Journal of Oilseeds Research

DOR- 365

Volume 21
Number 1
June, 2004
ISSN 0970-2776

Indian Society of Oilseeds Research
Estt : 1983

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

THE INDIAN SOCIETY OF OILSEEDS RESEARCH

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

EXECUTIVE COUNCIL FOR 2004-2005

President	:	Dr. G. Kalloo	
Vice-President	:	Dr. S.S. Duhoon	
General Secretary	:	Dr. A. Vishnuvardhan Reddy	
Joint Secretary	:	Dr. Dr. Y.P. Malik	
Treasurer	:	Dr. P. Padmavathi	
Councillors	:	Dr. S.S. Banga	(Northern Zone)
		Dr. N.K. Choubey	(Central Zone)
		Dr. V. Muralidharan	(Southern Zone)
		Dr. S.V. Sarode	(Western Zone)
		Dr. U.C. Kar	(Eastern Zone)

Editorial Board

Editor	:	Dr. Harvir Singh	
Assistant Editor	:	Dr. A. Vishnuvardhan Reddy	
Members	:	Dr. P.R. Kumar	Dr. S. Lingappa
		Dr. S.P. Palaniappan	Dr. M. Uday Kumar
		Dr. A. Bandopadhyay	Dr. S.L. Mehta
		Dr. Arvind Kumar	Dr. S.P. Tiwari

Patrons

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

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

ISSN 0970-2776
Volume 21
Number 1
June, 2004

Journal of OILSEEDS RESEARCH

Contents

DOR-365

Research Papers

Morphological characterization of released groundnut cultivars for the DUS requirement
K. Rajgopal, A. Bandyopadhyay, K. Chandran, H.B. Lalwani, N.R. Ghetia and P.K. Bhalodia ... 1
Genetic analysis of yield components and confectionery traits in crosses involving large seeded genotypes of groundnut
J.R. Dobaria, A.L. Rathnakumar and P.S. Bharodia ... 11
Stability analysis in large seeded groundnut genotypes for pod yield and its component traits
Mohan G. Bentur, K.G. Parameshwarappa and L.H. Malligawad ... 17
Response to selection for seed dormancy in groundnut
G.K. Naidu, M.V.C. Gowda and B.N. Motagi ... 21
Comparative studied on combining ability and heterosis for yield, yield components in Indian mustard on normal and saline soils
D. Kumar and Neetu Rathore ... 24
Development and characterization of low erucic acid/low glucosinolate lines in Indian mustard
J.S. Chauhan, M.K. Tyagi, S. Kumar, Poonam Tyagi, Nawaz Khan, S.K. Yadav and N.B. Singh ... 28
Modified triple test cross in sunflower
P. Venkata Ramana Rao, A. Vishnuvardhan Reddy, D. Lokanadha Reddy and M. Ganesh ... 34
Genotype x Environment interaction and stability analysis for oil content in American cotton
A. Narisi Reddy and A. Satyanarayana Bhaskar Reddy ... 36
Eco-physiology of yield expression in groundnut genotypes during post-monsoon season
P.N. Karanjikar, G.S. Jadhav and P.K. Wakle ... 39
Groundnut growth and yield as influenced by evapotranspiration deficits
S. Hemalatha, V. Praveen Rao and B.N. Reddy ... 42
Effect of residual fertility of different nitrogen management practices to *kharif* rice on the performance of *rabi* groundnut
M. Srinivasa Reddy, D. Srinivasulu Reddy and P.V.R.M. Reddy ... 47
Moisture sensitive growth periods and optimal sequencing of evapotranspiration deficits in Indian mustard
B. Vijay Kumar, V. Praveen Rao and B.N. Reddy ... 50
Production potential and economic feasibility of soybean based cropping systems
S.D. Billore and O.P. Joshi ... 55
Screening of pigeonpea varieties for their suitability as intercrop in soybean
S.D. Billore and O.P. Joshi ... 58
Phosphorus management in soybean-sunflower cropping system
S.N. Patil, R.B. Ulemale, S.S. Lande and A.M. Mahajan ... 62
Effect of tillage and plant density on performance of sunflower in rice fallows
P. Sesha Saila Sree and V. Sridhar ... 65
Isolation of salt endurant sunflower genotypes through *in vitro* screening techniques
D. Sassikumar, R. Sudhagar and A. Gopalan ... 69
Alley cropping and green leaf manures-effective means of integrated nutrient management for sustained returns of rainfed castor
K.P. Vani and G. Bheemaiah ... 73
Soil test based fertilizer recommendation for sunflower in Inceptisols of Tamil Nadu
R. Santhi, R. Natesan, K. Andi and G. Selvakumari ... 78
Effect of preceding *kharif* legumes and levels of NPK on the succeeding *rabi* sunflower
C.R. Chinnamuthu, A.S. Venkatakrishnan and P. Manickasundaram ... 82
Comparative performance of some water production functions for spring sunflower
Ramani Kanta Thakuria, Harbir Singh and R.K. Jhorar ... 86
Optimization of sunflower production under resource constraints
P. Sesha Saila Sree, V. Sridhar and D. Swapna Sree ... 92
Herbicidal management of weeds in sesame
Malam Singh Chandawat, I. Singh and M.S. Rathore ... 95
Population dynamics of aphids in relation to weather parameters in groundnut
V. Nandagopal, M.V. Gedia and A.D. Makwana ... 98
Systemic induced resistance in sunflower to *Alternaria* leaf blight by foliar application of SA and Bion
M. Venkata Sadhu Ratnam, P. Narayan Reddy, S. Chander Rao and Rama Bhadra Raju ... 104

Official publication of
The Indian Society of Oilseeds Research, Hyderabad
***J. Oilseeds Res.*, 21(1) : 1-223 (June, 2004)**

Field screening of linseed genotypes against the incidence of budfly and blight
M.P. Gupta . 108
Forecasting of sesame production in India
R. Kalpana Sastry, D. Rama Rao, V. Kiresur and R. Vizayakumari . 112
Seed composition and fatty acid profile of some tree borne oilseeds
G. Nagaraj and N. Mukta . 117
Production and economic factors growth in cultivation of groundnut crop in India
G. Singh and H. Chandra .. 121
Growth analysis of production and economic factors in rapeseed-mustard cultivation in India
G. Singh and H. Chandra .. 125
An expert tool for fertilizer management of rapeseed-mustard
Vinod Kumar, Arvind Kumar, O.P. Premi and Manoj Kumar .. 130

Short Communications

Differential response of groundnut genotypes for *in vitro* callus induction and regeneration using mature embryo explants
J. Ashok, B. Fakrudin, H. Paramesh, M.S. Kuruvinashetti and Kullaiswamy ... 134
Combining ability analysis in Indian mustard
S.P. Sharma, G.S. Sharma and B.R. Ranwah ... 137
Heterosis in relation to combining ability for seed yield and its contributing traits in Indian mustard
Mahak Singh and Lallu ... 140
Selection indices in Indian rapeseed and mustard
S. Hussain, G.N. Hazarika and P.K. Barua ... 143
Combining ability analysis for seed yield, growth, development traits and biomass partitioning in taramira
Yash Pal Yadav, Anil Kumar, Ravi Prakash and Ranvir Singh ... 146
Studying changes in populations under going recurrent S_1 selection in sunflower
V.K. Yadav, D. Roy and K.K. Khulbe ... 148
Evaluation of three-way hybrids in sunflower
V. Jayalakshmi and B. Narendra ... 152
Genetic divergence in the inbred lines of sunflower
K. Komuraiah, S. Sokka Reddy, A.R.G. Ranganatha and M. Ganesh ... 154
Identification of fertility restorers for CMS lines in sunflower
R.R. Wankhade, J.C. Rajput, I.S. Halakude, M.P. Kulkarni, N.W. Sawarkar and P.A. Dalvi ... 156
Response to selection for seed yield and yield attributes in sunflower
K.G.S. Seneviratne, M. Ganesh, A.R.G. Ranganatha, G. Nagaraj and K. Rukmini Devi ... 158
Stability of cytoplasmic male sterility systems in sunflower
A. Vishnuvardhan Reddy, Lakshmi Prayaga and V. Devasenamma ... 160
Genetic divergence analysis in sunflower
V.N. Laxminarayana, N. Sreedhar and A.J. Prabakaran ... 162
Components analysis in sunflower
C. Parameswari, V. Muralidharan and B. Subbalakshmi ... 165
Genetic divergence in newly developed sunflower genotypes
R. Shashidhar Reddy, Kuldeep Singh Dangi, A. Vishnuvardhan Reddy and S. Sudheer Kumar ... 166
Genetic analysis of yield and important traits in sunflower hybrids
C. Parameswari, V. Muralidharan, B. Subbalakshmi and N. Manivannam ... 168
Response of early *rabi* groundnut to spacing, irrigation and plant protection levels
M. Rama Jyothi, C. Radha Kumari, U. Obulamma and B. Lingam ... 171
Effect of potassium fertilization on growth, yield and yield attributes of groundnut cultivars in new Alluvial Zone of West Bengal
R.C. Samui, Subhendu Mandal and Anirban Mondal ... 173
Production potential and nitrogen requirement of Indian mustard in different crop sequences under brackish water
B.S. Sinsinwar, Arvind Kumar, O.P. Premi and Fateh Singh ... 175
Response of mustard to different land treatments and dates of sowing in sandy clay loam soils
C. Radha Kumari, D.S. Koteswara Rao and U. Obulamma ... 178
Effect of organics on Indian mustard
O.P. Premi, Arvind Kumar, Manoj Kumar and B.S. Sinsinwar ... 180
Response of mustard to phosphorus and sulphur levels in rice lowlands
Birbal Sahu, Vivek Kwatara and M.L. Nema ... 181
Effect of biofertilizers on seed yield and quality of sunflower
Ch. Pragathi Kumari, A. Lachanna and V. Satyanarayana ... 183
Response of sunflower hybrids to fertilizer levels on late sown rice fallows of lower Assam
S.K. Rautaray ... 185
Balance sheet of nitrogen, phosphorus and potassium as influenced by spacing and nutrient management in sunflower
C.M. Dev and S.K. Sarawgi ... 187

Effect of higher fertility levels combined with farmyard manure, row spacing on seed yield, oil yield and economics of sunflower
Shrikant Chitale, S.K. Upadhyay, R.K. Bajpai and B.S. Joshi ... 189
Study on sunflower based intercropping systems for Satpura plateau zone of Madhya Pradesh
N.S. Thakur, R.S. Sharma and Pratibha Singh ... 192
Feasibility of drip irrigation in castor under sandy loam soil of North Gujarat
K.S. Patel, P.G. Patel, G.N. Patel, J.K. Patel and H.C. Pathak ... 194
Performance of different safflower genotypes with varied soil salinity levels
S.D. More, D.S. Hangarge, C.V. Raghavaiah and B.M. Joshi ... 196
Profitable niger based intercropping studies with new crop combinations for different regions in India
A. Jyotishi, M.R. Deshmukh and S.S. Duhoon ... 198
Evaluation of niger productivity under resource constraints
N.S. Thakur, M.R. Deshmukh, R.K. Reddy and R.S. Sharma ... 200
Field efficacy of different insecticides against stem fly and girdle beetle on soybean
S.S. Keshbhat, U.S. Bidgire, D.S. Suryawanshi ... 202
Integrated management of Alternaria leaf blight of sunflower caused by *Alternaria helianthi*
Y.S. Amaresh, V.B. Nargund and B.V. Patil ... 204
Effect of temperature and pH on growth and sporulation of wilt causing pathogen in linseed
V. Souramma and Jyoti Singh ... 206
Field evaluation of linseed germplasm for resistance to alternaria blight and powdery mildew diseases
Jyoti Singh ... 208
Quality characteristics of some castor hybrids and varieties
M.K. Patel, H.C. Pathak, A.D. Raj and K.J. Desai ... 210
Variation in auxin production in the rhizosphere of soybean genotypes
A. Ramesh, S.D. Billore, S.K. Sharma, O.P. Joshi and V.S. Bhatia ... 212
Yield variations caused by source sink alterations in sesame
Lakshmi Prayaga and P. Lakshmamma ... 215
Effect of Cycocel on safflower growth and yield under rainfed Vertisol conditions
V.S. Kubsad, V. Rudra Naik, C.P. Mallapur and U.K. Hulihalli ... 218
Stress management in insect pests on oil palm
Kalidas Potineni ... 220

J. Oilseeds Res., **21(1):1-10 (2004)**

Morphological characterization of released groundnut, *Arachis hypogaea* L. cultivars for the DUS requirement

K. Rajgopal, A. Bandyopadhyay[1], K. Chandran, H.B. Lalwani, N.R. Ghetia and P.K. Bhalodia

National Research Centre for Groundnut, P.B. No.5, Ivnagar Road, Junagadh-362 001, Gujarat

(Received: June, 2002; Revised: August, 2003; Accepted: October, 2003)

Abstract

In the present era of Intellectual Property Rights (IPR), the distinctness of the cultivar from other released cultivars is the first of the triad of the DUS for granting any form of protection to the rights of its breads. Keeping this in view, basis of distinctness among seventy released groundnut (*Arachis hypogaea* L.) cultivars of which 17 each belongs to the virginia bunch and virginia runner type of the ssp. *hypogaea* and 33 belongs to the spanish type and three to valencia type of ssp. *fastigiata*, were studied. Each cultivar was scored for 17 traits, stem, leaf, flower, fruit and seed traits, and reaction to biotic stresses using the Descriptors for Groundnut developed by IPGRI/ICRISAT. The cultivars showed overlapping of descriptor states in various combinations of traits. The branching pattern and leaf colour could distinguish up to sub-species level. The testa colour was distinct in some of the cultivars that can be used as a diagnostic tool for identification of a few cultivars. In cluster analysis, a combination of 11 characters could distinguish all cultivars. The study indicated that distinction is possible between 70 cultivars using the 11 traits. However, the total number of groundnut cultivars released exceeds 120 and hence to meet DUS criteria as identification of cultivars, some of the distinct morphological characters in coalition with molecular characters may be necessary.

Key words: *Arachis hypogaea*, morphology, descriptors, distinctness, uniformity, stability

Introduction

In India, four botanical types of groundnut *viz.*, virginia bunch (HYB) and virginia runner (HYR) of the ssp. *hypogaea* var. *hypogaea*, spanish (VUL) of the ssp. *fastigiata* var. *vulgaris* and the valencia (FST) of ssp. *fastigiata* var.. fastigiata are under cultivation. (Krapovickas and Gregory, 1994). During the last eight decades about 120 improved cultivars have been released for commercial cultivation in India.

The cultivars released have not so far been extensively described for various heritable morphological traits to enable the identification of these cultivars and for unambiguous ascertainment of distinctness. To meet the requirement of the Plant Breeder's and Farmers rights, it is imperative to identify a set of morphological traits, which can be used for DUS (Distinctness, Uniformity and Stability) testing. In the present study, 17 heritable morphological traits were scored over three years on 70 released cultivars to understand the extent of variation which can be used for distinction of cultivars based on single trait or combinations of traits.

Materials and methods

Seventy groundnut cultivars developed in India were evaluated at the National Research Centre for Groundnut, Junagadh (21.31°N latitude, 70.36°E longitude and altitude of 61 m) in the Gujarat state. The soil is calcareous and medium black Vertisol. Fifty-six of the cultivars comprising four habit types, were assembled in summer 1995 and the rest fourteen in 1996. Twenty-eight of the cultivars were developed by pure line selection, 34 by hybridization and three by mutation breeding, two cultivars were direct introductions, and the pedigree of three cultivars are not known (Table 1). Fifty-six cultivars were evaluated for three *kharif* (rainy season) seasons of 1995, 1996 and 1997 and all 70 were evaluated for two years, 1996 and 1997. The entries were grown in a randomized block design with three replications. The cultivars of different habit forms were randomized within the block. A plot consisted of three rows of 4 m length. The experimental details were as follows.

[1] National Coordinator (NATP), Krishi Anusandhan Bhawan, IARI Campus, New Delhi-110 012.

Morphological characterization of released groundnut cultivars for the DUS requirement

Year	HYB	HYR	FST	VUL	Date of Sowing	Spacing (row-to-row x plant-to- plant)	Total rainfall (mm)	Rainy days
1995	12	15	2	27	12 July	60cmX10cm	505	38
1996	17	17	3	33	9 July	60cm X10cm	731	68
1997	17	17	3	33	30 June	75cm X10cm	856	50

Table 1 Passport information on the released cultivars

Name	Pedigree	YOR	Centre
Virginia bunch			
ALR 1	Pol.2 x PPG 4	1987	TNAU, Aliyarnagar
B 95	M 13 x Shulamith	1993	MPKV, Rahuri
BAU 13	BAU 6 x M 13	1993	BAU, Kanke
BG 2	X ray mutant of 41-C	1979	BAU, Kanke
GG 20	GAUG 10 x Robut 33-1	1991	GAU, Junagadh
HNG 2	—	--	RAU, Hanumangarh
ICGS 5	(Robut 33-1 x NCAc 316) F2	1992	ICRISAT, Patancheru
ICGS 76	TMV 10 x Chico	1989	ICRISAT, Patancheru
ICGV 86325	ICGS 20 x G 201	1994	ICRISAT, Patancheru
Kadiri 3	Selection from Robut 33-1	1978	ANGRAU, Kadiri
M 145	A1-1 x D 3	1968	PAU, Ludhiana
M 522	Punjab 1 x F 334-AB 14	1995	PAU, Ludhiana
RS 138	Selection from Brazilian culture	1989	RAU, Durgapura
RSB 87	Selection from Brazilian culture	1961	RAU, Durgapura
T 28	Selection from Bombay collection	1960	CAUA&T, Mainpuri
T 64	Selection from EC1664	1966	CAUA&T, Mainpuri
TMV 10	Natural mutant from Argentine	1970	TNAU, Tindivanam
Virginia runner			
Chandra	Selection from Ah114	1977	CAUA&T Mainpuri
Chitra	Spanish 5B-1 x EC1688	1984	CAUA&T Mainpuri
CSMG 84-1	Selection from MA10	1992	CAUA&T Mainpuri
GAUG 10	G 224-3 x GO 343	1973	GAU, Junagadh
GG 11	M 13 x GAUG10	1984	GAU, Junagadh
GG 12	Shulamith x GAUG 10	1991	GAU, Junagadh
GG 13	GAUG 10 x TMV 10	1994	GAU, Junagadh
Karad 4-11	Selection from local	1957	MPKV, Karad
Kaushal	Selection from T 28	1984	CAUA&T Mainpuri
M 13	Selection from NC13	1972	PAU, Ludhiana
M 197	C501 x U 4-7-2	1982	PAU, Ludhiana
M 335	M 13 x F7	1986	PAU, Ludhiana
M 37	A 1 x C 6-4-7-2	1980	PAU, Ludhiana
Punjab 1	Selection from Samrala local	1953	PAU, Ludhiana

Table 1 (Contd...)

Name	Pedigree	YOR	Centre
RS 1	Selection from local collection	1953	RAU, Durgapura
Somnath	TG 18 A (Induced mutant of TG 18 A x M13)	1990	GAU, Junagadh
UF 70-103	Introduction from USA	1984	PKV, Akola
Spanish			
AK 12-24	Selection from Local	1940	PKV, Akola
ALR 2	Selection from ICGV 86011	1997	TNAU, Aliyarnagar
Co 1	Ah 6279 x TMV 3	1979	TNAU, Coimbatore
Dh 3-30	Spanish Improved x US 4	1975	UAS, Dharwad
Dh 8	Selection from RS 144	1984	UAS, Dharwad
GG 2	J 11 x EC 16659	1983	GAU, Junagadh
GG 3	GAUG 1 x JL 24	1991	GAU, Junagadh
GG 4	CGC 3 x Chico	1993	GAU, Junagadh
Girnar 1	X 14-4-B-19-B x NCAc17090	1988	NRCG, Junagadh
ICGS 1	Selection from Robut33-1	1990	ICRISAT, Patancheru
ICGS 11	Selection from Robut33-1	1986	ICRISAT, Patancheru
ICGS 44	Selection from Robut33-1	1988	ICRISAT, Patancheru
ICGV 86590	X 14-4-B-19-B x PI 259747	1991	ICRISAT, Patancheru
J 11	Ah 4218 x Ah 4354	1964	GAU, Junagadh
JL 24	Selection from EC 94943	1978	MPKV, Jalgaon
K 134	Kadiri 3 x JL 24	1993	ANGRAU, Kadiri
MH 1	Selection from Faizpur 1-5	1975	CCSHAU, Hisar
RG 141	Robut 33-1 x NCAc 2821	1989	RAU, Durgapura
SB XI	Ah 4213 x Ah 4354	1965	GAU, Junagadh
SG 84	Selection from ICGS 1	1986	PAU, Ludhiana
Spanish improved	Selection from Spanish peanut	1905	UAS, Dharwad
TAG 24	Selection from TGS 2	1991	BARC, Trombay
TG 17	Dark green Mutant x TG1	1982	BARC, Trombay
TG 22	Robut 33-1 x TG 17	1992	BARC, Trombay
TG 26	BARCG 1 x TG 23	1995	BARC, Trombay
TG 3	Mutant of Spanish improved	1985	BARC, Trombay
TKG 19 A	TG 17 x TG 1	1993	KVK, Dapoli
TMV 2	Selection from Gudhiatham bunch	1940	TNAU, Tindivanam
TMV 7	Selection from Tenesse white	1967	TNAU, Tindivanam
TMV 12	Selection from Ugandan culture	1978	TNAU, Tindivanam
Tirupati 1	Selection from EC 106983/3-1	1989	ANGRAU, Tirupati
Tirupati 2	GAUG 1 x NCAc FLA-14	1991	ANGRAU, Tirupati
Valencia			
Gangapuri		--	JNKVV, Khargaon
MH 2	Selection from GDM	1978	CCSHAU, Hisar
MH 4	--	1990	CCSHAU, Hisar

*YOR = Year of release, ** Centre = Centre of release

Recommended agronomic practices were followed. The crop was protected from insect-pests by insecticides. No fungicide was sprayed so that the entries could be scored for three economically important diseases viz., early leaf spot (ELS), late leaf spot (LLS) and rust, which occur in sufficient intensity each year. The cultivars were scored for 25 morphological traits using IBPGR/ICRISAT descriptors for groundnut (1992) at various phenophases in each of three years. But only those 17 characters out of the 25, which are stable across the years, have been used for further analysis. Most of these descriptors are common with those specified by UPOV (1985) for studying distinctness in groundnut.

Cluster analysis was done on the basis of squared euclidian distance, first using all the 17 characters to understand the grouping among the cultivars. Then the analysis was repeated by excluding one character at a time. Then the analysis was repeated by excluding two characters in all combinations at a time and this elimination of characters combinations continued till any two cultivars failed to remain distinct.

Results and discussion

The branching pattern in the HYB and HYR cultivars was either alternate or irregular on the n+1 branches but invariably there was no flowers on the main axis (n). The VUL and FST cultivars had flowers on the main axis, and their n+1 branches had sequential or irregular arrangement of flowering nodes (Table 2). The stem surface was sub-glabrous in most of the HYB and HYR cultivars and moderate hairiness was observed in six cultivars of VUL and one of FST. The stem was devoid of pigmentation in most of the cultivars. Most of the HYB and HYR types had multiple pegs from the nodes whereas both single and multiple pegs were present in VUL and FST types. The standard petal colour was orange in most of the cultivars with a few exceptions of dark orange petals. The leaflet shape, leaflet tip and peg pigmentation did not show any particular pattern specific to any habit type. In general, leaflet colour was either green or dark green among the HYB, HYR and FST types and light green in the VUL types. However, the spanish type cultivar ALR 2 had dark green leaves, which is of a rare occurrence in this group. The cultivars had predominantly slight pod beak and slight pod reticulation and moderate pod constriction, but most of the descriptor states of these traits were found among the cultivars. Pod reticulation was absent in the cultivars JL 24, TG 26 and Gangapuri whereas prominent reticulation was observed in the cultivars BAU 13, TG 64, ALR 2 and TKG 19 A. A wide range of testa colours was observed among the cultivars although the majority of the cultivars had rose or salmon coloured testa. Among the HYB types, four cultivars, ALR 1, BAU 13, RS 138 and RSB 87 had red testa and one M 145, had dark red testa. The cv. TMV 10 had white flecks on red testa, which is a unique feature of this cultivar. Among the HYR collection, the cultivars Chitra and CSMG 84-1 had rose testa with white flecks, which distinguish these two from other cultivars. Among the FST group, Gangapuri could be identified by its smooth pods and red testa whereas MH 2 was distinguishable by its dwarf stature. The cultivars ALR 1, Chitra and CSMG 84-1 showed moderate resistance to ELS, LLS and rust whereas, AK 12-24, GG 2, GG 4, J 11, JL 24, SB XI, TMV 7 and MH 4 showed high susceptibility to these diseases. There was overlapping of descriptor states for many pf the traits among the cultivars although some patterns were found to distinguish among the cultivars (Table 3).

On the basis of seventeen traits, the cluster analysis gave many groups as there were cultivars. The squared euclidian distances between pairs of cultivars have been given in Table 4. By excluding six characters viz., branching pattern, nature of inflorescence, stem pigmentation, leaflet shape, leaflet tip and peg pigmentation similar grouping obtained with 17 characters was obtained and all the cultivars remained distinct. Thus these 11 traits were sufficient for distinguishing among the 70 cultivars. (Fig.1). Further reduction in number of characters for cluster analysis failed to distinguish between the cv. TMV 12 (cv no.63) and the cv. Dh 3-30 (cv no.38), and between the cv. Chandra (cv no.18) and the cv. M 335 (cv no.29) as the distance between the members of these pairs was zero (Table 4).

The study indicated no one morphological trait could distinguish a cultivar except by instances of testa colour. The study conducted by Bhagat *et al.*, (1984) with 34 released cultivars indicated a similar situation. Even alternate branching of vegetative and reproductive nodes on n+1 and lack of flowers on the main axis used to describe virginia types could not hold true among cultivars. For example cv. Somanth has irregular branching (n+1) and flowers on main axis. Due to hybridization for the development of new cultivars, several intermediate types have been developed (Singh *et al.*, 1992).

The pedigrees of the cultivars show that only a few parents have been involved in the development of the cultivars released so far. The cultivars predominantly used for incorporation of high yield in developing the cultivars through hybridization were M 13, GAUG 1, GAUG 10 and Robut 33-1. Similarly, RS 138, RSB 87 were developed through selection from a Brazilian culture and ICGS 1, ICGS 11, ICGS 44 and, Kadiri 3 were all developed from Robut 33-1. The narrow genetic base of the improved cultivars may be the reason for finding high degree of morphological homology among the released cultivars.

Table 2 The descriptors and their states for 17 qualitative traits among the released groundnut cultivars

Cultivar	BP	SH	SP	IN	FC	LC	LS	LT	PP	PB	PC	PR	SS	TC	EL	RU	LL
Virginia bunch																	
ALR 1	1	3	0	2	1	2	1	1	1	5	3	3	2	13	3	3	3
B 95	1	3	0	2	2	3	2	2	0	0	0	3	2	10	5	5	5
BAU 13	1	3	0	2	2	2	2	2	1	5	5	7	1	13	5	5	5
BG 2	1	3	0	2	2	2	2	2	1	3	3	3	2	10	5	5	5
GG 20	1	3	0	1	1	2	2	2	0	5	5	5	1	10	5	5	5
HNG (HPS) 2	4	3	0	2	2	2	2	2	1	3	5	5	2	10	5	5	7
ICGS 5	4	1	0	2	1	2	2	2	1	5	5	3	2	11	5	5	5
ICGS 76	1	1	0	2	1	2	2	2	1	5	5	3	1	11	5	5	7
ICGV 86325	4	3	0	1	1	2	2	2	0	0	3	3	1	11	5	5	5
Kadiri 3	4	3	0	2	1	2	2	2	0	0	3	3	1	10	5	7	7
M 145	1	1	0	2	1	2	2	2	1	5	5	3	1	14	5	5	5
M 522	4	1	0	2	1	2	2	2	1	3	5	5	1	11	7	5	7
RS 138	1	3	0	1	1	2	2	2	1	3	5	3	1	13	3	3	5
RSB 87	1	3	1	2	1	3	2	2	1	3	5	3	2	13	3	3	5
T 28	4	1	0	2	1	2	2	2	0	3	5	3	2	10	3	5	3
TG 64	4	3	0	2	1	2	2	2	1	3	5	7	1	10	5	5	7
TMV 10	1	3	0	1	1	3	2	2	1	5	3	0	1	13+2	5	5	7
Virginia runner																	
Chandra	1	3	0	2	1	2	2	2	1	3	5	5	2	11	5	5	5
Chitra	4	3	0	2	1	3	2	2	1	3	5	5	2	10+2	3	3	3
CSMG 84-1	4	3	0	2	1	2	2	2	1	0	5	5	2	10+2	3	3	3
GAUG 10	1	3	0	2	2	2	2	2	0	3	3	3	2	10	5	3	3
GG 11	1	3	0	1	2	2	2	2	0	3	3	3	2	10	5	3	5
GG 12	1	3	0	2	1	2	2	2	0	3	5	3	2	10	7	5	7
GG 13	1	3	0	2	1	2	2	2	1	3	3	3	2	10	3	3	5
Karad 4-11	4	3	0	2	2	1	2	2	0	0	3	3	2	10	3	5	3
Kaushal	4	1	0	2	2	2	2	2	0	3	5	3	2	10	5	5	5
M 13	1	1	0	2	1	2	2	2	1	3	5	5	2	11	3	5	5
M 197	1	3	0	2	1	2	2	2	1	3	5	3	2	10	3	5	5
M 335	4	1	0	2	1	2	2	2	1	3	5	5	2	11	5	5	5
M 37	4	1	0	1	2	3	2	2	0	3	5	3	2	10	5	5	5
PG 1	4	1	0	2	1	2	2	2	0	3	3	3	2	10	3	5	5
RS 1	1	3	1	2	2	2	2	2	1	0	3	5	2	10	5	5	5
Somnath	3	1	0	2	2	2	2	2	1	5	5	5	2	10	5	5	7
UF 70-103	4	1	0	2	1	2	2	2	0	3	3	3	2	10	5	7	7

Table 2 (Contd..)

Cultivar	BP	SH	SP	IN	FC	LC	LS	LT	PP	PB	PC	PR	SS	TC	EL	RU	LL
Spanish																	
AK 12-24	2	3	0	1	1	1	2	2	1	3	3	3	1	10	7	7	9
ALR 2	2	3	0	2	2	3	2	2	1	0	5	7	1	11	5	5	7
CO 1	3	3	0	1	1	1	2	2	1	3	5	3	1	11	5	5	7
Dh 3-30	2	1	0	1	1	1	2	2	1	3	3	3	1	10	5	5	5
Dh 8	2	3	0	1	1	1	1	1	1	0	5	3	2	11	5	7	7
GG 2	2	3	0	2	1	2	2	2	1	3	3	3	1	10	7	7	9
GG 3	2	3	0	1	1	1	2	2	1	3	3	5	1	11	5	5	9
GG 4	3	3	0	1	1	1	2	2	1	5	5	5	2	11	7	7	9
Girnar 1	2	5	0	2	2	1	2	2	1	5	5	5	1	10	7	3	9
ICGS 1	3	3	0	2	1	1	2	2	0	0	3	3	1	10	5	7	7
ICGS 11	2	3	0	2	1	2	2	2	1	0	5	3	1	10	5	7	7
ICGS 21	2	1	0	2	1	2	2	2	1	5	3	3	2	10	5	7	7
ICGS 44	2	3	0	2	1	2	2	2	0	0	5	3	2	10	5	7	7
ICGV 86590	2	1	0	2	1	2	2	2	0	5	5	5	2	11	3	3	5
J 11	2	3	0	2	1	1	2	2	0	3	5	3	1	11	7	7	9
JL 24	2	3	0	1	1	2	2	2	0	3	5	0	1	11	7	7	9
K 134	2	3	0	1	2	2	2	2	1	3	5	3	2	10	5	5	7
MH 1	2	5	0	1	1	1	2	2	1	3	5	3	1	11	7	9	9
RG 141	2	3	0	1	2	2	2	2	1	0	3	3	1	11	7	7	7
SB XI	2	3	0	1	2	1	2	2	1	3	3	3	1	11	7	7	9
SG 84	2	1	0	2	1	2	2	2	0	0	5	3	2	10	5	5	7
Spanish Improved	2	5	0	2	1	1	2	2	0	3	5	5	1	11	5	7	7
TAG 24	2	3	1	2	2	2	2	2	1	3	5	3	1	11	7	5	9
TG 17	2	3	0	2	1	2	2	2	1	5	5	5	2	10	5	5	7
TG 22	2	1	0	2	2	2	2	2	0	5	5	5	2	10	5	7	7
TG 26	2	3	0	2	2	2	2	2	0	3	3	0	1	10	7	5	7
TG 3	2	3	0	2	1	1	2	2	1	3	5	3	1	10	5	5	7
TKG 19 A	2	3	0	2	2	2	1	1	1	5	5	7	2	10	5	5	7
TMV 12	2	5	0	1	1	1	2	2	1	3	3	3	1	10	5	5	5
TMV 2	2	5	0	1	1	2	2	2	1	3	3	3	1	11	7	5	7
TMV 7	3	3	0	1	1	1	2	2	1	3	3	3	1	11	7	7	9
TPT 1	3	1	0	1	1	1	2	2	1	3	3	3	1	11	5	7	7
TPT 2	3	5	0	1	1	1	2	2	1	0	3	3	1	11	7	5	7
Valencia																	
MH 2	2	5	0	1	1	2	2	2	1	3	5	3	1	13	5	5	7
MH 4	2	1	0	2	1	2	2	2	1	3	5	3	2	10	7	7	9
Gangapuri	2	3	0	1	2	1	2	2	1	3	3	0	1	13	5	5	7

BP= branching pattern, SH = stem hairiness, SP=stem pigmentation, IN= Nature of inflorescence, FC= colour of standard petal, LC= leaf colour, LS= leaflet shape, LT= leaflet tip, PP= peg pigmentation, PB= pod beak, PC = pod constriction, PR= pod reticulation, SS= seed size, TC= testa colour, EL= Susceptibility to early leaf spot, RU= Susceptibility to rust , LL= Susceptibility to late leaf spot

Table 3 Distribution pattern of qualitative traits among the released groundnut cultivars

Trait	Virginia bunch			Virginia runner			Spanish			Valencia		
Branching pattern	1(10)	4(7)	--	1(8)	3(1)	4(8)	2(27)	3(6)	--	2(3)	--	--
Stem hairiness	1(5)	3(12)	--	1(7)	3(10)	--	1(6)	3(21)	5(6)	1(1)	3(1)	5(1)
Stem pigmentation	0(16)	1(1)	--	0(16)	1(1)	--	0(32)	1(1)	--	0(3)	--	--
Inflorescence	1(4)	2(13)	--	1(2)	2(15)	--	1(16)	2(17)	--	1(2)	2(1)	--
Flower colour	1(13)	2(4)	--	1(10)	2(7)	--	1(24)	2(9)	--	1(2)	2(1)	--
Peg pigmentation	1(5)	2(12)	--	1(8)	2(9)	--	1(9)	2(24)	--	1(3)	--	--
Leaf colour	--	2(14)	3(3)	1(1)	2(14)	3(2)	1(17)	2(15)	3(1)	1(1)	2(2)	--
Leaf shape	1(1)	2(16)	--	--	2(17)	--	1(2)	2(31)	--	--	2(3)	--
Leaflet tip	1(1)	2(16)	--	--	2(17)	--	1(2)	2(31)	--	--	2(3)	
Pod beak	0(3)	3(7)	5(7)	0(3)	3(13)	5(1)	0(8)	3(18)	5(7)	3(3)	--	--
Pod constriction	0(1)	3(5)	5(11)	--	3(7)	5(10)	--	3(14)	5(19)	--	3(1)	5(2)
Pod reticulation	0(1), 3(11), 5(3), 7(2)			-	3(10)	5(7)	0(2), 3(22), 5(7), 7(2)			0(1)	3(2)	-
Seed shape	1(10)	7(2)	-	-	2(17)	-	1(23)	2(10)	-	1(2)	2(1)	-
Testa colour	10(7), 11(4), 13(4), 14(1)		13-2(1),	10-2(2)	10(12)	11(13)	10(16)	11(17)	-	10(1)	13(2)	-
Susceptibility to ELS	3(4)	5(12)	7(1)	3(7)	5(9)	7(1)	3(1)	5(18)	7(14)	-	5(2)	7(1)
Susceptibility to rust	3(3)	5(13)	7(1)	3(5)	5(11)	7(1)	3(2), 5(14), 7(16), 9(1)			-	5(2)	7(1)
Susceptibility to LLS	3(2)	5(9)	7(6)	3(4)	5(10)	7(3)	5(3)	7(19)	9(11)	-	7(2)	9(1)

Figures in parenthesis indicate number of cultivars

Table 4 Squared euclidian distance (rounded to second place after decimal) between pairs of cultivars based on three different sets of number of characters

17 characters			11 characters			10 characters		
CV. No.	CV No.	Distance	CV No.	CV No.	Distance	CV No.	CV No.	Distance
54	65	2.00	54	65	1.00	38	63	0.00
58	62	2.00	6	51	1.00	18	29	0.00
47	55	2.00	10	47	1.00	54	65	1.00
10	44	2.00	35	40	1.00	33	62	1.00
35	40	2.00	15	31	1.00	47	55	1.00
4	32	2.00	26	30	1.00	49	52	1.00
15	31	2.00	27	29	1.00	26	51	1.00
26	30	2.00	24	28	1.00	34	46	1.00
7	29	2.00	21	22	1.00	10	45	1.00
24	28	2.00	49	54	1.50	35	40	1.00
18	27	2.00	10	45	1.50	28	31	1.00
21	22	2.00	18	27	1.50	18	27	1.00
19	20	2.00	4	6	1.50	21	22	1.00
64	68	3.00	10	44	1.67	33	59	1.50
37	66	3.00	64	68	2.00	10	44	1.50
45	61	3.00	37	66	2.00	26	30	1.50
33	59	3.00	61	63	2.00	15	28	1.50
49	50	3.00	58	62	2.00	4	21	1.50
6	16	3.00	33	59	2.00	33	58	1.67
13	14	3.00	34	55	2.00	6	33	1.75
33	58	3.50	19	20	2.00	23	69	2.00
35	69	4.00	13	14	2.00	17	68	2.00
38	63	4.00	7	8	2.00	64	67	2.00
41	54	4.00	4	32	2.33	56	66	2.00

Table 4 (Contd...)

17 characters			11 characters			10 characters		
CV. No.	CV No.	Distance	CV No.	CV No.	Distance	CV No.	CV No.	Distance
23	47	4.00	35	69	2.50	38	61	2.00
10	34	4.00	2	26	2.50	49	54	2.00
15	26	4.00	49	52	2.67	8	37	2.00
4	24	4.00	64	67	3.00	15	24	2.00
7	12	4.00	38	61	3.00	19	20	2.00
64	67	4.50	23	60	3.00	13	14	2.00
49	57	4.50	16	58	3.00	7	18	2.33
45	51	4.50	53	57	3.00	10	47	2.50
37	41	4.50	33	46	3.00	7	48	2.75
4	21	4.50	37	41	3.00	4	26	2.89
1	13	4.50	15	24	3.00	9	64	3.00
23	45	4.67	1	30	3.00	12	57	3.00
39	53	5.00	2	21	3.17	39	56	3.00
18	48	5.00	10	34	3.25	49	50	3.00
33	46	5.25	49	50	3.50	2	32	3.00
37	39	5.50	37	39	3.67	5	16	3.00
49	52	5.67	7	18	3.67	9	53	3.33
8	18	5.67	2	4	3.95	23	35	3.50
2	4	5.67	5	16	4.00	8	12	3.50
37	64	5.9[illegible]	7	12	4.20	5	6	3.50
37	70	6.10	49	53	4.30	4	15	3.67
23	35	6.22	2	15	4.67	23	34	3.75
23	60	6.44	37	56	4.75	39	41	4.00
15	25	6.50	5	33	4.83	1	13	4.00
49	56	6.75	10	23	4.83	10	38	4.20
1	8	6.92	9	64	5.00	8	39	4.50
37	49	6.96	11	17	5.00	42	49	4.60
5	38	7.00	7	48	5.17	10	23	4.75
11	17	7.00	10	35	5.17	8	9	4.78
6	33	7.70	9	37	5.25	2	4	4.90
37	42	7.94	42	49	5.57	11	17	5.00
3	36	8.00	2	25	5.77	1	7	5.00
7	9	8.00	9	70	5.89	2	25	5.25
2	5	8.05	10	38	5.97	10	60	5.36
10	15	8.13	9	42	6.07	8	42	5.55
6	23	9.00	1	7	6.76	1	19	6.38
7	19	9.50	3	36	7.00	8	70	6.53
1	3	10.29	2	19	7.21	5	43	6.57
2	6	10.42	5	10	7.64	3	36	7.00
7	10	10.96	2	5	8.33	2	10	7.34
2	43	12.74	1	3	9.00	2	5	7.69
1	11	12.94	1	9	10.83	1	3	9.40
2	37	14.29	1	2	12.61	2	8	11.40
2	7	15.58	1	43	14.46	1	2	12.38
1	2	18.36	1	11	21.37	1	11	20.87

Cv. No.= Cultivar number

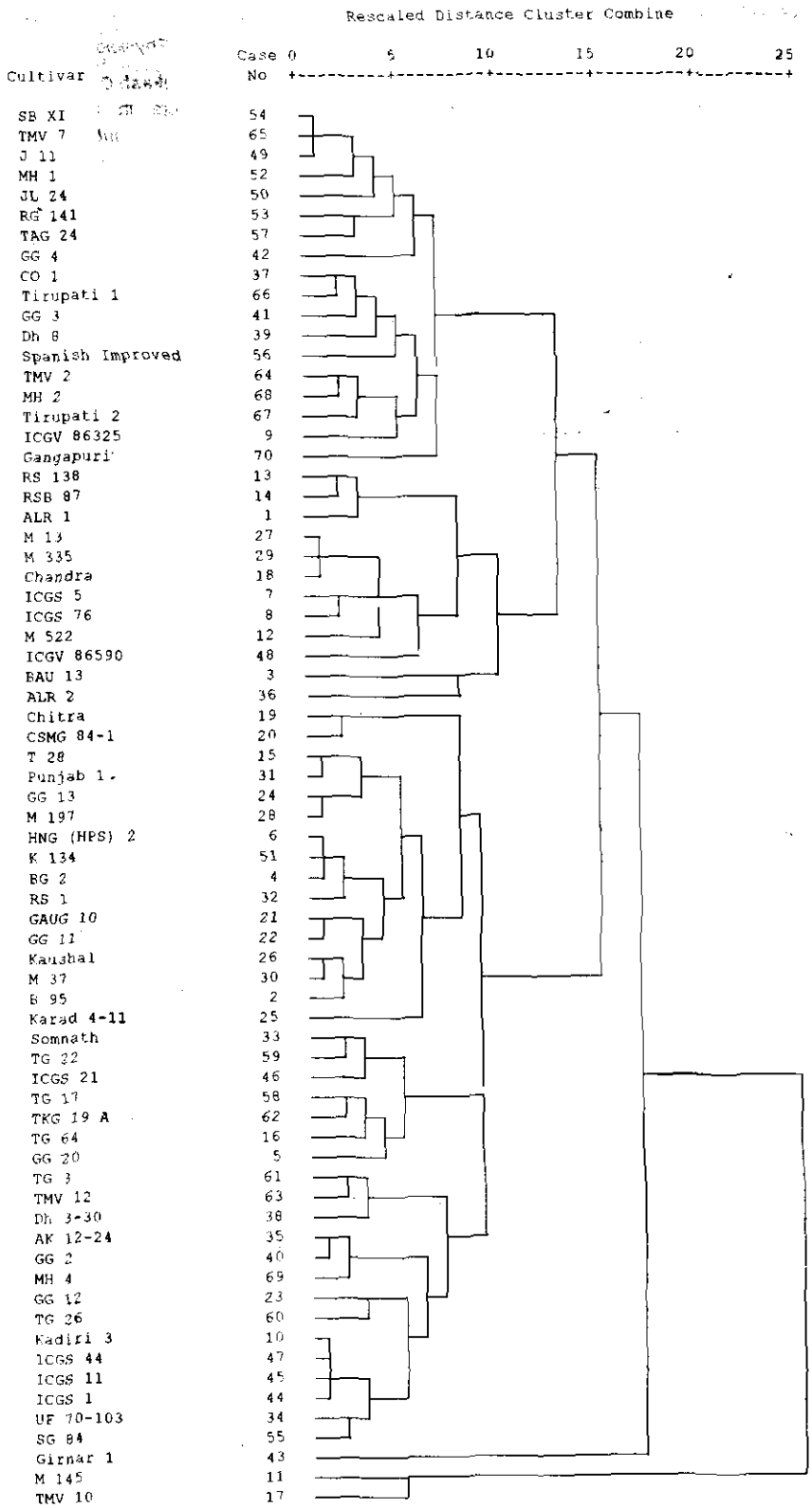


Fig.1 Dendogram of 70 released cultivars based on 11 morphological traits

With more than 120 released cultivars of groundnut in India, morphological traits alone may not suffice for the DUS criteria. Also, some of these traits may be influenced by environment. The electrophoretic studies on groundnut seed protein indicated variation in arachin polypeptides (Krishna *et al.*, 1986) and polypeptide composition (Bisha, 1979). DNA polymorphism was also detected in groundnut using AFLP technique (He and Prakash, 1997). Hence, collaboration through more consistent biochemical and molecular characters, which are less influenced by environment need to be explored for the delineation of groundnut cultivars for varietal protection.

The authors are grateful to Mr. Sugadh Singh for his assistance in maintaining the cultivars and recording of observations.

References

Bhagat, N.R., Taslim Ahmed, Lalwani, H.B. and Harender Singh. 1984. Characterization of improved groundnut *Arachis hypogaea* L. varieties. National Research Centre for Groundnut, Junagadh, pp. 1-58.

Bisha, S.M.M. 1979. Identification of cultivar differences in seed polypeptide composition of peanuts *Arachis hypogaea* L. by two dimensional polyacrylamide gel electrophoresis. *Plant Physiology*. **63**: 301-306.

He, G.H. and Prakash C.S. 1997. Identification of polymorphic DNA markers in cultivated peanut (*Arachis hypogaea*). *Euphytica- International Journal of Plant Breeding*. **97:** 143-149.

IBPGR and ICRISAT. 1992. *Descriptors for Groundnut*. International Board for Plant Genetic Resources, Rome, Italy; International Crops Research Institute for the Semi-Arid Tropics, ICRISAT, India, pp. 1-125

Krapovickas, A. and Gregory W.C. 1994. Taxonomia del genero *Arachis* (Leguminosae). *Bonplandia*, **8:** 1-187.

Krishna, I.G., Pawar, S. and Mitra, R. 1986. Variation and inheritance of the arachin polypeptides of groundnut. *Theoretical and Applied Genetics*, **73:** 82-87.

Singh, A.K., Ramanatha Rao V. and Mangesha M.H. 1992. Groundnut Genetic Resources: Progress and Prospects. *In Groundnut- a global perspective:* Proceedings of an International Workshop, 25-29 Nov. 1991, ICRISAT Centre, India (Nigam, S.N. ed.) ICRISAT, A.P. 502 324, India, pp. 297-309.

UPOV, 1985. Guidelines for the conduct of tests for distinctness, homogeneity and stability. International Union for the Protection of New Varieties of Plants. pp. 1-13.

J. Oilseeds Res., **21**(1): 11-16 (2004)

Genetic analysis of yield components and confectionery traits in crosses involving large seeded genotypes of groundnut, *Arachis hypogaea* L.

J.R. Dobaria, A.L. Rathnakumar and P.S. Bharodia

National Research Centre for Groundnut, P.B. No.5, Junagadh-362 001, Gujarat

(*Received:* June, 2002; Revised: July, 2003; Accepted: September, 2003)

Abstract

Genetic analysis of four yield components and three confectionery traits was carried out in five inter sub-specific crosses involving five Virginia and Spanish genotypes of groundnut, *Arachis hypogaea* L. Two confectionery traits namely sugar and protein contents exhibited predominantly additive genetic effects while pod yield and oil content were governed by dominance. Both additive and dominance genetic effects were observed in case of shelling out-turn and sound mature kernel. Kernel weight exhibited complex genetic control indicating higher order gene interaction. Population improvement procedures like biparental mating and modified recurrent selection scheme were suggested to improve pod yield and confectionery traits simultaneously.

Key words: Groundnut, genetic analysis, *confectionery traits*, *additive*, dominance, genetic effects, **recurrent** selection, large seeded

Introduction

Groundnut seeds are characterized by high oil (32-55%) and protein content (16-34%) and a low percentage of sugar and ash. The oil from the seed is of high quality and a large percentage of world production of groundnut is used as an edible oil source. In India, groundnut seeds contribute to 80% of the edible oil reserve and a substantial quantity of hand graded, large seeded genotypes from other wise small seeded genotypes are also exported to different countries for confectionery purposes. The popularity of groundnut seeds in human food make them a natural candidate for source of vegetable protein ingredients. A number of products with protein content ranging from 25-90% have been developed and used for the commercial production of flakes, flours, meals, concentrates and protein rich isolates. Significant amount of work has been accomplished in selection (Wynne and Cofflet, 1982) and development of large seeded genotypes (Dwivedi *et al.*, 1989). However, studies on the genetic systems governing these valuable confectionery traits like oil, protein and sugar contents in addition to trade yield components like kernel weight, sound mature kernels and shelling percent the appropriate breeding methodologies to be followed involving large seeded genotypes are very limited. The preset study aims at elucidating the genetics of these trade related quality characters in five inter sub-specific crosses involving large seeded genotypes of groundnut.

Materials and methods

The experimental material consisted of six generations *viz.*; P_1, P_2, F_1, F_2, BC_1 and BC_2 derived from five inter sub *specific crosses involving five Virginia parents namely* ICGV 93080, GG 20, ICGV 94225, ICGV 86564 and BAU 13 and five Spanish parents *viz.*, GG 5, J 38, TG 17, TG 19A and ICGS 21. Five crosses were effected in a crossing block during summer 1999 to obtain the F_1 hybrid seeds. The F_1 plants were backcrossed with the parents, P_1 and P_2, keeping the F_1s as the ovule parents to get their respective backcross families, BC_1 and BC_2 in *kharif*, 1999. The F_1s were also grown to obtain the F_2 seeds during the same season. With the reserved seeds of direct F_1 hybrids of the five cross combinations, seeds for all the six generations namely, P_1, P_2, F_1, F_2, BC_1 and BC_2 were obtained for the experiment. All the six generations were raised in a Randomized Block Design with three replications during summer season 2000. Each *replication consisted of a single row of 5 m length for each* P_1, P_2 and F_1, two rows for each of BC_1 and BC_2 and four rows of F_2 progenies. A uniform inter and intra row spacing of 60 and 20 cm was maintained uniformly for raising all the generations. Recommended agronomic practices and plant protection measures were adopted to raise a successful crop.

Observations on pod yield/plant (g), shelling (%), 100-kernel weight (g), protein content (%), sugar content (%) and oil content (%) were recorded on 10 randomly chosen plants in each of P_1, P_2 and F_1 generations while they were recorded on twenty plants in each plot of BC_1 and BC_2 families and forty plants in F_2s. The protein, total sugar and oil content in composite sample of 10-15 seeds of individual plant were estimated by Micro-Kjeldahl *method (Bremmer, 1965), Nelson-Somogyi colorimetric* method (Nelson, 1944), and nuclear magnetic resonance spectrometer (Model PC-20, Bruker India Scientific Co.

Pvt. Ltd), respectively. The data were subjected to generation mean analysis as suggested by Hayman (1958) and Jinks and Jones (1958). Scaling and non-scaling tests for each character were analysed as per the method suggested by Mather (1949) and Cavalli (1952). The genetic effects were estimated through Hayman's (1958) approach.

Results and discussion

The genetic effects of all the seven characters for the five crosses are presented in Table 1 along with the scales and respective X^2 values. Significant results are discussed character wise below.

Pod yield

The scaling test was significant in all the crosses for pod yield indicating that additive-dominance variance is inadequate to explain the observed variation for pod yield and indicated the presence of non-allelic interactions. Joint scaling tests further confirmed our results. Among the five crosses, three crosses namely GG 5 x ICGV 93080, J 38 x GG 20 and TG 19A x ICGV 86564 exhibited the importance of significant dominance effects in the presence of additive x additive and dominance x dominance interaction effects. Importance of dominance in governing pod yield in groundnut has been reported already (Sangha and Labana, 1982). Duplicate epistasis was detected in two crosses, J 38 x GG 20 and TG 19A x ICGV 86564 with the dominance components (h and l) exhibiting opposite signs.

Considering the segmental polyploidy in groundnut having two different genomes, role of duplicate epistasis in the inheritance of several quantitative and qualitative traits cannot be over ruled as evident from the present findings. Exploitation of dominance through hybrid breeding for improving pod yield in groundnut is not feasible looking into the operation of cleistogamy and consequent poor seed set upon hybridization (20%). Besides, the larger estimates of the non-fixable dominance x dominance variation may also hinder the pace of improvement of pod yield through simple selection methods. Hence, biparental mating in early segregating generations or few cycles of recurrent selection followed by pedigree selection may be effective for improving pod yield in large seeded groundnut cultivars.

100-kernel weight

The scaling and joint scaling tests were significant in all the crosses except for one cross, J 38 x GG 20 suggesting that additive-dominance model is insufficient to account for the variations observed for hundred kernel weight in these crosses. However, non-significance of the genetic components (d or h) in the cross, J 38 x GG 20 indicated the role of complex genetic systems governing kernel weight. The absence of significant additive and or dominance gene effects in the three other crosses viz., GG 5 x ICGV 93080, TG 19A x ICGV 86564 and ICGS 21 x BAU 13 further confirmed the above findings. However results conflicting to our present findings were reported in the literature (Sandhu and Khehra, 1976; Halward and Wynne, 1991). This may be due to the genotypes employed, method of analysis and the environmental conditions. In addition, most of the genotypes studied either directly or indirectly possessed exotic blood in them indicating the importance of selection of genotypes to breed special purpose varieties like confectionery groundnuts.

In the present study, only one cross holds promise for improving kernel weight, which exhibited significant dominance effect in the presence of all the three interaction effects. Duplicate epistasis was also detected in this cross, which may hinder with the selection at the early generations.

Kernel weight is an important criterion deciding the premium price of the export groundnuts. The complex genetic system observed in the present study cautions the early generation selection advocated (Sandhu and Khehra, 1976; Basu *et al.*,1988) for the improvement of kernel weight in the crosses involving small seeded genotypes and suggested postponing of selection to later filial generations to isolate superior large seeded genotypes.

Shelling out-turn

Epistasis was detected in all the five crosses. Predominance of dominance genetic effect was observed in all the crosses along with fixable additive x additive interaction effect. While both additive and dominance genetic effects were important in the cross, ICGS 21 x BAU 13. Importance of additive (Kumar and Patel, 1999) and dominance (Makne and Bhale, 1989) components of variation in the inheritance of shelling out-turn has been already reported by several authors.

Shelling out-turn is an important quality trait that determines the market value of bold seeded groundnut genotypes either for local consumption or for export purpose. Although the presence of both additive and dominance components may aid in developing high shellers through pedigree method, delaying the selection till the non-fixable interactions are eliminated in the population would yield desired results.

Sound mature kernel

The scaling and joint scaling tests detected epistasis in all the five crosses except for TG 17 x ICGV 94225. Predominance of additive genetic effect was observed in two crosses, TG 17 x ICGV 94225 and ICGS 21 x BAU 13, while additive and dominance genetic effects were observed in three crosses with greater magnitude of dominance components. Importance of additive and dominance components for sound mature kernel (%) has already been reported (Wynne *et al.*,1970; 1975; Bhagat *et al.*,1986). Among the interaction effects, the fixable additive x additive genetic components were significant only in cross, ICGS 21 x BAU 13, while dominance x dominance effect was significant and negative in one cross, TG 19A x ICGV 86564. While both additive x additive and dominance x dominance effects were significant in GG 5 x ICGV 93080.

Table.1 Components of generation means with 3 and 5 parameter models for different characters in groundnut.

