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CONTENTS

Effect of soil moisture regime on plant growth, fruiting, fruit quality and nutrient uptake of mango (<i>Mangifera indica</i>)	Ranbir Singh, J S Chandel and A R Bhandari	135
Nutritional status of healthy and declining citrus (<i>Citrus</i> species) orchards	J K Dey and D D Singha	139
Integrated nutrient management effect on rice (<i>Oryza sativa</i>) – wheat (<i>Triticum aestivum</i>) system productivity in subhumid ecosystem	D M Hegde	144
Effect of row arrangement on yield and monetary benefits in mulberry (<i>Morus indica</i>) + soybean (<i>Glycine max</i>) and mulberry + greengram (<i>Phaseolus radiatus</i>) intercropping	D R Dayakar Yadav and T D Nagendra Kumar	149
Field evaluation of cowpea (<i>Vigna unguiculata</i>) varieties for grain and fodder production and for multiple disease resistance in Nigeria	S A Adebitan and O O Olufajo	152
Development of maize variety resistant to the maize stalk borer (<i>Chilo partellus</i>)	V P S Panwar, B K Mukherjee and N N Singh	155
Mutational rectification of certain defects in the aerial podding genotype of 'TAP 5' groundnut (<i>Arachis hypogaea</i>)	G Vanisree and M V R Prasad	158
Integrated management of <i>Helicoverpa armigera</i> on gram (<i>Cicer arietinum</i>)	M M Sanap and V M Pawar	162
Efficacy of imidacloprid, a new insecticide for controlling <i>Myzus nicotianae</i> on flue cured virginia tobacco (<i>Nicotiana tabaccum</i>)	G Ramaprasad, U Sreedhar, S Sitaramaiah, S Nageswara Rao and S V V Satyanarayana	165
Field efficacy of botanical extracts for controlling major insect pests of Okra (<i>Abelmoschus esculentus</i>)	D Adiroubane and S Letchoumanane	168
Moisture-use pattern of a groundnut (<i>Arachis hypogaea</i>) based intercropping system in semi-arid environment*	G Karunasagar and S Narsa Reddy	171
Response of potato (<i>Solanum tuberosum</i>) to irrigation and nitrogen in Lahaul Valley of Himachal Pradesh	Y P Dubey, B P Kaistha and S K Bhardwaj	174
Heterosis for vitamin C in tomato (<i>Lycopersicon esculentum</i>)	R P Bhatt, V R Biswar, H K Pandey, G S Verma and Narendra Kumar	176
Stability in grain yield of buckwheat (<i>Fagopyrum tataricum</i>) in the dry temperate region of Himachal Pradesh	T R Sharma and H K Chaudhary	179
Factors affecting germination of spores of <i>Gliocladium virens</i>	D K Saha and Sitansu Pan	181
Susceptibility of cotton leafhopper (<i>Amrasca devastans</i>) to insecticides in Tamil Nadu	S Santhini and S Uthamasamy	184
Evaluation of promising germplasm genotypes of mulberry (<i>Morus</i> species) for higher productivity under irrigated condition	R S Malikarjunappa, H V Venkateshaiah, M S Eswar Rao, S B Dandin and U D Bongale	186



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Effect of soil-moisture regime on plant growth, fruiting, fruit quality and nutrient uptake of mango (*Mangifera indica*)

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ABSTRACT

A field experiment was conducted during 1990-92 to study the effect of soil-moisture regimes on plant growth, fruiting, fruit quality and mineral composition and to work out the irrigation water requirement for bearing mango (*Mangifera indica* L.) trees. Plant height, shoot growth, fruit retention, fruit quality, yield and leaf nutrient status were found significantly higher in trees irrigated at 20 and 40% depletion of available soil-moisture than those irrigated at 60% depletion of available soil-moisture and unirrigated control. There was 87 and 79% increase in yield when irrigation was applied at 20 and 40% depletion of available soil-moisture, respectively compared with the unirrigated control. Though the plant growth, yield and fruit quality were slightly better in trees irrigated at 20% depletion of available soil-moisture than those irrigated at 40% depletion of available soil-moisture but there was 8.07% saving of water in 40% irrigation treatment without any adverse effect on tree growth, yield and fruit quality as observed in trees irrigated at 60% depletion of available soil-moisture and unirrigated control. Trees required 21-23 irrigations amounting to 125.4 cm of irrigation water/year at 40% available soil-moisture depletion level.

Key words : soil-moisture regimes, irrigation, water requirement, yield, leaf nutrient, mango fruit quality

Water management in mango orchards is an important issue and a meagre information is available on this aspect. Irrigation plays an important role in the production of new flushes, improves fruit set and yield (Purushotham and Narasimham 1981), maintains proper moisture conditions, particularly during the dry spell (Young 1972). Tree growing under optimum soil-moisture conditions improve both growth and yield (Goode and Ingram 1971, Cepicka 1981) and accumulate more nutrients in the leaves (Menzel *et al.* 1986).

The sub-mountainous tract of Himachal Pradesh is quite suitable for the commercial cultivation of mango, where most of the orchards are unirrigated and give low yields of poor quality fruits. The present study was therefore, conducted to investigate the influence of different soil moisture regimes on growth, fruit yield and leaf nutrient status of mango (*Mangifera indica* L.) crop.

MATERIALS AND METHODS

A field experiment was conducted on 10-year-old (bearing) mango trees growing on silty clay-loam soil with deep water-table at the regional research station, Jachh of the university during 1990-92. The rainfall received during 1990,

1991 and 1992 was 1 996, 1 723 and 1 626 mm. The experiment was laid out in a randomized block design with 4 irrigation treatments and each treatment was replicated 4 times. I₀, control (no irrigation); I₁, irrigation at 20% available soil-moisture depletion; I₂, irrigation at 40% available soil-moisture depletion, and I₃, irrigation at 60% available soil-moisture depletion.

Before the start of the experiment, soil-moisture retention capacity up to 90 cm depth was determined by pressure plate membrane apparatus (Richards 1949) (Table 1). The experimental soil (0-30 cm) was silty-clay loam in nature with pH 7.0 and organic carbon was 0.92%. Initially, all the treatments received a common irrigation except the unirrigated control and, thereafter each tree was irrigated as per treatment schedule. The quantity of water applied was 27, 57 and 81 mm for the available soil-moisture depletion level of 20, 40 and 60%, respectively. The computed amounts of water/irrigation for 2 m plant basin were 129, 271 and 387 litres at 20, 40, and 60% available soil-moisture depletion levels, respectively. The growth parameters recorded were plant height, shoot growth, spread and fruit retention/panicle. After harvest, fruit yield and physico-chemical analysis of fruits were done with the standard procedures of AOAC(1970). It may, however, be mentioned that during 1991 there was no crop due to alternate bearing in mango.

Leaf sample collection, washing and drying for nutrient

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element analysis were done as suggested by Chapman (1964). Nitrogen in the plant samples was estimated by micro-kjeldahl method (AOAC 1970). Leaf samples were digested in nitric-perchloric (4 : 1) acid mixture and P in the digest was estimated by vanadomolybdo-phosphoric yellow colour method (Jackson 1970). K, Ca, Mg, Fe, Zn and Mn were estimated on Atomic Absorption Spectrophotometer.

The weekly irrigation water requirement computed for each month was used to determine the annual irrigation water requirement. Soil-moisture in different layers of 90 cm profile was determined gravimetrically before start of the experiment, before and after each irrigation and also, at the end of the experiment. Total water expense was computed considering the sum of the irrigation water applied, profile water use and total rainfall during the period of the experiment. The ground water table remained below 3 m in the growing season of the crop.

RESULTS AND DISCUSSION

Growth, yield and fruit quality

The data clearly indicate that trees irrigated at 20 and 40% available soil-moisture depletion levels, attained significantly more shoot growth, spread and height than those at 60% available soil-moisture depletion and un-irrigated control (Table 2). Maximum mean plant height (3.76 m), shoot growth (13.69 cm) and plant spread (3.11 m), respectively were recorded with irrigation at 20% available soil-moisture depletion level. While, the minimum height (2.75 m), shoot growth (13.69 cm) and spread (2.50 m) was recorded under un-irrigated control.

The plant height, shoot growth and plant spread decreased with the increase in available soil-moisture depletion levels of 20, 40, and 60%. The per cent increase in plant height over control was 41, 26 and 11% when irrigated at 20, 40 and 60% available soil-moisture depletion levels, respectively.

Table 1 Soil-moisture retention capacity at different tension (bar)

Depth (cm)	Soil-moisture content (%)							Available soil-moisture (%)
	0	0.3	1.0	3.0	5.0	10.0	15.0	
0-15	32.0	24.3	14.3	11.5	11.0	10.3	8.9	15.4
15-30	31.4	23.1	13.5	12.4	9.7	9.3	8.3	14.9
30-45	29.5	24.6	13.5	12.1	10.1	10.0	7.3	17.3
45-60	31.8	25.0	13.7	13.3	11.6	10.6	10.1	14.9
60-75	30.5	26.1	12.8	12.6	11.0	10.9	10.3	15.8
75-90	31.0	26.3	12.5	12.3	11.6	11.4	10.5	15.8

Table 2 Effect of soil-moisture regimes on tree growth, yield and quality of 'Dashehari' mango

Treatment	Year	Shoot growth (cm)	Plant Spread (cm)	Plant Height (m)	Fruit retention/panicle	Fruit length (cm)	Fruit breadth (cm)	Fruit weight (q)	TSS (%)	Yield kg/tree
I ₀	1990	14.13	2.65	2.39	2.08	7.28	4.87	103.0	17.2	25.5
	1991	12.99	2.99	2.83						
	1992	13.97	1.85	3.04	3.04	6.92	4.65	106.0	17.8	30.7
	Mean	13.69	2.50	2.75	2.56	7.10	4.76	104.5	17.5	28.1
I ₁	1990	16.98	2.94	2.86	2.72	9.61	5.62	127.7	18.8	48.5
	1991	26.93	3.53	3.87						
	1992	19.63	2.86	4.56	4.56	9.74	5.58	142.0	18.2	56.4
	Mean	21.18	3.11	3.76	3.64	9.68	5.60	134.9	18.5	52.4
		(56)	(24)	(41)	(48)	(35)	(29)	(30)	(6)	(87)
I ₂	1990	14.68	2.90	2.66	2.68	9.35	5.49	125.5	17.7	47.2
	1991	25.38	3.48	3.63						
	1992	18.98	2.82	4.01	4.01	9.62	5.42	139.0	18.4	53.4
	Mean	19.68	3.07	3.43	3.35	9.49	5.46	35.2	18.1	50.3
		(48)	(23)	(26)	(32)	(32)	(15)	(27)	(4)	(79)
I ₃	1990	14.25	2.82	2.57	2.41	8.56	5.18	109.5	17.3	33.0
	1991	20.52	3.26	3.11						
	1992	14.52	1.97	3.32	3.31	8.64	5.04	122.0	18.0	38.3
	Mean	16.43	2.68	3.00	2.86	8.60	5.11	115.7	17.6	35.6
		(21)	(7)	(11)	(16)	(9)	(8)	(11)	(0.5)	(27)
CD (P = 0.05)	1990	1.97	0.31	0.67	0.26	0.89	0.59	2.53	1.3	2.33
	1991	4.67	0.52	0.76						
	1992	2.84	0.08	0.68	0.68	0.67	0.48	3.72	3.64	4.52

Details of treatment are given under Materials and Methods

Figures in parentheses indicates increase (%) over the control

Similarly, per cent increase in shoot growth over control was 56, 48 and 21% and over plant spread 24, 33 and 7% when irrigated at 20, 40 and 60% available soil-moisture depletion levels, respectively.

The fruit retention/panicle, fruit size, weight, yield and total soluble solids (TSS) were greatly influenced by the irrigation treatments. But, significant effect was observed with irrigation at 20% available soil-moisture depletion level followed by 40% available soil-moisture depletion level (Table 2). Fruit retention, fruit size, fruit weight and fruit yield increased with the frequency of irrigation, ie from irrigation at 60-40, 40-20% available soil-moisture depletion levels. There was 87 and 79% increase in fruit yield in trees irrigated at 20 and 40% depletion of available soil-moisture respectively, over the control.

TSS contents were better in trees irrigated at 20 and 40% available soil-moisture depletion level than under un-irrigated control and irrigated at 60% available soil-moisture depletion. Tree growth, fruit yield and quality were better when irrigated at 20 and 40% available soil-moisture depletion levels. This, perhaps, is due to better and continuous availability of water and nutrients to plants. The results are in conformity with those of Goode and Ingram (1971) and Menzel *et al.* (1986), who emphasized the maintenance of optimum soil-moisture in readily available form during the growing season for better growth and fruit production. The lower tree growth and fruit yield, observed under water stress treatments (I₀ and I₃) is understandable due to lower moisture availability under them causing reduction in cell enlargement (Hsiao 1973).

Leaf nutrient status

Moisture regimes had significant influence on leaf nutrient status (Table 3). Trees irrigated at 20 and 40%

available soil-moisture depletion levels maintained significantly higher leaf N, K, Ca, Mg, Fe and Mn levels than those irrigated at 60% available soil-moisture depletion and un-irrigated control. The reason for this could be that higher soil-moisture levels increase the availability of mineral nutrients in soil for plant use (Menzel *et al.* 1986).

Scheduling of irrigation

The influence of irrigation treatments on tree growth, fruit yield (Table 4) and nutrient status (Table 3) were higher under irrigation at 20% available soil-moisture depletion level as compared to irrigation at 60% available soil-moisture depletion and un-irrigated control but was statistically at par with irrigation at 40% depletion of available soil-moisture during the 1990-92. This suggests that plant water deficit in 40% available soil-moisture depletion treatment was critical and below it there was reduction in plant growth and fruit yield. Therefore, it can be safely said that for optimum growth and yield that plants need to be irrigated at 40% available soil-moisture depletion level with no deleterious effect of water stress observed and saved 8.07% irrigation water over the irrigation at 20% available soil-moisture depletion (Table 2). Therefore, irrigation scheduled at 40% available soil-moisture depletion level is optimum for bearing mango trees.

Total water expense

The data on total water expense (Table 4) indicated that 22, 21 and 23 irrigation were required during 1990, 1991 and 1992 under 40% available soil-moisture depletion level amounting to 125.4, 119.7 and 131.8 cm of irrigation water, respectively. Contrary to this on an average 52 irrigations were needed with 135.9 cm of irrigation water under 20% available soil-moisture depletion level treatment. It is worth

Table 3 Effect of different moisture regimes on mean leaf nutrient contents of 'Dashehari' mango

Treatment	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Zn (ppm)	Cu (ppm)	Fe (ppm)
I ₀	1.49	0.14	0.44	3.02	0.38	20	113	182
I ₁	1.74	0.16	0.53	3.60	0.49	26	126	216
I ₂	1.63	0.16	0.53	3.46	0.48	24	122	208
I ₃	1.52	0.14	0.47	3.06	0.45	21	115	193
CD (P=0.05)	0.05	NS	0.04	0.30	0.05	3	7.4	9.2

Details of treatment are given under Materials and Methods

Table 4 Total water expense of 'Dashehari' mango

Treatment	Number of irrigation				Amount of irrigation water applied (cm)				Profile water use (cm)				Total water expense (cm)			
	1990	1991	1992	Mean	1990	1991	1992	Mean	1990	1991	1992	Mean	1990	1991	1992	Mean
I ₀									7.3	6.0	5.8	6.4	206.9	178.3	168.4	184.5
I ₁	50	47	59	52	135.0	126.9	148.8	135.9	8.5	8.2	8.3	8.3	343.1	307.4	316.7	322.4
I ₂	22	21	23	22	125.4	119.7	131.8	125.4	8.0	7.5	7.0	7.5	333.0	299.5	300.7	311.1
I ₃	11	10	12	11	89.1	84.0	97.2	90.1	7.1	6.3	6.0	6.5	295.8	262.6	265.8	274.7

Total water expense = sum of irrigation water applied + profile water use + total rainfall

Table 5 Average weekly irrigation water requirement of mango during the months of the year

Treatment	Year	Irrigation water (litres/2m diameter basin)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
I0	1990	97	129	16	193	290	290				129	161	161
	1991	97	97	161	193	290	258				129	161	129
	1992	97	97	83	258	322	322	65		32	161	97	97
	Mean	97	107	168	215	301	279	65		32	140	140	129
I2	1990	135	135	135	135	271	271				68	203	135
	1991	135	135	135	135	271	271				68	135	135
	1992	135	68	203	203	338	203	68		68	135	68	68
	Mean	135	113	158	158	293	248	68		68	90	135	113
I3	1990	97	97	97	97	193	193				97	97	97
	1991	97	97	97	97	193	97				97	97	97
	1992	97	97	97	193	193	193				97	97	97
	Mean	97	97	97	129	193	161				97	97	97

noting that during the off-year (1991) for mango crop the number of irrigations and the amount of water applied, along with the soil profile water use and the total water expense values obtained were lower as compared to the fruiting years of 1990 and 1992 (Table 4). This is understandable because of the reduced consumptive use during no fruit year. This finding is in agreement with that of Cull (1977) who emphasized the maintenance of soil-moisture content at more than 50% in the available range for better plant growth and fruit production. 10–12 irrigations were required in I₃ treatment amounting to 90.1 cm of irrigation water, but a significant reduction in plant growth, yield and quality of fruit were observed. The soil profile water use was slightly greater under I₁ as compared to other irrigation treatments. Total water expense was also greater in I₁ and it varied from 307.4–343.1 cm as compared to other irrigation treatments. In I₂, it varied from 299.5 to 333 cm with a saving of 6.0–11.21% water without reducing growth, fruiting and quality during the years of study.

Weekly irrigation water requirement

Weekly water requirement for irrigation of mango (Table 5) varied with the period of time depending upon the environmental conditions. During the summer season (April to June), greater amount of irrigation water was required in comparison to cold and rainy months of the year because of higher evapo-transpiration losses. It is obvious from Table 2 that yield under irrigation at 40% depletion of available soil-moisture treatment was not significantly different than 20% available soil-moisture depletion level irrigation treatment during all the 3 years. The weekly water requirement of 10–13-year-old bearing mango tree with irrigation at 40% available soil moisture depletion level is presented in Table 5. During summer months, i.e. March, April, May and June corresponding with active plant growth period, the irrigation water of 158, 158, 293 and 248 litres/week/plant, respectively is required for better growth and fruit yield. In October,

November, December, January and February, the respective irrigation water requirements are 90, 135, 113, 135 and 113 litres/tree. During July, August and September, however the mango plants generally do not require any irrigation because of the frequent rainfall. However, during July and September in 1992 the plants need 68 litres of irrigation water/plant because of less rainfall.

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Nutritional status of healthy and declining citrus (*Citrus reticulata*) orchards

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ABSTRACT

Healthy and declining citrus (*Citrus reticulata* Blanco) orchards of hills region of Assam were surveyed for ascertaining nutritional factor causing citrus decline. Both healthy and declining orchards of Karbi Anglong were high in K, but low in both Ca and P in respect of foliar content. In Karbi Anglong, fruit yield positively correlated with foliar K content. Effect of foliar concentration of K on the fruit yield was however, indirect. In North Cachar Hills, orchards were mostly low in Ca but commonly high in K in respect of foliar content. Declining orchards of North Cachar Hills were low in foliar P content. In North Cachar Hills, low fruit yield was associated with lower concentration of available Ca in soils, lower foliar Ca content, and narrow Ca : Mg ratio in leaf. Foliar concentration of K was regulated by soil concentration ratio of K : Ca + Mg or K : Mg in North Cachar Hills, and N : Ca in Karbi Anglong, whereas foliar Ca concentration was regulated by soil concentration ratio of K : Mg in both the locations. Soil-available Ca content, more than 288 kg/ha, and foliar Ca : Mg ratio, more than 8.70 were associated with healthy crop in North Cachar Hills. Soil parameters to the depth of 45 cm rather than surface layer (0–15 cm) were significantly correlated with fruit yield and foliar nutrient content.

Key words : nutritional status, citrus decline, Assam hills, *Citrus*

'Khasi mandarin' (*Citrus reticulata* Blanco) is very important horticultural crop of the hills region of Assam, viz Karbi Anglong and North Cachar Hills. It is grown in the untterraced hill slope without any supplementary dressing of chemical fertilizer. Some orchards are as old as 80 years. Of late, the region is experiencing steady decline in citrus production. Ramamurthy and Desai (1946) first identified iron toxicity and magnesium deficiency in the orchards. Since then, other workers conducted similar survey and reported nutrient deficiency ranging from boron to zinc and iron to zinc and calcium (Choudhary and Dutta 1950, Choudhary 1954, Dutta 1959, Prasad and Ghosh 1976, Ghosh *et al.* 1982, Ram and Prasad 1987). However, no study was undertaken to ascertain the cause of citrus decline in the hills region of Assam. Keeping in view the fact, a nutritional survey pertaining to major plant nutrient, viz N, P, K, Ca and Mg was undertaken in the orchards of the 2 hills districts of Assam.

MATERIALS AND METHODS

The selection of orchards was based on observation of yield characteristics of the orchards for few years. The orchards were selected on the basis of both number and weight of fruit plant. The orchards which recorded decline in both the parameters were considered as indication of citrus decline. Based on fruit yield/plant, the orchards were catego-

rized as low (<15 kg/plant), medium (15.1–50 kg/plant), high (>50 kg/plant) yielder. For the purpose of identification of limiting nutrient, low yielder was categorized as declining, and medium to high yielder as healthy orchard. Since 2 hill districts differ considerably in terms of physiography, climate and geology (Wadia 1966, Annual Report 1990) the orchards were sampled separately. Altogether, 14 orchards from Karbi Anglong and 8 orchards from North Cachar Hills were sampled. The 5 to 7-month-old spring flush leaf collected from non-bearing branches from both healthy and declining orchards along with soil samples at a depth, 0–15, 15–30 and 30–45 cm from exposed profile were dried and analysed for physio-chemical properties, available plant nutrient contents and foliar nutrient content (Jackson 1973).

Soils of Karbi Anglong were classified as fine, mixed, hyperthermic Ultic Paleustalf and thermic Typic Paleudult. The soils were very deep, well structured, sandy clay to clay loam in texture, acidic to weakly acidic and had high organic matter content. The soils of North Cachar Hills were classified as fine, mixed, thermic Typic Haplhumult. The soils were deep, well structured, silty clay to clay loam in texture, acidic and were rich in organic matter.

