Raichur - 584 101.
* ICRISAT, Patancheru,
Andhra Pradesh

P.S. DHARMARAJ
H.D. UPADHYAY*
V.K. DESHPANDE
B.S. SARALA
V.B. NARAGUND

Received for publication June, 1995

Table 1. Relative yield performance (q/ha) of R-8808 over checks

	Kharif			Rabi/Summer		
Years	R-8808	JL-24	KRG-1	R-8808	ICGS-11	KRG-1
1989-90	18.0	20.2	14.6	41.6	42.0	36.3
1990-91	23.6	22.8	21.3	36.4	33.1	18.1
1991-92	-	-	-	25.1	23.2	17.7
1992-93	16.5	11.0	7.3	37.7	27.6	26.8
Mean	18.2	16.3	12.1	35.2	29.5	24.4
% increase		11.6	50.0		19.0	44.5

Table 2. Reaction of R-8808 to Peanut Bud Necrosis Disease

	Kharif			Rabi/Summer			
	PBND incidence (%)			PBND incidence (%)			
Years	R-8808	JL-24	KRG-1	R-8808	JL-24	KRG-1	ICGS-11
1990-91	3.7	56.5	26.7	5.0	48.0	-	13.0
1991-92	0.0	52.3	23.7	2.2	36.0	38.7	13.0
1992-93	0.0	15.0	12.0	0.0	-	60.0	1.32
Mean	1.23	41.27	20.80	2.40	42.00	49.35	9.10

J. Oilseeds Res. 13 (1) 1996: 113-115
ISSN 0970-2776

GENETIC DIVERSITY IN INDIAN RAPESEED (*BRASSICA CAMPESTRIS* L.)

Indian rapeseed is the most important oilseed crop of Assam. In order to develop high yielding varieties of this crop, the extent of genetic variability and divergence was assessed in a set of 37 genotypes of Indian rapeseed collected from various places in India. The materials included 34 *toria*, 2 brown *sarson* and one yellow *sarson* genotype. They were grown in randomized block design with 3 replications in the experimental farm of the Department of Plant Breeding and Genetics, Assam Agricultural University, Jorhat during 1989-90 winter season. Each genotype was grown in plots of 3 rows, 5 m long and 50 cm apart. The seedlings were thinned to a spacing of 10 cm. Standard agronomic practices were followed in a raising the crop. Data on 10 competitive plants of the middle row were recorded for nine characters (Table-1). Genetic variability parameters were estimated following Allard (1960). Genetic divergence was assessed using D^2 analysis and Tocher's clustering method (Rao, 1952).

Significant genotype differences were observed for all the characters. There was substantial genetic variability for all the characters as evidenced in the ranges of phenotypic expression (Table-1). High coefficients of genotype variation (>10%) were observed for secondary branches/plant, yield/plant, 1000-seed weight and primary branches/plant, which are important components of seed yield per unit area. Heritability was high (> 80%) for seed weight and days to flowering and medium (>60%) for days to maturity and plant height.

Table 1. Variability for various characters in Indian rapeseed

Character	Mean	Range	GCV (%)	Heritability (%)	Genetic advance (%)
Days to flowering	25.5	20.3-33.3	9.1	81.4	16.8
Days to maturity	92.9	87.3-103.7	3.5	69.4	6.1
Plant height (cm)	118.4	78.0-150.2	9.9	64.8	16.4
Primary branches/plant	5.3	3.6-6.9	11.7	42.9	15.7
Secon. branches/plant	47	0.9-9.5	33.6	41.9	44.9
Siliquae/plant	151.0	76.9-269.0	19.0	35.7	23.4
Seeds/siliqua	19.3	17.5-22.3	3.4	26.8	3.7
1000 seed weight (g)	3.1	2.4-4.3	13.5	82.7	25.2
Seed yield/plant (g)	6.4	3.8-11.9	18.6	30.1	21.0

Received for publication May, 1995

Considerable amounts of genetic advance at 5 per cent selection intensity were recorded for secondary branches, seed weight, siliquae/plant, seed yield/plant, days to flowering, plant height and primary branches/plant. When genotypic variability, heritability and genetic advance were considered together, seed weight came up as the most potent character for selection for yield improvement, followed by days to flowering and plant height. Chowdhury and Chowdhury (1970) and Swamy Rao (1977) similarly observed significant variability and high heritability for this character, also in Indian rapeseed. Selection for bolder seeds while maintaining parity in the other yield components would be promising for yield improvements. The genetic system for this character appeared to be of predominantly additive type (Yadav *et al.*, 1985). For other important yield components recurrent recombination would probably enhance the genetic variability for simple selection or such recurrent matings should be adjunct to regular selection programme (Katiyar *et al.*, 1984).

On the basis of D^2 analysis the 37 genotypes could be grouped into 13 clusters (Table 2) including 7 solitary and 3 twin clusters. This reflected the existence of wide diversity among the genotypes. The *toria* genotypes were within themselves diverse, as several of them formed solitary and twin clusters. The yellow *sarson* and the brown *sarson* genotypes were distinct from each other

Table 2. Clustering of Genotypes of Indian rapeseed based on D^2 values

Cluster	No. of Genotypes	Composition of clusters
I	15	T 9, PT 30, PT 303, PT 8824, DT 3, DT 11, DT2, BT 2, NDT 188, NDTC 1, TWB 29/86, TH 68, TK 8802, PBT 15, PBT 29
II	3	PT 8801, PT 8831, GWLC 86/2
III	6	B 54, DT 6, TK 8803, JMT 2/88, JMT 6/88, TWB 29/86
IV	2	TH 108, Sangam
V	2	BSH 1, Pusa Kalyani
VI	2	TS 29, M 27
VII	1	TK 8801
VIII	1	JMT 4/88
IX	1	TL 15
X	1	DK 1
XI	1	STCC
XII	1	TH 119
XIII	1	B 9

and from the *toria* group. There was no general agreement between geographical and genetic diversity. However, some genotypes of common origin were grouped together. The two commercial varieties of Assam, viz., M 27 and TS 29 formed a distinct cluster, but STCC which also originated from local germplasm, was included in one solitary cluster. Thus, a given geographical area should not be presumed as uniform entity for genetic divergence.

The magnitudes of average inter-cluster distances revealed that cluster XIII (B 9, yellow *sarson*) was the most divergent cluster followed by cluster V (BSH 1 and Pusa Kalyani, brown *sarson*) and cluster VI (M 27 and TS 29, *toria*). Therefore, the *toria* and the *sarson* genotypes evaluated in this study were widely diverse. Similar genetic diversity between *sarson* and *toria* genotypes was reported by Agarwal (1976). Crosses between the divergent populations are expected to give greater heterosis and transgressive segregation for productivity traits, as was evidenced in this crop by Rai (1989) and Barua *et al.*, (1995).

Department of Plant Breeding & Genetics,
Assam Agricultural University,
Jorhat - 785 013.

P.K. BARUA
B. LANGTHASA
R.K. CHOWDHURY

Agarwal, B.L. 1976. Studies on genetic diversity and heterosis in rapeseed *Brassica campestris* L.) Ph.D. thesis, G.B. Pant University of Agriculture and Technology, Pantnagar..

Allard, R.W. 1960. Principles of Plant Breeding. John Wiley & Sons, Inc. New York.

Barua, P.K.; Chowdhury, R.K. and Hazarika, M.H. 1995. Augmentation of genetic diversity in Indian rapeseed through varietal hybridization. Proc. Sem. "Problems and prospects of agricultural research and development in northeast India". Nov. 27-28, 1995. Assam Agric. Univ., Jorhat (In press).

Chowdhury, R.K. and Chowdhury, J.K. 1970. Studies on variability and correlation in some varieties of brown sarson. J. Res. Punjab agric. Univ. 7: 296-300.

Katiyar, R.K., Gupta, V.K. and Arunachalam, V. 1984. An approach to population improvement in self-incompatible turnip rape. Indian J. agric. Sci. *54*: 41-44.

Rai, B. 1989. Heterosis breeding in self-pollinated oilseed crop Brassicas. In Heterosis Breeding. Proc. Natl. Seminar, BCKVV, Kalyani. PP. 25-33.

Rao, C.R. 1952. Advanced Statistical Methods in Biometrical Research. John Willey and Sons, Inc. New York.

Swamy Rao, T. 1977. Genetics of yield components in brown sarson. Genet. Iber. *29*: 219-227.

Yadav, I.S., Kumar, D. and Yadava, T.P. 1985. Inheritance of seed weight in brown sarson. J. Oilseeds Res. *2*: 272-276.

J. Oilseeds Res. 13 (1) 1996: 116-117
ISSN 0970-2776

PERFORMANCE OF *GOBHI SARSON* (*BRASSICA NAPUS* VAR. GSL 1) IN RELATION TO SOWING DATES AND ROW SPACINGS

A field experiment was conducted at SKUAST, Regional Agriculture Research Station, R.S. Pura, Jammu with Gobhi Sarson (*B. napus* Var. *GSL-1*) during winter season of 1991-92. The treatments comprising sowing dates (5, 15, 25 October, 4, 14, 24 November and transplanting 60 day old seedlings on 14 and 24 November) as main plots and three row spacings (30, 45 and 60 cm) as sub-plots were tested in a split-plot design with three replications. The soil was clay-loam with pH 7.5, low in available N and P and high in available K. Recommended dose of 30kg N and 30kg P_2O_5 was applied at the time of sowing and 30 kg N/ha was top dressed 20 days after sowing. The crop received irrigations at 20, 40 and 70 days after sowing. The plant density of 3.33, 2.22 and 1.66 lakh plants/ha was maintained by thinning plant to plant distance in case of 30, 45 and 60 cm spacing, respectively.

Date of sowing had significant effect on seed yield. The highest seed yield of 16.20 q/ha was obtained in 5 October sowing which was at par with 15 October Sowing. The reduction in yield with delayed sowing ranged between 4.4 to 39.0 per cent in case of direct seeding. Similar results have been reported by Tomar (1989). Transplanting of 60 day old seedlings on 14 and 24 November also recorded significantly higher yield, being 25.1 and 14.3 per cent, than direct seeding on these dates. Sowing on 5 October led to more plant height, development of more branches, siliqua/plant and 1000 seed weight than the other dates. However, sowing dates had no significant effect on length of siliqua, seeds/siliqua and oil per cent. There was a progressive reduction in the yield attributes in later dates (Table-1).

Significantly higher seed yield was recorded at 30cm row spacing than 45 cm and 60 cm. This could be due to higher plant population in 30 cm spacing. The lowest seed yield was obtained with 60 cm spacing which is in conformity with the results of Singh and Dhillon (1991). No significant interaction between sowing dates and spacing was observed.

SKUAST, Regional Agriculture
Research Station, R.S. Pura,
Jammu - 181 102.

K.L. BHAGAT
J.P. GUPTA
Y.P. KHANNA

Tomar, R.K.S. 1989. Effect of dates of sowing and plant population on yield of toria. J. oil seeds Res., 6 (1): 162-64.

Singh, T. and Dhillon, S.D. 1991. Response of toria (*Brassica campestris Var. toria)* to sowing dates and row spacing in South-Western Punjab. Indian. J. Agron. 36 (4): 614.

Received for publication February, 1995

Table 1 : Effect of sowing dates and row spacing on yield and yield attributes of Gobhi sarson

Treatments	Seed yield (q/ha)	Plant height (cm)	Primary branches/ plant	Secondary branches/ plant	Siliquae/ plant	Lenght of siliqua (cm)	Seeds/ siliqua	1000- seed weight (g)	Oil (%)
Dates of sowing:									
5 Oct.	16.20	154.4	6.1	6.2	163.7	6.5	23.1	4.0	34.8
15 Oct.	15.91	148.3	5.3	4.9	157.5	6.4	22.8	3.9	34.6
25 Oct.	15.48	145.4	5.3	4.9	134.8	6.2	22.7	3.9	34.9
4 Nov.	13.09	143.1	5.3	4.8	131.7	6.2	21.9	3.8	35.2
14 Nov.	10.28	142.7	5.1	3.9	127.6	6.2	21.4	3.6	35.1
14 Nov. (Transplanting)	12.87	142.7	5.0	4.2	140.6	6.4	22.3	3.5	35.4
24 Nov.	9.88	140.5	4.8	3.6	120.8	6.1	21.3	3.4	34.4
24 Nov. (Transplanting)	11.35	138.1	5.0	4.1	128.6	6.2	22.5	3.3	35.4
CD (0.05)	0.39	9.5	1.0	1.9	21.6	NS	NS	0.2	NS
Row spacing (cm)									
30	14.96	142.8	4.9	4.2	131.4	6.4	21.8	3.5	35.1
45	12.93	143.1	5.4	4.6	140.9	6.4	22.2	3.7	35.3
60	11.14	145.1	5.6	5.2	142.2	6.4	22.4	3.9	35.4
CD (0.05)	0.22	NS	0.6	1.0	11.7	NS	NS	NS	-

J. Oilseeds Res. 13 (1) 1996: 118-121
ISSN 0970-2776

ECONOMICS OF WEED CONTROL IN SOYBEAN (*GLYCINE MAX* (L.) MERRILL)

A field experiment was conducted during *Kharif* 1993, at Gandhi Krishi Vignana Kendra, University of Agricultural Sciences, Bangalore. The study involved seven herbicidal applications (two pre-sowing incorporations, three pre-emergence and two post-emergence), hand weeding twice (at 3rd and 6th week after sowing), weed free throughout and weedy check (Table 1). Among the weed control treatments pre-plant incorporation of Alachlor granules at 2.0 kg a.i./ha resulted in higher gross return (Rs. 27,200/ha), net return (Rs. 18,577/ha), profit per rupee invested (Rs. 2.15) and marginal benefit cost ratio (Rs. 8.26).