Cross	Scales				Parameters					
	A	B	C	$X^2_{(3)}$	m	(d)	(h)	(i)	(j)	(l)
Pod yield										
GG 5 x ICGV 93080	-5.79 ± 1.73**	-4.33 ± 2.22	-12.35 ± 3.47**	18.42**	14.13 ± 0.70**	-2.56 ± 1.15*	7.99 ± 3.79*	2.22 ± 3.65	-0.72 ± 1.27	7.89 ± 5.79
J 38 x GG 20	-2.58 ± 2.31	-1.92 ± 2.32	-20.12 ± 2.99**	53.12**	13.03 ± 0.57**	-2.69 ± 1.39	15.92 ± 3.73**	15.62 ± 3.61**	-0.33 ± 1.58	-11.12 ± 6.32
TG 17 x ICGV 94225	-0.56 ± 1.32	-4.22 ± 1.29**	-6.94 ± 2.16**	16.15**	11.09 ± 0.39**	-0.07 ± 0.67	2.31 ± 2.20	2.15 ± 2.08	1.82 ± 0.84*	2.63 ± 3.45
TG 19 A x ICGV 86564	0.72 ± 1.89	-2.17 ± 1.78	-13.08 ± 2.99**	24.03**	12.87 ± 0.55**	-1.32 ± 0.93	9.83 ± 3.07**	11.63 ± 2.90**	1.45 ± 1.22	-10.18 ± 4.80*
ICGS 21 x BAU 13	-2.55 ± 1.84	-6.12 ± 2.10**	-17.64 ± 3.35**	25.65**	12.98 ± 0.63**	0.99 ± 0.99	14.00 ± 3.46**	8.96 ± 3.24**	1.78 ± 1.19	-0.29 ± 5.32
100 kernel weight										
GG 5 x ICGV 93080	-1.14 ± 2.61	-18.18 ± 2.03**	-20.30 ± 4.62**	86.09**	48.28 ± 0.96**	-0.98 ± 1.33	-4.08 ± 4.87	0.97 ± 4.70	8.52 ± 1.44**	18.35 ± 7.07**
J 38 x GG 20	1.01 ± 2.51	-3.61 ± 2.92	-10.84 ± 5.66	6.87	48.76 ± 0.85**	-3.38 ± 0.83**	1.28 ± 1.47	[illegible]	[illegible]	[illegible]
TG 17 x ICGV 94225	5.68 ± 2.53*	-4.19 ± 2.89	-2.01 ± 5.39	7.96*	50.77 ± 1.22**	-0.93 ± 1.62	2.15 ± 5.97	3.49 ± 5.86	4.93 ± 1.85*	-4.98 ± 8.45
TG 19 A x ICGV 86564	15.17 ± 4.24**	-1.76 ± 3.82	-15.56 ± 6.81*	21.83**	62.56 ± 1.51**	-1.51 ± 2.50	33.23 ± 8.01**	28.97 ± 7.85**	8.46 ± 2.76**	-42.38 ± 12.11**
ICGS 21 x BAU 13	-2.44 ± 2.79	-12.88 ± 3.90**	-26.72 ± 6.40**	25.09**	53.57 ± 1.46**	-4.45 ± 2.12*	12.09 ± 7.35	11.39 ± 7.24	5.21 ± 2.31*	3.93 ± 10.64
Shelling out turn										
GG 5 x ICGV 93080	-8.60 ± 1.74**	-3.57 ± 2.10	-19.63 ± 3.30**	47.39**	66.54 ± 0.58**	0.46 ± 0.99	7.87 ± 3.29*	7.45 ± 3.08*	-2.51 ± 1.19*	0.47 ± 5.17
J 38 x GG 20	-5.58 ± 1.48**	-5.01 ± 1.68**	-30.06 ± 3.31**	66.59**	63.45 ± 0.75**	-0.05 ± 0.93	16.39 ± 3.60**	19.47 ± 3.54**	-3.29 ± 1.07**	-8.88 ± 4.99
TG 17 x ICGV 94225	-0.98 ± 2.29	-2.66 ± 2.69	-16.83 ± 4.09**	17.29**	60.97 ± 0.90**	-0.63 ± 1.58	11.45 ± 4.90**	13.18 ± 4.81**	0.84 ± 1.67	-9.54 ± 7.54
TG 19 A x ICGV 86564	0.07 ± 1.83	-2.47 ± 1.52	-12.61 ± 3.61**	14.49**	63.82 ± 0.83**	0.11 ± 1.08	9.08 ± 4.00*	10.21 ± 3.95*	1.27 ± 1.14	-7.81 ± 5.51
ICGS 21 x BAU 13	-9.09 ± 2.33**	-8.83 ± 2.82**	-25.30 ± 4.18**	50.10**	63.63 ± 0.94**	3.97 ± 1.69**	8.33 ± 5.15	7.37 ± 5.07	-0.12 ± 1.79	10.56 ± 7.96
SMK %										
GG 5 x ICGV 93080	-18.17 ± 3.42**	-22.38 ± 4.28**	-19.30 ± 5.34**	55.78**	79.74 ± 1.16**	8.41 ± 2.51**	17.11 ± 6.96*	21.24 ± 6.83**	2.10 ± 2.64	61.80 ± 11.37**
J 38 x GG 20	-19.24 ± 2.94**	-10.63 ± 3.72**	-65.00 ± 7.01**	90.55**	71.75 ± 1.57**	-1.51 ± 2.02	28.33 ± 7.65**	35.13 ± 7.50**	-4.31 ± 2.18	-5.26 ± 10.72
TG 17 x ICGV 94225	-8.31 ± 4.10*	-15.33 ± 3.83**	-33.40 ± 7.11**	33.44**	61.25 ± 1.57**	7.37 ± 2.39**	6.15 ± 8.07	9.75 ± 7.90	3.51 ± 2.70	13.88 ± 11.92
TG 19 A x ICGV 86564	13.51 ± 4.67**	11.20 ± 4.24**	12.53 ± 9.28	10.80*	74.00 ± 1.67**	1.82 ± 2.07	17.24 ± 8.50*	12.17 ± 7.86	1.15 ± 2.27	-36.88 ± 12.26**
ICGS 21 x BAU 13	-0.86 ± 2.76	-3.84 ± 3.76	-18.80 ± 6.28**	9.61*	78.46 ± 1.33**	7.22 ± 1.88**	12.82 ± 6.74	14.08 ± 6.34*	1.48 ± 2.15	-9.37 ± 9.82

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

Table.1 (conti.) Components of generation means with 3 and 5 parameter models for different characters in groundnut

Cross	Scales				Parameters					
	A	B	C	$X^{2(3)}$	m	(d)	(h)	(i)	(j)	(l)
					Protein content					
GG 5 x ICGV 93080	-6.42 ± 1.00**	-6.09 ± 0.94**	-18.00 ± 1.51**	205.06**	21.06 ± 0.36**	0.62 ± 0.66	6.67 ± 1.97**	5.48 ± 1.96**	-0.16 ± 0.67	7.03 ± 3.05*
J 38 x GG 20	-1.77 ± 1.19	-2.06 ± 1.21	-4.80 ± 1.88*	10.02*	20.14 ± 0.44**	3.66 ± 0.81**	0.17 ± 2.42	0.95 ± 2.40	0.14 ± 0.82	2.88 ± 3.76
TG 17 x ICGV 94225	-1.54 ± 0.89	-1.05 ± 0.94	-5.88 ± 1.54**	17.63**	20.08 ± 0.37**	-1.82 ± 0.62**	2.57 ± 1.95	3.29 ± 1.95	-0.24 ± 0.64	-0.69 ± 2.94
TG 19 A x ICGV 86564	2.03 ± 1.19	5.58 ± 1.03**	20.25 ± 1.63**	211.68	20.97 ± 0.35**	2.21 ± 0.72**	9.41 ± 2.05**	9.34 ± 2.01**	0.21 ± 0.75	1.61 ± 3.30
ICGS 21 x BAU 13	-3.30 ± 0.94**	-3.66 ± 0.88**	-10.68 ± 1.52**	60.55**	19.53 ± 0.33**	-1.16 ± 0.38*	4.07 ± 1.81*	3.70 ± 1.77*	0.18 ± 0.60	3.26 ± 2.78
					Sugar content					
GG 5 x ICGV 93080	-3.67 ± 0.78**	-3.74 ± 0.69**	-16.77 ± 1.63**	104.05**	7.08 ± 0.29**	1.40 ± 0.48*	9.61 ± 1.53**	9.36 ± 1.51**	0.03 ± 0.52	-1.95 ± 2.30
J 38 x GG 20	-2.36 ± 0.83*	-3.41 ± 0.80**	-4.61 ± 1.69*	77.84**	6.71 ± 0.39**	2.50 ± 0.53**	-1.34 ± 1.93	-1.16 ± 1.91	0.52 ± 0.56	6.93 ± 2.71*
TG 17 x ICGV 94225	2.84 ± 0.78**	-1.38 ± 0.81	-0.64 ± 1.87	18.41**	7.61 ± 0.31**	-1.37 ± 0.52*	1.56 ± 1.65	2.10 ± 1.63	2.11 ± 0.55**	-3.56 ± 2.49
TG 19 A x ICGV 86564	-3.93 ± 0.69**	-1.67 ± 0.65*	-1.66 ± 1.55	46.90**	7.67 ± 0.36**	1.17 ± 0.40**	-2.53 ± 1.69	-3.94 ± 1.67*	-1.13 ± 0.45*	9.54 ± 2.24**
ICGS 21 x BAU 13	-0.28 ± 0.76	-5.82 ± 0.85**	-5.90 ± 1.56**	33.28**	8.29 ± 0.37**	-1.44 ± 0.52**	-0.53 ± 1.81	-0.20 ± 1.79	2.77 ± 0.55**	8.30 ± 2.61*
					Oil content					
GG 5 x ICGV 93080	-5.10 ± 0.68**	-2.64 ± 0.53**	-7.20 ± 1.24**	88.63**	46.72 ± 0.28**	-1.64 ± 0.38**	-0.11 ± 1.39	-0.50 ± 1.37	-1.21 ± 0.40**	8.25 ± 1.98**
J 38 x GG 20	-6.72 ± 0.97**	-2.29 ± 0.57**	-11.05 ± 1.33**	120.32**	46.36 ± 0.2**	-4.14 ± 0.54**	-0.88 ± 1.69	2.03 ± 1.68	-2.21 ± 0.55**	6.98 ± 2.56*
TG 17 x ICGV 94225	-8.87 ± 0.64**	-10.40 ± 0.60**	-15.24 ± 1.27**	567.36**	48.18 ± 0.30**	2.28 ± 0.41**	-1.25 ± 1.29	-4.04 ± 1.49*	0.76 ± 0.42	23.33 ± 2.10**
TG 19 A x ICGV 86564	-6.69 ± 0.69**	-5.78 ± 0.71**	7.34 ± 1.08**	275.85**	46.95 ± 0.26**	0.66 ± 0.48	-7.35 ± 1.43**	-5.13 ± 1.43**	-0.45 ± 0.48	17.60 ± 2.22**
ICGS 21 x BAU 13	-11.53 ± 0.82**	-9.71 ± 0.68**	-14.99 ± 1.19**	520.96**	47.44 ± 0.28**	0.57 ± 0.52	-5.92 ± 1.56**	-6.29 ± 1.55**	-0.92 ± 0.52	27.58 ± 2.39**

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

Higher % of SMK is an important character which provides uniform seed lot. For improvement of this character the cross, ICGS 21 x BAU 13, which exhibited positive additive and additive x additive interaction effects holds promise. Transgressive variation may likely to appear in the early segregating generation. Hence simple selection through pedigree breeding for high SMK% is suggested. How ever postponing the selection to later generations may result in desirable results.

Protein content

For protein content, all the crosses exhibited significance of the scaling tests (Table 1), indicating the role of epistasis. Additive, dominance genetic effect was predominant in one cross each *viz.*, J 35 x GG 20 and GG 5 x ICGV 93080 respectively. Whereas, both additive and dominance gene actions were significant in TG 19A x ICGV 86564 indicating the importance of both additive and dominance genetic effects in governing protein content. Similar (Layrisse *et al.*, 1980; Makne and Bhale, 1989) and contradictory reports (Basu *et al.*,1988) to the present finding were also available in the literature. Three crosses, GG 5 x ICGV 93080, TG 19A x ICGV 86564 and ICGS 21 x BAU 13 exhibited the importance of additive x additive gene interaction effects. These crosses may be utilized through pedigree breeding for improving protein content as transgressive variation may be expected in the segregating population. In addition, the absence of dominance x dominance and additive x dominance gene interaction effects may also result in greater gain through selection and offer enough scope to effect selection at early generation. The cross GG 5 x ICGV 93080 exhibited complementary epistasis with **h** and **I** effects having same sign. This cross too holds promise to isolate superior recombinants with high protein content even in early segregating generations.

Sugar content

Epistasis was detected both in scaling and joint scaling tests. The additive genetic effect was significant in four crosses whereas both additive and dominance effects were significant in GG 5 x ICGV 93080. The results indicated the preponderance of additive genetic effect for sugar content. Studies on gene action governing sugar content are very scanty in the literature. However few workers indicated the role of additivity in the inheritance of sugar content (Basu *et al.*, 1988).

Our results clearly demonstrated the role of additive type of gene action in all the five crosses studied. The lower magnitude of ***h*** and ***I*** effects further encourages the improvement of sugar content in groundnut through pedigree selection. However to nullify the effects of non-fixable genetic components, selection for high sugar lines at later generation may yield desirable results.

Oil content

Significance of scaling and joint scaling tests indicated the presence of epistasis. Dominance was found to be important in governing oil content in two crosses, TG 19A x ICGV 86564 and ICGS 21 x BAU 13. The direction of dominance in these crosses was negative indicating low oil content was dominant over high oil content, a condition more favourable for developing confectionery groundnuts where low oil content in the seeds helps in manufacture of peanut butter and margarines with good shelf-life. Additive gene effect was significant and positive in only one cross, TG 17 x ICGV 94225 further confirming the observed role of dominance in the inheritance of oil content. Earlier reports of Makne and Bhale, 1987, Basu *et al.*, 1988, and Upadhyaya and Nigam, 1999 also corroborate with the present findings.

Oil content is most important quality attribute, which decides the market value of groundnut. The millers prefer cultivars with high oil content whereas lines with low oil content but having high protein and sugar contents are exported as confectionery grade groundnuts. The negative relationship between oil and protein (Holley and Hammons, 1968) and positive relationship between protein and sugar (Layrisse *et al.*, 1980) encourages the direct selection for high protein content that may eventually result in high sugar but low oil content. To improve the protein content a selection scheme as followed in soybean (Brim and Burton, 1979) may be followed in groundnut also.

Breeding for confectionery quality is of recent origin in groundnut in India. Our present findings indicated that the confectionery qualities like sugar and protein contents are predominantly under additive gene action while pod yield and oil content are controlled by dominance. Hence the breeding procedures aiming to improve confectionery qualities and pod yield in a population should accumulate favorable additive genes while simultaneously maintaining the heterozygosity. Population improvement procedures as followed in other self-pollinated crops may be difficult to apply in groundnut owing to the difficulties associated with cleistogamous inflorescence of groundnut. However use of recurrent selection scheme as followed in soybean (Brim and Burton, 1979) and other self-pollinated crops (Hanson *et al.*, 1967) may be adopted to improve the protein and sugar content.

References

Basu, M.S., Nagaraj, G. and Reddy, P.S. 1988. Genetics of oil and other major biochemical components in groundnut (*Arachis hypogaea* L.). *International Journal of Tropical Agriculture*, **6**:106-110.

Bhagat, N.R., Taslim Ahmad and Lalwani, H.B. 1986. Combining ability for pod and seed characters in groundnut. *Indian Journal of Agricultural Sciences*, **56**:480-483.

Bremmer, J.M. 1965. Total nitrogen. In: *Methods of Soil Analysis, Part 2* (Black, C.A. ed.). American Society of Agronomy, Madison, Wis. pp.1171-1175.

Brim, C. A. and Burton, G.W. 1979. Recurrent selection in soybean. II. Selection for increased percent protein in seeds. *Crop Science*, **19**:494-498.

Cavalli, L.L. 1952. An analysis of linkage in quantitative inheritance. In: *Quantitative Inheritance* (Reeve, R.C.R. and C.H. Waddington, eds.). HMSD, London. pp.135-144.

Dwivedi, S.L., Thendapani, K. and Nigam, S.N. 1989. Heterosis and combining ability studies and relationship among fruit and seed characters in peanuts. *Peanut Science*, **16**:14-20.

Halward, T.M. and Wynne, J.C. 1991. Generation mean analysis for productivity in two diverse peanut crosses. *Theoretical and Applied Genetics*, **82**:784-792.

Hanson, W.D., Probst, A.H. and Caldwell, B.E. 1967. Evaluation of a population of soybean genotypes with implication for improving self-pollinated crops. *Crop Science*, **7**:99-103.

Hayman, B.I. 1958. The separation of epistatic from additive and dominance variation in generation means. *Heredity*, **12**:371-391.

Holley, K. T. and Hammons, R.O. 1968. Strain and seasonal effects on peanut characteristics. Ga. *Agricultural Experimentation Station Research Bulletin*, **32**:27-31.

Jinks, J.L. and Jones, R.M. 1958. Estimation of the components of heterosis. *Genetics*, **43**:223-234.

Kumar, S.S. and Patel, S.A. 1999. Gene effects for pod characteristics in groundnut (*Arachis hypogaea*). *Indian Journal of Agricultural Sciences*, **69**:111-115.

Layrisse, A., Wynne, J.C. and Isleib, T.G. 1980. Combining ability for yield, protein and oil of peanut lines from South American centres of diversity. *Euphytica*, **29**:561-570

Makne, V.G. and Bhale, N.L. 1989. Inheritance of pod yield and its components in groundnut. *Journal of Maharashtra Agricultural University*, **14**:30-33.

Mather, K. 1949. *Biometrical Genetics*, 1st Edn., Dover Publications, Inc., New York.

Nelson, N. 1944. A photometric adaptation of Somogyi method for determination of glucose. *Journal of Biological Chemistry*, **153**:375-380.

Sandhu, B.S. and Khehra, A.S. 1976. The role of epistasis in the inheritance of yield and its components in groundnut. *Crop Improvement*, **3**:9-17.

Sangha, A.S. and Labana, K.S. 1982. Diallel analysis in groundnut (*Arachis hypogaea* L.) Part-2. Pod number and pod yield. *Theoretical and Applied Genetics*, **64**:59-63.

Upadhyaya, H.D. and Nigam, S.N. 1999. Detection of epistasis for protein and oil contents and oil quality parameters in peanut. *Crop Science*, **39**:115-118.

Wynne, J.C., Emery, D.A. and Rice, P.W. 1970. Combining ability estimates in *Arachis hypogaea* L. II. Field performance of F_1 hybrids. *Crop Science*, **10**:713-715.

Wynne, J.C. and Coffelt, T.A.. 1982. Genetics of *Arachis hypogaea* L. In : *Peanut Science and Technology*. American Peanut Research Educational Society, Yoakum, Texas, USA, pp.50-94.

Wynne, J.C., Rawlings, J.O. and Emery, D.A. 1975. Combining ability estimates in *Arachis hypogaea* L. III. F_2 generation of intra and inter sub-specific crosses. *Peanut Science*, **2**:50-54.

J. Oilseeds Res., **21**(1): 17-20 (2004)

Stability analysis in large seeded groundnut, *Arachis hypogaea* L. genotypes for pod yield and its component traits

Mohan G. Bentur, K.G. Parameshwarappa and L.H. Malligawad

Oilseeds Scheme, University of Agricultural Sciences, Dharwad-580 005, Karnataka

(Received: June, 2003; Revised: August, 2003; Accepted: November, 2003)

Abstract

Evaluation of large seeded groundnut genotypes was carried out over the seasons to know the existence of genotype x environmental (G x E) interactions for pod yield and its important traits. Significant genotype x environmental interactions was noticed for pod yield and its important traits like number of pods, shelling percent, kernel weight and per cent sound mature kernels, indicating that genotypes behaved differently in different environments in expression of these traits. Both predictable and unpredictable component of environmental variations prevailed for pod yield and kernel weight. Stability analysis revealed that none of the genotypes were stable for pod yield or kernel yield while genotypes M 13, ICGV 86564, ICGV 94217, TGLPS 3 and TGLPS 7 were stable for kernel weight. Only one genotype ICGV 94217 was stable for shelling per cent across the environments. In view of the better expression of certain characters under specific environmental conditions the study helps to isolate genotypes adapted to particular seasons.

Key words: G x E interactions, stability analysis, large seeded groundnut

Introduction

Unlike groundnut cultivated for the purpose of oil extraction, there is a need to satisfy several quality attributes in large seeded groundnut (Dwivedi and Nigam, 1995) meant for export. This assumes importance in view of stringent conditions laid by the importers on large seeded groundnut especially European market. As cultivation of groundnut in India is predominantly during *kharif* season both biotic and abiotic stresses determine the pod yield and also expression of component traits like number of pods per plant, shelling per cent, kernel weight and per cent sound mature kernels. The information pertaining to the role of genotype x environmental interactions (G x E) in the inheritance of pod yield and its related traits although quite ample in groundnut, is almost negligible in large seeded types. In view of the importance of large seeded groundnut for export there is a need to identify genotypes having stable pod yield across the environments with desirable kernel characteristics. Therefore, an attempt has been made in the present study to evaluate different groundnut genotypes with large kernels across the seasons to know the role of G x E interactions and also to analyze the stability of genotypes for different traits.

Materials and methods

The experimental material consisted of 13 large seeded groundnut genotypes from different habit groups exhibiting diversity for morphological and kernel characteristics. Out of 13 genotypes, two varieties M 13 and HPS-II-9701 were Virginia runner maturing in 130-140 days; seven varieties *viz.*, Somanath, ICGV 86564, ICGV 94217, TKG 19 A, TGLPS 1, TGLPS 3 and BAU-13 were virginia bunch types maturing in 115-120 days and four spanish bunch types TGLPS 4, TGLPS 7, JI 24 and TAG-24 maturing in 100- 110 days. The latter two were small seeded types, and they were used as checks since the kernels of these varieties are graded and used for export in Northern Karnataka.

A field experiment involving all the genotypes was laid out in a Randomized Complete Block Design with three replications during three different seasons *viz.*, *kharif*, 1999, *kharif*, 2000 and summer 2001 at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad. The experimental crop was raised by adopting a suitable spacing of 45 x 10 cm and normal dose of fertilizers during rainy seasons of 1999 and 2000. However the crop was raised under irrigation during summer 2001 by following all the agronomic practices including application of gypsum at the rate of 250 kg/ha. Pod yield was recorded on net plot basis and expressed as kg/ha. Further, the observations on shelling percent, sound mature kernels and 100-kernel weight were recorded from the bulk of individual plants in each genotype and replications.

Data collected was subjected to a two-way analysis of variance and the stability parameters were computed following the model proposed by Eberhart and Russell (1966).

Results and discussion

Analysis of variance (Table 1) for pod yield and its component traits revealed that the genotypes differed significantly for all the characters except shelling % indicating the presence of variability in the material. Similarly, environments in which the genotypes were grown were also differing significantly for all the characters except sound mature kernels. Variance due to G x E interactions was highly significant for all the characters indicating the differential response of genotypes in expression of the characters to varying environments. The existence of G x E interactions for pod yield and its important component traits has also been reported by several workers in groundnut (Wynne and Coffelt 1980, Kandaswami *et al.*,1986, Vindhiya Varman *et al.*,1989). Considering the stability of performance of genotypes for different characters across the environments, it was observed that the variance due to non linear component of environments (pooled deviations) was significant for pod yield indicating the role of unpredictable portion of environment influencing this trait. Similar results were also reported by Bhole *et al.*,1987,Vindhiya Varman *et al.*,1989 and Moinuddin *et al.*,1998.

Stability parameters like regression coefficients (b_i) and the deviations from the regression coefficients (S^2d_i) indicated that none of the genotypes were stable over the environments for pod yield except BAU 13 and ICGV 94217 as the deviations of these genotypes were non significant (Table 2). Expression of stability of genotypes for pod yield has also been reported by Yadava *et al.*, 1980, Kandaswami *et al.*,1986, Vindhiya Varman *et al.*,1989 and Moinuddin *et al.*,1998. However, five genotypes TGLPS 3 followed by TKG 19 A, TGLPS 4, TGLPS 7 and TGLPS 1 had below average stability and were specifically adapted to favourable environments (*kharif* 1999 and summer 2001) as they possessed high mean pod yield and b_i values greater than unity. The variety Somanath had high mean coupled with significant b_i as well as S^2d_i values indicating the unpredictable nature of this genotype across the environments. The checks JL 24, TAG 24 and M 13 were poorly adapted to unfavourable environments in view of b_i values less than the unity and low mean pod yield. Kernel yield being the function of pod yield and shelling percent was in line with the results of pod yield as regards to stability parameters.

Table 1 Pooled analysis of variance for stability in receipt of pod yield (kg/ha), kernel yield (kg/ha), number of pods/plant, shelling (%), 100-kernel weight and sound mature kernels

Source of variance	d.f.	Mean sum of squares					
		Pod yield (kg/ha)	Kernel yield (kg/ha)	No. of pods/plant	Shelling (%)	100 kernel weight (g)	Sound mature kernel (%)
Genotypes	12	1226917.3**	677522.3**	53.9**	17.750	204.699**	19.23**
Environment	2	19798656.0**	104273.1**	399.5**	70.77**	3193.268**	2.561
G x E	24	275746.6**	180544.6**	11.8**	9.98**	37.89**	6.69**
Environment (Linear)	1	39597266**	20854611**	798.9**	141.48**	6386.50**	5.10
G x E (Linear)	12	307763.7	2671585.6	10.0	12.30	23.36	8.28
Pooled deviation	13	224984.6**	1661495.4**	12.6**	7.08**	48.39**	4.71**
Pooled error	72	11496.5	2004.6	1.7	1.694	6.321	2.44

* and ** indicates significance at 5% and 1% probability levels, respectively.

Stability analysis of number of pods per plant revealed that the genotypes HPS II-9701 and TGLPS 3 were quite stable across the environments. The genotypes TGLPS 4, TGLPS 7 and Somanath were adapted to favourable environments (b_i>1, higher mean and significant deviations), while the genotypes ICGV 86564 and BAU 13 were specifically adapted to unfavourable environments. The results obtained are in accordance with the earlier reports of Kandaswami *et al.* (1986) and Moinuddin *et al.* (1998).

Table 2 Stability parameters of large seeded groundnut genotypes for pod yield (kg/ha), kernel yield (kg/ha), number of pods/plant, shelling (%), 100 kernel weight, sound mature kernels

Genotypes	Pod yield (kg/ha)			Kernel yield (kg/ha)			No. of pods/plant			Shelling (%)			100-kernel weight			Sound mature kernel		
	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
M 13	2301	0.90	676007**	1527	0.79	428036**	13.38	0.58	2.99	65.93	0.13	10.35*	57.78	1.03	-1.12	92.72	-0.99	1.67
ICGV 86564	1954	0.75	150581**	1311	0.68	54508**	18.06	1.29	21.2**	67.54	-0.50	-0.47	65.08	1.23	-1.44	93.49	-5.11	-0.56
JL 24	2359	0.59	196289**	1640	0.54	155592**	22.18	0.63	10.0**	69.42	-0.15	7.92	44.57	0.96	99.22**	92.09	4.48	17.34**
ICGV 94217	2084	0.77	2825	1420	0.77	-99	16.23	1.13	-0.1	67.33	0.97	-0.56	65.65	1.12	-1.61	93.53	-0.11	-0.63
TGLPS 1	3002	1.20	458810**	2142	1.33	273755**	22.73	0.64	14.8**	69.83	2.10	3.76	51.77	1.01	15.74	94.75	-2.78	0.51
TGLPS 3	3564	1.17	44440**	2461	1.21	-942	21.59	0.87	3.1	68.22	0.85	10.05*	59.19	1.10	21.65	95.71	-1.51	5.45
TGLPS 4	3229	1.23	107582**	2205	1.28	87685**	23.20	1.37	26.5**	67.17	1.46	6.65	62,62	1.31	39.64*	95.42	0.26	-0.81
TGLPS 7	3005	1.06	502878**	2079	1.09	324196**	24.28	1.10	18.6**	68.36	0.71	10.69*	58.07	0.94	0.85	94.88	-0.73	0.14
TKG 19A	*3361*	*1.40*	*429499***	*2282*	*1.40*	*171496***	*21.63*	*0.87*	*0.01*	*66.47*	*1.64*	*0.56*	56.49	0.87	48.06**	94.70	1.95	0.79
BAU 13	1762	0.75	5965	1109	0.67	-1324	18.10	0.87	38.9**	62.00	1.50	15.16**	63.17	1.22	319.90**	93.39	4.65	8.07
Somanath	3754	1.64*	152055**	2652	1.68*	60621**	30.22	1.91	20.5**	69.49	1.28	-0.54	54.32	0.98	26.10*	94.82	1.58	0.14
HPS II-9701	2550	0.60	40490**	1606	0.48	63106**	24.57	1.28	-0.4	63.01	-0.28	16.08**	47.14	0.72	8.25	91.17	-1.99	1.47

* and ** indicate significance at 5% and 1% probability levels, respectively.

Significant role of G x E interactions was evident for shelling per cent which is in conformity with the earlier reports of Mercer-Quarshie (1980), Norden *et al.* (1986) and Moinuddin *et al.* (1998). Shelling per cent in large seeded groundnut observed to be low when compared to normal groundnut with the exception of TGLPS lines and they were comparable to JL 24 check. The genotype ICGV 94217 was stable (b_i » 1, higher mean and significant deviations) for shelling with a mean of 67.4 per cent across the environments. The genotypes TGLPS 1, TKG 19A, TGLPS 4 and Somanath had higher shelling per cent exhibiting specific adaptation to only favourable environments and hence considered to have below average stability ($b_i > 1$). Whereas the genotypes JL 24 and ICGV 86564 possessed above average stability (b_i <1) and higher shelling per cent, hence, these were specifically adapted to unfavourable environments.

Among the different yield traits, kernel weight is the most important character for determining quality of HPS groundnut. The study revealed that seven out of 13 genotypes *viz.*, M 13, ICGV 86564, ICGV 94217, TGLPS 1, TGLPS 3, TGLPS 7 and HPS-II 9701 were stable in performance for kernel weight as seen from non-significant deviations and b_i values being nearer to unity. The genotypes M 13, ICGV 94217, TGLPS 1, TGLPS 3, TGLPS 7 revealed higher mean values, regression co-efficient equal to one and the least deviations from regressions. Therefore, these genotypes were almost stable in expression of kernel weight despite the varying environments and the results are in concomitant with the earlier reports of Kandaswami *et al.*,1986 and Vindhiya Varman *et al.*,1989. Non linear component of environment was highly significant for this trait indicating the unpredictable nature of the environment which is also in agreement with the earlier reports of Wynne and Coffelt (1980), Kumar *et al.* (1984) and Moinuddin *et al.* (1998). The check varieties TAG 24 and JL 24 were more of a unpredictable in nature on account of their significant deviations. Genotypes BAU 13 and TKG 19A were suitable for favourable environments in view of their high mean kernel weight. Further, genotype ICGV 86564 was specifically adapted to favourable environments exhibiting below average stability (i.e. $b_i > 1$) with superior overall mean (65.08) than the population mean. Whereas the genotype HPS -II- 9701 possessed lower kernel weight than the population mean with b_i lesser than unity thus considered to be having above average stability.

As regards to per cent sound mature kernels, all the genotypes except checks TAG 24 and JL 24 exhibited non significant deviations. Genotypes TKG 19 A, BAU 13 and Somanath exhibited below average stability (b_i >1) with specific adaptation to favourable environments. The lines TGLPS 1, TGLPS 3, TGLPS 4, TGLPS 7, ICGV 86564 and ICGV 94217 exhibited above average stability with specific adaptation to unfavourable environments.

In general, none of the genotypes were stable for pod yield across the environments (seasons). However, ICGV 94217 and BAU 13 were widely adapted to varying environments. The genotype TGLPS 4 was suited to favourable environments in view of better expression of pod yield, number of pods and shelling per cent. Among the yield traits kernel weight was less influenced by the environment and was the most stable trait in HPS groundnut. Therefore, the desired seed weight of HPS groundnut could be maintained both during kharif and summer by cultivating the genotypes ICGV 86564 followed by ICGV 94217 and TGLPS 3 due to their better stability.

References

Bhole, G.R., Narkhede, B.N., Patil, S.S. and Deokar, A.B. 1987. Phenotypic stability of pod yield in summer groundnut. *Journal of Oilseed Research*, **4**: 108-110.

Dwivedi, S.L., and Nigam, S.N. 1995. Breeding for the improved seed quality in groundnut (*Arachis hypogaea* L.) with special reference to export promotion; issues and opportunities, paper presented at workshop on "*Status of confectionery groundnut research in India and strategies for export promotion*, BARC, Trombay, April 1995, pp.10.

Eberhart, S.A. and Russell, R.A. 1966. Stability parameters for comparing varieties. *Crop Science*, **6**:36-40.

Kandaswami, M., Soundrapandian, G. and Kadambavana sundaram. 1986. Genetic variability and Genotype-Environment interaction in some quantitative characters of *Arachis hypogaea*. *Madras Agriculture Journal*, **73**(6): 301-307.

Mercer-Quareshie, H. 1980. Genotype x environment interactions in groundnut (Arachis hypogaea L.) tested in Northern Ghana. *Oleagineux*, **35**: 207-214.

Moinuddin, H.H., Reddy, B.G.S., Lohitaswa, H.C., Sheriff, R.A., Kulkarni, R.S. and Patil, B.R. 1998. Stability for yield and its components in groundnut (*A. hypogaea* L.) *Journal of Oilseeds Research*, **15**: 238-241.

Norden, A.T, Gorbet, D.W., Knauft, D.A. and Martin, F.G. 1986. Genotype x environment interactions in peanut multiline populations. *Crop Science*, **26**: 46-48.

Vindhiya Varman, P, Rathinaswamy, R., Sethupathi Ramalingam, R and Vaman Bhat, M. 1989. Phenotypic Stability for yield and quality characters in Groundnut. *Madras Agriculture Journal*, **76** (5): 247-251.

Wynne and Coffelt, T.A. 1980. The effect of genotype x environment interaction an varietal development in North Carolina and Virginia, *Proceedings of the American Peanut Research and Education Association*, K: 75.

Yadava, T.P., Parkash kumar and Yadava, A.K. 1980. Stability Analysis for Oil content and yield components in Groundnut (*Arachis hypogaea* L.). *Haryana Agricultural University Journal of Research*, **4**: 560-563.

J. Oilseeds Res., **21**(1): 21-23 (2004)

Response to selection for seed dormancy in groundnut, *Arachis hypogaea* L.

G.K. Naidu, M.V.C. Gowda and B.N. Motagi

Department of Genetics and Plant Breeding, University of Agricultural Sciences, Dharwad-580 005, Karnataka

(Received: December, 2002; Revised: June, 2003; Accepted: September, 2003)

Abstract

Dormancy being transient in nature and highly influenced by environment, studies on inheritance are inconclusive. Attempts towards dormant genotypes have met with limited success due to lack of simple selection methodology. In the present study among six selection schemes, selection in segregating generations at advanced generation was more effective than either early generation selection or continued selection. Continuous selection at all stages has resulted in elimination of potential segregants for pod yield combining dormancy. A simple strategy of breeding for dormancy could be crossing dormancy donors with adapted non-dormant cultivars, advancing segregating material either through bulk or single seed descent, evaluating single plant for dormancy at F_4 seed level and eventually testing for pod yield in replicated trials in later generations.

Key words: Groundnut, dormancy, response, selection, strategy

Introduction

Spanish bunch groundnut, *Arachis hypogaea* L. cultivars of subspecies *fastigiata* are popular because of early maturity, ease of harvesting, desirable pod features and suitability in multiple cropping under rainfed conditions. But they lack seed dormancy and hence suffer loss due to *in situ* germination when the matured crop is caught under rains. Virginia cultivars of subspecies *hypogaea* have dormancy but mature late. Dormancy being transient in nature and highly influenced by environment, studies on inheritancy are inconclusive. Many attempts were made for selecting dormant genotypes in available germplasm (Muhammed *et al.*, 1965), and material from intra- (Ramachandran *et al.*, 1967) and inter-sub-specific hybridization (Reddy *et al.*, 1985). But success was less because of lack of simple selection methodology. Present study envisages assessing the response to selection for dormancy and suggesting a breeding strategy to select dormant segregants in Spanish type groundnut.

Materials and methods

Material comprised of 24 populations derived from four crosses involving one ruling Spanish bunch cultivar (JL 24) and two Spanish dormant genotypes (Dh 8 and R 8972). Parents (JL 24, Dh 8 and R 8972) were studied along with populations for percent germination and pod yield per plant. The populations were advanced through different selection schemes *viz.*, no selection at any generation (NNN), selection at F_2 F_3 (DDN), at F_3 alone (NDN), at F_3 & F_4 (NDD), at F_4 alone (NND) and at all generations (DDD), under single seed descent method. 500 seeds were made into two halves, one half was tested for dormancy and other not for dormancy. The dormant seeds were treated with ethrel for advancing to next generation. The same procedure was followed in each generation.

Fifty seeds were sown in two rows of 2.5 m length in each of the selection schemes, 20 random plants were selected for analyzing seed dormancy and yield per plant both in selection schemes and parents. Based on the germination behaviour of the parents in the laboratory, the plants showing less than 50 % germination were considered as dormant (Table 1). Germination test was done at 7 days after harvesting by maintaining 10 % moisture in the seeds. Germination was assessed by drawing 25 random matured seeds from each plant. The seeds were rolled in 15 x 12 cm sized germination paper and stapled at both the ends. The rolls were covered with polythene sheet to ensure minimum loss of water through evaporation. These were then transferred to germination chamber and germination was recorded after five days. Dry weight of pods (g) was recorded on each plant and average weight per plant was computed for each population.

Results and discussion

In general, selection was effective for dormancy over non-selection (NNN), as indicated by higher percent of dormant plants lower germination. A single selection at advanced (F_4 seed level) generation (NND) was more effective than either

Table 1 Germination behaviour and frequency of dormant plants under different selection schemes

Selection scheme		JL 24 x Dh 8	Dh 8 x JL 24	JL 24 x R 8972	R 8972 x JL 24	Mean
DDD	(a)	61.5 ± 6.7 (30	45.5 ± 7.9 (55)	38.5 ± 8.5 (65)	23.5 ± 4.8 (85)	42.3 ± 7.0 (59)
	(b)	12.4 ± 0.4	13.5 ± 0.4	13.5 ± 0.4	13.6 ± 0.3	13.25 ± 0.4
DDN	(a)	55.5 ± 8.1 (50)	48.5 ± 6.6 (50)	31.0 ± 5.9 (55)	34.5 ± 7.3 (70)	42.4 ± 7.0 (56)
	(b)	17.6 ± 0.5	17.1 ± 0.6	15.8 ± 0.4	19.0 ± 0.4	17.4 ± 0.5
NDD	(a)	41.0 ± 6.3 (50)	25.5 ± 5.3 (80)	42.5 ± 7.9 (45)	22.0 ± 6.2 (70)	32.8 ± 6.4 (61)
	(b)	18.1 ± 0.5	17.8 ± 0.4	17.5 ± 0.3	18.8 ± 0.3	18.1 ± 0.4
NDN	(a)	42.5 ± 7.3 (60)	58.5 ± 6.5 (35)	42.5 ± 8.1 (45)	37.0 ± 6.0 (50)	45.1 ± 7.0 (48)
	(b)	18.9 ± 0.3	17.8 ± 0.3	18.1 ± 0.3	17.9 ± 0.4	18.2 ± 0.3
NND	(a)	36.5 ± 7.0 (60)	38.5 ± 5.6 (65)	33.5 ± 6.6 (60)	22.5 ± 5.2 (85)	32.8 ± 6.1 (68)
	(b)	18.8 ± 0.4	19.5 ± 0.5	17.0 ± 0.4	18.9 ± 0.5	18.6 ± 0.5
NNN	(a)	55.0 ± 5.5 (40)	68.5 ± 5.9 (20)	66.0 ± 6.5 (20)	65.0 ± 5.5 (25)	63.6 ± 5.9 (26)
	(b)	17.9 ± 0.3	17.6 ± 0.4	18.2 ± 0.3	17.3 ± 0.3	17.8 ± 0.3
Parents		**JL 24**	**Dh 8**	**R 8972**		
	(a)	88.0 ± 9.2	18.0 ± 9.2	2.0 ± 9.2		
	(b)	17.1 ± 1.8	15.0 ± 1.8	15.5 ± 1.8		

Where (a) Mean ± SE of germination %; (b) Mean ± SE of pod yield/plant
Figures in parenthesis indicate % dormant plants

early generation selection or continued selection (DDD, DDN and NDD), in all the crosses (Table 1). This could be due to fixation of alleles at later generations. Though correlation was non-significant between pod yield and germination (-0.294), the continuous selection (DDD) for dormancy has led to distinct reduction in pod yield (13.3g). This could be attributed to elimination of potential segregants for pod yield by early and continued selection for dormancy. In contrast, a single selection at F_4 did not affect pod yield (18.6 g) indicating its potential to give high yielding dormant lines. Further, except the selection schemes *in case of Dh 8 x JL 24, crosses involving* dormant genotypes as ovule parents, have shown better response to selection which could be due to maternal influence on the expression of dormancy (Ketring and Morgan, 1972). Based on heritability values, Khalfaoui (1991), suggested pedigree selection, which could be more cumbersome. Manoharan *et al.*, 1989, suggested selection at early stage followed by evaluation for dormancy at F_6/F_7 generation. However, this could lead to elimination of potential segregants for other characters as revealed in the present study. But, mass selection (seed level) for dormancy was more effective over plant selection in early generations (Hemanth, 1990), which could be due to independence of embryo genotype to the phenotype of the parent plant.

In the light of these discussions, a simple strategy of breeding for dormancy could be suggest. It could involve crossing dormancy donors with adapted non-dormant cultivars, advancing segregating material either through bulk or single seed descent method, evaluating single plants for dormancy at F_4 seed level and eventually testing for pod yield in replicated trials in later generations (Fig 1).

Acknowledgements: Authors are thankful to Indian Council of Agricultural Research, New Delhi, for providing financial assistance to conduct the research work.

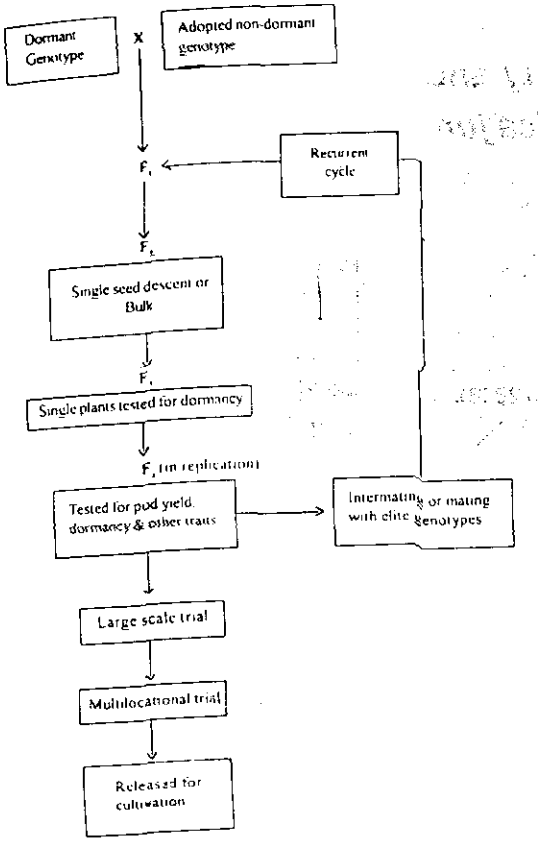


Fig-1 A strategy of selection for dormancy

References

Hemanth, 1990. Evaluation of early generations for dormancy and productivity in erect bunch groundnut. M.Sc. (Ag.) Thesis, University of Agricultural Sciences, Dharwad, p.156.

Ketring, D.L. and Morgan, P.W. 1972. Physiology of oilseeds IV. Role of endogenous ethylene and inhibitory regulators during natural and induced after ripening of dormant Virginia type peanut seeds. *Plant Physiology*, 50 : 382-387.

Khalfaoui, J.L.B. 1991. Inheritance of sed dormancy in a cross between two Spanish peanut cultivars. *Plant Science*, **18**(2) : 65-67.

Manoharan, V., Thangavelu, S. and Ramalingan, S.R. 1989. A breeding methodology to develop dormant bunch groundnut varieties. In: *National Symposium on Recent Advance in Genetics and Plant Breeding Research in India*, Banaras Hindu University, Varanasi, India.

Muhammed, V.S., Ramachandran, N. and Ramanathan, T. 1965. High yielding groundnut bunch cultivars with seed dormancy. *Madras Agricultural Journal*, **56** : 234-238.

Ramachandran, M., Loganathan, N.S., Sridharan, C.S., Chandrashekharan, N.R. and Krishnaswamy, P. 1967. Evolution of dormant bunch groundnut strains by hybridization. *Indian Journal of Agricultural Sciences*, **37** : 429-436.

Reddy, P.S., Zade, V.R. and Deshmukh, S.N. 1985. CGS 1-19, a new Spanish bunch groundnut cultivar with fresh seed dormancy. *Journal of Oilseeds Research*, **2** : 103-106.

J. Oilseeds Res., **21**(1): 24-27 (2004)

Comparative studies on combining ability and heterosis for yield and yield components in Indian mustard, *Brassica juncea* (L.) Czern & Coss. on normal and saline soils

D. Kumar and Neetu Rathore

Central Arid Zone Research Institute, Jodhpur-342 003, Rajasthan

(Received: June, 2003; Revised: October, 2003; Accepted: December, 2003)

Abstract

The nature and magnitude of combining ability and heterosis were studied for yield and its components in Indian mustard, *Brassica juncea* (L.) Czern & Coss. following 8 x 8 diallel analysis on normal (ECe 1.8 ds/m) and saline (ECe 106 dS/m) soils. Significant differences for *gca* and *sca* components were observed for all the traits on normal soil, whereas on saline soil, differences were significant for days to flowering for *gca* and pods/plant for *sca* only. Among the parents, CS-52 showed significant positive gca on both soils for pods/plant, whereas on saline soil, SAL-3 showed significant positive *gca* for seed yield. The parent CS-52 was also a good general combiner for early flowering on normal soil. The crosses NDR-9501 x RH-30 and Kranti x NDR-9501 showed maximum significant *sca* effects for yield on normal soil whereas, the only cross CSTR 338-1 x CZM-2 was characterized with maximum significant *sca* for this trait on saline soil. The crosses CSTR 338-1 x CZM-2 (33.61 %) and CSTR 338-1 x SAL-2 (5.2 %) showed maximum heterotic effects for seed yield on saline soil. However, on normal soil Kranti x NDR 9501 (29.8 %) and NDR 9501 x RH-30 (23.2%) showed maximum heterotic effects for seed yield. There was no cross showing significant positive heterosis for seed yield on both soils.

Key words: Indian mustard, saline soil, combining ability, heterosis

Introduction

Brassicas commonly known as rapeseed-mustard are considered the most valuable oilseed group of crops grown world wide. In India, progress in rapeseed-mustard production has been amazing in Rajasthan state, contributing almost 38 % of total *Brassica* production. However, due to obvious reasons, salinity of irrigation water is posing serious threat for maintaining pleatue of its productivity in arid Rajasthan. Agrotechniques for *Brassica* improvement for saline situations (seed rate, increased fertilization and irrigation management, etc.) are available (Kumar, 1995), but, these are the energy intensive technologies, therefore, proving costlier and unpopular on the commercial scale. However, use of salt tolerant genotypes and exploitation of heterosis and the selection of parents on the basis of combining ability may prove possible steps in accelerating pace of genetic improvement of this crop on saline lands, which may prove more harmful in arid situations. Information on this aspect are scarce and scattered (Thakral and Singh, 1995; Sood *et al.*, 2000). Hence, present study on eight genetically divergent parents was undertaken for assessing the heterosis and combining ability on normal and saline soil situations.

Materials and methods

Eight genotypes of Indian mustard [*Brassica juncea* (L.) Czern & Coss.] *viz.*, CS-52, CSTR 338-1, CZM-2, Kranti, NDR-9501, RH-30, SAL-2 and SAL-3 representing salt tolerance and susceptible nature were crossed in all possible combinations excluding reciprocals. The 28 F_1s and their 8 parents were grown in normal (ECe 1.8 dS/m) and saline soil (ECe 10.6 dS/m) situations in a Split Plot Design with three replications at CAZRI experimental farm during *rabi* season of 1998-99. Each treatment had 3.5 m long single row, the spacings between and within lines being 30 and 10 cm, respectively. Five irrigations each of 6 cm including presowing with the saline water (ECe 6.5 dS/m) were applied during the cropping season. Observations were recorded on five randomly selected plants for five characters. The combining ability analysis was done following method II model I of Griffing (1956) and heterosis (%) was assessed as per usual method. Salt build up in 0-30 and 30-60 cm soil depths was assessed at sowing and at crop harvest.

Results and discussion

An examination of the magnitude of mean squares revealed significant differences for general and specific combining ability for all the traits on normal soil, whereas

on saline soil differences in respect of *gca* and *sca* were significant only for days to flowering and number of pods/plant, respectively (Table 1). The *gca* values were of greater magnitude than the corresponding *sca* values for days to flowering, days to maturity, pods/plant, and 1000-seed weight on both soils, indicating involvement of additive genetic variances for them on normal soil. The *sca* component was more for seed yield on saline soil. Thus, genetic variances appeared to differ for the traits with the soil conditions. This was probably due to differences in soil properties in respect of nutrient and water availability, therefore, affecting uptake behaviour of the plants at the critical growth stages hence, allowing significant interaction between morphological traits and the soil types, leading to differences in genetic variance.

The variance ratio was much higher than unity for number of pods/plant on normal soil and 1000-seed weight on saline soil, which signified the involvement of additive gene effects for their expression, on respective soils. Days to flowering also looked more or less to be influenced by additive genetic variance irrespective of the soil situations. These results fall in line with those of Asthana and Pandey (1977), Bhadouria *et al.* (1991) and Singh *et al.* (2001) in Indian mustard. The seed yield appeared to be influenced through non-additive variance across the soil types confirming earlier findings of Thakral and Singh (1995) on saline soils and Singh and Mittal (1993), Sood *et al.* (2000) and Rao and Gulati (2000) on normal soils in this crop.

General combining ability effects: The parents *viz.*, CS-52, CSTR 338-1, CZM-2 and RH-30 earliest to flower (42 days) also showed significant negative *gca* effects for days to flowering on normal soil, revealing therefore, possibility of using these parents for earliness on such soils. On saline soil, the parents CSTR 338-1, CZM-2 and Kranti had significant negative *gca* estimates. The latter two parents with early flowering (44-46 days) might therefore, represent source of early partitioning on problem soils (Table-2). Of eight parents, CS-52 on both normal and saline soils had significant positive *gca* effects for number of pods/plant. This parent also exhibited higher number of pods across the soils. On saline soil, the only parent SAL-3 had significant positive *gca* effects for seed yield thus, providing good combiner for high yield on poor soil. SAL-3 being a salt tolerant genotype, having higher *per se* yield on such soils is likely to be good general combiner of yield. A general view on *gca* effects revealed that there was no parent as a good general combiner for all the traits in both the soils. However, CS-52, a salt tolerant parent appeared as good combiner for earliness and number of pods/plant on both soils.

Specific combining ability effects: Out of 28 crosses, three *viz.*, CS-52 x CSTR-338-1, CS-52 x SAL-3 and CSTR-338-1 x NDR-9501 exhibited significant negative *sca* effects for days to flowering on normal soil, these crosses also showed early flowering (39-43 days) tendency. However, the only cross CSTR-338-1 x Kranti was found to have significant negative *sca* effects for early flowering on saline soil but its *per se* performance was not adequate as it took 47 days to flower, thus, its use on saline soil was doubtful. As far maturity is concerned, the cross conditions and took almost equal number of days to mature (105-106 days) across the soils.

In normal soil, the two crosses *viz.*, NDR-9501 x RH-30 and Kranti x NDR-9501 showed maximum significant positive *sca* effects for seed yield. Appreciably their *per se* performance for grain yield was also maximum (245 and 250 g, respectively) on normal soil. On the contrary, the cross (CSTR-338-1 x CZM-2) with higher *per se* performance and significant positive *sca* effects for seed yield was also notable for significant *sca* value for pods/plant on two types of soil situations. The cross combinations with significant *sca* effects for yield and yield components are expected to give a high heterotic response in respective soils.

Heterosis: Heterosis for early flowering ranged from -1.05 to -7.0 % in normal and from -1.07 to -7.22 % in saline soils. The crosses *viz.*, CSTR 338-1 x NDR 9501, CZM-2 x SAL-2 and CSTR 338-1 x SAL-3 depicted heterosis of almost similar magnitude for earliness on two types of soils. Thus, possibility of development of early flowering hybrids existed for both soil situations. The parents involved in the hybrid combinations exhibited marked variations in flowering behaviour in respect of two soil types i.e., either being early or late in flowering.

The heterotic values for early maturity were of lower magnitude irrespective of the soil conditions confirming earlier findings of Asthana and Pandey (1977) and Choudhary and Sharma (1982) in normal soil conditions. Lower heterotic values for maturity could be due to less variation in maturity behaviour of the parents and their F_1s over two types of soils. Thus, it looked difficult to get early maturity hybrids in this crop.

The cross combination RH-30 x SAL-3 (132.62 %) showed maximum heterosis for number of pods/plant on saline soil, whereas SAL-2 x SAL-3 (11.57 %) and NDR 9501 x SAL-2 (7.17 %) showed positive heterosis with comparatively less magnitude on these soils. RH-30 with less number of pods (385/plant) was ill adapted parent to problem soil. RH-30 x SAL-3 was however, characterized with maximum *sca* effects (368.6) on saline soil.

The crosses NDR 9501 x RH-30 (30.25 %) followed by CZM-2 x RH-30 (23 %), Kranti x NDR 9501 (16.12 %) on normal soil and NDR 9501 x SAL-2 (43.33 %) followed by Kranti x NDR 9501 (32.2 %), CSTR 338-1 x NDR 9501

(28.15 %), CSTR-338-1 x CSM-2 (23.52 %) maintained maximum significant heterosis for 1000 seed weight on saline soils. Thus, possibility of hybrids with bolder seeds existed on both soil situations.

Heterotic values for seed yield were of greater magnitude in respect of Kranti x NDR 9501 (29.8 %) and NDR 9501 x RH-30 (23.2 %) on normal soil, confirming earlier results of Gupta *et al.* (1993); Sood *et al.* (2000) and Singh *et al.* (2001) in Indian mustard in normal soil conditions. Heterotic values on saline soils were of lesser magnitude, therefore, restricting possibility of developing high yielding hybrids for saline soils barring the only cross, CSTR-338-1 x CZM-2 (33.61 %) which had maximum significant *sca* effects also. Mean performance of these parents differed considerably, wherein CSSTR 338-1 proved less adapted to saline situations. The parents SAL-2, SAL-3 and RH-30 with good adaptation to saline conditions gave poor heterotic effects.

Table 1 ANOVA for combining ability in F_1s for phenological, yield and yield components in Indian mustard on normal (N) and saline (S) soils

Source of variation	D.f.	Days to 1st flowering		Days to maturity		Pods/plant		1000-seed weight		Seed yield	
		N	S	N	S	N	S	N	S	N	S
gca	7	40.6**	70.4**	6.5**	2.0	54735**	22407.7	0.31**	0.25	1370.8**	657
sca	28	6.5**	12.3	2.5**	1.7	25836**	21107.3*	0.23**	0.20	1009.8**	772
Error	35	1.9	14.4	1.5	1.2	15138	11320.9	0.11	0.18	545.9	455
$\sigma^2G/2\sigma^2$ σ^2S	-	0.92	0.91	0.83	0.69	2.99	0.67	0.72	1.40	0.73	0.06

Table 2 *gca* effects for phenological, yield and yield components on normal (N) and saline (S) soils

Parents	Days to 1st flowering		Days to maturity		No. of pods/plant		1000-seed weight		Seed yield	
	N	S	N	S	N	S	N	S	N	S
CS-52	-0.84*	-0.20	-0.95*	-0.49	94.25*	66.85*	0.08	0.14	-7.14	5.72
CSTR-338-1	-1.79**	-2.02*	-0.85*	-0.19	-64.96	-70.40*	-0.29**	-0.08	7.11	-8.02
CZM-2	-1.59**	-2.15*	-0.15	-0.44	-140.04	-62.35	-0.03	-0.14	-18.80**	-1.52
Kranti	-0.64	-2.35*	-0.45	0.46	24.74	16.50	0.14	-0.12	6.86	-6.53
NDR-9501	-0.39	0.35	-0.10	0.21	54.40	11.95	0.02	-0.04	6.36	0.73
RH-30	-0.94*	0.45	0.50	-0.49	-20.65	2.75	-0.03	-0.15	6.96	3.22
SAL-2	3.96	5.90**	0.50	0.56	15.66	43.30	-0.16	0.26*	-14.14*	-8.77
SAL-3	2.21	0.00	1.50*	0.36	36.65	-8.60	0.29**	0.15	12.16	15.18*
SE (gi) ±	0.41	1.00	0.36	0.31	36.30	31.4	0.10	0.10	6.90	6.30
SE (-gi-gj) ±	0.62	1.65	0.54	0.48	55.55	47.16	0.10	0.10	10.44	9.53

*P=0.05; ** P=0.01

References

Asthana, A.N. and Pandey, V.K. 1977. Combining ability and rank correlations in a dialled cross of Indian mustard and yellow sarson. *Science and Culture*, **30** : 151-152.

Bhadouria, S.S., Jain, S.G. and Tiwari, A.S. 1991. Combining ability analysis in Indian mustard. *Golden Jubilee Symposium Genetic Research and Education, Current Trends and the next 50 years*, 12-15 February, New Delhi.

Choudhary, S.K. and Sharma. 1982. Note on the inheritance of some quantitative characters in a cross of Indian mustard. *Indian Journal of Agricultural Sciences*, **52**(1) : 23-25.

Griffing, B. 1956. Concept of general and specific combining ability in relation to diallel crossing system. *Australian Journal of Biological Sciences*, **9** : 463-493.

Gupta, M.L., Gulzrfar Sandhu, G.S. and Gupta, T.R. 1993. Combining ability and heterosis for yield and its components in Indian mustard. *National Seminar on Oilseeds Research and Development in India : Status and Strategies, Extended Summaries*, Indian Society of Oilseeds Research, Hyderabad, pp.56-57.

Kumar, D. 1995. Salt tolerance in oilseed brassicas - present status and future prospects. *Plant Breeding Abstract*, **10**(65) : 1439-1447.

Rao Ganga, N.V.P.R. and Gulati, S.C. 2001. Comparison of gene action in F_1 and F_2 diallels of Indian mustard, *B. juncea* (L.) Czern and Coss. *Crop Research*, **21**(1) : 72-76.

Singh, G.P. and Mittal, R.K. 1993. Combining ability analysis for yield and yield contributing traits in Indian mustard, *B. juncea* (L.) Czern and Coss. *Annals of Agricultural Research*, **14**(2) : 205-210.

Singh, P., Sachan, S.P. and Singh, S.K. 2001. Genetics of yield components, glucosinolate and cake content in yellow seeded Indian mustard, *B. juncea* (L.) Czern and Coss. In Diamond Jubilee Symposium, *Hundred years of Post-Mendelian Genetics and Plant Breeding - Retrospect and Prospects*, Nov. 6-9, New Delhi, p.314.

Sood, O.P., Sood, V.K. and Thakur, H.L. 2000. Combining ability and heterosis for seed yield traits involving natural and synthetic Indian mustard, *B. juncea* (L.) Czern and Coss. *Indian Journal of Genetics*, **60** (4) : 561-563.

Thakral, N.K. and Singh Hari. 1995. Combining ability for yield components and oil content over saline environments in Indian mustard. *Journal of Oilseeds Research*, **12**(1) : 74-82.

