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Effect of summer greengram (*Phaseolus radiatus*) on rice (*Oryza sativa*)–wheat (*Triticum aestivum*) system

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ABSTRACT

A field experiment was conducted during 1991–92 to 1993–94 to study the effect of greengram [*Phaseolus radiatus* (L.) Wilczek] on rice (*Oryza sativa*)–wheat (*Triticum aestivum*) system. Green manuring of greengram gave higher values of growth and yield attributes, nutrient uptake and protein content of rice. Grain yield of rice as well as wheat increased significantly with the green manuring. Lower values of bulk density and *p*H, while higher organic carbon content was noted owing to green manuring. Application of N improved the growth and yield attributes, protein content and also NPK uptake. A significant increase in grain yield of rice was found up to 120 kg N/ha. Organic carbon increased at higher level of N.

Key words : greengram, cropping system, green manuring

Rice (*Oryza sativa* L.)–wheat (*Triticum aestivum* L. emend. Fiori & Paol.) system is the most widely adopted cropping system in the country and has become mainstay of cereal production. However, in northern parts of India, average yield of rice as well as wheat is very low. Inclusion of short duration pulses like greengram as a catch crop in rice–wheat system may be beneficial to the system by maintaining soil fertility and improving the soil properties when used as green manure. Green manuring can partially substitute the nitrogen fertilizer requirement of the subsequent crop (Meelu and Singh 1991). Hence a field trial was carried out to study the effect of greengram on rice–wheat system.

MATERIALS AND METHODS

The experiment was conducted during 1991–92 to 1993–94 at agronomy research farm of the university at Faizabad. The soil was silty loam with *p*H 7.8, organic carbon 0.38% and available N,P and K 226.3, 25.3 and 265.5 kg/ha respectively. Bulk density of the soil was 1.34 g/cm^3. The experiment was laid out in split-plot design with 3 replications, keeping greengram treatments in main plot and nitrogen levels in rice in sub plot. Treatments consisted of 8 practices in greengram, viz T_1, irrigation before harvesting of wheat–normal tillage–sowing of greengram; T_2, irrigation before harvesting of wheat–herbicide spray–sowing of greengram without tillage; T_3, harvesting of wheat–herbicide spray–dry-sowing of greengram without tillage followed by irrigation; T_4, harvesting of wheat–herbicide spray–irrigation–sowing of greengram without tillage; T_5, harvesting of wheat–irrigation–normal tillage-sowing of greengram; T_6, harvesting of wheat–irrigation–normal tillage-sowing of greengram for green manuring; T_7, harvesting of wheat–irrigation–normal tillage–sowing of greengram for pod picking and green manuring; T_8, summer fallow, and 3 levels of N for rice, viz N_1, 90 kg/ha; N_2, 120 kg/ha; N_3, 150 kg/ha.

The pre-sowing irrigation was given 6 days prior to harvesting of wheat or after harvesting of wheat as per treatment. Normal tillage includes 2 ploughing and planking. In case of sowing under zero tillage, a contact herbicide gramaxone @ 0.5 kg a i/ha was sprayed to kill the weeds. After harvesting of wheat–greengram crop was grown and incorporated as per treatment at 50 days after sowing.

Transplanting of rice was done with 25-days-old seedlings of 'Sarjoo 52' rice at the spacing to 20 cm x 10 cm using 2-3 seedlings/hill. Full dose of P (26.16 kg/ha) and K (49.80 kg/ha) and half dose of N (as per treatment) were applied at the time of last puddling. Irrigations to rice were given at different stages of crop growth according to the need. Rainfall received during *kharif* rainy season was 758, 737 and 942 mm in 1991–92, 1992–93 and 1993–94, respectively. Grain and straw samples were collected at harvest and analysed for total N,P and K content. Soil samples of 0–15 cm depth were collected after the harvest of rice and analysed for soil properties. Bulk density was determined *in situ* by core sampler. A uniform crop of wheat was grown with all the recommended package of practices after harvesting rice.

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RESULTS AND DISCUSSION

Rice

Growth and yield components: The values of all the growth and yield components were highest with treatment harvesting of wheat–irrigation–normal tillage–sowing of greengram for green manuring (T_6) (Table 1). The heading and maturity of rice were slightly delayed under this treatment. It may be attributed to proper growth and development of rice due to green manuring of greengram which increased the nitrogen-use efficiency by rice crop. It was followed by T_7 in which green manuring was done after picking of mature pods. These finding are in close confirmity with of Akram *et al.* (1982). Lower values of growth and yield characters under T_2, T_3 and T_4 over T_1 and T_5 might be due to zero tillage in greengram. However, the minimum values of all these characters were obtained with T_8 (summer fallow). This might be attributed to low organic carbon content in the soil and also due to its poor physical condition as it was higher in bulk density and *p*H (Table 4), which might have resulted in low-root density and poor water-holding capacity led to the lower values of growth and yield attributing characters.

Increasing levels of N from 90 to 150 kg/ha increased all the growth and yield attributes (Table 1). The number of days taken to 75% heading and maturity were higher at higher dose of nitrogen. Ramaswamy *et al.* (1985) also reported increase in dry-matter production and tillering of rice due to increase in N levels from 0–150 kg/ha. These results are supported by the findings of Tomar (1987) and Singh *et al.* (1989).

Grain yield: The significant variation in grain yield of rice was obtained due to differential treatments in greengram in 1992–94 (Table 2). The highest yield was recorded with T_6 followed by T_7 and both these treatments produced significantly higher grain yield over T_2, T_3, T_4 and T_8 during 1991–92 and 1992–93. However, T_6 and T_7 being at par gave significantly higher yield over all other tratments during 1993–94. The yield increase might be due to addition of organic matter and plant nutrients through green manure. This may also be attributed to increase of cation-exchange capacity, available phosphorus and exchangeable potassium when green manuring was done (Cosico 1990). Akram *et al.* (1982) reported maximum yield of rice with incorporation of green manure.

Nitrogen application up to 150 kg/ha continuously increased the grain yield in each year (Table 2). However, response was significant only up to 120 kg N/ha. This might be attributed to the fact that applied N tended to improve plant growth and development and yield attributes which in turn resulted in higher yield. The results are in close confirmity with those of Singh *et al.* (1989) and Mehta *et al.* (1996).