The choice of any weed control method, ultimately depends on economics and efficiency in controlling weeds. The cost of chemical weed control is actually less than that of manual weeding. This has been a major incentive to many farmers for switching over to herbicides. Shekar *et al.*, (1992) recorded maximum gross returns with pre-emergence application of Alachlor at 2.0 kg a.i./ha, as compared to other herbicides in soybean.

Economics of weed control was worked out considering prevailing rates of herbicides, labour units required for spraying and handweeding as the case may be. Total cost of cultivation included other input costs, labour cost, revenue charges and marketing charges. The following formulae were used to work out economics.

Gross return	=	*Seed yield x Market price of seeds/kg*		
Net return	=	Gross return	-	Cost of cultivation
Marginal return	=	Gross return from the particular weed control treatment	-	Gross return from the unweeded control treatment

$$\text{Benefit cost ratio} = \frac{\text{Net returns}}{\text{Total cost of cultivation}}$$

Economic analysis was done by taking into consideration additional net returns obtained over weedy check, and weed control cost (Philip and Roy, 1993).

Additional net returns	=	Net returns from particular weed control treatment	-	Net return from weedy check

The treatments were arranged in descending order of additional net returns and were taken on X-axis, additional net returns and cost of weed control were plotted on Y-axis.

The point at which the two curves meet would be the limit of acceptability. The treatments falling left to this limit are acceptable and the treatments falling right to this are liable to be rejected (Fig. 1).

Among the different weed control treatments, post-emergence application of Sethoxydim at 1.5 kg a.i./ha recorded highest total cost of cultivation (Rs. 11031/ha) and cost of weed control (Rs. 3144/ha) because of higher unit cost of the chemical (Table-1). The lowest total cost of cultivation and weed (control cost Rs. 8303 and 414/ha, respectively) were recorded with post-emergence application of Lactofen at 0.15 kg a.i./ha, mainly because of less amount of herbicide needed per ha, followed by pre-plant incorporation of Alachlor granules at 2.0 kg a.i./ha (Rs. 8623 and 736/ha, respectively). Pre-planting incorporation of Alachlor granules at 2.0 kg a.i./ha recorded higher gross return (Rs. 27200/ha) net return (Rs. 18577/ha), marginal return (Rs. 6080/ha)and higher

Received for publication April, 1995

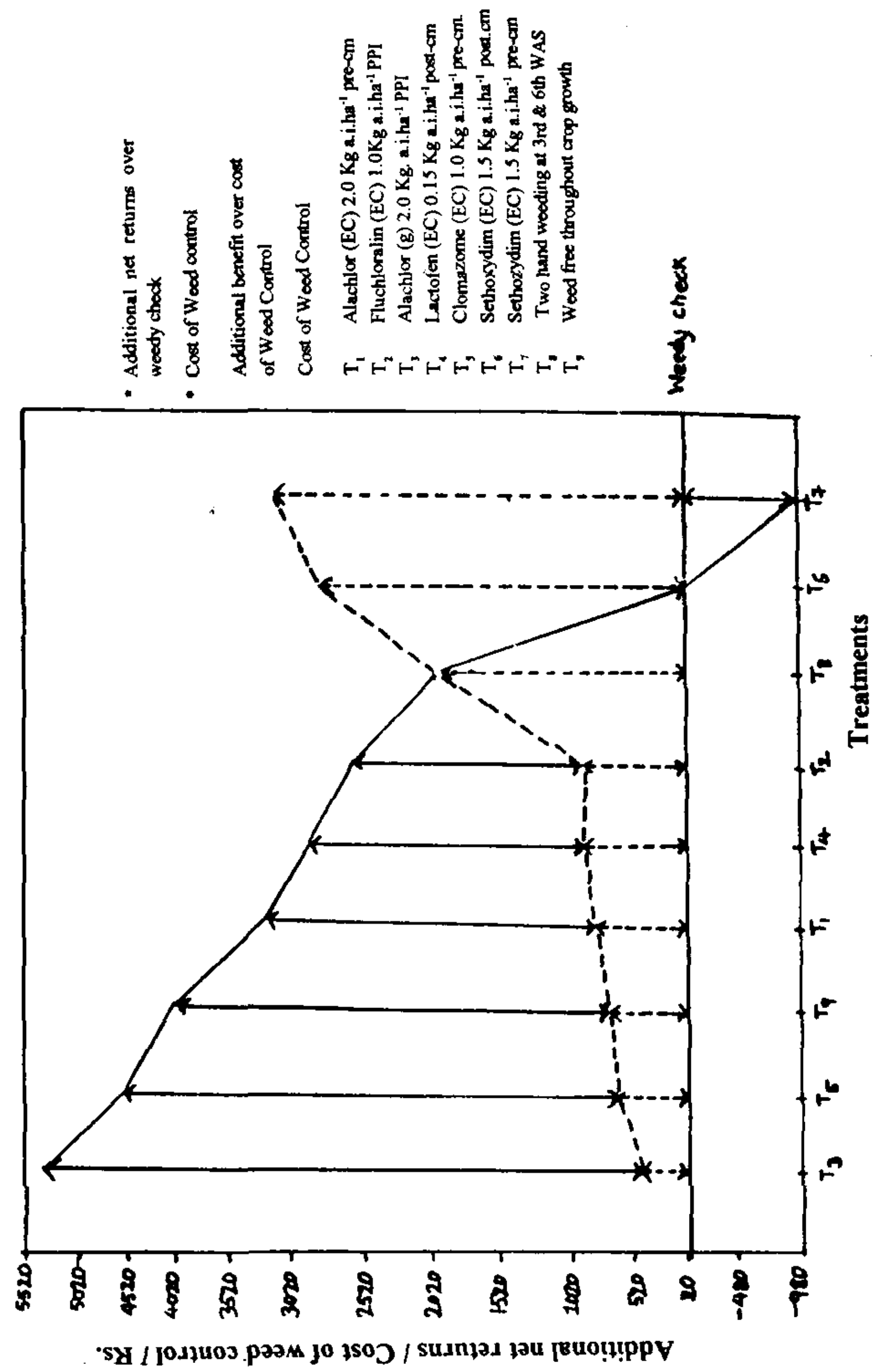


Fig. 1. Economic analysis of weed control in soybean

profit per rupee invested (Rs. 2.15) due to higher seed yield resulted from better weed control.

Pre-planting incorporation of Alachlor granules at 2.0 kg a.i./ha, Clomazome at 1.0 kg a.i./ha, weed free throughout, Alachlor (EC) at 2.0 kg a.i./ha, Lactofen at 0.15 kg a.i./ha, fluchloralin at 1.0 kg a.i./ha and hand weeding twice fall within the limit of acceptibility in the order, by virtue of their higher monetary benefits over cost of weed control (Fig. 1). Whereas post-emergence application of Sethoxydim at 1.5 kg a.i./ha and pre-emergence application Sethoxydim at 1.5 kg a.i./ha fall outside the limit of acceptability due to their higher costs of weed control over additional monetary benefit.

From this study, it can be inferred that pre-plant incorporation of Alachlor granules at 2.0 kg a.i./ha is highly economical in controlling weeds in soybean giving higher additional monetary return over cost of weed control, as compared to remaining treatments. However the results need further confirmation for large scale application.

Department of Agronomy,
University of Agricultural Sciences,
Bangalore - 65.

H.K. BASAVARAJU
H.V. NANJAPPA

Philip, K.T. and Roy, H.F., 1993. Weed control and the economic threshold. *Proc. Int. Symp. Indian Soc. Weed Sci., Hisar J.* 17-27.

Shekar, B.G., Nanjappa, H.V. and Rajappa, M.G., 1992. Weed control in soybean, herbicidal v/s cultural methods. *Mysore J. Agric. Sci., 26*: 372-379.

Table 1 : Economics of Weed Control in Soybean

Treatments	Total cost of cultivation (Rs./ha)	Cost of weed control (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	Marginal return (Rs./ha)	Profit per rupee invested
Alachlor (EC) 2.0 kg a.i./ha pre-em.	8959	1072	25425	16466	4305	1.84
Fluchloralin 1.0 kg a.i./ha PPI	8702	815	24480	15778	3360	1.81
Alachlor granules 2.0 kg a/i. ha PPI	8623	736	27200	18577	6080	2.15
Lactofen (CEC) 0.15 kg a.i./ha post-em.	8301	404	24480	16179	3360	1.95
Clomazome (EC) 1.0 kg a.i./ha pre-em	8659	772	26520	17861	5400	2.06
Sethoxydim (EC) 1.5 kg a.i./ha post-em.	11031	3144	24336	13305	3216	1.21
Sethoxydim (EC) 1.5 kg a.i./ha pre-em.	10959	3072	23216	12257	2096	1.12
Two hand weedings at 3rd & 6th WAS	*8967*	1080	24088	15121	2968	1.68
Weed free throughout crop growth	9687	1800	24088	15121	2968	1.68
Weedy check	*7887*	-	*21120*	*13233*	-	1.68

Cost of herbicides:

DAS	=	Days after sowing	Alachlor (48 EC)	=	Rs.240/lt	Soybean	=	Rs. 800/q.
Post-em.	=	Post-emergence	Alachlor (10 G)	=	Rs. 35 / kg			
PPI	=	Pre-plant incorporation	Clomazome (50 EC)	=	Rs. 350/lt.			
Pre-em.	=	Pre-emergence	Fluchloralin (45 EC)	=	Rs. 335/lt.			
WAS	=	Weeks After Sowing	Sethoxydim (12.5 EC)	=	Rs. 250/lt.			

J. Oilseeds Res. 13 (1) 1996: 122-123
ISSN 0970-2776

RESPONSE OF WINTER NIGER (*GUIZOTIA ABYSSINICA*) TO SOWING TIME AND FERTILITY LEVELS

Niger (*Guizotia abyssinica*) is traditionally grown during rainy season on hill tops and tribal belts of Madhya Pradesh with rare or no fertilizer usage resulting in low yields. Singh *et al.*, (1982) reported that its yield could be increased by raising it in the winter season under irrigated conditions. But there is dearth of information on proper sowing time and fertilizer requirement of winter season crop for Jabalpur region of Madhya Pradesh. Hence, an experiment was conducted at the Agricultural Engineering College Farm, Jabalpur (M.P.) during winter 1993-94. The soil of the experimental field was sandy loam in texture, neutral (pH 6.9) in reaction. It had 213 kg N, 12.6 kg P_2O_5 and 338 kg K_2O/ha. Twelve treatments consisting of four sowing dates (November 1, 19 and December, 10, 30) as main plot treatments and three fertility levels (O:O:O, 20:20:10 and 40:40:20 kg NPK/ha) as sub-plot treatments were tested in split-plot design with four replications. Crop Cv. Ootackmund was sown with a seed rate of 10 kg/ha in rows 25 cm apart in plots of size 4 x 3m. The crop received irrigations at sowing and at 30, 55 and 70 days after sowing. Data on yield attributes and seed yield were recorded at harvest.

The time of sowing had a significant influence on yield and yield attributes of niger (Table-1). The crop sown on 1 and 19 November produced maximum yield of 10.19 and 9.65 q/ha, but reduced significantly by delayed sowing on 10 or 30 December. This effect was mainly due to the significant reduction in number of capitula/plant and the number of seeds/capitulum in the later dates of sowing. The thousand seed weight reduced significantly when the crop was sown on 30 December compared to 1 November. Similar results were also reported by Belayneh *et al.*, Sharma and Kewat (1994) and Singh *et al.*, (1982).

Increasing levels of fertility significantly increased seed yield upto 40:40:20 kg NPK/ha, mainly due to significant improvement in number of capitula/plant and seeds/capitulum. Fertility levels had no marked influence on test weight of seeds. These results are in conformity with the findings of Trivedi and Ahlawat (1991) and Sharma and Kewat (1994).

From the foregoing it could be inferred that sowing niger upto 19th November, and application of 40:40:20 kg NPK/ha appeared to be ideal for winter season crop raised under irrigated conditions.