J. Oilseeds Res., **21**(1): 28-33 (2004)

Development and characterization of low erucic acid/low glucosinolate lines in Indian mustard, *Brassica juncea* (L.) Czern & Coss

J.S. Chauhan, M.K. Tyagi, S.Kumar, Poonam Tyagi, Nawaz Khan, S.K. Yadav and N.B. Singh

National Research Centre on Rapeseed-Mustard, Sewar, Bharatpur-321 303, Rajasthan

(Received: September, 2002; Revised: September, 2003; Accepted: October, 2003)

Abstract

Swarna [TERI (OE) M 21] (INGR 98001), a yellow seeded strain of *Brassica juncea* [L.] Czern. & Coss. was utilized as a source of low erucic acid (< 2%) and BJ 1058 was used as a low glucosinolate source to transfer the trait(s) to the high yielding varieties of Indian mustard, Varuna and Rajat. The selection for low erucic acid in F_2 generation brought forth enormous variation in different fatty acid profiles in subsequent generations, especially, oleic, linoleic and linolenic + eicosenoic acid. The oleic acid varied from 34.0- 50.3 %. Nevertheless, there were several plants possessing 55% oleic acid. Selected lines, except a few had comparable oil content with the parents, Varuna (39.2%) and TERI (OE) M 21 (38.4%). In general, the lines had higher 1000-seed weight and oil content in F_5 generation than in F_4 generation. The pattern of correlations for fatty acids was variable in F_2, F_3 and F_4 generations except for oleic acid which showed consistent relationship with linoleic and linolenic + eicosenoic acid in different generations. Parent -offspring regression revealed variable heritability estimates for different fatty acids, which declined from F_2 to F_3 generation. Six F_5 progenies having less than 40 μ moles glucosinolate content were characterized for days to maturity, plant height. 1000-seed weight, oil and protein content. Efforts are underway to combine low erucic and low glucosinolate traits to develop double low lines.

Key words: Indian mustard, erucic acid, *glucosinolate content*, *B. juncea*, heritability, correlations

Introduction

Mustard oil is the major edible oil in the Indian diet, especially in northwest and eastern parts. Except for the presence of high erucic acid (about 50 %), mustard oil is nutritionally better than other edible oils such as groundnut, sunflower and soybean as it contains low amount of saturated fatty acids and substantial amount of α-linolenic acid, which is an essential fatty acid. Large in take of oil with high erucic acid has been reported to be associated with myocardial fibrosis and lipidosis from studies on rats and monkeys (Gopalan *et al.*, 1974; Renard and Mc Gregor, 1976).Presence of glucosinolates in the seed meal restricts its diversified use as feed for poultry and piggery otherwise seed meal being high protein feed. Moreover, Indian seed meal fetches low price in international market as compared to that of United Kingdom and Germany. Further, yellow seeded varieties have higher oil, protein content and lower crude fibers than brown seeded varieties of the same species (Woods 1980). The Indian mustard breeding programme has been oriented to develop low erucic acid (<2%) and / or low glucosinolate (<30 μ moles/ g defatted seed meal) mustard cultivars in mid 80's. The present paper describes our attempts to improve oil and meal quality in Indian mustard.

Materials and methods

Low erucic acid: Swarna [TERI (OE) M 21] (INGR 98001), a yellow seeded strain of Indian mustard (*Brassica iuncea* [L.] Czern. & Coss.) was utilized as a source of low erucic acid (< 2%) to transfer the trait to the high yielding varieties, Varuna and Rajat. During 1996-97, F_1 crosses of Swarna were made with Varuna and Rajat and the advanced breeding lines were developed (Fig. 1). The single selfed plants were analyzed for different fatty acid profiles using gas liquid chromatography as described earlier (Chauhan *et al.*, 2001). The DEGS column was used in the GLC which does not separate linolenic and eicosenoic acid profiles. The peaks get merged to a single peak. During the crop season of 1999-2000 and 2000-2001, the F_4 and F_5 low erucic progenies were characterized for maturity, plant height. 1000-seed weight, oil content, seed yield/plant. Range, mean, coefficients of variability and correlations for different fatty acids were computed in different segregating generations following Gomez and Gomez (1984). Parent-offspring regression (Lush, 1940) analysis was used to estimate heritability in narrow-sense for different fatty acids.

Low glucosinolate: The only available source of low glucosinolate content, BJ 1058 was hybridized with Rajat to transfer alleles for low glucosinolate. Three hundred sixty five selfed F_2 plants of the cross BJ 1058 x Rajat were analyzed for glucosinolate content by TES TAPE method. The plants were grouped into four categories, *viz.*, + (low), ++ (medium), +++ (medium -high) and ++++ (high). The F_3 progenies of the plants showing +/++ reaction were generation advanced (Fig. 1). The F_5 and F_6 lines having less than 40 μ moles glucosinolate/g of defatted seed meal were characterized during 2000-2001 crop season for agro-morphological traits.

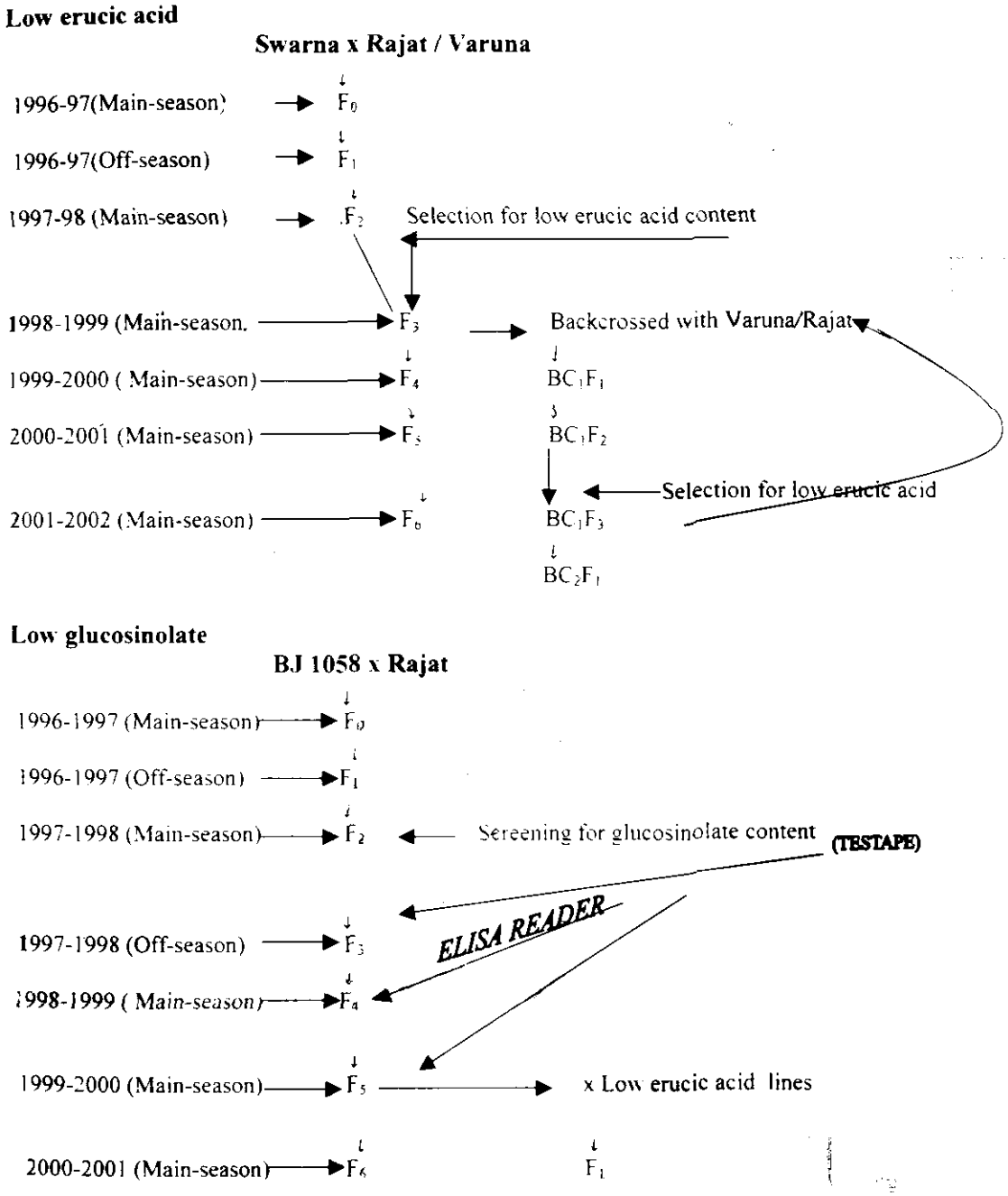


Fig. 1 Development of low erucic acid/low glucosinolate lines of Indian mustard

Results and discussion

Erucic acid content of TERI (OE) M 21 ranged from 0 to 6.1 % with mean value of 1.6 %. Similarly, erucic acid varied between 41.5 - 50.2 and 44.0 - 52.2 % in Varuna and Rajat, respectively. The F_1 of both the crosses TERI (OE) M 21 x Varuna and TERI (OE) M 21 x Rajat, showed intermediate level of erucic acid, being 33.2 % in the cross TERI (OE) M 21 x Varuna and 28.6% in the cross TERI (OE) M 21 x Rajat. The erucic acid content of the F_2 segregants ranged from 0 to 49.6%. Only 5 and 3.5% of the F_2 segregants had less than 2% erucic acid in the crosses TERI (OE) M 21 x Rajat and TERI (OE) M 21 x Varuna, respectively. Selection for low erucic acid practiced in F_2/F_3 generation brought forth significant variation in different fatty acid profiles, especially, oleic, linoleic and linolenic + eicosenoic acid (Table 1). Selection in F_3 generation was done for high oleic acid, oil content and 1000-seed weight.

The oleic acid varied from 24.6 - 50.3 % among the F_4 progenies. Nevertheless, there were several plants possessing about 55.0 % oleic acid. The mean saturated fatty acids were around 4% in F_3 and F_4 generations. Mean of fatty acids were marginally higher (2-3 %) in F_4 than F_3 generation. Several promising high oleic acid lines were identified and characterized for agro morphological characters (Table 2). Many low erucic acid lines, had comparable oil content with the parents, Varuna and TERI (OE) M 21. Nevertheless, these lines had low 1000-seed weight as compared to Varuna. In general, the lines had higher 1000-seed weight and oil content in F_5 generation than in F_4 generation. Similarly, in the cross. TERI(OE)M 21x Rajat, two PS lines had higher oleic acid than the low erucic parent, TERI (OE) M 21. In the back cross progenies, of both the crosses, oleic acid varied from 21.3 - 43.9 %. The F_5 progenies were intermitted to broaden the genetic base and recombine yield attributes. The selected low erucic acid BC_1 plants were further backcrossed.

Heritability: To predict the efficiency of selection in segregating generations it is imperative to know heritability, especially heritability in narrow-sense. Three methods of parent-offspring (F_2 vs F_3, F_2 vs F_4 and F_3 vs F_4) regression were used to estimate heritability to know the precise estimate as well as environment influence. Since, the F_2 and other two generations (F_3 and F_4) were grown in different years, the estimates could be biased. But F_3 and F_4 generations were grown simultaneously and hence the effects of environment were largely common to both the generations. Thus the heritability estimates based on F_3 vs F_4 regression may be more realistic. The heritability estimates varied widely. Palmitic acid showed high heritability in F_2 generation, which declined in advance generations (Table 3). The heritability estimates for stearic and linoleic acid were relatively consistent. Hence, selection in early generation for this trait could be effective. Oleic acid showed low heritability as estimated by F_2 vs F_3 and F_2 vs F_4 regression, but the estimate was relatively high (0.17) based on F_3 vs F_4 regression, thereby suggesting that selection for high oleic acid should be based on progeny performance in advance generations rather than single plant performance in early segregating generation. The linolenic + eicoseonic acids showed high heritability estimates, in general, which ranged between 0.40-0.80 suggesting the usefulness of single plant selection in F_2 segregating generation. Variable estimate of heritability could due to genotype, environment or their interaction (G x E).

Correlations: Pattern of correlations of fatty acids in different segregating generations was analyzed to predict the simultaneous selection for desirable combination of fatty acids. In the F_2 generation, erucic acid content was negatively and significantly correlated with palmitic (r= 0.411**), stearic (r= - 0.282**), oleic (r= - 0.839**), linoleic (r= -0.691**) and linolenic + o eicosenoic (r= -0.301**) acid. The pattern of correlation was variable in F_2, F_3 and F_4 generations except for oleic acid content which showed consistently negative relationship with linoleic and linolenic + eicosenoic acid content in F_3 and F_4 generations and positive relationship in F_2 generation (Table 4). Palmitic acid was positively correlated with stearic, oleic and linoleic acid in F_2 generation but this association was positive only with oleic acid in F_4 progenies (r=0.231**). Palmitic acid in F_2, F_3 and F_4 progenies were negatively and significantly correlated with linolenic + eicosenoic acid (Table 4). Stearic acid had negative and significant association with linolenic + eicosnoic acids in F_3 and F_4 progenies.

The relationship of palmitic acid with oleic acid was positive and significant only in F_2 and F_4 generation whereas stearic acid had similar association with oleic acid in F_2 and F_3 generation. Palmitic and stearic acid showed variable association with linoleic acid in F_3 and F_4 generation.

It seems that precursor of eicosenoic acid is oleic acid and same extra amount which was desaturated in biosynthetic pathway resulted in increased levels of linoleic and linolenic acids. Oleic acid increased with concomitant decrease in both linolenic and eicosenoic acids in zero erucic acid lines, hence estimation of linolenic + eicosenoic acid together will not affect the correlations. The negative correlation of erucic acid with oleic and linoleic acids is of paramount significance to develop varieties with low erucic acid and high contents of oleic and linoleic acids. The variable relationship between

fatty acids in different segregating generations could be the consequence of recombination of gene(s) controlling the inheritance of fatty acid profiles.

Glucosinolate content: Of the 365 selfed F_2 plants of the cross BJ 1058 x Rajat, only 98 plants showed ++ reaction and the remaining had either +++ or ++++. BJ 1058 also showed variable reaction + or ++. The number of plants with less than 50 μ moles increased with the generation advancement (Table 5). The selection was made for the lowest amount of glucosinolate content within and between families. Six plants having less than 40 μ moles glucosinolate content were characterized for days to maturity, plant height, 1000-seed weight, oil and protein contents (Table 6). These progenies had lower oil content and 1000-seed weight as compared to high yielding variety, Rajat. Hence, there is a need to improve the agronomic base of these lines.

Table 1 Range, mean and coefficient of variability (CV) for fatty acid profiles in F_2 (226 plants), F_3 (205 lines) and F_4 (199 lines) generation of the cross TERI (OE) M 21 x Varuna

Fatty acid	Range (%)			Mean ± SEm			CV (%)		
	F_2	F_3	F_4	F_2	F_3	F_4	F_2	F_3	F_4
Palmitic	1.3 - 5.6	2.1 - 5.3	1.3 - 6.5	3.2 ± 0.04	3.6 ± 0.04	3.3 ± 0.10	20.0	10.8	25.1
Stearic	T* - 2.7	T* - 2.7	T* - 2.6	0.5 ± 0.04	1.3 ± 0.06	0.3 ± 0.10	122.0	57.1	220.0
Oleic	8.5 - 53.6	33.6 - 53.7	24.6 - 50.3	22.0 ± 0.50	44.0 ± 0.28	39.3 ± 0.30	33.0	9.1	10.3
Linoleic	18.0 - 49.3	29.4 - 57.5	30.2 - 52.7	28.2 ± 0.34	38.1 ± 0.29	40.5 ± 0.30	18.0	10.6	9.2
Linolenic + Eicosenoic	11.2 - 39.3	0.9 - 21.3	3.8 - 25.9	20.7 ± 0.30	12.9 ± 0.15	16.4 ± 0.22	20.0	16.1	19.1
Erucic	0 - 49.6	0	0	25.4 ± 0.8	0	0	46.0		

*T : Traces

Table 2 Characteristics of some promising low erucic lines (F4) with high oleic acid, moderate seed weight, oil content and seed yield derived from the cross TERI (OE) M 21 x Varuna

Progeny	Seed colour	Oleic acid (%)	Maturity (days)		1000-seed weight (g)		Seed yield/plant (g)		Oil content (%)	
		F_4	F_4	F_5	F_4	F_5	F_4	F_5	F_4	F_5
166-50-1	Brown	48.7	133	128	4.5	4.7	11.3	13.5	35.9	37.2
91-6-6	Yellow	48.8	133	128	3.3	3.7	21.5	18.6	38.0	37.9
166-35-1	Brown	47.7	133	132	3.6	4.2	7.5	15.0	34.4	34.0
166-26-4	Brown	47.6	131	130	2.5	3.9	19.6	12.4	33.4	35.6
205-10-5	Brown	46.6	131	134	3.6	3.9	14.8	17.3	38.2	38.3
205-11-3	Brown	46.6	135	135	3.6	3.9	7.0	17.4	38.7	40.1
166-27-1	Brown	45.8	132	130	3.6	3.9	28.6	11.0	36.0	35.2
91-8-2	Yellow	43.8	134	128	2.6	2.9	14.0	12.3	39.1	39.9
91-32-3	Yellow	41.6	133	125	4.9	3.8	12.7	11.7	40.2	38.1
91-50-5	Yellow	45.7	136	130	2.6	3.5	17.6	26.5	38.3	39.6
91-22-1	Yellow	42.8	134	131	3.5	3.5	13.4	14.3	38.8	39.3
91-60-1	Yellow	43.5	134	125	3.2	3.9	14.5	14.5	36.3	38.7
91-61-3	Yellow	46.3	134	131	3.5	4.2	8.2	14.5	38.8	38.1
Varuna	Brown	9.3	140	134	5.7	6.2	15.2	31.5	39.8	39.2
TERI (OE) M 21	Yellow	43.5	126	127	2.9	3.6	12.5	15.2	38.2	38.4

Table 3 Heritability (narrow sense) estimates of different fatty acids in F_2 and F_3 generations of low erucic acid lines in the cross TERI (OE) M 21 x Varuna

Fatty acid	Regression		
	F_2 vs F_3 Heritability	F_2 vs F_4 Heritability	F_3 vs F_4 Heritability
Palmitic acid	0.56	0.36	0.02
Stearic acid	0.31	0.23	0.14
Oleic acid	0.03	0.05	0.17
Linoleic acid	0.09	0.18	0.11
Linolenic + Eiocosenoic acid	0.80	0.69	0.40

Table 4 Correlation coefficients (r) between different fatty acid profiles in F_2, F_3 and F_4 generations of the cross TERI (OE) M 21 x Varuna

Fatty acid	Generation	Stearic acid	Oleic acid	Linoleic acid	Linolenic + eicosenoic
Palmitic acid	F_2	0.249**	0.269**	0.518**	-0.122**
	F_3	-0.047	-0.084	0.096	-0.192**
	F_4	-0.178*	0.0231**	-0.193*	-0.336**
Stearic acid	F_2		0.298**	0.150**	-0.088
	F_3		0.608**	-0.686**	-0.150**
	F_4		-0.102	-0.129	-0.146*
Oleic acid	F_2			0.300**	-0.073
	F_3			-0.851**	-0.398**
	F_4			-0.706**	-0.573**
Linoleic acid	F_2				-0.015
	F_3				-0.087
	F_4				-0.074

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

Table 5 Frequency distribution for glucosinolate content (micro moles / g defatted seed meal) in the segregating generation of the cross BJ 1058 x Rajat

Range	Generation					
	F_3 (N=450)	F_4 (N=420)	F_5 (N=861)	F_6 (N=13)	BJ 1058 (N=54)	Rajat (N=39)
30-40	-	-	5	1	-	-
40-50	17	19	47	11	12	-
51-60	51	41	148	-	8	-
61-70	87	58	36	-	14	-
71-80	35	109	88	-	-	-
81-90	22	99	171	-	5	3
91-100	107	54	152	1	8	14
101-110	30	19	115	-	7	15
111-120	32	16	59	-	-	4
121-130	38	3	28	-	-	3
131-140	17	2	9	-	-	-
141-150	9	-	3	-	-	-
151-160	3	-	-	-	-	-
161-170	2	-	-	-	-	-

Table 6 Characteristics of low glucosinolate lines (F_5) derived from the cross BJ 1058 x Rajat

Strain	Glucosinolate content*	No. of plants	Maturity (days)	Plant height (cm)	Seed weight (g)	Oil content (%)	Protein content (%)
BPR 47-92-6-50	37.0-38.8	2	142	178	2.7	33.4	23.8
BPR 47-92-6-8	40.0	2	139	152	3.0	36.1	22.1
BPR 47-92-6-45	40.0	1	141	145	2.6	36.5	22.1
BPR 47-324-2-143	40.0	1	137	171	3.0	36.6	22.2
BJ 1058	33.0-40.0	8	132-139	150	2.9	38.0	21.4
Rajat	115.3	5	134	172	5.4	38.8	20.6

*micro moles / g defatted seed meal.

Future strategies:

- There is an imperative need for refining analytical techniques for fatty acid and glucosinolate content estimation to facilitate rapid and mass screening in early segregating generations.
- Intermating among selected low erucic/ low glucosinolate lines and back crossing with high yielding recurrent parent to broaden genetic base and improve yield potential.
- Further, hybridization between low erucic acid lines with low glucosinolate lines to combine double low trait.
- Utilization of double haploid technique tor early fixation of double low trait to hasten breeding efficiency.

References

Chauhan, J.S., Tyagi, M.K., Tyagi, Poonam, Kumar, P.R., Yadav S.K. and Kumar, Satyanshu. 2001. Analysis of fatty acid profiles of F1 hybrids and their parents in Indian mustard (*B. juncea* L. Czern & Coss.). *Annals of Agri-Bio Research*, 6(2) : 201-206.

Gomez, K.A. and Gomez, A.A. 1984. *Statistical Procedures for Agricultural Research*. 2nd Edn., pp.680, John Wiley and Sons, New Delhi.

Gopalan, C.D., Krishnamurthi, D., Sheonolikar, I.S. and Krishnamachari, K.A.V.R. 1974. Myocardial changes in monkeys fed on mustard oil. *Nutr. Metab.*, **16** : 352-365.

Lush, J.L. 1940. *Animal Breeding Plans*. Iowa State College Press, USA.

Renard, S. and Mc Gregor, L. 1976. Antithrombo genetic effects of erucic acid poor rapeseed oils in the rats. *Rev. Fr. Cros.*, **25**:339-396.

Woods, D.L. 1980. Association of yellow seed coat with other characteristics in mustard (*B. juncea* L.). *Cruciferae Newsletter*, **5** : 23-24.

J. Oilseeds Res., **21(1)**: 34-35 (2004)

Modified triple test cross in sunflower, *Helianthus annuus* L.

P. Venkata Ramana Rao, A. Vishnuvardhan Reddy[1], D. Lokanadha Reddy and M. Ganesh

Department of Genetics and Plant Breeding, College of Agriculture, Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad-500 030, AP

(Received: October, 2003; Revised: November, 2003; Accepted: December, 2003)

Abstract

Two genetically divergent CMS lines DCMS-5 and CMS 7-1A and eight proven restorer lines viz., RHA265, RHA271, RHA298, RHA341, RHA344, RHA345, RHA346 and DRS1 of sunflower, *Helianthus annuus* L. were crossed in a modified Triple Test Cross fashion. The resulting 16 hybrids were evaluated to study the components of genetic variance governing yield and its component traits. The additive component was significant for all the traits except days to maturity and plant height. The dominance component was significant for all the traits except plant height while the epistasis component was significant for all the characters studied. The three types of gene action were playing a significant role in the Sunflower population used in the study.

Key words: Triple test cross, sunflower, epistasis

Introduction

Genetic control of quantitative traits is the pre-requisite for designing an efficient breeding programme. However for yield is a complex phenomenon and breeder has to thoroughly understand the gene action controlling the component traits. Various biometrical designs are in vogue to understand the gene action controlling different traits. Most of the designs assume absence of the epistasis, which in reality is an important integral part of genetic variance. One of the best designs for detection of epistasis is triple test cross (Kearsey and Jinks, 1968). Though this design is efficient, however it requires four populations P_1, P_2, F_1 and F_2, hence it is a tedious and time consuming process. So, Jinks *et al.*, (1969) proposed a modification for this model in which a set of lines are crossed to two extreme testers. This design is simpler, instead of F_2 population a set of inbred lines (P_i) are crossed to two testers (L_1 and L_2) of opposite extreme to generate $\bar{L}_{1i}$ and $\bar{L}_{2i}$ families. Thus it requires only tester parents, inbreds and F_1s. In the present investigation an attempt was made to assess the genetic components of variance *viz.*, additive, dominance and epistasis in Sunflower using the modified triple test

Materials and methods

Eight inbred lines of sunflower with proven restoring ability and two testers (CMS lines) were crossed to generate 16 F_1 hybrids during *kharif*, 2001. The two testers DCMS-5 and CMS 7-1A even though belonged to single male sterile source (Petiolaris), they differed morphologically to a great extent for majority of the characters confirming that they contain several uncommon genes for the traits under study. The 16 F_1 hybrids along with their parents and four standard checks were evaluated during *rabi*, 2001 in a Randomized Block Design replicated twice. Each entry was sown in a single row of 3 m length with a spacing of 60 x 30 cm. Observations were made on five competitive plants per treatment in each replication on days to first flowering, days to 50 % flowering, days to maturity, plant height, stem diameter, head diameter, number of filled and unfilled seeds per head, seed filling %, 100 seed weight, seed yield per plant and oil content. The data were subjected to modified triple test cross analysis (Jinks *et al.*, 1969).

Results and discussion

To test the epistatic gene action, which is an integral part of genetic architecture, modified triple test cross (T.T.C) model was adopted using two extreme testers, which differed morphologically for several characters. The results so obtained (Table 1) gave the realistic information on additive, dominance and epistasis components of genetic variance without any inflation or deflation.

For testing variance due to epistasis instead of $\bar{L}_{3i}$ mean that is used in normal T.T.C, mean of a set of inbreds used (P_i) was taken in to consideration. The results revealed that variance due to epistasis ($\bar{L}_{1i} + \bar{L}_{2i} - P_i$) was significant for all the nine characters studied indicating the predominant role of epistasis in the genetic variance.

[1] Senior Scientist (Plant Breeding), Directorate of Oilseeds Research, Rajendranagar, Hyderabad-500 030, AP

Table 1 Detection of additive, dominance and epistatic components of variation in sunflower using modified T.T.C model over extreme testers NODL 2 and CMS 7-1A

Source	d.f.	Days to 50% flowering	Days to maturity	Plant height (cm)	Stem diameter (cm)	Head diameter (cm)	No. of filled seeds	100 seed weight (g)	Seed yield/plant (g)	Oil content (%)
Mean										
DCMS-5		57	88	90.9	1.22	7	427	2.22	9.45	37.06
CMS 7-1A		72	96	115	0.94	18	254.5	2.92	7.5	29.56
Additive										
Replications	1	0.6	0.76	190.4	0.02	0.2	14.1	0.1	0.5	0.2
Sums, $L_{1i} + L_{2i}$ (additive)	7	63.56**	12.7	211.3	0.062**	15.40**	35519.56**	4.53**	193.31**	57.20**
Sums x Blocks (Error)	7	1.70	4.56	167.8	0.008	2.01	212.06	0.052	1.04	1.015
Dominance										
Replications	1	1.56	1.00	0.81	0.066**	0.051	3.06	0.03	0.03	0.62
Differences, $L_{1i} + L_{2i}$ (dominance)	7	9.70**	7.53**	360.11	0.62**	32.96**	22239.84**	4.08**	263.42**	77.32**
Differences x Blocks (Error)	7	2.41	1.42	100.83	0.002	0.88	144.49	0.08	3.38	1.23
Epistasis										
Replications	1	0.00	2.25	3.5	0.01	0.425	4.92	0.05	1.45	0.0043
Sums, $L_{1i} + L_{2i} - P_i$	7	80.28**	25.67**	182.98**	0.20**	12.36**	76600.88**	4.73**	329.69**	77.82**
Sums x Blocks (Error)	7	1.87	2.23	3.5	0.0057	1.81	73.6	0.04	1.29	0.72

Note: L_1 and L_2 in the ANOVA represent the two testers employed, whereas P_i represents inbred lines
*, ** = Significant at 5% and 1% level, respectively.

The variance due to sums ($L_{1i} + L_{2i}$) was significant for all the traits except days to maturity and plant height. This revealed that additive component of genetic variance (D) was significant for all the traits excluding days to maturity and plant height.

The analysis of variance due to differences ($L_{1i} - L_{2i}$) measuring the dominance component (H) was significant for eight out of nine traits leaving plant height.

The degree of dominance ($\sqrt{H/D}$) was also significant (more than unity) for all the traits except days to maturity and plant height. This indicates that over dominance was the cause of high level of expression of these traits while characters days to maturity and plant height were governed by partial or incomplete dominance. Gupta and Khanna (1982) and Gangappa *et al.* (1997) reported presence of all the three types of gene action from generation mean analysis. Singh *et al.* (1987) studied three sets of T.T.C. and indicated that epistasis was integral part of genetic variation in sunflower. Satyanarayana *et al.* (2001) reported the significance of epistasis in sunflower.

Therefore it may be concluded that all the three components of genetic variance i.e. additive, dominance and epistasis were playing significant role in controlling the traits so the breeding programme to be followed should not only exploit fixable gene effects but also ponder the non-additive gene effects for further improvement of base population and broadening the genetic base.

References

Gangappa, E., Channakrishnaiah, K.M., Thakur, C. and Ramesh S. 1997. Genetic architecture of yield and its attributes in sunflower (*Helianthus annuus* L.). *Helia*, **20**:85-94.

Gupta, K.K. and Khanna K.R. 1982. Gene action and heterosis for oil yield and component characters in sunflower. *Indian Journal of Genetics and Plant Breeding*, **42**:265-278.

Jinks, J.L., Perkins, J.M. and Breese E.L. 1969. A general method of detecting additive, dominance and epistatic variation for metrical traits II. Application to inbred lines. *Heredity*, **24**:45-57.

Kearsey, M.J. and Jinks, J.L. 1968. A general method of detecting additive, dominance and epistatic variation for metrical traits.I. Theory. *Heredity*, **23**:403-409.

Satyanarayana, K.V., Ganesh, M., Ranganatha, A.R.G. and Sudheer Kumar, S. 2001. A comprehensive genetic analysis of quantitative traits in sunflower using Line X Tester and modified Triple Test Cross models. In Diamond Jubilee symposium on "Hundred years of post Mendelian Genetics and Plant Breeding - retrospect and Prospects" Indian Society of Genetics and Plant Breeding, November 6-9,2001, New Delhi. pp:317

Singh, S.B., Labana K.S. and Virk, D.S. 1987. Detection of epistatic, additive and dominance variation in sunflower (*Helianthus annuus* L.). *Indian Journal of Genetics and Plant Breeding*, **47**:243-247.

J. Oilseeds Res., **21**(1): 36-38 (2004)

Genotype x Environment interaction and stability analysis for oil content in American cotton, *Gossypium hirsutum* L.*

A. Narisi Reddy and A. Satyanarayana[1]

Regional Agril. Research Station, Acharya N.G. Ranga Agricultural University, Lam, **Guntur-522 034, AP**

(Received: August, 2002; Revised: August, 2003; Accepted: September, 2003)

Abstract

Fifty five genotypes of American cotton (*Gossypium hirsutum* L.) comprising of 10 parents and their 45 hybrids produced in a diallel fashion (without reciprocals) were evaluated for stability for oil control in four different environments. Both linear and non-linear components of Genotype x Environment interaction were important for oil content. The study of stability parameters revealed that NDLH 1678 x CWROK 165 and L 604 x NDLH 1678 and MCU 5 x NA 1325 were found stable over environments for oil control with high mean seed cotton yield.

Key words: Stability, cotton, G x E interaction

Introduction

The seed oil content (on dry weight basis) in Indian cultivars of *Hirsutum* cotton ranged from 20.9 to 27.6 % (Dani, 1984). Cotton seed oil is one of the rich source of edible oils in our country. In order to meet the growing demand for edible oils, it can be considered as one of the substitute to overcome their shortage. The consistency in performance over environments is essential to develop a stable variety or hybrid. The present studies were carried out to identify a cotton variety/hybrid which can perform consistently better over wide range of environmental conditions.

Materials and methods

The experimental material consisted of 45 F_1's obtained by crossing 10 diverse parents *viz.*, MCU 5, BN 1, L 389, NA 1325, AC 738, L 604, NDLH 1678, ARB 8824, CWROK 165 and ICMF 82 obtained from different cotton research stations produced in a diallel fashion (excluding reciprocals). Above material was grown in a Randomized Block Design with 3 replications in 4 environments during 1999-2000 at Regional Agricultural Research Station, Lam (Table 2). Recommended package of practices for the region were followed. Each genotype was grown in a 2 row plot of 6 m length adopting a spacing of 120 cm between rows and 60 cm within a row. Five competitive plants were randomly selected for recording data on oil percentage and seed cotton yield/plant(g). Seed oil content was analyzed by non-destructive Nuclear Magnetic Resonance Technique with New Port Analyser. The data were analyzed for stability as per Eberhart and Russell (1966).

Results and discussion

The pooled analysis of variance revealed that the mean squares due to genotypes were significant for oil content indicating the wider genetic diversity (Table 1). Mean squares due to environments (linear) were significant, indicating that the environments tested are different. The G x E interaction was also significant indicating the differential response of the genotypes to the environmental conditions. Genotype x Environment interaction for oil content was earlier reported by Dani (1989 a, b).The partitioning of the G x E interactions indicated that both linear and non-linear components of variance were important for seed oil content, indicating the importance of regression coefficient (bi) and deviation from regression (S^2di) for assessing the stability of the genotypes for oil content.

A perusal of mean performance for oil control indicated that, in general the hybrids had higher oil content compared to the parents in different individual environments and also in pooled over environments (Table 2). Seed oil control in parents ranged from 20.28 to 22.9% with a mean oil content of 21.5%, while in hybrids it ranged from 20.44 to 24.1% with a mean of 22.4% over environments. Similar results were earlier reported by Dani (1989a). In normal sowing conditions, the oil content was more in rainfed conditions (E_2) compared to the crop raised under irrigated conditions.

* Part of the Ph.D thesis submitted to ANGRAU, Rajendranagar, Hyderabad-500 030, AP

[1] Director of Extension, ANGRAU, Rajendranagar, Hyderabad-500 030, AP

Similar trend was observed both in parents and hybrids. While such differences between the samples of irrigated and rainfed crop when grown under delayed sowing conditions i.e. E_3 and E_4 were not observed. However, on an average there was reduction in the oil content by about 2 to 2.5% under delayed sowing conditions, indicating the influence of rainfall distribution pattern on oil control in cotton seed.

Three stability parameters *viz.*, the grand mean over the environments, the regression coefficient and squared deviation from the regression were considered to be important for stability of a genotype (Table 3). A genotype is considered stable in performance if it has high mean performance, unit regression coefficient (bi=1) and least deviation from regression (S^2di).

The crosses, MCU 5 x NA 1325 and L 389 x NDLH 1678 with high mean, recorded average response and predictable performance for oil control and hence these are considered as stable genotypes over environments. The cross NA 1325 x L 604 with high mean for oil content and above average response showed predictable performance under favourable environments. The crosses NDLH 1678 x CWROK 165 and L 604 x NDLH 1678 recorded high mean for seed cotton yield per plant also recorded mean above general mean, above average response and predictable performance for oil content. Among the parents, AC 738 exhibited high mean performance (22.93), average response (1.03) but its performance was unpredictable as it recorded significant S^2di (1.06**).

In the present investigation, among the high yielding hybrids MCU 5 x NA 1325 and L 389 x NDLH 1678 showed stable performance for oil content. The crosses NDLH 1678 x CWROK 165 and L 604 x NDLH 1678 which recorded high mean for seed cotton yield/ plant also recorded mean above general mean, above average response and predictable performance for oil content. In conclusion, the hybrids NDLH 1678 x CWROK 165 and L 604 x NDLH 1678 and MCU 5 x NA 1325 with high mean seed cotton yield and stable performance for oil content deserved further confirmatory tests over wide range of environments for exploitation as hybrids besides using for further exploitation in the segregating generations, as high oil content in the seed hybrids can be considered as value addition.

References

Dani, R.G. 1984. Variability of seed oil and productivity of some Indian cottons tested in Texas. *Indian Journal of Agricultural Sciences*, 54(7) : 550-556.

Dani R.G. 1989a. Genotype x Environment interactions for seed oil and protein content in cotton (*Gossypium hirsutum* L.). *Indian Journal of Genetics and Plant Breeding*, 49(2) : 237-240.

Dani, R.G. 1989b. Influence of season and location on seed oil content in Cotton (*Gossypium hirsutum* L.) *Journal of Cotton Research and Development*, 3(1) : 96-99

Eberhart, S.A. and Russell, W.A. 1966. Stability parameters for comparing varieties. *Crop Science*, 6 : 36-40.

Table 1 Analysis of variance for oil content and seed cotton yield

Source of Variation	d.f	Oil content (%)	Seed Cotton Yield/Plant(g)
Genotypes(G)	54	3.11**	1839.61**
G x E	162	1.33**	147.05**
Environment (linear)	1	538.62**	84505.51**
G x E (linear)	54	1.13**	263.27**
Pooled Deviation	110	1.41**	87.33**
Pooled error	432	0.73	30.97
Linear component	-	44.49	75.09
Non-linear component	-	55.51	24.91

*,** Significant at 5% and 1% level of probability, respectively

Table 2 Mean performance of parent and Hybrids for oil content (%)

Parents/Hybrids	E_1	E_2	E_3	E_4	Pooled
Parents	22.50	23.20	20.24	20.05	21.50
Hybrids	23.33	24.61	20.89	20.88	22.42
Average	23.18	24.35	20.77	20.73	22.25

E_1 = Normal saving - irrigated; E_2 = Normal sowing - rainfed; E_3 = Delayed sowing - irrigated and E_4 = Delayed sowing - rainfed

Table 3 Stability Parameters for Oil content and yield of cotton

S. No.	Parents/Crosses	Oil content (%)			Seed Cotton Yield (g/plant)		
		x	bi	S^2di	x	bi	S^2di
1	MCU 5	21.76	1.10	2.25**	110.50	0.85	-30.68
2	BN 1	20.28	0.80	1.18**	73.00	0.61	-13.32
3	L 389	20.97	0.87	-0.57	101.33	0.66	-28.42
4	NA 1325	22.42	0.72	-0.01	121.00	1.15	1.94
5	AC 738	22.93	1.03	1.06**	92.58	0.71	-29.10
6	L 604	20.46	1.19	-0.55	104.25	0.89	-19.22
7	NALH 1678	21.67	1.20	0.38**	123.58	1.32	-23.37
8	ARB 8824	21.40	0.67	0.34**	102.25	0.93	-27.06
9	CWROK 165	22.49	0.67	0.70**	120.67	0.93	-25.06
10	ICMF 82	20.64	0.51	-0.59	94.92	0.86	-7.99
11	MCU 5 x BN 1	22.07	1.14	-0.72	97.17	0.91	1.01
12	MCU 5 x L 389	22.74	0.98	-0.63	115.50	0.78	-7.66
13	MCU 5 x NA 1325	24.12	1.05	0.02	152.92	1.69	43.83**
14	MCU 5 x AC 738	21.56	1.76	-0.63	101.67	1.12	3.72
15	MCU 5 x L 604	22.80	1.26	1.36**	104.33	0.77	-25.68
16	MCU 5 x NDLH 1678	23.38	1.34	-0.35	121.08	0.90	-18.41
17	MCU 5 x ARB 8824	22.32	0.87	2.20**	104.17	0.59	-26.72
18	MCU 5 x CWROK 165	23.13	1.02	1.41**	145.50	1.75	6.16
19	MCU 5 x ICMF 82	20.65	1.51	-0.37	94.42	0.23	-19.48
20	BN 1 x L 389	21.92	1.66	1.66**	102.08	0.82	-2.92
21	BN 1 x NA 1325	22.75	1.01	-0.53	132.08	1.58	64.05**
22	BN 1 x AC 738	21.64	1.21	-0.44	119.50	1.33	-27.26
23	BN 1 x L 604	21.90	1.07	0.62**	113.25	1.24	486.04**
24	BN 1 x NDLH 1678	22.21	1.13	0.95**	136.25	1.58	-4.97
25	BN 1 x ARB 8824	22.95	1.40	-0.51	118.50	1.71	256.86**
26	BN 1 x CWROK 165	21.09	0.72	1.60**	143.08	1.17	17.74**
27	BN 1 x ICMF 82	22.29	0.66	-0.60	98.83	0.73	44.34**
28	L 389 x NA 1325	23.66	0.43	1.43**	147.25	1.35	17.59**
29	L 389 x AC 738	21.73	1.01	-0.26	82.67	0.06	-20.27
30	L 389 x L 604	22.23	1.28	2.87**	112.75	0.98	-29.68
31	L 389 x NDLH 1678	23.78	1.02	-0.56	142.17	1.53	158.04**
32	L 389 x ARB 8824	22.22	0.91	0.28*	89.42	0.18	-29.41
33	L 389 x CWROK 165	22.85	1.77	0.84**	117.92	0.99	-11.52
34	L 389 x ICMF 82	20.44	0.85	6.37**	78.08	0.64	107.18**
35	NA 1325 x AC 738	21.98	1.07	0.65**	122.50	1.30	11.79**
36	NA 1325 x L 604	23.98	1.12	-0.29	141.25	1.04	853.32**
37	NA 1325 x NDLH 1678	23.11	0.62	3.04**	148.67	1.46	399.2**
38	NA 1325 x ARB 8824	22.95	0.90	0.22	139.58	1.08	-16.25
39	NA 1325 x CWROK 165	22.72	0.75	2.39**	143.08	1.53	436.73**
40	NA 1325 x ICMF 82	21.86	0.41	0.09	104.17	0.90	-30.14
41	AC 738 x L 604	21.76	1.08	0.52**	91.50	0.72	49.62**
42	NA 738 x NDLH 1678	22.87	1.08	-0.23	117.42	1.00	-20.90
43	AC 738 x ARB 8824	22.21	0.55	5.97**	97.08	0.90	-10.40
44	AC 738 x CWROK 165	22.04	0.54	0.10	118.17	0.88	456.22**
45	AC 738 x ICMF 82	21.67	0.63	2.97**	72.25	0.45	70.83**
46	L 604 x NDLH 1678	22.60	1.53	-0.43	153.58	1.39	211.67**
47	L 604 x ARB 8824	23.83	0.91	0.50**	132.08	1.05	46.85**
48	L 604 x CWROK 165	22.16	1.31	0.96**	124.50	0.83	-11.68
49	L 604 x ICMF 82	22.72	1.12	0.30**	105.83	0.62	18.55**
50	NDLH 1678 x ARB 8824	22.60	1.04	0.06	140.25	1.32	55.82**
51	NDLH 1678 x CWROK 165	22.47	1.35	-0.35	162.42	2.16	18.51**
52	NDLH 1678 x ICMF 82	22.29	0.44	0.60**	103.92	0.55	65.09**
53	ARB 8824 x CWROK 165	22.30	1.16	-0.51	129.17	0.80	26.12**
54	ARB 8824 x ICMF 82	22.33	0.30	-0.59	106.08	0.46	-22.65
55	CWROK 165 x ICMF 82	22.44	1.29	0.38**	129.25	1.03	-12.53
	General mean	22.26	0.99		116.41		
	SEm ±	0.68	0.38		5.55		

*,** Significant at 5% and 1% level of probability, respectively

J. Oilseeds Res., 21(1): 39-41 (2004)

Eco-physiology of yield expression in groundnut, *Arachis hypogaea* L. genotypes during post-monsoon season

P.N. Karanjikar, G.S. Jadhav and P.K. Wakle

Marathwada Agricultural University, Parbhani-431 402, Maharashtra

(Received: January, 2003; Revised: July, 2003; Accepted: September, 2003)

Abstract

A Field experiment was conducted on medium deep Vertisol for two years at Marathwada Agricultural University farm at Parbhani to study eco-physiological responses of elite groundnut cultures to identify optimum planting window and genotypes adopted to post monsoon (*rabi*) season. Crops sown on 15th Sept. recorded significantly highest pod yield. The subsequent delay in sowing at 15 days interval significantly reduced the pod yield. TAG-24 and ICGS-11 were comparable in yield and both proved significantly superior to rest of the cultures in the post monsoon season. For 15th and 30th October sowing TAG-24 should be preferred.

Key words: Eco-physiology, genotypes, sowing dates, post-monsoon, adaptability

Introduction

Groundnut (*Arachis hypogaea*. L) is an important oilseed crop in India and accounts for 45% of the area and 55% of the total oilseeds production in the country. However, average productivity is very low (0.8 to 1.0 t/ha) compared to China and USA (3.0 t/ha).

The productivity of rainfed groundnut is unpredictable due to large variation in rainfall leading to drought or water logging, temperature, radiation and high incidence of pests and diseases. The productivity of summer groundnut is doubled than rainfed crop. However the crop demands large water requirements, often suffer from high temperature and also faces excessive vegetative growth and other problems associated with soil and water management. Most of the groundnut in Maharashtra is grown in black soil.

Opportunities exist for gain in productivity of groundnut based on crop's phenology and agroclimatological conditions prevailed during post monsoon season in Maharashtra. There is greater opportunity for matching the phonological developments of groundnut to desired temperature and photo periods in post-monsoon season (Sept.-Feb.) so as to minimize the coincidence of critical phases of growth with periods of environmental stress there by enhancing groundnut yield through eco-physiological approach.

Materials and methods

A field experiment was conducted on medium black Vertisol at Marathwada Agricultural University, Parbhani during 1996-97 and 1997-98 post-mansoon season. The Soil was clayey in texture with slightly alkaline in reaction. It was medium in available nitrogen and phosphorus and rich in potash with moderate available water holding capacity. A Split Plot Design was used with three replications. Four sowing dates (15th Sept., 30th Sept., 15th Oct. and 30th Oct.) constituted main plots and six genotypes (ICGS-11, ICGS-44, LGN-2, SB-XI, JL-24, and TAG-24)were subplots. The net plot size was 5.4 x 3.0 m. A uniform basal dose of 25 kg nitrogen and 60 kg P_2O_5/ha was applied. Seeds were treated with Bavistin @ 2.5 g/kg seed and sown on broad ridge and furrow with two lines on ridge at 30 x 10 cm inter and intra raw spacing. The crop was irrigated 5-6 times, each receiving 0.75 IW/CPE water.

Results and discussion

Yield and Yield attributes: Dry pod yield of groundnut was influenced significantly by sowing dates, genotypes as well as sowing dates (environment x genotypes interactions during both years.

Effect of sowing dates: Dry pod yield of groundnut was affected significantly by dates of sowing (Table 1). Early sowing on 15th September gave significantly higher dry pod yield than late sowing in both the years and in pooled analysis. The increase in dry pod yield of groundnut sown on 15th Sept. over sowing on 30th Sept. 15th Oct. and 30th Oct. was 25.7 %, 60.60 % and 69.5 %, respectively. The differences in the dry pod yield of groundnut sown in post-monsoon season at different sowing dates was also noticed by many research workers (Shelke *et al.*, 1987; Ghadekar, 1989; Padole *et al.*, 1994; Lodh, 1994; Bhoje, 1996) which is due to increase in the yield attributing

character like highest number of pods, shelling percentage and test weight.

The pod yield is a complex character which depends upon the expression of yield attributing character. The increase in pod yield of groundnut sown on 15th Sept. compared to later sowings was the result of increase in number of total and two seed pods/plant, shelling percentage and 100 seed weight. This may be attributed to crops exposure to favourable temperature regime during vegetative and reproductive stages, when sown on 15th and 30th September (Fig.1) which corroborates the results of Emery *et al.* (1981) and Bell (1986).

Table 1 Effect of sowing dates and genotypes on pod yield and yield attributes of groundnut

Treatment	Pod yield (kg/ha)			Yield attributes							
				Pods/plant				Shelling (%)		100 kernel weight (g)	
	1996-97	1997-98	Pooled	Two kernel pods		Total pods					
Sowing dates (D)				1996-97	1997-98	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98
15th September	2815	1078	1976	19	9	26	13	71.1	65.3	45.0	36.6
30th September	2293	601	1446	17	8	27	11	69.1	60.0	41.9	29.9
15th October	1132	400	766	9	4	15	7	66.1	58.4	37.2	25.3
30th October	614	571	593	5	8	8	11	62.7	62.9	32.9	41.6
SEm±	39	55	32	1.11	0.17	1.56	0.30	0.2	0.45	0.38	0.32
CD (P=0.05)	107	151	99	3.09	0.49	4.34	0.84	0.42	1.25	1.06	0.90
Genotype (V)											
ICGS-11	2140	743	1441	12	7	20	11	67.5	61.9	41.0	34.0
ICGS-44	1733	804	1269	12	7	19	11	68.6	63.5	43.2	35.4
LGN-2	1341	701	1019	13	7	19	10	67.1	65.6	38.4	34.9
SB-XI	1309	498	903	14	7	19	10	6.0	61.3	35.1	29.1
JL-24	1224	603	914	10	7	15	10	66.5	59.5	38.0	35.1
TAG-24	2534	628	1581	15	7	22	11	67.9	61.4	39.7	31.5
SEm±	34	47	30	0.68	0.28	0.93	0.34	0.39	0.39	0.53	0.45
CD (P=0.05)	94	130	84	1.89	NS	2.58	NS	1.09	1.08	1.47	1.25
Interaction (D x V)											
SEm±	77	94	61	1.37	0.57	1.86	0.69	0.78	0.79	1.06	0.90
CD (P=0.05)	214	260	168	NS	1.59	5.16	1.92	NS	2.16	2.94	2.50

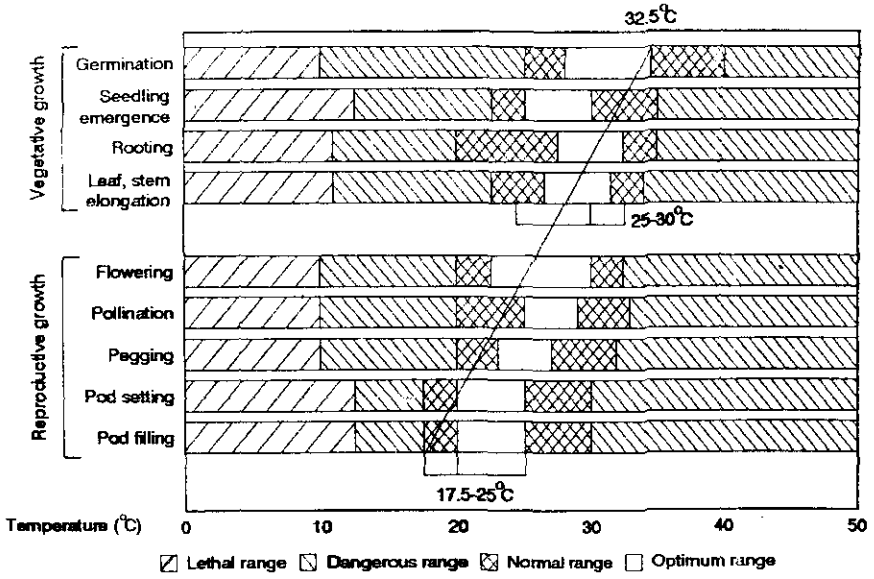


Fig 1 Critical temperatures of developmental processes in groundnut (Based on Ketring, 1986 and Ong, 1983b)

Table 2 Mean dry pod yield (kg/ha) as influenced by sowing dates x genotypes interaction at harvest

D/V	ICGS-11	ICGS-44	LGN-2	SB-XI	JL-24	TAG-24
			1996-97			
15th Sept.	3471	2686	2487	2634	2490	3300
30th Sept.	3539	2457	1484	1233	1605	3442
15th Oct.	1128	1409	784	760	582	2126
30th Oct.	423	580	610	587	220	1264
SEm±	77					
CD (P=0.05)	214					
			1997-98			
15th Sept.	1097	1360	1201	928	814	1067
30th Sept.	658	772	511	390	488	789
15th Oct.	598	495	394	280	388	248
30th Oct.	618	590	698	394	720	407
SEm±	94					
CD (P=0.05)	260					
			Pooled			
15th Sept.	2284	1924	1844	1791	1651	2184
30th Sept.	2099	1615	991	812	1047	2116
15th Oct.	863	952	589	520	485	1188
30th Oct.	519	585	654	491	470	837
SEm±	61					
CD (P=0.05)	168					

D/v = Dates/genotypes

Effect of genotypes: The pod yield of groundnut was markedly influenced by genotypes tested during both the seasons of experimentation. Genotype TAG-24 and ICGS-11 produced significantly highest pod yields during both the years and in pooled analysis. JL-24 and SB-XI produced lowest yield during first and second year, respectively. Similarly results were obtained by Lodh (1994) and Bhoje (1996).

Interaction effects: The interaction effect between genotypes and sowing dates was noticed during 1996-97 and 1997-98 (Table 2). The highest dry pod yield of 3539 kg/ha was recorded in 15th Sept. sown crop by ICGS-11. Pooled results revealed that ICAS-11 and TAG-24 were adopted to the second fortnight of Sept. [37-39 Meteorological weeks] (MW). Beneficial effects of early sowing of groundnut in *rabi* season (Sept.-Oct.) were also reported by other workers (Shelke *et al.*, 1987; Lodh, 1994; Bhoje, 1996).

In view of the above, it could be inferred that the optimal planting window (sowing time) of groundnut during post-monsoon season (Sept. to Feb.) is around 15th Sept. (37-38 MW). Erect spanish bunch genotype, TAG-24, and semi spreading genotype ICGS-11 are suitable for post-monsoon cultivation as both showed wider adaptability for second fortnight of September (37-38 MW).

References

Bell, M. 1986. Effect of sowing dates on growth and development of irrigated peanuts (*Arachis hypogaea* L.) cv. Early Bunch, in a monsoonal tropical environment. *Australian Journal of Agricultural Research*, **37** : 361-373.

Bhoje, V.S. 1996. Effect of sowing dates on growth and yield of groundnut (*Arachis hypogaea* L.) cultivars in post-monsoon season. M.Sc. Thesis, Marathwada Agricultural University, Parbhani, Maharashtra.

Emery, D.A., Sherman, M.E. and Vickers, J.W. 1981. The reproductive efficiency of cultivated peanuts IV. The influence of photo period on the flowering, pegging and fruiting of Spanish type genotype. *Agronomy Journal*, **73** : 619-623.

Ghadekar, S.R. 1989. Studies on growth and yield of groundnut as a post-rainy crop in Nagpur region. *Madras Agricultural Journal*, **76**(1) : 43-49.

Ketring, D.L. 1986. Phenological response of groundnut to temperature and water deficits. Breeding implications. Agrometeorology of groundnut. Proceedings of International Symposium, 21-26 August, 1985, ICRISAT Sahelian Centre, Niamey, Niger, Patancheru, AP, pp.26-29.

Lodh, S.S. 1994. Effect of sowing dates on growth and yield of groundnut (*Arachis hypogaea* L.) cultivars in *rabi* season. Ph.D. Thesis, Marathwada Agricultural University, Parbhani, Maharashtra.

Ong, C.K. 1983. Responses of temperature in a stand of pearl millet (*Pannisetum typhoides* S&H) II. Reproductive development. *Journal of Experimental Botany*, **34** : 337-348.

Padole, L.M., Ghadekar, S.R., Pathey, M.K. and Kene, D.R. 1994. Effect of meteorological parameters on NPK uptake and yield of groundnut. *Journal of Soils and Crops*, **3**(2) : 132-134.

Shelke, V.B., Tekale, G.R., Dahiphale, V.V. and Shinde, V.S. 1987. Effect of sowing dates on growth and yield of groundnut cultivars in *rabi* season. *Journal of Oilseeds Research*, **4** : 271-274.

J. Oilseeds Res., **21**(1): 42-46 (2004)

Groundnut, *Arachis hypogaea* L. growth and yield as influenced by evapotranspiration deficits

S. Hemalatha, V. Praveen Rao and B.N. Reddy

Dept. of Agronomy, College of Agriculture, A.N.G. Ranga Agril. University, Rajendranagar, Hyderabad-500 030, AP

(Received: July, 2003; Revised: November, 2003; Accepted: December, 2003)

Abstract

A field study was conducted during 1997-98 and 1998-99 on a sandy loam soil to study the response of groundnut to evapotranspiration deficits imposed at specific crop growth sub periods .The crop in fully irrigated control recorded maximum seed yield (2830 Kg/ha). The evapotranspiration deficits in all the crop growth sub periods significantly reduced the seed yield relative to the yield in fully irrigated control. The pod yield reduction in moisture stress at flowering and pegging, moisture stress at pod initiation and addition period, moisture stress at pod filling period was 20.6, 19.3 and 16.4 %, respectively as compared to control. Moisture stress at pod initiation and addition period was more sensitive to ET deficits than the other crop growth stages. However, the susceptibility of crop to ET deficits at flowering-pegging period, pod initiation addition period and pod filling period has found to be greatly reduced if the crop is conditioned by prior ET deficits.

Key words: Sunflower, groundnut, evapotranspiration deficit and pod/seed yield

Introduction

Irrigation planning is commonly predicted on complete avoidance of water deficits during crop growing season. In years of deficient water supply the irrigated acreage is therefore, reduced so that the evapotranspiration requirements of a crop can be met in full. An increase in the frequency of droughts, declining ground water table levels, increased cost of irrigation water resource development and indiscriminate use of fertilizers necessitate the need to shift out objective from producing maximum yield /unit area to maximum yield /unit amount of water (or) nutrients. The extent to which the crop yield can be maximized /unit amount of water (or) nutrient depends on how well field irrigation schedules are planned in time and quantity, considering periods of water scarcity to meet crop evapotranspiration requirements. Sunflower during *kharif* followed by groundnut is the most remunerative sequence (Reddy and Babu,1996) in the southern Telangana zone of Andhra Pradesh. Groundnut crop raised during winter season is often subjected to ET deficits during crop growing season leading to heavy yield expression. The present study was therefore, designated to find out the critical crop growth sub periods of groundnut as to their order of relative sensitivity to evapotranspiration deficits and to suggest optimal irrigation programmed to minimize yield losses under scarce water supply situation.

Materials and methods

The field experiment was conducted on a sandy loam soil during *kharif* and *rabi* seasons of 1997-98 and 1998-99 at the college farm of Acharya N G Ranga Agricultural University, Hyderabad (17 °.19' N, 78 °23' E and 542.3 m above mean sea level). The experimental soil had N,P and K_2O at 255,11.2 and 472 Kg/ha respectively, with PH 7.5, bulk density 1.66g/cm^3 and EC 0.12 dS/m. The available soil moisture determined as difference between moisture held at -0.03 Mpa and -1.5 Mpa was 84.4mm in 60 cm soil profile. The weekly mean maximum and minimum temperatures during *rabi*-groundnut cropping period was 29.87°C and 16.08° C. The seasonal growing degree-days amounted to 1642 and 1657 during 97-98 and 98-99 respectively The mean pan evaporation during the cropping period was 3.46 mm / day. The mean relative humidity was 65.79 %. The total precipitation was 154.7 and 29.0 mm during first and second years respectively. Since the rainfall occurred during the establishment -vegetative stage, the effective rainfall was deducted from the net irrigation requirement, while scheduling irrigations in different treatments.