RESULTS AND DISCUSSION

The data given in Table 1 revealed that citrus soils were acidic (pH 4.4–6.0) and deficient in available P₂O₅ (1–16 kg/ha). The ec was low (0.030–0.406 dS/m²). Most of the soils

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Table 1 Soil characteristics and fertility status of soils from declining and healthy citrus orchards from Karbi Anglong

Location	Status	Depth (cm)	Texture	pH (1:2.5)	EC (dS/m ²)	Org. M (%)	Available (kg/ha)				
							N	P ₂ O ₅	K ₂ O	Ca	Mg
Pavamari	D	0-15	cl	5.2	0.110	3.15	410	28	466	310	85
		15-30	cl	4.9	0.065	2.60	332	4	289	160	98
		30-45	c	5.1	0.042	2.45	320	5	300	100	75
Langerpan	D	0-15	scl	5.1	0.150	3.25	383	9	599	300	88
		15-30	cl	4.9	0.082	2.09	279	8	439	146	100
		30-45	cl	4.7	0.045	2.15	345	5	400	120	70
Deithor	D	0-15	sic	4.9	0.088	3.51	442	6	300	425	115
		15-30	sic	4.8	0.053	2.65	392	3	178	302	130
		30-45	c	4.9	0.040	2.75	433	2	189	212	112
Diethor	D	0-15	sic	4.9	0.091	3.44	461	7	377	330	105
		15-30	sic	4.7	0.055	2.80	517	4	167	270	122
		30-45	c	4.9	0.045	2.05	373	1	155	225	109
Diethor	D	0-15	sic	4.9	0.094	3.63	384	9	246	465	120
		15-30	sic	4.7	0.057	2.34	217	11	202	312	132
		30-45	c	4.9	0.060	2.44	234	5	280	158	35
Diethor	H	0-15	sic	4.9	0.060	2.44	234	5	280	158	35
		15-30	sic	4.9	0.036	1.72	217	3	213	72	44
		30-45	sic	5.3	0.140	4.36	351	8	336	470	117
Diethor	D	0-15	sic	5.0	0.045	2.64	172	11	157	300	129
		15-30	sic	5.1	0.030	2.77	203	10	202	212	110
		30-45	sic	5.1	0.085	3.50	401	10	347	142	34
Diethor	H	0-15	sic	5.1	0.085	3.50	401	10	347	142	34
		15-30	sic	4.8	0.039	1.52	334	10	269	65	48
		30-45	c	4.9	0.030	1.65	351	10	235	56	30
Diethor	D	0-15	sic	4.9	0.114	3.33	340	3	325	119	43
		15-30	sic	4.4	0.037	1.65	210	1	203	85	51
		30-45	sic	5.0	0.036	1.91	265	1	177	85	28
Diethor	D	0-15	sic	5.0	0.100	2.64	247	10	365	152	26
		15-30	sic	4.9	0.036	2.11	219	2	162	76	23
		30-45	c	4.7	0.034	1.52	198	4	122	85	17
Diethor	H	0-15	sic	5.0	0.084	2.71	250	7	433	123	26
		15-30	sic	4.7	0.054	2.11	222	3	339	85	34
		30-45	c	4.8	0.032	1.95	196	1	325	76	26
Diethor	H	0-15	sic	4.7	0.076	2.15	255	7	380	142	20
		15-30	c	4.9	0.051	1.62	195	1	393	109	26
		30-45	c	4.9	0.042	2.67	227	2	360	114	57
Gengfa	H	0-15	sl	5.8	0.100	1.72	220	9	298	166	23
		15-30	sl	4.8	0.054	0.99	141	3	136	85	9
		30-45	sl	5.0	0.038	0.59	112	4	122	76	6
Gengfa	H	0-15	scl	5.5	0.322	3.23	380	16	787	285	40
		15-30	scl	5.3	0.070	2.28	289	10	474	242	43
		30-45	cl	5.4	0.038	1.16	196	7	636	237	34

had high organic matter content to a depth of 45 cm (1.52–6.0%). Available N and K₂O were medium to high in the surface layer (220–568 and 246–820 kg/ha, respectively) and low to high in the subsurface (112–517 and 122–651 kg/ha, respectively). The content of magnesium tended to be higher in the subsurface than surface layer in Karbi Anglong. In respect of organic matter and all major nutrients (N, P, K, Ca and Mg) citrus orchards from North Cachar Hills were richer than that of Karbi Anglong.

The data presented in the Table 1 and 2 indicated that in Karbi Anglong, the declining orchards had higher soil contents of available N, P, Ca and Mg but, lower in respect of

available K than that of healthy orchards. Lower availability of K was reflected in its marginally lower (by 13%) foliar concentration in declining orchards as compared to healthy orchards (Table 4 and 5). Irrespective of fruit bearings, orchards from Karbi Anglong were optimum in respect of N and Mg, high in K, but low in P and Ca as indicated by foliar contents. Correlation study (Table 5) however, revealed significant positive correlation of foliar K content and fruit yield ($r = 0.741^*$) which might be attributed to indirect effect of close association of K and boron uptake in citrus. In citrus, low level of boron is associated with lower K content in leaf (Rajput and Sriharibabu 1985). Although boron status of soils

Table 2 Soil characteristics and fertility status of soils from declining and dealthy citrus orchards of North Cachar Hills

Location	Organic						Available (kg/ha)				
	States	Depth (cm)	Texture	pH (1:2.5)	EC dS/m ²	M(%)	N	P ₂ O ₅	K ₂ O	Ca	Mg
Jatinga	D	0-15	sic	4.9	0.162	5.94	534	10	459	285	80
		15-30	sic	4.8	0.060	3.50	401	10	347	152	70
Jatinga	D	0-15	sic	4.4	0.130	5.35	551	10	493	114	28
		15-30	sic	4.7	0.044	2.44	384	10	246	129	15
Jatinga	H	0-15	sic	5.2	0.192	5.05	560	7	610	546	63
		15-30	sic	4.8	0.071	3.33	405	3	325	342	46
Jatinga	D	30-45	c	5.2	0.039	2.97	380	9	339	347	40
		0-15	sic	4.8	0.206	4.52	490	7	488	204	60
		15-30	c	4.8	0.125	3.43	410	1	555	142	48
Jatinga	D	30-45	c	4.8	0.034	2.74	370	1	339	123	43
		0-15	sic	4.8	0.172	4.62	495	10	448	275	85
		15-30	c	4.9	0.073	3.08	400	7	325	157	68
Jatinga	H	30-45	c	5.3	0.086	2.71	372	4	301	133	37
		0-15	sic	6.0	0.406	5.08	565	7	820	598	134
		15-30	sic	4.8	0.082	3.14	410	7	651	342	68
Jatinga	H	30-45	c	5.2	0.060	3.17	410	4	529	351	71
		0-15	sic	5.4	0.152	6.07	568	10	594	525	77
		15-30	sic	5.3	0.120	5.08	417	12	471	345	59
Jatinga	D	30-45	c	5.2	0.091	3.96	384	12	471	342	48
		0-15	sic	5.6	0.145	4.95	518	12	459	252	80
		15-30	sic	5.5	0.126	4.42	408	4	347	140	65
Jatinga	D	30-45	c	5.4	0.126	4.36	384	6	347	128	39

D, Declining; H, healthy

Table 3 Soil characteristics and fertility status of declining and healthy (3 nos. each) citrus orchards from Karbi Anglong and North Cachar Hills (weighted mean Table)

Status	pH (1 : 2.5)	E.C. (d S/m ²)	Organic matter (%)	Available nutrient (kg/ha)				
				N	P ₂ O ₅	K ₂ O	Ca	Mg
<i>Karbi Anglong</i>								
Declining	4.89	0.095	3.00	372	6	229	305	117
Healthy	4.87	0.055	2.21	270	6	342	101	33
Difference (%)	4	72	36	38	0	-33	202	255
<i>North Cachar Hills</i>								
Declining	5.10	0.121	3.87	427	6	401	173	58
Healthy	5.21	0.135	4.21	455	8	534	415	67
Difference (%)	-2	-10	-8	-6	-25	-25	-58	-13

under study has not been presented here, there was report of boron deficiency in citrus soils of Assam (Choudhary and Dutta 1950).

In the declining orchards of North Cachar Hills, the soil concentration of only Ca was significantly lower (58%) than that of healthy orchards (Table 2). Lower availability of Ca was reflected in its lower foliar content (27%) in the declining orchards as compared to that of healthy one (Table 4). Foliar nutrient content further indicated that both healthy and declining orchards were optimum in N and high in K but, low in Ca (Table 3 and 4). Whereas, declining orchards were low in P, the healthy orchards were low in Mg. Correlation

study (Table 6) revealed that soil and foliar Ca had significant positive correlation with fruit yield ($r = 0.897^{**}$ and 0.757^* , respectively) thus indicating low Ca status as major limiting factor for citrus decline in North Cachar Hills. Significant positive correlation of soil Ca and pH ($r = 0.884^{**}$), soil pH and fruit yield ($r = 0.886^{**}$), and foliar Ca content and fruit yield indicated that the effect of soil Ca on fruit yield was through its favourable effect on soil pH and soil physical condition, and also as nutrient. Significant negative correlation of Ca and Mg in leaf ($r = 0.772^*$) indicated strong mutual antagonism of Ca and Mg uptake in citrus of North Cachar Hills. There was also significant positive correlation of ratio

Table 4 Foliar nutrient content (%) of citrus in the non-bearing branches in different location of Karbi Anglong and North Cachar Hills

Status	Status	Fruit Yield (kg/plant)	Nutrient content (%) in leaf				
			N	P ₂ O ₃	K ₂ O	Ca	Mg
<i>Karbi Anglong</i>							
Payomari (1)	D	3.98					
Langetpan (2)	D	Nil					
Deithor (3)	D	3.98					
Diethor (4)	D	Nil					
Deithor (5)	D	3.98					
Deithor (6)	H	36.00					
Deithor (7)	D	2.98	2.62	0.096	2.05	2.16	0.71
Deithor (8)	H	36.00	3.09	0.096	2.65	1.99	0.32
Deithor (9)	D	3.98	3.09	0.123	2.33	2.54	0.33
Deithor (10)	D	1.33	3.17	0.096	2.14	2.12	0.41
Deithor (11)	H	27.00	2.54	0.113	2.51	2.63	0.47
Deithor (12)	H	29.25	3.51	0.113	2.28	2.50	0.41
Gongfa (13)	H	34.95	3.00	0.113	2.46	2.76	0.56
Gongfa (14)	H	36.00	3.25	0.104	2.33	3.16	0.37
<i>North Cachar Hills</i>							
Jatinga (15)	D	1.33	2.66	0.096	1.91	1.57	0.69
Jatinga (16)	D	1.33	3.00	0.104	2.37	2.67	0.61
Jatinga (17)	H	27.00	3.51	0.151	2.00	2.80	0.31
Jatinga (18)	D	7.95	3.42	0.113	2.28	2.29	0.53
Jatinga (19)	D	Nil	3.21	0.128	2.23	2.19	0.34
Jatinga (20)	H	22.50	3.21	0.128	2.33	3.10	0.20
Jatinga (21)	H	36.00	3.17	0.104	2.19	3.03	0.20
Standard value (Reuther and Smith 1954)	H		2.40– 2.90	0.12– 0.16	1.20– 1.70	3.00– 5.50	0.30– 0.60

H, Healthy; D, declining

Table 5 Foliar nutrient content (%) of citrus from non-bearing branches, from healthy and declining (3 nos. each) orchards from Karbi Anglong and North Cachar Hills (Mean Table)

Status	Foliar Nutrient content (%)				
	N	P	K	Ca	Mg
<i>Karbi Anglong</i>					
Declining	2.96	0.105	2.17	2.27	0.48
Healthy	3.05	0.107	2.48	2.37	0.40
Difference	-3	-3	-13	-4	20
<i>North Cachar Hills</i>					
Declining	3.03	0.104	2.19	2.18	0.61
Healthy	3.30	0.128	2.17	2.98	0.24
Difference (%)	-8	-19	1	-27	154

of Ca : Mg in leaf and fruit yield ($r = 0.852^*$) which further indicated that low fruit yield in the declining orchards of North Cachar Hills was associated with narrow Ca : Mg ratio in leaf. It was therefore suggested that declining orchards of North Cachar hills be limed with calcite rather than dolomite to enhance soil pH as well as level of Ca in soil and also widen the ratio of Ca : Mg in leaf to increase the fruit yield.

An important point to be noted in the present study is that soil status of available K and Ca did not bear significant correlation with their respective foliar concentration in both

the locations. Significant correlation was however, obtained when concentration ratio K : Ca + Mg or K : Mg in soils in North Cachar Hills ($r = 0.926^{**}$ and 0.793^* respectively) and N : Ca in soils in Karbi Anglong ($r = 0.743^*$) were correlated with foliar K status. Similarly, foliar Ca status in both the locations was significantly correlated with concentration ratio K : Mg in soils ($r = 0.788^*$ and 0.943^* in Karbi Anglong and North Cachar Hills respectively). Thus, uptake of K and Ca in citrus was not related to their absolute concentration in soils, but to their relative concentration. In North Cachar Hills, higher K uptake was associated with wider K : Ca + Mg ratio, whereas in Karbi Anglong, the same was associated wider N : Ca ratio. Rajput and Sriharibabu (1985) also reported correlation of foliar K and soil N : Ca, in citrus. The observation suggested that K uptake in citrus was affected by more than 1 factor, which however, varied with location more particularly with soils.

The regression equations for nutrient content, concentration ratio in soils and nutrient content in leaf, fruit yield given below, revealed that in North Cachar Hills for every 100 kg/ha (weighted mean) increase in available Ca content in soils (0–45 cm), the fruit bearings increased by 4.80 kg/plant and for every 0.10% increase in foliar Ca content, fruit bearings increased by 2.04 kg/plant. For the same location, available Ca content of 288 kg/ha to the depth of 45 cm and foliar Ca : Mg ratio of 8.70 was associated with fruit bear-

Table 6 Correlation coefficient of soil parameters (weighted mean), foliar nutrient content and fruit bearings

Variables	Fruit yield (kg/plant)	Foliar concentration (%)		
		K	Ca	Mg
<i>Karbi Anglong</i>				
Soil pH	0.404	-0.078	0.512	0.276
Soil K	0.496	0.109	0.665	-0.341
Soil Ca	-0.186	-0.605	0.157	0.598
Soil Mg	-0.464	-0.562	-0.311	0.623
Foliar K	0.741*		0.120	-0.482
Foliar Ca	0.461			0.095
Foliar Mg	-0.253			
Soil K : Ca + Mg		0.397	0.567	
Soil K : Mg		0.301	0.788* (0.599)	
Soil N : Ca		0.743* (0.528)	-0.422	
Foliar Ca : Mg	0.352			
<i>North Cachar Hills</i>				
Soil pH	0.886** (0.729)	-0.043	0.642	-0.889** (-0.143)
Soil K	-0.613	0.285	0.607	-0.610
Soil Ca	0.897** (0.859*)	-0.220	0.644	-0.802* (-0.611)
Soil Mg	0.244	-0.251	-0.242	-0.407
Foliar K	0.075		0.515	-0.220
Foliar Ca	0.757*			-0.772*
Foliar Mg	-0.779*			
Soil K : Ca + Mg		0.926** (0.834*)	0.230	
Soil K : Mg		0.793* (0.254)	0.943** (0.280)	
Soil N : Ca		0.494	-0.407	
Foliar Ca : Mg	0.852*			

Significant at * $P = 0.05$; ** $P = 0.10$

Figure in parentheses denotes correlation coefficient of soil parameter at 0-15 cm depth

ings of 15 kg/plant.

Following are the regression equation:

Soil Ca content (x_1) vs fruit yield (y)

$$y = -13.225 + 0.098 x_1$$

Foliar Ca content (x_2) vs fruit yield (y)

$$y = -37.718 + 20.401 x_2$$

Foliar Ca : Mg (x_3) vs fruit yield (y)

$$y = -5.321 + 2.336 x_3$$

Comparison of correlation coefficient (Table 5) of foliar nutrient content, fruit bearings and soil parameter at surface layer (0-15 cm) with that to the depth of 45 cm (weighted mean) revealed that r-values were always lower and in most cases non-significant for surface layer than that for 45 cm depth, which suggested that for citrus, the effective root zone extended to the depth of 45 cm and as such, fertility evaluation for citrus should be extended to the depth of 45 cm rather than surface layer alone.

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Integrated nutrient management effect on rice (*Oryza sativa*) – wheat (*Triticum aestivum*) system productivity in subhumid ecosystem

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ABSTRACT

A long-term field experiment was initiated during 1983–84 at 8 locations (Ranjitsinghpura, Palampur, Pantnagar, Varanasi, Faizabad, Sabour, Jabalpur and Raipur) in rice (*Oryza sativa* L.) – wheat (*Triticum aestivum* L. emend Fiori & Paol.) cropping system. The results of the last 5–10 years indicated the possibility of substituting 50% N needs of rice through farmyard manure at Ranjitsinghpura, Palampur, Varanasi, Faizabad, Sabour and Raipur and through prickly sesban [*Sesbania cannabina* Pers. var *cannabina* Baker syn *Sesbania aculeata* (Retz.) Pers.] green-manure at Palampur and Raipur. In soils having high organic matter content at Pantnagar and high-clay soils at Jabalpur, N substitution by organic sources was not possible without any significant adverse effect on system productivity. Significant yield advantages with N substitution through farmyard manure at Palampur and prickly sesban green-manure at Raipur were also observed. Continuous rice–wheat cropping had variable effect on soil fertility depending on soil type, nutrient application and productivity levels. Integrated nutrient supply generally had beneficial effect on soil fertility.

Key words : integrated nutrient management, rice–wheat system

Rice–wheat sequential cropping is the most important cropping system in India occupying around 10.5 million hectares (Pandey 1992). Both rice and wheat are heavy feeders of nutrients and a system yielding 6.95 tonnes/ha rice and 3.86 tonnes/ha wheat may remove as much as 316 kg N, 28 kg P and 342 kg K apart from significant amounts of different secondary and micronutrients (Hegde and Pandey 1989). Earlier studies in this system have indicated the deleterious effect of continuous application of high amounts of fertilizers leading to decline in productivity due to limitation of one or more of micronutrients (Hegde 1992, Nambiar and Abrol 1989). Integrated nutrient supply involving conjunctive use of fertilizers and organic sources of nutrients (Roy 1992) assumes greater significance in India mainly due to 2 reasons. First, the need for continuous increase in per hectare yields in rice–wheat system requires the application of still higher amounts of nutrients than used at present and the present level of fertilizer availability and economic conditions of large number of farmers do not permit applying them in quantities adequate enough to meet the total plant nutrient needs at the desired level of productivity. Secondly, the results of several long-term experiments in different cropping systems reveal that long-term sustainability of productivity in intensive crop-

ping systems could be achieved only through integration of inorganic and organic sources of nutrients (Hegde *et al.* 1992, Nambiar *et al.* 1992, Singh and Yadav 1992). These studies were, therefore, initiated to study the effect of integrated nutrient supply on crop productivity and soil fertility in rice–wheat system.

MATERIALS AND METHODS

The field experiment is being carried out in fixed plots under the All-India Co-ordinated Research Project on Cropping Systems at 8 locations in subhumid ecosystem, viz Ranjitsinghpura (Jammu and Kashmir), Palampur (Himachal Pradesh), Sabour (Bihar), Jabalpur and Raipur (Madhya Pradesh). Soil type and some important physico-chemical characteristics of soils in the experimental fields at the initiation of studies are presented in Table 1.

There were 12 treatment combinations replicated 4 times in randomised block design. The treatments were T₁, control (no fertilizer); T₂, 50% recommended NPK to rice and wheat; T₃, 50% recommended NPK to rice and 100% recommended NPK to wheat; T₄, 75% recommended NPK to rice and wheat; T₅, 100% recommended NPK to rice and wheat; T₆, 50% NPK + 50% N (farmyard manure) to rice and 100% NPK to wheat; T₇, 75% NPK + 25% N (farmyard manure) to rice and 75% NPK to wheat; T₈, 50% NPK + 50% N (wheat straw) to rice and 100% NPK to wheat; T₉, 75% NPK + 25% N (wheat straw) to rice and 75% NPK to wheat; T₁₀, 50% NPK + 50%

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N (prickly sesban green manure) to rice and 100% NPK to wheat; T₁₁, 75% NPK + 25% N (prickly sesban green-manure) to rice and 75% NPK to wheat; T₁₂, 50% NPK to rice and wheat (conventional farmers' practice). Considering large variations in amount of fertilizers applied by farmers, a uniform dose of 50% recommended NP was fixed as the farmers' practice.

The study was initiated during 1983-84 at Pantnagar, 1984-85 at Faizabad and Sabour, 1985-86 at Ranjitsinghpura, Palampur, Varanasi and Jabalpur and 1988-89 at Raipur. The recommended levels of NPK (kg/ha) were 100 : 26.2 :

25.2, 90 : 17.5 : 33.6, 120 : 26.2 : 50.4, 100 : 26.2 : 33.6, 120 : 26.2 : 50.4, 80 : 17.5 : 16.8, 100 : 26.2 : 33.6, 120 : 26.2 : 33.6 for rice and 100 : 21.8 : 25.2, 120 : 39.3 : 25.2, 120 : 26.2 : 50.4, 120 : 26.2 : 33.6, 120 : 26.2 : 50.4, 100 : 21.8 : 21.0, 120 : 26.2 : 33.6, 100 : 26.2 : 33.6 for wheat at Ranjitsinghpura, Palampur, Pantnagar, Varanasi, Faizabad, Sabour, Jabalpur and Raipur, respectively. The rice varieties used were 'PC 19' (1985-86), 'Jaya' (1986-89, 91-93), 'IET 8885' (1989-91) at Ranjitsinghpura; 'Him 1' (1985-87, 88-89, 90-92), 'HPU 741' (1987-88, 89-90, 92-93) at Palampur; 'Jaya' (1983-86), 'PD 4' (1986-93) at Pantnagar; 'IET 5725'

Table 1. Some important characteristics of soils in the experimental fields

Character	Ranjitsinghpura	Palampur	Pantnagar	Varanasi	Faizabad	Sabour	Jabalpur	Raipur
Soil taxonomic class	Eutroch-repts	Udic Ha-plustalfs	Hapludolls	Aeric Ochro-qualfs	Udic Fluvents Fluvaquents association	Eutroch-repts	Chromu-sterts	Ochraqualfs-Ochraqualfs association
Soil texture	Loam	Silt loam	Silty clay loam	Silt loam	Silt loam	Loam	Clay	Sandy loam
Sand (%)	45.9	22.8	8.8	26.0	21.0	42.8	21.3	53.5
Silt (%)	33.1	53.5	61.4	54.1	56.2	35.4	17.9	18.5
Clay (%)	21.0	23.7	29.8	19.9	22.6	20.2	60.8	18.0
pH (1 : 2.5)	7.1	5.4	7.5	7.4	8.8	7.3	7.7	7.1
Electrical conductivity (dS/m)	0.16			0.11	0.50	0.15	0.20	0.25
Organic C (%)	0.80	0.61	0.99	0.39	0.37	0.39	0.62	0.65
Available N (kg/ha)	442	675		183	102	225	246	255
Available P (kg/ha)	14.0	21.9	15.6	17.9	13.8	22.5	18.4	11.7
Available K (kg/ha)	156	221	144	288	355	155	728	504
DTPA-extractable Zn (ppm)					1.01			
Cu (ppm)					1.20			
Mn (ppm)					6.28			
Fe (ppm)					8.50			

Table 2 Effect of integrated nutrient supply on the productivity (kg/ha) of rice and wheat

Treatment	Ranjitsinghpura (Ave of 8 years)			Palampur (Ave of 8 years)			Pantnagar (Ave of 10 years)			Varanasi (Ave of 8 years)		
	Rice	Wheat	Total*	Rice	Wheat	Total*	Rice	Wheat	Total*	Rice	Wheat	Total*
T ₁	2 958	1 307	3 969	1 710	632	2 171	3 000	1 665	4 365	1 125	992	2 004
T ₂	3 881	2 438	5 931	2 403	1 429	3 592	3 779	2 939	6 340	2 580	2 659	4 981
T ₃	3 984	3 040	6 627	2 377	2 088	4 227	3 729	3 755	7 111	2 683	3 789	6 204
T ₄	4 215	2 845	6 638	2 572	1 956	4 271	4 070	3 440	7 103	3 521	3 189	6 358
T ₅	4 694	3 345	7 570	2 767	2 246	4 736	4 696	4 031	8 257	4 035	4 038	7 669
T ₆	4 501	3 529	7 580	2 749	2 589	5 063	4 046	3 808	7 449	3 718	4 341	7 687
T ₇	4 606	2 969	7 114	2 748	2 104	4 577	4 084	3 691	7 367	4 070	3 809	7 472
T ₈	4 290	3 193	7 054	2 620	2 155	4 513	4 017	3 670	7 285	3 568	4 079	7 290
T ₉	4 548	3 013	7 106	2 570	1 969	4 282	4 156	3 589	7 329	3 845	3 711	7 171
T ₁₀	4 469	3 417	7 439	2 663	1 921	4 318	4 382	3 919	7 863	3 584	4 174	7 400
T ₁₁	4 646	3 043	7 224	2 825	2 005	4 597	4 505	3 727	7 781	3 861	3 873	7 348
T ₁₂	3 488	1 887	5 019	2 206	1 450	3 935	4 119	3 779	7 486	2 631	2 629	4 997
CD (P = 0.05)	48	55		226	166		225	121		131	105	<i>continued</i>

Details of treatment are given under Materials and Methods

*In terms of wheat equivalent

Table 2 continued....