Harvest index: Harvest index was not much influenced by various treatments (Table 1). However, it was lower under green manure treatment (T_6) may be due to better vegetative growth resulting higher straw yield owing to more available

Table 1 Growth and yield attributing characters, harvest index and protein content of rice as influenced by various treatments (mean of 3 years 1992–94)

Treatment	Plant height (cm)	No. of shoot/m² at 60 DAT	Leaf area index at 90 DAS	Dry-matter accumulation (g/hill)	Days to 75% heading	Days to maturity	No. panicles/m²	Weight of grains/panicle (g)	1 000-grain weight (g)	Harvest index (%)	Protein content (%)
Main plot (summer greengram)											
T_1	100.0	427.0	5.5	37.2	84.6	120.7	346.4	2.4	22.1	43.9	8.7
T_2	98.7	381.8	5.3	36.4	83.9	120.1	326.4	2.1	21.0	44.0	8.6
T_3	98.0	372.2	5.2	35.4	83.6	119.7	314.0	1.9	20.8	43.8	8.4
T_4	96.6	359.1	5.2	35.2	83.5	119.5	309.3	1.8	20.8	43.8	8.3
T_5	100.1	414.1	5.5	36.5	84.3	120.5	340.3	2.4	22.0	43.7	8.7
T_6	101.9	454.0	5.9	38.5	86.6	122.7	407.1	2.9	22.9	43.7	9.5
T_7	101.3	450.4	5.7	37.9	85.9	122.3	397.7	2.8	22.8	43.7	9.4
T_8	96.3	335.8	5.4	30.2	82.5	119.0	304.0	1.8	20.7	44.0	8.02
Sub plot (*kharif* rice : N level)											
N_1	96.5	374.8	5.2	34.2	83.4	119.1	316.7	2.0	21.4	44.0	8.5
N_2	99.3	399.4	5.4	35.9	84.4	120.6	345.9	2.2	21.6	43.8	8.7
N_3	102.1	423.8	5.8	37.6	85.2	122.1	366.9	2.5	21.9	43.6	9.2

DAT, Days after transplanting; DAS, days after sowing
Details of the treatments are given under Materials and Methods

Table 2 Grain yield (tonnes/ha) of rice and wheat as influenced by various treatments

Treatment	*Kharif* rice			Wheat	
	1992	1993	1994	1992–93	1993–94
Main plot					
(summer greengram)					
T_1	4.83	4.91	4.44	4.35	4.48
T_2	4.54	4.61	4.18	4.32	4.44
T_3	4.46	4.56	4.10	4.24	4.36
T_4	4.37	4.46	4.03	4.23	4.37
T_5	4.76	4.88	4.38	4.33	4.51
T_6	5.17	5.25	4.81	4.49	4.63
T_7	5.03	5.15	4.70	4.36	4.55
T_8	4.15	4.25	3.82	4.06	4.14
CD (P=0.05)	0.47	0.49	0.33	0.19	0.16
Sub plot					
(*kharif* rice : N level)					
N_1	4.31	4.45	3.98	4.26	4.39
N_2	4.72	4.[illegible]	4.36	4.30	4.44
N_3	4.95	5.[illegible]	4.59	4.33	4.47
CD (P=0.05)	0.27	0.[illegible]	0.25	NS	NS

NS, Non significant

Details of the treatments are given under Materials and Methods

Table 3 Nutrient uptake by rice plant at harvest as influenced by various treatments (mean of 3 years, 1992–94)

Treatment	Nutrient uptake (kg/ha)		
	N	P	K
Main plot			
(summer greengram)			
T_1	90.9[illegible]	14.41	82.24
T_2	88.80	14.10	80.73
T_3	85.73	13.40	77.47
T_4	83.30	13.22	75.25
T_5	88.29	14.00	81.08
T_6	97.75	15.51	87.26
T_7	94.35	14.93	86.95
T_8	80.[illegible]	12.17	71.50
Sub plot			
(*kharif* rice : N level)			
N_1	81.62	13.11	76.94
N_2	89.51	14.16	80.69
N_3	94.44	14.63	83.29

Details of the treatments are given under Materials and Methods

N due to increase in organic carbon after green manuring. Maximum value of harvest index (44.02%) was recorded with summer fallow (T_8). Increasing rates of N slightly decreased the values of harvest index.

Nutrient uptake: Appreciably higher quantity of N, P and K was accumulated by rice crop under the treatment T_6 (Table 3). Lowest uptake of N, P and K by rice was recorded under T_8, being 82.6, 78.5 and 81.9%, respectively of the maximum uptake values of these nutrients under T_6. The increase in nutrient uptake may be because of the residual effect of preceding crop taken as green manure which resulted in higher uptake. Gines *et al.* (1986) also observed increase in N uptake due to green manuring. Favourable effect of farmyard manure and prickly sesban [*Sesbania cannabina* (Retz.) Pers.] green-manure on N uptake is attributed to decreasing loss of released N during decomposition and their narrow C : N ratio (Bhandari *et al.* 1992).

Nutrient uptake increased with successive increase in N application up to 150 kg/ha. Values of uptake increased due to higher availability of nutrients which resulted in better growth and development of rice plants and ultimately more uptake of nutrients. Sharma (1983) reported the application of N enhanced the P uptake. Mahendran (1980) reported significant influence on K uptake due to higher levels of nitrogen.

Protein content: Highest protein content (95%) of rice grain was found under treatment T_5 (Table 1). Higher availability of N due to green manuring increased the protein content. The highest protein content of 9.5% was found with treatment T_6 which was 18.3% higher over treatment T_8. Nitrogen levels increased the protein content with increase in the N dose. This was due to the fact that as the N supply increased, uptake of N increased which is the constituent of protein.

Physico-chemical properties of soil: The bulk density was found lower under the treatments consisting normal tillage practices as compared with the zero-tillage in preceding crop (Table 4). This might be attributed to the relative looseness of the soil due to the tillage operation. The lowest value of bulk density was recorded under treatment T_6 due to the green manuring which increased the organic matter in the soil. Singh and Sandhu (1980) also observed similar results. Different N levels did not reasonably influence the bulk density.

Table 4 Effect of various treatments on physico-chemical properties of soil after the harvest of rice (mean of 3 years 1992–94)

Treatment	Bulk density (g/cc)	pH	Organic carbon (%)
Main plot			
(summer greengram)			
T_1	1.34	7.76	0.42
T_2	1.40	7.81	0.39
T_3	1.40	7.82	0.39
T_4	1.40	7.82	0.39
T_5	1.34	7.75	0.41
T_6	1.30	7.70	0.46
T_7	1.32	7.70	0.44
T_8	1.40	7.83	0.36
Sub plot			
(*kharif* rice : N level)			
N_1	1.33	7.80	0.38
N_2	1.34	7.77	0.41
N_3	1.35	7.74	0.44

Details of the treatments are given under Materials and Methods

The *p*H value of soil decreased slightly with green manure treatments (T_6 and T_7) due to addition of organic matter in soil. Increasing levels of N showed lower *p*H value.

The organic carbon content increased with green manuring (T_6) because of the soil incorporation of leguminous crop which added crop residues in soil. An increase in soil organic matter content due to the green manuring was also reported by Jin (1984). Increase in N levels resulted in increase in inorganic carbon content of the soil. This was because of the fact that N helps in the rotting and decomposition of organic matter.