The treatments included were four phosphorus levels i.e. 0, 30, 60 and 90 kg P_2O_5/ha to sunflower during *kharif*, combination of residual P (0,30,60 and 90 kg P_2O_5/ha applied to sunflower) and irrigation (I_1, I_2, I_3 and I_4) levels as main plots and four direct P levels (0,30,60 and 90 kg

P_2O_5/ha) as sub plots to groundnut during *rabi* season. The source of phosphorus applied was single super phosphate. The irrigation treatments comprised of fully irrigated control (I_1) moisture stress at flowering and pegging (I_2), moisture stress at pod initiation and addition (I_3) and moisture stress at pod filling period (I_4). Thus constituted sixty-four treatments in groundnut were tested in Split Plot Design with three replications during the *rabi* season.

Perusal of irrigation treatments revealed that in I_1 treatment the groundnut crop was fully irrigated based on soil - crop - climatic data, so that Eta is proceeded at maximum rate or it was not irrigated (Eta deficit) at all, as is the case in I_2 (Eta deficit at flowering and pegging period), I_3 (Eta deficit at pod initiation and pod addition period) I_4 (Eta deficit at pod filling period) treatments. In later treatments *viz.*, I_2, I_3 and I_4 if irrigated, the irrigation schedule that followed for the crop in fully irrigated control treatment (I_1) was duplicated and Etm for the following irrigation interval was assumed. If unirrigated, the Eta rate may have fallen below the Etm rate and the absolute difference for the period was expressed as an Eta deficit (Etd). Irrigation requirement of groundnut in I_1 treatment was based on soil-climatic parameters. The details of field water supply are given in Table 2. A 50 mm water meter was installed to deliver the required quantity of water in each plot. The gross and net plot size was 3.6 x 3.6 m and 3.0 x 3.2 m, respectively.

ICGS-11 groundnut test variety was sown on 20.10.1997 and 2.11.1998 in the first and second years, respectively by adopting a spacing of 30 x 10 cm to achieve a desired plant population of 3.33 lakh plants/ha. Other recommended agronomic practices *viz.*, a fertilizer dose of 40 N + 40 K_2O/ha and need based plant protection measures were followed. The ground water table was below six meters during the crop growth season. Hence, it was assumed that there was not any contribution from ground water table towards crop water needs.

For determination of crop Eta, the soil moisture was monitored by gravimetric method at four locations and at various depths in each treatment from surface to 60 cm soil depth before and after each irrigation and no intermediate dates as necessary (Table 1). The reference crop evapotranspiration (Eta) was estimated at specific crop growth subperiods based on Hargreaves method (Hargreaves and Samani, 1982). The crop was harvested on 11.02.1998 and 3.3.1999 in the first and second year, respectively. The water use efficiency (kg/ha - mm) was calculated as a ratio between seed yield and seasonal evapotranslation. To quantify the effect of Eta deficits on yield, the relationship between relative yield reduction and relative evapotranspiration deficit was worked out by regression analysis as suggested by Stewart *et al.* (1977):

$$(Ym-Ya)/Ym=Bo\ (Eta-Eta/Etm)$$

Where:

Ym=maximum yield in fully irrigated crop i.e., I

Ya=Actual seed yield of the crop as affected by Eta deficits

Etm=Seasonal evapotranspiration of fully irrigated crop

Bo=Yield reduction coefficient

Results and discussion

Yield as influenced by Eta deficits: Scheduling of irrigations at Eta=Etm through out the crop growing season (I_1) recorded the maximum pod yield (2830 kg/ha) which was significantly superior over other treatments (Table 3). Moisture stress at any one stage of the crop growth sub-periods reduced the pod yield I_2 (20 %), I_3 (19 %) and I_4 (16%) relative to fully irrigated control. The differences in pod yield between I_2 and I_3 were statistically not significant during both the years. Lowest pod yield was registered by I_2 treatment in both the years and on pooled basis. This could be attributed to a favourable soil water balance in I_1 treatment as was evident from mean Kc values (Eta/Eto ratio, nearer to 1.0 at flowering and pod initiation and addition period in both the years of study) an indicator of soil water deficit.

Adequate soil moisture balance in I_1, promoted the plants to produce significantly more plant height, which in turn put-forth more leaf area contributing to more drymatter (Table 3).

Boote and Hammond (1981) reported that stem morphology was altered by water deficits. Main axis and cotyledonary branches are shorter for water stressed groundnut plants because soil water deficit has been shown to cause drastic reduction in internodal length and rate of node development. Leaf area showed positive and significant (P=0.01) dependence on plant height (r=0.890). LAI accounted for 73.5% of variability in crop Eta on pooled basis.

Dry matter accumulation in groundnut is a result of leaf and stem growth during vegetative phase and a combination of pod and kernel growth concurrent with shifts in leaf and stem mass during reproductive phase. Therefore, reduced dry matter production in I_2 ,I_3 and I_4 treatments could be traced to similar reduction in plant height and leaf area index under these treatments. Dependence of dry matter on plant height (r=0.874),LAI (r=0.815) was apparent from significant correlation it had with these growth traits (Table 4).

Table 1 Determination of irrigation requirement of groundnut (1997-98 and 1998-99) in I_1 treatment based on soil-crop-climate parameters

Crop growth subperiod	Duration (days)	Eto mm/day	Kc	Etm mm/day	Root zone depth (cm)	Sa.D (cm)	P fraction	I=Sa.D.P/Etm	IRR
Vegetative	31	3.02	0.75	2.27	45	63.3	0.70	20	43.92
Flowering and pegging	26	2.78	1.03	2.84	60	84.4	0.59	18	43.98
Pod initiation and addition	29	3.46	1.03	3.58	60	84.4	0.59	14	49.76
Pod filling and maturity	33	4.61	0.80	3.68	60	84.4	0.625	15	53.28

Sa.D = Available soil moisture in the root zone
Etm = Maximum evapotranspiration
I = Irrigation interval
Eto = Reference crop evapotranspiration
P = Readily available soil moisture
Kc = Crop coefficient; IRR = Irrigation water depth

Table 2 Field water supply at various crop growth sub-periods

Treat-ment	Irrigation water supply-crop growth subperiods								Seasonal IRR (mm)		AWP mm		Effective rainfall (mm)		Field water supply (mm)	
	Vegetative		Flowering and pegging		Pod initiation and pod addition		Pod filling									
	98	99	98	99	98	99	98	99	98	99	98	99	98	99	98	99
I_1	0	36.5	49.8	100.3	105.7	102.4	52.8	107.5	208.3	346.8	84.4	84.4	67.4	9	360	440
I_2	0	58.2	0	0	129.2	173.8	52.8	107.5	182.0	339.6	84.4	84.4	81.6	9	348	423
I_3	0	36.5	49.8	100.3	0	0	137.2	191.9	186.9	328.7	84.4	84.4	67.4	9	338	422
I_4	0	36.5	49.8	100.3	105.7	102.4	0	0	155.4	239.3	84.4	84.4	67.4	9	307	333

Table 3 Yield, water use efficiency and seasonal Eta of groundnut as influenced by evapotranspiration deficits

Treatment	Pod yield (kg/ha)			Water use efficiency (kg/ha-mm)		Eta (mm seasonal)	
	1998	1999	Pooled	1998	1999	1998	1999
I_1	2757	2903	2830	8.18	7.83	338.4	370.8
I_2	2186	2309	2247	7.33	7.16	298.5	323.4
I_3	2223	2344	2283	7.54	7.28	295.1	322.9
I_4	2304	2427	2365	7.74	7.43	298.2	327.7
SEm±	18	27	21	0.12	0.14	-	-
CD (P=0.05)	55	80	62	0.35	0.42	-	-

Table 4 Growth and yield attributes of groundnut as influenced by evapotranspiration deficits at the time of harvest

Treatment	Plant height (cm)		Leaf area index		Drymatter (g/plant)		Average pods/plant		Average No. of matured pods/plant		100-kernel weight (g)		Shelling (%)		Harvest index	
	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999	1998	1999
I_1	23	23	5.0	4.8	27.5	27.3	12.5	12.8	11.1	11.0	41.8	43.1	62.1	62.4	41.7	43.8
I_2	21	20	4.6	4.3	26.7	25.4	11.2	11.3	9.1	9.3	39.2	40.4	59.8	59.9	33.7	35.7
I_3	21	18	4.5	4.1	26.1	25.6	10.8	10.0	8.4	8.6	38.0	39.2	58.6	58.8	34.6	36.6
I_4	21	21	4.9	4.4	25.4	25.5	11.3	11.5	9.3	10.3	36.9	38.2	57.3	56.9	35.1	37.4
SEm±	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.5	0.3
CD (P=0.05)	0.5	0.3	0.2	0.4	0.4	0.3	0.2	0.3	0.3	0.2	0.4	0.3	0.2	0.2	1.5	0.9

Thus accumulated photosynthates might have been responsible for significantly more number of pods per plant under I_1 treatment in comparison to other treatments. The number of pods per plant (r=0.875) and matured pods per plant (r=0.903) were found to be significantly and positively correlated to leaf area index. Further these trends may be assigned to the fact that irrigation water application at high frequency (Eta/Etm=1) during flowering, pegging and pod addition period seem to have provided favorable soil water balance in the top 4-5 cm soil layer for peg penetration and pod initiation. The higher 100-kernel weight was associated with I_1 treatment where in the crop was fully irrigated during pod filling period. Like wise I_2 (moisture stress at flowering and pegging period) and I_3 (moisture stress at pod initiation and addition period) treatments also registered superior 100 kernel weight over I_4.These results emphasized the importance of adequate water supply starting from flowering period in general and at pod filling period in particular for obtaining more number of pods with higher mean weight in turn contributing to higher kernel weight. However, improved kernel weight in treatments where water deficits were imposed during flowering and pegging period (I_2) and pod initiation and addition period (I_3) in comparison to (I_4) pod filling period treatment could be possibly through the mechanism of limited sink capacity i.e pods/plant (Reddy *et al.*, 1996).

The dependence of pod yield on number of pods per plant (r=0.845) mature pods per plant (r=0.901) and 100-kernel weight (r=0.811) was evident from significant (P=0.05) and positive association between them. The unfavourable soil moisture condition brought about significant reduction in yield contributing characters like number of pods per plant, matured pods/plant 100 kernel weight, shelling percentage and harvest index through reduction in photosynthetically active leaf area drymatter accumulation.

The greater sensitivity of flowering and pegging through pod addition period to Eta deficits could be partly related to the fact that the crop reaches its peak Eta rate (3.34 mm/day on mean basis) and LAI during this period. Therefore Eta deficit during this period reduced the final pod yield in one of the several possible ways. First, low soil moisture or water deficits during flowering and pegging period in I_2 treatment might have reduced turgour potential and leaf area expansion as evident from low LAI affecting the flowering. This effect could be an important impediment to pegging, pod initiation and addition as apparent from significantly lower number of pods per plant in I_3 treatment. Secondly, soil water status in the top centimeter or two of the soil is critical for peg entrance into the soil. Once pegs are in the soil, adequate soil moisture is needed for development of pegs into pods and that adequate water in the root zone could not compensate for lack of water in pegging zone for the first 30 days of peg development. After 30 days of sufficient pegging zone moisture, pods could continue normal growth in dry soil if roots had adequate moisture Suneetha Devi (1998) reported that seed growth could continue after full pod expansion with root supplied water even if surface moisture was inadequate.

Water use efficiency: Provision of favorable soil water balance duly accounting for evaporative demand of the atmosphere (Eta/Etm=1) was shown to enable in effective use water contributing to higher pod yield as well as water use efficiency as is evident from the fully irrigated control I_1 treatment. On the other hand Eta deficits at crop growth sub periods of flowering and pegging, pod initiation and addition and pod filling period caused significant reduction in water use efficiency as is evident from I_2, I_3 band I_4 treatments, owing to appreciable reduction in pod yield relative to Eta reduction in respective treatments.

Thus based upon the yield sensitivity coefficients (Ky) (Table 5) it can be deduced that the relative sensitivity of groundnut pod yield to moisture stress is highest in flowering and pegging period, moderate in pod initiation and addition period and least during pod filling period. The above information will enable the groundnut farmers in allocating of available limited water supplies to crop growth sub periods where in the response is highest leading to maximization of productivity per unit amount of water.

Table 5 Empirical estimates for the relationship between relative yield deficit (1-Ya/Ym) and relative evapotranspiration deficit (1-Eta/Etm) for groundnut under different treatments on pooled basis

Stage of the crop	Intercept(a)	Yield sensitivity coefficient (Ky)	Coefficient of determination R^2
Flowering and pegging period (I_2)	0.00001	1.673546**	0.986
Pod initiation and addition period (I_3)	0.00001	1.5003059**	0.989
Pod filling period (I_4)	0.00001	1.397579**	0.996

References

Boote, K.J. and Hammond, L.C. 1981. Effect of drought on vegetative and reproductive development of peanut. *Proceedings of American Peanut Research Educational Society*, B:86 (Abstract).

Hargreaves, G.H. and Samani, Z.A. 1982. Estimating potential evapotranspiration. *Journal of Irrigation and Drainage Division. American Society of Civil Engineers*, **108**(3) : 225-230.

Reddy, B.N. and Basu, S.N. 1996. Production potential, land utilization and economics of fertilizer management in summer sunflower based crop sequences. *Indian Journal of Agricultural Sciences*, **66**(1) : 16-19.

Reddy, P.R.R., Reddy, B.B., Praveen Rao, V. and Sarma, P.S. 1996. Effect of water deficits at different crop growth periods on growth and yield of groundnut. *Journal of Research Acharya N.G. Ranga Agricultural University*, **24**(2) : 147-149.

Stewart, J.I., Hagan, R.M., Pruitt, W.O., Hanks, R.J., Riley, J.P., Danielson, R.E., Franklin, W.I. and Jackson, E.B. 1977. Optimising crop production through control of water and salinity level in soil. Utah Water Research Laboratory, College of Engineering, Utah State University, Logan, p.191.

Suneetha Devi, K.B. 1998. Water production functions for maize (*Zea mays* L.) and groundnut (*Arachis hypogaea* L.) under limited water supply. Ph.D. Thesis submitted to Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad-500 030, A.P.

J. Oilseeds Res., **21**(1): 47-49 (2004)

Effect of residual fertility of different nitrogen management practices to *kharif* rice on the performance of *rabi* groundnut, *Arachis hypogaea* L.*

M. Srinivasa Reddy, D. Srinivasulu Reddy and P.V.R.M. Reddy

Department of Agronomy, S.V. Agricultural College, Tirupati-517 502, AP

(Received: May, 2003; Revised: August, 2003; Accepted: October, 2003)

Abstract

Field experiment was conducted during *rabi* seasons of 2000 and 2001, to evaluate the response of groundnut (*Arachis hypogaea* L.) to the residual effect of different nitrogen management practices adopted to preceding *kharif* rice. Residual effect of *kharif* rice treatments exerted marked influence on the dry matter production, yield attributes, yield and nitrogen uptake of groundnut. Application of 100% N through FYM to preceding rice crop has resulted in the highest total dry matter, number of pods/plant, pod weight, kernel weight, pod and haulm yield as well as nitrogen uptake of groundnut. The increase in pod yield of groundnut with application of 100% N through FYM to preceding rice crop was 14.84 and 18.24 % over no nitrogen to rice and 10.71 and 13.73 % over 100% N through fertilizer to rice during 2000 and 2001, respectively.

Key words: Residual fertility, *rabi* groundnut, nitrogen management, *kharif* rice

Introduction

Until recently, crop production research has been focusing attention on individual crops, disregarding the fact that each crop is only a component of cropping system. Nutrient prescription for crops is usually made based on the responses of individual crops without considering the cropping system as a whole, with the result that the recommendations often become unremunerative. Further, the nutrient needs of a crop in a cropping system are greatly influenced by the nature of preceding crop and the quantity of nutrients it received. For maintaining balanced nutrition in a cropping system, residual effect on the succeeding crop deserves a careful docideratum and quantitative evaluation to sustain the level of productivity on one hand and the soil health on the other.

Materials and methods

Field experiment was conducted during (2000 and 2001) on sandy loam soils of wetland block of S.V. Agricultural College Farm, Tirupati, with rice during *kharif* and groundnut during *rabi* and laid out in randomized block design replicated thrice. The same layout was followed during both the years of study. The soil was sandy clay loam in texture, slightly alkaline in reaction, low in organic carbon (0.27%) and available nitrogen (157.5 kg/ha) and medium in available phosphorous (22 kg/ha) and available potassium (190 kg/ha) at the start of the experiment. The treatments consisted of twelve N management practices to rice (T_1- No N, T_2-*Azospirillum* alone, T_3-GM N_{100}, T_4-GLM N_{100}, T_5-FYM N_{100}, T_6-F N_{100}, T_7-GM N_{50} + F N_{50}, T_8-GLM N_{50} + F N_{50}, T_9-FYM N_{50} + F N_{50}, T_{10}-GM N_{50} + F N_{50} + *Azo.*, T_{11}-GLM N_{50} + F N_{50} + *Azo.* and T_{12}-FYM N_{50} + F N_{50} + *Azo.*) and groundnut was raised in *rabi* to find out the residual effect of the treatments applied to *kharif* rice. The recommended dose of fertilizer was 80 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha. *Azospirillum* @2.5 kg/ha was thoroughly mixed with FYM and sand in the ratio of 1:10:20 and applied to the treatmental plots just before transplanting. The test variety of rice was Swarnamukhi (NLR-145) and that of groundnut was Vemana (K-134). The N content in different organic matters was determined (dhaincha, 0.61%; neem leaf, 0.54% and FYM, 0.58%) and the amount of these materials required to substitute the specified amount was incorporated into the soil 10 days prior to transplanting of rice. Rice was sown during 03-07-2000 and 05-07-2001 and groundnut was sown during 03-12-2000 and 14-12-2001 during the 1st and 2nd year of experimentation.

Results and discussion

Residual effect of different nitrogen management practices imposed on *kharif* rice has exerted marked influence on the dry matter production, yield attributes, yield and nitrogen uptake of groundnut.

* Part of the thesis submitted to Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad-500 030, A.P. for the award of Ph.D.

Supply of 100 per cent N through FYM (T_5) to preceding rice has recorded the highest dry matter production (Table 1), which was significantly superior to only the treatments of no N (T_1), *Azospirillum* alone (T_2) and F N_{100} (T_5) imposed to preceding rice. This might due to substantial amount of residual nutrients left by the treatments of preceding rice crop on succeeding groundnut crop (Table 3).

Table 1 Drymatter production and yield attributes of *rabi* groundnut as influenced by residual effect of different *kharif* rice treatments

Treatments to rice	Drymatter production (kg/ha)		No. of pods/plants		100 pod weight (g)		100 kernel weight (g)	
	2000	2001	2000	2001	2000	2001	2000	2001
T_1: No N	6453	5609	12.3	11.8	87.1	78.8	32.9	33.2
T_2: *Azospirillum* alone	6463	5642	12.4	11.8	87.6	79.6	33.0	33.2
T_3: GM N_{100}	6893	6008	13.4	13.0	88.5	83.2	34.2	34.6
T_4: GLM N_{100}	6913	6163	13.5	13.2	89.9	83.3	34.5	34.6
T_5: FYM N_{100}	7213	6441	13.8	13.6	91.9	85.7	35.6	35.1
T_6: F N_{100}	6540	5787	12.7	11.9	87.7	79.9	33.3	33.3
T_7: GM N_{50} + F N_{50}	6730	5836	12.8	12.2	88.6	82.3	33.9	33.8
T_8: GLM N_{50} + F N_{50}	6773	5997	12.9	12.3	89.3	82.9	34.0	34.0
T_9: FYM N_{50} + F N_{50}	7170	6330	13.7	13.4	91.4	84.8	35.2	34.9
T_{10}: GM N_{50} + F N_{50} + *Azo.*	6653	5795	12.8	12.0	88.0	82.2	33.8	33.8
T_{11}: GLM N_{50} + F N_{50} + *Azo.*	6750	5978	12.8	12.3	88.9	82.8	34.0	33.9
T_{12}: FYM N_{50} + F N_{50} + *Azo.*	7003	6315	13.6	13.3	90.1	84.2	34.9	34.8
SEm ±	149.0	148.0	0.20	0.38	1.34	1.64	0.65	0.51
CD (P = 0.05)	437	434	0.6	1.1	3.9	4.8	1.9	1.5

Table 2 Pod and haulm yield (kg/ha) as well as nitrogen uptake (kg/ha) of *rabi* groundnut as influenced by residual effect of different *kharif* rice treatments

Treatments to rice	Rice yield		Pod yield		Haulm yield		Nitrogen uptake	
	2000	2001	2000	2001	2000	2001	2000	2001
T_1: No N	3275	3525	2223	1962	4208	3575	81.6	77.4
T_2: *Azospirillum* alone	3572	3750	2243	2023	4234	3647	82.5	80.2
T_3: GM N_{100}	4773	4704	2433	2176	4460	3985	91.2	88.6
T_4: GLM N_{100}	4852	4801	2449	2228	4460	3985	91.5	90.6
T_5: FYM N_{100}	4606	4561	2553	2320	4627	4145	96.4	94.4
T_6: F N_{100}	5284	5181	2306	2040	4234	3715	84.1	80.7
T_7: GM N_{50} + F N_{50}	5140	5060	2356	2069	4376	3767	88.5	83.9
T_8: GLM N_{50} + F N_{50}	5168	5099	2397	2092	4410	3876	89.7	86.5
T_9: FYM N_{50} + F N_{50}	4994	4977	2544	2296	4662	4122	96.2	93.0
T_{10}: GM N_{50} + F N_{50} + *Azo.*	5191	5130	2331	2067	4338	3747	87.9	82.9
T_{11}: GLM N_{50} + F N_{50} + *Azo.*	5195	5143	2489	2080	4388	3852	89.6	85.0
T_{12}: FYM N_{50} + F N_{50} + *Azo.*	5006	4979	2475	2267	4527	4098	94.4	91.3
SEm ±	117.2	120.0	2.27	1.56	1.52	1.56	5.93	7.29
CD (P=0.05)	344	431	6.7	4.6	4.5	4.6	17.4	21.4

Table 3 Post-harvest soil nutrient status (kg/ha) and organic carbon (%) after rice as influenced by different nitrogen management practices

Treatment	*Kharif*, 2000				*Kharif*, 2001			
	Available N	Available P_2O_5	Available K_2O	Organic carbon	Available N	Available P_2O_5	Available K_2O	Organic carbon
T_1: No N	130.8	23.8	115.8	0.30	143.3	24.7	146.7	0.32
T_2: *Azospirillum* alone	136.5	24.0	119.2	0.30	149.7	24.7	150.7	0.32
T_3: GM N_{100}	187.5	25.8	138.3	0.39	190.6	26.3	176.3	0.42
T_4: GLM N_{100}	187.5	25.0	149.2	0.38	189.3	25.0	181.0	0.40
T_5: FYM N_{100}	198.3	29.7	174.2	0.40	194.5	30.6	204.7	0.43
T_6: F N_{100}	166.5	25.7	125.0	0.31	171.5	26.0	156.7	0.32
T_7: GM N_{50} + F N_{50}	170.8	26.3	134.2	0.36	181.5	27.3	172.0	0.38
T_8: GLM N_{50} + F N_{50}	173.3	27.3	139.2	0.36	182.7	27.8	180.7	0.38
T_9: FYM N_{50} + F N_{50}	177.7	29.3	154.2	0.39	187.5	30.3	189.7	0.40
T_{10}: GM N_{50} + F N_{50}+*Azo.*	177.5	26.5	138.3	0.37	186.7	27.7	179.5	0.39
T_{11}: GLM N_{50} + F N_{50}+ *Azo.*	170.0	27.0	137.5	0.36	180.5	27.7	175.3	0.38
T_{12}: FYM N_{50} + F N_{50}+ *Azo.*	175.8	28.3	151.5	0.37	183.7	29.0	186.5	0.39

The yield attributes of groundnut *viz.*, number of pods/ plant, hundred-pod weight and hundred-kernel weight (Table 1) as well as pod yield, haulm yield and nitrogen uptake (Table 2) were the highest with application of 100 per cent N through FYM to preceding rice crop (T_5), which was however, comparable with FYM N_{50} + F N_{50} (T_9), FYM N_{50} + F N_{50}+*Azo.* (T_{12}), GLM N_{100} (T_4) and GM N_{100} (T_3). This might be due to the residual effect with the treatments of the combination of FYM and the exclusive organic sources of N, which was comparatively higher than that of other combinations of organics and fertilizer N applied to preceding rice crop. Among the organic sources, differential residual response with different sources can be attributed to their pattern of mineralisation and proportion of their substitution. In the present study, the residual effect of organic sources at higher proportions was evident from higher dry matter accrual, number of pods/plant, 100-pod weight, pod and haulm yield as well as nitrogen uptake.

This clearly indicates that organic sources at higher proportions can only sustain the nutrient status of soil to produce reasonable residual effect. Organic manures, besides supplying nutrients to the current crop, quite often leave substantial residual effect on succeeding crops in the cropping system (Maskina and Meelu, 1984). Significant carry over effect due to substitution of nitrogen with higher proportions of organic sources to rice crop on the succeeding crops was also reported by Thimmegowda and Devakumar (1994) and Paulraj and Velayudham (1995). Residual effect of fertilizer nitrogen applied to rice was not traceable on the succeeding groundnut crop (Ramaseshaiah *et al.*, 1985).

References

Maskina, M.S. and Meelu, O.P. 1984. Farm yard manure (FYM) in a rice-wheat rotation. *International Rice Research News Letter*, **9**(5): 27.

Paulraj, N.J. and Velayudham, K. 1995. Direct and Residual effect of Missouri rock phosphate, organic manures and phosphobacteria in rice-blackgram system. *Madras Agricultural Journal*, **82**(3): 220-221.

Ramaseshaiah, K., Yogeswara Rao, Y. and Bheemaiah, G. 1985. Fertilizer requirement of groundnut grown in sequence with rice. *The Indian Journal of Agricultural Sciences*, **55**(1): 25-27.

Thimmegowda, S. and Devakumar M. 1994. Effect of residual fertility on yield of groundnut grown in rice fallows. *Indian Agriculturist*, **38**(4): 287-290.

J. Oilseeds Res., **21**(1): 50-54 (2004)

Moisture sensitive growth periods and optimal sequencing of evapotranspiration deficits in Indian mustard, *Brassica juncea* (L.) Czern & Coss

B. Vijay Kumar, V. Praveen Rao and B.N. Reddy[1]

Dept. of Agronomy, College of Agriculture, A.N.G. Ranga Agril. University, Rajendranagar, Hyderabad-500 030, AP

(Received: August, 2002; Revised: December, 2003; Accepted: January, 2004)

Abstract

The field experiment was conducted on a sandy loam soil during the winter season of 1995-96 and 1996-97 at Hyderabad to study the response of mustard, *Brassica juncea* (L.) Czern & Coss to deficit (ET) imposed at specific crop-growth subperiods *viz.*, vegetative, flowering-pod initiation and pod filling period besides, a fully irrigated control treatment. The crop in fully irrigated control treatment produced maximum mean pod yield of 1571 kg/ha. Water deficits at specific crop-growth subperiods except vegetative period caused drastic reduction in pod yield relative to fully irrigated control treatment. The yield sensitivity coefficient (Ky) indicated that the pod filling period in mustard was sensitive to Eta deficits than in vegetative and flowering-pod initiation periods, respectively. Likewise, the flowering-pod initiation period was more sensitive to Eta deficits than is vegetative period. Hence, it was concluded to sequence Eta deficits at vegetative period and direct the available water supplies to flowering-pod initiation period followed by pod filling period under deficient water supply situation to minimise yield losses.

Key words: Mustard, evapotranspiration deficit, yield sensitivity coefficient

Introduction

Pressure for improved efficiency in the use of irrigation water is mounting. This impetus is derived from dwindling ground water resumes and an increase in restrictions being placed on the abstraction from surface water resources will mean greater competition between those who seek water for irrigation, those who require its use for non-agricultural purposes, and those who simply with that the water resource be untouched and conserved. Irrigation planning in future is therefore, more likely to be based on a purposeful imposition of water (Eta) deficits controlled in intensity and time, and to meet the specified objectives.

Mustard an important oilseed crop in India, during winter season is often subjected to Eta deficits during crop growing season leading to heavy yield depression. The present study was, therefore, designed to quantify the relative sensitivity of crop to water deficit at specific crop-growth subperiods for optimal allocation of limited water supplies to minimise yield losses.

Materials and methods

The field experiment was conducted on a sandy loam soil during the winter season of 1995-96 and 1996-97 at the College Farm of Acharya N.G. Ranga Agricultural University, Hyderabad (17° 19' N, 78° 23' E and 542.3 m above mean sea level).

The weekly mean maximum temperature for the crop period ranged from 28.3°C to 34.6°C with an average of 30.0°C in the first year (1995-96) and from 26.8°C to 31.9°C with an average of 29.2°C in the second year (1996-97). The weekly mean relative humidity ranged from 29 to 93.0% with an average of 68.6% in 1995-96 and 21 to 88% with an average of 63.3% in 1996-97. Evaporation from (USWB Class A Pan evaporimeter) during the crop period in 1995-1996 ranged from 2.8 to 3.8 mm/day and from 2.1 to 4.9 mm/day in 1996-97 with *a wind velocity of 1.5 to 3.6 km/hr and1.6 to 4.2 km/hr in* 1995-96 and 1996-97, respectively. A total rainfall of 144 mm spread over two rainy days in 1995-96 was received during the vegetative period i.e., 20 days after sowing. Since the rainfall occurred during the establishment - vegetative stage, the effective rainfall (Dastane, 1974) was deducted from the net irrigation requirement, while scheduling irrigation's in different treatments.

The treatments consisted of seven variable water supply levels designed to allow moderate to severe Eta (water) deficits to develop in one or more of three specific crop-growth sub-periods *viz.*, vegetative (0-27 DAS),

[1] Principal Scientist, Directorate of Oilseeds Research, Rajendranagar, Hyderabad-500 030, A.P.

flowering and pod initiation and addition period (27-63 DAS) and pod filling (63-85 DAS) sub-periods including a fully irrigated control treatment (W-W-W). In any given growth sub-period, the crop in a given treatment was either irrigated (W) based on soil-crop-climatic data (Table 1) to ensure Eta proceeded at the potential rate (Etm) or it was not irrigated (D) at all. For instance the crop in D-W-W was not irrigated during vegetative growth sub-period i.e., from 0-7 DAS and was irrigated during the latter two crop-growth subperiods by supplying the water equivalent that lost in Eta. Likewise in treatments W-D-W, W-W-D, D-D-W, W-D-D, D-W-D, if the crop was irrigated (W) in a given crop-growth sub-period, the schedule followed in W-W-W was duplicated. Following an Etd in water deficit treatment at the end of the crop growth sub-period the root zone depth of the crop was replenished to field capacity moisture content. A 50-mm water meter was installed to deliver the required quantity of water in each plot.

Table 1 Determination of irrigation requirement for mustard (mean of 1995-96 and 1996-97) in treatment based on soil-crop climatic parameters

Crop growth sub period	Duration (days)	Etm (mm/day)	Rooting depth (D) (m)	Sa.D (cm)	P fraction	$I = \frac{(Sa.D.P)}{Etm}$	IRR (mm)
Vegetative	24	4.22	0.45	6.34	0.50	8	31.7
Flowering-pod initiation and addition	40	4.20	0.60	0.85	0.50	10	43.0
Pod filling	30	4.00	0.60	8.50	0.50	11	42.5

Etm = Maximum evapotranspiration
Sa.D = Available soil water in crop root zone depth
P = Critical soil moisture level
I = Irrigation interval
IRR = Irrigation requirement

The seven treatments were laid out in Randomized Block Design with four replications. Mustard variety, TM-4 was sown on 2nd November during 1995-96 and 29th October in second year (1996-97), respectively by adopting a spacing of 30 cm between rows and 10 cm between plants in a row with plot size of 7.2 m x 3.5 m. The fertilizer dose applied was 60 Kg N, 60 Kg P_2O_5 and 40 kg K_2O/ha with phosphorus and potash as basal (broadcast) and N in two split doses *viz.*, basal (broadcast) and 30 DAS (pocket application). The crop was subjected to Eta deficits by withholding water at different crop-growth sub-periods. The ground water table was below six meters during the crop-growing season hence; it was assumed that there was not any contribution from ground water table towards crop water needs.

The experimental soil had N, P_2O_5 and K_2O @ 270, 18.2 and 508 kg/ha, respectively with pH 7.5, bulk density 1.66 g/cm^2 and EC 10.3 dS/m. The available soil moisture determined as difference between moisture held at -0.03 MPA (Field capacity) 17.23% and -1.5 MPA (permanent wilting point 8.72%) was 84.4 mm in 60 cm soil profile.

For determination of crop Eta the soil moisture was monitored by gravimetric method at four locations and at various depths in each treatment from surface to 60 cm soil depth before and after each irrigation and on intermediate dates as necessary. The reference crop evapotranspiration deficit was estimated at specific crop growth sub-periods as per Hargreaves and Samani (1982). The crop was harvested on 2nd February and 31st January in (1995-96 and 1996-97) respectively.

To quantify the effect of Eta deficits on yield the relationship between relative yield reduction and relative evapotranspiration deficit was worked out by regression analysis as suggested by Stewart *et al.* (1977). The relationship is as follows:

$$[(Ym - Ya)/Ym] = Ky\ [(Etm - Eta)/Etm] \quad \ldots\ldots\ (1)$$

Where,

Ym = Maximum seed yield in fully irrigated crop i.e., W-W-W treatment

Ya = Actual seed yield of the crop as affected by Eta deficits

Etm = Seasonal evapotranspiration of fully irrigated crop

Eta = Seasonal evapotranspiration in water deficit treatments

Ky = Yield sensitivity factor

Results and discussion

Seed yield versus Eta deficit: The crop in fully irrigated control treatment (W-W-W) produced significantly higher pod yield in both the years (1488 kg/ha in 1995-96 and 1655 kg/ha in 1996-97) and on pooled basis (1571 kg/ha) (Table 2). Eta deficits at any crop growth sub-period except vegetative period (D-W-W) caused significant reduction (25.9 to 85.0 % on pooled basis) in pod yield relative to W-W-W treatment in both the years and on pooled basis. The better performance of the crop in W-W-W could be traced to favourable soil water balance in these treatments as evident from the Eta values and Eta/Eto ratios.

Growth stage sensitivity to Eta deficits: To examine the sensitivity of seed yield of mustard to Eta deficits the Stewarts S_2 function was adopted and the resultant yield response sensitivity coefficients (Ky) for specific crop growth subperiods were calculated by regression analysis and presented in Table 3.

The test statistic R^2 indicated that the explained total variation in relative seed yield deficit varied between 0.921 to 0.999, 0.808 to 0.999 and 0.967 to 0.999 in 1995-96, 1996-97 and on pooled basis, respectively. The R^2 values were highly significant in all the functions under different treatments in both the years and on pooled basis. Likewise, the Ky values in all the treatments were significant at P=0.01 in both the years and on pooled basis. This implies that the function is statistically acceptable with regard to fitting of the observed data considering the time of Eta deficit at specific crop-growth subperiods.

The Ky values which reflect the relative sensitivity of seed yield to Eta deficit varied with the crop-growth subperiod and with the magnitude of Eta deficit imposed at various growth periods and were positive and significantly different from zero.

Comparison of Ky values in D-W-W (Eta deficits at vegetative period alone), W-D-W (Eta deficits at flowering-pod initiation period) and W-W-D (Eta deficits at pod filling period alone) treatments indicated that the relative yield decrease for a given level of Eta deficit was least in vegetative period, intermediate in flowering-pod initiation period and highest in pod filling period. In the instance at hand the data on Ky values in Table 4 for D-W-W, W-D-W and W-W-D treatments revealed that the pod filling period of mustard is inherently 2.17 (or 217%) and 0.159 (15.9%) times in 1995-96, 2.57 (or 257%) and 0.006 (0.67%) times in 1996-97 and 2.75(275%) and 0.096 (9.6%) on pooled basis, is more sensitive to Eta deficits than in vegetative period and flowering and pod initiation period, respectively. Likewise, the flowering -pod initiation period of mustard is 1.73 (or 173%), 2.55 (or 255%) and 2.41 (or 241%) times more sensitive to Eta deficits than is vegetative period in 1995-96, 1996-97 and on pooled basis, respectively.

On the other hand when the magnitude as well as duration of ETa deficits was extended to two crop-growth subperiods as in case of D-D-W (Eta deficits both at vegetative period plus flowering-pod initiation period), and W-D-D (Eta deficits both at flowering-pod initiation period plus pod filling period) treatments, the Ky values obtained were low in comparison to W-D-W and W-W-D treatments where in Eta deficits were imposed only at a single crop-growth subperiod. However, it was interesting to note that the Ky values in D-W-D treatment where in the crop was subjected to ETA deficits both at vegetative period plus pod filling period had Ky values almost similar to that registered in W-W-D treatment. The Ky values under D-D-W, W-D-D and D-W-D treatments varied between 1.4060 to 2.0477 in 1995-96, 1.4399 to 2.0929 in 1996-97 and 1.4915 to 2.0663 on pooled basis. However, the sensitivity of seed yield to Eta deficits was more by sequencing them at vegetative period plus pod filling period (D-W-D) instead of a continuous stress either from sowing to the end of pod addition period (D-D-W) or from flowering to the end of pod filling period (W-D-D).

Table 2 Seed yield and crop evapotranspiration of mustard as influenced by Eta deficit at different crop growth subperiods

Treatment			Seed yield (kg/ha)			Seasonal crop evapotranspiration (mm)	
GS1	GS2	GS3	1995-96	1996-97	Pooled	1995-96	1996-97
W	W	W	1488	1655	1571	345.0	333.3
D	W	W	1395	1572	1484	309.5	299.6
W	D	W	677	642	660	239.4	233.1
W	W	D	1178	1150	1164	311.0	283.7
D	D	W	522	445	484	220.4	163.7
W	D	D	294	175	2345	148.1	143.3
D	W	D	967	1104	1036	286.1	280.2
SEm±			47.1	44.9	43.0	-	-
CD (P=0.05)			140.4	133.0	128.2	-	-

GS = Growth stage

Table 3 Crop coefficients for mustard as influenced by evapotranspiration deficits at different crop growth subperiods

Treatment	Crop growth sub-period											
	Establishment (0-9 DAS)		Vegetative (9-25 DAS)		Flowering-pod initiation (25-65 DAS)		Pod filling (65-87 DAS)		Maturity (87-96 DAS)		Total growing season (0-96 DAS)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
W-W-W	0.632	0.555	0.880	0.804	0.960	0.944	1.037	1.000	0.808	0.520	0.937	0.884
D-W-W	0.596	0.425	0.672	0.620	0.868	0.873	0.959	0.927	0.808	0.480	0.840	0.795
W-D-W	0.608	0.546	0.849	0.779	0.462	0.461	0.904	0.895	0.782	0.536	0.650	0.619
W-W-D	0.620	0.534	0.813	0.779	0.946	0.861	0.812	0.698	0.404	0.300	0.844	0.753
D-D-W	0.538	0.518	0.701	0.627	0.468	0.212	0.882	0.763	0.364	0.428	0.598	0.434
W-D-D	0.624	0.530	0.849	0.808	0.416	0.407	0.104	0.107	0.126	0.108	0.402	0.380
D-W-D	0.571	0.405	0.708	0.646	0.858	0.885	0.788	0.740	0.409	0.244	0.777	0.744

Table 4 Empirical estimates for the relationship between relative yield deficit (1-Ya/Ym) and relative evapotranspiration deficit (1-Eta/Etm) for mustard under different treatments

Treatment	Regression constants, coefficients and test statistics			
	Intercept (a)	Yield sensitivity coefficient (Ky)	*T-value for testing (Ky)*	Coefficient of R^2 determination
		1995-96		
D-W-W	-0.00373	0.6503**	5.920	0.921**
W-D-W	-0.00022	1.7811**	113.374	0.999**
W-W-D	0.00372	1.7963**	160.384	0.999**
D-D-W	0.00027	1.7963**	160.384	0.999**
W-D-D	-0.00006	1.4060**	313.675	0.999**
D-W-D	0.00035	2.0477**	130.057	0.999**
		1996-97		
D-W-W	-0.00614	0.5714**	3.559	0.808**
W-D-W	0.00104	2.0316**	60.767	0.999**
W-W-D	0.00060	2.0453**	49.923	0.998**
D-D-W	0.00003	1.4399**	159.378	0.999**
W-D-D	0.00003	1.5686**	631.131	0.999**
D-W-D	-0.00040	2.0929**	82.895	0.999**
		Pooled		
D-W-W	-0.00092	0.5592**	9.428	0.967**
W-D-W	0.00025	1.9117**	114.524	0.999**
W-W-D	0.00068	2.0971**	27.218	0.995**
D-D-W	0.00005	1.5963**	364.169	0.999**
W-D-D	-0.00002	1.4915**	578.006	0.999**
D-W-D	-0.00005	2.0663**	104.915	0.999**

** Significant at P=0.01

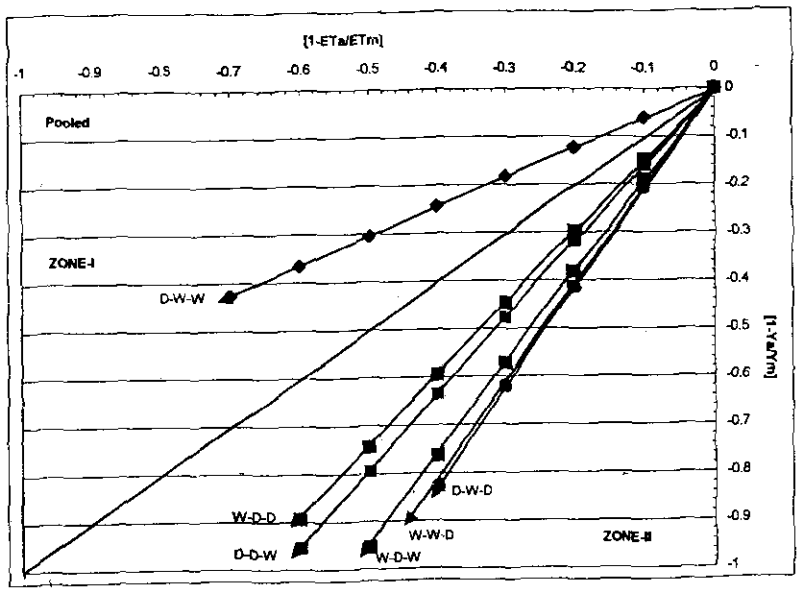


Fig.1. Relationship between relative yield deficit (1-Ya/Ym) and relative evapotranspiration deficit (1-Eta/ETm) under different treatments imposed on mustard crop

Optimal sequencing of Etd: To quantify 'optimal' and *'sub-optimal' sequencing of Etd, the treatments causing* large yield reduction were separated from those which brought about *minimum reduction in seed yield from Ym.* For spectrum of results in each growth subperiod the slope Ky value of the *relative yield reduction versus* relative Eta deficit relationship was established (Table 4). The Fig.1 represents the *yield sensitivity coefficients* ranging from 0.5592 to 2.0971 in 1995-96, 1996-97 and on pooled basis, respectively. The Etd sequence resulting in a Ky value of <0.6503 in 1995-96, <0.5714 in 1996-97 and <0.5592 on pooled basis (see Ky values in Zone 1 as shown in Fig.1) were considered to represent the 'optimal' sequencing of Etd. The 'optimal' Etd sequencing refers to the timing of Etd intensities which resulted in minimum reduction in yield (6.22%, 5.00% and 5.55% below Ym in 1995-96, 1996-97 and pooled basis, respectively. For the total seasonal Etd, the Etd timings which brought about 20.8 to 80.2 per cent in 1995-96, 30.5 to 89.4 per cent in *1996-97 and 25.9 to 85.0 per cent on pooled basis,* reduction in yield below Ym were denoted as *'sub-optimal'.*

References

Dastane, N.G. 1974. Effective Rainfall. FAO Irrigation and Drainage *Paper No.24, FAO, Rome, Italy.*

Hargreaves, G.H. and Samani, Z.A., 1982. Estimating potential evapotranspiration. *Journal of Irrigation and Drainage Division*, ASCE, **108** (3) : 225-230.

Stewart, J.I., Hagan, R.M., Pruitt, W.O., Hanks, R.J. Riley, J.P., Danielson, R.E., Franklin, W.I. and Jackson, E.B. 1977. Optimising crop production through control of water and salinity level in soil. Utah Water Research Laboratory, College of Engineering, Utah State University, Logan, p. 191.

J. Oilseeds Res., **21**(1): 55-57 (2004)

Production potential and economic feasibility of soybean, *Glycine max* (L.) Merrill based cropping systems

S.D. Billore and O.P. Joshi

National Research Centre for Soybean, Indore-452 017, Madhya Pradesh

(Received: October, 2003; Revised: December, 2003; Accepted: January, 2004)

Abstract

A field experiment conducted during 1994 to 1997 indicated that soybean, *Glycine max* (L.) Merrill - wheat (*Triticum aestivum* L. emend. Fiori and Pool) cropping system with 100 % NPK emerged as the most productive and remunerative cropping system than soybean - linseed and soybean - mustard. The energy analysis revealed that the soybean-wheat consumed significantly. Energy inputs and subsequently enhanced the energy net returns, energy use efficiency and energy productivity. While soybean-mustard was found the most energy intensive cropping system. Energy inputs increased with the fertility levels.

Key words: Cropping system, fertility level, energy

Introduction

The role of legumes in improving the sustaining soil fertility as well as the growth and yield of succeeding crops is well documented (Dhama and Sinha, 1985). Soybean, a legume cum oilseed crop has acquired a special niche in traditional cropping patterns in Madhya Pradesh in a short span of past three decades after its commercial cultivation picked up. Short duration, compact stature, availability of high yielding cultivars, comparative tolerance to adverse climatic conditions enabled the crop to fit in well in various cropping patterns (Bhatnagar *et al.*, 1996). Crops grown in *rabi* after soybean warrant evaluation for agronomic feasibility, economic viability and stability. The present study was therefore initiated to evaluate important *rabi* crops grown in sequence with soybean under varied fertility levels.

Materials and methods

A field study was conducted during 1994 to 1997, at Indore on Typic Chromusterts. The soil of experimental site analyzed: pH - 7.86, EC-0.14 dS/m, organic carbon - 0.30%, available P - 4.80 kg/ha and available K > 99.48 kg/ha. The treatments comprised of soybean followed by 3 *rabi* crops *viz.*, wheat (Sujata), linseed (R 17) and mustard (Pusa bold) grown on 3 fertility levels created by application of 0, 50 and 100% of the recommended fertilizer levels to respective crops which were replicated thrice. All the treatments were laid out on fixed plots in *Split Design with three replications*. The recommended NPK levels were: 100 : 21.5 : 24.9 kg NPK/ha for wheat, 60 : 13 : 17 kg NPK/ha for mustard and 30 : 7 : 0 kg NPK/ha for linseed. Soybean (JS 71 05) was grown with 100% recommended fertilizer level (20 : 26 : 17 kg NPK/ha). All these crops were grown by following standard cultivation practices.

The economics of each treatment was calculated as per the prevailing prices of inputs and outputs. The energy budget of the treatments were determined by using the conversion factors for each and every input, output and cultural activities as suggested by Mittal and Dhawan (1988). Energy intensiveness (EI) and energy productivity (EP) were worked out as per Burnett (1982) and Fluck (1979).

Results and discussion

Cropping system: Soybean was most productive in soybean-mustard crop sequence (Table 1). Among the *rabi* crops, wheat was the most productive followed by linseed and mustard. When systems were compared, soybean-wheat sequence emerged as the most productive and remunerative followed by soybean-linseed and soybean-mustard. Wheat is known to be more productive and cost effective when grown after pulse crop (Sawarkar *et al.*, 1995; Verma, 1997).

Enhancement in fertility levels remarkably improved the yield of all the crops (Table 1). The magnitude of yield enhancement was highest in soybean-wheat followed by soybean-linseed or soybean-mustard. On comparing the individual crops, the magnitude of residual fertility response was lower in soybean than in different *rabi* crops. The maximum enhancement in yield due to fertility was recorded in soybean-mustard followed by soybean-wheat and soybean-linseed. The net returns and B:C ratio

increased as the fertility levels increased. On the basis of net returns and B:C ratio, soybean-wheat was found to be most remunerative. The differential response of cropping systems may be due to the cereals, which are more fertilizer responsive than oilseeds and pulses. Similarly, Mahadev and Das (1997) reported that application of 100% of the recommended dose led to higher economic return in rice-based (wheat/mustard/groundnut) cropping system.

The interaction effect between cropping systems and fertility levels was found significant during all the years of study. Almost all the maximum values for different parameters were associated with soybean-wheat system. The residual effect of 100% fertility level was highest in soybean when grown after mustard and linseed.

Energy budget: Energy analysis of different treatments revealed that the soybean-wheat consumed maximum energy inputs followed by soybean-mustard and soybean-linseed (Table 2). The differences in energy inputs may be ascribed to soybean-wheat requiring higher doses of NPK, particularly N, which shared maximum energy input among the inputs (Billore *et al.*, 1996). Similarly, soybean-wheat possessed significant higher values of gross and net energy returns, energy use efficiency and energy productivity. Energy use efficiency increased as the levels of fertility increased in soybean-linseed and soybean-mustard, while in case of soybean-wheat, it increased only upto 50% fertility level and subsequently declined. The differences in energy indices might be due to the differences in yield levels and inputs in respective treatments. The most energy intensive cropping system was the soybean-mustard followed by linseed and wheat because energy intensiveness is the function of the yield, price and energy inputs. Similar views were extended by Vyas *et al.* (1993) and Billore *et al.* (1994; 1996). The interaction effect of cropping systems x fertility levels was found significant in case of all the energy indices.

Table 1 Yield and economical parameters of soybean based cropping systems under varied fertility levels (Pooled over 1994-97)

Cropping system	Fertility level	Seed yield (kg/ha)		Soybean equivalent yield (kg/ha)	Net returns (Rs/ha)	B:C ratio
		Kharif	*Rabi*			
Soybean-wheat	0 %	1089	2410	2666	17265	2.15
	50 %	1158	3085	3177	18111	2.40
	100 %	1243	3803	3770	22799	2.65
	Mean	1164	3100	3208	18281	2.40
Soybean-linseed	0 %	1077	846	2283	11787	2.06
	50 %	1091	946	2524	13146	2.15
	100 %	1326	1053	2920	16731	2.44
	Mean	1164	948	2575	13889	2.17
Soybean-mustard	0 %	1108	340	1741	4047	0.68
	50 %	1264	477	1840	6445	1.54
	100 %	1366	600	2090	8238	1.67
	Mean	1243	472	1812	6662	1.57
CD (P=0.05)	Cropping system and fertility level	57	651	354	3162	0.30
	Interaction	99	1128	588	5477	0.53

Table 2 Energy budget of soybean based cropping systems under varied fertility levels

Cropping system	Fertility level	Energy input (MJ/h)	Energy output (MJ/ha)		Energy use efficiency	Energy productivity (MJ/kg)	Energy intensiveness (Rs/MJ)
			Gross	Net			
Soybean-wheat	0 %	20887	51435	30548	2.46	0.115	0.795
	50 %	25039	62372	37333	2.49	0.123	0.799
	100 %	29142	74176	45034	2.45	0.130	0.790
	Mean	25023	63281	38258	2.53	0.122	0.795
Soybean-linseed	0 %	20112	36982	16870	1.84	0.113	0.878
	50 %	21153	39688	18535	1.88	0.119	0.863
	100 %	22146	45817	23671	2.07	0.132	0.781
	Mean	21470	41105	19635	1.91	0.120	0.850
Soybean-mustard	0 %	19637	24788	5151	1.26	0.090	1.340
	50 %	21743	30506	8763	1.40	0.085	1.210
	100 %	23789	35080	11291	1.47	0.088	1.330
	Mean	21743	30072	8329	1.38	0.083	1.230
CD (P=0.05)	Cropping system and fertility level	1506	6684	5535	0.20	0.010	
	Interaction	2607	11577	9587	0.36	0.220	

References

Bhatnagar, P.S.B., Joshi, O.P., Bhatia, V.S., Billore, S.D. and Ramesh, A. 1996. Soybean based cropping systems in India - A review. *Journal of Oilseeds Research*, **13**(1):1-6.

Billore, S.D., Singh, K. and Bargale, M. 1994. Energy productivity of sorghum-wheat sequence through long-term use of chemical fertilizers. *Indian Journal of Agronomy*, **39**(2) : 198-202.

Billore, S.D., Singh, K. and Bargale, M. 1996. Bioenergetics and *economic evaluation of cropping systems under Vindhyan* plateau. *Journal of Oilseeds Research*, **13**(1) : 42-48.

Burnett, M. 1982. Energy analysis of three conserved agro eco systems. In Basic Techniques in Ecological Farming. Hill Stuart B (Ed.) Brikhauser Verlag, Bostan, pp.183-195.

Dhama, A.K. and Sinha, M.N. 1985. Residual and cumulative effects of *kharif* legumes and P applied to them on succeeding wheat. A study on N and P concentration and their uptake. *Indian Journal of Agronomy*, **30** : 422-428.

Fluck, R.C. 1979. Energy productivity: A measure of energy utilization in agricultural systems. *Agricultural Systems*, **4** : 29-37.

Mahadev, P. and Das, M. 1997. Effect of preceding crop at different doses of fertilizer on productivity, nutrient utilization and fertilizer use efficiency of wet season rice. *Indian Journal of Agronomy*, **42**(4) : 614-617.

Mittal, J.P. and Dhawan, K.C. 1988. *Research Manual on Energy Requirements in Agricultural Sector.* ICAR, pp.20-23.

Sawarkar, S.D., Pannase, S.K. and Godyani, B.M. 1995. Economic analysis of wheat and chickpea based crop sequences. *Indian Journal of Agronomy*, **40**(1) : 1-3.

Verma, K.P. 1997. *Productivity and economics of different crop* sequences. *Indian Journal of Agronomy*, **42**(3) : 392-395.

Vyas, M.D., Billore, S.D. and Bargale, M. 1993. Energetics and economic feasibility of N and P application in linseed. *Crop Research*, **6**(2) : 202-205.

J. Oilseeds Res., **21**(1): 58-61 (2004)

Screening of pigeonpea, *Cajanus cajan* varieties for their suitability as intercrop in soybean, *Glycine max* L.

S.D. Billore and O.P. Joshi

National Research Centre for Soybean, Indore-452 017, Madhya Pradesh

(Received: September, 2003; Revised: November, 2003; Accepted: December, 2003)

Abstract

A field experiment was conducted during *kharif*, 1995 and 1997 to study the compatibility of pigeonpea varieties in soybean based intercropping system. Of the six pigeonpea varieties tested, ICPL 871 19 and ICPL 940 63 were found most compatible with soybean variety Ahilya 3 in 4:2 row ratio as adjudged by higher yield levels, soybean equivalent yield, land equivalent ratio (LER), relative crowding coefficient (RCC), monetary returns and income equivalent ratio (IER) with low competition ratio. Aggressivity values indicated that soybean dominated pigeonpea varieties except ICPL 840 31. This system also produced higher energy, energy use efficiency and energy productivity. ICPL 850 10 + soybean was found the most energy intensive.

Key words: Energy, intercropping, soybean, pigeonpea

Introduction

Soybean has now assumed the status of a prominent cash crop in Central India which has above 80% area of total coverage under the crop. Crop diversification appears to be a key to the sustainability of the cropping system. It is known that intercropping of soybean with pigeonpea offers yield stability and improved total production from the system (Prasad *et al.*, 1997) than its sole cropping. It also ensures adequate yield of one of the crops under aberrant weather conditions (Rao and Willey, 1980). Biological efficiency of any intercropping systems depends on the varietal compatibility of component crops and their spatial arrangement. However, information on this aspect is inadequate. Therefore, the present investigation was undertaken to evaluate the productivity, competitive indices, monetary advantage and energy balance of pigeonpea varieties in soybean based intercropping system under two spatial arrangements.

Materials and methods

A field experiment was conducted at Indore during *kharif*, 1995-96 and 1997-98. The soil was clayey, having pH 7.86, EC 0.14 ds/m, organic carbon 0.3 %, available P 4.86 kg/ha and available K > 99 kg/ha. The experiment was laid out in Randomised Block Design with three replications. Treatment combinations comprised sole soybean (Ahilya 3), sole pigeonpea (ICPL 850 10, ICPL 87, ICPL 840 31, ICPL 871 19, ICPL 940 62 and ICPL 940 63) and their combinations with soybean in 2:2 and 4:2 row arrangements were evaluated. The crops were sown in first week of July during both the years. A fertilizer dose of 20:26:17 kg NPK/ha to soybean and 20:22:0 kg NPK/ha to pigeonpea was applied as basal through urea, single super phosphate and muriate of potash in sole cropping systems. Intercropping treatments received only fertilizer level recommended for soybean.

The competitive ratio (Willey and Rao, 1980), the relative crowding coefficient (de Wit, 1960) and aggressivity (Mc Gilchrist 1965) were calculated. Energy inputs and outputs were computed using the conversion factors as suggested by Mittal and Dhawan (1988). Energy productivity and energy intensiveness were worked out as per Fluck (1979) and Burnett (1982), respectively. The total rainfall received during the crop period was 939 and 1106 mm in 1995-96 and 1997-98, respectively.

Results and discussion

Seed and soybean equivalent yield: Significant reduction in seed yield of soybean (24 to 40%) and pigeonpea (25 to 74%) was noticed when planted in intercropping systems as compared to their sole plantings (Joshi *et al.*, 1999). Although soybean yielded lower under 2:2 row ratio, the tendency of reduction when intercropped with ICPL 850 10, ICPL 87 and ICPL 840 31 was more than combination with other pigeonpea varieties. Soybean invariably yielded higher in 4:2 row ratio. Among the sole planted pigeonpea genotypes, seed yield of ICPL 940 63 (2134 kg//ha) was the maximum closely followed by ICPL 871 19 (2088 kg/ha). The lowest yield was observed with ICPL 840 31 (1122 kg/ha). The beneficial effect of intercropping could be judged by considering the total productivity in terms of soybean equivalent yield and comparing with sole soybean. The highest soybean

equivalent yield was recorded in soybean + ICPL 871 19 (4:2) which was at par with its 2:2 combination, soybean + ICPL 940 63 (4:2) and soybean + ICPL 940 63 in 2:2 row ratio. While, rest of the treatments differed non-significantly with sole soybean. These results are in agreement with) the earlier findings of Joshi *et al.* (1999). It may be noted that the intercropping systems reduced the quantum of fertilizer input.