College of Agricultural Engineering
JNKVV, Adhartal,
Jabalpur 482 004 (M.P.)

K.K. AGARWAL
K.K. JAIN
R.S. SHARMA
M.L. KASHYAP

Received for publication June, 1995.

Table 1. Effect of sowing time and fertility levels on yield attributes and seed yield of niger

Treatment	Number of capitula / plant	Number of seeds / capitulum	1000 seed weight (g)	Seed yield (q/ha)
Sowing time				
1 November	67.4	22.8	3.39	10.19
19 November	63.3	21.7	3:36	9.65
10 December	58.6	19.6	3.32	8.02
30 December	52.7	18.3	3.27	6.66
C.D. (0.05)	3.6	0.9	0.09	1.45
Fertility level: (N:P:K kg / ha)				
0:0:0	51.5	18.7	3.34	5.93
20:20:10	61.6	20.4	3.35	9.16
40:40:20	68.4	22.7	3.32	10.87
C.D. (0.05)	2.5	0.5	NS	1.30

Belayneh, Hiry, Riely, K.W. and Tadesa, Nagata, 1986. The effect of sowing date, seed rate and fertilizer on seed yield of niger in central highlands of Ethiopia. *J. Oilseeds Res.* 3: 216-222.

Sharma, R.S. and Kewat, M.L. 1994. Effect of sowing dates and fertilizer on yield attributes and seed yield of niger under rainfed condition. *Indian J. Agron.* 39: 148-150.

Singh, P.P., Nakhtore, C.L. and Motiramani, D.P. 1982. Yield potential of some niger varieties as influenced by sowing dates and row spacings. *Mysore J. Agric. Sci.* 16: 392-395.

Trivedi, S.J. and Ahlawat, R.P.S. 1991. Effect of nitrogen and phosphorus on growth and yield of niger. *Indian J. Agron.* 34: 432-433.

J. Oilseeds Res. 13 (1) 1996: 124-126
ISSN 0970-2776

SELECTION FOR HIGH KERNEL YIELD IN SUNFLOWER: THE IMPORTANCE OF KERNEL TO HULL RATIO

Sunflower is mainly grown as a rainfed crop during monsoon wherein, uncertainties of rainfall during mid vegetative phase lead to poor growth and productivity (Uma Shanker *et al.*, 1991). The productivity in terms of oil yield is a function of kernel yield and its oil percentage. However, the variation in kernel oil content is less compared to the seed oil content across the genotypes (Rabishankar, 1990). Therefore it appears that kernel yield per unit land area is a better expression of productivity in terms of oil yield.

In this context, the effect of moisture stress on kernel yield and the role of kernel to hull ratio on kernel yield were investigated in sunflower germplasm. A field experiment was therefore conducted at the University of Agricultural Sciences, Bangalore on red clay loam during summer, 1994. Twenty one germplasm lines including a check variety EC 68415 were sown in *split - plot design with two treatments (irrigated* control and stressed) in four replications in a plot size of 7.2 m^2 area. Moisture stress was imposed during mid vegetative phase (35 days after sowing to 70 DAS) by withholding irrigation. Crop was maintained following recommended package of practices.

Observations on leaf area at the end of stress period was measured following a non-destructive method (Nanja Reddy *et al.*, 1995). At harvest, the data on seed yield, total dry matter (TDM), test weight and kernel to hull ratio were recorded from plants in m^2 area. Kernel yield and the harvest index (HI) were also calculated.

Moisture stress during mid-vegetative phase decreased the seed and kernel yield by 50 and 45 per cent respectively over their respective controls (Table 1). This might be due to a reduction in leaf area index (LAI). Test weight and harvest index were affected least due to stress since, stress was alleviated by the time the seed filling process started. This is substantiated by a study of Sadras *et al.*, (1993), where he showed that the partitioning of assimilates to seed filling was not limited due to moisture stress.

Seed yield under a given environment is the product of TDM and HI (Nanja Reddy *et al.*, 1994). In the present study, the extent of

Table. 1. Growth and yield attributes in sunflower germplasm under irrigated - and stressed (S) conditions.

Character	Irrigated (I)	Stressed	% reduction Over I
Seed yield (gm^{-2})	190.00	113.40	40.3
Kernel yield (gm^{-2})	127.40	70.60	44.6
TDM (gm^{-2})	719.50	497.80	30.8
Harvest Index	0.26	0.23	11.5
Leaf area Index	2.94	1.64	44.2
Test weight (g/100 seed)	6.21	5.38	13.4
Kernel / Hull ratio	2.15	1.74	19.1

Received for publication May, 1995

relationship between seed or kernel yield and TDM was more compared to that of HI (Table 2). The highly significant positive relationship between LAI and TDM indicates the importance of LAI under stress conditions. The seed and kernel yields are correlated positively and significantly with each other. However, our interest of selection is for high kernel yield, because, kernel yield is a better expression of productivity since considerable variation exists for kernel/hull ratio (AICORPO, 1991). However, no relationship exists between K/H ratio and oil content (AIRCORPO, 1991). There is an indirect evidence to show that seed density or test weight are positively correlated to oil content (Seiler, 1983) and, the test weight is directly and significantly related with K/H ratio in the present study, especially under stress conditions (Table 2).

Table. 2. Correlation co-efficients between a few growth and yield attributes of sunflower germplasm under irrigated and stressed conditions.

Character			r - values	
			Irrigated	Stressed
1.	Seed yield Vs	TDM	0.95	0.89
		HI	0.59	0.24
		Test weight	0.52	0.46
2.	Kernel yield Vs	TDM	0.89	0.78
		Test weight	0.54	0.49
3.	TDM Vs LAI		0.78	0.70
4.	Seed yield Vs	Kernel yield	0.96	0.95
5.	K/H ratio Vs	Test weight	0.34	0.43
		HI	0.01	0.15
		Seed yield	0.22	0.31
		Kernel yield	0.45	0.59

TDM: Total dry matter, LAI: Leaf area index at the end of mid season stress (between 35 to 70 days after sowing):
r- values for significance at n-2 degrees of freedom are 0.43 $P< 0.05$, $P < 0.01$, 0.67 $P< 0.001$.

Though the seed yield was similar between two lines (Table 3) their kernel yields differed. Similarly, even though the kernel yield of two lines was same (Table 3), they differed in seed yield. These variations were due to the differences in K/H ratios. Further, it is also observed that the extent of relationship of K/H ratio with HI, test weight, kernel yield and seed yield were more under stress conditions (Table 2). This indicates the importance of K/H ratio under stress situations.

Therefore, we have selected lines namely, Acc 1634 and ACC 1651 which had high kernel yield under irrigated conditions with its least reduction under stress conditions. These lines were considered as drought tolerant lines in terms of kernel yield and thus oil productivity.

Since mid season stress limits the productivity by virtue of less dry matter accumulation, genotypes for high productivity should be selected for high kernel yield by selecting for high LAI (around 4.0), high K/H ratio and high test weight.

Table. 3. A few sets of sunflower genotypes showing similar seed yield with differing kernel yields and a similar kernel yield with differing seed yields.

	Germplasm		Kernel yield (gm^{-2})	Seed yield (gm^{-2})	K/H ratio
(a)	**Under stressed treatment (same seed yield with differing kernel yield)**				
I.	Acc	931	44.3	86.9	1.04
	M	114	55.9	88.9	1.69
II.	Acc	666	63.7	107.0	1.47
	EC	68415	79.6	108.0	2.80
III	Acc	1260	79.0	169.9	0.87
	Acc	1616	89.2	166.1	1.16
IV.	Acc	1135	82.7	134.0	1.61
	Acc	423	93.1	139.0	1.99
V.	Acc	1651	133.6	207.0	1.82
	Acc	456	154.1	205.1	3.02
(b)	**Under Control treatment (Same kernel yield with differing seed yield)**				
I.	EC	68415	135.8	172.0	3.75
	Acc	1609	135.5	224.0	1.53
II.	Acc	1616	140.8	240.0	1.42
	Acc	701	141.9	201.0	2.40
III.	Acc	456	209.3	267.0	3.63
	Acc	1638	214.9	313.0	2.19

Department of Crop Physiology and
* Project Co-ordinating Unit (Sunflower)
University of Agricultural Sciences
GKVK, Bangalore 560 065

Y.A. NANJA REDDY
R. UMA SHAANKER
K. VIRUPAKSHAPPA*
T.G. PRASAD

AICORPO, 1991. Annual Progress Report: Sunflower for the year, 1991-92, DOR, ICAR, Hyderabad, 229 pp.

Nanja REddy, Y.A., Sheshshayee, M.S., Uma Shaanker, R., Virupakshappa, K. and Prasad, T.G. 1994. Selection for high canopy assimilation rate is a good strategy to increase productivity in sunflower, *Helia*, 17: 45-52.

Nanja Reddy, Y.A., Keshava Murthy, M.N. Virupakshappa, K. and Uma Shaanker, R. 1995. An improved non-destructive method for rapid estimation of leaf area in sunflower genotypes *J. Agron.* (In Press, 1995).

Ravishankar, K.V. 1990. Drought tolerance studies in sunflower: Field evaluation of sunflower gemplasm for relative drought resistance at two crop growth stages. M.Sc. (Agri.). Thesis, University of Agricultural Sciences, Bangalore, Karnataka.

Sadras, V.O., Connor, D.J. and Whitfield, D.H. 1993. Yield, yield components and source-sink relationships in water stressed sunflower. *Field Crop Res.* 31: 27-39.

Seiler, G.J. 1983. Effect of genotype, flowering date and environment on oil content and seed quality of wild sunflower seed. *Crop Sci.*, 23: 1063-68.

Uma Shaanker, R., Ravishankar, H.M., Virupakshappa, K., Prasad, T.G. and Udaya Kumar, M. 1991. Sunflower Physiology - A detailed review monograph. University of Agricultural Sciences, Bangalore, Karnataka.

J. Oilseeds Res. 13 (1) 1996: 127-128
ISSN 0970-2776

EFFECT OF N, P AND FYM ON YIELD AND OIL CONTENT OF *GOBHI SARSON* AND *TORIA* INTERCROPPING

Intercropping of gobhi sarson (*Brassica napus* sub sp. *oleifera* var. *annua*) + toria (*B. campestris* var. *toria*) has been investigated to increase the productivity per unit area (Chaudhary and Singh, 1993). Soil fertility has been found to affect the quality and quantity of oilseed crops. Therefore, present investigation was taken up to study the effect of N, P and FYM levels on seed and oil yield and oil content of the component crops.

Gobhi sarson + toria were sown in 1:1 ratio using recommended seed rate (100%) of each for two consecutive years in October first week during 1992-93 and 1993-94, on silty clay loam acidic (pH 5.6) soil at HPKV, Palampur, in mid hills of N-W Himalayas. The soil was medium in available N (291 kg ha^{-1}), P (16.1 kg ha^{-1}), K (224 kg ha^{-1}) and organic carbon (0.72%). Available S content was 22 ppm.

Treatments comprising of 17 combinations of levels of N (40, 80 120 and 160 kg ha^{-1}) P (40 and 80 kg P_2O_5) ha^{-1}) and FYM (0, and 5 t ha^{-1} on dry weight basis) besides one absolute control, was laid out in randomised block design. Half N through urea, full P through single super phosphate, 40 kg K_2O ha^{-1} through muriate of potash and FYM were applied at sowing. FYM was broadcast and incorporated into soil before sowing while N, P and K were band placed. Remaining N was top dressed in *gobhi sarson* after harvest of *toria* in the second fortnight of January. The crops received irrigation at pre-sowing and flowering stages of gobhi sarson in mid April.

Oil content was determined by Nuclear Magnetic Resonance (N.M.R.) technique. Oil yield per unit area was worked out by multiplying the oil content by seed yield.

Effect on seed yield and quality: Gobhi sarson exhibited significant response to N upto 80 kg N ha^{-1} and 120 kg N ha^{-1} during 1992 and 1993 respectively, (Table 1). Toria responded significantly upto the highest dose of 80 kg N ha^{-1}.

Oil content in seeds of gobhi sarson and toria decreased with increase in levels of nitrogen. Depression in oil content with increased supply of nitrogen may possibly be due to the dilution effect. Increased supply of phosphorus did not increase the oil content. It is in conformity with the results of Reddy and Sinha (1989). Significant beneficial effect of FYM on oil content of gobhi sarson and toria was observed during 1993 only. Our study revealed a negative effect of nitrogen, no effect of phosphorus and positive effect of FYM on oil content. The difference between fertilized plots and control was not discernible.

Oil Yield: Because of the increased seed yield of crops with the increase in N, P and FYM, oil yield also increased significantly (Table 1). Mean data of total oil yield (gobhi sarson + toria) revealed significant response upto 120 kg N ha^{-1} in manured plots and upto 80 kg N ha^{-1} in unmanured plots. Similarly, application of 80 kg P_2O_5 ha^{-1} in conjunction with 5t FYM ha^{-1} gave significantly higher oil yield.