Residual effect on wheat yield: Green manuring treatment T_6 gave slightly higher grain yield over other treatments during 1992–93 and 1993–94. However, during 1991–92, grain yield of wheat was almost same under all the treatments as no treatment was applied (Table 2). Grain yield recorded under T_6 was significantly higher over T_3, T_4 and T_8. Increase in mean yield under treatment T_6 was to the extent of 0.27, 0.26 and 0.49 tonnes/ha over T_3, T_4 and T_8 respectively. This might be due to the higher organic matter under green manuring which resulted in more availability of plant nutrients to plant. Kumar and Yadav (1995) also recorded higher yield of wheat due to residual effect of farmyard manure and green manuring in rice–wheat cropping system. The lowest yield under T_8 was possibly due to slow supply of plant nutrients in the absence of green manuring/ legume cultivation.

There was no significant effect of nitrogen levels given to rice on wheat grain yield during all the years (Table 2).

It was concluded that green manuring of greengram either as a whole or after pod picking can increase the grain yield of rice and wheat grown in sequence. It also increased nutrient uptake by rice and organic carbon content in the soil after harvesting of rice.

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Effect of phosphorus and liming sources on rice (*Oryza sativa*) grain yield under transplanted conditions

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ABSTRACT

A field experiment was conducted during rainy season (*kharif*) 1992, 1993 and 1994 at Sirsi (Hillzone 9) of Karnataka to study the effect of lime and phosphorus sources on grain yield of rice under transplanted conditions. The experiment consisted of 6 sources of phosphorus and 2 levels of lime. Application of lime @ 500 kg/ha had significantly increased yield compared with without lime (control). The combination of rock phosphate + diammonium phosphate (50:50) had significantly increased yield (5 205 kg/ha) and was on par with diammonium phosphate alone (4 790 kg/ha) than rock phosphate (4 690 kg/ha). Net profit (Rs 7 114/ha) was higher in rock phosphate + diammonium phosphate (50:50) followed by the diammonium phosphate (Rs 5 920/ha) and lowest was in single superphoshate (Rs 4 651/ha).

Key words : liming, diammonium phosphate, transplanted, rock phosphate

Phosphorus fertilization had pronounced effect on rice (*Oryza sativa* L.) yield. In lateritic soil due to low *p*H, available phosphorus is subjected to transformation from available to non available form (Fe and Al phosphates). Liming (amendment) is generally practiced which mitigate ill effects of toxicity of Fe and Al by increasing *p*H of soil, supply bases like calcium and magnesium and lowers phosphorus fixation. Rock phosphate slowly soluble and recommended for acid soils. However, the deficiency of phosphorus was also observed under these conditions. There is a need for an alternative source of phosphatic fertilizer and their combinations that is readily and slowly available. This helps for increased uptake of phosphorus by plants. Rock phosphate is ideal source of P for lowland rice production (Packiaraj and Venkataraman 1991). The combinations of ammonium polyphosphate and single superphosphate had increased grain yield by 65% over diammonium phosphate (Raju *et al.* 1985).

MATERIALS AND METHODS

A field experiment was conducted at agricultural research station (Paddy), Sirsi during 1992–93, 1993–94 and 1994–95 under rainfed (*kharif*) condition. The soil type was lateritic have 5.6 *p*H and 88, 11 and 58 kg/ha available N, P and K respectively. Total annual rainfall of 2 457, 1 902 and 2 988 mm was received during 1992, 1993 and 1994 respectively. The experiment consisted of 12 treatment combinations with 2 levels of lime, viz L_0, without lime and L_1, @ 500 kg/ha of lime and 3 sources of phosphorus and their combinations, viz S_1, rock phosphate (RP), S_2, single superphosphate (SSP), S_3, diammonium phosphate (DAP), S_4, rock phosphate + single superphosphate (50:50), S_5, rock phosphate + diammonium phosphate (50:50) and S_6, single superphosphate + diammonium phosphate (50:50). Factorial randomised block design was followed with 3 replications. Long duration variety 'IET 7191' rice was transplanted at spacing 20 cm x 10 cm. Phosphorus (75 kg/ha) was applied as per treatment through 3 sources and K_2O (90 kg/ha) applied as basal dose. Nitrogen was applied (@ 75 kg/ha) in 3 splits, viz 50% basal, 25% at 30 days after planting, 25% at 50 days after planting.

RESULTS AND DISCUSSION

Data on yield components and grain yield (Table 1, 2) show that grain yield of rice was significantly increased with liming @ 500 kg/ha compared to without lime (Table 2) for 3 years. During 1992–93, significantly higher grain yield (4 975 kg/ha) was recorded in rock phosphate + diammonium phosphate (50:50) combination followed by rock phosphate + single superphosphate (50:50) combinations (4 820 kg/ha) compared to rock phosphate only (4 420 kg/ha). Similarly during 1993–94, rock phosphate + diammonium phosphate had increased grain yield (5 445 kg/ha) followed by diammonium phosphate (4 890 kg/ha) and lowest in rock phosphate + single superphosphate (4 415 kg/ha). Trends during 1994–95 was similar as that of 1993–94 and 1992–93.

Pooled analysis of data indicated that lime application

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Table 1 Yield attributes of rice as influenced by different treatments (pooled data of 3 years)

Phosphrous source	Panicle length (cm)			Panicles/m²			Grain yield (g/hill)			1 000-grain weight (g)		
	L_0	L_1	Mean	L_0	L_1	Mean	L_0	L_1	Mean	L_0	L_1	Mean
S_1	20.2	22.1	21.1	516	630	573	11.8	11.9	11.8	18.1	20.0	19.0
S_2	19.4	19.8	19.6	526	533	530	7.6	11.2	9.4	19.4	19.2	19.3
S_3	21.0	21.6	21.3	516	533	525	12.8	14.8	13.8	18.1	17.5	17.8
S_4	21.6	21.0	21.3	610	633	621	14.1	14.9	14.5	18.0	20.3	19.1
S_5	20.6	21.4	21.0	500	646	573	11.1	14.6	12.8	19.6	18.6	19.1
S_6	19.1	20.8	19.9	486	513	500	11.5	12.1	11.8	18.2	20.2	19.2
Mean	20.3	21.1		525	581		11.5	12.9		18.6	19.3	
		SEm±		CD (P=0.05)	SEm±	CD (P=0.05)		SEm±	CD (P=0.05)		SEm±	CD (P=0.05)
Liming (L)		0.19		NS	14.16	NS		0.30	NS		0.28	NS
P Source (P)		0.34		0.99	24.52	71.92		0.52	1.52		0.48	NS
Interaction (LxP)		0.48		1.39	34.68	101.71		0.73	2.15		0.67	NS

L_0, without lime; L_1, lime @ 500 kg/ha

S_1, rock phosphate (RP); S_2, single superphosphate (SSP); S_3, diammonium phosphate (DAP); S_4, RP+DAP (50:50); S_5, RP+SSP (50:50); S_6, SSP + DAP (50:50)