Land equivalent ratio: Land equivalent ratio varied from 1.20 - 1.53 for different intercropping systems denoting their greater biological efficiency (Table 1). The planting of soybean + pigeonpea in 4:2 row ratio was more efficient than planting in 2:2 row ratio. Planting of ICPL 871 19 and ICPL 940 63 with soybean in both the planting patterns gave higher land equivalent ratio, while remaining pigeonpea varieties showed greater biological efficiency in 4:2 row arrangements. The higher value of land equivalent ratio indicated greater biological efficiency and lower competition between crops (Holkar *et al.*, 1991).

Table 1 Effect of planting pattern and pigeonpea varieties on productivity, competition functions and monetary returns of soybean and pigeonpea intercropping system

Treatment	Yiel (kg/ha)		SEY (kg/ha)	Land equivalent ratio (LER)	Competitive ratio (CR)	Aggressivity (A)	Relative crowding coefficient (RCC)	Monetary advantage (Rs/ha)	Income equivalent ratio (IER)	
	Soybean	Pigeonpea							Soybean	Pigeonpea
Soybean (Ahilya 3)	2391	-	2391	1.00	-	-	-	-	-	-
ICPL 850 10	-	1416	2361	1.00	-	-	-	-	-	-
ICPL 87	-	1704	2841	1.00	-	-	-	-	-	-
ICPL 840 31	-	1122	1870	1.00	-	-	-	-	-	-
ICPL 871 19	-	2088	3481	1.00	-	-	-	-	-	-
ICPL 940 62	-	1548	2581	1.00	-	-	-	-	-	-
ICPL 940 63	-	2134	3557	1.00	-	-	-	-	-	-
ICPL 850 10 (4:2)	1820	557	2749	1.20	1.74	0.43	1.36	4425	1.11	0.83
ICPL 850 10 (2:2)	1539	759	2806	1.24	1.08	0.05	2.08	5181	1.12	0.84
ICPL 87 (4:2)	1671	887	3150	1.22	1.35	0.23	2.52	5412	1.25	0.78
ICPL 87 (2:2)	1551	1062	3322	1.27	1.04	0.14	3.05	6684	1.31	0.82
ICPL 840 31 (4:2)	1737	884	3212	1.51	0.92	0.05	9.87	10345	1.28	1.21
ICPL 840 31 (2:2)	1457	781	2760	1.30	0.87	-0.00	3.57	6065	1.10	1.04
ICPL 871 19 (4:2)	1815	1601	4485	1.53	0.99	0.12	10.40	14604	1.76	0.89
ICPL 871 19 (2:2)	1736	1510	4254	1.45	1.00	0.13	6.91	12417	1.67	0.85
ICPL 940 62 (4:2)	1736	987	3382	1.36	1.14	0.25	4.66	8513	1.34	0.92
ICPL 940 62 (2:2)	1615	872	2570	1.24	1.20	0.16	2.70	5657	1.22	0.84
ICPL 940 63 (4:2)	1798	1500	4299	1.45	1.07	0.14	7.17	12563	1.69	0.84
ICPL 940 63 (2:2)	1741	1437	4137	1.40	1.08	0.15	7.66	11131	1.63	0.81
CD (P=0.05)	251	512	867	0.21	0.25	0.12	3.44	3850	0.27	0.13

Competition ratio: Soybean was found more competitive, except with pigeonpea varieties ICPL 840 31 and ICPL 871 19 as these varieties showed faster vegetative growth during early stage. The results are in agreement with Rao and Willey (1 980) who reported that the competitive ability of crops increased with the development of plant canopy. The low competition ratio value of crop indicated lower yield levels of respective crop.

Aggressivity: Soybean, in general, showed positive values of aggressivity in intercropping systems indicating its dominance over pigeonpea. It was only early maturing ICPL 840 31 with speedy early growth was an exception. Holkar *et al.* (1991) and Prasad *et al.* (1997) made similar observations while working with soybean based intercropping systems.

Relative crowding coefficient: Relative crowding coefficient of soybean was greater than unity in all the intercropping systems, thereby clearly establishing the dominance of soybean over the varieties of pigeonpea tested. Similarly, the product of relative crowding coefficient of component crops was also more than unity in all the intercropping treatments revealing a non-competitive interference than the competitive one. The higher relative crowding coefficient values indicated better compatibility of pigeonpea varieties with soybean and resulted in higher yields. The result corroborates with the findings of Holkar *et al.* (1991) and Prasad *et al.* (1997).

Monetary advantages and income equivalent ratio: Maximum monetary advantage and income equivalent ratio was associated with ICPL 871 19 (4:2) (Rs 14,604/ha) closely followed by ICPL 940 63 (4:2), ICPL 871 19 (2:2), ICPL 940 63 (2:2) and ICPL 840 31 (4:2) (Rs 10,335). While the values for remaining treatments varied from Rs. 4,425 to 8,513/ha over sole cropping of soybean. Similarly, income equivalent ratio values for soybean were greater than one, revealing that intercropping of soybean with any of the pigeonpea varieties was beneficial than sole soybean. While the value of income equivalent ratio lower than unity for pigeonpea except of variety ICPL 840 31 indicated that pigeonpea in intercropping was not beneficial as compared to its sole cropping.

Energy budget: Working out the energy budget for the treatments revealed that the intercropping of pigeonpea with soybean consumed more energy inputs than their sole crops (Table 2). Among the pigeonpea varieties, ICPL 871 1 9 followed by ICPL 940 63 intercropping with soybean in both the planting patterns (2:2 and 4:2) produced highest energy output and proved better in energy use efficiency, and energy productivity as compared to other varieties of pigeonpea as well as their sole crops. Among the sole cropping systems, ICPL 940 63 being the maximum and remained at par with ICPL 871 19 and ICPL 87. While the lowest energy output, energy use efficiency and energy productivity was recorded in ICPL 840 31. The differences in energy indices may be due to differences in their yield levels and energy inputs of the respective treatments. However, the ICPL 850 10 was found most energy intensive in both the cropping systems. The variation in energy intensiveness might be due to variation in yield, price and energy inputs. Similar views were also extended by Deka and Pal (1995) in pigeonpea based intercropping systems and Verma *et al.* (1997) in wheat + mustard intercropping.

Table 2 Energy productivity as influenced by planting pattern and varieties of pigeonpea with soybean i- intercropping system

Treatment	Energy input (MJ/ha)	Energy output (MJ/ha)		Energy use efficiency	Energy productivity (MJ/kg)	Energy intensiveness (Rs/MJ)
		Sole cropping				
Soybean (Ahilya 3)	7504	35148	27644	4.68	0.31	0.313
ICPL 850 10	5426	31223	25797	5.75	0.39	0.250
ICPL 87	5426	37573	32147	6.92	0.47	0.212
ICPL 840 31	5426	24740	19314	4.56	0.31	0.320
ICPL 871 19	5426	46040	40614	8.84	0.58	0.173
ICPL 940 62	5426	34133	28707	6.29	0.43	0.233
ICPL 940 63	5426	47055	41629	8.67	0.59	0.170
		Intercropping soybean + pigeonpea				
ICPL 850 10 (4:2)	9003	39028	30025	4.33	0.29	0.340
ICPL 850 10 (2:2)	9003	39352	30349	4.37	0.30	0.330
ICPL 87 (4:2)	9003	44115	35112	4.90	0.33	0.300
ICPL 87 (2:2)	9003	46217	37214	5.13	0.35	0.290
ICPL 840 31 (4:2)	9003	45026	26023	5.00	0.34	0.290
ICPL 840 31 (2:2)	9003	38632	29629	4.29	0.29	0.340
ICPL 871 19 (4:2)	9003	61975	52972	6.88	0.47	0.210
ICPL 871 19 (2:2)	9003	58815	49812	6.53	0.44	0.220
ICPL 940 62 (4:2)	9003	47275	38272	5.25	0.36	0.280
ICPL 940 62 (2:2)	9003	42968	33965	4.77	0.32	0.300
ICPL 940 63 (4:2)	9003	59506	50503	6.61	0.45	0.220
ICPL 940 63 (2:2)	9003	57271	48268	6.36	0.43	0.230
CD (P=0.05)	-	11257	10338	1.49	0.10	0.060

Mean results of two years showed that intercropping of pigeonpea varieties with soybean was beneficial than sole soybean. Among the pigeonpea varieties, ICPL 871 19 and ICPL 940 63 emerged as better compatible for intercropping with soybean as evidenced from higher land equivalent ratio, relative crowding coefficient, monetary advantages, income equivalent ratio and lower values of competition ratio.

References

Burnett, M. 1982. Energy analysis of three conserved agro-ecosystems. (In) *Basic Techniques in Ecological Farming*, pp. 183-195. Hill Stuart B. (Ed.) Brikhauser Verlag, Boston.

Deka, J. and Pal, M. 1995. Bioenergetics of different sole and pigeonpea based cropping systems. *Indian Journal of Agricultural Sciences*, **65**(9): 639-643.

de Wit, C. T. 1960. On competition. Verslagen Van Land bow kundige onderzoekingen, **66**(8): 1-82.

Fluck, R. C. 1979. Energy Productivity: A measure of energy utilization in agricultural systems. *Agricultural Systems*, **4**: 29-37.

Holkar, S; Jagtap, J. G., Billore, S. D. and Mishra, V. K. 1991. Evaluation of soybean and pigeonpea genotypes grown in intercropping system. *Indian Journal of Agricultural Sciences*, **61**(2): 93-96.

Joshi, O. P., Billore, S. D. and Bhatia, V. S. 1999. Planting pattern of higher productivity of soybean and pigeonpea intercropping system. *Indian Journal of Agronomy*, **44**(2): 271-274.

Mc Gilchrist, C. A. 1965. Analysis of competition experiments. *Biometrics*, **21**:975-985.

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

Prasad, S. N., Singh, R. and Singhal, A K. 1997. Grain yield, competitive indices and water use in soybean based intercropping systems in South Eastern Rajasthan. *Indian Journal of Agricultural Sciences*, **67**(4): 150-153.

Rao, M. R. and Willey, R. W. 1980. Preliminary studies of intercropping combinations based on pigeonpea or sorghum. *Experimental Agriculture*, **16**(1): 29-40.

Verma, U. N., Pal, S. K., Singh, M. K. and Thakur, R. 1997. Productivity, energetics and competition function of wheat + Indian mustard intercropping under varying fertility level. *Indian Journal of Agronomy*, **42**(2): 201-4.

Willey, R. W. and Rao, M. R. 1980. A competitive ratio for quantifying competition between intercrops. *Experimental Agriculture*, **16**(2): 117-125.

J. Oilseeds Res., **21**(1): **62-64** (2004)

Phosphorus management in soybean, *Glycine max* (L.) Merr. - sunflower, *Helianthus annuus* L. cropping system

S.N. Patil, R.B. Ulemale, S.S. Lande and A.M. Mahajan

Oilseeds Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola-444 104, **Maharashtra**

(Received: April, 2002; Revised: September, 2003; Accepted: October, 2003)

Abstract

Optimum phosphorus requirement for soybean (*Glycine max* L. Merr.)- sunflower (*Helianthus annuus* L.) cropping sequence was studied during 1995-96 to 1999- 2000 through integrated use of organics and phosphorus solubilizing bacteria (PSB). The soybean (*kharif*)- sunflower (*rabi*) cropping system fertilized with 100% phosphorus for both the crops of higher productivity resulted in more productivity. However, for high benefit : cost ratio (2.36) and phosphorus economy, it was possible to reduce 50% dose of phosphorus needs of sunflower with seed treatment with PSB culture along with application of 5 t FYM/ha. The available phosphorus status of soil has enhanced where sunflower received 100% P. Substantial build up of available P was noticed in 100% P applied for both crops after each crop sequence.

Key words: Phosphorus, productivity, organics, PSB, BCR

Introduction

Among all the oilseed crops, soybean has occupied third place in the edible oil production in India. The area under soybean crop is increasing day by day as it can profitably replace the other legumes. Phosphorus plays important role in growth and development as well as maturity of crops. An adequate supply of phosphorus in the early stages helps in initiating its reproductive parts. It hastens maturity and improves quality of seed. Soybean-sunflower cropping sequence plays an important role in oilseed production in India. The phosphorus management involving the conjunctive views of fertilizers and organic sources assumed great importance recently due to paucity of phosphatic fertilizers and need to sustain productivity (Nambiar and Abrol, 1989).

Soybean and sunflower are the most nutrient exhaustive crops. The existing system is based on the nutrient requirement of individual crop ignoring the carryover effect of the fertilizer or manure to the preceding crop. Organic sources of nutrients applied to the preceding crop benefit the succeeding crop to a great extent (Hegde, 1998). Hence a study was conducted to find out the optimum phosphorus management through organic and phosphorus solubilizing bacteria (PSB).

Materials and methods

The field experiments were conducted at Oilseeds Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *kharif* and *rabi* seasons of 1995-96 to 1999-2000 on fixed sites in Randomized Block Design with four replications. Ten treatments were imposed in the experiment (Table 1). The soil of the plot was Vertisol with pH 7.9. Initial available P status of soil was 14.3 kg /ha with available N 147.2 kg/ha and available K 372 kg/ha, respectively. Soybean variety PKV-1 and sunflower variety PKVSH-27 were grown as test crops with a recommended dose of fertilizer 30:75:30 NPK kg /ha (soybean) and 80:60:40 NPK kg/ha (sunflower) during all the years. Recommended dose of N and K was applied uniformly to all the treatments. Diammonium phosphate (DAP) was used as a source of P. The phosphorus solubilizing bacteria (PSB culture) was used for seed dressing as per treatment.

Results and discussion

System productivity

Application of 100% recommended P (75 kg P_2O_5/ha) to *kharif* soybean recorded significantly the highest seed yield (2284 kg /ha) over 50% recommended P and no phosphorus application. Highest seed yield was obtained with higher levels of P application as reported by Kesavan and Morachan (1973).

The pooled data of five years indicated that any reduction in application to soybean had significant adverse effect on its productivity even where the preceding sunflower received full P (Table 1). In sunflower, it was possible to reduce 50% P need when PSB and 5 t FYM/ha were used along with 100% P to preceding soybean.

Any reduction in P application had significant adverse effect on seed yield of sunflower. However, when PSB and 5 t FYM /ha were used, the yield was at par with treatment receiving 100% P by both crop sequences. The results also showed that 50% P needs of sunflower could be substituted by application of 5 t FYM/ha when the preceding crop of soybean receiving 100% P. Similar results was also reported by Bobde *et al.* (1998).

Table 1 Influence of phosphorus management on ancillary characters and seed yield of soybean-sunflower cropping system (five years average)

Treatment		Soybean				Sunflower					Seedyield (kg/ha)		B:C ratio
Soybean	Sunflower	Plant height (cm)	No. of pods/ plant	Seed yield/plant (g)	100 seed weight (g)	Plant height (cm)	Head diameter (cm)	Seed yield/plant (g)	100 seed weight (g)	Oil content	Soybean	Sunflower	
T_1 : 100% P	100 % P	48	39	9.9	11.9	118	11.4	17.5	3.3	40.1	2284	1122	2.40
T_2 : 50%	100% P	44	34	7.8	9.7	120	10.9	15.7	3.2	40.3	1806	1093	2.16
T_3 : 0% P	100% P	41	31	6.5	8.7	118	10.9	16.8	3.0	39.6	1500	1070	2.04
T_4 : 100% P	50% P	45	36	8.7	11.1	118	10.4	13.3	2.7	39.5	2118	884	2.21
T_5 : 100% P	50% P + PSB	45	38	9.0	12.2	118	10.1	13.6	2.9	39.7	2192	1000	2.36
T_6 : 100% P	50% P + 5 t FYM/ha	44	39	9.1	11.3	125	10.6	14.9	3.1	40.0	2227	1058	2.12
T_7 : 100% P	50% P + PSB + 5 t FYM/ha	43	34	9.6	11.1	127	10.7	15.7	3.1	40.1	2264	1100	2.16
T_8 : 100% P	PSB	42	36	8.8	11.1	118	9.6	12.9	2.9	40.6	2097	769	2.22
T_9 : 100% P	5 t FYM/ha	45	37	8.8	10.9	118	9.9	14.4	2.8	40.3	2131	909	2.06
T_{10} : 100% P	PSB + 5 t FYM/ha	45	37	9.0	11.5	120	10.1	14.3	2.9	40.0	2143	1011	2.14
SEm±		0.69	1.09	0.30	0.22	0.12	0.04	0.30	0.07	0.30	24	14	
CD (P=0.05)		2.07	3.02	0.91	0.67	0.37	0.12	0.61	0.21	NS	72	39	

The total productivity measured in terms of soybean seed equivalents showed the maximum with 100% P applied to each crop of the system. Similar results were also reported by Bhatnagar *et al.*,(1996) and Raskar *et al.*, (2000). The crop productivity was declined by 34 and 21% when the recommended P was reduced to 50% P and 0%P. Either one crop, the 50% substitution of P to sunflower by 50% P with PSB could also recorded slightly higher net monetary returns and benefit cost ratio (2.36) than 100% P to both crops. The net monetary returns from the system also indicated the possibility of reducing 50% P to sunflower by application of PSB and/or 5 t FYM/ha with marginal decline in profitability.

Soil fertility

There was substantial build up of soil P in all the treatments over years, while the mean available phosphorus content in the soil (21.03 kg/ha) was increased by 47.6% over its initial P value of 14.3 kg/ha. The build up was maximum with application of 100% P to both crops. Shanti and Sreenivasa Raju (2001) observed that application of P at different levels resulted in increase in content of available P after harvest of sunflower.

Yield and yield components

The data pertaining to yield components of soybean *viz*, pods/plant, yield/plant and test weight and with regard to sunflower *viz*, oil content, head diameter and yield/plant also followed similar trend and recorded highest with application of 100% P to both crops. Application of P significantly increased seed yield, number of pods/plant, seed yield/plant and oil yield. This might be due to abundance of P in seeds which stimulated the formation to filled compact seeds and increase in seed number (Kesavan and Morachan , 1973; Mishra *et al.*, 1995).

References

Bhatnagar, P.S., Joshi, O. P., Bhatiya V. S., Billone S.D. and Ramesh, R. 1996. Soybean based cropping systems in India – A Review. *Journal of Oilseeds Research*, **13** (1) : 1-6.

Bobde, G.N., Deshpande, R. M., Kandalkar, D. M. and Turankar, V. L. 1998. Nutrient management of soybean based cropping system. *Indian Journal of Agronomy*, **43** (3) : 390-392.

Hegde, D. M. 1998. Integrated nutrient management for production of oilseeds – A Review. *Journal of Oilseeds Research*, **15** (1) : 1-17.

Kesavan, G. and Morachan, Y. B. 1973. Response of soybean varieties to graded doses of nitrogen and phosphorus. *Madras Agricultural Journal*, **60** (1) : 23-26.

Mishra, A., Dash, P. and Paikaray, R. K. 1995. Yield and nutrient uptake by winter sunflower as influenced by nitrogen and phosphorus. *Indian Journal of Agronomy*, **40** (1):137-138.

Nambiar, K.K.M. and Abrol, I.P. 1989. Long term fertilizer experiments in India - An over view. *Fertilizer News*, **34** (4) : 11-20 & 26.

Raskar, V. S., Bhoi, P. G. and Shinde, S. H., 2000. Productivity and economics of soybean based cropping sequence under irrigated conditions. *Indian Journal of Agronomy*, **45** (3) : 477-482.

Shanti, M. and Sreenivasa Raju, A. 2001. Status of inorganic P fractions in Alfisol after harvest of sunflower. *Journal of Oilseeds Research*, **18** (1) :64-65.

J. Oilseeds Res., 21(1): 65-68 (2004)

Effect of tillage and plant density on performance of sunflower, *Helianthus annuus* L. in rice fallows

P. Sesha Saila Sree and V. Sridhar

Regional Agricultural Research Station, Nandyal-518 503, AP

(Received: August, 2003; Revised: November, 2003; Accepted: December, 2003)

Abstract

Field experiments were conducted during summer seasons of 1998-99 to 2000-01 to study the influence of tillage and plant density on performance of sunflower in rice fallows on Vertisols. Highest yield of sunflower was obtained with conventional tillage (i.e. ploughing twice with country plough followed by harrowing twice with blade harrow), which was significantly higher over minimum and reduced tillage. Recommended plant population resulted in highest seed yield compared to 75% and 200% of recommended population. The oil yield was also maximum under conventional tillage practice with recommended plant population.

Key words: Sunflower, tillage, spacing, plant population density

Introduction

The limitations of water resources in command, tankfed and well-irrigated areas demands the cultivation of irrigated dry crops after rainy season puddled rice. Pulses and oilseeds hold promise in such situations by virtue of their low water requirement. Sunflower has emerged as a potential oilseed crop after rice. Krishna and Reddy (1997) reported higher production efficiency and net returns from rice – sunflower sequence in Andhra Pradesh. The soil condition after puddled rice poses limitation for growing arable crops and thus yield levels of crops following rice are generally low as compared to the normal yield of these crops. The main problems for crops grown after puddled rice are low plant stand establishment due to larger clods formed by rice stubbles, restricted root growth and poor aeration due to formation of hard pan in sub soil and low nutrient use efficiency due to adverse physical, chemical and biological environment in the rhizosphere. In order to determine the optimum tillage requirement for better plant stand establishment and to trade off between tillage practices and seed rate, the present investigation was carried out for achieving optimum tilth and plant stand for normal yield of sunflower.

Materials and methods

Field experiments were conducted on Vertisols of Regional Agricultural Research Station, Nandyal, Andhra Pradesh during summer seasons of 1998-99, 1999-2000 and 2000-01 wherein rainy season puddled rice was the previous crop. Sunflower hybrid APSH 11 was sown under three tillage practices (*viz.*, conventional tillage, reduced tillage and minimum tillage) as main plots and four spacings *viz.*, 75 x 30 cm (75% of recommended plant population: 44,444 plants/ha); 60 x 30 cm (Recommended plant population: 55,555 plants/ha); 45 x 30 cm (125% of recommended plant population: 74,074 plants/ha); and 45 x 20 cm (200% of recommended plant population: 1,11,111 plants/ha) as sub plots. The Split Plot Design was adopted with three replications. The soil of the experimental field was low in available nitrogen (192 kg N/ha), high in available phosphorus (28.6 kg P/ha) and medium in available potassium (218 kg K_2O/ha) with a pH of 7.6. Conventional tillage comprised of ploughing twice with country plough (criss-cross) followed by harrowing twice with blade harrow (criss-cross), reduced tillage consisted of ploughing once with country plough followed by harrowing once with blade harrow and in minimum tillage, the surface biomass of weeds and paddy stubbles were suppressed by using herbicide and after a week's time, with a pre-sowing light irrigation furrows were opened in between rows of paddy stubbles and sowing was done by hand dibbling as per the sub plot treatments during last week of January. The crop received three irrigations during the crop growth period.

Results and discussion

Effect of tillage: During 1998-99, tillage treatments significantly influenced the plant population, head diameter, seed yield and oil yield of sunflower. The seed yield was higher with conventional tillage (1006 kg/ha) followed by minimum tillage (990 kg/ha), which were almost similar (Table 1). Significantly lower yield (734 kg/ha) was obtained with reduced tillage. Like seed yield, the oil yield was also significantly higher with conventional tillage (344 l/ha) followed by minimum tillage (328 l/ha). Lowest oil yield was with reduced tillage (253 l/ha).

Table-1 Effect of tillage and plant population on yield attributes and yield of sunflower in rice fallows

Treatment	Final plant population ('000/ha)				Head diameter (cm)				Seed yield (kg/ha)				Oil yield (l/ha)			
	1998-99	1999-00	2000-01	Mean	1998-99	1999-00	2000-01	Mean	1998-99	1999-00	2000-01	Mean	1998-99	1999-00	2000-01	Mean
Tillage																
Conventional	40.9	43.3	42.2	42.1	9.0	8.3	7.8	8.4	1006	1180	1047	1078	344	409	345	366
Reduced	39.5	39.5	39.8	39.8	8.1	7.9	7.4	7.8	734	977	780	814	253	307	253	271
Minimum	37.8	38.1	39.0	39.0	8.5	7.8	7.5	7.9	990	830	690	836	328	278	218	275
SEm±	0.6	2.0	0.4	0.4	0.2	0.3	0.3	0.1	20	105	41	66	5	33	14	21
CD (P=0.05)	2.1	NS	1.7	1.7	0.5	NS	NS	0.3	77	NS	161	259	20	NS	51	82
Spacing																
75 x 30 cm	24.9	25.9	26.0	26.0	8.9	8.5	8.0	8.5	970	887	741	866	330	297	238	288
60 x 30 pm	30.7	33.0	32.0	32.0	8.7	8.3	7.6	8.2	923	1072	913	969	313	363	302	326
45 x 30 cm	44.8	44.2	45.0	44.7	8.6	7.8	7.4	7.9	966	1033	900	966	326	355	290	324
45 x 20 cm	57.3	58.2	58.0	57.9	8.0	7.3	7.2	7.5	780	924	803	836	265	312	258	278
SEm±	0.5	1.4	0.7	0.3	0.3	0.3	0.1	0.1	25	69	38	26	8	21	12	9
CD (P=0.05)	1.4	4.2	2.1	0.9	NS	NS	0.3	0.3	76	NS	114	78	24	NS	36	26
Interaction																
SEm±	0.8	2.4	1.2	0.6	0.4	0.6	0.2	0.2	44	119	66	46	14	37	21	15
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	131	NS	NS	136	42	NS	NS	45

Table 2 Interaction effect of tillage and plant population on seed and oil yield of sunflower in rice fallows

Tillage/ Spacing	Seed yield (kg/ha)										Oil yield (l/ha)									
	1998-99					Pooled mean					1998-99					Pooled mean				
	75x30 cm	60x30 cm	45x30 cm	45x20 cm	Mean	75x30 cm	60x30 cm	45x30 cm	45x20 cm	Mean	75x30 cm	60x30 cm	45x30 cm	45x20 cm	Mean	75x30 cm	60x30 cm	45x30 cm	45x20 cm	Mean
Conventional	911	1148	1062	902	1006	947	1284	1111	969	1078	323	394	357	303	344	322	442	377	323	366
Reduced	833	789	735	580	734	782	841	857	775	814	285	267	250	210	253	261	277	286	260	271
Minimum	1167	832	1101	858	990	869	782	931	764	836	382	277	371	281	328	282	258	309	250	275
Mean	970	923	966	780		866	969	966	836		330	313	326	265		288	326	324	278	

Interaction	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)
For comparing two spacing means at same tillage practice	43.8	131.4	45.2	135.6	13.8	41.4	14.9	44.7
For comparing two tillage means at same or different spacings	44.0	130.7	45.8	136.1	14.1	41.9	15.4	45.8

The superior performance of sunflower in conventional and minimum tillage over reduced tillage can be attributed to more number of plants at maturity and increased head diameter (Table 1). During 1999-2000, yield attributes and yield of sunflower were not influenced significantly due to tillage treatments. During 2000-01, tillage practices markedly influenced the yield of sunflower. The seed yield, oil yield and final plant population were higher in conventional tillage and lower in minimum tillage. The magnitude of yield increase in conventional tillage was 52% over minimum tillage. Oil yield obtained in conventional tillage was significantly higher compared to minimum and reduced tillage.

The results of the pooled data over three years revealed that the performance of sunflower in conventional and minimum tillage was on par with respect to seed yield and the yield recorded in conventional tillage was significantly superior to that in reduced tillage. On an average, conventional tillage gave an increase in seed and oil yields to the tune of 32.4% and 35.1%, respectively over reduced tillage. The better performance of sunflower by practicing tillage operation through ploughing followed by rotovation is reported by Pratibha *et al.* (1994).

Effect of population: *During 1998-99, seed yield among* 75, 100 and 125% recommended plant population was on par and all the three treatments were significantly superior to 200% recommended plant population (Table 1). This was due to significantly higher head diameter. During 1999-2000, number of plants at maturity was significantly higher at 200% of recommended plant population, which can be attributed to optimum competition for the growth. However, different plant populations did not influence the seed and oil yields of sunflower in rice fallows. During 2000-01, seed and oil yield between 100% and 125% recommended plant population were on par but *significantly superior to 200% and 75% of recommended* plant populations while all the yield attributes recorded were significantly higher at 75% of recommended plant population level. Significantly lower plant population than optimum might have resulted in lower seed yield of sunflower at 75% of recommended plant population.

The pooled data revealed that higher seed yield could be obtained when sunflower was grown at its recommended and 125% of recommended plant population i.e. 55,555 and 74,074 plants/ha. Decreased per plant productivity at 200% of recommended population and reduced number of plants at 75% of recommended population could not compensate the yield that was achieved under 100% recommended plant population.

Interaction effect: During 1998-99, the interaction effects between tillage and plant population were found to be significant in respect of seed and oil yield (Table 2). The minimum tillage either at 75% or 125% of recommended plant population recorded significantly higher seed and oil yield. The interaction effect was not significant regarding yield attributes and yield of sunflower grown after *kharif* rice in 1999-2000. During 2000-01, head diameter, seed and oil yields were not significant.

The mean seed yield over three years recorded significant increase in conventional tillage over reduced and minimum tillage practices. The 100% and 125% recommended plant population gave significantly higher seed yield (Table 2). Any decrease or increase in plant population adversely affected the seed yield. Similar trend was observed in case of oil yield due to the interaction effect. The overall low yield levels of the crop in rice fallows might be due to formation of larger clods, which have interfered in prolific root distribution and development of sunflower crop while the plant emergence and plant population was normal in the treatments. The effect is seen with the reduction in head diameter and number of filled seeds thereby affecting seed setting and filling resulting in lower test weight and final yield (Reddy and Sudhakara Babu, 1999).

Conventional tillage is quite effective on the productivity of sunflower. Further, seed rate recommended for normal crop can also be used for growing sunflower in rice fallows.

References

Krishna, A. and Reddy, A. K. 1997. Production potential and economics of different rice (*O. sativa*) based cropping systems in Andhra Pradesh. *Indian Journal of Agricultural Sciences*, **67** (12): 551-553.

Pratibha, G., Pillai, K.G., Satyanarayana, V. and Mir Mustaffa Hussain. 1994. Productivity of certain oilseed crops as influenced by different tillage systems in rice based cropping systems *In* Prasad M V R *et al.*, (eds.) *Sustainability in Oilseeds*, Indian Society of Oilseeds Research, pp: 297-301.

Reddy, B.N. and Sudhakara Babu, S.N. 1999. Effect of tillage and plant density on establishment and productivity of sunflower in rice fallows under two soil types Proceedings. *International Symposium on sunflower and other oilseed crops in developing countries.*, February 9-12, 1999, Maputo, Mozambique. pp, 155-161.

J. Oilseeds Res., **21**(1): 69-72 (2004)

Isolation of salt endurant sunflower, *Helianthus annuus* L. genotypes through *in vitro* screening techniques

D. Sassikumar, R. Sudhagar and A. Gopalan

Tamil Nadu Agricultural University, Coimbatore-641 003, Tamil Nadu

(Received: April, 2003; Revised: September, 2003; Accepted: December, 2003)

Abstract

To identify the salt tolerant sunflower genotypes, *in vitro* techniques *viz.*, cell membrane stability test, tetrazolium test and paper towel method were employed. The critical or base concentration limit has been fixed as 3.39 dS/m through tetrazolium test. The assessment of seedling characters using paper towel method indicated a general reduction in shoot and root length, vigour index and drymatter production with increasing salt concentration. A maximum critical concentration to study the growth attributes has been fixed as 13 dS/m. The inhibition dose for 50% reduction in plant height was estimated using probit analysis and the graph plotted against coefficient of variation (CV) and mean to identify salt endurant genotypes. The genotypes GP 255, GP 336 and SF 54 were identified as salt endurant whilst Morden, 336 B and SF 7 were categorized as susceptible.

Key words: Sunflower, salt stress, *in vitro* screening

Introduction

Sunflower, the few among the prime oilseed crops of India gained momentum because of its quality worth oil content, but the productivity gets eclipsed due to the unsuitable soil environment especially soil salt content. Chemical reclamation of soil is cost effective and thus the better option is to deploy the genotypes that withstand and yield better. Screening genotypes in natural salty lands sometimes may give erroneous results. Hence, it is imperative to screen the genotypes *in vitro* and it could further ease the breeding cycle (Delgado and Sanchez-raya, 1998; Sajjan *et al.*, 1999). Earlier workers *viz.*, Muralidharadu *et al.* (1998); Tekin and Bozcuk (1998) and Sajjan *et al.* (1999) attempted *in vitro* screening of sunflower genotypes and enlightened the salt provoked alterations in the seed and young seedlings. They were limited only to single salt mostly NaCl to identify the salt induced effects. The present inquest utilized the triple salt for screening sunflower genotypes in controlled environment in different modes to fix the critical salt concentration and to identify **salt tolerant sunflower** genotypes.

Materials and methods

Twenty five diverse sunflower genotypes were utilized for the study. The experiments were carried out at induced salt combinations *in vitro* at Tamil Nadu Agricultural University, Coimbatore. The salt solution comprised of Cl: CO_3: HCO_3 ions with sodium base and prepared by mixing of one molar solution of NaCl, Na_2CO_3 and $NaHCO_3$ in 7:2:1 ratio as per the report of Singh and Singh (1999). The mixture was diluted five times with double distilled water. From these base concentrations known aliquots *viz.*, 10, 25, 50, 50, 100 and 150 ml were taken and diluted with one litre of ½ strength Hoagland solution (Hoagland and Arnon, 1936) depending upon the concentration required for the experiment. Final salt concentration of the solution was measured using EC meter and expressed as dS/m.

Cell membrane stability test: Five dehulled seeds in each genotype were immersed in solution with different concentrations of known electrical conductivity *viz.*, 2.05, 4.83, 8.70, 12.64 and 17.38 dS/m along with control (EC of 0.06 dS/m). The experimental set up was kept at room temperature for 48 hr and replicated twice in Factorial Complete Randomized Block Design. At the completion of the stipulated time the final conductivity was recorded using EC meter. The rate of the injury to cell membrane was estimated through the measurement of electrolyte leakage from the cells. The injury to cells due to the salt was worked out as per Blum and Ebercon (1981).

Tetrazolium test: Free hand tangential sections of tissues from the hypocotyl region of the stem (10 days old) in each genotype were placed in tubes at 0.61, 3.39, 6.19 and 8.77 dS/m EC for 24 hr at room temperature. After the prescribed time, the solution was drained and sections were washed free of salts with distilled water. Adequate quantity of 0.1% tetrazolium chloride solution was added to each vial containing the sections and kept for a day Later tissues were examined for colouration as per Monk and Wiebe (1961).

Growth analysis: Five seeds of each genotype were germinated in 2.32, 9.48, 13.65 or 17.36 dS/m EC concentrations. Concentration range was fixed based on the reports of Ashok Kumar *et al.* (1997). Paper towel method (ISTA, 1999) was used for germination test and was replicated twice. The experimental setup was maintained in germination room with a relative humidity of 70% and temperature of 27±1 °C. The growth parameters *viz.*, root length, shoot length and dry matter production were determined on the 10th day after sowing besides recording the germination percentage on the 4th day of the treatment. The observations were taken on five seedlings in each genotype at each concentration. Vigour index and percent reduction in seedling height with increasing salt concentrations were computed. The data were subjected to probit analysis to fix the ID 50 level for each genotype , the mean of the genotype across the environment and its co-efficient of variation were estimated using AGRISTAT. Genotypes were grouped as tolerant and susceptible by plotting the mean values against the co-efficient of variation in a graph.

Results and discussion

The extent of damage to the cell membrane is commercially used as a measure of tolerance to various stresses including salt (Leopold and Willing, 1983). In this experiment the degree of injury to cell membrane in a fixed concentration of salt was considered for grouping genotypes as tolerant and susceptible to surfeit salt. It is inferred that the sunflower genotypes suffered a cell membrane injury of 20.2 to 38.3 % at the concentration of 2.05 dS/m EC and injury percent escalated approximately to 20.4 % more with every 4 dS/m increase in the salt concentration (Fig. 2). The percent increase in the injury of cell membrane showed declining trend up to 17.38 dS/m EC. At this concentration (17.38 dS/m) all the genotypes exhibited more than 95% injury to the cell membrane. Genotypes among themselves exhibited greater variation in terms of percent injury towards differential salt concentrations and at any given EC level. Accordingly the genotypes *viz.*, CO2, 6B, GP 93, GP 255, GP 336 and SF 60 which had shown relatively very low injury at various salt concentrations were grouped as tolerant genotypes, concurrently 336 B, Morden, 86 B3 and CO3 were categorized as susceptible. It can be argued that tolerant genotypes adopt to stress through osmotic adjustment with an increase in cellular K^+ ions and organic acid concentrations (Blum and Ebercon, 1981).

Tetrazolium test: The highest EC salt concentration in which all the tissues developed colour in tetrazolium salt was recorded as the critical salt concentration and the genotypes were screened accordingly. The results indicated that all the genotypes developed medium red to dark red colour at the salt concentration of 0.61 dS/m EC. At the next level of salt concentration (3.39 dS/m) certain genotypes as Surya, 86B3, GP 86, SF 83, SF 30, SF 60 and SF 7 did not develop colour and categorized as susceptible genotypes. This concentration (3.39 dS/m) can be considered as critical for screening sodicity in sunflower. The genotypes SF 54, SF 34, GP 93 and 6B were grouped as tolerant as their tissues exhibited colour in the extreme concentration of 8.77 dS/m. Apart from this the genotypes CO 4, GP324, SF83, SF45 have developed colour up to 6.19 dS/m EC concentrations and this can be considered as moderately tolerant.

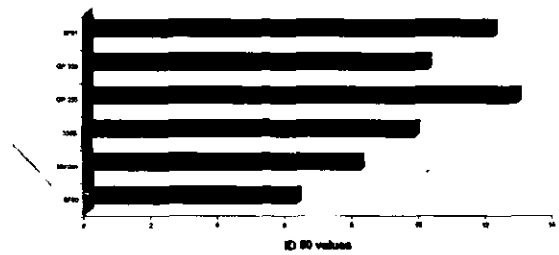


Fig 1 Effect of salt stress on seedling height reduction

Seedling growth: Owing to salt stress, the genotypes showed a general decrease in shoot length, root length, drymatter production and vigour index along with more reduction in percent germination with the increasing levels of salt *viz.*, 2.32, 5.35 and 9.48 dS/m. Such reduction in stress is attributed to the inhibition of hydrolysis of endosperm reserves (Ramana and Rama Das, 1978) and the translocation of food reserves from endosperm to embryo (Sheoran and Garg, 1978; Sharma, 1996) or induced earlier aging of tissues and extensive lignifications of the xylem elements due to salinity. Similar findings were also reported in sunflower by earlier workers (Muralidharudu *et al.*, 1998; Tekin and Bozcuk, 1998; Sajjan *et al.*, 1999).

A perusal of data on reduction in seedling height with increasing salt concentration denoted the differential responsiveness of the genotypes towards salt stress (Fig. 1). Fifty percent reduction in seedling height was attained by the genotypes at different concentrations depending upon the genotype buffering capacity to adjust with stress. The inhibition dose (ID 50) for sunflower to sodium chloride stress was reported as 66 m mol/l (Santos *et al.*, 1999). In the present study the inhibition dose ranged from 6.30 dS/m (SF 60) to 12.87 dS/m (GP

255) EC. This ID 50 value was extrapolated to group tolerant and susceptible genotypes. The genotypes that attained ID 50 at lower concentration itself were grouped as susceptible.

Based on this, SF 7, Morden, CO 2, 302 B and SF 60 were grouped as susceptible while CO 4, GP 255, SF 54, GP 161, 336 B and Surya were catagorised as tolerant. It can also be concluded that the maximum critical concentration for studying the impact of salt stress on the growth attributes is 13 dS/m.

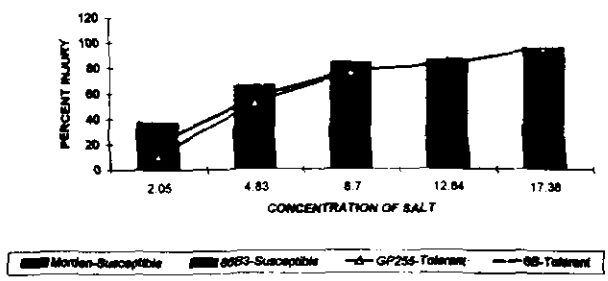


Fig 2 **Response of tolerant and susceptible genotypes to salt stress - per cent injury of cell membrane**

It is general consensus that, lower salinity or alkaline condition stimulates growth and dry matter production in certain crops (Sam Cherian *et al.*, 1999). In contrast, inhibitory effect on dry matter production and plant height is seen at higher concentrations (Polijakoff - Mayber and Lerner, 1999). Hence, the consistent performance of the genotypes at various salt concentrations can be taken as effective selection criteria for screening them for salt stress. Keeping this in view, two parameters *viz.*, dry matter production and vigour index (computed from root length +shoot length and germination%) were considered for screening tolerant and susceptible genotypes. In CV and mean plot, high mean with less CV indicates susceptibility. Thus genotypes SF 54, GP 86, CO4, 6B and GP 336 are endurant whereas 302B, Morden, 326 B and 86B3 were found out as susceptible genotypes (Fig 3 & 4).

The susceptible genotypes attained ID 50 at the concentration of 6.75 dS/m EC but the tetrazolium test and membrane integrity test revealed 50 % injury at EC values of 3.39 and 4.83 dS/m, respectively. Hence, it is concluded that 3.5 to 7.0 dS/m is the range of critical salt concentration to screen the sunflower genotypes for salt tolerance at seedling level. Based on different experiments, The genotypes GP 255, GP 336 and SF 54 were identified as tolerant while Morden, 336 B, 86B3 and SF 7 were identified as susceptible to salt stress at seedling level.

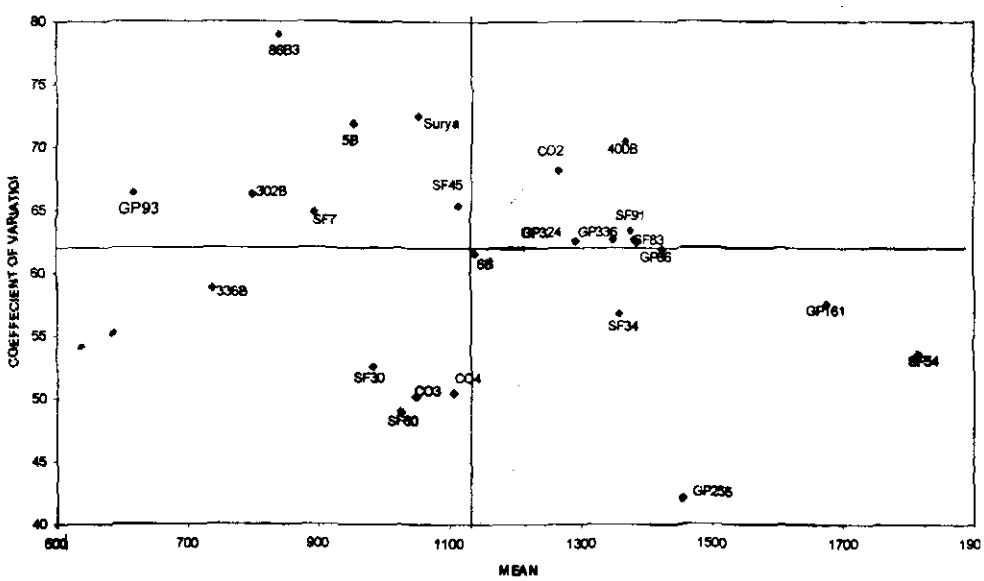


Fig 3 Genotype grouping based on vigour index

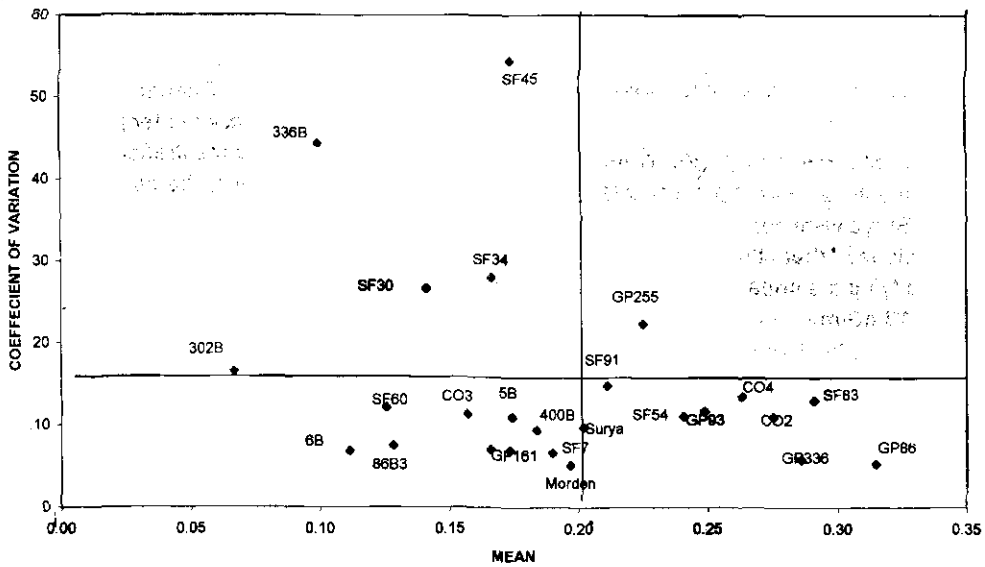


Fig-4 Genotype grouping based on drymatter production

References

Ashok Kumar, K.L., Chawla, I.H.., Sharma, M.K.., Sharma D.R and Khosla. B. K. 1997. Response of sunflower to irrigation with waters at different salinities. *Journal of Indian Society of soil Science*, **45**(2): 409-410.

Blum, A. and Ebercon, A, 1981. Cell membrane stability as a measure of drought and salt tolerance in wheat. *Crop Science*, **21**:37-47.

Delgado, I.C. and Sanchez-raya. A.J. 1998. Nutritional response of sunflower (*Helianthus annuus* L.) to Fe application under saline conditions. *Phyton (Bunes aries)* **62** (1/2): 79-86.

Hoagland, D.R. and Arnon, D.I. 1936. The water culture method for growing plants without soil. Cal. Agr. Exp. Sta. Cire. 347.

ISTA. 1999. International rules for seed testing. *Seed Science & Technology*, 27: Supplement rules.

Leopold, J. R. and Willing, B.P. 1983. Salt tolerance in soybeans. 1. *Evaluation of a technique for assessing cellular* membrane thermo stability. Crop Science, **19**: 75-78.

Monk, R.W. and Weibe, H.H. 1961. Salt tolerance and protoplasmic hardiness of various woody and herbaceous ornamental plants. *Plant Physiology*, **36**: 478-82.

Muralidharudu, Y., Haripriya, C.V., Patil, S.G., Hebbara, M. and Sastry, J.A. 1998. Effect of salinity on germination and early growth in sunflower. *Helia*, **21**(29):95-101.

Polijakoff-Mayber, A. and Lerner, H.R. 1999. Plant in saline environments. In *Handbook of Plant and Crop Stress*. Marcel Dekkar Inc., New York.

Ramana, K.V.R. and Rama Das, S. 1978. Physiological studies on the influence of salinity and alkalinity. I. Changes in growth, respiration, carbohydrates and fats during seedling growth of radish (*Raphanus sativus* L.). *Indian Journal of Plant Physiology*, **21**: 93-105.

Sajjan, A.S., Badanur, V.P. and Sajjanar, G.M. 1999. Effect of external water potential seed germination, seedling growth and vigour index in some genotypes of sunflower. Proceedings of recent advance in management of arid ecosystem. *Journal of Plant Physiology*, **155**(6): 655-672.

Sam Cherian., Reddy, M.P. and Pandya, J.B. 1999. Studies on *salt tolerance in Avicennia marina (Forstk.) Vierb: Effect* of NaCl salinity on growth, ion accumulation and enzyme activity. *Indian Journal of Plant Physiology*, **4**(4): 266-270.

Santos, C.L., Das, V. and Calderia, G. 1999. Comparative response of*I*, annuus plants and calli exposed to NaCl: 1. Growth rate and osmotic regulation in intact plants and calli. *Journal of Plant Physiology*, **4**(4): 266-270.

Sharma, S.K. 1996. Effects of salinity on uptake and distribution on Na^+, Cl^- and K^+ in two wheat cultivars. *Biologia Plantarum*, **38**(2): 261-267.

Sheoran, IS. and Garg, O.P. 1978. Effect of salinity on the activities of RNAse, DNAse and protease during germination and early seedling growth of mungbean. *Physiologia Plantarum*, **44**.171-174.

Singh, R. K and Singh, R. A. 1999. Effect of salinity on sodium, potassium and proline content of chickpea genotypes. *Indian Journal of Plant Physiology*, **4**(2): 111-113.

Tekin, F. and Bozcuk,C. 1998. Effects of salt and exogenous putrescence on seed germination and early seedling growth on *Helianthus annuus* L. var Santafe. *Turkish Journal of Biology*, **22**(3):331 -340.

J. Oilseeds Res., 21(1): 73-77 (2004)

Alley cropping and green leaf manures - effective means of integrated nutrient management for sustained returns of rainfed castor, *Ricinus communis* L.

K.P. Vani and G. Bheemaiah

Department of Forestry, College of Agriculture, A.N.G. Ranga Agril. University, Rajendranagar, Hyderabad-500 030, AP

(Received: August, 2002; Revised: August, 2003; Accepted: September, 2003)

Abstract

In a two years study, the seed yield of castor, *Ricinus communis* L. was significantly high when alley cropped with *Dalbergia sissoo* during both the years of 1996 (659 kg/ha) and 1997 (689 kg/ha) than sole cropping. Green leaf manuring with *Leucaena* resulted in much higher yields of castor with values of 626 kg/ha (1996) and 704 kg/ha (1997) when compared with other green leaf manures of *Dalbergia* and *Albizia*. Application of nitrogen significantly influenced the seed yield of castor. Conjunctive use of green leaf manure + 40 kg N/ha produced significantly on par yields of castor under alley cropping with that of 80 kg N/ha under sole cropping. Both net returns and B:C ratio were significantly high under alley cropping (Rs. 2621, 0.59) during 1996 and 1997 (Rs. 3683, 0.91). Leucaena green leaf manuring resulted in higher net returns and B:C ratio of Rs. 1626 and 0.40, respectively (1996) and Rs. 2802 and 0.69 (1997). Other sources, green leaf manures also produced equally better yields of castor. Nitrogen applied at 80 kg/ha produced higher net returns and B:C ratio. Integrated use of organic and inorganic sources of nitrogen had produced much higher returns than sole application of nitrogen or green leaf manures.

Key words: Alley cropping, green leaf manuring, castor, *Dalbergia, Albizia*

Introduction

Castor is an important oilseed crop of the country and state of Andhra Pradesh as well, largely cultivated as rainfed crop. The productivity of the crop is very low owing to poor management practices. Adoption of cropping systems and integrated nutrient management practices was the immediate thrust in oilseed research to maximise the production of oilseeds. Alley cropping, version of agroforestry, a system approach ensures use of green leaf manures, as the trees are pruned during cropping. Green leaf manures which are eco-friendly, augments the efficiency of applied fertilizer nitrogen and increases the yields and returns besides sustain the soil health (Kang *et al.*, 1990). Practices of such nature are imperative to boost the yields and returns of castor on sustainable basis in drylands. It was reported that the yields and returns of castor were high under alley cropping with subabul with green leaf manuring (Bheemaiah *et al.*, 1998). Therefore, the present study was initiated.

Materials and methods

The field experiment on response of rainfed castor to application of green leaf manures and nitrogen alley cropped with *Dalbergia sissoo* was carried out during *kharif* seasons of 1996 and 1997 at Students' Farm, College of Agriculture, Hyderabad. Double Split Plot Design was used with three replications. The soil of the experiment was low in organic carbon and available nitrogen in sole cropped area while in alley cropped area both organic carbon and available nitrogen were found medium. Similar status was observed in respect of P and K. Green leaf manures of *Albizia* and *Leucaena* were obtained from the stands nearby while *Dalbergia* green leaf was obtained by pollarding trees of the experimental area and applied along with recommended dose of P at 5 t/ha 15 days before sowing in the plots earmarked both in alley cropping and sole cropping by opening furrows. Nitrogen was applied as per the treatments. The gross and net plot size was 8 m x 4 m and 4 m x 4 m in alley and sole cropped area, respectively. The crop variety Aruna was sown on 17.7.1996 and 14.7.1997 by dibbling at a spacing of 60 x 30 cm both in alley cropped and sole cropped area and harvested on 15th October 1996 and 30th October, 1997. The gross returns were calculated taking into account the volume of wood obtained from *Dalbergia* in each plot and converted on hectare basis.

Results and discussion

Seed yields: Significant differences were observed in seed yield of castor (Table 1) due to cropping systems

with values of 659 kg/ha (1996) and 689 kg/ha (1997) under alley cropping and found superior to sole cropping of castor (505 and 607 kg/ha). The reasons attributed are reduced bulk density and improved organic matter leading to better growth and yield components. From alley cropping studies, Bheemaiah *et al.* (1998) reported similar results.

Leucaena green leaf manure (GLM_1) had resulted in significantly higher seed yield of castor during 1996 (626 kg/ha) and 1997 (704 kg/ha) over without green leaf manuring (511 and 526 kg/ha). Seed yield of castor with *Albizia* (GLM_2) and *Delbergia* (GLM_3) was also equally higher over GLM_0. However, both *Leucaena* and *Albizia* green leaves produced much better seed yields over *Dalbergia* due to less fibre and lignin content and more concentration of polyphenols as reported by Hussain *et al.* (1994).

80 kg N/ha had produced an increase of 94.5% (1996) and 98.4% (1997) seed yield over N_0 (374 and 410 kg/ha) but the increase was not much over N_{40} in both the year and significantly superior to both N_0 and N_{40}.

All the interaction effects were found significant. Alley cropping with GLM_1, AC with 80 kg N/ha and GLM_1 with 40 kg N/ha produced higher seed yields when compared to other treatments during both the years. However, alley cropping with GLM_1 at N_{40} had 760 kg/ha (1996) and 828 kg/ha (1997) which was superior over without green leaf manuring at N_{80} (745 and 725 kg/ha). Similar trend was observed under sole cropping. *Albizzia* (GLM_2) and Dalbergia (GLM_3) also produced similar effects under alley cropping with N_{40}. Presumably timely decomposition and release of nutrients as per crop demand under integrated use of GLMs and nitrogen might have lead to increased yields. Escalada and Ratilla (1998) also found that green leaf manures with nitrogen application would enhance mineralization leading to higher yields.

Table 1 Seed yield (kg/ha) of castor as influenced by cropping systems, green leaf manures and nitrogen levels

Treatment	1996				1997			
	N_0	N_{40}	N_{80}	Mean	N_0	N_{40}	N_{80}	Mean
Sole cropping (SC)								
GLM_0	263	470	570	434	271	516	663	483
GLM_1	349	618	679	548	402	743	818	654
GLM_2	335	585	666	528	406	743	823	657
GLM_3	347	529	653	510	386	694	817	632
Mean	323	551	642	505	366	674	780	607
Alley cropping (AC)								
GLM_0	348	672	745	588	352	630	725	569
GLM_1	500	760	851	704	521	828	914	754
GLM_2	428	753	833	671	480	811	883	725
GLM_3	425	756	831	671	468	791	872	710
Mean	425	735	815	659	455	765	848	689
GLM_0	305	571	657		311	573	694	
GLM_1	524	689	765		461	785	866	
GLM_2	381	669	749		443	777	853	
GLM_3	386	643	742		427	742	844	
Overall means of M.T. - Cropping systems, S.T. - Green leaf manures, S.S.T - Nitrogen levels								
M.T.	505	659			607	689		
S.T.	511	626	600	590	526	704	691	**671**
S.S.T.	374	643	728		410	719	814	

Interaction	SEd±	CD	SEd±	CD
MT	1.98	8.2	5.39	23.22
ST	5.09	11.10	7.46	16.25
MT x ST	6.54	13.83	10.61	22.59
SST	4.30	8.78	4.80	9.79
MT x SST	5.34	12.57	7.73	24.30
ST x SST	8.68	18.12	10.82	22.79
MT x ST x SST	8.22	18.51	11.97	30.90

GLM_0 - No green leaf manuring; MT = Main treatment; GLM_1 - *Leucaena* greenleaf manuring; ST = Sub-treatment
GLM_2 - *Albizia* greenleaf manuring; SST = Sub-sub treatment; GLM_3 - *Dalbergia* greenleaf manuring

Net returns: Alley cropping had higher net returns of Rs. 2621/ha (1996) and Rs. 2683/ha (1997) with an increase of 303% (1996) and 142.5% (1997) over sole cropping through increased seed yield associated with additional biomass from the trees and improved site conditions. Sharma *et al.* (1997) reported that higher net returns from alley cropping could be due to effect of trees in providing wood yield and improved soil physical properties. Significant differences were observed in net returns due to green leaf manures application with Rs. 2802/ha in GLM_1 followed by GLM_2 (Rs. 2544/ha) and GLM_3 (Rs. 2542/ha) during 1997. However, during first year, noticeable effect was not observed due to low yields of crop because of high rainfall during capsule formation stage. Application of 80 kg N/ha resulted in significantly higher net returns of Rs. 2369/ha (1996) and Rs. 3651/ha (1997) with an increase of 20.4% (1996) and 10.2% (1997) over 40 kg N/ha due to increased availability of nutrients resulting in higher yield (Table 2).

Table 2 Net returns (Rs/ha) of castor as influenced by cropping systems, green leaf manures and nitrogen levels

Treatment	1996				1997			
	N_0	N_{40}	N_{80}	Mean	N_0	N_{40}	N_{80}	Mean
Sole cropping (SC)								
GLM_0	0.0	824	1183	669	0.0	1647	2656	1434
GLM_1	0.0	955	1202	719	0.0	2324	2727	1683
GLM_2	0.0	691	1096	595	0.0	2327	1923	1417
GLM_3	0.0	646	992	546	0.0	1908	2715	1541
Mean	0.0	779	1218	665	0.0	2051	2505	1519
Alley cropping (AC)								
GLM_0	1287	2640	2978	2301	1992	4113	4680	3595
GLM_1	1255	3094	3248	2532	2170	4547	5046	3921
GLM_2	1000	3035	3438	2491	1820	4405	4779	3668
GLM_3	1000	3061	3421	2494	1727	4235	4680	3547
Mean	1135	2958	3271	2621	1927	4325	4796	3683
GLM_0	643	1732	2080		996	2880	3668	
GLM_1	627	2025	2225		1085	3436	3886	
GLM_2	500	1863	2267		910	3366	3788	
GLM_3	500	1653	2206		863	3072	3697	
Overall means of M.T. - Cropping systems, S.T. - Green leaf manures, S.S.T - Nitrogen levels								
M.T.	649	2621			1519	3683		
S.T.	1485	1626	1543	1453	2515	2802	2542	2544
S.S.T.	567	1968	2369		963	3188	3651	
Interaction		SEd±	CD		SEd±	CD		
MT		17.07	7349		103.49	445.35		
ST		47.87	104.30		113.76	247.89		
MT x ST		61.06	128.11		173.56	366.96		
SST		48.95	99.86		91.95	187.59		
MT x SST		59.05	131.64		148.27	465.97		
ST x SST		93.17	193.50		188.39	393.86		
MT x ST x SST		83.21	183.42		203.46	547.47		

All the treatments interactions influenced the net returns. Alley cropping with GLM_1 at 80 kg N/ha produced more net returns in both the years. However, the net returns obtained under alley cropping with GLM_1 at 40 kg N/ha were Rs. 3094/ha (1996) and Rs. 4547/ha (1997) and were comparable with GLM_0 at 80 kg N/ha (Rs. 2978 and Rs. 4680/ha) indicating advantage of conjunctive use of green leaf manures, nitrogen levels which might have increased the seed yield due to increased availability of nutrients. Palled *et al.* (1997) reported similar results.