Treatment	Faizabad (Ave of 9 years)			Sabour (Ave of 9 years)			Jabalpur (Ave of 8 years)			Raipur (Ave of 5 years)		
	Rice	Wheat	Total*	Rice	Wheat	Total*	Rice	Wheat	Total*	Rice	Wheat	Total*
T ₁	1 928	993	2 728	1 616	913	2 367	2 328	896	2 991	2 236	1 050	3 062
T ₂	3 243	2 206	5 125	2 777	1 837	4 336	3 267	1 621	4 561	3 708	2 073	5 410
T ₃	3 436	3 277	6 369	2 837	2 913	5 466	3 550	2 580	5 775	3 776	2 379	5 777
T ₄	4 034	2 904	6 535	3 273	2 655	5 601	4 573	2 251	6 367	4 423	2 390	6 371
T ₅	4 355	3 319	7 238	3 975	3 064	6 641	4 719	2 678	6 925	4 838	2 622	6 976
T ₆	4 100	3 476	7 166	3 759	3 229	6 672	4 339	2 537	6 442	4 898	2 810	7 218
T ₇	4 429	3 083	7 069	3 978	2 834	6 414	4 780	2 353	6 655	4 880	2 695	7 087
T ₈	4 036	3 144	6 768	3 546	2 968	6 159	3 885	2 609	6 105	4 665	2 797	6 995
T ₉	4 038	2 986	6 620	3 723	2 773	6 124	4 029	2 083	5 709	4 630	2 711	6 878
T ₁₀	4 071	3 226	6 890	3 590	2 994	6 175	4 874	2 413	6 800	5 104	2 900	7 494
T ₁₁	4 268	3 052	6 893	3 718	2 826	6 172	4 917	2 300	6 725	5 032	2 881	7 410
T ₁₂	3 311	2 059	5 039	2 853	1 836	4 404	2 913	1 562	4 194	4 452	2 374	6 381
CD (<i>P</i> = 0.05)	158	123		96	83		319	184		136	96	

(1985–89), 'Sarjoo 52' (1989–93) at Varanasi; 'Masur' (1984–86), 'Sarjoo 52' (1986–93) at Faizabad; 'Sita' at Sabour; 'Kranti' at Jabalpur and 'R 269' (1988–90), 'Kranti' (1990–93) at Raipur. The wheat varieties used were 'HD 2329' at Ranjitsinghpura; 'S 308' at Palampur; 'UP 2003' at Pantnagar; 'UP 262' at Faizabad; 'K 7410' (1984–85), 'HUW 55' (1985–89), 'HD 2204' (1989–92), 'HUW 234' (1992–93) at Faizabad; 'UP 1204' (1984–87), 'UP 26' (1987–93) at Sabour; 'Lok 1' at Jabalpur and 'Swati' (1988–89), 'HI 1077' (1989–93) at Raipur.

The N content in different organic materials were determined during each year and their amounts required to substitute a specified amount of N as per the treatments were calculated. Crop residues were incorporated 2 weeks before and farmyard manure and green-manure a week before rice transplanting. Rice was transplanted between 15 June and 15 July and harvested in October in different years at various locations. For wheat, land after rice harvest was prepared by taking care to avoid mixing of soil from plot to plot. Wheat was drilled between 15 November and 10 December in different years at various locations and harvested in April. Standard production practices recommended for rice and wheat at different locations were adopted for raising the experimental crops in all the years.

Soil was analysed after wheat harvest during 1992–93 at Ranjitsinghpura, Palampur, Faizabad, Sabour, Jabalpur and Raipur; and the changes in nutrient status from initial levels were monitored. Only composite soil samples were used for analysis and hence the data were not analysed statistically. The grain yield data up to 1992–93 were pooled. The system productivity was expressed in terms of wheat equivalent after converting rice yield into wheat based on market prices and adding it to wheat yield.

RESULTS AND DISCUSSION

System productivity

Rice-wheat system required application of 100% of the

recommended fertilizers for individual crops and any reduction in fertilizer application to either of the crops significantly reduced the yield (Table 2). At Ranjitsinghpura, application of 100% NPK through fertilizers recorded significantly highest rice yield followed by 25% N substitution by green-manure and farmyard manure. Wheat yield was significantly highest in the treatment receiving 50% N for rice through farmyard manure. 50% N substitution by green-manure in rice also resulted in significantly higher wheat yield than the treatment receiving 100% NPK through fertilizers for both crops. The total productivity indicated the possibility of substituting 50% N through farmyard manure and green manure.

At Palampur, substitution of 25 to 50% N for rice by different organic sources had no significant adverse effect on rice yield. Wheat yield was significantly highest when 50% N for rice was substituted by farmyard manure. Considering the total productivity, 50% N for rice could be substituted by farmyard manure with considerable yield advantage. With a small loss in productivity, green manure, farmyard manure and crop residue could also be used to substitute 25% N in rice and an economy of 25% in fertilizer use of wheat could be achieved.

At Pantnagar, highest rice yield was recorded with 100% NPK through fertilizer which was at par with 25% N substitution by green manure. Wheat yield was highest when rice and wheat received all the nutrients through fertilizers although it was at par with the treatment receiving 50% N for rice through green manure. Considering the total productivity, it was not possible to substitute a part of fertilizer N through any of the organic sources without adverse effect.

At Varanasi, 25% N substitution by farmyard manure resulted in similar yield as the application of 100% NPK through fertilizers. The treatment receiving 50% N through farmyard manure and green manure for rice recorded significantly higher wheat yield than that receiving 100% NPK through fertilizers for both rice and wheat. The system pro-

Table 3 Effect of integrated nutrient supply on organic carbon and available N status in soil

Treatment	Organic C (%)				Available N (kg/ha)			
	Palampur	Faizabad	Sabour	Jabalpur	Ranjitsinghpura	Palampur	Jabalpur	Raipur
T ₁	0.55	0.23	0.20	0.66	162	715	252	187
T ₂	0.56	0.32	0.23	0.65	214	665	249	215
T ₃	0.58	0.35	0.32	0.69	247	727	260	231
T ₄	0.62	0.34	0.34	0.70	237	696	263	230
T ₅	0.65	0.39	0.39	0.72	301	702	266	240
T ₆	0.64	0.51	0.46	0.68	287	746	257	275
T ₇	0.62	0.45	0.43	0.62	310	708	241	252
T ₈	0.62	0.43	0.42	0.72	266	658	266	239
T ₉	0.66	0.41	0.41	0.74	271	709	270	235
T ₁₀	0.68	0.46	0.45	0.71	293	715	265	245
T ₁₁	0.69	0.45	0.43	0.69	292	721	260	232
T ₁₂	0.60	0.27	0.31	0.66	183	696	252	229
Initial value	0.61	0.37	0.39	0.62	442	675	246	255

Details of treatments are given under Materials and Methods

Table 4 Effect of integrated nutrient supply on available P and K status in soil

Treatment	Available P (kg/ha)					Available K (kg/ha)				
	Ranjitsinghpura	Palampur	Faizabad	Sabour	Jabalpur	Ranjitsinghpura	Palampur	Faizabad	Sabour	Jabalpur
T ₁	5.1	31.4	7.6	4.0	11.2	82	248	277	112	588
T ₂	7.4	43.6	12.9	6.3	12.6	91	248	292	123	714
T ₃	8.2	58.6	15.9	7.5	13.8	91	239	285	127	826
T ₄	10.6	48.7	17.0	7.0	13.2	91	231	278	129	728
T ₅	17.9	40.6	20.4	10.2	15.4	97	260	290	134	756
T ₆	12.0	45.1	19.4	10.7	16.8	97	235	305	144	840
T ₇	15.2	56.4	22.0	10.5	13.6	97	264	292	139	770
T ₈	10.6	56.2	16.9	9.9	15.8	97	243	324	136	812
T ₉	10.8	44.5	15.3	9.9	17.0	98	231	308	135	882
T ₁₀	10.6	41.2	17.9	10.1	16.8	97	248	293	139	784
T ₁₁	10.6	54.3	19.0	9.9	17.6	83	231	281	139	896
T ₁₂	6.7	36.3	11.2	8.2	15.4	72	256	294	127	770
Initial value	14.0	21.9	13.8	22.5	18.4	156	221	355	155	728

Details of treatments are given under Materials and Methods

ductivity also indicated the possibility of substituting 50% N for rice by farmyard manure. More or less similar trend was observed at Faizabad and Sabour.

At Jabalpur, 25% N substitution by farmyard manure and 25% to 50% N substitution by green manure recorded similar yields as application of 100% NPK through fertilizers. However, wheat yield was highest with 100% NPK application through fertilizers in both seasons although it was at par with the treatments receiving 50% N for rice through farmyard manure and crop residue. The productivity of the system indicated the possibility of substituting 50% N for rice through green manure with a small loss in production.

At Raipur, it was possible to substitute 25 to 50% N needs of rice through farmyard manure and green manure with significant yield advantages with green manure. Wheat yield was significantly higher in all the N substitution treatment than application of 100% NPK through fertilizers for both

rice and wheat except 25% N substitution by farmyard manure and crop residue. The system productivity indicated the possibility of substituting 25 to 50% N needs of rice through different organic sources and with considerable increase in productivity with green manure.

The differential response to N substitution by organic sources could probably be related to soil characteristics at these sites (Nambiar *et al.* 1992). At Pantnagar, higher initial organic carbon status must have hindered decomposition of organic sources of nutrients. Likewise, at Jabalpur, clay soil with poor aeration must have hindered the decomposition of organic sources of nutrients. Among the organic sources, farmyard manure with narrower C : N ratio was the best which probably released adequate N for use by rice. Crop residue with wider C : N ratio, must have immobilised soil N leading to inadequate supply of N to rice crop. However, at Raipur centre, with adequate moisture due to high rainfall and fa-

Table 5 Effect of integrated nutrient supply on micro-nutrient status of soil at Faizabad

Treatment	Available Zn (ppm)	Available Cu (ppm)	Available Mn (ppm)	Available Fe (ppm)
T ₁	0.53	0.67	4.05	6.82
T ₂	0.47	0.62	4.45	6.11
T ₃	0.51	0.70	4.42	5.89
T ₄	0.52	0.63	4.31	6.11
T ₅	0.42	0.73	4.60	5.97
T ₆	0.73	0.98	5.40	7.79
T ₇	0.63	0.92	5.22	6.90
T ₈	0.65	0.84	5.09	6.78
T ₉	0.59	0.82	4.89	6.40
T ₁₀	0.62	0.88	5.31	6.57
T ₁₁	0.60	0.81	5.11	6.83
T ₁₂	0.49	0.66	4.39	5.92
Initial value	1.01	1.20	6.28	8.50

Details of treatments are given under Materials and Methods.

avourable temperature, even crop residue decomposed quickly and released the transformed N at a rate adequate enough to meet the needs to rice crop.

Soil fertility

There was a decline in soil organic carbon content in unfertilized plots with continuous rice-wheat cropping except at Jabalpur where a small build up was noticed (Table 3). Integrated nutrient supply improved the organic carbon content which was obviously due to addition of organic matter (Nambiar *et al.* 1992).

The available N content declined in all the treatments at Ranjitsinghpura. However, the decline was of smaller magnitude in treatments with integrated nutrient supply. At Palampur and Jabalpur, there was slight improvement in available N in most of the treatments but the effect of integrated nutrient supply was not conspicuous. At Raipur, there was small decline in available N in all the treatments except that which had 50% N through farmyard manure for rice. Decline in available N was mostly observed in locations with high level of productivity due to higher N uptake by the crop.

The available P at Ranjitsinghpura declined in all the treatments except when 100% NPK was added through fertilizers (Table 4). At Palampur, there was substantial build up in available P in all the treatments and among the organic sources, build up was maximum with crop residue. Application of large amounts of P through fertilizers/organic sources must have resulted in P build up. At Faizabad also, in all the plots supplied with recommended amounts of P, there was small build up in available P. At Sabour, in all the treatments

there was decline in available P probably due to lesser application of P than its uptake. The decline in available P at Jabalpur in all the treatments was probably due to high P fixation in Vertisols.

As regards available K is concerned, there was decline in all the treatments at Ranjitsinghpura, Faizabad and Sabour, but at Palampur, there was a small build up. Even at Jabalpur, there was a small build up in available K in fertilized plots. Organic sources generally tended to decrease the magnitude of decline in available K possibly due to higher K supply when used for N substitution. At current levels of productivity, the K uptake must have been much higher than its application, but still the change in available K after continuous rice-wheat cropping was of smaller magnitude probably because crop requirement of K was largely met from non-exchangeable pool of soil K (Swarup and Singh 1989). Continuous rice-wheat cropping at Faizabad resulted in decline in micronutrient status in all the treatments but the decline was lesser with integrated nutrient supply (Table 5).

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Effect of row arrangement on yield and monetary benefits in mulberry (*Morus indica*) + soybean (*Glycine max*) and mulberry + greengram (*Phaseolus radiatus*) intercropping

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ABSTRACT

A field experiment was conducted during 1989–91 to investigate the effect of intercropping 'Kanva 2' mulberry (*Morus indica* L.) + soybean [*Glycine max* (L.) Merr.]; and mulberry + greengram (*Phaseolus radiatus* L.) on yields of component crops, total land productivity and monetary benefits under different row arrangements. Total yield was consistently greater in intercropping than in monocropping mainly due to increase in legume population between mulberry plants. Monetary benefits were consistently higher in intercropping either in mulberry–soybean and or in mulberry + greengram than with the sole mulberry crop. With increase in plant population density both soybean and greengram showed decline in nodule population. Although intercropping mulberry with soybean or mulberry with greengram gave up to 40% higher overall yield advantage for the economic viability, mulberry + soybean or mulberry greengram row arrangement in 1 : 2 ratio proved better

Key words: intercropping, mulberry, soybean, greengram, productivity, monetary benefit, nodule count, row effect, *Glycine max*, *Morus indica*, *Phaseolus radiatus*

Intercropping of legumes and cereals is common in south-east Asia for both food and feed, and mixed cropping in Indian agriculture is a common practice. Legume with any other crop combination provide higher income due to better utilization of land, biomass production and addition to nitrogen to soil by nitrogen fixation. There are many reports on the beneficial effect of grain legumes such as soybean [*Glycine max* (L.) Merr.] due to its ability to fix atmospheric nitrogen and leave the soil enriched (Singh and Kashyap 1983, Saxena and Chandel 1984, Chowdary and Rosario 1993). There is however a dearth of precise information about the level of benefit derived by mulberry and legume from each other in terms of yield component, monetary value, nodulation and possible nitrogen transfer from legume crop to the soil. Hence, an effort was made to understand the effect of legume intercrops in the normal mulberry crop by adopting 1, 2 or 3 rows of a legume inbetween mulberry rows.

MATERIALS AND METHODS

A field experiment was conducted during the south-west monsoon of 1989–91 at the institute farm, situated at 13.35 N and 76.50 E, at 914 m above mean sea level. Recommended package of practices was adopted to raise the crops (UAS, Bangalore 1985). Main crop was 'Kanva 2' mulberry (*Morus*

indica L.) and the subsidiary crop was 'Monata' soybean and greengram (*Phaseolus radiatus* L.). The experiment was laidout in randomized block design and replicated 4 times. Mulberry was spaced at 120 cm row-to-row and 60 cm plant-to-plant, which formed the main plot. Various row combinations formed the subplots, and the gross size of each subplot was 5.4 m x 4.8 m. Each experiment contained 2 sole crop subplots, one of mulberry and second of soybean at each population density, which were planted beside the main experimental crop. Same treatment were applied for mulberry–greengram also.

In mulberry, the sole soybean crop was spaced at 30 cm between rows and 15 cm between plants. In 1 : 1 row arrangement each subplot contained 128 soybean plants arranged in rows between mulberry plants. In 1 : 2 rows arrangement, the number of plants was doubled, ie 256 soybean plants in 2 rows between mulberry. In 1 : 3 row arrangement, 384 soybean plants were planted in 3 rows between mulberry plants.

In mulberry–greengram the number of arrangement, plant population and spacing of greengram was similar to mulberry–soybean intercropping.

The soybean and greengram crops were sun-dried, threshed and their yield/hectare was estimated by proportion. Mulberry leaves were harvested twice, first at 9 weeks after pruning and second after 13 weeks. The total yield from

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Table 1 Yield of crop, net income and nodules/plant of mulberry (M) and soybean (S) in intercropping

Yield	Monocrop		Intercrop			F ratio
	M	S	M + S (1 : 1)	M + S (1 : 2)	M + S (1 : 3)	
Net income (Rs/ha)	12 250	9 790	14 860	16 430	17 240	43.02**
Yield (kg/ha)						
Mulberry	9 800		7 950	7 850	7 340	
Soybean		1 400	5.03	5.09	3.01	
Nodules/plant		6.05	5.03	5.09	3.01	
SEm ±	0.46					
CD (<i>P</i> = 0.05)	1.43					
CD (<i>P</i> = 0.10)	2.00					

***P* < 0.01; **P* < 0.05. Yield is based on actual cost; Mulberry leaf @ Rs 1.25/kg, soybean Rs 7/kg; mean of 80 plants from 4 replicates

Table 2 Yields of crop, net income and nodules/plant of mulberry (M) and greengram (G) in intercropping

Yield	Monocrop		Intercrop			F ratio
	M	S	M + S (1 : 1)	M + S (1 : 2)	M + S (1 : 3)	
Net income (Rs/ha)	15 370	3 780	15 780	15 940	15 970	1 549.90**
Yield (kg/ha)						
Mulberry	12 300		12 050	11 860	12 770	
Soybean		1 420	800	120	140	
Nodules/plant		7.10	6.00	5.30	4.80	
SEm ±	1 549.90					
CD (<i>P</i> = 0.05)	0.14					
CD (<i>P</i> = 0.10)	0.59					

***P* < 0.01; **P* < 0.05. Yield is based on actual cost; Mulberry leaf @ Rs 1.25/kg, soybean Rs 7/kg; mean of 80 plants from 4 replicates

both the harvests was pooled and calculated as per the procedure of IARI, New Delhi (1987). The net income of each species was calculated based on the actual cost, ie mulberry leaf @ Rs 1.25/kg; soybean seed @ Rs 7.00/kg and greengram seed at Rs 9.00/kg. Nodules were counted during early and peak growth, ie 25 days and 80 days after sowing, respectively from each subplot and expressed per plant which is the mean of 80 plants (Table 1, 2) for both the legume crops. Soil samples were taken out at pre-sowing and at post-harvest dates of all treatment plots for assessment of nitrogen in soils. The pre-sampled soil contained 21.6 kg/ha nitrogen and 32 kg/ha available phosphorus in mulberry-soybean. In mulberry-greengram the plot showed 32.4 kg/ha nitrogen and 32 kg/ha available phosphorus.

Analysis of variance was used to assess the treatment effects. Data for the sole mulberry, soybean and greengram plots were analysed.

RESULTS AND DISCUSSION

Crop yield

In mulberry-soybean intercrop, the yield of mulberry leaf decreased due to intercropping, ie 1 850 kg/ha in 1-row planting, 1 950 kg/ha in 2-rows planting and 1 150 kg/ha in 3-rows of soybean plant density compared with the sole mulberry crop (Table 1). But the soybean-seed yield increased

with increase in row-planting density. On 3-row soybean intercropping the seed yield was 1 150 kg/ha compared with 1 400 kg/ha under soybean crop alone.

In mulberry-greengram too the mulberry yield was affected under intercropping, due to increase in greengram planting density. The mulberry leaf yield decreased marginally, ie 250 kg/ha in 1-row, 440 kg/ha in 2-row and 470 kg/ha in 3-row plant density compared with sole mulberry crop.

The yield advantage in intercropping is attributed to better utilization of one or more growth resources by the component crops due to their complementary effect (Willey 1979). Although total productivity of an intercropping system can be greater, productivity of at least 1 or even both component crops is usually less than that of respective sole crops in intercropping (Natarajan and Willey 1980, Rees 1986), similar trend was observed in the present study.

Net income

The net income calculated under intercropping was higher than in pure stand either of mulberry or legume crop. Maximum net income of Rs 17 240/ha from 1 : 3 row ratio was followed by Rs 16 430/ha in 1 : 2 and Rs 14 860/ha in 1 : 1; all were statistically significant than the sole crop. However, it was non-significant between 1 : 2 and 1 : 3 intercrops. The plots with sole crop of mulberry yielded a net income of Rs

12 250/ha from 2 harvest and soybean crop alone of Rs 9 790/ha within a cropping duration of 100 days. The economic viability of sole cropping, intercropping of mulberry + soybean and mulberry + greengram under various planting densities shows (Table 2) that intercropping 1 : 2 mulberry soybean is more appropriate in view the other advantages like optimum land utilization and nodule number (Table 1, 2).

In mulberry–greengram intercrop maximum net income was Rs 15 970/ha in 1 : 3 ratio followed by 1 : 2 (Rs 15 940/ha), which was significant over the monocrop. Though 1 : 1 intercrop yielded Rs 15 780/ha, it was non-significant over the mono crop. The net income under monocropping was Rs 15 370/ha from 2 mulberry leaf harvests and Rs 3 780/ha from greengram crop within the cropping duration of 80 days. Although there was economic advantage in adopting intercropping system, only a marginal increase was achieved because all of them gave similar monetary benefits.

Nodule population and N accumulation in soils

The number of nodules/plant decreased with increase in plant population density. But the nitrogen content in soil increased with increase in plant density due to biological nitrogen fixation. Singh and Kashyap (1983) also reported similar finding in soybean.

In mulberry soybean intercrop, the pre-treated soybean seeds with *Rhizobium* inoculum showed change in nodule number/plant at 100 days after sowing. With increase in plant density the number of nodules formed/plant decreased, ie from 6.05 nodules/plant under sole soybean to 5.09 nodules/plant in 2-row, and 3.01 nodule/plant in 3-row intercrop planting density (Table 1, 2). However, soil analysis of the post-harvest soybean plot showed an increase in available nitrogen up to 13.4 kg/ha in the soil intercropped with soybean.

In mulberry–greengram intercrop at 80 days after sowing the pre-treated greengram seeds with *Rhizobium* inoculum showed decrease in nodule number/plant with increase in greengram planting density. Sole greengram plots contained 7.1 nodules/plant which gradually decreased under intercropping from 6.0 nodules/plant in 1 row to 5.3 nodule/plant in 2 rows and 4.8 nodules/plant with 3 rows. The data of post-harvest soil analysis showed an increase in available nitrogen of 8.7–11.7 kg/ha depending on the planting density in soil intercropped with greengram.

Thus the total yield of each species was highest when grown in pure stand, which marginally decreased when additional row or rows were inserted between the main crop. The maximum benefit was derived from mulberry–soybean or mulberry greengram as intercrop in 1 : 2 row arrangement besides the advantage of additional of nitrogen to soil and optimum land utilization.

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Field evaluation of cowpea (*Vigna unguiculata*) varieties for grain and fodder production and for multiple disease resistance in Nigeria

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ABSTRACT

A field study was conducted during 1992-94 in rainy season (July-October) to evaluate 12 cowpea [*Vigna unguiculata* (L.) Walp.] varieties for grain and fodder production, and their resistance to the major prevalent diseases at Bauchi in Nigeria. Cowpea varieties 'IAR 4/48-15-1', 'IT 89 KD-288', 'IT 89 KD-275', 'IAR 7/180-4-5', 'IAR 2/180-4-9', and 'IAR 2/180-4-12' significantly gave higher seed yields than others. Highest fodder (dry and fresh) yields were obtained in 6 varieties, and high seed as well as fodder yields in 'IAR 2/180-4-12', 'IAR 7/180-4-5', 'IAR 2/180-4-9' and 'IT 89 KD-288'. Only 'IAR 7/180-4-5' showed multiple disease resistance to scab (*Elsinoe phaseoli* Jenkins), anthracnose [*Colletotrichum lindemuthianum* (Sacc and Magnus) Lams-Scrib.] and bacterial blight [*Xanthomonas campestris* pv *phaseoli* (Smith) Dye].