Table 2 Grain yield of rice and net returns as influenced by phosphorus sources and liming

Phosphrous source	Grain yield (kg/ha) 1992–93			1993–94			1994–95			Mean of 3 years			Net returns (Rs/ha pooled 3 years)		
	L_0	L_1	Mean	L_0	L_1	Mean	L_0	L_1	Mean	L_0	L_1	Mean	L_0	L_1	Mean
S_1	4 156	4 684	4 420	4 620	5 030	4 825	4 800	4 860	4 830	4 520	4 860	4 690	5 655	5 865	5 760
S_2	3 960	4 130	4 045	4 540	4 620	4 580	4 660	4 650	4 655	4 385	4 455	4 420	4 889	5 414	4 651
S_3	4 070	5 350	4 710	4 785	4 995	4 890	4 760	4 790	4 775	4 540	5 040	4 790	5 576	6 264	5 920
S_4	4 080	5 870	4 975	5 070	5 820	5 445	5 160	5 230	5 195	4770	5 640	5 205	6 271	7 958	7 114
S_5	4 600	5 040	4 820	4 200	4 630	4 415	4 880	4 840	4 860	4 560	4 840	4 700	5 563	5 633	5 598
S_6	4 490	4 250	4 370	4 390	4 610	4 500	4 760	4 860	4 810	4 545	4 575	4 560	5 369	4 744	5 056
Mean	42.20	48.90		46.00	49.50		48.40	48.70		45.50	49.00	5 554	5 813		
	SEm±	CD (P=0.05)		SEm±	CD (P=0.05)		SEm±	CD (P=0.05)		SEm±	CD (P=0.05)		SEm±	CD (P=0.05)	
Liming (L)	90	290		80	250		90	NS		90	270		64	190	
P Source (P)	170	490		190	590		150	490		160	480		188	562	
Interaction (LxP)	240	NS		210	NS		220	NS		230	NS		236	NS	

L_0, Without lime; L_1, lime @ 500 kg/ha

was superior over without lime. Grain yield increased by 8% with liming compared with the control. Among different sources of phosphorus and their combinations, rock phosphate + diammonium phosphate (50:50) was significantly superior over the application of rockphosphate alone. Grain yield increased by 12.6% with application of rock phosphate + diammonium phosphate (50:50) compared with the basal application of rockphosphate. Higher grain yield under rock phosphate + diammonium phosphate (50:50) may be due to higher number of panicles (621/m²), grain weight (14.5 g/hill) and also panicle length (21.3 cm) which positively correlated to the grain yield per ha (Table 1). Lower grain yield of paddy with application of single superphosphate was due to the poor yield components. The reduction in yield with single superphosphate is due to transformation of water-soluble phosphorus to non available form of phosphorus in acidic condition. Similarly Packiaraj and Venkataraman (1991) have reported that paddy yields were lower with application of single superphosphate and rock phosphate.

In combination of rock phosphate + diammonium phosphate, P from diammonium phosphate released in the beginning and P from rock phosphate released slowly, thereby supply of P to crop continuously and this increase in the yield.

Similar results were reported by Sah and Mikkelsen (1983). Net returns (pooled data of 3 years) was significantly higher (Rs 7 114/ha) with application of rock phosphate + diammonium phosphate (50:50) followed by diammonium phosphate (Rs 5 920) and lowest net income observed was in single superphosphate (Rs 4 651/ha). Net returns increased by 23.5% with application of rock phosphate + diammonium phosphate (50:50) compared with the basal application of rockphosphate.

Application of lime significantly increased the grain yield than the control. This might be due to creation of favourable physical and chemical conditions in the soil and better availability and uptake of nutrients. Similar results were reported by Budhar (1992), Raju *et al.* (1985) and Prasad *et al.* (1983).

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Yield and trace metal levels in rice (*Oryza sativa*) as influenced by flyash, fertilizer and farmyard manure application

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ABSTRACT

A field investigation on rice (*Oryza sativa* L.) was carried out in rainy season (*kharif*) 1994 to study the influence of flyash, fertilizer and farmyard manure application on yield and trace metal content in rice and its availabiliy in soil. Flyash, fertilizer and farmyard manure application in soil significantly increased the yield of rice over the control, but fertilizer alongwith flyash proved to be superior to that with application of flyash and manure. Trace metal content in rice grain at 50 and 100% NPK level in combination with 10 tonnes of farmyard manure did not vary significantly at 4 and 8% flyash. Nickel content of rice grain (7.6 mg/kg) showed a significant increase at 8% level of flyash addition compared with 4% level (4.4 mg/kg). Total uptake of some heavy metals (Pb, Ni and Co) by rice grown in 4 and 8% flyash amended soil were higher compared with the farmyard manure treated plots or that not treated with flyash. Flyash did not significantly influence the availability of trace metals in soil. Results suggest that 4% flyash addition results in higher grain yields of rice without any possible trace metal contamination of soil and plant.

Key words : flyash, fertilizer, farmyard manure, rice, heavy metals

Flyash is a hazardous industrial waste from coal fired power plants. Coal consumption in the country has increased over the years in need for energy. Coal utilization of 180 million tonnes per annum with 35% ash in power plant is likely to add about 63 million tonnes of ash per year by 2000 AD (Bose and Singh 1989). This huge amount of flyash evolved is dumped in ash disposal area which create problems of degradation and environmental hazards. Besides the present use of flyash in making bricks and cement refractory products, flyash disposal in agricultural land is a viable alternative. In agricultural soils, flyash can be used as a soil amendment or multinutrient source to benefit crop production and can partly solve the problem of its disposal. The present study was undertaken in transplanted rice crop with flyash from Bokaro steel plant. A detailed characterization of flyash from different sources have been presented elsewhere (Kumar 1997).

MATERIALS AND METHODS

A field experiment was conducted in the experimental area of the university with 'IR 36' rice (*Oryza sativa* L.) as a test crop during rainy season 1994 on a sandy clay loam soil. The soil had *p*H 7.2; Organic C 5.1 g/kg; CEC 15.2 C mol (P+)/ kg; Available N and P 150.5 and 15.56 kg/ha; DTPA extractable Fe 120; Mn 65.5; Zn 2.1; Cu 1.6; Co 1.8; Pb 5.4; and Ni 0.31 mg/kg.

Flyash was collected in bulk from ash disposal site of Bokaro steel plant. Bokaro flyash was moderately acidic in reaction (*p*H 6.0) and texturally sandy loam. It had EC 0.21 dS/m; water holding capasity 65.90%; Ca and Mg 10.64 and 5.75 C Mol (p+)/kg; moisture 21.5% and organic C 13.0 g/kg. Total N, P, K, S, Fe, Mn, Zn, Cu, Pb, Ni and Co content in flyash was 95, 7 150, 8 052, 256, 15 445, 207, 175, 221, 97, 129 and 193 mg/kg, whereas available content was 39, 104, 200, 97, 15, 5, 1.6, 1.5, 2.3, 1.4 and 3.5 mg/kg respectively.