Received for publication September, 1995

Himachal Pradesh Krishi Vishvavidyalaya,
Palampur.

B.S. MANKOTIA[1]
H.L. SHARMA[2]

Chaudhary, J.B. and Singh, C.M. 19993. Effect of intercropping gobhi sarson (*Brassica campestris* var. *toria*) on their land equivalent ratio and net returns. *Indian J. agric. Sci.* 63 (2) : 825-826.

Reddy, B.N. and Sinha, M.N. 1988. Yield and phosphorus utilization of mustard as influenced by phosphorus at various levels of nitrogen and moisture regimes. *Fert. News.* 33(2): 31-37.

Table 1. Effect of N, P and FYM on seed and oil yield (q ha^{-1}), and oil content (%) of *gobhi sarson* and *toria*

Treat-ments	Gobhi sarson				Toria				Total oil yield (Mean of two years)
	Seed yield		Oil content		Seed yield		Oil content		
	1992-93	1993-94	1992-93	1993-94	1992-93	1993-94	1992-93	1993-94	
N levels (kg ha^{-1})									
40	9.84	5.54	47.03	46.08	2.26	1.80	42.76	39.58	4.42
80	12.03	7.66	46.45	46.20	3.05	2.46	42.87	40.51	5.73
120	11.48	9.57	46.47	45.83	3.47	2.98	42.06	39.61	6.20
160	11.27	9.98	45.95	45.10	3.85	3.47	40.96	38.98	6.32
S.Ed.	0.55	0.41	0.34	0.29	0.16	0.16	0.66	0.72	0.18
CD (0.05)	1.12	0.83	0.68	0.59	32.8	0.33	1.34	NS	0.36
P levels (kg P_2O_5 ha^{-1})									
40	10.41	6.76	46.66	45.66	2.89	2.47	42.23	39.49	5.08
80	11.89	9.62	46.29	45.94	3.35	2.89	42.09	39.85	6.26
S.Ed.	0.39	0.29	0.24	0.20	0.11	0.12	0.48	0.51	0.13
CD (0.05)	0.80	0.59	NS	NS	0.23	0.24	NS	NS	0.26
FYM levels (t ha^{-1})									
0	10.39	6.18	46.32	45.59	2.65	1.72	42.11	39.06	4.71
5	11.92	10.21	46.63	46.01	3.66	3.63	42.21	40.27	6.62
S.Ed.	0.39	1.29	0.24	0.20	0.11	0.12	0.47	0.51	0.13
CD (0.05)	0.79	0.59	NS	0.41	0.23	0.24	NS	1.04	0.26
Control vs others									
Control	15.31	1.81	47.03	45.70	1.01	1.15	42.60	38.87	2.10
Others	11.15	8.19	46.48	45.80	3.15	2.68	42.16	39.67	5.67
S.Ed.	0.80	0.59	0.49	0.42	0.23	0.24	0.96	1.05	0.27
CD (0.05)	1.64	1.21	NS	NS	0.48	0.49	NS	NS	0.55

J. Oilseeds Res. 13 (1) 1996: 129-130
ISSN 0970-2776

NITROGEN FIXATION AND YIELD OF SOYBEAN [*GLYCINE MAX* (L.) MERR.] AS INFLUENCED BY NITROGEN, PHOSPHORUS, *RHIZOBIUM* AND SUBMERGENCE

Soybean [*Glycine max* (L.) Merr.] is fast gaining popularity in the South-Eastern zone of Madhya Pradesh during the rainy season. The nitrogen requirement of the crop is quite high and a major part of this requirement is met through biological nitrogen fixation. Nutrient supply and *Rhizobium* inoculation can affect the nitrogen fixation and yield of soybean. Farmers in this region face problem of submergence during vegetative and reproductive stages of the crop. The present experiment was conducted to study the effect of nitrogen, phosphorus, *Rhizobium* and submergence on nitrogen fixation and yield of soybean at Indira Gandhi Agricultural University, Raipur, Madhya Pradesh during *kharif* 1992. The soil was clayey with available N, P_2O_5 and K_2O of 235.2, 13.74 and 330 kg/ha, respectively, and pH 7.1. The seven treatments laid out in randomized block design replicated thrice, comprised of 30 kg N/ha applied as basal with no P ($N_{30}P_0$), 60 kg P_2O_5/ha with no N (N_0P_{60}), 30 kg N/ha and 60 kg P_2O_5/ha as basal + 20 kg N/ha at pod filling stage at 70 DAS ($N_{30+20}P_{60}$), 30 kg N/ha and 60 P_2O/ha as basal ($N_{30}P_{60}$), 30 kg N/ha and 60 kg P_2O_5/ha as basal + *Rhizobium* inoculation ($N_{30}P_{60}$ + Rh), 30 kg N/ha and 60 kg$N_{30}P_{60}$/ha as basal + submergence at vegetative stage consisting of 5 cm standing water for 7 days from 38 to 44 DAS ($N_{30}P_{60}$ + Su.V) and 30 kg N/ha and 60 kg P_2O_5/ha as basal + submergence at full bloom stage consisting of 5 cm standing water for 7 days from 58 to 64 DAS ($N_{30}P_{60}$ + Su.F). Potassium at 30 kg K_2O/ha was uniformly applied to all the treatments. Total N balance was obtained by subtracting N supplied through fertilizer + native soil N from total N uptake and available soil N added together [N balance = (Total N uptake + Available soil N at harvest) - (Fertilizer N + Native soil N)], which was used by Nambiar *et al.*, (1988). George *et. al.*, (1988) reported that the total N accumulation in some non-nodulating soybean cultivars was to the extent of 70-95 kg N/ha without supply of any

Table 1. Effect of nitrogen, phosphorus, rhizobium and submergence on nitrogen balance, fixation and grain yield of soybean

Treatment	Total N uptake (kg/ha)	Available soil N at harvest (kg/ha)	N Supplied + Native soil N (kg/ha)	N Balance (kg/ha)	N fixed (kg/ha)	Grain yield (kg/ha)
N_{30} P_o	183.77	279.22	265.20	197.79	97.79	1902
N_oP_{60}	207.13	287.71	235.20	259.64	159.64	2077
$N_{30+20}P_{60}$	232.54	304.56	285.20	251.90	151.90	2243
N_{30} P_{60}	220.71	299.48	265.20	254.99	154.99	2170
N_{30} P_{60} + Rh	238.45	308.53	265.20	281.78	181.78	2295
$N_{30}P_{60}$+Su.V	203.15	284.68	26520	222.63	122.63	2093
N_{30} P_{60}+Su. F	183.93	281.42	265.20	200.15	100.15	1946
S. Em ±	1.06	1.34			1.14	24
CD (P 0.05)	2.31	2.93	–	–	2.48	53

Received for publication April, 1995

fertilizer nitrogen. Therefore, 100 kg N/ha was considered to be accumulated in soybean plants from sources other than atmospheric N fixation. Thus, 100 kg N/ha was deducted from the N balance to work out N fixation by soybean crop (Table 1).

The results indicated that, basal dose of N and P ($N_{30}P_{60}$ + Rh) helped in adequate growth of the crop and *Rhizobium* inoculation facilitated significantly higher N fixation (Table 1). Top dressing of N at pod filling stage (N_{30+20} P_{60}) gave seed yield on par with N_{30} P_{60} + Rh but the N fixation reduced significantly. This may be attributed to the suppressed nodulation due to nitrogen top dressing observed by Rennie *et. al.*, (1982). The treatment $N_{30}P_{60}$ + Rh gave significantly highest grain yield (2295 kg/ha) and fixed more N (181.78 kg/a) than other treatments. Significantly lowest N fixation and grain yield was observed with $N_{30}P_0$ and N_0P_{60} as compared to $N_{30}P_{60}$. However, more adverse effect was observed when P was not applied ($N_{30}P_0$). This emphasizes that P nutrition is more important than N in soybean as the crop can meet N requirement by biological fixation, but cannot sustain under P deficiency. These results confirm the findings of Rajput *et. al.*, (1991).

Detrimental effect of submergence on N fixation and grain yield was more pronounced in full bloom stage as compared to vegetative stage (Table 1). Submergence at vegetative stage did not affect much, as the plants recovered in later stages of growth but submergence at full bloom stage had more detrimental effect as the N need of plant and N fixation are greater at the beginning of reproductive phase. Similar findings were reported by Scott *et al.*, (1989). Submergence at full bloom stage resulted in only 100.15 kg/ha N fixation.

Thus, the results of the present study show that *Rhizobium* inoculation and Phosphorous nutrition along with 30 kg N/ha as basal dose is important for higher N fixation and grain yield. Submergence at full bloom stage was found to be more harmful than at vegetative stage for N fixation and yield.

Department of Agronomy,
Indira Gandhi Agricultural University,
Raipur, Madhya Pradesh - 492 012.

C. SARKAR
R.S. TRIPATHI

George, T., Singleton, P.W. and Bohlool, B.B. 1988. Yield, soil nitrogen uptake, and nitrogen fixation by soybean from four maturity groups at three elevations. *Agronomy Journal* 80: 563-567.

Nambiar, P.T.C., Rupela, O.P. and Kumar Rao, J.V.D., 1988. In Biological Nitrogen Fixation - Recent Developments. (ed. N.S. Subba Rao) P 30. Oxford & IBH Pub. Co., New Delhi.

Rajput, R.L., Kaushik, J.P. and Verma, O.P. 1991. Yield and nutrient uptake in soybean as affected by irrigation, phosphorus and row spacing. *Indian J. Agronomy* 36 (4): 549-552.

Rennie, R.J., Dubetz, S., Bole, J.B., and Muendel, H.H. 1982. Dinitrogen fixation measured by 15N isotope dilution in two canadian soybean cultivars. *Agronomy Journal.* 74: 725-730.

Scott, H.D., De Angulo, J., Daviels, M.B. and Wood, L.S., 1989. Flood duration effects on soybean growth and yield *Agronomy Journal.* 81: 631-636.

J. Oilseeds Res. 13 (1) 1996: 131-132
ISSN 0970-2776

EFFECT OF NITROGEN AND PLANT DENSITY ON YIELD, YIELD ATTRIBUTES AND QUALITY OF NIGER (*GUIZOTIA ABYSSINICA* CASS.)

Information on improved varieties of niger is quite limited as varietal improvement programme has been limited to selection among the heterogeneous populations in this oilseed crop (Khare and Rao, 1985). Further, its cultivation as a mixed crop on rainfed land having low fertility status restricts the productivity. Little attention has been paid to increase the yield potential of niger having wider adaptability. The present study was therefore undertaken to assess the optimum nitrogen and plant density requirement for obtaining higher yield and better seed quality of niger.

A field experiment was conducted at the Central Research Station, Bhubaneswar during *kharif* 1992-93 in a split-plot design with N levels as main-plot and plant density as sub-plot with three replications. The net plot size was 14.4 m^{-2} and sub-plot size was 3.6 m^2. The soil was of sandy loam type with a pH of 5.5 having low organic carbon (0.39%) and total N (0.04%) and optimum level of available P (12.3 kg ha^{-1}) and K (82 kg ha^{-1}). Nitrogen was applied as per the treatment through urea in 2 splits, half as basal and the remaining half at 30 days after sowing.

The crop received a uniform basal dose of 40 kg P_2O_5 and 40 kg K_2O ha^{-1} through single super phosphate and muriate of potash, respectively. The crop matured in 144 days and was harvested.

It was found that maintaining a plant density of 66 plants m^{-2} resulted in significant enhancement in yield of niger which has been due to more number of capitula m^{-2} and weight of capitula (Table 1). The number of seeds per capitulum did not significantly differ with variation in plant density. In contrast, the test weight of seeds was higher with lower plant density than with higher plant population. However, this attribute did not reflect in the final seed yield of the crop when the same was extrapolated on unit area basis. Because at lower plant density there was a reduction in the number of capitula to the tune of 56.4%. The inter and intra-plant competition might be responsible to reduce the test weight, but the competition did not seem to be sufficient enough to affect the final seed yield adversely (Khare and Rao, 1985).

Seed yield and yield attributes significantly varied with fertilization. Although application of 60 kg ha^{-1} gave the highest yield, the yield enhancement was significant only upto 40 kg N/ha^{-1} compared to control. Control plots had the lowest value but was at par with 20 kg N ha^{-1}. A dose of 40-45 kg N ha^{-1} has been reported to be optimum as well as economical for obtaining higher seed yield of niger (Sahu *et al.*, 1988).