Key words : cowpea, *Vigna unguiculata*, grain and fodder yields, resistance, scab, anthracnose, bacterial blight

In west African countries, cowpea [*Vigna unguiculata* (L.) Walp] is the most important indigenous grain legume that is utilized for several purposes. A disease-free cowpea crop giving good-quality abundant seeds and haulms is highly desirable. However, various studies on cowpea improvement in the past were directed only at obtaining high grain yields while neglecting the quantity of haulms that could be produced after harvesting the seeds. Therefore, this study was undertaken to fulfil these objectives.

MATERIALS AND METHODS

The experiment was conducted in the rainy season (July-October) during 1992-94 at the Yelwa teaching and research farm of the university at Bauchi (10°7' 9°49' E; 609 m altitude), which is located in the Guinea Savanna Zone in Nigeria. During the 1992-94, 12 cowpea lines or varieties including 10 improved and 2 locally grown ('Bauchi' and 'Kananado') were used. The entries were replicated 4 times in randomized complete block design with plots of five 6 m rows spaced 0.75 m.

Planting was done on flat with 2 seeds sown/stand. Weeds were controlled by application of paraquat immediately after sowing the seeds. Subsequent weed control was done by hand-hoeing at 3-week intervals. Cypermethrin (Cymbush 10 EC, and dimethoate (Perferthion 40EC) were applied @ 0.75 litre/ha twice to control the insect pests, ie first at flower bud-

initiation and the second at mid-podding (when 50% of plants have started to pod). No fungicidal spray against diseases was done to allow the plants become naturally infected. From previous field observations and pathogenicity tests in the laboratory, the most prevalent diseases affecting cowpea at the experiment site were scab (*Elsinoe phaeoli* Jenkins), anthracnose [*Colletotrichum lindemuthianum* (Sacc. and Magnus) Lams-Scrib.) and bacterial blight [*Xanthomonas campestris* pv *phaseoli* (Smith) Dye]. At 3 weeks after sowing, the plants were inoculated with conidial suspension (350 000 conidia/ml) of each of the 3 causal agents by spraying from a knapsack sprayer to increase natural infection.

All plants in the sample region of 3 central rows of 4 m length were counted at 3 weeks after sowing. Ten plants were randomly selected, tagged and examined for the presence of visible aerial symptoms of the 3 diseases. Six readings were taken at bi-weekly intervals starting from 4 weeks after sowing. Disease incidence was calculated from the total number of plants examined. Plants were scored for disease severity on 1-5 scale where 1, no symptom; 2, up to 25% plant parts affected; 3, 26-50% plant parts affected; 4, 51-75% plant parts affected and 5, more than 75% plant parts affected.

Data were collected also on the number of days from sowing to 50% anthesis, number of pods/plant (from a sample of 10 plants/plot), number of seeds/pod (from a plot sample of 50 pods), 100-seed weight, number of days from sowing to 95% maturity, and pod and seed yields. Fresh and dry fodder yields were also determined. Data collected were

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Table 1 Yield components, grain and fodder yields of 12 varieties of cowpea in 1992-94

Variety	Days to 50% anthesis	Pods/plant	Seeds/pod	100-seed weight (g)	Days to maturity	Threshing (%)	Seed yield (kg/ha)	Fodder yield (kg/ha)	
								Fresh weight	Dry weight
'IAR 4/48-15-1'	56.1	30.9	11.7	15.4	84.6	70.1	1 742.8	2 040.8	1 450.2
'IT 81 D-994'	48.1	15.9	9.8	18.0	77.6	66.8	704.4	1 956.2	1 164.8
'IAR 2/180-4-12'	56.7	14.8	7.6	11.9	80.0	74.4	1 254.3	2 736.6	1 816.3
'IAR 7/180-4-5'	64.2	28.8	8.1	13.8	80.9	68.4	1 516.7	4 330.1	2 822.3
'IAR 2/180-4-9'	63.8	21.2	11.3	11.4	85.1	77.8	1 480.5	2 789.8	2 195.4
'IAR 72'	60.2	17.7	6.7	15.0	85.7	65.0	947.8	3 121.8	2 529.2
'IT 89 KD 275'	50.9	25.0	7.7	16.3	79.0	65.6	1 625.0	2 228.7	1 446.6
'IT 87 D 2075'	54.5	14.8	8.2	17.8	82.9	71.6	1 111.7	2 465.4	1 786.0
'IT 89 KD 288'	62.8	24.5	8.0	19.5	82.2	66.8	1 662.5	2 745.2	1 819.5
'Karnanado'	71.8	9.6	5.3	20.8	90.0	65.1	814.2	3 081.7	2 539.7
'Bauchi local'	66.2	7.9	4.2	18.1	92.2	55.1	447.8	2 340.3	2 007.2
Mean	59.3	18.5	7.9	16.3	83.5	67.6	1 196.8	2 661.2	1 941.4
CV (%)	12.6	28.2	31.1	15.9	5.6	12.7	39.2	36.2	27.5
LSD (5%)	11.3	8.8	3.0	5.1	5.0	16.8	598.6	1 269.3	640.4

pooled together and averaged over the three years before analysis. The effect of year on the cowpea varieties was calculated.

Statistical analysis of variance of data were carried out to evaluate the significance of differences ($P < 0.05$) among the cultivars and the years. The means were separated with Fisher's least significant difference (F-LSD).

RESULTS AND DISCUSSION

In 1992, except for cowpea varieties 'IT81D-994' and 'IAR 2/180-4-12' which were early in flowering, the other varieties did not show appreciable increase in seed yield. Early flowering of the plants in varieties 'IT 89 KD-275' and 'IT 87 D-2075' increased seed yield. Varieties 'IAR 4/48-15-1' and 'IT 89 KD-288' gave higher seed yield as well as fodder yields. The highest fodder yield was obtained from 'IAR 72', 'IAR 7/180-4-5', 'IAR 2/180-4-12', 'IAR 2/180-4-9' and 'IAR 89 KD-288'. Considering these varieties, except 'IAR 2/180-4-12' and 'IAR 72', others and 'IAR 4/48-15-1' gave yield and yield component that were significantly higher than other varieties.

In 1993, except 'IAR 4/48-15-1', earliness in flowering neither increased fodder nor seed production. Similar to 1992, 'IAR 7/180-4-5' produced high fodder and seed yields. High fodder yields were also obtained from 'IAR 2/180-4-12', 'IAR 7/180-4-5', 'IAR 2/180-4-9' and 'IT 89 KD-288'. In 1994 contrary to 1992 and 93 results, short period of flowering in 'IAR 4/48-15-1'. 'IT 89 KD-275' greatly increased seed yield but not fodder yield except in 'IT 89 KD-275'.

During the 3 years, except for varieties 'IAR 4/48-15-1', 'IAR 2/180-4-12', and 'IT KD-275', other varieties which were early in flowering did not show appreciable increase in seed yield (Table 1). This observation confirms the finding of Oseni *et al.* (1992) who observed that days to flowering showed significant negative correlation with seed yield.

Although 'IAR 7/180-4-5', 'IAR 2/180-4-9' (which produced lightest seeds) and 'IT 89 KD-288' did not flower early, they gave high pods/plant, seed yields as well as fodder yields. This observation although contradicts that of Oseni *et al.* (1992) agreed with that of Chauhan and Joshi (1980).

The highest seeds/pod was obtained from 'IAR 4/48-15-1' and 'IAR 2/180-4-9', whereas the least from the local controls ('Karnando' and 'Bauchi') which matured much later than most other varieties (Table 1). On the contrary, they gave the heaviest seeds. It was observed that the 2 varieties and 'IT 81 D-994' and 'IAR 72', which all had low threshing percentages, gave the least seed yields. Varieties 'IAR 2/180-4-12', 'IAR 7/180-4-5', 'IAR 2/180-4-9', 'IAR 72', 'IT 89 KD-288' and 'Karnanado' gave highest fodder yields. Although the local controls gave low seed yields, high fodder yields obtained from them could be attributed to their spreading growth habit which might have subsequently led to the production of high biomass as compared to the erect

Table 2 Effect of year on yield components, grain and fodder yields of 12 cowpea varieties

Parameter	Year			
	1992	1993	1994	LSD (5%)
Days to 50% anthesis	60.5	57.6	59.8	NS
Pods/plant	19.7	17.4	18.5	NS
Seeds/pod	8.3	7.2	8.2	NS
100-seed weight (g)	16.6	16.1	16.3	NS
Days to maturity	88.6	76.2	85.7	10.8
Threshing (%)	69.5	65.8	77.9	8.3
Seed yield (kg/ha)	1 330.2	971.1	1 289.1	NS
Fresh fodder weight (kg/ha)	2 786.0	1 879.7	1 694.2	NS
Dry fodder weight (kg/ha)	2 250.1	1 879.7	1 694.2	516.4

Table 3 Incidence and severity of 3 major cowpea diseases on 12 varieties of cowpea in 1992-94

Variety	Scab		Anthracnose		Bacterial blight	
	Incidence (%)	Severity ^a	Incidence (%)	Severity ^a	Incidence (%)	Severity ^a
'IAR 2/180-4-9'	45.5	2.00	70.0	3.75	48.8	2.50
'IAR 2/180-4-12'	0.0	1.00	0.0	1.00	7.5	1.25
'IAR 4/48-15-1'	0.0	1.00	0.0	1.00	0.0	1.00
'IAR 7/18-4-5'	0.0	1.00	35.6	2.25	0.0	1.00
'IAR 72'	74.6	3.50	79.0	3.75	70.0	3.00
'IT 81 D-994'	83.0	4.00	59.0	3.25	62.3	3.50
'IT 87 D-2075'	45.0	2.25	51.5	2.50	68.4	3.00
'IT 89 D-249'	57.0	3.75		1.00	37.4	2.00
'IT 89 KD-275'	58.8	3.25	65.6	3.00	29.0	2.25
'IT 89 KD-288'	68.5	3.00	0	1.00	10.3	1.05
'Karnanado'	10.0	1.20	0	1.00	0	1.00
'Bauchi check'	19.5	1.25	0	1.00	0	1.00
Mean	37.6	2.17	30.1	2.04	27.8	1.89
CV (%)	25.1	21.4	14.6	18.9	11.0	27.4
LSD (5%)	8.9	0.42	9.2	0.28	7.0	0.37

^aRating were on a scale of 1, no symptom to 5, more than 75% plant parts affected

varieties.

The effect of year in days to anthesis, pods/plant, seeds/pod, 100-seed weight, seed and fresh fodder yields was not significant (Table 2). However, the cowpea varieties took significantly more days to mature in 1992 and 1994 and 1993. Statistically similar threshing percentages were observed on the varieties in 1992 and 1993 and these were lower than that obtained in 1994. Also, dry fodder yield obtained in 1992 was comparable to that of 1993 but was significantly higher than that of the 1994 value.

Varying degrees of susceptibility/resistance were exhibited by the different varieties to the various diseases. (Table 3). 'IAR 2/180-4-9', 'IAR 2/180-4-12', 'IAR 7/180-4-5' and 'Karnando' were resistant whereas 'IT 81 D-994', 'IAR 72', 'IT 89 KD-275' and 'IT 89 KD-288' were most susceptible to scab. While no disease symptom of anthracnose was observed on 6 varieties, others were infected with the disease being most severe on 'IAR 2/180-4-9', 'IAR 72', and 'IT 81 D-994'. Four varieties were resistant to bacterial blight while among the others infected, the disease was most severe on 'IT 81 D-994'. Four varieties were resistant to bacterial blight while among the others infected, the disease was most severe on 'IT 81 D-994', 'IAR 72' and 'IT 87 D-2075'. Only 'IAR 7/180-4-5' showed multiple resistance to

the 3 diseases.

Since 'IAR 7/180-4-5' is high yielding in terms of fodder and seed production and it is equally resistant to the 3 most prevalent diseases in the area of study, its seeds could be released to the farmers for onward commercial production.

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Development of maize (*Zea mays*) variety resistant to the maize stalk borer (*Chilo partellus*)

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ABSTRACT

The resistant present in Antigua Gr I and double cross 'Colombian hybrid H 207' was utilized as a source of resistance to develop maize (*Zea mays* L.) resistant to the maize stalk borer (*Chilo partellus* Swinhoe). As the insect resistance in maize is mainly under the influence of additive genes, the population improvement procedure for breeding resistant maize variety was adopted which is more efficient to capitalise on the additive genetic component. The resistant genes of Antigua Gr I were super-imposed upon the resistant gene combination of 'H 207'. Three cycles of half-sib and full-sib were followed and in each cycle the progenies were subjected to artificial infestation by the egg masses (black-head stage) of *Chilo partellus*. The progenies showing rating less than 5 on rating scale 1–9 were considered for further testing and incorporation. In this process, a balanced medium maturity (90–95 days) composite of selected families was derived and designated as entomological borer resistant (EBR) composite endowed with a good level of resistance and yield potential.

Key words : breeding, *Chilo partellus*, maize, resistance, *Zea mays*

Maize (*Zea mays* L.) is one of the main commodities that contribute to the sustenance directly or indirectly of the human population. Although, a large number of insect pests attack maize crop at one or the other stage of the crop growth, only half a dozen are serious and require attention. The maize stalk borer (*Chilo partellus* Swinhoe) is the key pest distributed all over India and is the target pest that determines priorities in breeding for enhancement of resistance. Singh *et al.* (1962) observed that a large segment of maize population having little or no infestation in nature were subsequently wiped out with the increase in borer population. They suggested that for the success of breeding for resistance programme, evaluation of maize lines under artificial infestation is imperative. Sequel to that, a large number of exotic and indigenous maize germplasm have been evaluated under artificial infestation against maize stalk borer *Chilo partellus*. Chatterji *et al.* (1973 a and b) while screening a large number of germplasm from different parts of India and different countries of world found 'Antigua Gr. I' and a 'Colombian hybrid H 207' to possess high level of resistance to the maize stalk borer *Chilo partellus* under artificial infestation.

They further evaluated the parent of 'H 207' hybrid to find out the parental contribution to resistance in this hybrid so that they may be directly incorporated into indigenous

agronomically improved varieties to increase their resistance to *Chilo partellus*. To their surprise, all the parental inbreds were highly susceptible and hence could not be exploited as resistance source. The genes resistance to stalk borer are not available in high yielding background in the maize germplasm screened so far. The double cross hybrid combining extremely high resistance alongwith high yielding genes was selected to generate segregates with new combinations giving both resistance as well as good yield potential so that they could either be stabilized in the form of new inbred lines (recycled inbred) or transfer certain of the coupling phase linked gene combinations into the elite genotypic background. Considering the genetic nature of resistance present in the double cross hybrid 'H 207' and to utilize high level of resistance that existed in 'Antigua Gr I' (a low yielder). Sarup *et al.* (1974) suggested an alternative procedure to use these important material as source of resistance to develop maize cultivars resistant to the maize stalk borer *Chilo partellus*.

MATERIALS AND METHODS

Colony of the maize stalk borer Chilo partellus

Healthy and vigorous colonies of the maize stalk borer, *Chilo partellus* were maintained by collecting fresh larvae/pupae from the field every year.

Mass culturing of Chilo partellus

One of the most important basic requirement for breeding

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for resistance is the efficient mass rearing of the insects. Siddiqui and Chatterji (1972) and Siddiqui *et al.* (1977) formulated suitable artificial diets based on indigenously available ingredients with simple preparation procedure for the rearing of *Chilo partellus* in the laboratory in large numbers. Rearing of maize stem borer was carried out in controlled rooms maintained at $27^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and 70 to 90% relative humidity. All the precautions were taken to establish and maintain healthy vigorous maize stalk borer colonies by the trained personnel of the project.

Germplasm sources

'Antigua Gr. I' and 'Colombian hybrid H 207' having fairly good resistance were utilized in the present studies.

Method of uniform artificial infestation

Artificial infestation with maize stalk borer *Chilo partellus* was done using egg masses. The egg masses (20–25 eggs) pinned on tissue paper ready to hatch (black-head stage) were transferred to field for infestation. The requisite number of eggs were pinned inside the plant whorls after 5.00 PM in 14–15-day-old crop. This practice is in use in India for the last 3 decades.

Evaluation for resistance

Rating scale 1–9 (1, healthy, 9, dead-heart) to quantify the degree of resistance or susceptibility present in the plants after infestation was followed. The leaf injury was rated 30–35 days after the release of insects in the field.

Effective selection/breeding scheme

Considering the resistance level in 'Antigua Gr I' (a low yielder) and the genetic resistance present in the double cross hybrid 'H 207' a breeding for resistance cultivar procedure proposed by Sarup *et al.* (1974) was followed to improve the resistance level and also agronomic characters such as yield.

'Colombian hybrid H 207' was grown as female lines in 96 rows during *khariif* (rainy season). 'Antigua Gr I' was grown as male lines in 50 rows. The row length was 5 m. After every 2 female rows 1 male row was grown. Artificial infestation with eggs of maize stalk borer *C. partellus* was done in female rows only. Pinned tissue paper containing 20–25 eggs (black-head stage) of *C. partellus* were introduced in the whorls of maize plants when the crop was 14–15-day-old. Observations on the leaf injury rating were taken in 35-day-old crop on rating scale 1–9. At the time of tassel emergence, rows of 'H 207' were detasselled which were pollinated from the pollen of 'Antigua Gr I' rows. At harvest, only the best ears from the resistant plants showing leaf-injury rating less than 5 were selected. About 500 such ears were selected which represented the first set of half-sib ears. These formed the half-sib progenies for the next cycle. In this way, 2 cycles of recombination were taken. In the terminal cycle of recombination, 250 half-sib families were selected. A progeny test was carried out to determine the yield potential

and other agronomic traits. In a parallel insect nursery, artificial infestation with *C. partellus* eggs was carried out to select resistant families. Based on the results of field resistance from the progeny test and insect nursery testing, selected families were again put to half-sib block in the next cycle. The pollinator was a balanced composite of selected families. The harvested families were again put into progeny test and in insect nursery. A programme to stabilize and improve best families obtained earlier was undertaken by using full-sib procedure. The best half-sib families were grown in rows. Plant to plant crosses were made between the best plants in the families. In the next cycle of full-sib progenies so obtained were put into progeny test and insect nursery for yield and resistance, respectively. Selected families were used for next cycle of full-sib derivation. Three full-sib cycles were repeated till the desired level of resistance was obtained. Ultimately, the best families were extracted for yield and borer resistance.

RESULTS AND DISCUSSION

Gene frequency for insect resistance in maize is low in the most maize germplasm Scott *et al.* (1964) reported that resistance against the European corn borer *Ostrinia nubilalis* (Hubner) was mainly under the influence of additive genes. While evaluating 'Colombian hybrid H 207' its parental inbreds and single crosses. Sarup *et al.* (1974) however found low magnitude of additive gene effects in the case of *C. partellus*. Keeping this in view, the population improvement procedure for breeding resistant maize variety was adopted which is most efficient to capitalize on the additive genetic component. 'Antigua Gr I' being low grain yielder can not be used as such by farmers and maize growers. Also, Colombian hybrid, H 207 which possess considerable resistance to *C. partellus* did not offer a practicable possibility either as a direct source of resistance or as a commercial end product which is likely to breakdown in due course. The inbred parents being highly susceptible, preclude their production and subsequent exploitation in the production of hybrid. Hence, 2 available sources of resistance, viz 'Antigua Gr I' (leaf injury rating 5.7) and hybrid 'H 207' (leaf injury rating 5.8) were used to develop a maize cultivar to reinforce resistance to *C. partellus*. The resistant genes of 'Antigua Gr I' were super-imposed upon the resistant gene combination of 'H 207' and then new resistant and high yielding gene combinations were sorted out in ear-to-row progenies. The female rows of H 207 were artificially infested by maize stalk borer, *C. partellus*. About 500 ears were harvested from plants showing leaf injury rating below 5. In this way, 2 cycles of recombination were carried out and every time the ears from resistant plants showing leaf injury rating below 5 were considered. Half-sib method of selection combined with simple back cross with 'Antigua Gr I' allows the flexibility of rejecting susceptible gene combinations in the form of susceptible half-sib families. Promising 250 half-sib families were stabilized in subsequent cycles and further improved by following 3 cycles of full-sib selection. The balanced

composite of selected resistant families was derived and designated as entomological borer resistant composite (EBR). This medium maturity (90-95 days) composite possessed a good level of resistance and yield potential. When evaluated under artificial infestation by *C. partellus*, the leaf injury rating ranged between 3 and 4 on rating scale 1-9 and was found consistently in least susceptible group. EBR composite may serve as a source of resistance against the maize stalk borer. It can also be exploited further for breeding varieties/hybrids endowed with resistance to *C. partellus*.

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Mutational rectification of certain defects in the aerial podding genotype 'TAP 5' of groundnut (*Arachis hypogaea*)

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ABSTRACT

A study was initiated to rectify early senescence defect of TAP 5 aerial pod-bearing mutant of 'Tatu' groundnut (*Arachis hypogaea* L.) through induction of mutations using the chemical mutagens ethyl methane sulphonate (0.3%) and sodium azide (3mM). Seven slow senescent mutants were identified which bred true. Several agronomically desirable mutants such as compact canopy and profusely branched mutants with shorter internodes were also selected, which retained the aerial pod bearing attribute of the parent.

Key words : Aerial podding genotype, ethyl methane sulphonate, sodium azide, senescence

The limited progress in groundnut (*Arachis hypogaea* L.) breeding has been attributed partly to the subterranean pod bearing habit of the plant (Wynne and Gregory 1981). The aerial podding attribute in groundnut was first observed by Prasad (1985) as mutant of the Brazilian groundnut variety 'Tatu'. These true breeding mutants exhibiting satisfactory pod development by aerial gynophores offer new opportunity for improving the productivity of groundnut plant due to the enhancement of the number of fruiting sites as suggested by Wynne and Gregory (1981). Madhavi (1988) observed that the yield potential of the aerial podding genotype 'TAP 5' is limited severely by its early leaf senescence. Therefore, an experiment to induce mutations in the aerial podding genotype 'TAP 5' groundnut to rectify its defect by developing slow senescing mutants was taken up.

MATERIALS AND METHODS

Well-developed 400 dry seeds of the aerial podding genotype 'TAP 5' per treatment were pre-soaked in water for 23 hr and treated for 3 hr at room temperature ($24^{\circ} \pm 1^{\circ}\text{C}$) with 2 chemical mutagens, viz sodium azide (3 mM) and ethyl methane sulphonate (0.3%) as described by Prasad (1972) and Prasad *et al.* (1985). Seeds soaked in water were maintained as control. After the mutagenic treatment, the seeds were washed in running tap water for 30 min to remove the excess mutagen. The seeds were then sown together with the control on ridges by hand dibbling with a spacing of 60 cm between the rows and 20 cm between the

seeds within a row to raise the M_1 generation during *kharif* rainy season 1990. The same spacing for sowing was adopted throughout the study. The total plant population in the M_1 generation was 368 in the ethyl methane sulphonate treatment and 324 in the sodium azide treatment.

All the seeds obtained separately from each M_1 plant were sown to grow M_2 generation along with the control in *rabi* winter season 1990–91. In the M_2 generation, each plant was thoroughly examined to identify mutants and also at random 10 M_2 plants were sampled from each plant-to-row progeny for advancing to the M_3 generation. The M_2 generation consisted of 6 823 plants in the ethyl methane sulphonate treatment and 5 634 plants in the sodium azide treatment. Single plant progenies were grown in M_3 generation during *kharif* 1991 and their breeding behaviour was studied. Data on vegetative and reproductive attributes were collected from 20 randomly selected plants in each progeny to estimate means (Prasad *et al.* 1985).