The treatments comprised of different flyash levels added with and without farmyard manure and NPK fertilizers. The plot size was 5 m x 4 m and flyash @ 4% (89.6 tonnes/ha) and 8% (179.2 tonnes/ha) were added in each plot as per treatment combinations before puddling and recommended dose of NPK (100:60:40), 50% NPK level were supplied through urea, superphosphate and muriate of potash fertilizers. Full dose of P and K and half dose of N were applied before transplanting and remaining dose of N was applied in 2 equal splits. Recommended agronomical practices were followed. At maturity crop was harvested, grain and straw samples were collected. DTPA extractable trace metals in soil were analysed (Lindsay and Norvell 1978)

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Table 1 Effect of flyash, fertiliser and farmyard manure application on yield of rice (tonnes/ha)

Treatment	Yield		Per cent increase in yield due to treatment	
	Grain	Straw	Grain	Straw
0% flyash	3.54	3.76		
4% flyash	3.82	4.32	8.0	14.8
8% flyash	4.17	4.96	17.8	31.8
4% flyash + 50% NPK	4.33	5.10	22.3	37.9
8% flyash + 100% NPK	4.85	6.23	37.1	65.2
4% flyash + 10 tonnes farmyard manure/ha	4.08	5.63	15.4	49.4
8% flyash + 10 tonnes farmyard manure/ha	4.36	6.04	20.3	60.5
4% flyash + 10 tonnes farmyard manure/ha + 50% NPK	4.63	5.96	30.9	58.2
8% flyash + 10 tonnes farmyard manure/ha + 100% NPK	3.99	5.98	12.7	58.8
10 tonnes farmyard manure/ha	3.77	4.45	6.5	18.1
CD (P=0.05)	0.36	0.74		

Table 2 Effect of flyash, fertilizer and farmyard manure application on trace metal content (mg/kg) in rice grain

Treatment	Trace Metals						
	Fe	Mn	Zn	Cu	Co	Pb	Ni
0% flyash	104	42	53	30	5.8	3.3	4.0
4% flyash	114	55	57	33	7.1	3.9	4.4
8% flyash	115	56	58	33	7.3	4.1	7.6
4% flyash + 50% NPK	124	57	56	31	7.0	3.8	6.5
8% flyash + 100% NPK	136	57	60	35	7.5	3.9	6.5
4% flyash + 10 tonnes farmyard manure/ha	112	53	55	32	7.2	3.9	5.6
8% flyash + 10 tonnes farmyard manure/ha	132	46	56	35	7.7	4.0	7.2
4% flyash + 10 tonnes farmyard manure/ha + 50% NPK	147	53	57	32	8.2	3.8	6.3
8% flyash + 10 tonnes farmyard manure/ha + 100% NPK	159	61	60	37	8.6	5.1	7.4
10 tonnes farmyard manure/ha	126	50	53	31	6.3	3.6	5.9
CD (P=0.05)	26	12	4	3	1.6	0.6	1.4

Table 3 Effect of flyash, fertilizer and farmyard manure application on DTPA extractable trace metals (mg/kg soils) after rice.

Treatment	Trace Metals						
	Fe	Mn	Zn	Cu	Co	Pb	Ni
0% flyash	91	24	2.9	3.8	2.6	7.0	0.5
4% flyash	92	23	2.5	4.2	2.7	8.1	0.6
8% flyash	85	28	3.0	4.3	3.3	7.5	0.4
4% flyash + 50% NPK	94	26	2.8	3.9	3.4	9.2	0.7
8% flyash + 100% NPK	92	24	2.9	4.4	3.4	8.6	0.7
4% flyash + 10 tonnes farmyard manure/ha	83	23	3.1	4.1	3.6	8.3	0.7
8% flyash + 10 tonnes farmyard manure/ha	93	24	2.7	3.9	3.1	8.5	0.7
4% flyash + 10 tonnes farmyard manure/ha + 50% NPK	93	25	2.7	3.5	2.5	8.0	0.6
8% flyash + 10 tonnes farmyard manure/ha + 100% NPK	93	24	3.7	4.2	3.9	8.2	0.8
10 tonnes farmyard manure/ha	91	21	3.3	5.0	2.2	9.6	0.8
CD (P=0.05)	NS	NS	1.2	0.9	1.0	2.1	0.2

by Atomic Absorption Spectrophotometer (AAS) (GBC 902). Grain and straw samples were digested (HNO_3:$HClO_4$:H_2SO_4 in 10:4:1) as described by Piper (1966) and trace metal content in the digest was determined by AAS and the uptake values computed.

RESULTS AND DISCUSSION

Yield of rice

Grain yield of rice varied from 3.54 (control) to 4.85 (8% flyash + 100% NPK) and straw yield from 3.76 (control) to 6.22 tonnes/ha (8% flyash + 100% NPK), respectively.

Flyash, fertilizer and farmyard manure application in soils significantly increased the yield of rice over control (Table 1). Fertilizer use along with flyash proved to be superior to that with combined application of flyash and manure in enhancing grain yield of rice. It was interesting to note that 10 tonnes/ha farmyard manure had similar effect as that of 4% flyash level on straw and grain yield of rice. Increase in grain and straw yield of rice ranged form 6.5 to 37.1 and 14.8 to 65.2% respectively with different treatments. Increase in yield was highest with 8% flyash added with full dose of fertilizer (100% NPK). Singh and Singh (1986) reported that 20% flyash application in soil significantly increased the straw and grain yield of rice. Rao *et al.* (1990) showed maximum growth and biomass accumulation with 15% flyash addition. Singh *et al.* (1996) reported a significant increase of dry matter yield of rice up to 16% flyash incorporation in pot culture studies. The present study indicates that 8% (W/W) level of flyash was beneficial for rice crop when applied along with chemical fertilizers. Flyash do not contain adequate plant nutrients in available form to sustain high crop yields and thus it can at best be used as a supplement to chemical fertilizers.

Trace metal content in rice grain

Concentration of different trace metals, viz, Fe, Mn, Zn, Cu, Co, Pb and Ni in rice grain were highest in 8% flyash + farmyard manure +NPK plots (Table 2). The increase in content of trace metals compared with the control plots ranged from 104 to 159 (Fe), 42 to 61 (Mn), 53 to 60 (Zn), 30 to 37 (Cu), 5.8 to 8.6 (Co), 3.3 to 5.1 (Pb) and 4.0 to 7.4 (Ni) mg/kg. Trace metal contents in rice grain at 50 and 100% NPK level added with 10 tonnes farmyard manure did not vary significantly with 4 and 8% flyash levels. Data reveal that with 8% flyash incorporation in soil, trace metal content in rice grain was not much influenced. But, this is not true for Ni content of rice grain which showed a significant rise (7.6 mg/kg) at 8% level compared to that at 4% level of flyash addition (4.4 mg/kg). The results obtained are in conformity with the findings of Page *et al.* (1979) and Rao *et al.* (1990). The study points out the need to monitor the trace metal levels (especially Ni, Pb) in plants grown in flyash dumps. Trace metal uptake by rice crop showed similar trends as in case of yield with different treatments. Graded levels of flyash incorporation in soil significantly increased the uptake of trace metals by rice crop. Higher uptake of Pb, Ni and Co by rice grown in flyash amended soil was recorded as compared to that treated with farmyard manure or that not treated with flyash.