Benefit cost ratio (BCR): During both the years of study alley cropping had higher BCR (0.59 and 0.91) due to high seed yield and additional wood yield. Green leaf manure had significant influence on BCR with higher values of 0.40 (1996) and 0.69 (1997) under GLM_1 followed by GLM_2, GLM_3 and GLM_0. The increase of BCR with GLM_1 over GLM_0 is marginal due to additional cost of green leaf manure application but green leaf manures would help to sustain soil health on long term basis. From an alley cropping study Bheemaiah *et al.* (1998) obtained similar B:C ratios with green leaf manuring of *Leucaena*. B:C ratio was found significantly higher with 80 kg N/ha with values of 0.59 (1996) and 0.92 (1997) (Table 3).

Interaction of different treatments significantly influenced the B:C ratio of castor in both the years. Alley cropping with green leaf manure of tree leaves with 40 kg N/ha had resulted in B:C ratio of 0.81 (1996) and 1.13 (1997) which were found higher than no green leaf manure at 80 kg N/ha (0.60 and 1.10). Therefore, that alley cropping helped to increase the yield and returns of castor than sole cropping. Green leaf manures of these nitrogen fixing trees with 50% recommended dose of nitrogen resulted in much higher yields and returns from rainfed castor.

Table 3 Benefit cost ratio of castor as influenced by cropping systems, green leaf manures and nitrogen levels

Treatment	1996				1997			
	N_0	N_{40}	N_{80}	Mean	N_0	N_{40}	N_{80}	Mean
Sole cropping (SC)								
GLM_0	0.00	0.37	0.30	0.22	0.00	0.60	0.89	0.49
GLM_1	0.00	0.24	0.28	0.17	0.00	0.58	0.65	0.41
GLM_2	0.00	0.21	0.28	0.16	0.00	0.58	0.66	0.41
GLM_3	0.00	0.19	0.25	0.15	0.00	0.48	0.64	0.37
Mean	0.00	0.25	0.27	0.17	0.00	0.56	0.71	0.42
Alley cropping (AC)								
GLM_0	0.34	0.62	0.60	0.52	0.53	1.03	1.10	0.89
GLM_1	0.34	0.77	0.77	0.75	0.58	1.13	1.19	0.97
GLM_2	0.27	0.76	0.81	0.63	0.48	1.11	1.13	0.91
GLM_3	0.27	0.77	0.81	0.61	0.44	1.06	1.10	0.87
Mean	0.31	0.73	0.75	0.59	0.51	1.08	1.13	0.91
GLM_0	0.17	0.50	0.45		0.27	0.82	0.99	
GLM_1	0.17	0.51	0.53		0.29	0.86	0.92	
GLM_2	0.14	0.49	0.56		0.24	0.85	0.89	
GLM_3	0.14	0.48	0.53		0.22	0.77	0.87	
Overall means of M.T. - Cropping systems, S.T. - Green leaf manures, S.S.T - Nitrogen levels								
M.T.	0.17	0.59			0.42	0.91		
S.T.	0.33	0.40	0.39	0.38	0.69	0.69	0.66	**0.62**
S.S.T.	0.15	0.53	0.59		0.25	0.82	0.92	

Interaction	SEd±	CD (P=0.05)	SEd±	CD (P=0.05)
MT	0.008	0.019	0.012	0.028
ST	0.011	0.024	0.013	0.031
MT x ST	0.015	0.032	0.021	0.045
SST	0.012	0.026	0.011	0.022
MT x SST	0.017	0.036	0.017	0.037
ST x SST	0.023	0.049	0.022	0.047
MT x ST x SST	0.021	0.046	0.024	0.054

References

Bheemaiah, G., Madhusudhan, T., Subrahmanyam, M.V.R. and Syed Ismail. 1998. Effect of green leaf manuring and nitrogen application on growth and yield of rainfed castor alley cropped with subabul. *Indian Journal of Agricultural Sciences*, **68**(11) : 722-725.

Escalada, R.G. and Ratilla, B.C. 1998. Effect of Leucaena biomass application in conjunction with fertilizers on Cassava and taro yields in the Philippines. *Agroforestry System*, **41** : 251-266.

Hussain, A., Arshed, M. and Javed, M. 1994. Contribution of leaves of *Dalbergia sissoo* and other leguminous trees to soil mineral nitrogen and crop nutrition. Dalbergia proceedings of an International Workshop. Ed. Sidney B, Wesley, James M, Roshekto. Nitrogen fixing tree Research Report, Special Issue.

Kang, B.T., Reynolds, L. and Atakrah, A.N. 1990. Alley farming. *Advances in Agronomy*, **43** : 315-359.

Palled, Y.B., Manuappa, K., Desia, B.K., Guggari, A.K. and Prabhakar, A.S. 1997. Effect of subabul green manuring on alley cropped maize under irrigated red soils. *Indian Journal of Agronomy*, **42**(1) : 188-190.

Sharma, D.C., Taneja, P.L. and Bisht, A.P.S. 1997. Biomass productivity and nutrient cycling in *Dalbergia sissoo* plantation. *Indian Forestry*, **114** (1-12) : 261-269.

J. Oilseeds Res., **21**(1): 78-81 (2004)

Soil test based fertiliser recommendation for sunflower, *Helianthus annuus* L. in Inceptisols of Tamil Nadu

R. Santhi, R. Natesan, K. Andi and G. Selvakumari

Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore-641 003, TN

(Received: December, 2002; Revised: September, 2003; Accepted: October, 2003)

Abstract

Soil Test Crop Response (STCR) correlation studies were conducted with sunflower on Inceptisols of Coimbatore during *kharif*, 2000 and *rabi*, 2001 and fertiliser prescription equations under Integrated Plant Nutrition System (IPNS) were developed. Using these equations, test verification trial was conducted at University farm and the fertiliser prescription equations were refined to achieve the yield targets aimed at. A ready reckoner of fertiliser doses at varying soil test values for attaining 1.5 and 2.0 t/ha yield target of sunflower have been worked out. The results have been verified in farmers' field of Coimbatore district. The percent achievement of the targets aimed was more than 90 indicating the validity of the equations for prescribing fertiliser doses for sunflower. STCR treatments recorded relatively higher Response Ratio (RR) and Benefit-Cost Ratio (BCR) over general recommended dose and farmer's practice and STCR-IPNS treatments recorded relatively higher RR and BCR over STCR-NPK alone treatments. Post – harvest soil sample analysis for NPK revealed that there is maintenance of soil fertility.

Key words: Sunflower, Inceptisols, STCR studies, test verification trials

Introduction

Oilseed crops constitute the second largest agricultural produce in India after food grains. It is observed that the energy rich oilseed crops are grown in energy starved conditions. Oilseeds are grown on poor soils, which are further becoming poorer day by day. This is the main reason for low productivity of these crops. Sunflower is one of the important oilseed crops with a very low productivity of 550 kg/ha and hence the productivity has to be improved (Mandal *et al.*, 2002). Again, increasing the crop productivity demands higher inputs, which are costly. Therefore, there is a need for improvement of input use efficiency through proper utilisation of the interaction effects of plant nutrients, by balanced nutrition of crops. However, the constant escalation of fertiliser prices in the recent years has caused a severe set back to balanced nutrition of sunflower crop too. So there is much scope to increase the productivity by exploiting full potential of sunflower by better management practices and balanced nutrition. Hence, the present study was undertaken to verify the validity of fertiliser prescription equations under IPNS for sunflower in mixed black soils of Coimbatore district and to advocate which yield target gives the highest Benefit Cost Ratio (BCR) and Response Ratio (RR) to the farmers in that region.

Materials and methods

Following the Inductive cum Targeted yield model of Ramamoorthy *et al.* (1967), Soil Test Crop Response (STCR) correlation studies were carried out and fertiliser prescription equations under IPNS were developed for sunflower as below:

$$FN = 10.29\,T - 0.45\,SN - 0.68\,ON$$
$$FP_2O_5 = 7.36\,T - 2.18\,SP - 0.80\,OP$$
$$FK_2O = 12.69\,T - 0.45\,SK - 0.64\,SK$$

To test verify these equations on mixed black soils (Perianaickenpalayam soil series), verification trial was conducted at TNAU farm, Coimbatore during *kharif*, 2000 with variety CO 2. To achieve the targeted yields, the equations were refined as below using this trial data.

$$FN = 9.60\,T - 0.49\,SN - 0.68\,ON$$
$$FP_2O_5 = 4.20\,T - 1.87\,SP - 0.80\,OP$$
$$FK_2O = 9.24\,T - 0.45\,SK - 0.64\,OK$$

where, FN, FP_2O_5, FK_2O are fertiliser doses and SN, SP, SK are soil test values in kg/ha.

NR - Nutrient requirement in kg /q of seed yield

Cs, Cf and Co is the per cent contribution of nutrients from soil, fertiliser and organic manures respectively.

T is the yield target in q/ha.

A ready reckoner of fertiliser doses at varying soil test values for attaining 1.5 and 2.0 t/ha yield targets of

sunflower have been worked out. The results were verified in farmer's field of Coimbatore district (Kalipalayam, Kovilpalayam block) during *rabi*, 2001 with variety CO 2. The initial soil $KMnO_4$-N, Olsen-P and NH_4OAC-K of TNAU farm soil were 196, 9.0 and 810 kg / ha and that of farmer's field were 204, 30 and 560 kg/ha respectively. There were six treatments, which were replicated four times in a randomized block design. The treatment details and doses of fertilisers applied are furnished in Tables 1 and 2. Based on initial soil tests for NPK and targets aimed at, fertiliser doses were applied for STCR treatments.

For IPNS treatments, FYM @ 12.5 t/ha was applied basally, along with 50% N, and full P_2O_5 and K_2O. Fifty per cent of N was top dressed on 30th day after sowing. Routine agronomic practices were carried out periodically. Seed yield was recorded at harvest. Using the data on seed yield, fertiliser doses applied and cost of fertiliser inputs and produce, the parameters *viz.*, Response Ratio (RR) and Benefit – Cost Ratio (BCR) were worked out (Response Ratio = Response in kg/ha/Quantities of fertiliser N, P_2O_5 and K_2O applied in kg/ha; Benefit–Cost Ratio = Cost of additional seed yield over control/Cost of fertiliser N, P_2O_5 and K_2O applied).

Post-harvest soil samples were also collected and analysed for the status of available N (Subbiah and Asija, 1956), available P (Olsen *et al.*, 1954) and available K (Hanway and Heidal, 1952).

Results and discussion

In both the locations, the highest seed yield was recorded with 2.0 t/ha – IPNS treatment, which was on par with 2.0 t/ha – NPK alone followed by 1.5 t/ha - IPNS and 1.5 t/ha - NPK alone (Table 1 and 2). The seed yields recorded under STCR treatments were significantly higher than that under general recommended and farmer's practice/control. The mean seed yield ranged from 530 kg/ha in control to 1665 kg/ha in 2.0 t/ha – IPNS treatment in TNAU Farm and from 1346 kg/ha in farmer's practice to 1890 kg/ha in 2.0 t/ha IPNS treatment. The highest percent achievement of the yield targets aimed at was recorded with 1.5 t/ha yield targets (97.0 – 101.7). However, the 2 t/ha yield target was not achieved during *kharif*, 2000 and hence, the basic parameters *viz.*, the nutrient requirement, the contribution of nutrients from soil and fertiliser were refined using this trial data (Table 3). The refined fertiliser prescription equations were again test verified during *rabi*, 2001 and it was found that both the yield targets (1.5 and 2.0 t/ha) tested were achievable. Yield targeting with IPNS recorded relatively higher percent achievement than that aimed under NPK alone (Tables 1 and 2). This might be ascribed to the release of nutrient ions with mineralisation of organic manures, which helps in maintaining the continuous availability of nutrients throughout the crop growth (Khatik and Dikshit, 2001). The positive influence of IPNS in increasing the seed yield of sunflower was also reported by Mandal *et al.* (2002).

Table 1 Test verification trial on sunflower (TNAU Farm, Coimbatore)

Treatment	Fertiliser nutrient doses applied (kg/ha)			Seed yield (kg/ha)	% achieve-ment	RR (kg/kg)	BCR	Post-harvest soil sample value (kg/ha)		
	N	P_2O_5	K_2O					N	P	K
General recommended dose	40	20	20	925	-	4.94	2.33	192	9.0	796
1.5 t/ha - NPK alone	66	91	10*	1360	90.7	4.97	3.39	200	11.0	804
2.0 t/ha - NPK alone	118	128	10*	1610	80.5	4.22	2.95	214	12.0	795
1.5 t/ha - IPNS**	26	69	5*	1455	97.0	9.25	3.91	210	13.0	834
2.0 t/ha - IPNS**	78	106	5*	1665	83.3	6.00	3.17	228	12.0	851
Control	0	0	0	530	-	-	-	180	8.0	650
SEd±				58				7	0.84	12
CD (P=0.05)				124				16	1.79	24

* Maintenance dose; ** IPNS-FYM @ 12.5 t/ha

Table 2 Test verification trial on sunflower (Farmer's field, Coimbatore)

Treatment	*Fertiliser nutrient doses applied (kg/ha)*			Seed yield (kg/ha)	% achieve-ment	RR (kg/kg)	BCR	*Post-harvest soil sample value (kg/ha)*		
	N	P_2O_5	K_2O					N	P	K
Blanket	40	20	20	1400	-	6.26	4.88	200	28	560
1.5 t/ha - NPK alone	44	7	10	1415	94.3	7.66	5.19	202	32	576
2.0 t/ha - NPK alone	92	28	10	1812	90.6	6.86	5.24	210	30	565
1.5 t/ha - IPNS**	14	5*	5*	1526	101.7	8.81	7.67	220	34	580
2.0 t/ha - IPNS**	62	13	5*	1890	94.5	7.33	7.40	224	32	584
Farmer's practice	50	40	50	1346	-	4.76	4.35	202	34	580
SEd±				53				6	3	9
CD (P=0.05)				113				13	7	20

RR = Response Ratio; BCR = Benefit Cost Ratio; * Maintenance dose; **IPNS-FYM @ 12.5 t/ha

Table 3 Soil test based fertiliser recommendations for various yield targets of sunflower (kg/ha)

	Basic data				*Fertiliser adjustment equations*	*Response ratio (kg/kg)*
	NR (kg/q)	CS (%)	CF (%)	CO (%)		
N	2.56	13.2	26.78	18.21	$FN = 9.60\ T - 0.49\ SN - 0.68\ ON$	4.3
P	1.44	27.93	34.20	11.95	$FP_2O_5 = 4.20\ T - 1.87\ SP - 0.80\ OP$	
K	2.68	10.79	29.00	15.34	$FK_2O = 9.24\ T - 0.45\ SK - 0.64\ OK$	

Soil Test Values (kg/ha)			Yield targets (t/ha)					
			1.5 t/ha of seed yield			2.0 t/ha of seed yield		
$KMnO_4$-N	Olsen-P	NH_4OAC-K	FN	FP_2O_5	FK_2O	FN	FP_2O_5	FK_2O
150	8	200	70	48	49	119	70	95
160	10	210	66	44	44	114	65	90
170	12	220	61	41	40	109	62	86
180	14	230	56	36	35	104	58	81
190	16	240	51	33	31	99	54	77
200	18	250	46	29	26	94	50	72
210	20	260	41	26	22	89	47	68
220	22	270	36	22	17	84	43	63
230	24	280	31	18	13	79	39	59
240	26	290	26	14	8	74	35	54

The mean response ratio (RR) for various treatments ranged from 4.94 kg/kg in general recommended dose to 9.25 kg/kg in 1.5 t/ha – IPNS treatment in TNAU Farm and from 4.76 kg/kg in farmer's practice to 8.81 kg/kg in 1.5 t/ha – IPNS treatment. Between the two targets tried, targeting for 1.5 t/ha recorded relatively higher RR than with 2.0 t/ha though it has recorded significantly higher yields. Likewise IPNS treatments recorded higher RR when compared to the respective NPK alone treatments. General recommended dose recorded 4.94 – 6.26 kg/kg, which is lower than STCR treatments (Tables 1 and 2).

The mean BCR ranged from 2.33 in blanket to 3.91 in 1.5 t/ha – IPNS in TNAU farm and from 4.35 in farmer's practice to 7.67 in 1.5 t/ha–IPNS. The trend of results is same, as that of RR. Between the targets aimed, 1.5 t/ha recorded higher BCR over 2.0 t/ha. When NPK alone and IPNS treatments were compared, IPNS recorded higher BCR (Tables 1 and 2). Though the yields recorded under NPK alone and IPNS were statistically on par there is saving of fertiliser inputs and utilisation of FYM available in the farm holdings, which has reflected in terms of BCR. The beneficial effect of organics on the economics of crop production was also reported by Khatik and Dikshit (2001).

The data on $KMnO_4$-N, Olsen-P and NH_4OAc-K indicated the built up and maintenance of soil fertility due to soil test based fertiliser recommendation and IPNS. The increase could be due to the contribution of nutrient sources and enrichment of available pool of the soil. The favourable effect of FYM on fertility status of soil may be attributed to greater availability of nutrients to plants in the presence of organic manures due to their solubilising effect of different forms of nutrients present in soil and their own contribution (Subba Rao *et al.*, 1998). Therefore for getting targeted yields and profit with sunflower in black soils of Tamil Nadu, soil test based fertiliser recommendation under IPNS could be followed (Table 3).

References

Hanway, J.J. and Heidal, H. 1952. Soil analysis methods as used in Iowa State College, Soil Testing Laboratory. *Iowa State College Agriculture Bulletin*, **57**: 1-13.

Khatik, S.K. and Dikshit, P.R. 2001. Integrated use of organic manures and inorganic fertilisers on yield, quality, economics and nutrition of sunflower grown in Haplustert clay soil. *Agricultural Science Digest*, **21**(2): 87-90.

Mandal, K.G., Ghosh, P.K., Wanjari, R.H., Hati, K. M. and Bandyopadhyay, K. K. 2002. Practical implication of nutrient x nutrient interaction to boost oilseeds productivity in India. *Fertiliser News*, **47**(7): 13-26.

Olsen, S.R.,Cole, C.V., Watanabe, F. S. and Dean, L.A. 1954. Estimation of available Phosphorus in soils by extraction with sodium bicarbonate. *U.S.D.A. Circular No.* 939.

Ramamoorthy, B., Narasimham, R.L. and Dinesh, R.S. 1967. Fertiliser application for specific yield targets of Sonora 64 (wheat). *Indian Farming*, **17** (5): 43-45

Subba Rao, A., Damodar Reddy, D., Sammi Reddy, K and Takkar, P.N. 1998. Crop yields and phosphorus recovery in soybean-wheat cropping system on a Typic Haplustert under integrated use of manure and fertilizer phosphorous. *Journal of the Indian Society of Soil Science*, **46**: 249-253.

Subbiah, B.V. and Asija, G.L. 1956. A rapid procedure for determination of available nitrogen in rice soils. *Current Science*, **31**: 196.

J. Oilseeds Res., **21**(1): 82-85 (2004)

Effect of preceding *kharif* legumes and levels of NPK on the succeeding *rabi* sunflower, *Helianthus annuus* L.

C.R. Chinnamuthu, A.S. Venkatakrishnan and P. Manickasundaram

Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore-641 003, Tamil Nadu

(Received: June, 2003; Revised: August, 2003; Accepted: October, 2003)

Abstract

Field experiments were carried out for three years in *kharif-rabi* sequence to evaluate the performance of *rabi* sunflower raised with different levels of NPK succeeding *kharif* leguminous crops *viz.*, urdbean, mungbean, soybean and groundnut. Sunflower succeeding *kharif* groundnut recorded the highest seed yield in all the three years of experimentation and the increase was 38, 70 and 86% over fallow-sunflower system. Recommended dose of NPK to sunflower recorded higher plant height, head diameter, 100 seed weight and seed yield compared to 75, 50% NPK and no fertilizer application. The *interaction indicated that application of 100%* recommended NPK to *rabi* sunflower grown after *kharif* groundnut recorded significantly higher seed yield than the other sequences in all the three years of study.

Key words: Legumes, fertilizer and sequence

Introduction

Crop rotation assumes greater significance in sustaining the crop productivity and soil fertility. Continuous cultivation of exhaustive crops impairs the soil fertility (Sanjay Kumar and Prasad, 1999). Monocropping has a negative effect on enzymatic activities particularly in soils of rainfed areas showing lower values of microbiological and biochemical properties than native soils (Pascual *et al.*, 2001). Continuous cropping of maize, wheat/sunflower recorded lower yields as compared to growing these crops in sequence with legumes. The low yield under monocropping can be attributed to removal of nutrients and moisture from the same soil depth over years (Palaniappan, 1985). Sunflower yields are often low when grown after small grains or corn than after legumes. Crop rotation supported by scientific fertilizer management can lead to sustained productivity besides, maintaining soil fertility and keeping weeds, insects, and pests under control. Studies are available with nutrient management for sunflower in different context. The present study is aimed at selection of suitable *kharif* legumes preceding *rabi* sunflower and to appraise the nutrient requirement of sunflower succeeding legumes for maximum and profitable productivity.

Materials and methods

Field experiments were conducted in the research farm of Tamil Nadu Agricultural University, Coimbatore for three years (1997-1999) in *kharif* (June-September) - *rabi* (November-February) sequence. The experiment was laid out in Split Plot Design with three replications. The type of the experimental site was sandy loam and neutral in reaction. The soil available nutrient status of nitrogen, phosphorus and potash was medium, low and high, respectively.

The study was carried out under protective irrigation. During *kharif* season, the legume crops *viz.*, groundnut, soybean, mungbean and urdbean along with one fallow treatment for comparison were assigned to the main plots and sowing was taken up during June-July. After the harvest of legume crops, sunflower was raised during *rabi*, dividing each main plot into four subplots and assigning the fertilizer levels (Table 2). The recommended dose of 40:20:20 kg/ha NPK was applied to sunflower as per treatment through urea, single super phosphate and muriate of potash, respectively. Entire quantity of phosphorus and potassium and 50% nitrogen was applied as basal at the time of sowing. The remaining 50% nitrogen was applied as top dressing 30 days after sowing. Sunflower was raised on ridges and furrows with a spacing of 45 cm between rows and 30 cm between plants. The yield and yield attributing data was recorded and economics was worked out.

Results and discussion

The data on growth and yield attributes showed that the plant height, head diameter and test weight were favourably influenced by both the cropping sequences and fertilizer levels tried (Table 1). Among the crop sequences studied, sunflower, succeeding groundnut significantly influenced the yield parameters in all three years of experimentation recording the highest plant height, head diameter and test weight of seed. Application of 100% of

NPK fertilizer positively influenced all the yield attributing characters. The interaction effect of crop sequence and fertilizer levels was found to be significant. Application of 100% recommended dose of fertilizer to sunflower under groundnut-sunflower sequence recorded the highest values of growth and yield parameters.

Sunflower succeeding groundnut recorded highest seed yield in all the three years of study (Table 2). The seed yield increase in groundnut-sunflower sequence was 70% compared with that of fallow sunflower sequence. Similarly legumes preceding sunflower also increased the seed yield of sunflower compared with that grown after fallow and the increase was 37, 34 and 30% with urdbean, mungbean and soybean, respectively. The beneficial residual effect of legumes on the succeeding crops in sequence is quite evident, supporting the findings of many earlier workers (Misra and Rout, 1996; Dwivedi *et al.*, 1998; Sanjay Kumar and Prasad, 1999).

With regard to application of fertilizers, a linear increase was noticed with increasing levels of fertilizer and the highest seed yield was recorded with application of 100% recommended dose of NPK to sunflower. The interaction effect of crop sequences and fertilizer levels was significant during all the three years of study and a linear and progressive yield increase was observed under groundnut-sunflower cropping sequence combined with the application of graded levels of fertilizer. The highest seed yield of 1239 kg/ha of sunflower was recorded under groundnut-sunflower cropping sequence with application of 100% of recommended dose of fertilizer. The yield increase with application of full recommended dose under groundnut-sunflower sequence was 51.5% compared with that of fallow-sunflower with 100% fertilizer application to sunflower. Thus the beneficial influence of groundnut as a preceding legume was much pronounced with application of higher levels of fertilizer in increasing the productivity of succeeding sunflower.

The economic analysis of the results (Table 3) indicated that among the crop sequences, groundnut-sunflower was most remunerative in terms of gross and net returns with the benefit cost ratio of 4.78. Urdbean and mungbean were also found to be remunerative compared with that of fallow treatment registering increased returns and cost benefit ratio. Among the fertilizer levels a progressive increase in gross returns, net returns and benefit cost ratio was observed with the increasing levels of fertilizer application. The maximum benefit cost ratio of 3.68 was obtained with the application of 100% recommended dose of fertilizer.

It is evident from the study that groundnut must be preferred as a preceding legume during *kharif* for enhancing the productivity of succeeding sunflower and 100% recommended dose of fertilizer to sunflower may be applied for maximizing the system productivity.

Table 1 Morphological attributes of sunflower as influenced by treatments

Treatment	Plant height (cm)			Head diameter (cm)			100 seed weight (g)		
	1997	1998	1999	1997	1998	1999	1997	1998	1999
Crop sequence									
Urdbean-Sunflower	135	134	136	10.6	10.9	11.2	4.0	3.9	3.8
Mungbean-Sunflower	132	130	132	10.4	10.7	10.9	3.9	3.9	3.9
Soybean-Sunflower	132	131	133	10.3	10.5	10.6	3.8	3.8	3.9
Groundnut-Sunflower	138	139	140	11.9	12.3	12.4	4.1	4.1	4.1
Fallow-Sunflower	126	124	127	9.7	9.1	9.8	3.7	3.7	3.8
SEm±	0.75	0.56	0.75	0.10	0.11	0.12	0.04	0.03	0.04
CD (P=0.05)	2.4	1.8	2.4	0.33	0.37	0.41	0.14	0.10	0.13
Fertilizer Levels									
Control	125	126	128	10.0	10.1	10.2	3.5	3.5	3.5
50% NPK	131	130	132	10.8	10.5	11.0	4.0	3.8	4.0
75% NPK	134	134	135	11.2	10.9	11.7	4.0	4.0	4.1
100% NPK	138	137	137	11.8	11.3	12.3	4.2	4.1	4.2
SEm±	0.60	0.53	0.60	0.06	0.05	0.06	0.02	0.02	0.02
CD (P=0.05)	1.7	1.5	1.7	0.17	0.14	0.18	0.07	0.06	0.06

Varieties : Groundnut cv. VIR 2; Soybean cv. CO 1; Mungbean cv. CO 3; Sunflower cv. CO 3

Table 2 Seed yield of sunflower (kg/ha) as influenced by the treatments

Treatment	Fertilizer levels				
	Control	50% NPK	75% NPK	100% NPK	Mean
First year (1997)					
Urdbean-Sunflower	582	854	994	1051	870
Mungbean-Sunflower	565	844	987	1019	854
Soybean-Sunflower	575	781	854	1058	817
Groundnut-Sunflower	568	935	985	1184	918
Fallow-Sunflower	381	553	795	940	667
Mean	534	793	923	1050	
Second year (1998)					
Urdbean-Sunflower	650	874	992	1264	945
Mungbean-Sunflower	646	846	1070	1194	939
Soybean-Sunflower	654	790	987	1269	925
Groundnut-Sunflower	1136	1258	1296	1294	1246
Fallow-Sunflower	536	644	696	744	655
Mean	724	882	1008	1153	
Third year (1999)					
Urdbean-Sunflower	568	774	922	1022	822
Mungbean-Sunflower	544	757	897	1001	800
Soybean-Sunflower	544	755	846	978	781
Groundnut-Sunflower	743	934	1149	1238	1016
Fallow-Sunflower	443	748	634	769	599
Mean	568	754	890	1002	

	1997		1998		1999	
	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)
Sequence	17	56	16	36	5	17
Fertilizer	25	72	7	14	5	15
F at S	23	52	15	31	11	32
S at F	24	59	15	33	11	33

Table 3 Economic analysis of the treatments (Rs/ha)

Treatment	Mean over three years				
	Sunflower Equivalent yield (kg/ha)	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio (Rs/ha)
Crop sequence					
Urdbean-Sunflower	2425	6364	23356	16992	3.67
Mungbean-Sunflower	2541	6380	24472	18092	3.84
Soybean-Sunflower	2067	7656	19902	12246	2.60
Groundnut-Sunflower	3626	7303	34921	27618	4.78
Fallow-Sunflower	640	3056	6161	3005	1.95
Fertilizer levels to sunflower					
Control	-	5789	19417	13628	3.35
50% NPK	-	6123	21313	15190	3.48
75% NPK	-	6304	22509	16205	3.57
100% NPK	-	6470	23810	17340	3.68

References

Dwivedi, V.D., Namdeo, K.N. and Chaurasia, S.C. 1998. Economic feasibility of legume and non-legume based double cropping systems under rainfed conditions. Indian Journal of Agronomy, **43**(3): 404-406.

Misra, M. and Rout, K.K. 1996. Effect of agronomic management practices on soil fertility under jute (*Corchorus capsularis*) - groundnut (*Arachis hypgaea*) - blackgram (*Phaseolus mungo*) cropping system. *Indian Journal of Agronomy*, **41** (4): 546-549.

Palaniappan, S.P. 1985. *Cropping systems in the tropics: Principles and Management*. Wiley Eastern Limited and Tamil Nadu Agricultural University. pp.33.

Pascual, J. Ros, A.M., Hernandez, T. and Garcia, C. 2001. Effect of long-term monoculture on microbiological and biochemical properties in semiarid soils. *Communications in Soil Science and Plant Analysis*. **32** (3-4): 537-552.

Sanjay Kumar and Prasad, N.K. 1999. Soil fertility and yield as influenced by different legume-wheat (*Ttiticum aestivum*) sequences. *Indian Journal of Agronomy*, **44** (3) : 488-492.

J. Oilseeds Res., **21**(1): 86-91 (2004)

Comparative performance of some water production functions for spring sunflower, *Helianthus annuus* L.

Ramani Kanta Thakuria[1], Harbir Singh[2] and R.K. Jhorar[3]

Chaudhary Charan Singh Haryana Agricultural University, Hisar-125 004, Haryana

(Received: March, 2003; Revised: July, 2003; Accepted: September, 2003)

Abstract

Results are presented of a two-year study comparing performance of some water production functions for spring sunflower under four irrigational treatments, *viz.*, one irrigation at seedling; two, one each at seedling and buttoning; three, one each at seedling, buttoning and flowering; four, one each at seedling, buttoning, flowering and seed developing stage, along with a no post sown irrigation – control, averaged over four antitranspirant treatments, *viz.*, kaolin ($H_2 Al_2 Si_2 O_8 H_2 O$ @ 7 %), Alar (B9 / $C_5 H_{12} N_2 O_3$ @ 0.001 %), potassium sulphate ($K_2 SO_4$ @ 4 %) along with a no antitranspirant – control. Crop production functions, relating seed yield of sunflower with consumptive use of water (CU)/ evapotranspiration (ET) with and without consideration of time of water deficit during crop growth sub-periods, were derived. The total growing season of sunflower was divided into five sub–periods. Eleven water production functions, including seven that did not consider growth stage during water deficit and four that did, were tested to quantify the relationship between sunflower seed yield and CU. Values of R^2 for water production functions relating seed yield of sunflower and total season CU (ET) were significant ($P < 0.05$ or $P < 0.01$) and ranged from 0.92 to 0.99. Sunflower was sensitive to water deficit during buttoning, flowering to seed development / maturity stage (reproductive phase). In general, water production functions that considered growth stages during water deficit explained well-observed yield differences.

Key words: Irrigation, seasonal evapotranspiration /consumptive use, seed yield, sunflower, water production functions, water stress

Introduction

Crop production depends on the environmental factors and genetic constitution of crop plant. Climatic, biotic and adaphic parameters are some of major components of the crop environment and may be manipulated by management towards increased crop yields (Flinn, 1971). Water is scarce in most of the dry regions of the world. Limited availability of water at any stage of crop growth, particularly at the critical stage, influences its yield. Therefore, supplemental supply of water by artificial means is inevitable. The functional form of relationship between yield and water use by plants (crop water production function) helps in optimizing the use of scarce water supply and prediction of crop yield / profitability of irrigation. The linear and non linear form of water production functions, both with and without considering the time of water deficit have been developed and used for various crops (Neghassi *et al.*, 1975; Rahman *et al.*, 1980; Singh *et al.*, 1987; Singh *et al.*, 2001[a & b]) under different conditions. The present investigation was undertaken for spring sunflower (*Helianthus annuus* L.) grown on sandy loam soil to compare the performance of some crop production functions under variable irrigations.

Materials and methods

The experiment was conducted on sunflower hybrid 'MSFH-8' during spring seasons of 1999-2000 and 2000-2001 at Chaudhary Charan Singh Haryana Agricultural University Farm, Hisar (75.46° E, 22.10° N, 215.0 m above msl). The experimental soil, a sandy loam (*Typic ustochrepts*), contained soil moisture 17.72 % at – 0.03 MPa and 7.42 % at – 1.5 MPa on gravimetric basis with bulk density of 1.39 – 1.44 g / cc. The soil contained 176.5 kg available N, 17.0 kg available P and 301.0 kg available K / ha and had alkaline reaction (pH, 8.2). The weather during 2000-2001 was dry (4.0 mm rainfall in May) but cloudy at later (reproductive phase) stage. During first year (1999-2000) 1.0, 14.0, 24.0 mm showers were received during February, May and June,

[1] Scientist (Agronomy), Regional Agricultural Research Station, Assam Agricultural University, North Lakhimpur, Assam.
[2 and 3] Professor (Agronomy) and Associate Professor (Soil Water Engineering), respectively.

respectively. The mean pan evaporation was 3.1, 4.8, 9.6, 10.4 and 9.9 mm / day (1999-2000) and 3.0, 4.6, 9.3, 10.4 and 11.7 mm / day (2000-2001) during February, March, April, May and June, respectively. The treatments consisted of five irrigation levels [no post sown irrigation (unirrigated), 1 irrigation at seedling, 2, one each at seedling and buttoning, 3, one each at seedling, buttoning and flowering, and 4, one each at seedling, buttoning, flowering, and seed developing stage] in main plots and four treatments of antitranspirant [Kaolin ($H_2 Al_2 Si_2 O_8 H_2 O$ @ 7.0 %), Alar (B_9 / $C_5 H_{12} N_2 O_3$ @ 0.001 %), Potassium sulphate ($K_2 SO_4$ @ 4.0%) and no antitranspirant spray –control] in sub plots, replicated thrice in split block / strip plot design. Sunflower hybrid 'MSFH-8' was sown on 18 February 1999 and 24 February 2000 by dibbling the seed at 30 cm interval in rows 60 cm apart. Phosphorus @ 50 kg / ha (uniform) and half of the nitrogen (50 kg / ha) were applied at the time of sowing and remaining half (50 kg / ha) was top-dressed after first irrigation / after seedling stage. A buffer channel of 0.5 m width was provided on all sides of main plot. The seasonal evapotranspiration (ET) / consumptive use of water (CU) was computed as water added + effective rainfall + D soil water. Due to low intensity, all the rain received was considered as effective rainfall.

The initial production functions were developed without considering the crop stage at which water deficit occurred, i.e., relationship between yield and total seasonal evapotranspiration (ET). Five such equations were adopted and compared from those summarized by Nagel (1974):

Linear: $Y = a + b\,(ET)$ (i)

Quadratic: $Y = a + b\,(ET) + c\,(ET)^2$ (ii)

Cubic: $Y = a + b\,(ET) + c\,(ET)^2 + d\,(ET)^3$ (iii)

Square root: $Y = a + b\,(ET) + c\,(ET)^{0.5}$ (iv)

Power function: $Y = a.\,(ET)^b$ (v)

Where, Y = crop yield, seed / grain yield or dry matter yield; ET = total seasonal ET and a, b, c and d = empirically drived constants.

By replacing ET in equation (i) with ET deficit (maximum seasonal ET minus actual ET), Stewart (1972) proposed the following relationship:

Stewart (1972) $$Y = a + b\left(\frac{ET_d}{ET_m}\right) \quad [vi]$$

Where, ET_d = seasonal ET deficit, and ET_m = maximum seasonal ET i.e. ET with unlimited water availability.

Water deficit (expressed as soil water deficit / plant water deficit / ET deficit) is related to the amount by which stress reduces crop yield (Hiler and Clark, 1971). Keeping this in view, Singh *et al.* (1987) proposed the following relationship to relate crop yield with the seasonal ET deficit without considering the time of water deficit:

Singh *et al.* (1987) $$Y = a + b\left\{1 - \left(1 - \frac{ET}{ET_m}\right)^2\right\} \quad [vi]$$

The timing of water deficit may be more important than the magnitude in predicting the yield as water deficit timing greatly influenced the crop yield (Hiler and Clark, 1971; Stewart, 1972; Barrett and Skogerboe, 1980). Nagel (1974) suggested that the crop growth stage during water deficit must be considered for any yield function to be representative. Therefore, crop water production functions considering time of water deficit at various stages of crop growth after Jensen (1968), Stewart (1972), Minhas *et al.* (1974) and Singh *et al.* (1987) were also considered in present analysis. These crop production functions might be expressed as:

Jensen (1969): $$\frac{Y}{Ym} = a\prod_{i=1}^{n}\left(1 - \frac{ET}{ETm}\right)_i^{\lambda i} \quad [viii]$$

Stewart (1972): $$\frac{Y}{Ym} = a + \sum_{i=1}^{n}\lambda_i\left(1 - \frac{ET}{ETm}\right)_i \quad [ix]$$

Minhas *et al.* (1974): $$\frac{Y}{Ym} = a\prod_{i=1}^{n}\lambda_i\left\{1 - \left(1 - \frac{ET}{ETm}\right)_i^2\right\}^{\lambda_i} \quad [x]$$

Singh *et al.* (1987): $$Y = a + \sum_{i=1}^{n}\lambda_i\left\{1 - \left(1 - \frac{ET}{ET_m}\right)^2\right\}_i \quad [xi]$$

Where, Y_m = maximum crop yield which occurred when a crop reached ET_m, i = integer number of crop growth stages / sub periods, å = represents series summation, Õ = represented series multiplication, a = empirically derived constant, and li= empirically developed factor which quantified crop sensitivity to water stress during different growth stages / sub-periods.

The sunflower plant growth period from sowing to maturity was divided into five growth sub-periods as: i. Sub-period I covering 0 to 30 DAS (sowing to seedling), ii. Sub-period II covering 31 to50 DAS (seedling to buttoning), iii. Sub-period III covering 51 to 70 DAS (buttoning to flowering), iv. Sub-period IV covering 71 to 90 DAS (flowering to seed development complete) and v. Sub-period V covering 91 to 115/116 DAS (seed development complete to maturity).

Results and discussion

Data on seed yield and consumptive water use (CU) / ET measured during different crop growth stages / sub-periods and seasonal CU (total) for various irrigational treatments are presented in Table 1. Individual observation of CU and seed yield (2 replications) rather than mean values were used for the development of water production functions for sunflower hybrid 'MSFH-8'.

Table 1 ***Seed yield (kg/ha), consumptive use of water (mm) during different growth stages/sub-periods and seasonal consumptive water use of sunflower as influenced by irrigation***

Treatment	Seed yield (kg/ha)	Consumptive water use (mm)					
		Crop growth stages/sub-periods*					
		a	b	c	d	e	f
1999-2000							
No post sowing irrigation (unirrigated)	727	59.63	51.93	34.51	28.50	29.85	204.42
1 irrigation at seedling stage	1212	59.63	84.82	49.67	33.82	33.52	261.46
2 irrigations one each at seedling, and buttoning stage	1583	59.63	84.82	101.13	34.66	34.46	314.7
3 irrigations one each at seedling, buttoning and flowering stage	1908	59.63	84.82	102.95	69.53	35.17	352.1
4 irrigations one each at seedling, buttoning and flowering and seed developing stage	2193	59.63	84.82	103.34	70.44	60.45	378.68
L S D (P =0.05)	145	-	-	-	-	-	-
2000-2001							
No post sowing irrigation (unirrigated)	363	62.53	54.61	26.16	24.46	15.10	182.86
1 irrigation at seedling stage	912	62.53	84.22	51.61	26.63	21.54	246.53
2 irrigations one each at seedling, and buttoning stage	1281	62.53	84.22	97.32	31.26	22.46	297.59
3 irrigations one each at seedling, buttoning and flowering stage	1540	62.53	84.22	99.50	57.05	24.77	328.07
4 irrigations one each at seedling, buttoning and flowering and seed developing stage	*1750*	*62.53*	*84.22*	*98.93*	*58.98*	*56.53*	*361.19*
L S D (P =0.05)	133	-	-	-	-	-	-
Pooled							
No post sowing irrigation (unirrigated)	545	61.08	53.27	30.34	26.48	22.47	193.64
1 irrigation at seedling stage	1062	61.08	84.52	50.64	30.23	27.53	254.00
2 irrigations one each at seedling, and buttoning stage	1432	61.08	84.52	99.23	32.96	28.45	306.24
3 irrigations one each at seedling, buttoning and flowering stage	1724	61.08	84.52	101.23	63.29	29.97	340.12
4 irrigations one each at seedling, buttoning and flowering and seed developing stage	1971	61.08	84.52	101.13	64.71	58.50	369.97
L S D (P =0.05)	142	-	-	-	-	-	-

* a sowing to seedling (0-30DAS), b seedling to buttoning (31-50 DAS), c buttoning to flowering (51-70 DAS); d flowering to seed development completion (71-90 DAS), e seed development completion to harvest maturity (91-115 / 116 DAS), f Season's total

Production functions with out considering time of water deficit

The estimated values of the regression coefficients for water production functions (linear, quadratic, third degree polynomial, square root, power, Stewart, 1972, Singh *et al.*, 1987) relating seed yield of sunflower and seasonal consumptive use (CU) / evapotranspiration (ET) with out considering time of water deficit ranged from 0.90 to 0.99 in 1999-2000, from 0.94 to 0.99 in 2000-2001, and from 0.92 to 0.99 for pooled data (Table 2). The F values for testing R^2 were significant (P=0.01) in most of the cases except Singh *et al.* (1987) where it was non significant though R^2 values were very high. One or more of regression coefficients for quadratic (Eq. 2) and square root (Eq. 4) during two years and for pooled data were non significant. Similarly, third degree polynomial (Eq. 3) had both the regression coefficients non significant during 2000-2001. The water production function after Stewart, 1972 (Eq. 6) may be expressed in linear term. Therefore, R^2, F and t values for regression coefficient equal that of the linear function (Eq. 1) – Table 2. In general, marginal yield decreased with increase in CU / ET and therefore, the relationship between yield and CU / ET should be non linear (Nagel, 1974; Barrett and Skogerboe, 1980). Considering the non linearity of CU / ET yield relation for sunflower hybrid 'MSFH-8', third degree polynomial and power functions may be considered appropriate. The linear (Eq. 1 and Eq. 6) also performed well and are simple to describe the relationship between seasonal CU/ ET and seed yield of sunflower.

Table 2 Estimated values of regression constant and coefficients and statistical parameters for testing crop production functions for sunflower without considering time of water deficit

Crop production functions	Regression constant and coefficients and t# values for testing coefficients				R^2	F values for testing R^2
	a	b	c	d		
1999-2000						
Linear [Eq. i]	-955.696	8.193(40.95)*	-	-	0.9952	1677.17**
Quadratic [Eq. ii]	-461.642	4.630(2.14)^{NS}	0.0061(1.66)^{NS}	-	0.9965	1022.41**
Third degree polynomial [Eq. iii]	-5454.571	58.869(12.07)**	-0.185(-10.81)**	0.0002(11.18)**	0.9998	12790.64**
Square root [Eq. iv]	775.154	14.333(3.26)*	-207.482(-1.40)^{NS}	-	0.9962	939.84**
Power [Eq. v]	0.067	1.753(38.02)**	-	-	0.9945	1445.23**
Stewart (1972) [Eq. vi]	2149.604	-3105.30(-40.95)**	-	-	0.9952	1677.17**
Singh *et al.* (1987) [Eq. vii]	-4215.16	6157.54(8.69)**	-	-	0.9042	75.52^{ns}
2000-2001						
Linear [Eq. i]	-1029.72	7.735(48.37)**	-	-	0.9965	2339.72**
Quadratic [Eq. ii]	-1317.69	9.988(6.43)**	-0.0042(-1.46)^{ns}	-	0.9973	1335.31**
Third degree polynomial [Eq. iii]	-1515.59	12.313(0.81)^{ns}	-0.0129(-0.22)^{ns}	-	0.9974	765.98*
Square root [Eq. iv]	-2198.58	3.243(1.07)^{ns}	146.013(1.48)^{ns}	-	0.9974	1345.15**
Power [Eq. v]	0.0026	2.291(18.63)**	-	-	0.9774	347.21*
Stewart (1972) [Eq. vi]	1769.94	-2799.66(-48.37)**	-	-	0.9965	2339.72**
Singh *et al.* (1987) [Eq. vii]	-3610.47	5172.125(10.78)**	-	-	0.9356	116.13^{ns}
Pooled						
Linear [Eq. i]	-991.536	7.967(67.13)**	-	-	0.9982	4506.81**
Quadratic [Eq. ii]	-917.235	7.410(5.31)**	0.00099(0.40)^{ns}	-	0.9982	2017.21**
Third degree polynomial [Eq. iii]	-3159.28	32.716(3.37)*	-0.0912(-2.59)*	0.00011(2.62)*	0.9991	2474.72**
Square root [Eq. iv]	-810.151	8.636(3.14)*	-22.185(-0.24)^{ns}	-	0.9982	1988.49**
Power [Eq. v]	0.019	1.959(27.83)**	-	-	0.9897	774.49*
Stewart (1972) [Eq. vi]	1960.260	-2951.8(-67.13)**	-	-	0.9982	4506.81**
Singh *et al.* (1987) [Eq. vii]	-3393.78	5645.49(9.63)**	-	-	0.9206	92.78^{ns}

The values in parenthesis are t-values, * Statistically significant (P=0.05),
** Statistically significant (P=0.01), NS= Statistically not significant (P=0.05)

Production functions considering time of water deficit

R^2 values for various production functions considering time of water deficit during different growth sub-periods have been very high (Table 3). The F values for testing R^2 for various production functions were significant (P=0.01). In general, seed yield of sunflower was represented well by different production functions under study with high R^2 and F values. The magnitude and significance of sensitivity factors (I_i), however, varied during crop growth sub-periods for different production functions. Various functions (Jensen, 1968; Stewart, 1972; Minhas *et al.*, 1974; Singh *et al.*, 1987) had significant regression coefficients (I) in 1999-2000, 2000-2001 and pooled data as well. Based upon pooled data, degree of sensitivity of seed yield by water deficit /stress during different growth stages as measured by the absolute values of the sensitivity factor (I) decreased in order of sub-period II (seedling to buttoning), III (buttoning to flowering), IV (flowering to seed development complete) and V (seed development complete to maturity) for most of the water production functions (Table 3 and Fig. 1). This indicated that sunflower crop was sensitive to water deficit spanning over buttoning, flowering to seed development/harvest maturity (reproductive phase). Field studies (Baldev Raj *et al.*, 1999; Singh *et al.*, 2001[a]) have shown water deficit during reproductive phase caused maximum reduction in seed yield of sunflower.

Table 3 Estimated values of regression constant and coefficients and statistical parameters for testing crop production functions for sunflower considering time of water deficit

Crop production functions	Regression constant and coefficients and t[#] values for testing regression coefficients					R^2	F values for testing R^2
	A (intercept)	II (I_2)	III (I_3)	IV (I_4)	V (I_5)		
1999-2000							
Jensen (1968) [Eq.viii]	0.999	0.639(42.20)**	0.350(42.79)**	0.253(29.88)**	0.258(24.29)**	0.9998	1169.13**
Stewart (1972) [Eq. ix]	0.999	-0.349(-27.22)**	-0.315(-36.29)**	-0.278(-31.41)**	-0.312(-29.90)**	0.9998	7526.55**
Minhas *et al.* (1974) [Eq. x]	0.997	1.079(13.39)**	0.766(27.38)**	0.604(20.38)**	0.725(17.05)**	0.9997	5267.13**
Singh *et al.* (1987) [Eq. xi]	-1.083	0.238(3.76)*	0.551(21.05)**	0.548(19.90)**	0.742(19.56)**	0.9995	2911.69**
2000-2001							
Jensen (1968) [Eq.viii]	0.981	1.231(11.67)**	0.431(9.84)**	0.305(6.94)**	0.135(4.45)**	0.9990	1331.66**
Stewart (1972) [Eq. ix]	0.991	-0.504(-12.92)	-0.368(-15.15)**	-0.341(-13.52)**	-0.187(-9.83)**	0.9990	1866.90**
Minhas *et al.* (1974) [Eq. x]	0.992	2.369(3.52)	0.910(6.89)**	0.712(6.02)**	0.311(4.40)**	0.9987	1031.92**
Singh *et al.* (1987) [Eq. xi]	-0.928	0.316(1.05)	0.607(7.31)	0.643(8.46)**	0.354(7.17)**	0.9983	766.13**
Pooled							
Jensen (1968) [Eq.viii]	0.993	0.844(32.61)	0.386(30.77)	0.273(21.34)**	0.192(16.00)**	0.9998	8368.32**
Stewart (1972) [Eq. ix]	0.996	-0.411(-28.69)	-0.34(-36.53)	-0.303(-31.57)**	-0.246(-27.16)**	0.9998	8850.46**
Minhas *et al.* (1974) [Eq. x]	0.994	1.434(11.37)	0.835(24.39)	0.648(19.00)**	0.479(15.09)**	0.9998	6651.34**
Singh *et al.* (1987) [Eq. xi]	-0.912	0.226(2.77)	0.584(20.63)	0.584(20.69)**	0.512(19.26)**	0.9996	3851.89**

[#] The values in parenthesis are t-values, * Statistically significant (P= 0.05),
** Statistically significant (P=0.01), NS= Statistically not significant (P= 0.05)

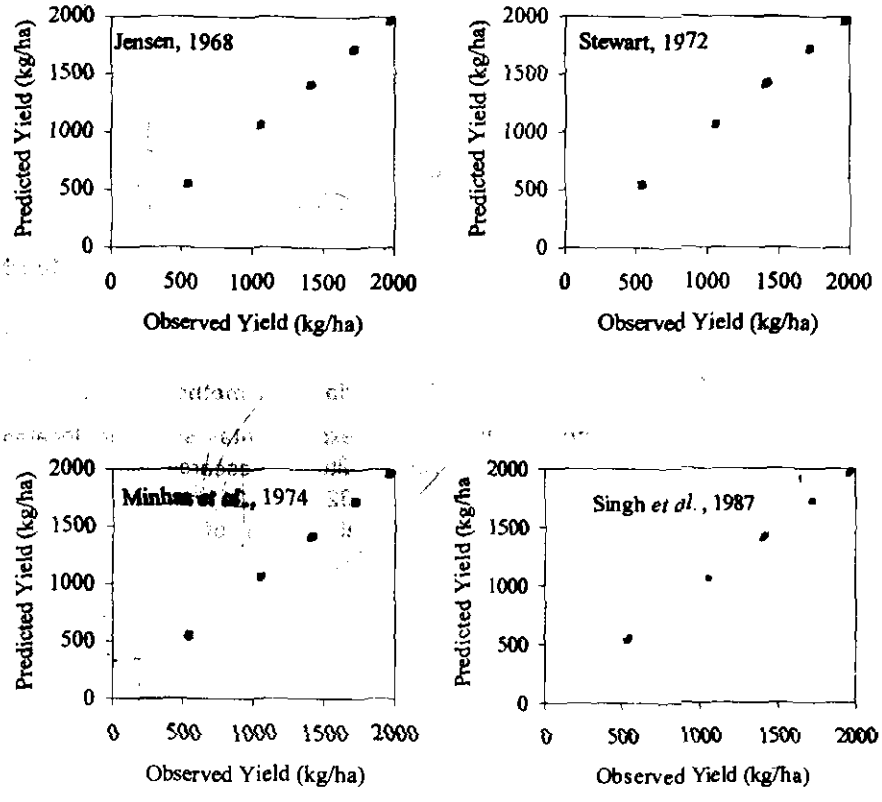


Fig-1 Relationship between observed yield (pooled) and predicted yields by four methods on sunflower hybrid "MSFH-8" subjected to water deficit at different growth stages

References

Baldev Raj, Singh, T. and Singh, Harbir 1999. Genotypes, irrigation and fertility effects on seed yield, water use and water-use efficiency of spring sunflower (*Helianthus annuus*). *Indian Journal of Agricultural Sciences*, **69** (2): 101-105.

Barrett, J.W.H. and Skogerboe, V.1980. Crop production function and the allocation and use of irrigation water. *Agriculture Water Management*, **3**:53-58.

Flinn, J.C.1971. The simulation of irrigation systems. In Dent, J.B. and Anderson, J.R. (eds.) *System Analysis in Agricultural Management*. Wiley and Sons, Australia, pp.123-151.

Hiler, E.A. and Clark, R.N.1971. Stress day index to characterize effect of water stress on crop yield. *Transactions of American Society of Agricultural Engineers*, **14**:757-765.

Jensen, M.E.1968. Water consumption by agricultural plants. In Kozlowskie, T.T. (ed.) *Water deficit and plant growth*. Vol. II. Academic Press New York, pp.,1-22.

Minhas, B.S., Parikh, K.S. and Srinivasan, T.N. 1974. Towards the structure of a production function for wheat yield with dated inputs of irrigation. *Water Resources Research*, **10**:383-393.

Nagel, F.W. 1974. Water yield relation in wheat –growing in Negev (Israel). *International Communication of Irrigation and Drainage Memoirs*, **2**: 264-309.

Neghassi, H.M., Heerman, D.F. and Smika, D.F. 1975. Wheat yield models with limited soil water. *Transactions of American Society of Agricultural Engineers*, **18**: 549-553.

Rahman, S.M., Talukdar, S.V., Kaul, A.K. and Biswas, M.R. 1980. Yield response of semi dwarf wheat variety to irrigation on a calcareous brown flood plain soil of Bangladesh. *Agriculture Water Management*, **3**: 217-225.

Singh, Harbir, Singh, M., Jhorar, R.K., Singh, T. and Singh, V.P. 2001[a]. Some water production functions for predicting yield of sunflower (*Helianthus annuus* L.) as influenced by water use. *Crop Research*, **21**(3): 312-316.

Singh, Harbir, Ingram, K.T. and Jhorar, R.K. 2001[b]. Comparison of some water production functions for rice. *Tropical Agriculture (Trinidad)*, **78**:95-103.

Singh, P., Wolkewitz, H. and Kumar, R. 1987. Comparative performance of different crop production functions for wheat (*Triticum aestivum* L.). *Irrigation Science*, **8**: 273-290.

Stewart, J.I. 1972. Prediction of water production functions and associated irrigation programme to minimize crop yield and profit losses due to limited water. Thesis, University of California, Davis, U.S.A. 225pp.

J. Oilseeds Res., **21**(1): 92-94 (2004)

Optimization of sunflower, *Helianthus annuus* L. production under resource constraints

P. Sesha Saila Sree, V. Sridhar and D. Swapna Sree

Regional Agricultural Research Station, Acharya N.G. Ranga Agricultural University, **Nandyal-518 503, Andhra Pradesh**

(Received: August, 2003; Revised: November, 2003; Accepted: December, 2003)

Abstract

Field experiments were conducted during *kharif* seasons of 2000,2001 and 2002 at Regional Agricultural Research Station, Nandyal, AP to assess the combination of production factors on growth and yield of sunflower in Vertisols. The results indicated that adoption of whole package of practices *viz.*, fertilizer + plant protection + thinning + weeding resulted in significantly higher seed yield (1217 kg/ha) and net returns (Rs. 11285/ha). Among the various single factor production constraints, weeding was found to be most crucial followed by thinning, fertilizer and plant protection. With two-factor limitation, either without fertilizer or thinning or plant protection, sunflower seed yield was reduced by 42% as compared to full package. Absence of weeding along with fertilizer and thinning together reduced the sunflower yield by 68.3%.

Key words: Sunflower, production constraints

Introduction

Sunflower, *Helianthus annuus* L. in recent years, gained importance due to its wider adaptability, short duration, photo insensitivity, allows it to be fitted into various cropping systems. Despite the impressive increase in acreage and production over the last two decades, average productivity of sunflower remained far low (681 kg/ha) (Anonymous, 2002-03). Different production factors (fertilizer, thinning, weeding and plant protection) contribute towards the crop stand, plant growth and ultimately the yield of sunflower. Though the input management had been given due importance, the percent contribution, or the losses due to their non-availability to the sunflower crop are yet to be quantified under scarce Rainfall Zone of Andhra Pradesh. Hence the experiment was conducted to identify the major constraints and their contribution in sunflower production under rainfed conditions.

Materials and methods

The experimental site was located at the Regional Agricultural Research Station, Nandyal, AP (15°29' E,78°32' N and 211 m above mean sea level and average annual rainfall of 750 mm). The experiment was conducted for three consecutive years 2000, 2001 and 2002 during *kharif* season on deep black soil with pH 8.2, low in available N (174 kg/ha), medium in available P_2O_5 (20.4 kg/ha) and high in available K_2O (284 kg/ha). The experiment was laid out in Randomized Block Design with nine treatments replicated four times on sunflower hybrid KBSH-1. Gross plot size of the experiment was 5.4 m x 4.8 m and the net plot size was 4.2 m x 4.2 m. The treatments consisted of full package and deletion of one or more inputs like fertilizer, plant protection, thinning and weeding (Table 1). Sunflower crop was sown by dropping seed behind the plough in marked row width of 60 cm. A uniform dose of 60 kg N + 60 kg P_2O_5 + 30 kg K_2O/ha through urea, single super phosphate and muriate of potash, respectively was applied to the treatments including fertilizer. Entire quantity of P and K fertilizers and half quantity of N was applied as basal and remaining half quantity of N was top dressed at 30-35 days after sowing (DAS). Plant protection measures consisted of seed treatment with Imidacloprid @ 5g/kg seed as protection against thrips and spraying of chemicals as and when the pest/disease incidence was noticed. The treatments involving thinning operation comprised of thinning the plant population at 10-15 DAS leaving one plant/hill in order to maintain optimum plant stand of 55,555 plants/ha. Weeding operation comprised of intercultivation followed by hand weeding twice at 20 and 40 DAS. Rainfall during 2000, 2001 and 2002 amounted to 1004, 371.8 and 290.6 mm, respectively.