In the present study, the leaf area of standing crop was measured without destroying the plant by adopting the method suggested by Madhavi (1988) for both mutants and the parent. The total number of leaves of each plant were counted in the field and fourth leaf from the top (a representative leaf) of each primary branch was collected. The leaf area of the freshly collected sample leaves was measured with leaf area meter. The total leaf area of the plant was calculated using the formula:

$$\text{Total leaf area} = \frac{\text{Leaf area in cm}^2 \text{ of the samples leaves}}{\text{Number of sample leaves}} \times \text{Total number of leaves of the plant}$$

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Table 1 Leaf area, canopy diameter and circumference, plant height, primary and secondary branches of mutants isolated in M_2 generation of 'TAP 5' along with their M_3 progeny means

Mutant	Mutagen	Leaf area at 60 days after emergence (cm ²)		Canopy diameter at maturity (cm)		Canopy circumference at maturity (cm)		Plant height at maturity (cm)		Number of primary branches at maturity		Number of secondary branches at maturity	
		M_2	M_3	M_2	M_3	M_2	M_3	M_2	M_3	M_2	M_3	M_2	M_3
Control		1 639.2	1 477.9	48.4	62.6	142.3	166.3	42.8	49.3	4.4	4.1	1.9	0.0
Slow senescing large leaf mutants	(1) EMS ^a	3 123.8	2 818.6	69.0	66.8	170.0	175.5	40.0	50.1	8.0	6.1	3.0	2.5
	(2) EMS	3 019.2	2 911.2	74.0	68.8	190.0	180.9	46.0	49.0	8.0	5.3	4.0	3.1
	(3) EMS	2 952.7	2 619.6	72.0	71.0	180.0	190.4	40.0	51.5	6.0	6.4	2.0	4.2
	(4) NaN ₃ ^b	2 896.9	2 613.1	69.0	64.3	178.0	165.5	46.0	40.6	9.0	6.5	5.0	2.5
	(5) NaN ₃	2 419.9	2 521.4	75.0	81.4	190.0	201.6	45.0	50.1	6.0	5.5	0.0	3.0
	(6) NaN ₃	2 684.1	2 418.2	67.0	66.2	170.0	172.0	40.0	55.6	7.0	8.6	1.0	3.5
Alternate branching mutants	(1) EMS	3 046.3	2 596.5	60.0	70.2	160.0	172.5	42.0	52.5	10.0	5.5	4.0	4.2
	(1) EMS	2 713.8	2 588.6	70.0	66.5	180.0	170.9	32.0	30.3	9.0	6.0	8.0	6.5
	(2) EMS	2 488.3	2 016.1	64.0	67.3	170.0	175.5	34.0	34.5	10.0	6.8	9.0	5.3
	(3) EMS	2 814.5	2 294.1	72.0	69.3	185.0	180.4	37.0	45.3	11.0	10.0	9.0	7.4
	(5) NaN ₃	1 715.3	1 819.5	85.0	73.4	207.0	195.6	36.0	38.3	6.0	7.2	5.0	4.2
Compact canopy mutants	(5) NaN ₃	1 881.6	1 629.5	79.0	70.0	200.0	183.8	37.0	40.2	5.0	5.1	7.0	5.5
	(1) EMS	1 325.5	1 099.9	31.0	41.1	132.0	148.2	36.0	40.2	6.0	4.1	3.0	2.5
	(2) EMS	1 651.5	2 022.4	33.0	40.2	130.0	142.2	40.0	39.0	5.0	5.2	4.0	4.1
	(3) EMS	1 543.3	1 393.2	30.0	35.5	133.0	145.4	42.0	41.3	5.0	4.8	2.0	3.2
	(4) EMS	1 723.1	1 671.9	34.0	42.3	135.0	150.3	34.0	43.2	8.0	7.3	7.0	5.8
	(5) NaN ₃	1 337.6	1 632.2	31.0	43.1	120.0	136.2	50.0	50.0	4.0	4.0	3.0	2.5
Profusely branched mutants	(5) NaN ₃	1 025.5	944.9	27.0	38.0	122.0	130.2	45.0	49.0	4.0	4.6	4.0	3.5
	(6) NaN ₃	929.6	1 058.3	32.0	42.2	125.0	141.4	48.0	46.0	4.0	5.0	2.0	0.0
	(1) EMS	2 742.9	2 189.9	66.0	62.0	170.0	169.1	45.0	42.5	10.0	8.2	16.0	9.9
Profusely branched mutants with shorter internodes	(2) EMS	2 421.1	2 441.4	65.0	60.0	175.0	170.1	46.0	52.4	9.0	7.5	18.0	10.3
	(3) EMS	2 654.6	2 344.2	70.0	68.2	185.0	178.5	51.0	56.2	8.0	6.9	17.0	8.4
Profusely branched mutants with shorter internodes	(5) NaN ₃	2 647.5	2 415.6	76.0	71.0	180.0	185.5	27.0	32.0	12.0	9.5	10.0	8.5
	(5) NaN ₃	2 279.7	2 056.4	83.0	72.5	229.0	195.4	25.0	30.6	10.0	6.4	9.0	6.5

^a, Ethyl methane sulphonate (0.3%); ^b, sodium azide (3mM)

RESULTS AND DISCUSSION

A wide range of mutants with altered morphological attributes were observed in the M_2 generation. The objective of the study was achieved with the isolation of 7 slow-senescent mutants, 4 in the sodium azide treatment and 3 in the ethyl methane sulphonate treatment (Tables 1, 2). The characteristic features of these mutants were high leaf area at 60 days after emergence and increased size of the leaves. These mutants bred true in the M_3 generation for retention of green leaf mass even at pod maturity, thereby signifying their slow senescent nature. The mutants were also characterized by higher biomass, higher branch number and canopy diameter. They recorded higher number of aerial pods, higher pod and kernel yields than the parent which could be due to the presence of physiologically active canopy for a longer duration than the parent.

Although investigations of this type are not many, some researches have led to the development of mutants for physiological attributes such as slow senescence (Ashley 1984) in

groundnut and other crops, viz barley (Gustafson *et al.* 1971, Nilan 1972), wheat (Khvostova *et al.* 1965, Kumar 1977) and rice (Swaminathan *et al.* 1970, Reddy *et al.* 1975). These mutants are expected to be of immense use in groundnut breeding.

Out of the 5 alternate branching mutants, 3 were identified in ethyl methane sulphonate treatment and 2 in the sodium azide treatment. These mutants bred true in the M_3 generation for the alternate branching character and showed higher yield than the parent (Table 2). The alternate branching mutants reported in our study are of a systemic nature involving a change at the subspecific level. Prasad *et al.* (1984) and Nagabhushanam *et al.* (1992) also reported the occurrence of alternate branching mutants from the sequentially branching parents.

Several other agronomically desirable mutants were also isolated (Table 1). Seven compact canopy mutants, of which 4 in the ethyl methane sulphonate treatment and 3 in the sodium azide treatment were selected. These mutants had re-

Table 2 Subterranean mature pods and aerial pods, subterranean mature pod and kernel weight and total dry-matter of harvest at mutants

Mutant	Mutagen	Number of subterranean mature pods		Number of aerial pods		Subterranean mature pod weight (g)		Number of subterranean mature kernels		Subterranean mature kernel weight (g)		Total dry-matter at harvest (g)		
		M ₂	M ₃	M ₂	M ₃	M ₂	M ₃	M ₂	M ₃	M ₂	M ₃	M ₂	M ₃	
Control		17.9	12.7	5.3	4.5	15.1	9.0	23.7	18.3	7.2	6.2	39.7	19.0	
Slow senescing large leaf mutants	(1) EMS ^a	53.0	42.1	12.0	9.3	59.8	38.5	104.0	81.2	46.9	27.9	96.8	62.4	
	(2) EMS	43.0	44.8	11.0	10.2	41.6	37.1	70.0	74.1	30.1	23.0	75.7	49.6	
	(3) EMS	46.0	40.5	9.0	9.3	43.8	32.5	74.0	68.4	31.5	20.1	68.2	56.0	
	(4) NaN ₃ ^b	34.0	29.1	10.0	9.5	32.3	24.2	48.0	46.2	19.2	13.2	78.7	52.4	
	(5) NaN ₃	32.0	28.4	8.0	8.3	31.6	26.4	50.0	39.4	20.4	14.0	65.5	54.0	
	(5) NaN ₃	30.0	30.3	9.0	7.5	30.8	25.3	56.0	40.4	21.6	13.2	66.6	40.3	
Alternate branching mutants	(5) NaN ₃	39.0	36.3	10.0	8.8	40.9	30.3	65.0	53.1	22.7	20.2	72.5	45.2	
	(1) EMS	43.0	25.3	0.0	0.0	40.2	24.3	68.0	44.6	24.5	13.3	59.8	42.4	
	(2) EMS	38.0	22.4	0.0	0.0	34.7	20.5	41.0	38.1	18.3	12.5	62.3	38.1	
	(3) EMS	40.0	30.0	0.0	0.0	38.9	27.0	66.0	54.0	23.4	17.5	84.0	49.1	
	(5) NaN ₃	18.0	25.1	0.0	0.0	17.9	23.8	24.0	40.1	9.5	12.2	50.0	40.6	
	(5) NaN ₃	20.0	23.5	0.0	0.0	21.8	20.8	30.0	39.0	11.1	10.9	61.0	39.1	
Compact canopy mutants	(1) EMS	31.0	27.2	0.0	0.0	29.1	23.1	43.0	36.3	17.1	12.0	41.8	36.1	
	(2) EMS	27.0	21.4	0.0	0.0	25.6	19.3	45.0	39.1	18.2	10.3	40.1	39.2	
	(3) EMS	28.0	22.5	0.0	0.0	29.6	20.4	58.0	42.6	20.7	12.1	39.0	36.2	
	(4) EMS	30.0	25.8	0.0	0.0	28.8	22.2	68.0	40.7	21.0	11.2	39.7	30.5	
	(5) NaN ₃	27.0	23.4	0.0	0.0	27.4	20.4	37.0	35.2	13.3	10.2	30.9	29.4	
	(5) NaN ₃	26.0	21.5	0.0	0.0	24.1	23.2	35.0	25.2	12.6	9.6	31.5	32.3	
Profusely branched mutants	(6) NaN ₃	22.0	15.5	0.0	0.0	20.0	15.4	29.0	38.2	11.6	11.3	31.0	30.0	
	(1) EMS	49.0	32.1	9.0	8.2	44.1	27.5	71.0	49.7	29.8	18.9	115.7	50.8	
	(2) EMS	33.0	30.9	7.0	6.5	35.6	26.3	55.0	46.1	20.5	14.2	76.7	49.3	
	(3) EMS	36.0	29.5	8.0	7.7	32.7	24.2	48.0	38.7	21.0	12.9	73.3	41.3	
	Profusely branched mutants with shorter internodes	(5) NaN ₃	30.0	20.2	10.0	9.0	30.1	20.2	41.0	30.2	16.6	9.3	99.4	50.2
		(5) NaN ₃	28.0	19.2	8.0	8.3	28.4	18.5	38.0	35.5	12.0	11.6	61.4	38.1

^a, Ethyl methane sulphonate (0.3%); ^b, sodium azide (3mM)

duced canopy diameter and increased number of branches than the parent and bred true for these characters.

In the ethyl methane sulphonate treatment, 3 profusely branched mutants were observed. These mutants were characterized by an increase in the number of secondary and primary branches and an enhancement of the canopy diameter, the leaf area at 60 days and the yield. These mutants bred true for number of secondary branches in the M₃ generation. Two profusely branched mutants with shorter internodes were identified only in the sodium azide treatment. Reduced plant height and increased number of branches were the characteristic features of these mutants. In the M₃ generation, they bred true for the reduced internodal length and also recorded higher kernel yield than the control (Table 1, 2).

The mutants identified in the present study not only represent new gene mutation for the respective attributes they were selected for but also resulted in increased yield. Therefore, all the mutants reported above could be of profound value in groundnut breeding programmes which have to be strengthened with new genetic variability as suggested by

Gregory *et al.* (1973) and Prasad (1988).

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Integrated management of *Helicoverpa armigera* on gram (*Cicer arietinum*)

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ABSTRACT

A field experiment was conducted during 1993-96 for controlling gram pod borer (*Helicoverpa armigera* Hubner.) infesting gram (*Cicer arietinum* L.). Integrated pest management treatment comprising endosulfan 0.07%, neem-seed-kernel extract 5% and nuclear polyhedrosis virus @ 250 larval equivalents/ha were evaluated. The field trial conducted during winter 1993-96 revealed that 3 spray application starting from initiation of flowering and subsequent 2 sprays at fortnightly intervals with first 2 sprays either with nuclear polyhedrosis virus @ 250 larval equivalent/ha or neem-seed-kernel extract 5% followed by third spray with endosulfan 0.07% were most effective in controlling the gram pod borer and gave 26.94 and 27.29% increase in yield.

Key words : management, *Helicoverpa armigera*, neem-seed-kernel extract, nuclear polyhedrosis virus

Gram (chickpea) *Cicer arietinum* L. is a major winter pulse crop of Maharashtra and is badly damaged by gram pod borer (*Helicoverpa armigera* Hubner.) from early vegetative stage to podding stage. Several researchers have attempted various formulations of conventional insecticides, synthetic pyrethroids and chemicals of plant origin independently and recommended 2 sprays, first at 50% flowering and second 15 days thereafter (Sinha *et al.* 1983, Babu and Rajsekharan 1984, Chhabra and Kooner 1985, Bhalani and Kotadia 1986 and Sachan 1990). However, due to reported ineffectiveness of most of the insecticides and their ill-effects, an alternative strategy (Integrated pest management) involving chemical insecticide (endosulfan), plant extract (neem-seed-kernel extract) and microbial insecticide (nuclear polyhedrosis virus) were evaluated for controlling *H. armigera* on gram at Rahuri.

MATERIALS AND METHODS

A field experiment was conducted in randomized block design with 3 replications for 3 consecutive winter seasons from 1993-94 to 1995-96 on 'Vishal' (Phule G 87207) gram at Rahuri. The crop was sown during first fortnight of November and was raised by following the normal agronomic practices. In 2 spray application schedule spraying of insecticides was given at 50% flowering and a fortnight thereafter while in the case of 3 spray application schedule first spraying was given at initiation of flowering and subsequent applications were given at an interval of fortnight with high volume knapsack sprayer @ 500 litres spray fluid/ha. The

treatment considered of endosulfan 0.07%, neem-seed-kernel extract 5% and semi-purified suspension of nuclear polyhedrosis virus 250 larval equivalents (0.5 litre/ha). These were used in the spray sequences, viz T₁, endosulfan-endosulfan; T₂, endosulfan-neem-seed-kernel extract; T₃, endosulfan-nuclear polyhedrosis virus; T₄, neem-seed-kernel extract-nuclear polyhedrosis virus; T₅, neem-seed-kernel extract-nuclear polyhedrosis virus-nuclear polyhedrosis virus; T₆, neem-seed-kernel extract-nuclear polyhedrosis virus-endosulfan; T₇, nuclear polyhedrosis virus-nuclear polyhedrosis virus-endosulfan; T₈, neem-seed-kernel extract-neem-seed-kernel extract-endosulfan; T₉, nuclear polyhedrosis virus-nuclear polyhedrosis virus-nuclear polyhedrosis virus; T₁₀, neem-seed-kernel extract-neem-seed-kernel extract-neem-seed-kernel extract; T₁₁, endosulfan-endosulfan-endosulfan and T₁₂, the control. Podborer damage was recorded on 5 randomly sampled plants from middle rows of each plot at maturity by counting the total number of healthy and infested pods from which pod damage (%) was calculated and converted into arcsin angles for statistical analysis. Yield/plot was recorded and analysed statistically. Based on pooled data returns/rupee investment for different treatments were worked out.

RESULTS AND DISCUSSION

Pod damage

The pooled data of 3 years on pod damage indicated significant differences during individual years as well as pooled mean pod damage. All the treatments except 2 spray application of endosulfan-endosulfan during 1993-94, endosulfan-neem-seed-kernel extract and neem-seed-kernel extract-nu-

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Table 1 Integrated management of gram pod borer on gram

Treatment	Average pod damage				Grain yield/kg/ha				Cost of treatment	Returns rupee investment
	1993-94	1994-95	1995-96	Mean	1993-94	1994-95	1995-96	Mean		
T ₁	19.00 (25.8)	9.77 (18.16)	9.12 (17.56)	12.63 (20.52)	1 722	1 840	1 944	1 835	530	0.73
T ₂	12.83 (20.95)	12.25 (20.43)	15.16 (22.89)	13.41 (21.42)	1 625	1 826	2 129	1 860	535	1.13
T ₃	11.87 (20.10)	8.37 (16.74)	10.48 (18.86)	10.24 (18.56)	1 631	1 888	2 083	1 867	790	0.48
T ₄	11.93 (19.48)	9.30 (17.33)	14.32 (22.21)	11.58 (19.67)	1 958	1 860	1 944	1 920	795	1.11
T ₅	11.49 (19.77)	9.71 (18.14)	9.19 (17.65)	10.13 (18.52)	1 854	1 985	2 210	2 016	1 320	0.92
T ₆	15.91 (23.47)	6.77 (15.08)	7.25 (15.60)	9.97 (18.05)	2 041	1 972	2 476	2 163	1 060	2.65
T ₇	9.88 (18.25)	6.59 (14.87)	8.63 (17.02)	8.36 (16.71)	2 125	2 160	2 314	2 200	1 315	2.19
T ₈	15.24 (22.96)	8.03 (16.43)	6.21 (14.48)	9.82 (17.95)	1 826	2 270	2 522	2 206	805	4.28
T ₉	14.37 (22.25)	9.02 (17.48)	7.68 (15.87)	10.35 (18.53)	1 819	1 944	2 476	2 080	1 575	0.98
T ₁₀	13.29 (21.34)	8.90 (17.34)	10.13 (18.53)	10.77 (19.07)	1 763	1 854	2 256	1 957	810	1.48
T ₁₁	14.16 (22.09)	8.40 (16.83)	7.01 (15.27)	9.85 (18.06)	1 888	2 004	2 256	2 049	795	2.57
T ₁₂	21.51 (27.62)	9.75 (18.15)	15.62 (23.26)	15.62 (23.01)	1 465	1 819	1 916	1 733		
SEm ±	0.79	0.70	0.57	1.26	105	88	61	69		
CD (P = 0.05)	2.32	2.05	1.68	3.70	310	261	180	203		
CV (%)	6.25	7.03	5.44		10.17	7.91	4.83			

Cost : Gram gran @ Rs 900/100 kg; endosulfan @ Rs 165/litre; nuclear polyhedrosis virus @ Rs 850/litre; neem-seed-kernel extract @ Rs 6/kg; soap powder @ Rs 20/kg; operational charges Rs 100/treatment.

clear polyhedrosis virus during 1995-96 and endosulfan-endosulfan, endosulfan-neem-seed-kernel extract and neem-seed-kernel extract-nuclear polyhedrosis virus from the pooled mean were observed to be significantly superior over the control in reducing pod damage. However, the lowest damage of 9.88 and 6.59% was noticed in the treatment with 3 spray application of nuclear polyhedrosis virus-nuclear polyhedrosis virus-endosulfan during 1993-94 and 1994-95 while during 1995-96 minimum damage of 6.21% was observed in the treatment with neem-seed-kernel extract-neem-seed-kernel extract-endosulfan. Based on pooled mean data it was revealed that the treatment with 3 spray application of nuclear polyhedrosis virus-nuclear polyhedrosis virus-endosulfan was the most effective in recording the lowest damage of 8.36% which was significantly superior to 2 spray application of endosulfan and endosulfan-neem-seed-kernel extract where as rest of the treatments were at par with it.

Grain yield

The differences in grain yield were significant in all the years, maximum yield of 2 125 kg/ha was obtained from the

treatment with 3 spray application of nuclear polyhedrosis virus-nuclear polyhedrosis virus-endosulfan during 1993-94, however, the highest yield of 2 270 kg/ha and 2 522 kg/ha was received from the treatment with neem-seed-kernel extract endosulfan during 1994-95 and 1995-96 seasons, respectively.

Pooled mean data on yield revealed that except 2 spray application of insecticides all the 3 spray application treatments were significantly superior to the control. The maximum yield of 2 206 kg/ha was recorded from the treatment with 3 spray application of neem-seed-kernel extract-neem-seed-kernel extract-endosulfan which was significantly superior than the treatments with all 2 spray application and 3 spray application of neem-seed-kernel extract whereas rest of the treatments with 3 spray application was at par with it.

Economics and returns/Re investment

Analysis of cost : benefit ratio revealed that maximum return of Rs 4.28 per rupee investment was obtained from the treatment with 3 spray application of neem-seed-kernel extract-neem-seed-kernel extract-endosulfan followed by Rs

2.65 from the treatment with neem-seed-kernel extract-nuclear polyhedrosis virus-endosulfan and Rs 2.57 from the treatment with 3 sprays of endosulfan. Obviously the returns obtained from the treatment with nuclear polyhedrosis virus-nuclear polyhedrosis virus-endosulfan which was most effective in reducing pod damage was comparatively less (Rs 2.19) due to its high price, however, due to increased realization of the limitations of conventional insecticides it is necessary to include neem-seed-kernel extract and nuclear polyhedrosis virus in integrated management of pod borer infesting gram.

Sachan (1992) recommended endosulfan 350 g ai/ha or fenvalerate or cypermethrin @ 50 g ai/ha and nuclear polyhedrosis virus @ 250 larval equivalents/ha along with adjuvants like teepol, tinopal and jaggery in combination with half dose of insecticide or followed by endosulfan 0.07% for controlling *H. armigera* on gram.

It was concluded that for controlling *H. armigera* on gram first 2 sprays either with nuclear polyhedrosis virus 250 larval equivalents or neem-seed-kernel extract 5% followed by

third spray of endosulfan 0.07% were quite effective and economical.

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Efficacy of imidacloprid, a new insecticide for controlling *Myzus nicotianae* on flue cured virginia tobacco (*Nicotiana tabacum*)

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ABSTRACT

A field experiment was conducted during 1991–94 to evaluate the performance of a new insecticide imidacloprid and other insecticides for controlling tobacco aphid (*Myzus nicotianae* Blackman) on flue cured virginia tobacco (*Nicotiana tabacum* L.). Both the formulations of imidacloprid (70 water soluble powder) and 200 soluble concentrates/litre at 50 g ai or acephate 750 g ai/ha as 2 foliar sprays or combination of imidacloprid 70 water soluble powder at 100 g ai/ha as plant hole treatment + 1 foliar spray of imidacloprid 200 soluble concentrates/litre at 50 g ai/ha effectively controlled the aphids throughout the season and recorded better yield of cured leaf, bright-leaf and grade index. Oxydemeton methyl 0.05% foliar spray controlled the aphid effectively only up to 8 days after spray.

Key words : flue cured virginia tobacco, *Nicotiana tabacum*, aphid, *Myzus nicotianae*, insecticides, imidacloprid

The flue cured virginia tobacco (*Nicotiana tabacum* L.) is infested by several insect pests, of which tobacco aphid (*Myzus nicotianae* Blackman) causes significant loss to tobacco directly by their feeding and honey dew deposition on which sooty mold grows and makes the leaves unfit for curing. It was reported that tobacco aphids cause an avoidable loss of green leaf, cured leaf and bright-leaf to an extent of 607 kg, 125 kg and 70.3 kg/ha, respectively (CTRI 1993). Sreedhar *et al.* (1993) reported its infestation to be as high as 80–100% in the unprotected fields in Andhra Pradesh in 1990–91. The extent of loss during this year was estimated as 430 kg of cured leaf/ha and the avoidable loss was Rs 10 991/ha. It was earlier reported that aphids on tobacco could be effectively controlled by spraying of oxydemeton methyl 0.025%, dimethoate 0.02% and phosphamidon 0.02% (Joshi and Rao 1971, CTRI 1979). Recently spraying of acephate 0.075% is recommended (CTRI 1989). Of late chemical control failures against tobacco aphid were reported when sprayed with recommended insecticides. Harlow and Lampert (1990) reported that red form of the tobacco aphid was more difficult to control. Acephate was reported to be ineffective year after year against tobacco aphid (NCARS 1990). Sreedhar *et al.* (1993) reported the ineffectiveness of dimethoate and phosphamidon against *Myzus nicotianae* in Andhra Pradesh. The registered insecticides that provide adequate control continued to decrease. Hence it became imperative to find out suitable and effective insecticide for control of the aphid. Imidacloprid, a new contact-cum-systemic insecticide was

tested in its 2 formulations 70 water soluble powder and 200 soluble concentrates/litre along with the recommended insecticides acephate and oxydemeton methyl and the results are presented. Imidacloprid belongs to the nitroguanidine group of active ingredients and acts as a stomach and contact insecticide. It acts by interfering with transmission of nerve impulse in insects. Like acetyl-choline, the naturally occurring signal substance, imidacloprid stimulates certain nerve cells by acting on a receptor protein in the nerve fibre membrane.