Trace metal availability in soil

Flyash did not significantly influence the availabiltiy of Fe and Mn in soil. Similar was the situation with most of the trace metals. Flyash incorporation in soil along with farmyard manure and chemical fertilizers showed an increase in trace metal availability in soil (Table 3). This could primarily be due to farmyard manure application. It is apparent from the results that under waterlogged situation, the availability of trace metals were not affected by flyash incorporation in the soil.

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Development rate and growth duration of rice (*Oryza sativa*) in response to delayed transplanting

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ABSTRACT

An experiment was conducted during 1994–95 at Cuttack on the effect of delayed transplanting on the rate of development and duration of growth in rice (*Oryza sativa* L.) over 2 sets of seedlings differing in their age at the time of transplanting on alluvial soil (haplaquept). Number of days and of growing degree-days to reach active tillering, panicle initiation, flowering, milky white grain and 80% panicle ripe were computed. Yield, panicle weight and test weight were measured, and straw yield and vegetative growth index were calculated. Correlations were calculated for these values with number of days and with number of growing degree-days at each stage of development. In delayed transplanting, significant correlations occurred between yield factors and growing degree-days, rate of development and duration of growth. Number of days to reach each stage of development was significantly reduced by delayed transplanting, whereas there was no reduction in number of growing degree-days. On entry mean basis, neither number of accumulated growing degree-days nor number of days was correlated with grain yield, straw yield or test weight. Both the parameters could be useful for predicting rate of development and duration of growth; however, since number of growing degree-days is less variable throughout the season, its use is beneficial.

Key words: growth stages, growing degree-days, rice, *Oryza sativa*, seedling age, transplanting date, temperature

The response of plant development and growth to temperature was noted by Reamure in 1735. He proposed the thermal constant concept which evolved into the heat unit and growing degree methods for determining plant response to temperature (Nuttonson 1948). Although crop development from transplanting to flowering can be influenced to some extent by factors such as energy supply, humidity, nutrients and water stress, it is principally controlled by temperatures and photoperiod (Ritchie 1993, Horie 1994, Shaykewich 1995).

Rice (*Oryza sativa* L.) is sensitive to variable temperature and moisture at different stages of plant development (Manalo *et al.* 1994). Manalo *et al.* (1994) and Gao *et al.* (1992) found that anthesis is the most sensitive stage to tempereature extremes. Summerfield *et al.* (1992) reported that high temperatures reduced duration of both vegetative and reproductive phases of rice plant development, but the effect on the reproductive phase was less pronounced that on the vegetative phase.

We assessed the effects of temperature and delayed transplanting on the rate of development, duration of growth, and yield of rice to determine whether number of days or number of growing degree-days was the better predictor of plant development.

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MATERIALS AND METHODS

The materials used were 7 cultures of rice viz, 'IET 13231', 'IET 13232', 'IET 13238', 'IET 13239', 'IET 13285', 'Ratna' and 'Vikas'. All entries were sown in field on 3 dates with 2 sets of seedlings differing in their age (30 and 45 days) at the time of transplanting. The field studies were conducted on an alluvial loam soil (Haplaquept) at the Institute, Cuttack during 1994–95 and replicated thrice. A plot size of 12 m^2 area with 20 cm x 15 cm spacing was followed. The seedlings at 30 and 45 days were planted on 15 July (I planting), 30 July (II planting) and 14 August (III planting). Normal fertilizer dose (50 kg N in 3 splits–50% at planting and the rest in equal doses at the mid-tillering and booting stages, 11 kg P and 21 kg K/ha as basal) were followed.

Rate of plant development was assessed as the number of days from transplanting to tillering, panicle initiation, flowering, milky white grain and 80% panicle ripe stages. Number of days to a certain stage was recorded when half of the plants in a plot were at that stage. Plants from 1 m^2 area were harvested at ground level and air-dried. Each bundle of culms was weighed to give biological yield; then the bundle was threshed and grain weight and test weight were recorded. Grain yield was computed from the weight of the threshed seed. Harvest and vegetative growth indices were calculated.

Continuous readings of temperature (daily minimum and maximum), relative humidity and precipitation were recorded at the experimental site. The growing degree-days on per day basis were calculated according to the formula by Nuttonson (1948).

GDD = [Daily minimum temperature + daily maximum temperature]/2–base temperature

where daily minimum temperature is 10°C if the actual daily minimum temperature is $\leq$ 10°C, daily maximum temperature is 30°C if the actual daily maximum temperature is > or <30°C; and base temperature is 10°C (Gadekar *et al.* 1988). Data from each transplanting date in each seedling age were analyzed as being from separate experiment. For statistical analysis, seedling age and transplanting dates were considered as random variables and then entires were fixed. All tests of significance were conducted at the 0.05 level unless otherwise indicated.

RESULTS AND DISCUSSION

The growing degree-days and the number of days to reach panicle initiation, flowering and 80% panicle ripe differed significantly between the sets of seedlings with different age indicating the variations in plant ontogeny. Co-efficient of variation for number of days to developmental stages ranged from 0.7 to 6.9%, whereas it ranged from 0.9 to 7.7% for number of growing degree-days. By delaying the transplanting of 30-day-old seedlings, the number of days to reach any stage of rice plant devleopment decreased. The decrease was significant between the I and II transplanting stages. But, with the 45-day-old seedlings, the differences due to delayed transplanting were less pronounced.

The growing degree-days required to reach all 5 stages of development in 30-day-old seedlings were generally maximum at followed by I and III transplanting dates. At active tillering, the growing degree-days showed trends of maximum at II followed by I and III transplanting dates. In the case of 45-day-old seedlings, the growing degree-days to any stage of development except 80% panicle ripe were highest at the I transplanting date. Generally, the growing degree-days requirement to reach any stage of plant development was less subject to a constant downward trend over the transplanting dates than the number of days required to reach any stage of development. For example, in both sets of seedlings with 2 different ages, the number of days required to reach any stage of development at particular transplanting date differed significantly from those of all other transplanting dates, whereas the differences in the growing degree-days were not significant. Delayed transplanting of 30-day-old seedlings had no effect on biological yield or harvest index and no signifiant effects on grain and straw yields, and test weight (Table 1). In 45-day-old seedlings, transplanting date had no effect on the bundle weight or straw yield, but grain yield, harvest index and test weight were significantly reduced by delayed transplanting.