The highest oil content (33.9%) was obtained at 20 kg N ha^{-1} beyond which it tended to decline. In contrast, the protein content showed a gradual increase with increasing levels of nitrogen. The reduction in oil content (Zaman, 1988) and increase in protein content (Mahler and Cardes, 1971) due to N fertilization have been ascribed to degradation of carbohydrates in TCA cycle which by reductive amination and transamination process form more amino acids and thereby increase protein content in seeds. Plant density did not affect the oil and protein content in seeds, while the yield of these two traits was dramatically higher at dense plant stands than sparse populations, owing to higher seed yields obtained in the former than in the latter case.

Received for publication December, 1994

Department of Plant Physiology,
Orissa University of Agriculture
and Technology, Bhubaneswar-751 003,
Orissa.

B. PATRO
M. KAR
S.C. BISWAL

Khare, A.K. and Rao, S. 1985. Effect of varying plant densities on yield components of niger. *J. Oilseeds Res.* 2:299-302.

Mahler, B.P. and Cardes, E.H. 1971. Biological Chemistry, Harper and Rao, New York, 722-724.

Sahu, P.K., Mishra, R.C. and Rao, S.V. 1988. Effect of varieties, nitrogen levels and spacings on seed yield of niger. *J. Oilseeds Res.*, 5: 86-88.

Zaman, A. 1988. Effect of N and P on yield attributes, seed yield and oil content of irrigated safflower in lateritic soils. *Annals of Arid Zone*, 27 (1): 37-40.

Table 1 : Effect of nitrogen and plant density on yield, yield components and quality of niger

Treatments	Number of capitula m^{-2} x 10^3	Number of seeds per capitulum	Capitula weight (gm^{-2})	1000 seed weight (g)	Seed yield (kg ha^{-1})	Oil yield (gm^{-2})	Protein content (%)	Protein yield (g m-2)
Nitrogen levels (kg ha^{-1})								
0	0.8	8.2	51.5	3.44	216.2	6.98 (32.3)*	24.2	5.23
20	0.9	8.9	71.8	3.72	308.9	10.44 (33.9)	25.4	7.82
40	1.1	9.9	84.0	3.5	375.1	12.04 (32.1)	25.8	9.68
60	1.3	7.9	94.1	3.73	380.9	12.24 (32.2)	26.1	9.92
S.Em ±	0.16	0.7	12.3	0.16	44.0	-	-	-
C.D. (0.05)	NS	NS	NS	108.0	-	-	-	-
Plant density (m^{-2})								
66	1.6	8.2	112.2	3.48	468.0	14.98 (32.0)	25.1	11.75
33	1.1	8.4	78.1	3.49	312.2	10.11 (32.4)	25.3	7.89
22	0.8	9.3	56.8	3.76	271.3	8.81 (32.5)	25.3	6.86
17	0.7	9.0	51.3	3.76	228.0	7.46 (32.7)	25.8	5.88
S. Em, ±	0.1	0.7	8.6	0.09	33.0	-	-	-
C.D. (0.05)	0.2	NS	17.8	0.19	68.0	-	-	-

* Figures in parentheses indicate oil and protein content in percentage

J. Oilseeds Res. 13 (1) 1996: 133-135
ISSN 0970-2776

EFFECT OF S AND Mg FERTILIZATION ON AVAILABLE S AND Mg IN SOIL AND THEIR UPTAKE BY SUNFLOWER

Response of sunflower to application of sulphur and magnesium depends on the nutrient status of soil (Chandrasekara Reddy and Krishna Murthy, 1984; Subba Rao *et al.*, 1990). Information on the availability of S and Mg and their uptake pattern during different growth stages of sunflower, especially when grown in Alfisol, is scanty. With this in view, a field trial was conducted in Irugur soil series of Agricultural Research Station, Bhavanisagar to evaluate the influence of fertilization with sulphur and magnesium on the available S and Mg contents in soil and their uptake by sunflower crop during different growth stages.

The soil was sandy loam with a pH of 7.2 and was medium in available sulphur (18 kg ha^{-1}) and magnesium (15 kg ha^{-1}). The field trial during *rabi*, 1993 was laid out in a Factorial Randomised Block Design with 16 treatment combinations, each replicated thrice. The gross plot size was 5m x 3m. The treatments comprised of 4 levels each viz., 0, 15, 30 and 45 kg ha^{-1} of sulphur and magnesium.

The crop received a uniform basal dose of 50 Kg P_2O_5, 40 kg K_2O and 35 kg N/ha in the form of diammonium phosphate, muriate of potash and urea, respectively. Remaining 50 per cent of N was top dressed when the crop was 30 days old. Sunflower seeds (Var. Morden) were sown during July, 1993 and the crop was harvested during September, 1993. Soil and plant samples were collected at grand growth (35 DAS), flowering (50 DAS) and maturity stages. Soil samples were analysed for available S (Black, 1965) and Mg (Jackson, 1973). Plant samples were analysed for total S and Mg by standard methods (Jackson, 1975) and the uptake was computed.

It was observed that at the grand growth stage, the highest available S content of 21.8 kg ha^{-1} was recorded with 45 kg S/ha^{-1}. Available S content at 30 Kg Mg ha^{-1} level (18.4 kg ha^{-1}) was on par with 45 kg Mg ha^{-1} but was significantly higher than that of no magnesium (18.2 kg ha^{-1}). The available S contents were significantly higher with 45 Kg S/ha^{-1} both at flowering (20.4 kg ha^{-1}) and harvest (18.3 kg ha^{-1}) stages than the rest of the treatments. In both the stages, available S content observed with 45 kg Mg ha^{-1} was significantly higher than without Mg application but was on par with 15 and 30 kg Mg ha^{-1} treatments. The decrease in available S status observed with advancement in age of sunflower crop in the present study might be due to crop removal and also by its transformation in soil (Singh and Sahu, 1986).

Variations in available Mg content in sulphur applied plots were not significant at all the three stages of crop growth. At all the stages of crop growth, Mg availability with 45 kg Mg ha^{-1} was significantly higher than rest of the treatments, while 30 kg Mg, 15 kg Mg ha^{-1} were on par. A marked reduction in available S and Mg contents was observed from vegetative to maturity stages,

Received for publication January, 1995

which could be due to continuous absorption, assimilation and metabolism of Mg with advancement in crop age. Application of sulphur and magnesium increased S uptake at all the stages of crop growth which could be attributed to the enhanced dry matter production and seed yield. This is confirmed by significant positive relation observed between Mg uptake and S uptake (r= 0.267*). Similar observations were made by Gangwar and Parameswaran (1976), Sagare *et al.*, (1990) and Sreemannarayana and Sreenivasa Raju (1994).

At the vegetative stage, application of 45 kg S ha^{-1} recorded significantly higher Mg uptake than the rest of the treatments. But among the magnesium levels, the highest Mg uptake was recorded at vegetative and flowering stages with 30 kg Mg ha^{-1}. Thus, application of Mg and S have significantly increased the uptake of Mg. The increase may be attributed to the increased dry matter production and seed yield.

Dept. Soil Science & Agrl. Chemistry
Tamil Nadu Agrl. University
Coimbatore-641 003.

V.V. KRISHNA MURTHY
K.K. MATHAN

Black, C.A. 1965. *Methods of Soil Analysis* - Part II. American Soc. Agron. Inc. Madison.

Chandrasekhar Reddy, K. and Krishnamurthy, P. 1984. Uptake of nutrients, oil content and yield of groundnut as influenced by P, K, Ca, Mg and S. *The Andhra Agric. J.*. 31 (1): 34-38.

Gangwar, M.S. and Parameswaran, P.M. 1976. Phosphorus-sulphur relationship in sunflower. I. Effect of phosphorus and sulphur on yields. *Oil Seeds J.* 63 (3): 28-32.

Jackson, M.L. 1973. *Soil Chemical Analysis*. Prentice Hall of India (Pvt) Ltd., New Delhi.

Sagare, B.N., Guhe, Y.S. and Atre, A.H. 1990. Yield and nutrient harvest by sunflower in response to sulphur and magnesium application in Typic Chromusterts. *Plant Physiol.* 4(1): 15-21.

Singh, H.G. and Sahu, M.P. 1986. Response of Oilseeds to sulphur *Fert. News* 31 (9): 23-30.

Sreemannarayana, B. and Sreenivasa Raju, A. 1994. Influence of nature and applied sulphur on yield and S uptake by sunflower at different stages of growth. *J. Indian Soc. Soil Sci.*, 42 (1): 80-84.

Subba Rao, R., Soundarajan, M.S. and Sankara Reddi, G.H. 1990. Effect of ratio of K, Ca, Mg on yield attributes of irrigated groundnut. *Indian Potash J.* 3:2-7.

Table 1 : **Effect of sulphur and magnesium on yield, available S and Mg in soil and their uptake by sunflower at different stages of growth**

	Seed yield	Total dry matter yield			Availability (kg ha-1) in soil						Plant Uptake (kg ha $^{-1}$)					
					Sulphur			Magnesium			Sulphur			Magnesium		
	(q ha^{-1})	V (q ha $^{-1}$)	F	H	V	F	H	V	F	H	V	F	H	V	F	H
Sulphur (kg/ha)																
0	13.8	9.2	24.7	31.6	14.5	14.3	13.8	60	58	52	4.3	7.8	4.8	4.3	7.2	2.6
15	14.1	10.9	25.4	33.8	17.6	17.3	16.2	58	58	52	4.6	8.1	4.9	4.4	7.3	2.6
30	14.6	12.6	25.9	36.0	19.3	18.8	17.2	62	56	54	4.8	8.4	5.0	4.5	7.2	2.6
45	15.1	12.8	26.7	38.7	21.8	20.4	18.3	60	54	53	5.0	8.5	5.1	4.6	7.3	2.7
CD (0.05)	0.6	1.4	3.4	1.6	0.3	0.2	0.2	NS	NS	NS	0.1	0.1	0.1	0.1	NS	NS
Magnesium (kg/ha)																
0	14.2	10.6	25.8	32.2	18.2	17.5	16.2	54	48	38	4.7	8.1	5.0	4.3	7.0	2.4
15	14.3	11.7	26.3	35.1	18.2	17.6	16.4	60	56	58	4.6	8.2	4.9	4.4	7.2	2.6
30	14.5	12.4	27.2	36.2	18.4	17.8	16.3	60	60	56	4.7	8.3	5.0	4.6	7.3	2.8
45	14.6	14.6	29.9	36.5	18.4	17.9	16.5	66	62	58	4.7	8.2	4.9	4.5	7.3	2.9
CD (0.05)	0.2	1.4	3.4	1.6	NS	0.2	0.2	2	2	2	0.1	NS	NS	0.0	10.2	0.02

V = Vegetative; F = Flowering; H = Harvest; NS = Non-significant

J. Oilseeds Res. 13 (1) 1996: 136-138
ISSN 0970-2776

SCHEDULING OF IRRIGATION IN LINSEED BASED ON STRESS DAY INDEX

Water requirement of linseed crop varies during different phases of its growth. For efficient use of water in crop production, irrigation based on crop phenology, is important. This investigation was taken up to determine crop susceptibility values for seed and fibre yield of linseed and to delineate critical stages for moisture stress by using the Stress Day Index (SDI) concept proposed by Hiler *et al.*, (1974).

An experiment was conducted during *Rabi* season of 1993-94 at the Main Research Station, Hebbal, Bangalore, on a sandy loam soil. Mean values of field capacity, permanent wilting percentages and bulk density of the soil to a depth of 90 cm were 15.83 per cent, 10.69 per cent and 1.58 g/cm^3, respectively. The study included five irrigation levels viz., irrigation at 125 mm CPE throughout (I_1), Irrigation at 62.5 mm CPE throughout (I_2), Irrigation at 125 mm CPE upto 75 DAS and at 62.5 mm CPE afterwards (I_3), Irrigation at 62.5 mm CPE upto 75 DAS and later at 125 mm CPE (I_4), Irrigation at 62.5 mm CPE between 10 to 40 DAS and 76 days to harvest and at 125 mm CPE between 41 and 75 DAS (I_5) tested in a randomised block design with three replications. The crop was sown on 9th November, 1993 at 30 cm row spacing between rows and 10 cm between plants in 3.6 m x 3.0 m plots.

The irrigation water equivalent to 5 cm depth was applied at each irrigation with the help of Parshall flume of 7.5 cm throat-width. Stress Day Index (SDI) concept as formulated by Hiller *et al.*, (1974) was applied as follows:

$$SDI = \sum_{i=1}^{n} (CS_i \times SD_i)$$

Where CS = indicates the crop susceptibility factor, the susceptibility to a given water deficit at a given growth stage (i)

Crop susceptibility was determined experimentally as the fractional reduction in yield resulting from fixed water deficit during a given growth stage i.e.,

$$CS_i = \frac{X - X_i}{X}$$

Where, X = Yield from non-stress treatment

X_i = Yield in the moisture stress treatment that was subjected to deficit during ith growth stage.