MATERIALS AND METHODS

The experiment was conducted under field condition at the institute farm during 1991–92, 1992–93 and 1993–94 season to assess the efficacy of 2 formulations of the new insecticide imidacloprid viz, imidacloprid 70 water soluble powder and imidacloprid 200 soluble concentrates/litre along with acephate, oxydemeton methyl and the botanical insecticide nicotine sulphate. The experiment was laid out in randomized block design with 3 replications using 'Hema' flue cured virginia tobacco (*Nicotiana tabacum* L.) with the following treatments: T₁, Imidacloprid 70 water soluble powder 100 g ai/ha plant hole treatment (treating the plant hole just before planting); T₂, Imidacloprid 70 water soluble powder 200 ai/ha plant hole treatment; T₃, Imidacloprid 70 water soluble powder 100 g ai/ha plant hole treatment + imidacloprid 200 soluble concentrates/litre @ 50 g ai/ha; T₄, imidacloprid 200 soluble concentrates/litre 50 g ai/ha foliar spray; T₅, imidacloprid 200 soluble concentrates/litre 100 g ai/ha foliar spray; T₆, imidacloprid 70 water soluble powder 50 g ai/ha foliar spray; T₇, imidacloprid 70 water soluble powder 100 g

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ai/ha foliar spray; T₈, nicotine sulphate 0.4% foliar spray; T₉, oxydemeton methyl 25 emulsifiable concentrate 0.05% foliar spray; T₁₀, acephate 75 soluble powder 750 g ai foliar spray and T₁₁, control.

The plot size was gross 5.6 m x 4.8 m and net 4.0 m x 3.6 m. To maintain optimum level of aphid infestation, 5 plants/plot were inoculated with 100 aphids on each plant coinciding with the appearance of aphids naturally in the field.

Observations on the aphid population were made on 5 plants randomly selected from each plot and the method of Sreedhar *et al.* (1993) was followed. Observations on aphid population were recorded before each spraying. During 1991–92 season observations were recorded 2, 4 and 15 days after first spray; and 2 and 10 days after second spray, whereas during 1992–93 and 1993–94 season observation were recorded 2, 4, 8 and 15 days after both the spraying. Yield data on green leaf, cured leaf, bright-leaf and grade index were also collected. The data were subjected to analysis of variance.

RESULTS AND DISCUSSION

Aphid indices in different treatments during 1991–92 season indicated that aphid infestation was effectively controlled by plant hole treatment of imidacloprid 70 water soluble powder @ 100 g ai (T₁) and 200 g ai/ha (T₂) and also its combination treatment imidacloprid @ 100 g ai as plant hole

treatment + 1 foliar spray of imidacloprid 200 soluble concentrates/litre @ 50 g ai/ha (T₃) up to 42 days after planting (2 days after first spray). Foliar spray of imidacloprid water soluble powder and soluble concentrate/litre formulations (T₄, T₅, T₆, T₇) and acephate (T₁₀) were significantly more effective in controlling the tobacco aphid at 15-days after first spray and 10 days after second spray compared with the foliar spray of oxydemeton methyl (T₉) and nicotine sulphate (T₈). Among all the treatments nicotine sulphate 0.4% was least effective (Table 1).

Pooled analysis of the data of 1992–93 and 93–94 season showed that all the insecticides tested were significantly more effective than control up to 15 days after first spray and 2 days after second spray. The combination treatment of imidacloprid 70 water soluble powder as plant hole treatment @ 100 g ai + 1 foliar spray of imidacloprid 200 soluble concentrate/litre @ 50 g ai/ha (T₃), 2 foliar sprays of imidacloprid 70 water soluble powder (T₆, T₇) and 200 soluble concentrates/litre (T₄, T₅) formulation at both lower (50 g ai) and higher (100 g ai) doses, acephate 0.075% (T₁₀) and oxydemeton methyl 0.05% (T₉) at 15-days-interval were equally effective and superior to plant hole treatment of imidacloprid at 100 g and 200 g ai/ha (T₁, T₂) and 2 foliar sprays of nicotine sulphate 0.4% (T₈) in all the observations (Table 1). Though nicotine sulphate was significantly more effective than plant hole treatment of imidacloprid 70 water soluble powder at both lower and higher doses (T₁, T₂) up to

Table 1 Efficacy of imidacloprid and other insecticides for controlling tobacco aphid on flue cured virginia tobacco

Treatment	Means aphid population/plant											
	Days after*			Pre-spray	Days after first spray**				Days after second spray			
	I spray		II spray		2	4	8	15	2	4	8	15
	2	15	10									
T ₁	1.78 (2.18)	15.30 (241.20)	24.08 (579.11)	14.79 (234.27)	17.54 (309.19)	23.11 (533.03)	43.09 (1 884.70)	55.74 (3 119.30)	56.25 (3 210.47)	66.54 (4 426.07)	56.65 (3 294.60)	53.90 (3 079.44)
T ₂	1.00 (0)	9.52 (90.66)	14.80 (217.97)	16.75 (580.82)	17.58 (310.00)	23.32 (543.93)	38.20 (1 689.06)	57.04 (3 253.85)	58.79 (3 474.98)	65.18 (4 250.89)	52.88 (2 986.46)	50.35 (2 815.81)
T ₃	1.00 (0)	9.23 (85.18)	13.79 (189.08)	16.86 (291.33)	3.03 (8.21)	1.25 (0.61)	1.51 (1.26)	3.11 (13.58)	3.65 (19.34)	4.43 (30.32)	5.80 (55.56)	6.74 (77.27)
T ₄	4.68 (20.93)	12.72 (161.92)	7.18 (50.51)	18.78 (380.31)	2.13 (3.93)	1.00 (0)	1.24 (0.61)	3.40 (16.74)	1.25 (0.61)	1.76 (2.63)	1.00 (0.00)	2.72 (9.32)
T ₅	1.00 (0)	8.77 (76.93)	4.96 (23.58)	17.04 (296.55)	1.76 (2.63)	1.00 (0)	1.00 (0)	2.65 (9.21)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.64 (2.09)
T ₆	6.23 (37.79)	9.03 (81.48)	4.13 (16.03)	16.76 (285.09)	1.00 (0)	1.00 (0)	1.00 (0)	3.32 (12.88)	1.00 (0.00)	1.00 (0.00)	1.25 (0.60)	2.77 (9.77)
T ₇	6.10 (36.22)	8.19 (67.06)	2.27 (4.16)	20.28 (424.14)	2.13 (3.55)	1.00 (0)	1.40 (1.09)	2.75 (10.10)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	2.41 (6.77)
T ₈	24.93 (620.62)	45.24 (2 046.59)	59.56 (3 546.48)	18.26 (364.06)	17.70 (321.19)	21.23 (461.19)	36.20 (1 337.28)	51.17 (2 687.57)	24.10 (588.19)	33.11 (1 108.64)	43.10 (2 141.84)	52.82 (2 993.45)
T ₉	5.39 (28.04)	21.45 (460.80)	15.66 (244.29)	18.14 (334.32)	2.13 (3.55)	1.25 (0.61)	2.65 (6.16)	7.12 (62.88)	1.74 (2.55)	1.85 (3.15)	4.20 (26.79)	9.29 (153.79)
T ₁₀	1.00 (0)	8.30 (68.98)	5.16 (25.68)	18.70 (351.72)	2.64 (6.36)	1.25 (0.61)	1.40 (1.09)	5.00 (26.37)	1.00 (0.00)	1.00 (0.00)	1.25 (0.61)	3.69 (19.77)
T ₁₁	37.31 (1 391.20)	54.40 (2 931.17)	63.25 (3 999.29)	22.32 (501.79)	30.41 (931.18)	41.43 (1 175.48)	56.78 (3 224.78)	64.22 (4 124.96)	64.69 (4 184.25)	66.73 (4 451.36)	59.15 (3 560.48)	51.20 (2 872.91)
SEm ±	0.96	2.57	1.85	0.99	0.80	1.41	1.18	1.09	1.24	0.77	1.22	0.70
CD (P = 0.05)	2.84	7.59	5.45	2.74	2.21	3.91	3.28	3.03	3.45	2.14	3.37	1.95

Details of treatments are given under Materials and Methods

Figures in parentheses are retransformed means; *1991–92; **1992–94

Table 2 Yield and quality of flue cured virginia tobacco treated with various insecticides for aphid control (pooled data of 3 season)

Treatment	Green leaf (kg/ha)	Cured leaf (kg/ha)	Bright leaf (kg/ha)	Grade index
T ₁	9 530	1 464	606	1 030
T ₂	10 430	1 536	607	1 091
T ₃	10 182	1 582	679	1 153
T ₄	8 854	1 399	610	1 059
T ₅	8 869	1 447	640	1 085
T ₆	9 306	1 427	612	1 043
T ₇	9 321	1 422	639	1 130
T ₈	8 526	1 279	507	902
T ₉	8 821	1 458	622	1 068
T ₁₀	9 492	1 491	643	1 097
T ₁₁	7 747	1 165	431	812
SEm ±	268	42	30	33
CD (P=0.05)	742	115	83	91

15 days after first spray and 8 days after second spray build up of aphid infestation was observed in nicotine sulphate treated plots from 4 days after each spray. The plant hole treatment of imidacloprid + foliar spray of imidacloprid 200 soluble concentrates/litre (T₃) was equally effective as 2 foliar sprays of both the formulations of imidacloprid (T₄, T₅, T₆ and T₇), acephate (T₁₀) and oxydemeton methyl (T₉) up to 2 days after second spray while at 4, 8 and 15 days after second spray it was inferior to all these treatment except oxydemeton methyl. Oxydemeton methyl was equally effective as combination treatment (imidacloprid 70 water soluble powder 100 g ai plant hole treatment + imidacloprid 200 soluble concentrates/litre 50 g ai foliar spray) at 8 days after second spray while it was inferior at 15 days after second spray (Table 1).

Pooled analysis of the yield data of 3 seasons revealed that all the insecticidal treatments except nicotine sulphate (T₈) recorded significantly higher yield of cured leaf, bright-leaf and grade index compared with the control (Table 2). For green leaf all the treatments were superior to control. Among different treatments imidacloprid plant hole treatment at higher dose (T₂) and the combination treatment of imidacloprid plant hole treatment + foliar spray (T₃) recorded superior yields over all the foliar spray treatments (T₄ to T₁₀). The combination treatment (T₃) recorded maximum cured leaf yield and while not differing from higher dose of imidacloprid plant hole treatment (T₂) it recorded significantly superior yields over all other treatments which were on par with each other. The combination treatment (T₃) recorded maximum bright leaf yield and grade index but it remained at par with all other treatments with respect to bright-leaf yield. Whereas for grade index it remained at par with higher dose of imidacloprid plant hole treatment (T₂), foliar sprays of both the formulations of imidacloprid at higher doses (T₅, T₆), oxydemeton methyl (T₉) and acephate (T₁₀). However no significant differences were observed between lower and

higher doses of imidacloprid plant hole treatment as well as imidacloprid foliar sprays.

Efficacy of different insecticides in controlling the tobacco aphid *Myzus nicotianae* and their effect on yields in 3 seasons indicated that tobacco aphid can be effectively controlled throughout the season by 2 foliar sprays of both 70 water soluble powder and 200 soluble concentrates/litre formulations of imidacloprid @ 50 and 100 g ai/ha or acephate 0.075% or combination treatment of imidacloprid 70 water soluble powder @ 100 g ai/ha as plant hole treatment + 1 foliar spray of imidacloprid 200 soluble concentrates/litre @ 50 g ai/ha, while oxydemeton methyl 0.05% foliar spray effectively controlled the aphids only up to 8 days after spray. Effectiveness of acephate, oxydemeton methyl and least effectiveness of nicotine sulphate is in accordance with the findings of Cheng and Hanlon (1988), Semtner *et al.* (1990) and Sreedhar *et al.* (1993). It was concluded that tobacco aphid *M. nicotianae* can be effectively controlled on flue cured virginia tobacco in black soils throughout the season by 2 foliar sprays of imidacloprid (70 water soluble powder and 200 soluble concentrates/litre) @ 50 g ai or acephate 750 g ai/ha or combination treatment of imidacloprid 70 water soluble concentrate @ 100 g ai/ha as plant hole treatment + foliar spray of imidacloprid 200 soluble concentrates/litre @ 50 g ai/ha.

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Field efficacy of botanical extracts for controlling major insect pests of Okra (*Abelmoschus esculentus*)

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ABSTRACT

A field experiment was conducted during 1994 to evaluate efficacy of 3 plant extracts viz, sacred basil (*Ocimum sanctum* L.), Malabar nut (*Adhatoda vesica* Nees), Chinese chaste tree (*Vitex negundo* L.) and synthetic insecticides, viz endosulfan and carbaryl, and their combination products in controlling okra jassids, *Amrasca biguttula biguttula* (Ishida) and fruit-borers, *Earias* spp during rainy season (*kharij*) 1994 by spraying them at 10, 25 and 40 days after sowing. All the treatments suppressed both the jassids population and fruit borer incidence.

Key words : okra, botanicals, pest management

Okra [*Abelmoschus esculentus* (L.) Moench] is an important vegetable crop grown all over India. It hosts jassids *Amrasca biguttula biguttula* (Ishida) and fruit-borers *Earias* spp during the growth period. A number of synthetic insecticides are used for controlling of leaf hopper, *Amrasca biguttula biguttula* (Ishida) and fruit-borer *Earias* spp. (Krishnakumar and Srinivasan 1987). Synthetic chemicals cause side effect on the ecosystem. Recent advances in agricultural research are directed towards development of growth regulators, anti-feedants, repellants and phago-deterrant of natural origin which are less toxic besides being easily biodegradable in nature (Rajasekaran and Kumraswamy 1985).

Sacred basil (*Ocimum sanctum* L.) planted around the house to repel the mosquitoes and other insects has an essential oil which is a potent insecticide and fungicide. Malabar nut (*Adhatoda vesica* Nees) which is another common indigenous plant used as manure and pesticide. *Adhatoda vesica* leaves were also found effective against *sitotraga cerealella* at 2% concentration for 6 months (Chellappa and Chelliah 1976). Tamil Nadu farmers use chinese chaste tree (*Vitex negundo* L.) leaves for protection of stored rice (Ahmed and Keppel 1987). Therefore an attempt was made to study the efficacy of *Ocimum sanctum*, *Adhatoda vesica*, *Vitex negundo* for controlling okra jassids, *Amrasca biguttula biguttula* and fruit-borers *Earias* spp.

MATERIALS AND METHODS

The experiment was conducted during (*kharij*) rainy season 1994 in the horticultural farm of the college at Karaikal.

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Leaves of sacred basil, chinese chaste tree and malabar nut were collected and 50 g each of them were ground into a paste and dissolved in water seperately to get 5% spray solution. Plant extracts having 2.5% concentration were also prepared seperately and they were mixed with endosulfan and carbaryl and following treatments were evaluated.

The treatments were T₁, sacred basil 5%; T₂, malabar nut 5%; T₃, chinese chaste tree 5%; T₄, carbaryl 0.1%; T₅, endosulfan 0.07%; T₆, sacred basil 2.5% + carbaryl 0.05%; T₇, sacred basil 2.5% + endosulfan 0.035%; T₈, malabar nut 2.5% + carbaryl 0.05%; T₉, malabar nut 2.5% + endosulfan 0.035%; T₁₀, chinese chaste tree 2.5% + carbaryl 0.05%; T₁₁, chinese chaste tree 2.5% + endosulfan 0.035% and T₁₂, the control (water spray).

The trial was laid out in a randomised block design in plots 4 m x 5 m. Each treatment was replicated thrice. First spray was done 10 days, second at 25 days and third at 40 days after sowing.

Number of leaf hoppers, *Amrasca biguttula biguttula* (Ishida) was counted before each spray and also at 24, 48, 72 hr and 7 days after treatment. Five plants were selected at random in each plot and number of nymphs and adults were counted from 2 leaves on top, 2 leaves on bottom and 2 leaves at middle.

The collected data were pooled and mean population were worked out seperately for 10, 13, 25, 40 and 43 days after sowing. The efficacy of the plant extracts has been worked out by comparing it with the untreated control plot.

For the assessment of fruit-borer *Earias* Spp incidence, fruits were harvested from 10 plants at random from each plot at regular intervals and seperated the borer damaged fruits. The percentage of total healthy fruits was worked out and

compared with the control. The fruits were harvested on alternate days and has been grouped into a total of 3 harvests. The efficacy of treatments was also worked out up to 60 days after sowing.

RESULTS AND DISCUSSIONS

Efficacy of botanicals against Okra jassid

Population of jassids on the 10th day after sowing was the pre-treatment count. On the 13th day ie 3 days after treatment suppression of jassids population was observed in all the treatments (Table 1). The treatment T₄, carbaryl 0.1% was found to be most effective than the treatments T₅, endosulfan 0.07% and T₆, sacred basil 2.5% + carbaryl 0.05%, though these treatments were found to be on par with each other. The combination treatments, viz sacred basil 2.5% + endosulfan 0.035%; T₈, malabar nut 2.5% + carbaryl 0.05%; T₉, malabar nut 2.5% + endosulfan 0.035%; T₁₁, chinese chaste tree 2.5% + endosulfan and T₁, sacred basil 5% were also found to be on par with carbaryl 0.01%. The treatments T₂, malabar nut 5% and T₃, chinese chaste tree 5% were also found to be significantly superior than the control.

Population counts made on the 25th day after sowing shown the efficacy of the treatment 15 days after treatment. Among the treatments, the treatment T₅, endosulfan 0.07% suppressed the jassid population were effectively, but on par with the treatments T₄ carbaryl 0.1%, T₆ sacred basil 2.5% + carbaryl 0.05%, T₇ sacred basil 2.5% + endosulfan 0.035%, T₈ malabar nut 2.5% + carbaryl 0.05%, T₉ malabar nut 2.5% + endosulfan 0.035%, T₁₀ chinese chaste tree 2.5% + carbaryl 0.05%, T₁₁ chinese chaste tree 2.5% + endosulfan 0.035%.

On the 40th day count, all the treatments were found on par with each other and significantly superior to the untreated control. The non-significant difference among the treatments

Table 1 Population of Jassids (*Amrasca biguttula biguttula*) under different management programmes in okra

Treatment	Population of Jassids/3 plants on day*				
	10	13	25	40	43
T ₁	33.6 ^b	31.8 ^{bcd}	32.4 ^{bc}	29.3 ^b	25.2 ^{bc}
T ₂	35.6 ^b	34.2 ^{bc}	36.4 ^b	30.6 ^b	26.7 ^b
T ₃	39.9 ^{ab}	36.1 ^b	30.4 ^{bcd}	29.2 ^b	22.3 ^{bc}
T ₄	43.2 ^a	26.2 ^d	26.8 ^{cd}	25.6 ^b	18.7 ^c
T ₅	41.0 ^b	26.3 ^d	24.2 ^d	25.9 ^b	18.3 ^c
T ₆	33.7 ^b	26.5 ^d	27.2 ^{cd}	27.4 ^b	20.3 ^{bc}
T ₇	36.2 ^{ab}	28.1 ^{cd}	29.6 ^{bcd}	27.8 ^b	20.6 ^{bc}
T ₈	39.3 ^{ab}	29.4 ^{bcd}	29.9 ^{bcd}	28.4 ^b	20.7 ^{bc}
T ₉	33.7 ^b	32.8 ^{bcd}	30.4 ^{bcd}	28.9 ^b	20.6 ^{bc}
T ₁₀	39.2 ^{ab}	32.9 ^{bcd}	30.4 ^{bcd}	28.5 ^b	21.3 ^{bc}
T ₁₁	38.1 ^{ab}	31.3 ^{bcd}	27.3 ^{cd}	29.0 ^b	21.1 ^{bc}
T ₁₂	34.7 ^b	72.9 ^a	80.7 ^a	90.6 ^a	97.2 ^a

*Mean of 3 replication

Details of treatments are given under Materials and Methods

In a column mean followed by a common letter are not significantly different at 5% level by Duncan's multiple range test

may be due to less persistence nature of the treatments due to easy biodegradable nature. On the 43rd day, ie 3 days after treatment. Significant difference in the suppression of jassid population was observed in all the treatments when compared to the control. The plots treated with endosulfan 0.07% was found to have less jassid population followed by carbaryl 0.1% treated plot and the treatments were on par with each other. The other treatments, viz sacred basil 2.5% + carbaryl 0.05%, T₁ sacred basil 2.5% + endosulfan 0.035%, T₉ malabar nut 2.5% + endosulfan 0.035%, T₈ malabar nut 2.5% + carbaryl 0.05%, T₁₁ chinese chaste tree 2.5% + endosulfan 0.035%, T₁₀ chinese chaste tree 2.5% + carbaryl 0.05%, T₃ Chinese Chaste tree 5% and sacred basil 5% were also found to be on par with the insecticides alone treated plots.

Okra borer incidence against plant extract spray

The fruit borer incidence was grouped into 3 harvest and analysed statistically for the percentage of borer infestation on the 30th (I harvest), 45th (II harvest) and 60 (III harvest) day after sowing (Table 2).

On the first harvest group, the fruit-borers incidence was very low in the treatment T₁₁, chinese chaste tree 2.5% +

Table 2 Borer incidence (%) under different management programme

Treatment	Harvest			Pooled borer incidence
	I	II	III	
T ₁	53.6 ^b (47.1)	69.0 ^b (56.2)	61.0 ^b (51.4)	61.2 ^b (51.5)
T ₂	25.8 ^c (30.5)	73.2 ^b (59.0)	38.4 ^c (38.3)	45.5 ^c (42.6)
T ₃	45.4 ^c (42.4)	19.3 ^f (26.1)	17.8 ^{de} (24.9)	27.5 ^d (31.1)
T ₄	17.0 ^f (24.3)	10.3 ^g (18.7)	20.7 ^{de} (27.1)	16.0 ^{ef} (23.4)
T ₅	14.0 ^f (22.0)	3.5 ^h (10.8)	14.9 ^a (22.7)	10.8 ^f (18.5)
T ₆	35.7 ^d (36.7)	12.4 ^g (20.6)	23.0 ^d (28.6)	23.7 ^{de} (28.6)
T ₇	15.4 ^f (23.1)	25.1 ^e (30.0)	39.0 ^c (38.6)	26.5 ^d (30.6)
T ₈	17.9 ^f (24.9)	44.6 ^e (41.9)	22.4 ^d (28.2)	28.3 ^d (31.7)
T ₉	49.7 ^{bc} (44.8)	2.4 ^h (8.9)	7.6 ^f (16.0)	19.9 ^{ef} (23.2)
T ₁₀	32.6 ^d (34.8)	37.9 ^{cd} (38.0)	3.6 ^g (10.9)	24.7 ^{de} (27.9)
T ₁₁	3.7 ^g (11.1)	37.2 ^d (37.6)	6.1 ^{fg} (14.3)	15.7 ^f (21.0)
T ₁₂	65.4 ^a (54.0)	79.0 ^a (63.0)	74.9 ^a (60.2)	73.1 ^a (59.1)

*Mean of 3 replications

In a column mean followed by a common letter are not significantly different at 5% level by Duncan's multiple range test

Figures within parentheses are $\sqrt{\text{arc-sin}}$ transformed values

endosulfan 0.035% and superior than the rest of the treatments. The treatments sacred basil 2.5% + endosulfan 0.035%, T₄ carbaryl 0.1%, T₈ malabar nut 2.5% + carbaryl 0.05% were on par with each other statistically and following the treatment T₁₁. The treatment T₂, malabar nut 5% was followed by T₁₀, chinese chaste tree 2.5% + carbaryl 0.05%; T₆, sacred basil 2.5% + carbaryl 0.05%; T₃ chinese chaste tree 5%, T₉ malabar nut 2.5% + endosulfan 0.035% and T₁ sacred basil 5%. All the treatments were significantly superior than the untreated control.