Table 1 Means and least significant differences (LSD) for grain yield, harvest index, straw yield and test weights of rice transplanted on different dates with 30- and 45-day old seedlings

Date of transplanting	Trait			
	Grain yield (t/ha)	Harvest index (%)	Straw yield (t/ha)	Test weight (g/1000 seed)
30-day old seedlings				
15 July (I)	3.49	43.37	4.51	19.5
30 July (II)	2.82	41.21	4.02	18.5
August 14 (III)	2.68	38.62	4.27	19.7
LSD	0.266	NS	0.256	0.741
45-day old seedlings				
15 July (I)	2.81	38.18	4.48	18.7
30 July (II)	2.27	38.51	4.37	17.8
August 14 (III)	2.57	36.72	4.42	17.4
LSD	0.211	1.941	NS	0.65

Delayed transplanting of seedlings with both age groups led to increase in vegetative growth index, whereas duration of vegetative growth based on number of days until heading decreased. Changes in growth duration to various stages due to delayed transplanting were most pronounced for flowering and 80% panicle ripe indicating that these stages could be optimal for studying the response of rice plant to delayed transplanting. Nass and Reiser (1975) showed that wheat genotypes with high grain filling rate and short grain-filling duration produced high grain yields, especially in areas with a short growing season. In support of this theory, straw yield was decreased. In areas with long growing season, it might be desirable to select short rice genotypes with decreased vegetative biomass (or straw yield) while maintaining duration of vegetative growth similar to the normal duration for the area. Recent rice breeding has put emphasis on selecting genotypes with decreased growth duration but increased vegetative growth rate (Khush 1995, Muralidharan *et al.* 1996). A balance between growth rate and duration of growth leads to phenotypic plasticity for yield.

With the 30 and 45-day-old seedlings, factors other than temperature limit the value of using the accumulated growing degree-days for predicting development of rice plant. For example, solar radiation was much below than the normal and low solar radiation could cause over estimation of the number of effective growing degree-days per month. Neither the growing degree-days nor duration of growth could be useful to predict grain yield, harvest index, straw yield, or test weight with any degree of accuracy. With the exception of extremely early transplanting dates, the growing degree-days predicted when the rice plants would reach various stages of development with greater precision than did duration of growth as measured by number of days to a given developmental stage. Lommis and Cornor (1992) also observed that the relative variation of any heat unit method is

Table 2 Correlations of number of days and accumulated growing degree-days required to reach various stages of development, and of vegetative growth index with grain yield, harvest index, straw yield and test weight on an entry mean basis

Date of transplanting	Trait			
	Grain yield (tonnes /ha)	Harvest index (%)	Straw yield (tonnes/ ha)	Test weight (g/1 000 seed)
Active tillering				
GDD	0.367	0.634	–0.693	0.598
Days	0.269	0.536	–0.675	0.603
Panicle initiation				
GDD	0.247	0.717	–0.679	0.584
Days	0.201	0.465	–0.651	0.575
Flowering				
GDD	0.148	0.743	–0.804*	0.591
Days	0.115	0.430	–0.845	0.478
Milky white				
GDD	0.091	0.662	–0.717	0.591
Days	0.152	0.426	–0.685	0.550
80% panicle ripe				
GDD	0.086	0.372	–0.788*	0.539
Days	0.220	0.509	–0.771*	0.524
Vegetative index	–0.362	–0.621	0.909**	–0.453

*P=0.05, **P = 0.01

considerably less than for calendar days. Horie (1994) emphasized that it is the mean daily temperature which controls crop development to flowering, rather than any specific effect of either day or night temperature. Few of the correlations of grain and straw yield, harvest index, test weight with days or the number of growing degree days to reach various developmental stages were significant (Table 2). In addition, only straw yield was significantly associated with vegetative growth index suggesting that neither growth duration nor developmental rate had much influence on grain yield. The growing degree-days concept predicts development of a crop solely from the accumulated growing degree day units above the base temperature, with no attention being given to the influence of day-length, light intensity, disease, moisture or CO_2 concentration. Incorporation of these factors into a thermal-unit model is to increase its accuracy in designing an ideotype of a crop in a target environment. Our results support the idea that a model that incorporates these additional factors is needed. This will help to optimize productivity by matching ontogeny to the weather of the target environment (Lawn *et al.* 1995) and where unfavourable extremes are unavoidable to minimize their coincidence with more vulnerable stages.

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Effect of population density of *Chenopodium album* on wheat (*Triticum aestivum*)

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ABSTRACT

A study was conducted during 1992–93 on weed density effect of *Chenopodium album* on wheat (*Triticum aestivum* L. emend.Fiori & Paol.) in pots at Mymensingh, Bangladesh. Three densities of the weed (56, 112 and 224/m^2) were established in each of the 3 crop densities (56, 112 and 224/m^2). Results showed that dry matter of wheat/plant, grain yields/plant and weed dry matter/plant were reduced progressively with the increase in both weed and crop densities. However, significantly higher grain yield/pot was observed due to increase in crop density. No effect of weed density on grain yield/pot was noted. The effect of crop and weed density on number of tillers/plant, number of panicles/plant and number of grains/panicle were similar to that of grain yield/plant. The interaction effect of crop and weed density was significant only in weed dry matter/plant when monoculture of weed was included. The crop tolerated the detrimental effects of *C. album* up to weed density of 224/m^2 without much loss in its yield The competitive ability of the weed as measured by aggressivity was significantly higher at low density of weed but it was unaffected under different crop densities.

Key words : *Chenopodium album*, weed density, crop density, aggressivity, wheat, *Triticum aestivum*

Chenopodium album (locally called as *bathua*) is an important weed of wheat (*Triticum aestivum* L. emend Fiori & Paol.) all over the world (Holm *et al.* 1977). In Bangladesh, more than 70% of weed vegetation in wheat is composed of this species (Karim *et al.* 1993). Harrison (1990) reported that a low infestation of *C. album* left uncontrolled for a single season is capable of producing enough seeds to maintain weed population that could exceed economic thresholds for several years. Since the competitive relationship between crop and weed are density dependent (Firbank and Watkinson 1985), the knowledge on the effect of different densities of *C. album* and that of wheat on yield of the crop is important to make weed control decisions. Although the effect of weed competition on wheat in mixed population of weeds was studied in the country (Khan and Rahman 1975, Khan *et al.* 1976, Shaha 1986) information on the effect of different densities of *C. album* on wheat is not available.