Results and discussion

Growth and yield components : Adoption of full package of practices resulted in significant enhancement of head diameter, filled seeds/head and 100 seed weight of sunflower during all the three years of experimentation (Fig. 1a, 1b and 1c) as well as in pooled results (Table 1).

Among the single factors of production, thinning followed by weeding operations resulted in significantly lower head diameter, lowest number of filled seeds/head and 100 seed weight as compared to fertilizer and plant protection measures. With two-factor limitation, either without fertilizer or plant protection; and without thinning resulted in significantly lowest head diameter compared to exclusion of fertilizer and plant protection from full package. Deletion of fertilizer + thinning from full package resulted in 19 and 7% reduction in filled seeds/head compared to deletion of either fertilizer or thinning along with plant protection, respectively over years (Table 1). When all the three factors *viz.*, fertilizer, thinning and weeding were not adopted, reduction in head diameter, filled seeds and 100 seed weight to the extent of 38%, 52% and 23% respectively was observed as compared to adoption of full package of practices.

Table 1 Yield attributes and yield of sunflower under resource constraints (Pooled mean over three years, 2000-2002)

Treatment	Plant height (cm)	Head diameter (cm)	No. of filled seed head	100-seed weight (g)	Seed yield (kg/ha)	Percent reduction in yield over FP	Net returns (Rs/ha)	B:C ratio
Full Package (FP)	115	12	653	4.3	1217	-	11285	2.61
FP - Fertilizer (F)	104	11	552	3.8	840	31.0	7632	2.53
FP - Plant protection (PP)	116	11	574	4.1	977	19.7	8180	2.26
FP - Thinning (T)	112	9	378	3.6	758	37.7	4685	1.69
FP - Weeding (W)	104	9	440	3.7	574	52.8	1785	1.25
FP - (F + PP)	106	11	490	3.7	809	33.5	7662	2.71
FP - (PP +T)	113	9	426	3.6	712	41.5	4355	1.68
FP - (F + T)	112	9	397	3.6	737	39.4	6242	2.29
FP - (F + T + W)	108	7	316	3.3	386	68.3	1262	1.27
SEm±	405	0.6	40	0.1	96	-		
CD (P=0.05)	NS	1.8	116	0.3	281	-		

Seed yield : The production constraint factors resulted in significant yield reduction, which was in the order of weeding > fertilizer > plant protection > thinning during 2000 (Table 1). However, in subsequent years and in pooled results it was in the order of weeding > thinning > plant protection > fertilizer application (Fig 1d).

Adoption of full package of practices produced maximum seed yield of sunflower. The yields were significantly reduced in absence of any of four production factors either alone as fertilizers, plant protection, thinning and weeding or in combinations as fertilizer + plant protection, plant protection + thinning, fertilizer + thinning and fertilizer + plant protection + weeding. Studies conducted at various locations also indicated the need for adoption of full package of practices to obtain the highest yield of sunflower (Anonymous, 1998-99, 1999-2000, 2000-01 and 2001-02).

On an average, full package of practices resulted in achieving highest yield of 1217 kg/ha which was reduced to 52.8%, 37.7%, 31% and 19.7% without weeding, thinning, fertilizer and plant protection, respectively. The combinations of different resource constraints further reduced the yield of sunflower. Fertilizer, thinning and weeding operations together accounted for 68.3% of total production influencing through head diameter, filled seeds and 100 seed weight while plant height remained unchanged.

Economics: Economics indicated that full package rendered the highest gross (Rs 18255/ha) and net (Rs 11285/ha) returns while the highest value of B: C ratio (2.71) was recorded with full package without fertilizer and plant protection followed by full package (2.61).

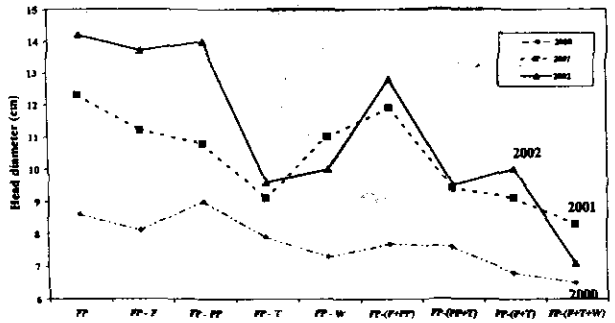


Fig 1a. Head diameter

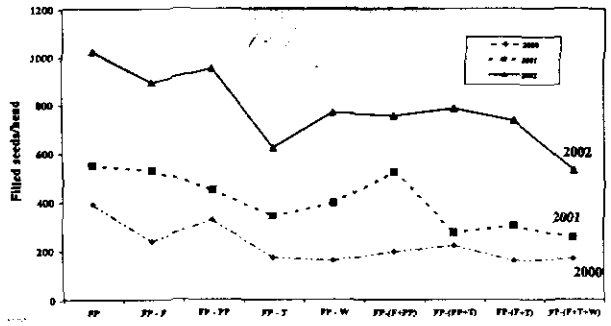


Fig 1b. Filled seeds per head

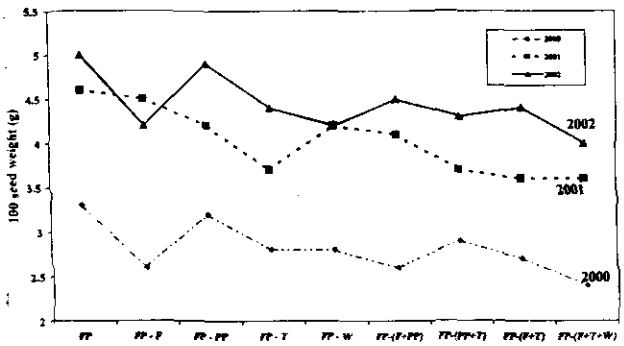


Fig 1c. 100 seed weight

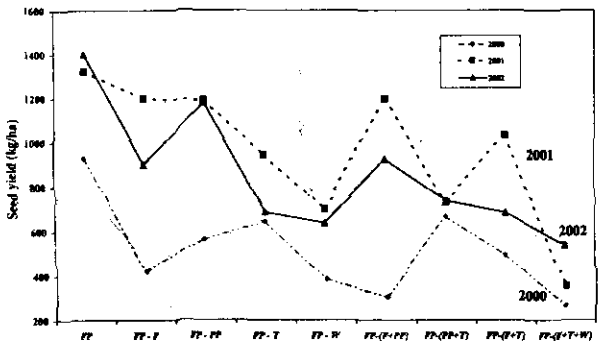


Fig 1d. Seed yield

Fig. Yield attributes and yield of sunflower during 2000, 2001 and 2002

References

Anonymons. 1998-1999. *Annual Progress Report of Sunflower.* Directorate of Oilseeds Research, Hyderabad 500030 AP. pp., 109-112.

Anonymons. 1999-2000. *Annual Progress Report of Sunflower.* Directorate of Oilseeds Research, Hyderabad 500030 AP. pp., 109-112.

Anonymons. 2000-2001. *Annual Progress Report of Sunflower.* Directorate of Oilseeds Research, Hyderabad 500030 AP. pp., 109-112.

Anonymons. 2001-2002. *Annual Progress Report of Sunflower.* Directorate of Oilseeds Research, Hyderabad 500030 AP. pp., 109-112.

Anonymons. 2002-2003. *Annual Progress Report of Sunflower.* Directorate of Oilseeds Research, Hyderabad 500030 AP. pp., 109-112.

J. Oilseeds Res., **21**(1): 95-97 (2004)

Herbicidal management of weeds in sesame, *Sesamum indicum* Linn.

Malam Singh Chandawat, I. Singh and M.S. Rathore

Dept. of Agronomy, Agricultural Research Station, Rajasthan Agril. University, Mandor, Jodhpur-342 304, Rajasthan

(Received: September, 2002; Revised: July, 2003; Accepted: September, 2003)

Abstract

A field experiment was conducted during *Kharif* seasons of 1994, 1995 and 1996 at ARS, Mandor revealed that pre plant incorporation of alachlor granules @ 2 kg/ha followed by weeding at 30 days after sowing (DAS) proved to be the best weed management tool providing maximum seed yield (713 kg/ha), net return (Rs. 10,736/ha) and B:C ratio (1: 2.17).This treatment also gave the highest weed control efficiency (86%) and the lowest weed competition index. Though hand weeding twice at 20 and 30 DAS minimized weed count and weed biomass and gave seed yield equivalent to alachlor granules PPI @ 2 kg/ha + weeding at 30 DAS but it was found to be uneconomic to the farmers because of lower benefit : cost ratio (1.89:1).

Key words: Alachlor, pendimethalin, metalachlor, hand weeding, sesame

Introduction

Weed infestation in sesame (*Sesamum indicum* Linn.) is one of the main factors for loss in yield to the tune of 15–80 %. Weeds drain the fertilizers applied and moisture conserved before sowing and thus has a greatest competitive effect on crop. The conventional method of weed control is time consuming, expensive and laborious. It is more favourable to use chemicals due to scarcity in availability of human labour during peak season (Kannan and Wahab, 1995). Therefore, the present attempt has been made to identify a suitable weed management practice in sesame grown in the arid Western plains of Rajasthan.

Materials and methods

An investigation was under taken during rainy seasons (*kharif*) of 1994, 1995 and 1996 at Agricultural Research Station, Mandor, Jodhpur on loamy sand soils (aridisol) having pH 8.1, low nitrogen (170 kg/ha), medium phosphorus (23 kg/ha) and high potassium content (330 kg/ha). The experiment, consisting of twelve treatments was laid out in Randomized Block Design with four replications (Table 1). The plot size was 5 m x 3 m. Sesame variety "RT 46" was sown with onset of monsoon in every season at 30 x 15 cm (row x plant) spacing. The crop was fertilized with 40 kg N (half as basal and half 30 DAS) and 20 kg P_2O_5/ha as basal dose. Alachlor granules were incorporated in the plots prior to sowing whereas, liquid formulations were applied with the help of knapsack sprayer fitted with flat fan T- jet nozzle at spray volume of 750 l/ha. The crop received 302, 336 and 548 mm rain during 1994, 1995 and 1996 growing seasons, respectively. The predominant weeds in crop were *Amaranthus spinosus, Cenchrus biflorus, Trianthema portulacastrum, Boerhaavia diffusa, Cynodon dactylon* (L.) Pers., *Tribulus terrestris, Euphorbia microphylla, Phyllanthus niruri, Digera arvensis, Corchorus tridens, Heliotropium ovalifolium, Portulaca oleracea* and *Celosia argentia* etc.

Results and discussion

Effect on weeds: A reference to weed data in Table 1 revealed that all the herbicidal treatments with or without weeding recorded significant reduction both in population and biomass compared to weedy check at 20, 30 DAS and harvest. The lowest weed count and biomass throughout the crop growth cycle was recorded with pre-plant incorporation of alachlor granules @ 2 kg/ha along with one hand weeding at 30 DAS. The number of weed/m^2 with this treatment was 24 at 20 DAS, which was reduced to 4 at harvest stage. At harvest stage, the weed dry matter was reduced by 435 g/m^2 with pre plant incorporation of alachlor granules @ 2 kg/ha + weeding at 30 DAS (71 g/sq. m) compared to un weeded check (506 g/sq. m).

Effect on crop: All the weed control treatments significantly improved the yield and its parameters over weedy check (Table 2). Use of alachlor granules @ 2 kg/ha along with one hand weeding at 30 DAS yielded maximum numbers of primary branches/plant (4.5), capsules/plant (63) and plant height (127 cm) which were reflected on the highest yield of sesame (713 kg/ha). These parameters were at par with that observed under hand weeding twice at 20 and 30 DAS and use of alachlor

liquid @ 1.5 kg/ha as pre emergence application followed by hand weeding at 30 DAS. On pooled basis, pre plant incorporation of alachlor granules @ 2 kg/ha + hand weeding at 30 DAS and pre emergence application of alachalor liquid @ 1.5 kg/ha + hand weeding at 30 DAS increased the seed yield by 424 and 381 kg/ha over weedy check, respectively. Chauhan and Gurjar (1998) and Singh *et al.* (2001) also reported similar results in sesame. Role of hand weeding followed by use of chemical was proven essential. Use of alachlor granules @ 2 kg/ha as pre plant incorporation with out any hand weeding gave significant increase of 211 kg/ha in seed yield over weedy check. When this treatment was super imposed with one hand weeding at 30 DAS further increase of 213 kg/ha in seed yield was observed. Similar trend of significance was observed in all weed control treatments. Pre-emergence application of metolachlor @ 2 kg/ha + one hand weeding at 30 DAS and pendimethalin @ 0.5 kg/ha were proven superior over weedy check but, the magnitude of increase in seed yield due to these treatments was not equivalent to that of alachlor granules @ 2 kg/ha and alachlor liquid @ 1.5 kg/ha + one hand weeding at 30 DAS. Results are in close conformity with the findings of Ibrahim *et al.* (1988); Kannan and Wahab (1995).

Table 1 Effect of different weed management practices on weed population, weed dry matter, weed competition index and weed control efficiency in sesame (pooled data of three seasons)

Treatment	No. of weeds/sq.m			Weed drymatter (g/sq.m)			Weed competition index (%)	Weed control efficiency (%)
	20 DAS	30 DAS	Harvest	20 DAS	30 DAS	Harvest		
Unweeded check	163	163	124	62.2	71.9	506	59.3	0
Hand weeding at 20 DAS	137	10	10	57.4	26.5	114	31.5	77
Hand weeding at 30 DAS	167	159	10	60.8	33.3	104	28.7	79
Hand weeding at 20 and 30 DAS	142	11	8	60.7	16.4	71	0.0	86
Alachlor (liquid @ 1.5 kg /ha) PE	24	24	8	13.5	18.3	210	32.3	58
Alachlor (liquid @ 1.5 kg /ha) PE + Hand weeding at 30 DAS	25	26	4	17.9	22.9	62	5.6	88
Alachlor (granules @ 2 kg/ha) PPI	19	18	4	16.7	20.9	180	29.6	64
Alachlor (granules @ 2 kg/ha) PPI + Hand weeding at 30 DAS	24	25	4	16.6	21.2	71	0.0	86
Pendimethalin (@ 0.5 kg /ha) PE	42	41	10	27.8	30.1	207	40.6	59
Pendimethalin (@ 0.5 kg /ha) PE + Hand weeding at 30 DAS	42	43	8	22.7	25.9	62	23.5	88
Metolachlor (@ 2 kg /ha) PE	39	38	10	33.5	38.2	303	39.4	40
Metolachlor (@ 2 kg /ha) PE + Hand weeding at 30 DAS	32	32	6	22.3	29.1	75	22.1	85
CD (P=0.05)	23	22	2	9.4	9.4	45	-	-

DAS = Days after sowing; PE = Pre-emergence

Table 2 **Effect of different weed management practices on yield attributes, seed yield and net returns of sesame (pooled data of three seasons)**

Treatment	Plant height (cm)	Primary branches/ plant	Capsules/ plant	Test weight (g)	Seed yield (kg/ha)				Net returns (kg/ha)	B:C ratio
					1994	1995	1996	Pooled		
Unweeded check	104	3.1	32.8	2.65	300	44	523	289	3358	1.11
Hand weeding at 20 DAS	120	4.0	49.3	2.77	565	85	808	486	6492	1.54
Hand weeding at 30 DAS	119	3.8	49.1	2.77	643	86	788	506	6932	1.65
Hand weeding at 20 and 30 DAS	125	4.3	62.0	2.83	809	128	1194	710	10220	1.89
Alachlor (liquid @ 1.5 kg /ha) PE	122	4.1	49.4	2.73	400	109	933	481	6882	1.86
Alachlor (liquid @ 1.5 kg / ha) PE + Hand weeding at 30 DAS	127	4.3	59.7	2.82	818	117	1075	670	9990	2.10
Alachlor (granules @ 2 kg /ha) PPI	122	4.2	51.1	2.76	390	111	1000	500	7000	1.75
Alachlor (granules @ 2 kg/ha) PPI + Hand weeding 30 DAS	127	4.5	61.5	2.80	825	132	1183	713	10736	2.17
Pendimethalin (@ 0.5 kg /ha) PE	112	3.6	44.1	2.74	383	82	800	422	5484	1.44
Pendimethalin (@ 0.5 kg /ha) PE + Hand weeding 30 DAS	122	3.8	54.1	2.70	590	111	927	543	7096	1.46
Metolachlor (@ 2 kg /ha) PE	121	3.7	44.4	2.74	332	85	873	430	5060	1.15
Metolachlor (@ 2 kg /ha) PE + Hand weeding at 30 DAS	121	4.0	52.3	2.75	512	108	1040	553	6716	1.23
CD (P=0.05)	7.7	0.4	05.2	0.08	143	22	137	190	-	-

HW = Hand weeding, DAS = Days after sowing, PE = Pre-emergence and PPI = Pre-plant incorporation

Economics of weed management: Pre plant incorporation of alachlor granule @ 2 kg/ha + one hand weeding at 30 DAS was the most economical treatment giving maximum net returns of Rs 10,736/ha with a benefit cost ratio of 2.17:1. Next in order was hand weeding twice at 20 and 30 DAS (Rs.10,220/ha) closely followed by pre emergence application of alachlor liquid @ 1.5 kg/ha + one hand weeding at 30 DAS (Rs 9,990/ha). Therefore, the present finding suggest that application of alachlor granule @ 2 kg/ha followed by one hand weeding at 30 DAS can provide better cost effective weed management in sesame.

References

Chauhan, D. V. S. and Gurjar, B. S. 1998. Mechanical and chemical weed control in sesame. (*Sesamum indicum L.*). *Indian Journal of Agronomy*, **43** : 480-483.

Ibrahim, A. F., El Wekil, H. R., Yehia, Z. R. and Shaban, S. A. 1988. Effect of some weed control treatments on sesame (Sesamum indicum Linn.) and associated weeds. *Journal of Agronomy and Crop Science*,**160** (5): 319-324.

Kannan, K. and Wahab, K. 1995. Economics of nitrogen and weed management in sesame. *Madras Agricultural Journal*, **82** (2): 154-155.

Singh, P. K., Om Prakash and Singh, B. P. 2001. Studies on the effect of N-fertilization and weed control technique on weed suppression, yield and nutrients uptake in sesame (Sesamum indicum Linn.). *Indian Journal of Weed Science*, **33**(3&4) :139-142.

J. Oilseeds Res., **21**(1): 98-103 (2004)

Population dynamics of aphids (*Aphis craccivora* Koch and *Hysteroneura setariae* Thomes) in relation to weather parameters in groundnut, *Arachis hypogaea* L.

V. Nandagopal, M.V. Gedia and A.D. Makwana

National Research Centre for Groundnut, Ivnagar Road, P.B. No.5, Junagadh-362 **001, Gujarat**

(Received: April, 2003; Revised: November, 2003; Accepted: December, 2003)

Abstract

The peak population of aphid *Aphis craccivora* Koch groundnuts was recorded between December and January and much lower populations from April to September. *Hysteroneura setariae* Thomes population was very low. The multiple correlation of *A. craccivora* population with parameters like Temperature (av.), soil temperature (10 cm depth) and vapour pressure have been found significant (r=0.59 and 0.53 for *A. craccivora* for cropped and fallow area). The multiple correlation coefficients were 0.59 and 0.53 with weather parameters for *A. craccivora* in crop and fallow respectively. The cylindrical trap with castor oil as glue worked well in trapping the aphid populations.

Key words: Population dynamics, *Aphis craccivora, Hysteroneura setariae,* groundnut

Introduction

Aphids were not considered to be a serious pest of groundnut until late 1980s (Brar and Sandhu, 1975; Brar, 1981; Padgham *et al.,* 1990; Nandagopal, 1992). Seven species of aphids were recorded on groundnut as vectors of Peanut Stripe Virus (PSTV) (Singh *et al.,* 1993), with *A. craccivora* as the major species, causing pod losses up to 40%. With a heavy infestation, plants become chlorotic and leaves curl, but Rangaswamy and Rao (1964) reported that the pod formation is also adversely affected. Another species *H. setariae* transmits four viruses in other crops.

Forecasting pest abundance and its timing are the important aspects of Integrated Pest Management (Dent, 1991). Though the presence of *A. craccivora* is recorded throughout the year, its dispersal is most noticeable when the populations are abundant, especially in summer (Dixon, 1985). Precise information is lacking on the factors affecting the population abundance and survival of aphids on groundnut in this region. Therefore the present study was initiated.

Materials and methods

Field experiments were conducted from 1993 to 2000 at NRCG, Junagadh, Gujarat. Groundnuts were sown in the first week of every month in a 25 m^2 (5 row 5m length) plot, which forms a part of 20 ha of the rainy season crop. A yellow plastic tray (36 x 24 x 6 cm) with 5 cm depth filled with water was used as a trap. Ten ml of kerosene was added to the water. A flat sticky trap was made up of a square (22 cm) 175 μm thick PVC sheet, on both sides of which castor oil was smeared. It was fitted to a bamboo stick at a height of 40 cm. A cylindrical sticky trap made up from an empty oil tin (28 cm x 20 cm diameter, fitted on a rod at 50 cm height). The surface of the tin was covered with yellow plastic sheet, the outer surface of which was smeared with castor oil. Each of these different traps were installed in the groundnut plot and a fallow area, approximately 800 m away.

Observations were made on the aphids population (*A. craccivora and H. setariae)* at Standard Week (SW) intervals from October through February. Temperature, humidity, soil temperature (10 and 20 cm depth), rainfall, rainy days, sunshine hours and wind velocity were recorded from a weather station located at the experimental site. A simple correlation and multiple regression was worked out and the prediction equations for aphids were calculated.

Results and discussion

Relatively few, *H, setariae* were trapped in comparison to *A. craccivora.* The population of *A. craccivora* was low during April to September (20/trap in Cylindrical trap/week in crop and 16/trap/week in fallow) (Fig. 1a and 1b), but reached a peak between December and January, recording over 800 *aphids*/trap/week in crop and 600/trap/week in the fallow. The period of peak activity coincided with the summer groundnut crop being the major irrigated crop, as the temperature increased.

There was a highly significant correlation for *A. craccivora* population from cropped and fallow area with average temp. soil at 10 cm depth and the vapour pressure in the area (Table 1 and 2). The regression equation for the prediction of *A. craccivora* on crop and fallow were computed. In cropped area, the number of predicted population was nearer to the actual population for both the species of aphids. During this period of observation all these weather parameter were recorded lowest, being winter season. The multiple correlation coefficient was 0.59 and 0.53 with weather parameters for *A. craccivora* in crop and fallow respectively. Weather being a complex phenomena, we have under taken stepwise regression to fix the important parameter which affected the population of these two aphid species.

The simple and multiple regression coefficient between aphid population and weather parameter indicated that temperature (av.), soil temperature (10 cm depth) and vapour pressure played a significant role on the population build up of aphids. The correlation and regression have clearly indicated the dependence of above weather parameters. The calculated value for *H. setariae* were r=0.57 and 0.56 for cropped and fallow area, respectively (Table 1) (Fig 1c and 1d).

Table 1 Simple correlation matrix of aphids with weather parameters in groundnut (October-March, 1994-95 to 1999-2000)

Aphid	R^2	Correlation with abiotic factors		
		Av. Temp. (°C)	Soil Temp. (°C)	Vapour pressure
A. craccivora				
Crop area	0.355	-0.590**	-0.585**	-0.486**
Fallow area	0.280	-0.510**	-0.524**	-0.453**
H. setariae				
Crop area	0.330	-0.564**	-0.545**	-0.509**
Fallow area	0.311	-0.544**	-0.536**	-0.500**

Fig. 1a.Weather v/s *A.craccivora* (crop) in Cylindrical trap

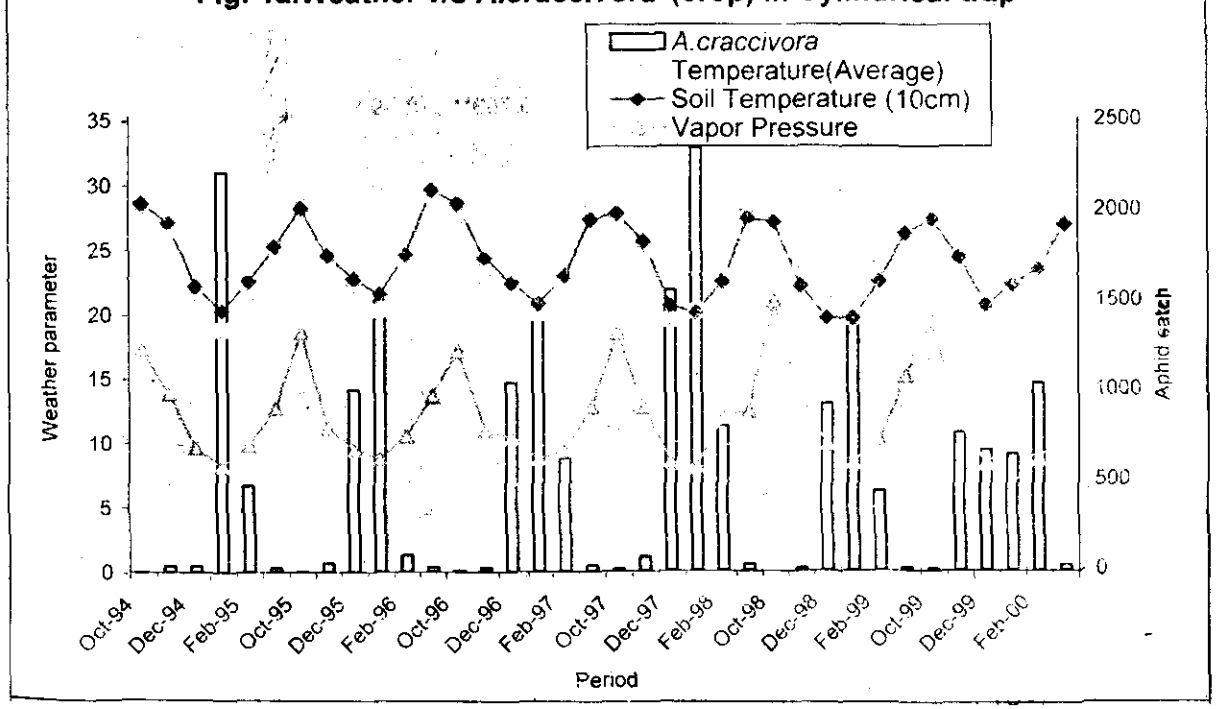


Table 2 Correlation between weather parameters and aphids population

Aphid	Weather parameter	Oct. 94 - March, 95	Oct. 95 - March, 96	Oct. 96 - March, 97	Oct. 97- March, 98	Oct. 98 - March-99	Oct. 99 - March 2000
Maximum temperature (°C)							
A. craccivora	Crop area	-0.623**	-0.516**	-0.558**	-0.674**	-0.721**	NS
	Fallow area	-0.639**	-0.521**	-0.580**	-0.588**	-0.691**	NS
H. setariae	Crop area	NS	-0.605**	-0.685**	-0.672**	-0.551**	NS
	Fallow area	-0.328*	-0.568**	-0.670**	-0.670**	NS	NS
Minimum Temperature (°C)							
A. craccivora	Crop area	-0.567**	NS	NS	-0.799**	-0.679**	NS
	Fallow area	-0.562**	NS	NS	-0.708**	-0.678**	NS
H. setariae	Crop area	NS	-0.590**	-0.638**	-0.757**	-0.664**	-0.673**
	Fallow area	NS	-0.582**	-0.657**	-0.586**	-0.590**	NS
Average temperature (°C)							
A. craccivora	Crop area	-0.604**	NS	-0.530**	-0.777**	-0.763**	NS
	Fallow area	-0.608**	NS	-0.552**	-0.684**	-0.749**	NS
H. setariae	Crop area	NS	-0.638**	-0.703**	-0.753**	-0.678**	-0.673**
	Fallow area	NS	-0.616**	-0.708**	-0.806**	-0.594**	
Soil temperature (10 cm depth) (°C)							
A. craccivora	Crop area	-0.601**	NS	-0.551**	-0.626**	-0.680**	NS
	Fallow area	-0.593**	NS	-0.581**	-0.728**	-0.680**	NS
H. setariae	Crop area	-0.529**	-0.653**	-0.762**	-0.803**	-0.677**	-0.692**
	Fallow area	NS	-0.643**	-0.763**	-0.884**	-0.599**	NS
Soil temperature (20 cm depth) (°C)							
A. craccivora	Crop area	-0.605**	NS	-0.563**	-0.819**	NS	NS
	Fallow area	-0.600**	NS	-0.701**	-0.727**	NS	NS
H. setariae	Crop area	-0.526**	-0.652**	-0.781**	-0.798**	NS	-0.681**
	Fallow area	NS	-0.649**	-0.771**	-0.860**	NS	NS
Vapour pressure							
A. craccivora	Crop area	NS	NS	NS	-0.675**	-0.651**	-0.491**
	Fallow area	NS	NS	NS	-0.587**	-0.629**	NS
H. setariae	Crop area	-0.519**	-0.572**	-0.578**	-0.615**	-0.589**	-0.585**
	Fallow area	NS	-0.565**	-0.578**	-0.757**	-0.562**	NS

Fig. 1b. Weather v/s *A.craccivora* (fallow) in Cylindrical trap

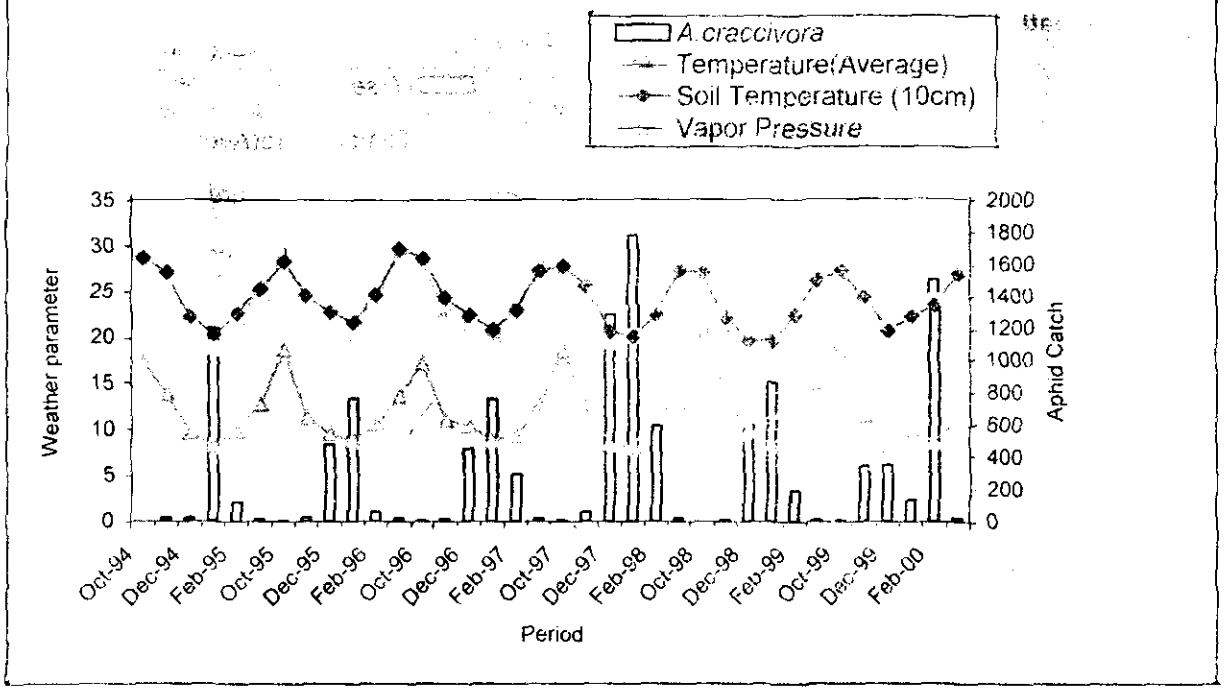


Fig 1b

Fig 1c. Weather v/s *H.setatriae* (crop) in Cylindrical trap

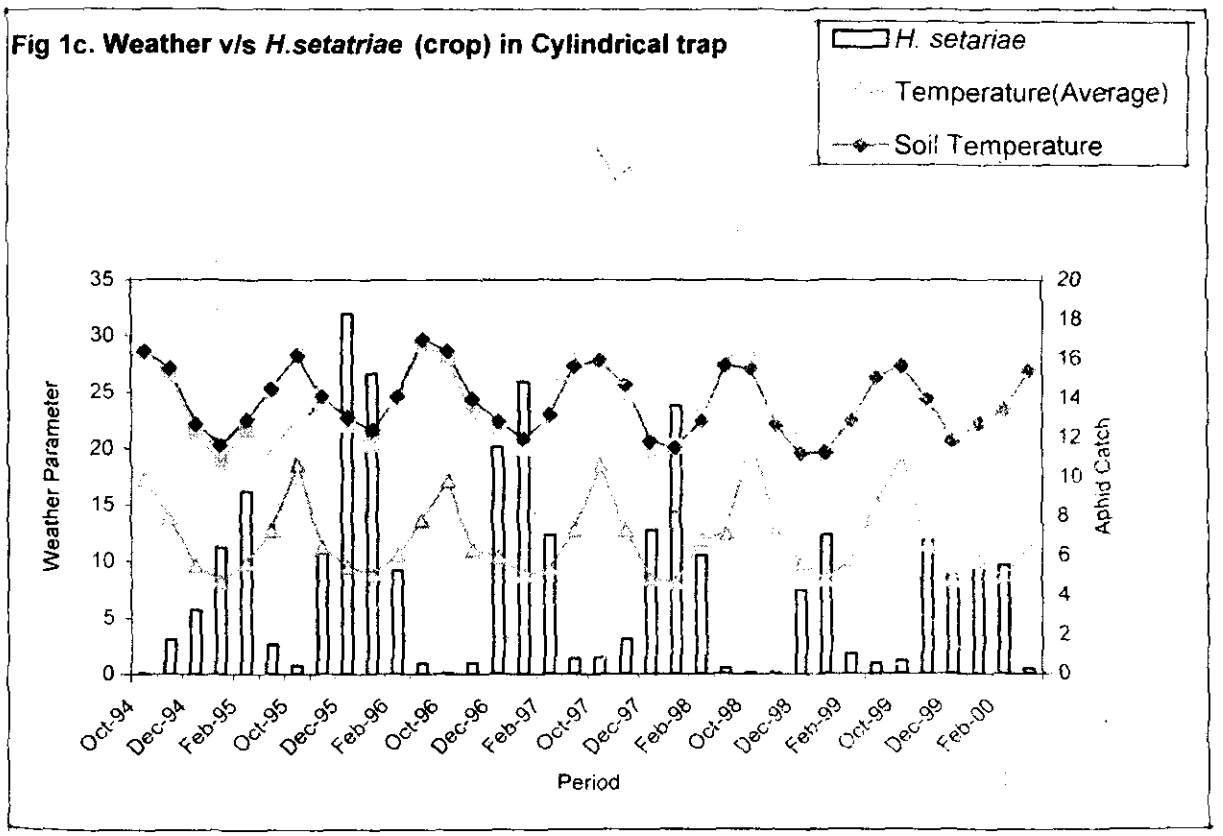


Fig 1c

Fig 1d. Weather v/s *H.setariae* (fallow) in Cylindrical trap

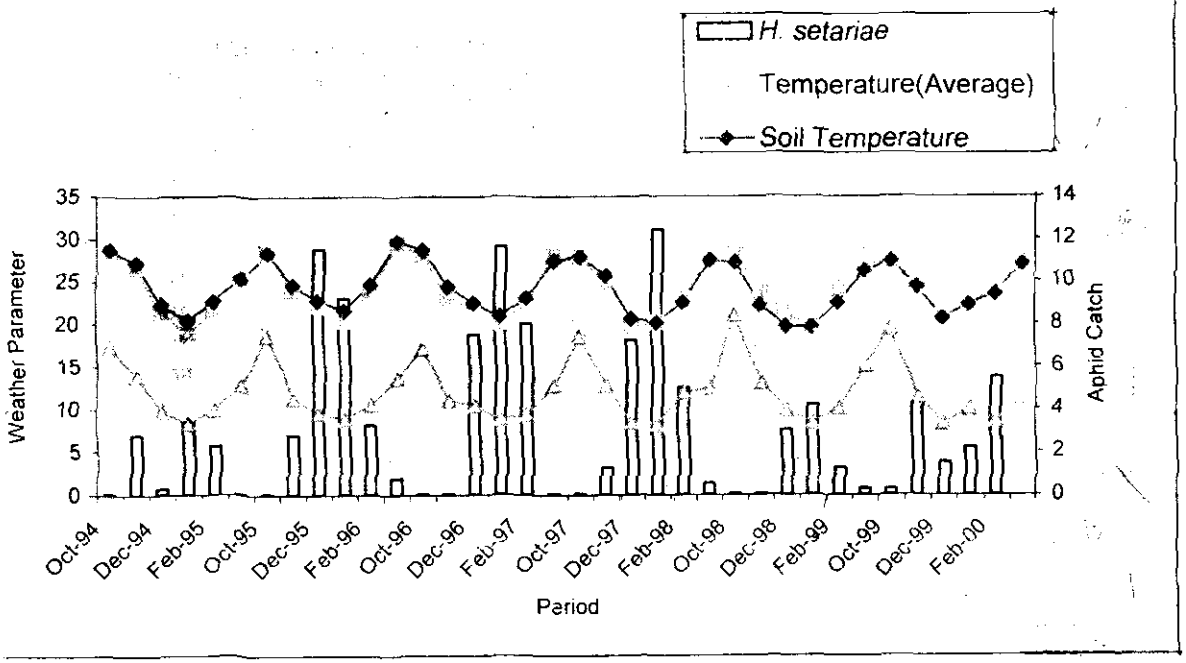


Fig.1d

During the studies, population of *H. setariae* was less in numbers (maximum 16/week/trap) which suggested that the weather factors are not that much conducive for multiplication compared to *A. craccivora*, which appeared in thousands. As a result, postnatal development periods and generation times are short and reproduction rates, are potentially very high (Dixon, 1987).

For multiple regressions, the best variables were the vapour pressure and soil temperature at 10 cm depth which were the results of low temperature prevailed from the period SW 45 to 52 and SW 1 to 12.

This is in confirmation with Roychoudhury and Jain (1993) who showed a negative correlation of aphids with mean, maximum and minimum temperature. Similarly, Sheikh *et al.* (1999) predicted the population of aphids in groundnut using a limited period data, which also included minimum temperature as contributing factors.

All through the years of observations, the populations of aphids, *A. craccivora* was abundant (maximum of 3542/trap/week) and the species, *H. setariae* recorded maximum of 32 aphids/week/trap. The SW 45 to 15 was peak period of activity for both the species. February 1st to 2nd week is the sowing period for summer groundnut through well irrigation. After germination, by the time the crop produced sufficient leaves, it would be SW 9-10. Probably because of these reasons, only the peanut strip virus (PStV) has been consistently recorded higher and in most of the field 50% plants were removed and destroyed during summer season of 1993 to 1995 (our unpublished work). These two aphids have been well documented as vector for PStV virus (Singh *et al.*, 1993).

Low temperature favoured the population of aphids. The other important weather parameters such as soil temperature at 10 cm depth and vapour pressure were also responsible for multiplication of alate forms of aphids. The aphids are being vector of many viral diseases of food and fiber crops, it would be easy to initiate the management of the aphids, to avoid the spread of viral diseases such as Peanut Stripe Virus diseases and to reduce loss (Singh *et al.*, 1993). Cylindrical trap was found to be superior in trapping the aphids, which are carried by wind being passive flier, could be used effectively to monitor these two species of aphids as well as other aphids in different crops and cropping systems.

It is now possible to forecast the population occurrence of *A. craccivora* and *H. setariae* based on the weather parameter prevailing over a short period. The cost of making a forecast using locally made gadgets is relatively small. Forecasting and early warning are both meant for warning of environmental conditions that are suitable for the occurrence of an epidemic. Presumably factors such as temperature, vapour pressure and soil temperatures

are likely to be important, while other factors such as migration may also be involved and precise information are likely to vary from place to place. In our situations, early detection is also possible after collection of epidemiological data and detecting the actual occurrence of an epidemic as soon as it begins.

The prediction of population can be made using average temperature, soil temperature at 10 cm depth and the vapour pressure in this area. This can be ensured taking these parameters for the period SW 43 to 45. Based on the prediction formula, the calculations for actual and predicted are coming closer. For the post-rainy sowing i.e., by the second or third week of February every year, the weather data of the above three independent factors can be taken into account and the population can be predicted. When the population is predicted, accordingly, the management/control options can be finalized in advance.

References

Brar, K.S. 1981. Note on the comparative susceptibility of groundnut varieties to *Aphis craccivora* Koch. *Madras Agriculture Journal*, **68** : 207-208.

Brar, K.S. and Sandhu, B.K. 1975. A note on the evaluation of resistance among different cultivars against aphid and grey weevil. *Science and Culture*, **41** : 445-448.

Dent, D. 1991. *Insect Pest Management.* Walling Ford, CAB International, pp.604.

Dixon, A.F.G. 1985. Structure of aphid population. *Annual Review of Entomology*, **30** : 155-174.

Dixon, A.F.G. 1987. Parthenogenetic reproduction and the rate of increase in aphids. (Eds.) Minks, A.K. and Harrewijn, P. In *Aphids, their biology, Natural enemies and Control.* World Crop Pests, Vol. 2A : 269-289, Amsterdam, Elsilvier.

Nandagopal, V. 1992. Studies on integrated pest management in groundnut in Saurashtra. Ph.D. Thesis, Saurashtra University, Rajkot, pp.246.

Padgham, D.E., Kimmins, F.M. and Ranga Rao, G.V. 1990. Resistance in groundnut (*Arachis hypogaea* L.) to *Aphis craccivora* (Koch.). *Annals of Applied Biology*, **117** : 285-294.

Rangaswamy, S.V. and Rao, D. 1964. Classified list of minor pests of important crops in India. *Aphids Lal Baugh*, **9** (3) : 9-12.

Roychoudhury, R. and Jain, R.K. 1993. Effect of climatological factors on the population of aphids and whiteflies in Lucknow region of Uttar Pradesh (India). *International Journal of Tropical Plant Diseases*, **11**(2) : 197-206.

Sheikh, A.M., Patel, H.R. and Pandey Vyas. 1999. Predicting the outbreak and spread of pests and diseases using weather parameters. *Proceedings of the National Workshop on Dynamic Crop Simulation Modelling for Agrometeorological Advisory Services.* National Centre for Medium Range Weather Forecasting. Department of Science and Technology, January, 1999, 249-256.

Singh, V., Ghewade, M.P. and Reddy, P.S. 1993. Peanut Stripe Virus disease - Present status and its management. *International Journal Pest Management*, **39** : 422-430.

J. Oilseeds Res., **21**(1): 104-107 (2004)

Systemic induced resistance in sunflower to *Alternaria* leaf blight by foliar application of SA and Bion

M. Venkata Sadhu Ratnam, P. Narayan Reddy, S. Chander Rao[1] and Rama Bhadra Raju

Department of Plant Pathology, Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad-500 030, AP

(Received: December, 2002; Revised: August, 2003; Accepted: October, 2003)

Abstract

Foliar application of Salicylic acid (SA) and Bion solutions to Sunflower induced systemic resistance to *Alternaria helianthii* (Hansf.) Tubaki and Nishihara. SA at 15 mM were effective in inducing resistance, however SA at 20 mM had phytotoxic effect. Studies indicated that lag period of 3-7 days is required for induction of systemic resistance.

Key words: Systemic acquired resistance (SAR), induced systemic resistance (ISR), Salicylic acid (SA), Bion, *Alternaria helianthii*

Introduction

Sunflower (*Helianthus annuus* L.) is one of the important oilseed crops grown in the world. It is cultivated in an area of 183.98 lakh ha with a production of 209.03 lakh tonnes and a productivity of 1136 kg/ha (Damodaram and Hegde, 2002). Although, India stands third in sunflower cultivation (21.0 lakh ha) but sixth in production (15.0 lakh ha) with a productivity of 714 kg/ha (Anonymous, 1999). There are several limitations for increasing production of sunflower, one of them being diseases. Alternaria leaf blight constitutes a potential threat to all sunflower growing regions of the wold (Yang, 1988). Although, several fungicides are available to manage this disease, development of resistance to fungicides by plant pathogens is a major limiting factor. Further, in the development and use of chemical agents for crop disease management, considerable attention must be given to the preservation of the global environment. By keeping all these points in view, investigation was carried out for utilization of induced systemic resistance in managing Alternaria leaf blight in sunflower.

Materials and methods

Sunflower leaves infected with *A. helianthii* were collected from Directorate of Oilseeds Research, Rajendranagar, the pathogen was isolated by tissue segment method and further purified by single spore isolations. For pathogenicity studies, Alternaria susceptible open pollinated variety 'Morden' was planted in 18 cm diameter pots (three plants/pot). With a mixture of soil and farm yard manure (FYM) in 4:1 ratio and maintained on glass house benches. The inoculum was prepared by washing the conidia of *A. helianthii* from 15 days old culture grown on sunflower leaf extract medium in petriplates. Five ml of sterile distilled water was added to each plate and the conidia were scraped with the help of camel hair brush. The spore suspension was filtered through three layers of cheese cloth. Tween 20 @ 0.1% (Polyoxyethylene Sorbiten monoleate), surfactant was added to the suspension to enable uniform spread of inoculum on the leaves. The conidial concentration was monitored using haemocytometer.

Thirty days old plants were inoculated in the glass house by spraying conidial suspension (10,000 conidia/ml) of Alternaria on leaves with a hand sprayer. Control was maintained by spraying with sterile distilled water only. Inoculated plants were kept in the incubation chamber made up of polythene sheets in the glasshouse for 48 h colane at R.H. 95%.

Salicylic Acid (SA; 2-hydroxy benzoic acid MS ICN biochemicals Inc; Thame U.K.) was dissolved in sterile distilled water containing 0.1% tween 20 as a wetting agent, to produce 15 mM, 1.5 mM and 0.15 mM S.A solutions. Bion (acibenzolar-s-methyl; benzothiodiazole, CGA 245704; benzo (1,2,3) thiadiazole-7-carbothioicacids-methylester (MS Novartis India Ltd, Mumbai) as water dispensable granule (WG 50%) was dissolved in sterile distilled water to produce 5mM, 0.5mM and 0.05mM Bion solutions.

The effect of SA and Bion in inducing disease resistance was observed after one day, replicate plants from each treatment were taken and their second formed leaves were inoculated with *A. helianthii*. Similarly other plants were inoculated at 3,5,7 and 9 DAT and disease reduction over control was calculated (Ishii *et al.*, 1999).

Slide germination technique (Montgomery and Moore, 1938) and poisoned food technique (Nene and Thapliyal, 1979) were employed to test the efficacy of salicylic acid and Bion against *A., helianthii in vitro*.

[1] Scientist (SG), Directorate of Oilseeds Research, Rajendranagar, Hyderabad-500 030, A.P.

Slide germination technique: Four concentrations (1000, 100, 10, 1 mg/ ml each) of SA and bion were prepared. Two drops of each concentration were pipetted into the cavity slide and allowed to dry. Equal quantity of spore-suspension was placed over the dried inducer chemical solution and incubated at 27±1°C for 5 h. The trial was replicated five times. Suitable control was maintained with distilled water. After 5 h of incubation, spore-germination counts were recorded and germination % was calculated.

Poisoned food technique: Different concentrations (1000, 100, 10, 1 μg/ml) of AS and Bion were prepared and poured into sterilized petriplates. Small disc (0.8 cm diameter) of *A. helianthii* culture was placed at the centre of each poisoned plate. These radial growths of the fungal mycelium was recorded at 7, 14 and 21 days after inoculation.

Estimation of total phenols: Plants were treated with salicylic acid and Bion. Later the phenolic content of treated plants was estimated at different intervals as per Mahadevan and Sridhar, 1996.

Results and discussion

Inoculation of the second formed leaf with *A. helianthii* 24h before the application of SA and Bion on first formed leaf had no influence on the infectivity of the pathogen (Table 1). Bion 5 mM had significantly higher disease control (22.43%) at 1 DAT. Similar trend was observed with 5 DAT, 7 DAT and 9 DAT. However, the differences observed between 7 DAT and 9 DAT were not significant. The results revealed that treating first formed leaves with SA 15 mM and Bion 5 mM can induce resistance to *A. helianthii* in the second formed leaves and the induced resistance persisted for atleast 9 days after treatment. Similar results were also reported by Weete (1992) and Frey and Carver (1998).

Studies on spore germination of *A. helianthii* showed (Table 2) that less spore-germination was observed at SA 1000/μg ml. Similar results on damping off seedlings disease reported by Chen-Chunquan *et al.* (1999) indicated that, zoospore germination of *Pythium aphanidermatum* was reduced on application of SA at 1000 μg/ml. SA and Bion foliar application inhibited the radial growth of *A. helianthii* at 1-100 μg ml (Table 3). At higher concentration (1000 μg ml) complete inhibition of mycelial growth was observed with SA. The reduction in spore germination and mycelial growth of *A. helianthii* not only resulted a direct effect as inducers on the pathogen, but also protection was achieved in *in vivo*. This might be due to the results of induced resistance and also the direct effects of the inducer chemical on the pathogen.

Table 1 Effect of application SA and Bion to first formed leaves on resistance of second formed sunflower leaves to *Alternaria helianthii*

Treatment	Disease reduction (%) over control						Mean
	1 DBT	1 DAT	3 DAT	5 DAT	7 DAT	9 DAT	
SA 15 mM	0.93 (5.13)	9.77 (17.72)	19.92 (26.50)	51.77 (46.01)	63.89 (53.10)	63.62 (52.94)	34.98 (33.57)
SA 1.5 mM	0.13 (1.21)	6.81 (15.12)	15.90 (23.20)	33.77 (35.40)	34.53 (35.92)	34.90 (36.19)	21.01 (24.51)
SA 0.15 mM	0.13 (1.21)	4.99 (10.57)	9.87 (17.66)	7.79 (14.59)	14.95 (22.40)	15.00 (22.73)	8.79 (14.86)
Bion 5 mM	1.20 (6.24)	22.43 (20.54)	25.79 (30.47)	57.45 (49.30)	68.03 (55.57)	68.79 (56.04)	40.22 (37.36)
Bion 0.5 mM	0.13 (1.21)	6.17 (10.37)	15.09 (22.63)	26.50 (30.35)	41.24 (39.93)	41.80 (40.25)	21.82 (24.12)
Bion 0.05 mM	0.13 (1.21)	6.25 (14.47)	10.26 (16.88)	13.53 (17.78)	33.38 (35.28)	36.21 (36.97)	16.63 (20.43)
Mean	0.44 (2.70)	10.44 (14.80)	16.13 (22.89)	31.80 (32.23)	42.67 (40.36)	43.38 (40.85)	23.90 (25.80)

Figures in parenthesis are arc sine transformed values

	SEd±	CD (P=0.05)
Periods	1.58	3.15
Treatments	1.71	3.40
Interaction	4.19	8.33

Table 2 **Effect of SA and Bion on spore germination of *Alternaria helianthii in vitro***

Treatments	Spore germination (%) at different concentrations (µg/ml)					Mean
	1000	100	10	1	0	
SA	66.20 (54.45)**	78.43 (62.32)	91.45 (73.01)	91.59 (73.15)	95.34 (77.59)	84.60 (68.10)
Bion	76.75 (61.17)	80.88 (64.07)	93.03 (74.71)	91.83 (73.41)	95.34 (77.49)	87.56 (70.19)
Mean	71.47 (57.81)	79.65 (63.20)	92.24 (73.86)	91.71 (73.28)	95.34 (77.59)	86.08 (69.15)

Data in parenthesis are arc sine transformed values

	SEd±	CD (P=0.05)
Concentrations	0.36	0.73
Treatments	0.23	0.46
Interaction	0.51	1.03

Table 3 **Efficacy of SA and Bion on radial growth of *Alternaria helianthii* at four concentrations (µg/ml)**

Treatment	Growth reduction (%) over control			Mean
	7 DAI	14 DAI	21 DAI	
SA 1000	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)
SA 100	8.12 (12.50)	35.88 (36.20)	32.38 (34.00)	25.47 (27.57)
SA 10	12.00 (15.69)	16.81 (20.94)	10.48 (18.38)	13.10 (18.33)
SA 1	4.67 (7.81)	36.37 (36.64)	7.01 (15.01)	16.02 (19.82)
Bion 1000	66.73 (54.85)	65.94 (54.76)	71.57 (58.15)	68.08 (55.92)
Bion 100	64.76 (53.85)	53.39 (46.99)	57.33 (49.52)	58.49 (50.12)
Bion 10	39.48 (38.14)	46.25 (42.79)	45.81 (42.56)	43.85 (41.16)
Bion 1	25.24 (26.56)	22.77 (28.26)	21.85 (27.44)	23.29 (27.42)
Mean	40.12 (37.42)	47.17 (44.57)	43.30 (41.88)	43.53 (41.29)

Data in parenthesis are arc sine transformed values

	SEd±	CD (P=0.05)
DAI	2.06	3.99
Treatments	3.40	6.73
Interaction	5.89	11.69

Table 4 **Effect of SA and Bion application on the phenolic content of sunflower leaves at different time intervals**

Treatment		Total phenols expressed as catechol equivalents (mg/g)					Mean
		1 DAT	3 DAT	5 DAT	7 DAT	9 DAT	
SA 15 mM							
	First leaf	0.51	0.58	1.07	1.47	1.47	1.01
	Second leaf	0.51	0.57	0.88	1.23	1.23	0.88
	Third leaf	0.51	0.57	0.88	1.18	1.20	0.86
Bion 5 mM							
	First leaf	0.51	0.63	1.21	1.51	1.51	1.06
	Second leaf	0.51	0.59	0.98	1.25	1.25	0.90
	Third leaf	0.51	0.59	0.98	1.25	1.25	0.90
Mean		0.51	0.59	1.00	1.32	1.32	0.93

	SEd±	CD (P=0.05)
DAT	0.01	0.02
Treatments	0.01	0.02
Interaction	0.03	0.05

There was no significant difference between the treatments at one day after the application of chemicals on phenolic content of leaves. However, changes observed from 3 DAT to 9 DAT were significant both with SA and Bion. The total phenols were maximum with Bion after 7 DAT (1.52 mg/g) followed by SA (1.47 mg/g) in first leaf. In all the cases, differences observed in Phenolic content of second and third formed leaves were not significant (Table 4). Generally 3 to 7 days are required for the induction of defense mechanism (Frey and Carver, 1998; Jeum *et al.*, 2000). The study indicates, resistance in sunflower to *A. helianthii* can be enhanced systematically through foliar application of SA and Bion.

References

Anonymous. 1999. Annual progress report of sunflower (1998-99). Directorate of Oilseeds Research, Rajendranagar, Hyderabad.

Chen-Chunquan, Belanger, R.R., Benhanau, N., Paulitz, T.C. and Chen, C.Q. 1999. Role of salycylic acid in systemic resistance induced by *Psedumonas* spp., against *Pythium aphanidermatum* in cucumber roots. *European Journal of Plant Pathology*, **105** : 477-486.

Damodaram, T. and Hegde, D.M. 2002. Oilseeds situation, 1997-2000. *A statistical compendium.* Directorate of Oilseeds Research, Rajendranagar, Hyderabad, pp.115-138.

Frey and Carver, T.L.W. 1998. Induction of systemic resistance in pea to pea powdery mildew by exogenous application of salicylic acid. *Journal of Phytopathology*, **146** : 239-245.

Ishii, H., Tomita, Y., Horio, T., Narusak, Y., Nakazawa, Y., Nishimura, K. and Iwamoto, S. 1999. Induced resistance of acibenzedas-S-methyl (CGA 245704) to cucumber and Japanese pear disease. *European Journal of Plant Pathology*, **105** : 77-85.

Jeum, Y.C., Siegrist, J. and Buchemaver, H. 2000. Biochemical and etiological studies on mechanisms of systemically induced resistance to *Phytophtora infestans* in Tomato plant. *Journal of Phytopathology*, **148** : 129-140.

Mahadevan and Sridhar, R. 1996. Folin-Phenol method to estimate total phenols. *Methods in Physiological Plant Pathology*, Fourth Edition, Sivakasi Publications, Indira Nagar, Chennai, pp.155-156.

Montgomery, H.B.S. and Moore, M.H. 1938. A laboratory method for testing the toxicity of protective fungicides. *Journal of Pomology and Horticultural Science*, **15** : 253-256.

Nene, Y.L. and Thapliyal, P.N. 1979. *Fungicides in plant disease control.* Oxford and IBH Publishing Company, New Delhi 2nd Edition, p.507.

Weete, J.D. 1992. Induced systemic resistance to *Alternaria cassiae* in sickli pod. *Physiological and Molecular Plant Pathology*, **40** : 437-445.

Yang, S.M. 1988. Diseases of cultivated sunflower in Liaoming Province, Peoples Republic of China. *Plant Disease*, **72** : 546.