On the second harvest group less fruit-borers damage was recorded in T₃, *adhathoda* 2.5% + endosulfan 0.035% followed by T₅, endosulfan 0.07 which were on par with each other. The treatment T₄, carbaryl 0.1% was followed by T₆, sacred basil 2.5% + carbaryl 0.05% and they were on par with each other. The treatment T₃ + chinese chaste tree 5% was followed by T₇, sacred basil 2.5% + endosulfan 0.035% followed by T₁₀, chinese chaste tree 2.5% + carbaryl 0.05% T₈, malabar nut 2.5% + carbaryl 0.05%, T₁, sacred basil 5%, T₂, malabar nut 5%. All the treatments were significantly superior than the untreated control.

On the third harvest group, T₁₀ chinese chaste tree 2.5% + carbaryl 0.05% was found to be the least among the treatments. However, the treatment T₁₁, chinese chaste tree 2.5% + endosulfan 0.035% was found to be par with the treatment T₁₀ and also with the treatment T₉, malabar nut 2.5% + endosulfan 0.035% followed by T₅ endosulfan 0.07% and T₃, chinese chaste tree 5%, T₄ carbaryl 0.1%, T₈ malabar nut 2.5% + carbaryl 0.05%, T₆ sacred basil 2.5% + carbaryl 0.05%, T₂ malabar nut 5%, T₇ sacred basil 2.5% + endosulfan 0.035% and T₁ sacred basil 5%. In this group also, all the treatments were significantly superior than the untreated control.

Since no common trend was not observed all these 3 harvest groups, the borer incidence for all the 3 harvest were pooled and analysed statistically. The fruit-borer damage was minimum in the treatment T₃, endosulfan 0.07% followed by T₁₀, chinese chaste tree 2.5 + carbaryl 0.05%, T₄ carbaryl 0.1%, T₈ malabar nut 2.5% + carbaryl 0.05%. All these treatments were on par with each other. The treatments T₆ sacred basil 2.5% + carbaryl 0.05%, T₃ chinese chaste tree 5%, T₈ malabar nut 2.5% + carbaryl 0.05% were on par with each other followed by T₂ malabar nut 5% and T₁ sacred basil 5%. All the treatments were significantly superior than the control.

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Moisture-use pattern of a groundnut (*Arachis hypogaea*)-based intercropping system in semi-arid environment*

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Key words : groundnut, intercropping irrigation, *Arachis hypogaea*, moisture-use

Intercropping or mixed cropping is viewed to realize maximum production under input adequacy (Singh and Singh 1985). A complexity of factors determine the viability of an intercrop system. These include type of component crops, their productivity, monetary returns, climatic conditions, soil-moisture availability and compatibility of component crops. Though research on resource utilization in intercrops is in vogue, underground resource utilization studies are few (Reddy and Reddy 1993). The present study aims at studying the crop compatibility and water-use pattern in groundnut (*Arachis hypogaea* L.) based intercropping systems.

A field trial was conducted during (winter season) 1991–93 at the college farm, Rajendranagar on a loamy-soil. The top 60 cm soil on weight basis had field capacity 17.11%, permanent wilting point 7.07% with bulk density 1.60 g/cc. The soil also had pH 7.6, electrical conductivity 0.28 dS/m, organic carbon 0.44% with 215.0, 20.8 and 305.1 kg/ha of available N, P and K, respectively. The experiment was laid out in split-plot design with 3 irrigation regimes (IW : CPE ratio of 0.8, 1.0 and 1.2) as main plots and 7 cropping systems, viz C₁, sole groundnut; C₂, sole sunflower (*Helianthus annuus*); C₃, sole indian mustard [*Brassica juncea* (L.) Czernj & Cosson]; C₄, sole pigeonpea [*Cajanus cajan* (L.) Millsp.]; C₅, groundnut + sunflower; C₆, groundnut + indian mustard; C₇, groundnut + pigeonpea as subplots and the treatments were replicated 4 times. The component crops were sown at 50% of sole crop population in 3 : 1 row arrangement. The groundnut in sole and intercrop systems was given 20 : 40 : 50 kg NPK/ha. The other component crops in the intercrop system were given 50% of their respective recommended fertilizer doses by placement along the rows. Two common irrigation (50 mm each) were given for crop establishment. Irrigation depth (50 mm) was measured with the help of parshall flume and the rainfall, if any, between 2 irrigations was considered for determining subsequent irrigation date.

* Short note

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The data on evaporation was obtained from USWB open pan evapometer from the nearby agromet observatory.

Soil-moisture depletion in 0–20, 20–40 and 40–60 cm layers was determined thermo-gravimetrically before and after each irrigation. Actual evapo-transpiration (ET) was estimated from the water balance equation :

$$P + I = R + D + ET + M$$

where P, precipitation; I, irrigation; R, run off; D, deep percolation losses; ET, time rate of evapo-transpiration; and M, change in soil-water storage (all the components are in mm). The crop water-use efficiency was computed after converting winter crop yields into groundnut pod equivalent as a ratio of pod yields to seasonal evapo-transpiration (ET).

Seasonal crop evapo-transpiration increased with an increase in irrigation levels (Table 1). The seasonal ET for IW : CPE ratio of 0.8, 1.0 and 1.2 as a mean of 2 years were 31.2, 38.2 and 41.3 cm, respectively. The increase in seasonal crop ET with increase in irrigation frequency in all cropping systems attributes to higher evaporational losses due to increased availability in the crop root zone. The rate of evapo-transpiration (mm/day) also increased with the irrigation levels. The mean evapo-transpiration rates of IW : CPE ratios of 0.8, 1.0 and 1.2 were 2.7, 3.3 and 3.6 mm/day, respectively. However, the crop water-use efficiency decreased with increased irrigation levels in both the years. The water-use efficiency as a mean of 2 years decreased from 6.8 in I₁, to 6.58 in I₂ and further to 5.86 in I₃. As water-use efficiency is a ratio of yield to evapo-transpiration, the higher water-use efficiency in lower irrigation frequency was due to lesser reduction in yield than due to higher water received which ultimately varied the water-use efficiency.

The irrigation regimes had a marked effect on the moisture use pattern. The per cent extraction decreased with increase in soil depth (Table 1). The mean depletion from 0–20, 20–40 and 40–60 cm soil layers were 45.5, 33.1 and 21.4%, respectively. The contribution from the top (0–20 cm) layer increased with increase in irrigation frequency. This could be due to more soil evaporation from frequent wetting. During the first stage of soil evaporation, the rate of

Table 1 Influence of irrigation and cropping system on groundnut pod equivalent, seasonal evapo-transpiration (ET), evapo-transpiration rate, crop water-use efficiency and soil-moisture extraction (% of total)

Treatment	Groundnut-pod equivalent (kg/ha)		Seasonal ET (cm)		Crop water-use efficiency (kg/ha-mm)		Evapo-transpiration rate (mm/day)		Soil-moisture extraction (% of the total) depth of soil (cm)		
	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93	0-20	20-40	40-60
<i>Irrigation</i>											
I ₁	1 985	2 254	34.29	31.08	6.36	7.24	2.7	2.6	43.1	32.3	24.6
I ₂	2 373	2 645	38.32	38.04	6.19	6.96	3.3	3.2	45.9	33.1	21.0
I ₃	2 303	2 578	41.51	41.0	5.49	6.22	3.6	3.4	47.5	34.0	18.5
SEm +	54	34			0.17	0.20					
CD (P=0.05)	187	199			0.57	0.69					
<i>Cropping system</i>											
C ₁	2 459	2 646	37.14	36.23	6.59	7.26	2.9	2.8	46.5	32.8	20.7
C ₂	1 798	1 989	31.43	31.22	5.71	6.36	3.3	3.2	49.7	30.2	20.1
C ₃	1 923	2 235	31.09	30.33	6.27	7.51	3.3	3.1	44.2	33.1	22.7
C ₄	1 056	1 288	36.92	36.55	2.96	3.64	2.9	2.8	45.1	31.7	23.2
C ₅	2 946	3 237	40.64	40.34	7.21	7.99	3.2	3.1	44.0	35.1	20.9
C ₆	3 013	3 360	40.36	40.62	7.60	8.37	3.2	3.2	44.4	35.0	20.6
C ₇	2 349	2 693	41.79	41.58	5.64	6.53	3.3	3.2	44.3	35.2	20.5
SEm +	90	96			0.62	0.58					
CD (P=0.05)	255	273			1.76	1.65					

I₁, IW : CPE = 0.8; I₂, IW : CPE = 1.0, I₃, IW : CPE = 1.2

C₁, Sole groundnut; C₂, sole sunflower; C₃, sole indian mustard, C₄, sole pigeonpea; C₅, groundnut + sunflower; C₆, groundnut + indian mustard; C₇, groundnut pigeonpea

evaporation is controlled by heat energy input and is about 90% potential evapo-transpiration (Jensen *et al.* 1990).

Thus, immediately after wetting, the evaporation from a wet bare soil is approximately same as that from a free water surface and the amount of water retained in the top 10 cm soil layers influence the rate of evaporation (Reddy 1993). Since frequent irrigation contributed more moisture to the surface layer, the extraction pattern also showed accordingly.

The seasonal evapo-transpiration values were high in intercropping systems (Table 1) compared to the sole crops. This might be due to better root penetration and proliferation of crops of different growth habit, extracting moisture simultaneously from different layers. The greater coverage of inter space with leaf canopy in intercropping system with plant density of 150% accounted for greater transpiration losses than sole crops. Pigeonpea being a long duration crop consumed more water on a season basis and prompted for high seasonal evapo-transpiration when intercropped with groundnut. Seasonal evapo-transpiration values were appreciably low for sole sunflower and mustard crops presumably due to their short growing season. Among sole crops, sunflower registered high rate of evapo-transpiration (3.3 mm/day). Among the intercropping systems though the differences were not appreciable, groundnut + pigeonpea recorded high ET rate (3.3 mm/day).

Water-use efficiency as a mean of 2 years, was found to be highest (7.99 kg/ha mm) with groundnut + mustard intercropping system. This intercrop system was closely followed by groundnut + sunflower. The least water-use effi-

ciency (6.09) among intercrops was recorded with the groundnut + pigeonpea which could be due to the poor water-use efficiency by the component crop of pigeonpea. The water-use efficiency of sole sunflower was on par with that of groundnut + pigeonpea intercrop. Among sole crops, highest water-use efficiency was observed with groundnut and least with pigeonpea.

The extraction pattern of soil-moisture among different cropping systems differed widely in both the years. Sole sunflower extracted more moisture (49.7%) from the top layer compared with all the other cropping systems. The moisture extraction in the 20-40 cm soil layer was more (35.10%) as a mean of all intercrop combinations compared to the mean of all sole crops (31.95%) because of greater root proliferation in the soil layer. Sole crops of pigeonpea (23.2%) and mustard (22.75) extracted more moisture from deeper layer (40-60 cm) because of deep root system; while the extraction from the same layer was 20.1, 20.7 and 20.7% for sole crops of sunflower and groundnut and mean of all intercropping systems, respectively.

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Response of potato (*Solanum tuberosum*) to irrigation and nitrogen in Lahaul Valley of Himachal Pradesh*

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Key words : potato, *Solanum tuberosum*, irrigation, nitrogen, Lahaul Valley

Lahaul Valley comes under dry temperate zone of Himachal Pradesh and receives annual rainfall of less than 300 mm. Potato (*Solanum tuberosum* L.) produced here is of better quality due to disease-free environment and used as seed potato throughout India. Water and nitrogen are the major inputs which play a vital role in its production. An attempt was made to find out the effect of these 2 variables on potato yield and nutrient uptake in the valley.

The experiment was laid out in factorial randomized block design with 3 replications during summer 1993 at Kukumseri (30° 40' 77" and 32° 69' 57" N and 76° 46' 34" and 78° 41' 34" E, 2 462 m above mean sea-level). The soil was sandy loam in texture and neutral in soil reaction with 0.84% of organic carbon. The available N P K contents were 365, 35 and 315 kg/ha, respectively. The treatment combination consisted of 4 levels of irrigation, viz 4-day intervals (M₁), 8-days intervals (M₂), 12-day intervals (M₃) and 16-day intervals (M₄); and 4 levels of nitrogen, viz 75, 100, 125 and 150 kg N/ha; along with recommended levels of phosphorus (44 kg P/kg) and potassium (41 kg K/ha). 'Kufri Chandramukhi' potato was planted on the ridges at 0.45 m x 0.15 m spacing on 26 May and harvested on 22 September 1993.

* Short note

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Tuber and haulm yield varied significantly among different irrigation and nitrogen levels. Tuber yield increased with increase in irrigation and nitrogen levels (Table 1). Akin to irrigation, the N application followed similar trend. The treatment combination of M₄ and 150 kg N/ha resulted in the maximum yield (Table 1), and M₂ with 75 kg N/kg gave minimum yield. Irrigation increased average tuber yield and reduced the adverse effect of N application in causing nitrate accumulation in tubers (Zbiec *et al.* 1989).

The N, P and K uptake by tubers and haulms differed significantly among different irrigation and nitrogen levels. The interaction effect of irrigation and N were also significant in respect of the uptake by tubers and haulms. Total uptake of N, P and K by tuber and haulms were maximum in treatment combination M₁ and 150 kg N/ha and minimum in M₄ and 75 kg N/ha. The respective maximum uptake of N, P and K were 81.82, 11.34 and 70.91 kg/ha by tubers and 77.65, 8.87 and 67.77 kg/ha by haulms; the minimum being 42.16, 6.62 and 45.99 kg/ha by tubers and 30.35, 4.86 and 39.33 kg/ha by haulms. This was due to probable better moisture combination during the plant growth which promoted the translocation of available and applied nutrient from soil, which in turn were better utilized by plant in the presence of sufficient moisture and ultimate increased nutrient uptake. The finding confirms those of Roy and Tripathi (1986).

Table 1 Effect of irrigation and nitrogen levels on tuber and haulms yield of potato

Irrigation level	N (kg/ha)									
	75	100	125	150	Mean	75	100	125	150	Mean
	<i>Tuber yield (Mg/ha)</i>					<i>Haulm yield (Mg/ha)</i>				
M ₁	30.06	32.89	35.57	38.96	34.37	29.45	31.45	33.44	40.34	33.60
M ₂	28.89	31.18	33.90	36.20	32.54	29.60	30.00	33.14	36.80	32.40
M ₃	27.22	28.29	30.96	33.40	29.97	26.29	28.34	30.01	38.29	30.90
M ₄	25.55	27.04	29.51	31.75	28.46	24.20	26.34	29.73	36.71	29.90
Mean	27.83	29.85	32.48	35.08		27.43	28.17	31.78		37.88
CD (P = 0.05)		M	N		M x N	M		N		M x N
		2.37	2.37		NS	2.88		2.88		7.42

Details of irrigation levels are given in text

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Heterosis for vitamin C in tomato (*Lycopersicon esculentum*)*

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Key words : heterosis, vitamin, tomato, hybrid vigour, *lycopersicon esculentum*, ascorbic acid

Hybrid vigour in tomato [*Lycopersicon esculentum* (L.) Mill.] was first observed by Hedrick and Booth (1908). Since then a number of workers have reported heterosis in tomato for quantitative characters (Singh and Swarup 1971 and Singh *et al.* 1978). However, scanty information is available on qualitative traits at mid-hill conditions of Uttarakhand. Since ascorbic acid is an important qualitative character in tomato, hence the present study deals to assess the extent of heterosis for this trait.

Experiment was carried out with 12 genetically diverse cultivars, viz 'Punjab Chhuhara', 'Punjab Kesari', 'Marglobe', 'EL 13', 'Sweet 72', 'T 1', 'Co 3', 'Pant Bahar', 'Arka Saurabh', 'Shakti', 'NDT 5' and 'Azad Kranti' along with their 66 F₁ hybrids in a randomized block design with 3 replications at the defence agricultural research laboratory, Pithoragarh, during 1995–96. For ascorbic acid determination, red riped fruits were randomly selected from 5 plants and a composite sample was made. The ripen fruits were extracted with metaphosphoric acid. Randomly selected fruits in each replication were utilized for the estimation of ascorbic acid by 2, 6 dichlorophenol indophenol titration method (AOAC 1970). Heterosis was calculated as per formula of Allard (1960).

Range, mean values and heterosis percentage for ascorbic acid indicated that the parents varied widely in ascorbic acid content ranging from 13.52 ('Arka Saurabh') to 28.41 ('Pant Bahar') with mean values of 19.91 mg/100 g. Ascorbic acid content in F₁s varied from 10.76 ('Arka Saurabh' x 'Azad Kranti') to 38.17 ('Marglobe' x 'Shakti') with mean of 22.91 mg/100 g. Among the 66 cross combinations, 38 hybrids (57.58%) had significantly higher amount of ascorbic acid in comparison to better parent however, only 6 hybrids (9.09%) performed positive and significant heterosis for ascorbic acid over top parent ('Pant Bahar'). Average performance of F₁s surpassed the mean of the parents by 15.07%.

The heterosis percentage over better and top parent are presented in Table 1. Significant positive and highest heterosis

over better parent was expressed in cross 'El 13' x 'Arka Saurabh' (60.40%) followed by 'Marglobe' x 'Shakti' (52.44%), 'Arka Saurabh' x 'NDT 5' (43.19%) and 'Punjab Chhuhara' x 'Arka Saurabh' (41.84%). However, crosses showing maximum amount of ascorbic acid content were 'Marglobe' x 'Shakti' (38.17 mg/100 g), 'Punjab Kesari' x 'Pant Bahar' (37.84 mg/100 g) and 'T 1' x 'Azad Kranti' (33.6 mg/100 g). Significant positive and highest heterosis percentage over top parent ('Pant Bahar') for ascorbic acid content was found in cross 'Marglobe' x 'Shakti' (34.55 mg/100 g), 'Punjab Kesari' x 'Pant Bahar' (33.19 mg/100 g) and 'T 1' x 'Azad Kranti' (18.55 mg/100 g). On the basis of mean ascorbic acid content, parents were classified into 3 groups, viz low, mid and high. Parents of low ascorbic acid content were 'Punjab Chhuhara', 'EL 13', 'Arka Saurabh', 'Shakti' and 'NDT 5' (13.52–17.90 mg/100 g) while high content in 'Marglobe', 'T 1' and 'Pant Bahar' (23.89–28.41 mg/100 g) and medium in 'Punjab Kesari', 'Sweet 72', 'Co 3' and 'Azad Kranti' (20.15–22.06 mg/100g).

It was observed that in most F₁s, derived from parents having high amount of ascorbic acid (high x high) showed non significant or negative heterosis, however, F₁ involving parents of low ascorbic acid content (low x low) and medium ascorbic acid content (mid x mid) expressed high percentage of positive significant heterosis, similar to the finding of (Singh *et al.* 1976) and also found significant positive heterosis over mid-parent (1.95–45.90%) and (2.5–45%) over better parent. Dod *et al.* (1992) observed 1.38–12.0% and 2.0–2.0% significant heterosis over better and top parent, respectively. (Patil *et al.* 1988) found this variation from 35.56–45.96% over best parent (Sindhu *et al.* 1989 and Mandal *et al.* 1989) also found significant heterotic variation among tomato genotypes for quality traits. In the present study positive significant heterosis varied from 0.59–60.41% over better parent and 0.88–13.35% over top parent, supported the trends of variation reported by the earlier workers for this trait.

Thus considering the magnitude of heterosis for ascorbic acid content, the crosses 'Marglobe' x 'Shakti', 'Punjab Kesari' x 'Pant Bahar' and 'T 1' x 'Azad Kranti' were identified as best heterotic combinations.

* Short note

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Table 1 Mean values and heterosis (%) for vitamin C in 12 x 12 diallel in tomato

Parent/ Hybrid	Ascorbic acid content (mg/100 g) Mean	Heterosis over		Parent/ Hybrid	Ascorbic acid content (mg/100 g) Mean	Heterosis over	
		BP	TP			BP	TP
'Punjab'	15.87	-	-	4 x 6	24.03	0.59**	-
'Chuhara' (1)							
'Punjab Kesari' (2)	20.15	-	-	4 x 7	26.94	25.01**	-
'Marglobe' (3)	25.04	-	-	4 x 8	31.62	11.29**	-
'EL 13' (4)	15.51	-	-	4 x 9	24.88	60.41**	-
'Sweet 72' (5)	22.06	-	-	4 x 10	15.83	2.06**	-
'T 1' (6)	23.89	-	-	4 x 11	13.78	-	-
'Co3' (7)	21.55	-	-	4 x 12	22.19	10.01**	-
'Pant Bahar' (8)	28.41	-	-	5 x 6	27.16	13.68**	-
'Arka Saurabh' (9)	13.52	-	-	5 x 7	26.30	19.22**	-
'Shakti' (10)	14.77	-	-	5 x 8	21.89	-	-
'NDT 5' (11)	17.90	-	-	5 x 9	24.45	10.83**	-
'Azad Kranti' (12)	20.26	-	-	5 x 10	22.62	2.54**	-
1 x 2	14.77	-	-	5 x 11	23.65	7.21**	-
1 x 3	20.39	-	-	5 x 12	20.82	-	-
1 x 4	20.20	27.28**	-	6 x 7	25.86	8.25**	-
1 x 5	27.38	24.11**	-	6 x 8	23.50	-	-
1 x 6	21.73	-	-	6 x 9	22.49	-	-
1 x 7	21.15	-	-	6 x 10	26.23	9.79**	-
1 x 8	21.24	-	-	6 x 11	15.15	-	-
1 x 9	22.51	41.84**	-	6 x 12	33.68	40.98**	18.55**
1 x 10	20.16	27.03**	-	7 x 8	20.00	-	-
1 x 11	22.88	27.82**	-	7 x 9	18.10	-	-
1 x 12	20.89	3.11**	-	7 x 10	17.18	-	-
2 x 3	26.65	6.43**	-	7 x 11	30.37	40.93**	6.90**
2 x 4	21.75	7.94**	-	7 x 12	17.40	-	-
2 x 5	26.61	20.63**	-	8 x 9	24.70	-	-
2 x 6	26.64	11.51**	-	8 x 10	28.66	0.88**	0.88**
2 x 7	26.29	21.99**	-	8 x 11	18.82	-	-
2 x 8	37.84	33.19**	33.19**	8 x 12	31.21	9.86**	9.86**
2 x 9	20.49	1.69**	-	9 x 10	21.15	43.10**	-
2 x 10	19.11	-	-	9 x 11	15.75	-	-
2 x 11	23.31	15.68**	-	9 x 12	10.76	-	-
2 x 12	16.81	-	-	10 x 11	20.12	12.40**	-
3 x 4	20.39	-	-	10 x 12	23.49	15.94**	-
3 x 5	19.37	-	-	11 x 12	21.06	3.94**	-
3 x 6	22.88	-	-				
3 x 7	21.10	-	-	CD ($P=0.05$)		0.176	0.176
3 x 8	23.55	-	-	CD ($P=0.1$)		0.232	0.232
3 x 9	22.88	-	-				
3 x 10	38.17	52.44**	34.35**				
3 x 11	25.96	3.67**	-				
3 x 12	26.87	7.31**	-				
4 x 5	20.45	-	-				

** $P=0.1$

-No heterosis or negative heterosis

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Stability in grain yield of buckwheat (*Fagopyrum tataricum*) in the dry temperate region of Himachal Pradesh*

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Key words : *Fagopyrum tataricum*, buckwheat, yield stability

Among the pseudo-cereals cultivated in the dry temperate regions of Himachal Pradesh, buckwheat [*Fagopyrum tataricum* (L.) Gaertn.] covers largest area. The grain yields are unstable and the farmers generally grow mixture of landraces. Till now, no variety has been released for the region having high and consistently superior grain yield performance in all the buckwheat growing pockets. Hence, there is an urgent need to evaluate the stability of yield performance of the landraces as well as other strains in the dry temperate zone of Himachal Pradesh which can sustain the yield

crop. The experiment were laid out in randomized block design with 3 replication during each year. Data were analysed following Eberhart and Russell (1966).