The Stress Day (SD) factor is a measure of the moisture stress. In this experiment, Cumulative Pan evaporation value of 125 mm was chosen as SD.

SDI_0 (average SDI) was found out as follows:

$$SDI_0 = \sum_{i=1}^{n} \frac{SDI}{\text{Number of stressed treatments}}$$

Using this SDI_0, SD at irrigation was calculated as follows:

Received for publication December, 1995

$$\text{SD at irrigation} = \frac{SDI_0}{CS}$$

Stress day index concept helps in delineation of critical stages for moisture stress, scheduling irrigation efficiently and quantification of stress (as a parentage of yield decline compared to unstressed treatment).

The highest crop susceptibility factor of 0.28 and significantly less seed yield with I_3 (irrigation at 125 mm CPE upto 75 DAS and later at 62.5 mm CPE) indicated 28 per cent yield loss due to moisture stress between 10 and 75 DAS revealing that branching and flowering stages are critical for moisture stress (Table 1). This was followed by 0.25 CS factor in I_5 (Delayed irrigation at 125 mm CPE between 41 and 75 DAS) which coincided with flowering stage indicating flowering stage to be single-most critical sage for moisture stress. The levels of soil moisture in general, had an adverse effect on the performance of the crop except stress level of 125 mm CPE during 76 days to harvest (the stage of capsule development) viz., I_4 irrigation schedule which recorded significantly higher seed yield (5.03 q/ha) and negative crop susceptibility factor (-0.07) indicating an yield advantage of 7 per cent due to stress of 125 mm CPE at 76 days to harvest stage.

Whereas stress created due to delayed irrigation at 125 mm CPE ratio between 41 and 75 DAS (I_5) and 10 days to 75 DAS (I_3) caused greater reduction in fibre yield (41 and 46 per cent, respectively) indicating that 10 to 40 DAS (vegetative stage upto full branching) and 41 to 75 DAS (flowering stage) are critical in their moisture requirement for fibre formation and development.

Total economic yield followed the same trend as that of seed yield. Stress created at later stage during capsule development (I_4) caused only 9 per cent reduction in total economic yield with 10 per cent saving in irrigation water. Thus the stress day index concept can be used for irrigating the crop more frequently i.e. at low values of SD at irrigation during critical stages (indicated by highest CS factor value) and less frequently (higher values of SD at irrigation) during other stages.

Department of Agronomy
Agricultural College,
GKVK, UAS, Bangalore - 560 065.

Y.H. GOPALAKRISHNA
B.K. RAMACHANDRAPPA
H.V. NANJAPPA

Hiler, E.A., Howell, T.A., Lewis, R.B. and Boos, R.P., 1974. Irrigation timing by the Stress day index method. *Transactions ASAE* 17: 393-398.

Table 1 : Stress day Index values as influenced by moisture stress during different stages in linseed

	Irrigation Schedules						Crop susceptibility factor (C.S.)			Stress day factor (SD)	SDI			SDI_0			*SD at irrigation (mm)*		
	10-40 days	41-75 days	76 days to harvest	Seed yield (q/ha)	Fibre yield (q/ha)	Seed+ Fibre (q/ha)	Seed yield (q/ha)	Fibre yield (q/ha)	Seed+ Fibre (q/ha)	(mm of CPE)	Seed yield	Fibre yield	Seed+ fibre yield	Seed yield	Fibre yield	Seed+ fibre yield	Seed yield	Fibre yield	Seed + Fibre yield
	CPE (mm)																		
I_1	125.0	125.0	125.0 (5)	3.82	1.79	5.61	0.23	0.34	0.26	125	28.75	42.50	32.50	21.56	46.87	31.25	93.74	137.85	120.19
I_2 (No stress)	62.5	62.5	62.5 (8)	4.94	2.71	7.65	-	-	-	-	-	-	-	-	-	-	-	-	-
I_3	125.0	125.0	62.5 (6)	3.54	1.46	5.00	0.28	0.46	0.34	125	35.00	57.50	42.50	21.56	46.87	31.25	77.00	101.89	91.91
I_4	62.5	62.5	125.0 (7)	5.03	1.91	6.94	-0.07*	0.29	0.09	125	-8.75*	36.25	11.25	21.56	46.87	31.25	125.00*	161.62	347.22
I_5	62.5	125.0	62.5 (7)	3.71	1.58	5.28	0.25	0.41	0.31	125	31.25	51.28	38.75	21.56	46.87	31.25	86.24	114.31	100.00
	S.Em ±			0.10	0.01														
	C.D at 5%			0.29	0.07														

* Crop susceptibility factor showing negative value reveal yield advantage due to stress of 125 mm CPE at 76 days to harvest stage Hence SD at irrigation shall be equal to SD (125 mm CPE).

Figures in the parenthesis indicate the total number of irrigation.

J. Oilseeds Res. 13 (1) 1996: 139-140
ISSN 0970-2776

ESTIMATION OF LOSSES DUE TO POD BORERS IN OILSEED CROPS

Oilseeds, such as groundnut, sesame and castor cultivated in Saurashtra region of Gujarat State were found infested by the pod borers mainly false wireworm (*Penthicoides seriatoporus* Fair.) and earwig (*Anisolabis annulipes* Luc.) in groundnut (Kapadia, 1994), pod borer (*Antigastra catalaunalis* Dup.) in sesame and capsule borer (*Dichocrosis punctiferalis* Guen.) in castor and causing severe yield losses. The infested seeds often become unfit for crushing. The yield losses in oilseeds due to pod borers have been reported to be 9 to 23 per cent in castor (Singhvi *et al.*, 1972) and 174 kg/ha (Shah and Vora, 1971); 8.9 to 71.5 per cent (Singh, 1983), 27 to 40 per cent (Abraham *et al.*, 1977) and 63.93 per cent (Rohilla and Singh, 1992) in sesame and 25% pod damage in groundnut (Kapadia, 1994). However, the percentage loss in weight of seeds due to these pod borers in Gujarat State has not been assessed and hence this study was made.

To assess the economic importance of pod borers in groundnut, sesame and castor, healthy and infested pods of groundnut and sesame were collected at random from the fields at Main Dry Farming Research Station, Gujarat Agricultural University, Targhadia. Healthy and infested castor capsules were collected at random from farmers fields. They were shelled out when fully dry. Seeds threshed out of the infested pods manually were sorted into the healthy and infested ones. The percentage of the infested seeds was calculated on the basis of total number of seeds. Weight of healthy and infested seeds was recorded and percentage loss in weight was then calculated.

Losses in weight and percentage of the damaged seeds in groundnut, sesame and castor (Table 1) revealed that the percentage of the infested seeds

Table 1. Percentage seed infestation and weight loss in oilseed crops due to pod borers

	Parameter	Groungnut (JL-24) pods infested with wireworms and earwig	Sesamum (Guj. Til-1) pods infested by *A. catalaunalis*	Castor (GCH 4) capsules infested by *D. punctiferalis*
1.	Wt. of 100 healthy seeds (g)	39.00	0.42	19.59
2.	Wt. of 100 infested seeds (g)	15.91	0.00	7.24
3.	Loss in wt (%)	59.21	100.0	63.04
4.	% of infested seeds in the damaged pods	63.54 (70/192)*	73.39 (4830/6581)*	42.25 (107/261)*

* Number of infested seeds out of total seeds

Received for publication August, 1994

in groundnut was 63.54 and percentage weight loss in the infested seeds was 59.21. In sesame, the percentage seed damage in the infested pods was 73.39 and the weight loss was 100 per cent as compared to the weight of healthy seeds. The infested seeds were totally consumed by the sesame pod borer. The castor capsule borer caused 42.25 per cent seed damage in the infested capsules and the loss in weight of the infested seeds was to the tune of 63.04 per cent in comparison to the weight of healthy seeds.

The study indicated that the percentage weight loss of seeds damaged by the pod borers was 59.21 in groundnut, 100.00 in sesame and 63.04 in castor.

Main Dry Farming Research Station,
Gujarat Agricultural University,
Targhadia - 360 003.

M.N. KAPADIA

Abraham, E.V; Natarajan, K. and Murugesan, M. 1977. Damage by pests and phyllody to sesame in relation to time of sowing. Madras agric. J. 4: 298-301.

Kapadia, M.N. 1994. Record of three false wireworms infesting groundnut in Gujarat. GAU. Res. J. 19(2): 128-129.

Rohilla, H.R. and Singh, R. 1992. Evaluation of spray schedule and assessment of yield losses in sesamum caused by sesamum leaf roller, *Antigastra catalaunalis* (Duponchel) (Pyralidae: Lepidoptera). Indian J. Ent. 54 (1): 48-53.

Shah, A.H. and Vora, V.J. 1971. Entomology in Gujarat Agricultural University in ten years. Maganize, N.M. College of Agriculture, Navsari, 1971, 5(1): 198-199.

Singh, R. 1983. M.Sc. Thesis, Department of Entomology, Haryana Agricultural University, Hissar.

Singhvi, S.M., Balan, J.S. and Yadava, T.P. 1972. Note on varietal susceptibility of castor shoot and capsule borer, *Dichocrosis punctiferalis* Guen. (Lepidoptera· Pyralidae). Indian J. agric. Sci., 42 (3): 269-270.

J. Oilseeds Res. 13 (1) 1996: 141-143
ISSN 0970-2776

EFFECT OF SUNFLOWER MOSAIC VIRUS ON GROWTH AND YIELD PARAMETERS IN SELECTED GENOTYPES OF SUNFLOWER*

Sunflower (*Helianthus annuus* Linn.) is known to be susceptible to many diseases incited by fungi, bacteria, virus and virus-like organisms (Kolte, 1985) under natural conditions. Several virus and virus-like diseases have also been reported to occur on this crop causing considerable losses, though definite information is not available (Kolte, 1985; Bidari *et al.*, 1987; Venugopal Rao *et al.*, 1987. Jitendramohan, 1992; Nagaraju *et al.*, 1995). Sunflower mosaic virus was reported by the present workers (Nagaraju *et al.*, 1995) from Karnataka. The exact loss due to the infection of this virus was not known under field conditions. Hence, a field study was taken up to asses the effect of this virus on the growth and yield parameters by inoculating at different stages of crop growth.

Experiments were conducted at the GKVK campus of the University of Agricultural Sciences, Bangalore during Kharif 1994. The sunflower mosaic virus culture was maintained in the insect proof glass house on sunflower cv. KBSH 1. Two sunflower cultivars, viz., Morden and KBSH-1 which were susceptible to this virus were sown in 10 rows of 3m. length following 60 x 30 cm spacing. The treatments were tested in RBD with three replications. Standard extract of the virus inoculum was prepared using sodium phosphate buffer (0.067M. pH 7.0) containing 0.5 per cent sodium sulphite at the rate of 1 ml per gram of leaf sample. Using celite as abrasive (0.025 g/ml of extract), inoculation was carried out on 10 day old seedlings (two rows in each cultivar) as 1st treatment. Similarly, 2nd and 3rd treatments were imposed at 20 and 30 days after sowing and the last 2 rows in each cultivar were left uninoculated and maintained as control. Observations on days to express symptoms after inoculation, per cent transmission, plant height (cm), head diameter (cm), number of days taken to 50% flowering, no. of days taken to maturity, no. of leaves/plant, stem diameter (cm), seed yield/plant (g), 100 seed weight (g), no. of seeds/head, no. of filled seeds/head and per cent filling were recorded.

The results revealed that the virus took 12-15 days to infect and express symptoms in both the cultivars and at all the stages of inoculation. However, the per cent transmission varied with the cultivars and age of seedlings at inoculation. It was highest when the seedlings were inoculated at 10 days after sowing (28 to 40%) and declined as the age of seedlings increased at inocultaion (16 to 24%). Hybrid, KBSH 1 (24 to 40%) was found more susceptible than Morden (16 to 28%) under field conditions. (Table 1).

There was no effect of either the virus or the age of seedlings at inoculation on the number of days taken to 50% flowering, number of days taken to maturity and number of leaves per plant, on both the cultivars.

The mean plant height was 12.2 cm in healthy as against 92.4, 98.0 and 101.8 cm when inoculated at 10, 20 and 30 days after sowing, respectively. A reduction of 15.9 to 20.1 percent over control was recorded among the cvs. and it was reduced as the age of the seedlings at inoculation increased (7.6 to 11.7%).

While the uninoculated plants maintained a mean stem diameter of 1.40 cm, inoculation at 10, 20 and 30 days resulted in stem diameter of 1.05, 1.20 and 1.25, cm respectively. The percent reduction in stem diameter over control in the cultivars ranged from 15.4 to 33.3 when they were inoculated at 10 days age and reduced as the age of the seedlings increased at inoculation (7.7 to 20.0).

A reduction in head diameter over control of 31.4 to 33.9 per cent was observed in the cultivars and

* Part of PhD thesis submitted by the Sr. author to the University of Agricultural Sciences, Bangalore, 1995.