J. Oilseeds Res., **21**(1): 108-111 (2004)

Field screening of linseed, *Linum usitatissimum* Linn. genotypes against the incidence of budfly, *Dasyneura lini* Barnes and blight, *Alternaria lini* Dey

M.P. Gupta

Zonal Agricultural Research Station, J.N. Krishi Vishwa Vidyalaya, Tikamgarh-472 001, MP

(Received: June, 2003; Revised: November, 2003; Accepted: December, 2003)

Abstract

Forty nine genotypes of linseed (*Linum usitatissimum* Linn.) were screened under natural infestation conditions against the incidence of budfly (*Dasyneura lini* Barnes) and Alternaria blight (*Alternaria lini* Dey) during five consecutive *rabi* seasons of 1997-98 to 2001-02 at JNKVV, Zonal Agricultural Research Station, Tikamgarh (M.P.). Entries, JLT-84-5-1, JLT-84-12-1, JLT-24, JLT-26, LMH-91-24 and LMH-16-5 (6.2-10%) reacted as resistant against the incidence of budfly on the basis of five years pooled mean, whereas, genotypes, 5610, EC-1392, RLC-29, JLT-84-12-1, LMH-43 and LCK-93-24 (4.2-4.9%) were highly resistant against the infestation of Alternaria blight. Grain yield was highest in genotypes, LMH-16-5 (2120 kg/ha) followed by LMS-5-38 (2116 kg/ha), JLT-90 (2092 kg/ha), JLT-24, JLT-84-5-1 (2056 kg/ha), Kangra local (2037 kg/ha), NL-97 (2032 kg/ha), LCK-9211 (2019 kg/ha) and JLT-26 (2005 kg/ha). Thus, four genotypes, LMH-16-5, JLT-24, JLT-84-5-1 and JLT-26 were resistant to both the pests as well as high yielding. Budfly susceptible genotype, LC-54 had longer blooming period (38 days) and budfly resistant genotypes, LMH-16-5 and JLT-26 had lesser blooming period (27-30 days). However, this behaviour did not correlate with all the genotypes.

Key words: Budfly, Alternaria blight, linseed, resistance

Introduction

Linseed, *Linum usitatissimum* Linn. is affected by a number of insect pests and diseases, although only few of them are of economic importance. Budfly. *Dasyneura lini* Barnes among the insect pests and Alternaria blight (*Alternaria lini* Dey) among the diseases are the most devastating pests causing yield losses to the extent of 88% (Pal *et al.,* 1978; Jakhmola and Yadav, 1983) due to budfly and 60 % due to Alternaria blight (Chauhan and Shrivastava, 1975). Use of resistant/tolerant varieties is the most effective and economic way to manage these pests. But, no high yielding varieties could be evolved so far with multiple resistance to both the pests (Lingappa *et al.,* 2003). Keeping these facts in view, present investigations on the field screening of linseed genotypes against the incidence of budfly and Alternaria blight were carried out to identify the high yielding pest resistant genotypes.

Materials and methods

Thirty four genotypes during 1997-98 and forty nine genotypes of linseed during 1998-99 to 2001-02 were sown during the end of November in all the five *rabi* seasons. Two rows of 4 m length of each genotype were sown at 30 cm row spacing in Randomised Block Design and three replications during each season. Infester row of budfly susceptible variety, Neelum was raised around the crop to serve the inoculum. The crop was grown on recommended agronomic practices under natural infestation conditions.

Observations on the incidence of budfly and Alternaria blight were recorded at the dough stage following the guidelines of AICRP (Anonymous, 1985). Grain yield was also recorded and observations of all five years were pooled.

Results and discussion

Reaction against the incidence of budfly : Budfly damage varied significantly among the genotypes during all the five seasons of study being highest during 1998-99 (11.9 to 63.9%) followed by 1997-98 (4.0. to 50.9%) capsule damage. However, in rest of the years, incidence of budfly was mild (Table 1). Mean incidence of budfly (5 years) also varied significantly with 6.6-26.4% capsule damage. Genotypes, JLT-84-5-1 (6.2%), JLT-84-12-1 (6.6%), JLT-24 (7%), JLT-26 (8.1%), LMH-91-24 (9.6%) and LMH-16-5 (10%) reacted as resistant on the basis of pooled mean incidence. Whereas, Neelum (26.4%), Kiran (25.4%) and LC-54 (25.2%) were susceptible in reaction. Rest of the 40 entries were moderately resistant against the incidence of budfly. Malik (1999) has also reported LC-54 and Neelum as susceptible to budfly.

Table 1 Mean % capsule damage due to budfly in linseed genotypes and mean blooming period

Entries	% capsule damage due to budfly						Mean blooming period (days)
	1997-98	1998-99	1999-2000	2000-01	2001-02	Mean	
IC-16392	25.0 (29.9)	30.4 (33.5)	7.2 (15.5)	11.3 (19.6)	2.4 (8.9)	15.3 (22.7)	28
J-23	26.8 (31.2)	27.7 (31.8)	16.4 (23.8)	22.5 (28.3)	9.3 (17.9)	20.5 (26.6)	37
JLT-24	4.0 (11.5)	8.3 (16.4)	8.8 (17.2)	10.7 (19.1)	3.9 (11.2)	7.0 (15.1)	32
JLT-26	6.5 (14.7)	23.0 (28.5)	4.8 (12.5)	5.3 (13.3)	1.1 (6.0)	8.1 (15.0)	30
JLT-46	8.1 (16.5)	23.1 (28.6)	7.3 (15.6)	15.9 (23.3)	2.9 (9.8)	11.5 (18.8)	39
JLT-83	21.3 (27.4)	39.8 (39.1)	8.1 (16.4)	17.8 (24.9)	5.1 (13.1)	18.4 (24.2)	37
JLT-84-5-1	4.3 (11.9)	9.9 (18.4)	6.0 (14.1)	7.8 (16.2)	2.8 (9.6)	6.2 (14.0)	35
JLT-84-12-1	5.3 (10.8)	15.3 (23.0)	4.7 (12.4)	4.8 (12.6)	2.9 (9.8)	6.6 (13.7)	35
JLT-90	9.6 (18.1)	22.0 (27.9)	7.6 (15.9)	6.5 (13.5)	6.1 (14.3)	10.4 (17.9)	34
JLT-93	12.2 (20.4)	15.4 (23.0)	6.5 (14.7)	11.9 (20.2)	5.2 (13.2)	10.2 (18.3)	38
Kiran	33.1 (35.0)	63.9 (53.2)	6.8 (15.0)	13.6 (21.7)	9.5 (18.0)	25.4 (28.6)	34
LC-54	19.9 (26.5)	44.0 (41.6)	25.1 (30.0)	18.5 (25.5)	18.6 (25.5)	25.2 (29.8)	38
LMH-6-5	5.0 (12.9)	42.0 (40.4)	7.7 (16.1)	14.2 (22.0)	4.0 (11.5)	14.6 (20.6)	30
LMH-43	12.8 (20.9)	23.2 (28.8)	3.0 (13.2)	11.2 (19.6)	4.8 (12.7)	11.0 (19.0)	35
LMH-91-24	4.5 (12.2)	22.6 (28.4)	4.7 (12.3)	9.7 (18.1)	6.3 (14.5)	9.6 (17.1)	33
LMH-90	6.8 (15.1)	53.7 (47.2)	12.7 (20.8)	9.6 (18.1)	4.1 (11.7)	17.4 (22.6)	33
LCK-85-28	23.8 (29.1)	29.0 (32.6)	11.6 (19.8)	19.4 (26.2)	5.0 (12.9)	17.8 (23.1)	37
LCK-92-11	34.0 (35.5)	22.3 (28.0)	15.3 (22.9)	15.8 (23.4)	6.2 (14.4)	18.7 (24.8)	39
LCK-93-03	30.1 (33.1)	19.3 (25.9)	15.4 (22.8)	14.4 (22.3)	10.4 (18.8)	17.9 (24.6)	24
LCK-93-24	22.4 (28.1)	18.5 (25.4)	7.7 (16.0)	8.0 (16.3)	7.8 (16.2)	12.9 (20.4)	35
LCK-94-36	15.1 (22.8)	40.9 (39.7)	8.6 (17.0)	14.3 (21.9)	5.7 (13.8)	16.9 (23.0)	31
Neela	16.0 (23.5)	32.9 (34.9)	8.9 (16.7)	16.0 (23.6)	5.9 (14.1)	13.9 (22.6)	31
Neelam	50.9 (45.5)	34.3 (35.8)	14.7 (22.4)	16.5 (24.0)	15.7 (23.3)	26.4 (30.2)	30
NL-97	20.3 (26.8)	40.7 (39.6)	3.2 (10.1)	7.3 (15.6)	6.5 (14.8)	15.6 (21.4)	37
NL-8804	19.2 (25.9)	38.1 (38.1)	3.2 (10.2)	13.8 (21.8)	6.1 (14.3)	16.1 (22.1)	33
RL-1011	16.5 (24.0)	18.0 (25.1)	13.3 (21.3)	15.4 (22.9)	5.2 (13.2)	13.7 (21.3)	36
RLC-29	15.4 (23.1)	44.0 (41.5)	8.3 (16.5)	8.1 (16.5)	4.4 (12.1)	16.0 (21.9)	37
RLC-40	26.5 (30.9)	40.6 (39.6)	8.7 (17.1)	13.6 (21.6)	4.9 (12.8)	18.9 (24.4)	37
T-397	20.1 (26.5)	33.3 (35.2)	13.0 (21.0)	19.7 (26.3)	5.0 (12.9)	18.2 (24.4)	32
672 EC-1427	20.1 (26.5)	35.3 (36.4)	8.4 (16.8)	12.9 (21.1)	3.0 (10.0)	15.9 (22.2)	37
692	26.2 (30.7)	47.2 (43.4)	8.9 (16.9)	9.3 (17.7)	5.2 (13.2)	19.4 (24.4)	30
1189	7.0 (15.3)	25.0 (30.0)	11.3 (19.3)	13.4 (21.5)	7.0 (15.3)	12.7 (20.3)	38
1216 JRF-1	10.7 (17.8)	29.7 (33.1)	6.7 (15.3)	6.3 (14.5)	8.6 (17.1)	11.0 (19.6)	39
1341 LC-1	19.7 (26.3)	33.8 (35.5)	15.7 (23.4)	14.2 (22.1)	6.3 (14.5)	17.9 (24.4)	32
5610	—	32.6 (34.8)	11.0 (19.6)	12.3 (20.4)	8.0 (16.4)	16.0 (22.8)	25
ACCNo.-442	—	39.9 (39.1)	14.7 (22.4)	20.6 (27.0)	4.5 (12.2)	19.9 (25.2)	32
ACCNo.-1396	—	47.2 (43.4)	8.0 (16.4)	17.8 (24.9)	12.8 (21.0)	21.4 (26.4)	31
A-958	—	37.5 (37.8)	12.4 (20.6)	12.1 (20.4)	7.2 (15.6)	17.3 (23.6)	28
CI-1466	—	39.4 (38.9)	11.9 (20.0)	15.1 (22.8)	14.4 (22.3)	20.2 (26.0)	25
CI-1956	—	35.3 (36.4)	17.6 (24.7)	15.8 (23.3)	18.4 (25.4)	21.8 (27.4)	33
EC-1392	—	32.0 (34.4)	1.5 (5.7)	7.0 (15.3)	13.6 (21.6)	13.5 (19.2)	27
EC-1424	—	21.9 (27.9)	5.7 (13.7)	10.2 (18.7)	7.8 (16.2)	11.4 (21.8)	25
JRF-3	—	23.8 (29.2)	19.0 (25.9)	7.9 (16.2)	3.6 (10.9)	13.6 (20.5)	31
JRF-4	—	22.5 (28.3)	5.0 (12.8)	9.2 (17.6)	6.0 (14.2)	10.7 (18.2)	29
JRF-5	—	23.9 (29.2)	14.8 (22.5)	17.4 (24.6)	7.9 (16.3)	16.0 (23.1)	26
Kangra Local	—	23.2 (28.7)	11.8 (20.0)	11.3 (19.6)	5.1 (13.0)	12.8 (20.3)	30
LCK-88062	—	42.3 (40.5)	11.6 (19.9)	17.6 (24.6)	6.1 (14.3)	19.4 (24.8)	25
LMH-16-5	—	22.4 (28.1)	4.3 (11.7)	7.6 (15.9)	5.9 (14.1)	10.0 (17.4)	27
LMS-5-38	—	29.8 (33.0)	8.0 (16.4)	16.6 (23.9)	7.8 (16.2)	15.5 (22.4)	26
S Em ±	(1.97)	(2.00)	(1.45)	(1.35)	(1.38)	(1.10)	
CD (P=0.05)	(5.58)	(5.67)	(4.10)	(3.82)	(3.90)	(3.11)	

Figures in parenthesis are angular transformed values.

Table 2 Mean % bud damage due to Alternaria blight and grain yield

Entries	% bud damage due to Alternaria blight						Grain yield (kg/ha)
	1997-98	1998-99	1999-2000	2000-01	2001-02	Mean	
IC-16392	23.0 (28.7)	7.0 (15.3)	2.6 (9.3)	2.9 (9.7)	3.1 (9.7)	7.7 (14.5)	1852
J-23	15.6 (23.2)	7.9 (16.3)	3.7 (11.0)	2.6 (9.1)	1.5 (7.0)	6.3 (13.3)	1972
JLT-24	9.2 (17.7)	14.3 (22.1)	4.2 (11.7)	3.0 (9.9)	5.2 (13.0)	7.2 (14.9)	2056
JLT-26	9.3 (17.7)	10.6 (18.6)	4.8 (12.5)	0.4 (2.6)	3.1 (10.1)	5.7 (12.3)	2005
JLT-46	16.7 (24.1)	7.5 (15.8)	6.4 (14.8)	5.2 (13.1)	2.9 (9.7)	7.7 (15.5)	1866
JLT-83	16.2 (23.7)	9.7 (18.0)	2.1 (8.2)	6.7 (15.0)	2.8 (9.6)	7.5 (14.9)	1778
JLT-84-5-1	12.8 (20.9)	11.2 (19.5)	3.3 (10.1)	3.1 (10.2)	3.2 (10.1)	6.8 (14.2)	2056
JLT-84-12-1	10.2 (18.6)	4.5 (12.2)	2.4 (7.3)	3.4 (10.5)	2.5 (9.1)	4.6 (11.5)	1843
JLT-90	20.1 (26.6)	15.9 (23.4)	3.2 (9.9)	5.0 (12.9)	2.7 (9.4)	9.4 (16.4)	2092
JLT-93	20.3 (26.7)	17.8 (24.9)	3.0 (9.9)	4.7 (12.5)	2.1 (8.2)	9.6 (16.4)	1931
Kiran	16.8 (24.2)	6.4 (14.7)	3.5 (10.8)	3.6 (10.7)	4.4 (12.1)	6.9 (14.5)	1574
LC-54	21.2 (27.4)	7.8 (16.2)	10.5 (18.9)	2.8 (9.2)	5.7 (13.6)	9.6 (17.1)	1685
LMH-6-5	34.4 (35.9)	15.9 (23.5)	4.8 (12.5)	6.7 (14.9)	2.7 (9.0)	12.9 (19.2)	1583
LMH-43	10.0 (18.4)	5.5 (13.5)	1.6 (5.6)	1.7 (7.1)	4.8 (12.6)	4.7 (11.4)	1449
LMH-91-24	10.0 (18.4)	10.8 (19.1)	8.2 (16.6)	5.9 (14.0)	6.9 (15.0)	8.4 (16.6)	1867
LMH-90	25.9 (30.6)	12.1 (20.2)	2.9 (9.7)	3.3 (10.5)	7.3 (16.0)	10.3 (17.4)	1889
LCK-85-28	13.0 (21.1)	7.3 (15.5)	2.1 (8.0)	4.3 (11.9)	4.4 (12.5)	6.2 (13.8)	1704
LCK-92-11	11.3 (19.6)	8.9 (17.3)	4.0 (11.3)	3.2 (9.9)	4.2 (12.0)	6.3 (14.0)	2019
LCK-93-03	15.5 (23.2)	7.6 (15.9)	5.6 (14.1)	2.6 (9.3)	4.0 (11.5)	7.1 (14.8)	1560
LCK-93-24	8.2 (16.6)	7.6 (15.9)	2.6 (9.0)	2.7 (9.4)	3.2 (10.5)	4.9 (12.3)	1685
LCK-94-36	9.6 (17.9)	10.5 (18.0)	13.1 (21.1)	6.3 (14.5)	6.1 (14.3)	9.1 (17.2)	1769
Neela	20.0 (26.5)	10.5 (18.7)	3.6 (10.8)	4.1 (11.7)	4.3 (12.0)	8.5 (15.9)	1810
Neelam	13.3 (21.2)	10.5 (18.9)	4.8 (12.6)	2.9 (9.7)	3.5 (10.9)	7.0 (14.7)	1847
NL-97	13.7 (21.7)	9.4 (17.8)	2.3 (8.7)	1.7 (7.4)	4.7 (12.4)	6.4 (13.6)	2032
NL-8804	15.5 (23.2)	9.1 (17.6)	7.4 (15.6)	5.3 (13.3)	4.2 (12.0)	8.3 (16.3)	1592
RL-1011	26.8 (31.1)	10.6 (18.9)	4.4 (12.1)	2.8 (9.5)	3.7 (11.1)	9.7 (16.5)	1810
RLC-29	6.8 (14.8)	6.3 (14.6)	3.6 (12.2)	2.4 (8.8)	3.4 (10.6)	4.5 (12.2)	1787
RLC-40	16.1 (23.6)	11.6 (19.8)	3.5 (10.4)	5.4 (13.4)	5.7 (14.0)	8.5 (16.2)	1945
T-397	11.3 (19.6)	10.4 (18.8)	7.1 (15.4)	3.6 (10.7)	2.5 (8.9)	7.0 (14.7)	1652
672 EC-1427	13.5 (21.5)	12.7 (20.8)	2.8 (9.0)	3.7 (11.1)	3.0 (10.0)	7.1 (14.5)	1866
692	26.3 (30.8)	7.2 (15.5)	4.7 (12.2)	3.2 (10.2)	3.5 (10.8)	9.0 (15.9)	1880
1189	28.7 (32.2)	7.8 (16.2)	8.9 (17.3)	8.1 (16.5)	4.8 (12.3)	11.7 (18.9)	1523
1216 JRF-1	37.4 (37.7)	28.4 (32.2)	20.3 (26.7)	9.2 (17.6)	7.8 (16.6)	20.6 (26.2)	1731
1341 LC-1	25.1 (30.1)	7.9 (16.3)	3.0 (9.6)	2.2 (8.4)	5.8 (14.4)	8.8 (15.8)	1855
5610	---	8.8 (17.3)	2.0 (8.1)	3.2 (10.0)	3.0 (10.0)	4.2 (11.4)	1592
ACC No.-442	---	13.9 (21.9)	4.2 (11.8)	5.2 (13.0)	4.5 (12.2)	6.9 (14.7)	1509
ACC No.-1396	---	12.5 (20.9)	3.3 (10.4)	2.8 (9.4)	8.7 (17.2)	6.8 (14.5)	1528
A-958	---	17.9 (24.7)	7.6 (16.0)	1.9 (7.9)	7.6 (15.4)	8.7 (16.0)	1899
CI-1466	---	9.0 (17.7)	5.2 (13.2)	2.5 (8.8)	7.2 (15.4)	6.0 (13.8)	1344
CI-1956	---	10.5 (19.4)	6.8 (15.1)	3.9 (11.2)	8.8 (17.2)	7.5 (15.7)	1369
EC-1392	---	8.4 (16.9)	1.8 (7.6)	0.8 (5.1)	6.6 (15.0)	4.4 (11.1)	1945
EC-1424	---	10.3 (19.0)	5.3 (13.3)	4.5 (12.2)	10.0 (18.2)	7.5 (15.7)	1346
JRF-3	---	42.8 (41.6)	19.1 (25.9)	21.9 (27.8)	21.1 (27.9)	26.2 (30.8)	954
JRF-4	---	35.6 (36.9)	40.4 (39.5)	14.4 (22.3)	21.7 (28.1)	28.0 (31.7)	1282
JRF-5	---	24.9 (30.2)	13.9 (21.9)	9.6 (18.0)	5.6 (13.8)	13.5 (21.0)	1324
Kangra Local	---	13.0 (21.1)	4.5 (12.2)	2.4 (8.8)	4.5 (12.2)	6.1 (13.6)	2037
LCK-88062	---	14.2 (22.7)	6.2 (14.4)	3.4 (10.5)	4.2 (11.5)	7.0 (14.8)	1685
LMH-16-5	---	17.9 (24.7)	6.0 (14.2)	4.0 (11.4)	5.0 (12.9)	8.2 (15.8)	2120
LMS-5-38	---	11.3 (19.4)	3.2 (10.3)	2.7 (9.5)	3.6 (10.7)	5.2 (12.5)	2116
S Em ±	(2.50)	(2.70)	(1.95)	(1.83)	(1.79)	(2.45)	133.5
CD (P=0.05)	(7.07)	(7.63)	(5.51)	(5.18)	(5.06)	(6.80)	377.5

Figures in parenthesis are angular transformed values.

However, during 1998-99 with high incidence of bud fly 1998-99, only two entries i.e., JLT-24 (8.3%) and JLT-84-5-1 (9.9%) reacted as resistant. Whereas, entries, JLT-84-12-1, JLT-26, LMH-91-24 and LMH-16-5 resistant on mean incidence basis behaved as moderately resistant. Genotypes, Kiran and LMH-90 were highly susceptible, 27 entries were susceptible and only 18 entries reacted as moderately resistant during this season.

Correlation coefficient between mean blooming period (24-39 days) and % capsule damage was computed and found to be non significant (0.047). Thus these findings differ with the findings of Malik *et al.*(1991) and Rai *et al.* (2000) that varieties having longer blooming period were severely infested by the budfly as compared to those with shorter blooming period. However, budfly susceptible genotype, LC-54 had longer blooming period (38 days) and resistant genotypes, LMH-16-5 and JLT-26 had shorter blooming period (27-30 days). But, this behavior was not exhibited in all genotypes.

Reaction against the incidence of Alternaria blight : Alternaria bud blight incidence varied significantly among the genotypes being 8.2-37.4, 4.5-42.8, 2.0-40.4, 1.7-21.9 and 1.5-21.7% respectively during 1997-98 to 2001-02. Pooled mean incidence also varied significantly (4.2-38%) among the genotypes. Six genotypes *viz.*, 5610, EC-1392, RLC-29, JLT-84-12-1, LMH-43 and LCK-93-24 (4.2-4.9% bud damage) reacted as highly resistant, 36 (5.1-10% bud damage) reacted as resistant and five, LMH-90 (10.3%), 1189 (11.7%), LMH-6-5 (12.9%), JRF-5 (13.5%) and JRF-1(20.6%) reacted as susceptible and two, JRF-3 (26.2%) and JRF-4 (28%) reacted as highly susceptible to Alternaria blight (Table 2).

However, during the year of high incidence of Alternaria blight (1997-98 and 1998-99), no genotype behaved as highly resistant. Genotypes reacted as highly resistant on pooled mean basis reacted only as resistant during the years of higher incidence. Thus, eight genotypes, *viz.*, RLC-29 (6.8 and 6.3%), JLT-84-12-1 (10.2 and 4.5%), LMH-43 (10 and 5.5%), LCK-93-24 (8.2 and 7.6%), JLT-26 (9.3 and 10.6 %), EC-1392 (8.4%), 5610 (8.8%) and CI-1466 (9%) behaved as resistant. Thirty six genotypes were moderately resistant. Genotypes, JRF-1, JRF-3 and JRF-4 were found highly susceptible to Alternaria blight.

Multiple resistance : Genotypes, JLT-84-5-1, JLT-84-12-1, JLT-24, JLT-26, LMH-91-24 and LMH-16-5 were found resistant to budfly as well as Alternaria blight.

Grain Yield : Grain yield was recorded only during *rabi* seasons of 1999-2000, 2000-01 and 2001-02 and varied significantly among the genotypes during all three seasons. Correlation coefficient between mean capsule damage caused by budfly and grain yield and between incidence of Alternaria blight and grain yield were also computed being r=0.?27 and –0.480 respectively which indicated that with the increase in susceptibility to each of the pest the grain yield was reduced. However, mean grain yield was maximum in genotypes, LMH-16-5 (2120 kg/ha), LMS-5-38 (2116 kg/ha), JLT-90 (2092 kg/ha), JLT-24 (2056 kg/ha), JLT-84-5-1 (2056 kg/ha), Kangra local (2037 kg/ha), NL-97 (2032 kg/ha), LCK-9211 (2019 kg/ha) and JLT-26 (2005 kg/ha) (Table 2).

Among these high yielding genotypes , LMH-16-5, JLT-24, JLT-26 and JLT-84-5-1 were also resistant to both the pests. Thus, these four multi-resistant genotypes with high yields may be further evaluated/improved for the development of high yielding multi-resistant varieties of linseed.

Similar efforts have been also made by Malik and Singh (1997) against the incidence of budfly and Alternaria blight and identified Neela as resistant to both the pests but with poor yields. However, in present studies, Neela reacted as moderately resistant to budfly and resistant to Alternaria blight with average yield of 1810 kg per ha.

References

Anonymous, 1985. Proceedings of XXVII Annual Progress Report of AICRP on Oilseeds (Linseed Entomology), Directorate of Oilseeds Research, Hyderabad.

Chauhan, L.S. and Shrivastava, K.N. 1975. Estimation of loss of yield caused by blight disease of linseed. *Indian Journal of Farm and Science*, **3**:107-109.

Jakhmola, S.S. and Yadav, H.S. 1983. Susceptibility of linseed cultivars to budfly (*Dasyneura lini* Barnes). *Indian Journal of Entomology*, **45** (2) : 165-170.

Lingappa, S., Patil, R.K. and Kulkarni, K.A. 2003. Management of insect pests of oilseed crops- Linseed. In.. *Thematic Papers* of National Seminar on "Stress management in oilseeds for attaining self reliance in vegetable oils" held at Directorate of Oilseeds Research, Hyderabad, January, 28-30, 2003 (eds. Mangala Rai, Harvir Singh and D.M. Hegde). pp.16-17.

Malik, Y.P. 1999. Varietal preference and economic injury level of budfly *Dasynuera lini* Barnes in linseed. *Journal of Oilseeds Research*, **16**(1): 97-100.

Malik, Y.P., Singh, B. and Pandey, N.D. 1991. Role of blooming period in linseed budfly (*Dasyneura lini* Bernes) resistance. *Indian Journal of Entomology*, **53** (2): 276-279.

Malik, Y.P. and Singh, S.V., 1997. Evaluation of linseed germplasm against budfly, *Dasyneura lini* Barnes and some important diseases. *Journal of Insect Science*, **10** (1) : 70-71.

Pal, S., Shrivastava, J.L. and Pandey, N.D. 1978. Effect of different dates of sowing on the incidence of *Dasyneura lini* Barnes (Diptera : Cecidomyiidae). *Indian Journal of Entomology*, **40** : 433-434.

Rai H.S., Gupta M.P. and Verma, M.L. 2000. Screening of linseed germplasm for resistance against linseed budfly, *Dasyneura lini* Barnes and role of blooming period. In: *Extended Summaries* of National Seminar on "Agriculture Scenario Challenges and Opportunities", held at College of Agriculture, Gwalior (M.P.) November, 11-12, 2000, pp.159.

J. Oilseeds Res., **21**(1): 112-116 (2004)

Forecasting of sesame, *Sesamum indicum* L. production in India

R. Kalpana Sastry, D. Rama Rao, V. Kiresur[1] and R. Vizayakumari[2]

National Academy of Agricultural Research Management, Rajendranagar, Hyderabad-500 030, AP

(Received: September, 2002; Revised: July, 2003; Accepted: September, 2003)

Abstract

The paper analyzes the future production scenario of sesame in India and suggests strategies to enhance its production. The forecasting is carried out on secondary data and is supplemented with qualitative assessment based on experts opinions. The forecast indicates that average production of sesame will increase from the present about 0.55 mt to about 0.8 mt by 2010 AD. Low yields, lack of standardized techniques for hybrid seed production and a lack of basic research were some major deterrents identified. Breakthrough in sesame research for development of hybrids and positive market is predicted to offset the constraints and ensure a modest future to sesame. Strategies focusing research along with hastening technology transfer policy is considered critical to sustain the growth of sesame production in India.

Key words: Forecasting, sesame

Introduction

India became near self-sufficient in edible oils by 1991 as a result of launching of technology mission on oilseeds in 1986 by the Government of India (Prasad *et al.*, 1994). The enhanced oilseed production came largely from rapeseed and mustard, soybean and sunflower (Virupakshappa and Kiresur, 1997; Rama Rao *et al.*, 2000). However, sesame though being the oldest traditional crop, could not register significant gains. In reality, the area and production under this crop has not shown adequate growth rate with the yield levels lowering especially during last five years (Singh *et al.*, 1997; Paroda, 2000). Our studies based on simple statistical analysis of secondary data could not provide adequate answers to understand this situation. In an effort to provide plausible answers to this, it was found necessary to analyze the sesame system in a holistic manner.

The future of a commodity not only depends on the need for the commodity but also on other competing crops or choices available to farmers, socio-economic factors, consumer habits, state policies, trade and private sector role. In-depth analysis of such a system would have to integrate quantitative with qualitative information. In such a scenario, the future projections need to integrate statistical (historic) data with qualitative information. Systems approach coupled with technological forecasting provides a means to achieve this. This study is aimed to fulfill this felt need so as to identify the constraints and potentials of sesame crop in the future, i.e., by 2010 AD.

Materials and methods

A blend of forecasting techniques was used to integrate qualitative and quantitative information in making the forecasts. The quantitative forecasts were made based on statistical analysis of secondary data for trend and growth in conjunction with brainstorming and Delphi methods for qualitative issues (Rohtagi *et al*, 1979; Martino, 1983; Makridakis, 1998).

The data were collected from a range of primary and secondary sources. The primary data was collected with the help of oilseed experts across the country. Secondary data was collected from various publications on oilseeds (GOI, 2001; CMIE, 2001; Damodaram and Hegde, 2001; Ramanjaneyulu *et al.*, 2001; FAO, 2002).

The key quantitative and qualitative issues were identified through brain storming session and discussions with experts (Rama Rao *et al.*, 2000). The issues comprised of various aspects of oilseeds such as cultivation, research and development, seeds, marketing, consumption, alternate uses, processing and state policies.

Results and discussion

Growth : The average yield of sesame during 1979-2001 was about 300 kg/ha, as the crop was grown under sub-optimal conditions in India. The oilseeds in India showed changes in the area, production and yield after 1986. This corresponds to initiation of mission-mode program to accelerate the oilseed sector embarked by the national government. While the program continues even today, the initial gains seem to be offset by early 1990s. Hence, the sesame data was analyzed for growth for the three periods, namely 1979-85, 1986-93 and 1994-2001. The

[1] University of Agricultural Sciences, Dharwad, Karnataka
[2] Regional Agricultural Research Station, ANG Ranga Agricultural University, Jagityal, AP.

compound annual growth rates of area, production and productivity of sesame (Table 1) show that there is rise in the growth rate in the period, 1986-93. Compound growth rates in 1979-85 for both area (-1.6%) and production (4.3%) went up to 1.4% and 7.8%, respectively, in the period 1986-93. Growth rate for yield too increased from 2.5% in 1979-85 to 6.4 % in 1986-93.Period 1986-93 assumed significance as the gains were not sustained in the next period i.e., 1994-2001, when rates for area, production and yield decreased.

Table 1 Compound annual growth rates of area, production and yield of sesame

Period	Compound annual growth rate (%)		
	Area	Production	Yield
1979-85	-1.6	2.5	4.3
1986-93	1.4	7.8	6.4
1994-01	- 4.0	-1.5	2.6

Source: *Oilseeds Situation-A Statistical Compendium*, Damodaram and Hegde, 2001.

Statistical forecast: A simple forecast based on trend extrapolation of historic data projects a shockingly low area of 1.5 m. ha and 0.4 m. tonnes for sesame area and production. But most experts on sesame differed with this and there was a broad consensus predicting sesame to show modest gain and sustain its area and production in the coming decade.

Cybernetic diagram for sesame: To provide a more realistic forecast a systemic view is attempted by incorporating qualitative and quantitative factors in cybernetic diagram illustrated in Fig. 1.

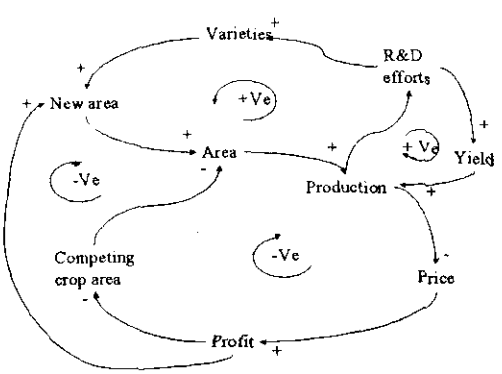


Fig 1 Cybernetic diagram for sesame

The cybernetic diagram showed the cause and effect relationship among the identified variables of the system (Mohapatra *et al.*, 1994). It is characterized with feedback loops having positive and negative polarities. This polarity in turn reflects whether the flow is reinforcing or inhibiting over time. In case of sesame, the important variables were identified in a brainstorming workshop involving experts from research, development, academic, trade and processing sectors. Results of the model simulation indicate a balanced outlook, i.e., –ve and +ve factors balance each other. Concerted efforts in research and development would lead to higher yields, production and area even with available varieties. Factors like low prices and competing crops would negate these effects. Strategic planning to thwart this threat, perhaps can sustain the crop. Keeping this model in view, details on contributing factors are discussed below.

Exploitable yield and technology time gap: The national average annual yield of sesame during 1979-2001, is 300 kg/ha while the realizable yield with improved technology is twice this; thus the realizable yield gap in sesame accounts for nearly 50 % of the actual yield. Time to achieve the realizable yield (i.e. yield of improved varieties / hybrids) was forecasted by fitting yield data (1979-2001) to the growth model using the formula (Martino, 1983).

$$y = L / (1+a\, e^{-bt})$$

where, L is upper limit to growth of the variable y, t is time and a and b are the coefficients evaluated by fitting the data.

The model depicted in Fig. 2 gives the time required for achieving the desired yield by using improved technologies as about 22 years. Even though sesame is oldest oilseed crop, the time lag to achieve the realizable yield is large as the crop is largely grown under dry land farming. It is thus, a challenge to look and frame the ways and means to exploit the realizable yield potential in this crop.

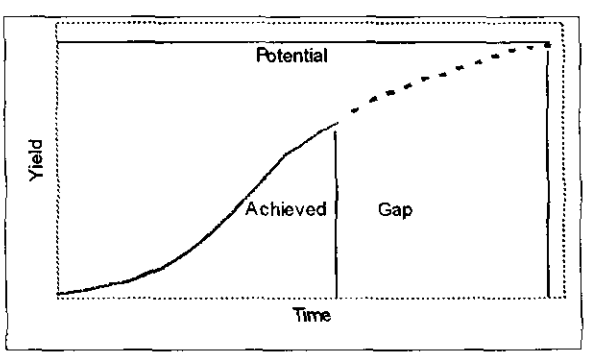


Fig 2 Growth model for depicting time for realizing yield

Major technological advances like that in castor (Rama Rao *et al.*, 2000) and better dissemination techniques for the improved methods can reduce this gap. The technology transfer through public system for sesame is forecasted to remain low as at present. However, some positive changes are expected through the entry of private sector entry in seed marketing.

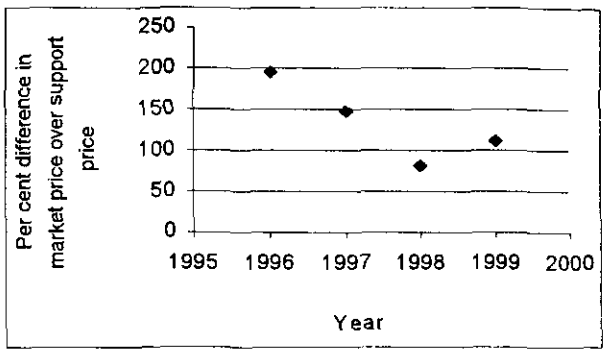
Quality seed: Production and distribution of certified seed to farmers is one of the major developmental tools in promotion of a crop vis-à-vis area under cultivation. The quantity of seed required is about 13800 tonnes (@ 6 Kg/ha) and the actual production is about 7 % of this. As there are no hybrids of this crop, experts opine that, seed replacement of 15 to 20 % is sufficient as farmers can use the home grown seed for about five to six years. In other words, though seed multiplication is not commensurate with required quantity for this crop, it cannot be considered major constraint in the absence of hybrids. However, there is need to coordinate quality seed multiplication to introduce hybrids in this crop.

Competing crops: One of the major reasons for shift in area under oilseed crops in the past has been due to competition from other profitable crops. During the last decade, there have been remarkable changes in the area under oilseed crops. Based on the data available though primary and secondary sources and opinions of experts, the major competing crops identified for sesame are groundnut, millets and pulses. Delphi forecast indicated that these crops may indent into the sesame area based on market prices and their relative profitability. On the other hand, sesame is likely to spread into non-traditional areas by 2010 AD and they are:

* Hilly areas of Uttar Pradesh, Madhya Pradesh, Himachal Pradesh and Maharashtra,
* Rice fallows in new project areas,
* Rainfed areas in Rajasthan, Madhya Pradesh, Uttar Pradesh, Karnataka and Andhra Pradesh.

The crops likely to be replaced by sesame are niger, minor millets, *Pennisetum* and sorghum. Thus, rice fallow situation, change over to multiple cropping from single/two crops, inter cropping and catch crop would be the major contributors for growth of sesame in India.

Price : Government support price provides assurance from market risk. The government is supporting sesame through minimum support price scheme from 1995-96 onwards. The difference in average price of sesame seed in market with the prevailing government support price is shown in Fig. 3. It is evident that market prices are always higher than the government support price.

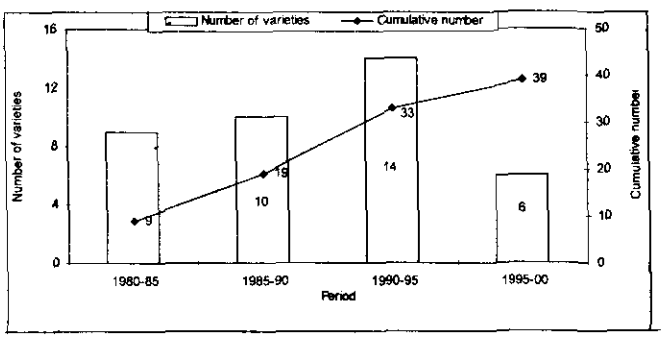


Source : Agricultural Statistics at a Glance, 2001.

Fig 3 Comparative market price over support price of sesame seed

Though government support price assures minimum returns and is a tool to avoid distress sales. In international market, the average world export price of sesame is in the range of Rs 3500 to Rs 4500/tonne during 1997-2000 (FAO, 2002), which is much higher than the open market price in India during the same period. Thus, Indian sesame has no threat from international markets. Marketing sesame is not a serious constraint but growers feel that the support price need to be more realistic as it would further push up and stabilise the open market price.

High yielding varieties / hybrids: Sesame is a seasonal and location bound crop. A particular variety does not perform uniformly in all locations and in all seasons. A number of varieties and hybrids have been released for various sesame growing locations in the country. The number of sesame varieties released during1980-2000, is depicted in Fig. 4.



Source : Oilseeds Situation-A Statistical Compendium, Damodaram and Hegde, 2001.

Fig. 4 Varieties and hybrids released in sesame (1980-2000)

About 39 improved varieties of sesame were developed during 1980- 2000. Up to 1995 there has been a steady increase in the number of varieties with a maximum of 14 varieties during 1990-95. However, only five cultivars were developed during the last five years. This reflects the early gains of technology mission program initiated in 1986. It is matter of concern that there has been a sudden decline during the past five years and the pace of development has not been on a sustainable mode. The possible causes leading to this and its future are discussed below.

The performance of varieties released is not uniform and yield of a new variety represents a measure of research in developing it. It is interesting to note that, 75 % of the varieties released in sesame were having yield above the threshold (yield with improved technology). The decline in release of newer varieties in the recent past is an indication that it would be difficult to look for more conventional varieties and the newer varieties have to come from hybrids and biotechnology, which can promise varieties with yield greater than the present threshold level. In other words, some major research breakthroughs are key to new varieties / hybrids and hence to the future of this crop.

Research breakthroughs : Based on Delphic survey some major research breakthroughs that are considered possible by experts in the next ten years in sesame are:

* Development of photo insensitive varieties with low senescence,
* Exploitation of germplasm for HYVs.
* Varieties for specific end uses like bold white seed
* Commercialization of newer end-use varieties
* Biofertilizer and biocontrol agents
* Value-added food products like sweetened candies, perfumes and sesame meal

The yield levels for new varieties/hybrids evolved by 2010 AD will be about 1000 kg/ha for varieties and 2000 kg/ha for hybrids. At present private sector share in sesame seed business is insignificant and by 2010 AD it would have market share of 20% for improved varieties and 75% for hybrids. This is critical to arrest declining trend in area under this crop.

There is a need to develop sustainable hybrid seed production techniques under farmer's field conditions as the cross-pollination is mostly by insects. The potential of enhancing crop productivity to a certain level being inherent, these have to be proved in field in order to sustain farmers interest in the crop.

Publications: Research results are generally disseminated through publications, which are good measure of research effort. Like improved varieties, number of publications is another means to reflect the research output. Manpower being a key resource in research, publications per scientist provides a measure of the effort. The average number of papers per scientist per year was calculated from the publications data during 1989-91 and 1997-99. It is of concern to note that the number of papers per scientist per year of 0.15 low. Further, publication data also indicated that basic research on sesame is at low key and experts also concurred on this. Basic research is low, as bulk of the scientists are in experimental research. Further, drop in number of new varieties emanated from this constraint. Thus a shift in research focus to basic area is pre requisite for contemplated research breakthroughs as discussed above. The forecast indicates a small shift to basic research which is critical to development of knowledge leading to development of new improved varieties and hybrids in this crop.

Consumer preferences to oils :Survey on consumer choices of edible oils show (Table 2) that the sesame oil is least preferred by all income categories. The results do not show any changes in consumption of sesame oil in future either on health or on economic grounds. In other words, sesame oil continues to be used for specific purposes as is being used at present.

Table 2 Consumer preferences for edible oils

Preference	Preferences of consumption
1	Rapeseed-mustard, Palm oil, Groundnut, Safflower
2	Groundnut, Rapeseed-mustard
3	Soybean, Safflower, Rapeseed-mustard
4	Sesame, Others*

* Other oils like vanaspati / ricebran oil / cotton seed oil

Production forecast: Forecasts for sesame area and production by 2010 AD are given in Table-3. The forecasts were made by the trend based on past two decade data, delphi and consultation with oilseed experts. As indicated earlier, the projections for area and production by trend forecasting are 1.6 m.ha and 0.4 m. tonnes, respectively. The corresponding forecast by Delphi was 2.3 million ha and 1.0 million tonnes, respectively. A combined forecast was prepared in consultation with oilseed experts with due consideration to the above factors and the final forecasts are 2 m. ha for area and 0.8 million tonnes for production. The production of sesame in 2010 AD will be 0.27 m.tonnes higher than the average production of 0.53 m. tonnes during 1997-00. The contributions of area and productivity to the growth in sesame production will be 6

% and 94 % respectively, i.e., the additional production would largely come from yield enhancement.

Table 3 Forecasts for sesame area, production and yield by 2010 AD

	Area (million hectares)	Production (million tonnes)
Trend	1.6	0.4
Delphi	2.3	1.0
Combined forecast	2.0	0.8

Assuming the present use of sesame continues in the next decade, sesame oil production would be around 320 thousand tonnes by 2010 AD, which is higher by about 80,000 tonnes than the present. As India continues to import edible oil to meet domestic demand, this additional quantity will be used in the domestic sector.

Conclusions

This paper attempts to project the future situation for sesame crop in India. This would be necessary to prioritize the already dwindling status of sesame research and production in this country. Even though this is a traditional crop for centuries, the recent past indicates decline in its area. However, present usage patterns in conjunction with the research/developmental efforts for the crop show a modest future for it. Possible research achievements in evolving HYV/ hybrid coupled with limited entry of private sector in seed marketing is likely to offset this downward trend. Our study shows that basic research in this oilseed needs to be strengthened. It was seen that very slow technology transfer process is the main reason for high realizable yield gap in sesame. Development of improved varieties / hybrids is critical to the research and extension systems in both public and private sectors to speed up transfer of technologies. The potentialities being limited for the crop in terms of diversification or very high productivity levels, price competitiveness would be a major force for the growers in the present day product-driven agricultural trade. In such a scenario, sesame crop sustains and its production is forecasted to increase from present 0.5 mt to about 0.8 mt by 2010 AD.

References

CMIE, 2001. Agriculture Production Year

Damodaram, T. and Hegde, D.M., 2001. *Oilseeds situation - A statistical compendium.* Directorate of Oilseeds Research, Hyderabad.

FAO, 2002. www.fao.org

GOI, 2001. *Agricultural Statistics at a Glance*, Directorate of Economics & Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture.

Makridakis, Spyros. 1998. *Forecasting Methods and Applications.* John-Wiley, New York.

Martino, J. P. 1983. *Technological Forecasting for Decision Making.* Elsevier Science Pub, Amsterdam.

Mohapatra, P.K.J., Mandal, P. and Bora, M.C., 1994. *Introduction to System Dynamics Modeling.* University Press, Orient Longman, Hyderabad.

Paroda, R. S., 2000. Chairman's speech in National Seminar on Oilseeds and Oils - Research and Development needs in the Millennium from February 2-4, 2000, Indian Society of Oilseeds Research, Rajendranagar, Hyderabad.

Prasad M. V. R., Kalpana Sastry, R., Raghavaiah, C.V., and Damodaram, T. 1994. *Sustainability in Oilseeds.* Indian Society of Oilseeds Research, Hyderabad, India.

Rama Rao, D., Kiresur, V. and Kalpana Sastry, R. 2000. *Technological forecasting of future oilseeds scenario in India.* NAARM, Hyderabad, India.

Ramanjaneyulu, G.V., Ramana Rao, S.V. and Hegde, D.M., 2001. *A decade of frontline demonstrations in oilseeds – An overview.* Directorate of Oilseeds Research, Rajendranagar, Hyderabad.

Rohtagi, P. Rohtagi K. K. and Bowander B., 1979. *Technological Forecasting.* Tata Mc Graw Hill Pub, New Delhi.

Singh, R.P., Reddy, P.S. and Kiresur, V., 1997. Sustainable oilseeds production systems in India. In: *Efficient management of dryland crops in India – Oilseeds.* Indian Society of Oilseeds Research, Hyderabad, pp.1-20.

Virupakshappa, K., and Kiresur, V. 1997. *Oilseeds – Policy options for plenty.* The Hindu Survey of Indian Agriculture 1997, pp.61-65.

World Bank, 1997. India, The Indian Oilseed Complex: Capturing Market Opportunities, Volume 1, Main.

J. Oilseeds Res., **21**(1): 117-120 (2004)

Seed composition and fatty acid profile of some tree borne oilseeds

G. Nagaraj and N. Mukta

Directorate of Oilseeds Research, Rajendranagar, Hyderabad-500 030, AP

(Received: December, 2002; Revised: June, 2003; Accepted: September, 2003)

Abstract

The oil and protein contents with their fatty acid profiles of 15 tree oilseeds were analysed. The oil content of seeds ranged from 4.6% in *Parkinsonia aculeata* to 37.4% in *Pongamia pinnata*. Protein content was the lowest in *Melia azedarach* (7.9%) and highest in *Albizzia lebbek* (30.9%). Oleic and linoleic acid were the major fatty acids in seven species each while *Jatropha curcas* had an equal proportion of both the fatty acids.

Key words: Tree borne oilseeds, phenology, oil content, fatty acid profile, protein content

Introduction

India has made tremendous progress in the production of annual oilseeds as a result of the technological advances and area expansion (Rai *et al.*, 2002). However, the wide demand supply gap still exists and the bridging of this gap needs immediate attention. At this juncture, when further area expansion is not feasible, the need to tap the perennial sources of oil gains importance. India has a vast array of non-traditional oilseeds, particularly the forest and tree oilseeds. Many of the species have been in use by ethnic communities since time immemorial, as they provide edible grade oil and possess medicinal and pesticidal properties. Besides, the oils find use in a wide range of industrial applications and also have export potential. Exploitation of the same has become essential for their utilization in the edible and non-edible oil industry to reduce the pressure on the annual oilseeds (Bhattacharya, 2002).

Among the many factors affecting the utilization of the oil and protein from seeds, the major one is the source of availability of seeds. In order to develop the system on a sustainable basis, in addition to collection of seeds from existing trees, the setting up of plantations may form a viable alternative. Presently large quantities of the minor forest products including tree borne oilseeds are consumed locally. The exploitation of these products should therefore, be preceded by the efforts for their renewal on a sustainable basis (Mukta, 2002). In this context, at the Directorate of Oilseeds Research, Hyderabad, a plantation of various tree species was established on shallow marginal soils under rainfed conditions. The flowering and fruiting phenology of the trees, oil and protein contents of the seeds along with the fatty acid profile of 15 tree oilseeds have been studied. Their importance and scope for their utilization are discussed.

Materials and methods

Trees of 15 species were planted at the Research farm of the Directorate of Oilseeds Research, Hyderabad on erosion prone Alfisols with poor soil fertility under rainfed conditions. The site receives an annual rainfall of 700 mm and air temperature during the months of May-June reaches upto 43^{0}C. The trees were planted during 1988-89 and observations on flowering and fruiting phenology were recorded at regular intervals. Seeds of these plant species were collected during 1997-98 and 1998-99 seasons after proper maturity. These were studied and analysed for oil (soxhlet extraction) and protein (Kjeldahl N x 6.25) contents. The oil was extracted with petroleum ether which was interesterified with methanolic KOH (Paquot, 1979). The methyl esters of fatty acids were separated on a DEGS column at 180^{0}C in an AIMIL gas chromatograph. Nitrogen (40 ml/min) was the carrier gas. The detector and oven temperatures were maintained at 250^{0}C. The identification of the fatty acids was based on comparison of RT values of standards.

Results and discussion

The juvenile period for all the species studied ranged from 0.5 to 4 years (Table 1). Species like *Jatropha curcas* flowered early while *Pongamia pinnata* took 4 years for the initiation of flowering. The seed maturity of 10 species occurred in the first half of the year while three species i.e., *Anonna, Leucaena* and *Jatropha* matured in the latter half. Seed maturity during the monsoon has been the major hindrance in collection programmes of tree borne oilseeds. In the present study, majority of the species matured before or after the monsoon so collection programmes could be successfully organised.

Ease of seed removal is another factor which will affect the extraction and utilization of oil. Among the species studied, the seed separation from fruit was found to be difficult for only three species *Melia, Anonna* and marking nut. However, most of the leguminous tree species have hard seed coats and need special processing techniques for oil extraction.

Oil and protein content: The oil content of the seeds ranged from 5-10% in *Albizzia, Acacia, Leucaena, Melia* and *Parkinsonia*. Marking nut seeds contained around 17% oil. *Pithecellobium* seeds contained 18% oil while Garg (1996) reported an oil content of 16%. *Anonna, Bauhinia, Ceiba, Simarouba* and *Moringa* contained 20-30% oil while the seeds of *J. curcas* and *Pongamia pinnata* contained 30-40% oil.

The protein content on whole seed basis ranged from 8-28%. Lower level of protein was observed in *Melia* (7.9%), *Anonna* (13.6%), *Bauhinia* (13.9%), *Parkinsonia* (15.6%) *Simarouba* (16.5%) and *Acacia* (17.6%). In the case of *Acacia*, Sita Devi *et al.* (1979) have reported total protein content of 19.6%. *Albizzia, Leuceana, Ceiba* and *Moringa* seeds contained higher level of protein (25-30%) while seeds of the remaining five species viz., Semecarpus, *J. curcas, Erythrina indica, Pongamia* and *Pithecellobium* seeds had protein in the range of 20-25%. Ambasta (1986) has reported higher value of protein in seeds of *Pithecellobium* (30%) and edibility of seeds of *Parkinsonia* with glutelin and albumin being the primary proteins.

Fatty acid profile: *Fatty acid composition of the oils* derived from the tree borne oilseeds showed wide variations (Table 2). Palmitic, palmitoleic, stearic, linoleic, linolenic, arachidic and behenic acids were the fatty acids identified in one or the other of these vegetable oils. Except for lower values for *Moringa* and *Melia*, all other species contained palmitic acid ranging from 10-21%. However, higher values of palmitic acid were reported by Garg (1996) in case of *Melia* (9.7%) and Raval and Toliwal (1996) for *Moringa* (12.3%). In the present study, the highest value was recorded in the case of *Ceiba pentandra* (20.6%). *Simarouba* (23%) was the richest in stearic acid followed by *Albizzia* (15%) while the other species exhibited the normal range of 3-12%. Variable values of stearic acid have been reported in mature seeds of *Jatropha curcas* ranging from 3.9% in the present study to 5.25 % reported by Raina and Gaikwad (1987). However, Datta and Pandey (1996) could not detect the presence of stearic acid during GLC analysis of mature seed.

Table 1 Flowering and fruiting phenology of some tree borne oilseeds

Species	*Family*	*Common name*	Number of years to first flowering	*Time of flowering*	Period of harvesting	Ease of threshing*
Acacia nilotica	Mimosaceae	Babul	3-4	July	March-April	++
Albizzia lebbek	Mimosaceae	Siris	2	Feb-March	June-Aug	+++
Anonna squamosa	Annonaceae	Sitaphal	3	July-Aug	Nov	+
Bauhinia spp	Caesalpiniaceae	Kachnar	3	Sept-Oct	March	+++
Ceiba pentandra	Bombacaceae	Kapok	2-3	Nov-Dec	May	++
Erythrina indica	Fabaceae	Dadhap	2-3	Dec-Feb	April	+++
Jatropha curcas	Euphorbiaceae	Ratanjyot	0.5	July-Aug	Aug-Oct	+++
Leucaena leucocephala	Mimosaceae	Subabul	1.5-2	April, July	Nov-Dec	+++
Melia azedarach	Meliaceae	Persian lilac	1.5-3	July	April – June	+
Moringa oleifera	Moringaceae	Saijan	1.5-2	Feb	May – Aug	+++
Parkinsonia aculeata	Caesalpiniaceae	Vilayati babul	2.5-3	Jan, Aug	April-May	++
Pithecellobium dulce	Mimosaceae	Jangli jalebi	2.5-3	Jan-Feb	May-June	++
Pongamia pinnata	Fabaceae	Karanj	4	March, July	Feb-March	+++
Semecarpus anacardium	Anacardiaceae	Marking nut	3-5	July-Aug	Jan- March	+
Simarouba glauca	Simaroubaceae	Aceitino	3	Dec	April	++

* Ease of threshing + = very difficult, ++ = medium, +++ = easy seed removal

Table 2 Seed composition and fatty acid profile of some tree borne oilseeds

Genera	Total oil content (%)	Seed Protein (%)	Palmitic acid 16:0	Stearic acid 18:0	Oleic acid 18:1	Linoleic acid 18:2	*Other fatty acids
Acacia nilotica	7.4	17.6	12.5	11.5	28.3	44.5	-
Albizzia lebbek	5.3	30.9	17.1	14.7	23.4	54.9	-
Anonna squamosa	25.9	13.6	15.0	10.6	48.0	24.7	18:3 = 1.4
Bauhinia spp	20.4	13.9	10.0	11.9	20.4	47.5	20:0 = 1.7, 22:0 = 0.4
Ceiba pentandra	28.1	25.0	20.7	2.8	32.7	42.1	16:1=0.6
Erythrina indica	16.2	19.7	14.9	7.7	61.4	5.7	20:0=3.8, 22:0=4.3
Jatropha curcas	33.0	23.0	12.6	3.9	41.8	41.8	-
Leucaena leucocephala	7.9	27.8	17.9	8.4	18.7	55.0	-
Melia azedarach	7.5	7.9	8.4	4.0	23.7	62.9	20:0=0.5
Moringa oleifera	20.5	24.5	7.3	6.0	77.0	0.6	20:0=3.9, 22:0=2.8, 16:1=2.0
Parkinsonia aculeata	4.6	15.6	16.5	7.2	31.6	44.0	-
Pithecellobium dulce	17.9	21.4	20.1	4.6	43.2	29.8	18:3=2.8 20:0=2.3
Pongamia pinnata	37.4	20.2	11.3	6.4	54.5	17.0	18:3=4.5, 20:0=5.2
Semecarpus anacardium	16.8	23.2	14.4	6.8	60.0	7.7	20:0=4.8, 22:0 6.3
Simarouba glauca	27	16.5	11.3	23.0	64.9	1.6	-

* 16:1=Palmitoleic acid; 18:3= Linolenic acid; 20:0=Arachidic acid; 22:0=Behenic acid

Oleic acid was the major fatty acid in *Moringa* (77%), *Simarouba* (65%), *Erythrina* (61%), *Semecarpus* (60%), *Pongamia* (55%), *Anonna* (48%), and *Pithecellobium* (43%). Linoleic acid was the predominant fatty acid in the case of *Melia* (63%), *Albizzia* (55%), *Leucaena* (55%), *Bauhinia* (48%), *Parkinsonia* (44%), *Acacia* (44%) and *Ceiba* (42%). The lowest level of linoleic acid was observed in *Moringa* (0.6%).

Among the minor fatty acids, palmitoleic acid was observed in *Moringa* (2%) and *Ceiba* (0.6%) only. However, it has been reported by Garg (1996) in case of *Pithecellobium* (3.1%) also. Linolenic acid was observed in four species *viz.*, *Pongamia* (4.5%), *Pithecellobium* (3%), *Anonna* (1.4%) and *Ceiba* (1.1%). Arachidic acid was little more widespread and was present in *Semecarpus* (5%), *Erythrina* (4%), *Moringa* (4%), *Bauhinia* (2%), *Pithecellobium* (2%) and *Melia* (0.5%). Behenic acid (22:0) was observed in *Semecarpus* (6%), *Erythrina* (4%), *Moringa* (3%) and *Bauhinia* (0.4%).

Raina and Gaikwad (1987) reported that the fatty acid composition of 'Curcas oil' was found to be affected by stage of maturity and season of harvest. The variable values obtained in the other species as discussed above may also be dependant on these factors. The variations can also be attributed to the regional difference in seed sources and variations in the analytical techniques adopted.

Utilization: From the point of view of utilization, palmitic, stearic and oleic acids find uses in soaps, detergents, plastics, coated papers, rubber coatings, candles, crayons, waxes, lubricating greases, polishes, buffing agents and cosmetics. Linoleic acid and linolenic acid though categorized as essential fatty acids, for human nutrition, have uses in the paint and varnish industry, because of their higher unsaturation. Most of the tree borne oilseeds depending on the oil content and availability can easily be utilized for the above purposes depending upon their fatty acid composition. *Moringa* seeds are edible, and hence its oil can easily be utilised as edible oil when available in sufficient quantities. Raval and Toliwal (1996) have found no harmful effects of this oil in a feeding study conducted on rats. This oil was low in 16:0 which is considered problematic to cardiac patients. Further, the oil being rich in oleic acid (18:1) and very low in linoleic acid is very stable and should serve as very good frying oil. Higher levels of stearic acid in *Simarouba* would be useful in avoiding hydrogenation and also serve as cocoa butter substitute. The unsaponifiable matters of some of the vegetable oils may find uses as pesticides, medicines etc.