Significant mean squares due to genotypes suggested the presence of genetic variation amongst the lines evaluated (Table 1). Environment also played its role in determining the grain yield potential of genotypes as was evident from significant mean sum of squares due to genotype x environment. Further partitioning of this component showed the presence of both linear and non-linear types of g x e interactions. The linear component of g x e was predominant over that on non-linear type to predict the yield performance in different environments.

Estimates of stability parameters, viz mean (X), regression coefficient (bi) and deviation from regression (S²di), enunciated that most of the varieties with poor and average grain yields were associated with unit regression coefficient (b=1) and least deviation from regression (Coefficient S²di = 0) hence stable in their performance (Table 2). The released

Table 1 Analysis of variance for different environment for grain yield in buckwheat

Source	df	Mean sum of square for grain yield
Genotype	9	34.22***
Environment	3	131.66***
Genotype x environment	27	4.98**
Environment + (G x E)	30	17.65***
Environment (linear)	1	394.98***
Genotype x environment (linear)	9	8.08***
Pooled deviation	20	3.10**
Pooled error	80	1.10

*Pooled error $P=0.05$; ** $P=0.01$ respectively; pooled deviation $*P=0.05$, $**P=0.01$, respectively

for a longer period.

Two high yielding pure lines of buckwheat, viz 'KBB 1' and 'KBB 3' was developed at univeristy regional station, Kukumseri, Lahaul and Spiti (Kapoor and Chaudhary 1994) and 8 accessions, viz 'IC 13141', 'IC 13145', 'IC 13411', 'IC 18869', 'IC 18889', 'PRB 8901', 'Himpriya' and 'VHC 26' collected from NBPGR station, Phagli, Shimla were evaluated for grain yield at research sub station, Leo during summer 1993–96 under arid moisture-stress conditions. Recommended package of practices were followed to raise good

Table 2 Estimates of stability parameters in different environments for grain yield in buckwheat

Genotype	Grain yield (kg/ha)		
	Mean (X)	Regression coefficient (b)	Deviation from regression coefficient (S ² d)
'IC 131411'	1 775	1.13	2.10
'IC 13145'	1 298	1.91**	5.56**
'IC 13411'	1 901	0.95	3.46*
'IC 18869'	1 668	1.29	-0.44
'IC 18889'	1 400	0.63	2.22
'Himpriya'	1 594	1.10	3.17*
'PRB 8901'	1 210	0.25*	1.16
'VHC 26'	1 199	0.54	1.54
'KBB 1'	1 397	0.97	-0.35
'KBB 3'	1 984	1.18	1.56
Grand mean	1 482		
SE ±	101		

* $P=0.05$; ** $P=0.01$

* Short note

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variety 'Himpriya' was found average performing and unstable ($S^2d_i = 0$). The 'KBB 3' gave highest grain yield followed by 'IC 13411'. Out of these 2 high yielding genotypes 'KBB 3' was associated with unit regression coefficient ($b=1$) and low deviation from regression ($S^2di \neq 0$), hence observed to a stable genotype. 'IC 13411' had high yield, unit regression coefficient ($b=1$) and $S^2di \neq 0$, so observed unstable genotype.

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Factors affecting germination of spores of *Gliocladium virens**

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Key words : germination, *gliocladium* spp, conidial germination, *G. virens*, phialospores chlamyospores

Very little is known about factors affecting germination of phialospores and chlamyospores of *Gliocladium* spp. Jackson *et al.* (1991) observed bacto-peptone (1.0%) agar supports only 35.0% conidial germination of *G. virens* (G 20) at 25°C but with the addition of 1.0% glucose germination was augmented further. They subsequently noted the influence of temperature on the conidial germination of *G. virens*, the optimum being 30°C (Jackson *et al.* 1991). This study deals with the effect of some external nutrient sources on the germination of phialospores and chlamyospores of *G. virens*.

* Short note

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The germination behaviour of phialospores and chlamyospores of 4 isolates of *G. virens* was studied *in vitro* at 30°C in different stimulants including tap water and distilled water. The spore suspension of phialospores and chlamyospores in distilled water was prepared to give a population count of 20-25 phialospores and 10-12 chlamyospores, respectively per microscopic field under x 20 objective. The stimulants were grape juice, malt extract, dextrose, sucrose, D-mannitol and a few other inorganic salts like ammonium-nitrate, ammonium phosphate and sodium nitrate.

Among the different exogenous stimulants used (Table 1) dextrose showed highest stimulatory effect on germina-

Table 1 Germinability of phialospores^a and chlamyospores^b of *Gliocladium virens* isolates in different stimulants at 30°C after 24 hr

Stimulant/ isolates (1 000 µg/ml)	Spores germination (%)							
	15 GV ₁		26 GV ₁		IAGV ₂		IAGV ₆	
	a	b	a	b	a	b	a	b
Dextrose	80.32* (63.66)**	57.99 (49.60)	56.81 (48.91)	40.00 (39.23)	57.70 (49.93)	56.66 (48.83)	50.80 (45.46)	80.00 (63.43)
Sucrose	79.45 (63.04)	76.66 (61.11)	27.61 (31.70)	50.00 (45.00)	52.83 (46.62)	56.66 (48.83)	27.28 (31.49)	69.99 (56.78)
D-mannitol	36.82 (37.36)	53.33 (46.91)	7.91 (16.33)	50.00 (45.00)	28.14 (32.04)	66.66 (54.73)	11.61 (19.92)	44.99 (42.12)
Ammonium nitrate	83.79 (66.26)	49.99 (44.99)	31.81 (34.33)	46.66 (43.08)	38.26 (38.21)	80.00 (63.43)	42.81 (40.87)	75.00 (60.00)
Sodium nitrate	32.61 (34.82)	34.16 (35.76)	0 (4.05)	31.09 (33.89)	32.95 (35.03)	40.00 (39.23)	0.9 (4.05)	40.00 (39.23)
Ammonium phosphate	70.29 (56.97)	40.00 (39.23)	32.11 (34.52)	26.66 (31.08)	40.88 (39.74)	65.33 (53.93)	39.47 (38.92)	66.66 (54.73)
Control	42.89 (40.91)	37.33 (37.66)	40.58 (39.57)	36.33 (37.07)	39.54 (38.96)	40.00 (39.23)	31.94 (34.41)	20.00 (26.50)
		SEm ±		CD (P=0.05)				
Stimulant		3.83		10.61				
Isolate		2.89		8.01				
Type of spore		2.05		5.68				
Isolate x type of spore		4.09		11.33				

* Each insertion is an average of 5 observations; **figures in parentheses are angular transformed values

Table 2 Germinability of phialospores^a and chlamydo-spores^b of *Gliocladium virens* isolates in vitamin and some natural stimulants at 30°C after 24 hr

Stimulants/ isolates	Spores germination (%)							
	15 GV ₁		26 GV ₁		IAGV ₂		IAGV ₆	
	a	b	a	b	a	b	a	b
Ascorbic acid (1 000 /µg/ml)	86.95* (68.83)**	82.00 (64.89)	100.0 (90.0)	90.28 (71.83)	100.0 (90.0)	86.95 (68.82)	100.0 (90.0)	78.0 (62.03)
Glucose (10 000/µg/ml)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)
Ascorbic acid (1 000/µg/ml)								
Malt extract (1000/µg/ml)	93.89 (75.69)	66.66 (54.73)	87.07 (68.92)	43.33 (41.17)	81.31 (64.38)	75.0 (60.0)	72.08 (58.05)	46.66 (43.08)
Grape juice (1 : 5 dilution)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)
Tapwater	12.06 (20.32)	33.66 (35.46)	0.0 (4.05)	32.33 (34.65)	22.06 (28.01)	31.66 (34.24)	0.0 (4.05)	30.0 (33.21)
Distilled water	42.89 (40.91)	37.33 (37.66)	40.58 (39.57)	36.33 (37.07)	39.54 (38.96)	40.0 (39.23)	31.94 (34.41)	20.0 (26.56)
		SEm ±		CD (P = 0.05)				
Stimulant		2.81		7.80				
Isolate		2.30		6.36				
Type of spore		1.62		4.50				
Stimulant x isolate x type of spore		7.96		22.06				

* Each insertion is an average of 5 observations; **Figures in parentheses are angular transformed values

tion of both the spore forms followed by ammonium nitrate, sucrose and ammonium phosphate while D-mannitol had the least. In sodium nitrate germination was reduced compared to the control. The respective isolate and both spore forms behave differentially in different stimulants. Ascorbic acid alone and in combination with glucose increased the germination of both the spore types. Over and above phialospore had significantly higher germination than chlamydo-spores.

Grape juice at 5 folds dilution with distilled water and malt extract at 1 000 /µg/ml lead to 2.5 and 2.0 times increase in germination compared with the control (Table 2). Pooled data showed that isolate 15 GV₁ had highest (66.0%) and IAGV₆ had lowest (56.0%) germination, other isolates being intermediate in nature.

The germination of phialospores in distilled water was 32% (IAGV₆) to 43% (15 GV₁) and that of chlamydo-spores 20% (IAGV₆) to 40% (AGV₂). In tap water the germination of phialospores was 0.0 (IAGV₆, 26 GV₁) to ≤ 22% (IAGV₂) and that of chlamydo-spores was in between 30% (IAGV₆) and 33% (15 GV₁).

The phialospores of *Trichoderma* spp and *Gliocladium* spp. are known to germinate easily on many substrates (Papavizas 1985). However, Danielson and Davey (1973) claimed that phialospores of *Trichoderma* spp. always require an exogenous nitrogen source for germination but the *Gliocladium* spp do not. The need for nutritional stimulation for the germination of spores of these organisms is also known

(Nelson *et al.* 1985, Jackson *et al.* 1991). Kang *et al.* (1989) reported temperature optima (30°C) for germination of phialospores of *G. virens*.

In the present study among 3 carbon sources used dextrose was better utilized over sucrose and D-mannitol and nitrogen in ammonium form than nitrate form. Danielson and Davey (1973) obtained better germination of *Tricho-derma* spp. with complex nutrition sources.

Tap water in this occasion contains several soluble salts in addition to high amount of different iron (Fe) compounds that might have proved inhibitory to the germination of phialospores and chlamydo-spores.

In the present study it was observed that glucose individually at 10 000 µg/ml marginally increased germination of both spore forms compared to control. The germination of spore, irrespective of their forms and nature in distilled water distinctly indicated its nature of nutrient independibility.

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Susceptibility of cotton leafhopper (*Amrasca devastans*) to insecticides in Tamil Nadu*

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Key words : cotton leafhopper, insecticidal treatment, mortality, resistance, *Amrasca devastans*

The cotton leafhopper (*Amrasca devastans* Dist.) is a major pest of cotton (*Gossypium* spp.); many of the varieties and hybrids are susceptible to this pest. The desapping by adults and nymphs along with the injection of toxic saliva by insects devitalizes the plants (Bhat *et al.* 1984, Mabbet *et al.* 1984, Ahmed *et al.* 1986 and Matthews 1989). This necessitates the control of this pest by continuous evaluation of newer forms of insecticides. The pest problem is aggravated more rapidly by the development of resistance to insecticides and control failures in many areas. Hence, a study was undertaken to assess the susceptibility of leafhopper to insecticides in Tamil Nadu.

The leafhopper adults were collected from 3 different cotton production centres, viz Annur, Udumalpet in Coimbatore District and Tamil Nadu Agricultural University Campus at Coimbatore where upland cotton is grown extensively. The adult of leafhopper were collected from 'MCU 5' cotton plants aged 45-50 days, 3-5 days after application of dimethoate (30 EC) @ 750 ml/ha in all the locations and

brought to the laboratory for further study.

The field collected adult population was exposed to treatments listed in Table 1. A population of leafhopper collected from the field was also maintained on 25-40-days-old 'MCU 5' plants under green-house condition for other studies.

Pooled plants of 'MCU 5' cotton at 25 days were sprayed insecticides using an atomiser on both the adaxial and abaxial surface of leaves, shade dried and introduced inside the screen cages. Ten adult leafhoppers from each of the population and location were introduced into each plant covered with glass chimney (14 cm x 10 cm) and the top of chimney with muslin cloth to confine the adults. There were 4 replications. Mortality of the adults was recorded after 1, 3 and 7 days of treatment. In case of control plants water was sprayed.

The third instar nymphs of the leafhopper (F₁ generation) population reared at the insectory were exposed to insecticidal treatment and observations were recorded as described for adults. Mean mortality of adults/nymphs were calculated and the data were analysed using Duncan's (1951) multiple range test (DMRT).

The data on mortality of leafhopper indicated that chemicals methyl demeton, dimethoate and phosalone were effective

* Short note

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Table 1 Effect of insecticides on field collected adults and first generation nymphs of leafhopper

Insecticide	Mortality of leafhopper						
	Adult			Nymph (F ₁)			
	Coimbatore	Annur	Udumalpet	Coimbatore	Annur	Udumalpet	
Methyldemeton 25 EC	0.05%	70.00 (59.79) ^a	66.67 (54.78) ^a	63.33 (52.78) ^a	53.33 (46.92) ^a	53.33 (46.92) ^a	53.33 (46.92) ^a
Dimethoate 30 EC	0.06%	56.67 (48.85) ^b	53.33 (46.92) ^b	53.33 (46.92) ^{ab}	46.67 (43.08) ^{ab}	46.67 (43.08) ^{ab}	43.33 (41.15) ^{ab}
Endosulfan 35 EC	0.07%	40.00 (39.14) ^c	43.33 (41.07) ^b	36.67 (37.22) ^b	30.00 (33.00) ^b	36.67 (37.22) ^b	26.67 (30.79) ^{bc}
Phosalone 35 EC	0.07%	50.00 (45.00) ^b	50.00 (45.00) ^b	50.00 (45.00) ^{ab}	43.33 (41.15) ^{ab}	40.00 (39.23) ^{ab}	36.67 (37.22) ^{bc}
Phosphamidon 85 wsc	0.17%	53.33 (46.92) ^b	50.00 (45.00) ^b	50.00 (45.00) ^b	46.67 (43.08) ^{ab}	43.33 (41.15) ^{ab}	40.00 (39.23) ^{ab}
Control		0 (0.01) ^d	0 (0.01) ^c	0 (0.01) ^c	0 (0.01) ^c	0 (6.14) ^c	0 (0.01) ^d

Figures in parentheses are $\sqrt{\text{arc-sin}}$ percentage transformation.

In a column, means followed by the same letter are not significantly different ($P < 0.05$ Duncan's multiple range test)

tive in reducing the adult population of leafhopper; methyl demeton was significantly superior to other chemicals with a mortality of 70.00, 66.67 and 62.33%, respectively for Coimbatore, Annur and Udumalpet populations. The mortality of third instar nymphs of leafhopper indicated that all the chemicals were effective with a mortality ranging from 26.67–33.3% at different locations indicating the chemicals at the recommended doses were not as effective as has been reported earlier (Vidhyasekaran *et al.* 1989, Patel and Yadav 1995). The results indicate that the population of leafhopper at different production centres has picked up tolerance to various chemicals which needs to be confirmed through further studies.

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Evaluation of promising germplasm genotypes of mulberry (*Morus species*) for higher productivity under irrigated condition*

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Mulberry (*Morus indica* L.) is the basic food plant of silkworm (*Bombyx mori* L.) and its cultivation is the first and primary activity in sericulture. The 'M 5' ('Mysore 5' or 'Kanva 2' or 'K 2') is the most popular genotype extensively cultivated. Improved mulberry genotypes are very limited to suit different cultivation practises and agro-climatic conditions. Development of superior genotypes involves systematic evaluation for various desirable parameters of germplasm collections as well as selected genotypes (Shikata *et al.* 1985, Govindan *et al.* 1988, Bari *et al.* 1988, Susheelamma *et al.* 1992, Bongale and Chaluvachari 1993). The study was conducted to identify the mulberry genotypes for higher productivity and to evaluate for promising genotypes from the germplasm (Table 1).

The field trial was conducted at the main campus of the institute at Bangalore during 1990-94. Eight mulberry genotypes evaluated, 4 were exotic, viz 'English Black' (France), 'Miuraso' (Paraguay), 'Mizusawa' (Japan) and 'Zimbabwe' (Zimbabwe) and 4 indigenous, viz 'Mother Graft', 'Kaliakutahi', 'Viswa' and 'S 54' along with 'M 5' as the control. These genotypes were evaluated in a partial lattice design with 4 replicates. The number of plants/replicate was 28 with plot size of 4.2 m x 2.4 m. The soil was red sandy

loam with pH of 6.8. Saplings at 90-days were planted (1 sapling/pit) with 60 cm x 60 cm plant spacing and maintained for 1 year without pruning. The package of practises included 5 prunings/year (Choudhury *et al.* 1991). Farmyard manure @ 20 tonnes/ha/year was applied and N, P and K were applied @ 280, 120 and 120 kg/ha/year, respectively in 5 equal split doses, corresponding to number of harvest/year. Data on plant height, internodal distance, fresh weight of 100 leaves, leaf-water content, leaf-water loss 6 hr after harvest and leaf yield on whole-plot basis were collected for 2 years and were analysed statistically.

The genotypes showed significant differences for all the parameters (Table 2). The plant height ranged from 95.54 cm ('Miuraso') to 138.23 cm ('Mizusawa') among the 8 genotypes and 'Mizusawa' has showed highly significant increase over 'M 5' (119.81 cm) during both the years. The values of other genotypes were on par with the control. The internodal distance ranged from 4.93 cm ('S 54') to 6.68 cm ('Mizusawa') and that of 'Mother Graft' (5.28 cm), 'Miuraso' (4.78 cm), 'S 54' (4.93 cm) and 'Viswa' (5.24 cm) were significantly shorter. The fresh weight of 100 leaves ranged from 239.19 g ('Kaliakutahi') to 498.02 g ('Mizusawa'). The values were significant in 'Zimbabwe' (457.37 g) and 'Mizusawa' compared with the 'M 5' (325.90 g) during both the years and in 'Viswa' (393.67 g) only during 1992-93. The leaf-water content ranged from 75.87 ('Mother Graft')

* Short note

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Table 1 Growth, yield, quality and propagation parameters of 9 mulberry genotypes from germplasm (mean data of 9 harvests)

Genotype	Plant height (cm)	Internodal distance (cm)	Fresh weight of 100 leaves (g)	Leaf-water content (%)	Leaf-water loss 6 hr after harvest (%)	Sprouting (%)	Rooting (%)
'Mizusawa'	205.66	5.46	575.05	74.22	14.71	91.00	72.00
'Miuraso'	206.30	4.97	450.67	75.10	14.30	75.00	64.00
'Zimbabwe'	176.43	4.92	538.08	73.63	10.38	91.00	42.00
'English Black'	166.94	4.92	566.64	76.20	15.81	70.00	62.00
'Kaliakutahi'	199.66	4.63	354.79	74.42	20.57	88.00	73.00
'Mother Graft'	179.21	4.22	385.83	72.76	20.37	96.00	82.00
'S 54'	173.32	3.86	486.43	75.46	12.98	95.00	76.00
'Viswa'	167.57	4.00	526.70	75.53	14.50	97.00	80.00
'M 5'	182.38	4.55	403.30	73.14	18.53	96.00	89.00

Table 2 Mean performance of morpho-biological variables and leaf yield for 9 mulberry genotypes (mean data of 5 harvests/year)

Genotype	Plant height (cm) Mean*	Internodal distance (cm) Mean*	Fresh weight of 100 leaves (g) Mean*	Leaf-water content (%) Mean*	Leaf-water loss 6 hr after harvest (%) Mean*	Leaf yield/ replicate (kg) Mean*
'Mizusawa'	138.23**	6.68	498.02**	78.24*	11.00**	65.33
'Miuraso'	95.54	4.94**	320.95	77.25	12.22	41.43
'Zimbabwe'	105.28	6.28	457.37**	77.35	11.51	43.63
'English Black'	104.03	5.55	338.47	76.15	13.02	41.95
'Kaliakutahi'	123.32	5.42	239.19	75.96	16.21	44.16
'Mother Graft'	120.03	5.28**	251.26	75.87	14.10	63.98
'S 54'	100.85	4.93**	318.56	77.52	12.64	56.12
'Viswa'	112.58	5.24**	358.57	77.65	11.59	66.10
'M 5'	119.81	5.70	325.90	77.00	12.50	66.34
F test	HS	HS	HS	HS	HS	HS
SEM ±	2.38	0.09	14.20	0.17	0.29	2.11
CD (P = 0.05)	8.61	0.22	37.11	1.10	1.06	7.68
CD (P = 0.01)	11.68	0.29	50.35	1.50	1.44	10.42

*Mean data of 1992-93 and 1993-94.

@P = 0.05; NS, no significant differences between means; S, differences between means are different HS, differences between means are significant @P = 0.01; *P = 0.05; **P = 0.01

to 78.24% ('Mizusawa'). When compared with 'M 5' (77%), 'Mizusawa' (77.54%) has highly significant values during 1993-94 and in pooled data. The leaf-water loss 6 hr after harvest ranged from 16.21 ('Kaliakutahi') to 11% ('Mizusawa') and it was significant in 'Mizusawa' (10.77%) and 'Zimbabwe' (11.05%) during 1993-94 compared with 'M 5' (13.10%). The leaf yield/replicate ranged from 41.43 ('Miuraso') to 66.10 kg ('Viswa'). Non-significant differences were found among the 8 genotypes compared with 'M 5' (66.34 kg). Based on the yield performance the genotypes 'M 5', 'Viswa', 'Mizusawa' and 'Mother Graft' can be clubbed into 1 group and 'Kaliakutahi', 'Zimbabwe', 'English Black' and 'Miuraso' can be clubbed into another group while 'S 54' stands in between.

Shikata *et al.* (1985) observed that among the 6 mulberry genotype, 'Tai-Song 2' showed highest values for length and weight of branches and leaf yield. Bari *et al.* (1988) identified clone numbers 17 and 58 as best performers for leaf yield/plant out of 60 clonal lines, 1 indigenous genotype and 3 improved selections. Govindan *et al.* (1988) reported that among 6 mulberry genotypes 'Mysore Local', 'M 5' and 'S 41' showed rapid growth and number of leaves/shoot after pruning but in fresh weight of 100 leaves 'S 30', 'S 36', 'S 41' and 'S 54' were better. Susheelamma *et al.* (1992) based on evaluation of 9 promising genotypes from germplasm for better leaf yield reported that accession numbers 142, 203 and 141 had a genetic potential for yield compared with the control. Sastri *et al.* (1988) reported that out of 6 mulberry genotypes the leaf-water loss 7 hr after harvest was less in 'S 30' and 'S 36' and difference was not significant in other genotypes. Mulberry genotypes with tall branches and short internodal distance were considered as criteria for screening and selecting improved genotypes (Ogure 1977).

Thus 'Mizusawa' performed better than other genotypes

for plant height, fresh-weight of 100 leaves, leaf-water content, leaf-water loss 6 hr after harvest and almost equally in respect of leaf yield. 'Viswa' performed better with fresh weight of 100 leaves and internodal distance and was second in overall performance.

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