Received for publication December, 1995

its effect was decreased with increase in the age of the seedlings at inoculation (18.2 to 25.4%). The average head diameter in control was 12.0 cm whereas, it was 8.1, 8.5 and 9.4 cm, respectively when 10, 20 and 30 days old seedlings were inoculated.

The percent reduction in number of seeds/head was 9.3 to 12.6 over control, which further decreased as the age of the seedlings at inoculation increased (4.2 to 4.3%). However, the percent reduction in filled seeds/head over control ranged from 18.3 to 33.8 among cultivars, and this reduction was less when the age of the seedlings at inoculation was more (6.2 to 17.8%). The average total number of seeds/head in control was 965.5 while it was 856.4, 895.6 and 945.0 with inoculation of 10, 20 and 30 day old seedlings. The average number of filled seeds per head in control was 786.6 as against 598.8, 624.4 and 704.0, respectively with inoculation of 10, 20 and 30 day old seedlings. Similar trend was noticed in per cent seed filling of the head. While it was 80.8 percent in control with inoculation of 10, 20 and 30 day old seedings, it was 67.7, 67.3 and 74.7 per cent respectively.

The per cent reduction in seed yield over control ranged from 32.2 to 42.8 when 10 day old seedlings were inoculated and the trend decreased as the age of the seedlings at inoculation increased (8.7 to 21.1 at 30 days). An average seed yield of 30.4 g/plant was recorded in healthy, while it was 19.4, 21.5 and 26.3 g, respectively with inoculation of 10, 20 and 30 day old seedlings. Similar trend was observed in test weight also wherein, 13.2 to 28.7 per cent was recorded with inoculation of 10 day old seedlings as opposed to 1.3 to 4.2 in 30 day old seedlings. An average test weight of 4.11 was recorded in healthy plants as against 3.23, 3.37 and 3.99, respectively with inoculation of 10, 20 and 30 day old seedlings.

The sunflower mosaic virus was found to affect all the growth and yield parameters of sunflower under field conditions except the number of days taken to flowering, maturity and number of leaves per plant. Irrespective of cultivars or the age of the seedlings at inoculation, there was no difference in days taken to infect and express symptoms after inoculation. However, the per cent transmission of the virus was more in KBSH 1 than in Morden under field conditions. With regard to plant height, head diameter, stem diameter, number of seeds per head, number of filled seeds per head, per cent seed filling, seed yield and 100 seed weight, there was considerable reduction over control, especially when the seedlings were inoculated at very young stage. It was also found that the per cent reduction in all the parameters over control decreased as the age of seedlings at inoculation increased. Jitendramohan (1992) reported that a strain of cucumber mosaic virus reduced the seed yield of sunflower upto 20 per cent, 100 seed weight by 24.40 per cent and seed number per plant by 28.10 per cent.

[1] Project Co-ordinating Unit (Sunflower),
[2] Department of Plant Pathology, UAS, GKVK, Bangalore - 5600 065.
[3] IIHR, Hessarghatta, Bangalore - 560 089.

NAGARAJU[1]
V. MUNIYAPPA[2]
S.J. SINGH[3]
K. VIRUPAKSHAPPA[1]

Bidari, V.B., Gangappa, H.K. and Mahalingappa, D.M., 1987, Phyllody - A new menace to the sunflower leading to sterility. *Curr. Sci.*, 56: 984-956.

Jitendramohan, 1992. Identification and epidemiology of viruses affecting oilseeds crops in Western Uttar Pradesh, with special reference to Mustard and Sunflower mosaic. Final Progress Report of the Project from May 7, 1988 to May 6, 1991, Janata Vedic College, Meerut University, Baraut, UP, 30 pp.

Kolte, S.J., 1985, Sunflower diseases *In Diseases of Annual Edible Oilseed Crops.* V. III. pp9-96. CRC Press, Florida, 194 pp.

Nagaraju, Muniappa, V., Singh, S.J. and Virupakshappa, K., 1995. Occurrence of a mosaic virus disease on sunflower in Karnataka. *Indian Phytopath* (sent for publication).

Venugopal Rao, R., Madhusudan, T. and Sastry, K.S., 1987, Studies on a mosaic disease of sunflower. *J. Oilseed Res.*, 4: 286-288.

Table 1 : **Effect of sunflower mosaic virus infection on the growth and yield parameters of sunflower cultivars.**

Sl. No.	Parameters studied	Age of seedlings at inoculation in days (DAS)											
		Morden			No inoculation	KBSH 1			No inoculation	Average			No inoculation
		10	20	30		10	20	30		10	20	30	
1.	Days to express symptoms	12-15	12-15	12-15	–	12-15	12-15	12-15	–	12-15	12-15	12-15	–
2.	Per cent transmission	28.0	24.0	16.0	–	40.0	40.0	24.0	–	34.0	32.0	20.0	–
3.	Plant height (cm)	74.5	78.6	82.3	93.2	110.2	117.3	121.2	131.2	92.4	98.0	101.8	112.2
4.	Head diam. (cm)	7.8	8.3	8.8	11.8	8.3	8.7	9.9	12.1	8.1	8.5	9.4	12.0
5.	Days to 50% flowering	55	56	56	56	63	62	62	62	59	59	59	59
6.	Days to maturity	86	85	87	87	98	98	98	98	92.0	91.5	92.5	92.5
7.	No. of leaves per plant	24	24	24	24	27	27	27	27	25.5	25.5	25.5	25.5
8.	Stem diam. (cm)	1.0	1.2	1.3	1.5	1.1	1.2	1.2	1.3	1.05	1.20	1.25	1.40
9.	Seed yield (g/head)	13.36	14.26	18.42	23.35	25.37	28.63	34.18	37.42	19.4	21.5	26.3	30.4
10.	100 seed weight (g)	3.05	3.10	4.10	4.28	3.41	3.63	3.88	3.93	3.23	3.37	3.99	4.11
11	No. of seeds per head	681.3	694.9	759.0	750.8	1031.5	1096.3	1131.0	1180.1	856.4	895.6	945.0	965.5
12	No. of filled seeds/head	387.2	392.5	478.4	581.9	810.4	856.3	929.6	991.3	598.8	624.4	704.0	786.6
13	Per cent seed filling	56.8	56.5	66.5	77.5	78.6	78.1	82.2	84.0	67.7	67.3	74.7	80.8

DAS = Days After Sowing

J. Oilseeds Res. 13 (1) 1996: 144-148
ISSN 0970-2776

EPIZOOTIC OF THE ENTOMOFUNGAL PATHOGEN, *NOMURAEA RILEYI*, ON LEPIDOPTEROUS PESTS OF OILSEED CROPS.

The fungus *Nomuraea rileyi* (Farlow) Samson is known to be a natural mortality factor of many lepidopterous insect pests. Natural occurrence of epizootics of *N. rileyi* have been observed on *Spodoptera exigua* (Phadke *et al.*, 1978). *Helicoverpa armigera* (Gopalakrishnan and narayanan, 1989) and *Junonia Orithyia* (Rajak *et al.*, 1991).

This article reports the occurrence of an epizootic of *N. Rileyi* on various lepidopterous pests of oilseed crops at the Directorate of Oilseeds Research farms located at Rajendranagar and Narkhoda. The epizootic of *N. rileyi* was facilitated by favourable environmental conditions that prevailed during *kharif*, 1995 (Table 2).

The first natural incidence of *N. rileyi* was recorded on *S. litura* on 60-70 days old castor crop during the last week of August, 1995 in a field plot where the fungus was sprayed for the control of *S. litura* on *rabi* groundnut during 1994. Infected larvae were found dead on the soil surface with typical symptoms of *N.rileyi* infection. The natural occurrence of the fungus during *Kharif*, 1995 on *S. litura* is probably due to its survival through the summer season and availability of sufficient inoculum to cause mortality in a susceptible pest population.

N. rileyi incidence was also observed as an epizootic late in the crop season between October 12 - 25, 1995 on insect pests of various crops grown in contiguous and isolated field plots where *N. rileyi* was applied as a foliar spray during 1992 and 1993 and in some which had no previous history of artificial treatment. Infected *S. litura* larvae were recovered from groundnut crop at harvesting stage (12 x 12 m^2 plots, 6 plots) and late sown castor (80 days old crop, 200 m^2 plot), castor, and groundnut (100 m^2 plot) at harvesting stage (Table 1).

Table 1. *N. rileyi* **infected larvae recorded during the epizootic**

Pest species	Number of infected larvae recovered on different crops					
	Groundnut	Castor		Niger	Castor + Pigeonpea	Pigeonpea
		30 Aug	17-25 Oct			
S. litura137	35	57	-	7	10	
Plusia sp.	33	-	8	30	-	-

Received for publication December, 1995

Fungus infected *S. litura* larve were recorded on soil (Fig. 1a), weeds, grasses (Fig. 1b), field bunds, groundnut and castor plants (Fig. 1c). Initially the infected larvae were recognised by their mummified nature with a white confluent mycelial mat on the cuticular surface. After two to three days all the infected larvae showed profuse green sporulation. On pigeonpea and castor both as sole and intercrops, a low incidence of *H. armigera* was observed (1-2 larve per 10 plants). Only a stray incidence of *N. rileyi* infection of this pest was observed probably due to the low pest density. A moderate incidence of *N. rileyi* infected green semilooper, *Plusia sp.*, was recorded on niger and groundnut. No living larvae were recorded on these crops. Infected larvae with posterior end broader than the anterior region were found fastened on to plant parts in a looping action with head and anterior abdominal region in a raised position (Fig. 1d). Intense green sporulation was observed on the mummified cadavers of both early and late instar larvae.

Infected larvae of different pest species were collected from the field and the fungus was isolated on Saboraud's Maltose Agar medium with yeast extract addition (SMAY). Fungus spore was harvested and tested at 2 x 10" conidia l^{-1} concentration against early 3rd instar *S. litura* larvae in the laboratory. Larval mortality due to fungus was about 95% at the end of 6 days after treatment. The Koch's postulate was confirmed by reisolating the same fungus from artificially infected caterpillars.

Table 2. Meteorological data during the occurrence of *N. rileyi* epizootic

Period	Rain (mm)	Mean Relative Humidity (%) Morning	Mean Relative Humidity (%) Evening	Mean Temp (°C) Max	Mean Temp (°C) Min
August 22-30	156.2	88.7	68.5	27.6	22.9
October 9 - 25	283.0	92.6	76.0	27.4	21.4

During *N. rileyi* epizootic, eventhough fungal infection was observed on *S. litura* larvae, interestingly no infection was observed on castor semilooper (*Achoea janata*) on castor even at a population of 1-2 larvae per plant during the last week of August as well as in the second spell of *N. rileyi* incidence under more favourable conditions of humidity and temperature during the second fortnight of October, 1995 (Table 2) when the population density of castor semilooper was 5-6 larvae per 10 plants. Susceptibility of castor semilooper to the local isolate that caused the epizootic was investigated by conducting a laboratory bioassay. Freshly isolated fungus was tested at three doses viz., 2, 3 and 4 x 10^{11} conidia l^{-1} against late 2nd instar larvae. A low larval mortality due to fungus (10-15%) was recorded only at the higher concentrations tested. Considering the field observations and laboratory studies it is inferred that castor semilooper is perhaps the least susceptible to the local isolate of *N. rileyi*. Further investigation on the nature of chitinolytic enzymes produced by the fungus and the composition of larval cuticle may explain the low susceptibility observed in castor semilooper.

A high natural occurrence of *N. rileyi* on *S. litura* was first observed on castor and groundnut crops located at DOR farms during *Kharif*, 1988. Subsequently, the fungal pathogen was isolated, multiplied and field tested against *S. litura* on castor and groundnut crops during the years 1992-1994 at different locations in DOR farm (Vimala Devi, 1994). The intensity of *N. rileyi* infection during 1995 was high (67% of the recovered larvae) in field plots with a history of *N. rileyi* artificial application compared to its occurrence in previously untreated plots (33%). However, even in these artificially untreated plots a natural occurrence of *N. rileyi* on *S. litura* was observed in 1992. Therefore, it is inferred that the epizootic during August and October, 1995 could probably be due to the expression of the established pathogen under ideal conditions of humidity and temperature.

N. rileyi has been reported to cause late-season epizootics of caterpillar pests of soybeans which generally produced a relatively heavy load of soil-borne conidia which act as a natural reservoir for the seasonal initiation of *N. rileyi* epizootics in soybean caterpillars (Ignoffo *et al.*, 1977). Enough conidia to initiate an epizootic are available from the larvae that died the previous field season (Ignoffo *et al.*, 1978) as *N. rileyi* incidence of only 10% in a population of 100,000 caterpillars (per 0.4 hectare) can provide the same inoculum as the release of 100 g of conidia (Ignoffo, 1985). Sprenkel and Brooks (1975) and Ignoffo *et al.*, (1976) demonstrated that an epizootic can be initiated artificially by applying *N. rileyi* prior to the time when natural epizootics normally occur. The epizootic at our farms occurred late in the season when the pest damage to the crops had already been done and the pest density was on the decline. Considering this the augmentative approach of introducing the pathogen prior to its natural occurrence when the susceptible pest population is at non-economic levels would facilitate build-up of the inoculum to controlling levels subsequently.

Directorate of Oilseeds Research
Rajendranagar
Hyderabad 500 030

P.S. VIMALA DEVI
Y.G. PRASAD
B. RAJESWARI
L. VIJAYA BHASKAR

Gopalakrishnan, C. and Narayanan, K., 1989. Epizootiology of *Nomuraea rileyi* (Farlow) Samson in field populations of *Helicoverpa (=Heliothis) armigera* (Hubner) in relation to three host plants. *Journal of Biological control* 3: 50—52.

Ignoffo, C.M. 1985. Manipulating enzootic-epizootic diseases of arthropods. pp 243-262. *In:* Biological control in Agricultural IPM systems. Academic Press, New York.

Ignoffo, C.M., Garcia, C. Hostetter, D.L. and Pinnel, R.E. 1977. Laboratory studies of the entomopathogenic fungus *Nomuraea rileyi*: Soil-borne contaminations of soybean seedlings and dispersal of diseased larvae of *Trichoplusia ni*. *Journal of Invertebrate Pathology* 29: 147-152.

Ignoffo, C.M., Garcia, C., Hostetter, D.L. and Pinnel, R.E. 1978. Stability of conidia of an entomopathogenic fungus, *Nomuraea rileyi*, in and on soil, *Environmental Entomology* 7: 724-727.

Ignoffo, C.M., Marston, N.L., Hostetter, D.L. and Puttler, B. 1976. Natural and induced epizootics of *Nomuraea rileyi* in soybean caterpillars. *Journal of Invertebrate Pathology* 27: 191-198.

Phadke, C.H., Rao V.G. and Pawar, S.K. 1978. Natural outbreak of the muscardine fungus *Nomuraea rileyi* (Farlow) Samson on leaf eating caterpillar, *Spodoptera exigua* H.B. in Maharashtra. *Current Science* 47: 476.

Razak, R.C., Sandhu, S.S., Mukherjee, S.Khare, S. and Gupta. A 1991. Natural outbreak of *Nomuraea rileyi* (Farlow) Samson on *Junonia orithyia* (Nymphalidae: Lepidoptera). *Journal of Biological Control* 5: 123-124.

Sprenkel, R.K. & Brooks, W.M. 1975. Artificial dissemination and epizootic initiation of *Nomuraea rileyi*, an entomogenous fungus of lepidopterous pests of soybeans. *Journal of economic entomology* 68: 847-851.

Vimala Devi, P.S. 1994. Conidia production of the entomopathogenic fungus *Nomuraea rileyi* and its evaluation for the control of *Spodoptera litura* (Fab) on *Ricinus communis*. Journal of Invertebrate pathology 63: 145-150.

LEGENDS

Fig. 1. a) Fungus infected *Spodoptera litura* on soil, b) grasses, c) castor and **d) Fungus infected green semi-looper,** *Plusia sp.*, on niger

J. Oilseeds Res. 13 (1) 1996: 149-150
ISSN 0970-2776

PROTEIN, OIL AND GLUCOSINOLATE CONTENTS IN SOME ELITE GENOTYPES OF INDIAN MUSTARD (*BRASSICA JUNCEA L* (CZERN & COSS)

Mustard and rapeseed are grown primarily for their oil which has high contents of erucic acid and other polyunsaturated fatty acids. The oil cake of mustard which is rich in proteins with fairly balanced amino acid composition is utilized for livestock feeding from times immemorial. But their use is restricted due to the presence of glucosinolates, which check palatability and cause goitrogenicity in animals (Hill, 1979).

Thirtynine genotypes of Indian Mustard (*Brassica juncea*) were grown in randomised block design with three replications during the crop season 1992-93 at NDRI, Karnal. Two levels of nitrogen fertilization viz., 50 and 80 kg N/ha were used in the experiment. Seed samples were collected from five representative plants from each replication for quality analysis. Total glucosinolate content was estimated according to McGhee *et al.*, (1965), which is based upon the reaction of silver with thioglucosides, oil content by NMR and protein estimation was done as per AOAC (1980). Analysis of variance and F-test was done as per standard statistical procedure [Panse and Sukhatme, 1967].

Analysis of variance revealed significant differences among the varieties for all the three characters studied. The protein content in the genotypes ranged from 20.13, to 26.21 and 23.27 to 29.98 with 50 and 80 kg N/ha, respectively (Table 1). The protein yield was significantly higher with high doses of nitrogen than with low dose of N. Nitrogen is a basic constituent of protein and with increase in the rate of nitrogen application, the nitrogen availability increased which resulted in increased protein content in seeds (Dhindsa and Gupta, 1974).

The oil content of mustard seeds ranged from 41.12 to 46.62 and 39.94 to 44.80 per cent with 50 and 80 kg N/ha, respectively. The rate of nitrogen application did not reveal significant effect on oil content. Bishnoi and Singh, (1978) and Khan (1980) reported similar findings.

Glucosinolate content ranged from 1.707 to 1.987 and 1.703 to 2.001 with 50 and 80 kg N/ha, respectively. Genotypic differences were significant and glucosinolate content was significantly higher with higher dose of nitrogen than with lower dose (Table 1). Low glucosinolate mustard meal can form a good source of protein for livestock (Miller *et al.*, 1962).

Directorate of Wheat Research,
Karnal - 132 001, Haryana

SUSHILA KUNDU
R.P.S. DHAKA

A.O.A.C. 1980. Official methods of Analysis, Association of Official Agricultural Chemists, Washington, D.C.

Bishnoi, K.C. and Kanwar Singh, 1979. Oil yield and quality parameters of three Raya Varieties as affected by sowing time and nitrogen. Indian J. Agron *24* (3): 255-285.

Dhindsa, K.S. and Gupta, S.K. 1974. Variability in chemical composition of Raya *(Brassica juncea Czer & Closs)* HAU J. Res., IV (3): 192—195.

Hill, R., 1979. A review of the toxic effects of Rapeseed meals with observation on meal from improved varieties. Brit. Vet. J., *135*: 3—16.

Khan, G.M., 1980. Water use efficiency, yield and quality of Raya in relation to water stress, sowing methods and N. levels. Ph.D. thesis. HAU, Hisar.

Mc Ghee, J.E., Krik, L.D. and Mustakas, G.C., 1965. Methods for determining thioglucosides in *Crambe abyssinia* J.A.O.C.S., *42*: 889-891.

Miller, R.W., Van Elten, C.H., Mc Grew, C. Wolf, I.A. and Jones, O. 1962. Aminoacid composition and seed meals from thirty one species of Cruciferale. J. Agril. Food Chem. *10*:426.

Panse, V.G. and Sukhatme, P.V., 1967. Statistical methods for agricultural worker. ICAR, New Delhi.

Received for publication November, 1995

Table 1. *Genotypic variations in protein, oil and glucosinolate content of mustard under two N levels.*

S.No.	Genotype	Proten content (%)		Oil content (%)		Glucosinolate content (%)	
		50 N	80 N	50 N	80 N	50 N	80 N
1.	Gangawati	24.10	24.49	42.20	41.76	1.809	1.880
2.	Krishna	25.67	24.78	41.47	42.49	1.899	1.967
3.	Indra	24.39	24.24	44.17	43.90	1.895	1.971
4.	Pusa Bold	24.45	24.87	43.95	44.80	1.903	1.946
5.	Pusa Bahar	22.23	23.27	43.58	41.06	1.947	1.977
6.	Pusa Barani	23.01	24.97	45.30	42.90	1.814	1.856
7.	Pusa Basant	25.99	26.66	42.79	42.20	1.914	1.986
8.	Vardan	26.21	25.07	43.99	44.03	1.817	1.855
9.	Kranti	25.38	27.48	42.73	42.29	1.839	1.867
10.	Vaibhav	23.07	29.09	44.23	40.85	1.903	1.927
11.	Rohini	22.49	24.73	44.63	42.41	1.866	1.933
12.	Prakash	24.10	26.15	44.15	43.88	1.833	1.907
13.	Varuna	25.92	27.62	42.17	40.50	1.886	1.962
14.	Pant Rai	25.82	28.90	41.33	41.63	1.919	1.930
15.	P.Pai-2030	24.20	26.65	43.75	40.86	1.772	1.844
16.	Pant Rai-52	24.05	26.52	45.83	41.79	1.862	1.870
17.	RW-351	23.53	24.68	43.23	41.40	1.776	1.893
18.	RL-1359	24.25	27.11	46.42	41.44	1.883	1.851
19.	RH-30	23.24	24.74	44.67	42.11	1.910	1.937
20.	RH-791	20.13	27.28	45.57	42.63	1.943	2.001
21.	RH-819	25.87	26.10	42.79	42.14	1.920	1.703
22.	RH-7846	25.20	26.69	43.14	43.00	1.931	1.963
23.	RH-8113	23.09	26.94	44.49	43.55	1.887	1.886
24.	RH-851	23.01	24.10	45.65	43.50	1.662	1.937
25.	RLM-514	23.35	24.77	43.28	41.36	1.707	1.883
26.	RLM-198	24.01	29.89	43.58	43.01	1.821	1.865
27.	RLM-619	21.87	25.61	44.45	42.39	1.772	1.896
28.	TM-4	24.88	27.87	44.01	40.43	1.737	1.777
29.	TM-2	24.24	25.99	41.12	39.94	1.849	1.923
30.	Dira-343	23.41	25.15	44.52	44.13	1.817	1.860
31.	Dira-337	23.87	25.48	43.81	42.14	1.987	1.981
32.	PR-8801	21.58	25.08	44.32	43.69	1.884	1.949
33.	RW-5613-1	25.17	25.59	44.02	44.52	1.784	1.889
34.	NDR-8604	23.24	25.25	44.64	44.58	1.931	1.951
35.	NDR-8603	25.43	27.32	42.97	42.20	1.829	1.903
36.	B-380	23.61	24.08	43.77	43.38	1.829	1.903
37.	B-195	24.85	25.37	45.06	44.17	1.795	1.968
38.	RC-89	26.03	27.56	42.48	39.98	1.809	1.885
	39.RC-164	24.20	25.77	44.69	43.45	1.960	1.970
	Grand Mean	24.09	25.77	43.83	42.47	1.859	1.914
	CD (0.05)	0.827	0.903	1.697	2.838	0.590	0.590

INFORMATION FOR CONTRIBUTORS

Contributions from the members only on any aspects of oilseeds research will be considered for publication in the Journal of Oilseeds Research. Papers for publication (in triplicate) and book reviews should be addressed to the Editor, Journal of Oilseeds Research, Directorate of Oilseeds Research, Rajendranagar, Hyderabad - 500 030, India.

Manuscript should be prepared strictly according to the GUIDELINES FOR AUTHORS published in Volume 12, No.1 and should not exceed 15 typed pages including Tables and Figures. Short communications should not exceed five typed pages including Tables and Figures.

Articles from the Journal of Oilseeds Research are being regularly indexed in AGRINDEX and abstracted in CAB abstracting Journal and Biological Abstracts.

Membership Tarriff w.e.f. 1.1.1997

Annual Subscription

India	Abroad
Individuals: Rs. 75=00 + Admission fee Rs. 10/-	U.S.$ 50.00
Institutions: Rs. 600=00 Students: Rs. 40=00 + Admission fee: Rs. 10=00	U.S.$ 100.00 (Postage extra)

Life membership : Individuals : Rs. 800=00
+ Adm. fee Rs. 10=00

For subscription, please contact the General Secretary, Indian Society of Oilseeds of Research. Directorate of Oilseeds Research, Rajendranagar, Hyderabad - 500 030, India.

TARIFF FOR ADVERTISEMENTS

Location	2 issues (Rs.)	1 issue (Rs.)
Back Cover (Inside)	8000/-	5000/-
Page faing back cover	3000/-	1500/-
Inside full page	2500/-	1500/-
Inside half page	1500/-	750/-

Over all size : 21.0 cm height (max.) x 14.0 cm width (max.)
Print area : 1) Back cover & full page : 18.00 cm x 14.0 cm
2) Half page : 9.00 cm x 14.0 cm

Indian Society of Oilseeds Research thankfully acknowledges the financial assistance received from Indian Council of Agricultural Research, New Delhi for Printing this Journal.

Editod and Published by the Indian Society of Oilseeds Research
Directorate of Oilseeds Research, Rajendranagar, Hyderabad 500 030.
Typesetting and Printed at K.S. Latha Photo Offset Printing Works
Sultan Bazar, Hyderabad. Phone 514907