The competitiveness of a weed is dependent on a number of factors, among which the effect of crop density is important (Medd *et al.* 1985). In general, under higher number of crop plants/unit area less growth of weed is occurred and vice-versa. Optimum plant density of wheat at which the competitive effect of *C. album* can be minimised to the economic threshold level is not known in Bangladesh. An investigation was, therefore, undertaken to observe the effect of different densities of *C. album* on the growth and yield of wheat and the effect of different densities of wheat on the growth and development of the weed and wheat, and also the effect of different densities of weed and wheat on the competitiveness of *C. album*.

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MATERIALS AND METHODS

Establishment of weed and wheat seedlings

Pot-experiment was conducted in the net house of the department of agronomy of the university at Mymensingh, during November 1992 to March 1993. Pots (30 cm diameter x 30 cm depth) were filled with silty loam soil mixed with cowdung @ 70 g/1 kg of soil. Urea @ 102 kg/ha, triple superphosphate @ 85 kg/ha and muriate of potash @ 50 kg/ha were well mixed with the soil before sowing of wheat. Three densities (4, 8 and 16 plants/pot) of *C. album* were established. The crop and weed densities were equivalent to 56, 112 and 224 plants/m^2. The treatments were arranged in a split-plot design. Monoculture of crop and weed under those 3 densities were also maintained. The border pots were surrounded by one row of extra pots to avoid the side effects. Wheat seeds were sown as per treatment specification on 1 November 1992 @ 3 seeds/hill. The seedlings of *C. album* were raised from soil reserve, since the soil was collected from the field with heavy infestation of the weed. Post-sowing watering was done to enhance seed germination in the pots. Crop and weed seeds which germinated more or less at the same time, ie after 5–7 days of wheat sowing were used as test materials. Late-germinated ones and weeds of other species were removed time to time from the pots. Uniform distribution of weed seedlings within the pots was maintained by replanting young seedling where necessary. Thinning of wheat seedlings was done after 10 days of crop emergence to maintain the required densities. Weeds matured earlier than the crop and they were harvested on 2 March 1993. The crop was harvested on 10 March. Before harvesting, the plant height, number of tillers, number of panicles/plant were recorded. Wheat grains were separated from the panicles by hand and grain yields were recorded at 14% moisture level. Harvested weed and wheat plants were dried in an oven at 80°C for 72 hours to record the dry weight.

Competitive ability

An additive technique was followed where the density of each components (crop or weed) in a mixture was identical to that of its corresponding pure stand. Aggressivity was used to measure the competitive ability according to the formula

$$AGR=(W_{ab}/W_{aa})-(W_{ba}/W_{bb})$$

where AGR, aggressivity of the weed ("a") in relation to crop ("b"); W_{aa} and W_{bb}, weight/plant of weed and crop, respectively in monoculture; W_{ab} and W_{ba}, weight/plant of weed and crop, respectively in mixtures with each other. The greater value of aggressivity indicates higher competitive ability of the weed (McGilchrist and Trenbath 1971). Aggressivity values of weeds were calculated under different densities of crop and weed. Correlations were studied between yields of crop and weed, and the density of crop/weed. The calculated data were analysed statistically and the mean differences were adjudged as per LSD test.

RESULTS AND DISCUSSION

Effect of weed density

Although the competitive effect of *C. album* rendered the reduction of wheat dry matter, the effect of different densities was insignificant. About 14% dry matter was reduced due to weed competition. However, negative correlation was noticed between the wheat dry matter accumulation and weed density (Fig 1). The rate of decrease was less as the weed density increased.

The grain yield reduced significantly when compared with the weed-free grain yield. However, the comparative effect of 3 weed densities was again insignificant, causing very little yield differences (Fig 2). Campbell (1979) in his pot experiment also found only slight competition of *Chenopodium album* against maize. At the highest weed density (224 plants/m^2) the corresponding dry matter accumulation of weed was only 57 g/m^2 which indicates more intra-specific competition occurred with increase in density and finally the effects of *C. album* on wheat grain was nullified. Less effect of the weed under the highest density was substantiated by the fact of progressive reduction of per plant weight of weed with increase in weed density (Fig 3). Among the yield components, number of tillers/plant and number of panicles/plant were significantly influenced by weed competiton when compared with the weed-free crop. However, plant height, number of grain/panicle and 1000-grain weight were unaffected. Again no difference was observed in the effects of weed density on those plant characters (Table 1).

Effect of crop density

Significant effect ($P < 0.05$) of crop density was found on dry-matter accumulation of weed. Weed dry matter was severely reduced with the increase in crop density. On an average, about 90% of weed dry matter was reduced due to crop competition. The effect of different densities was also significant (Fig 4). However, the competitive effects of wheat on *C. album* decreased with increase in crop density and no difference was found between the effects of 112 and 224 weeds/m^2.

Crop dry matter was progressively reduced with the increase in crop density and significantly lowest values were observed due to the highest density (Fig 5). Number of tillers and number of panicles/plant were also reduced with the increase in crop density, but the plant height, number of grains/panicle and 1 000-grain weight were unaffected (Table 1). Although the grain yield/plant reduced with the increase in crop density, the per pot yield increased significantly (Fig 6). The results indicated that increasing wheat density up to 224 plants/m^2 the crop could produce 2.42 tonnes/ha of wheat which is in the range of optimum yield of the variety. Although the inter-specific competition reduced the values of yield attributes, the overall effects of higher number of plants/unit area might led to higher production of wheat grains. Very little dry-matter production of weed at this crop

Table 1 Effects of density of (a) *C. album* and (b) wheat on the plant characters of 'Sonalika' wheat.

Weed or wheat density (plants/m^2)	Plant characters of wheat				
	Plant height	Tillers (no./plant)	Panicles (no./plant)	Grain (no./panicle)	1 000-grain weight (g)
C. album					
0	68.39	1.60	1.88	29.56	38.73
56	67.22	1.13	1.79	28.87	38.42
112	67.15	1.04	1.76	28.39	38.01
224	65.99	1.00	1.68	28.34	38.01
LSD (P=0.05)	2.79	0.37	0.17	3.14	1.08
Wheat					
56	68.56	2.10	2.69	30.99	36.37
112	68.38	0.89	1.60	28.79	38.82
224	64.63	0.16	1.05	26.59	38.69
LSD (P=0.05)	3.79	0.41	0.39	2.67	3.00

Fig 1 Effect of *C. album* density on the dry matter of wheat

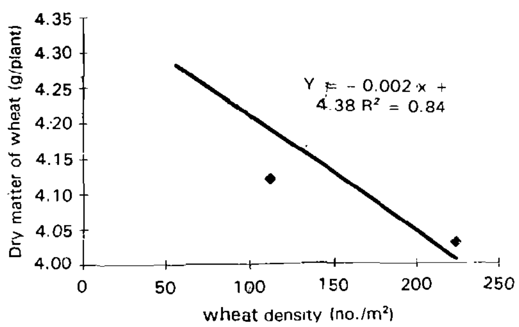


Fig. 2 Grain yield of wheat under different *C. album* densities

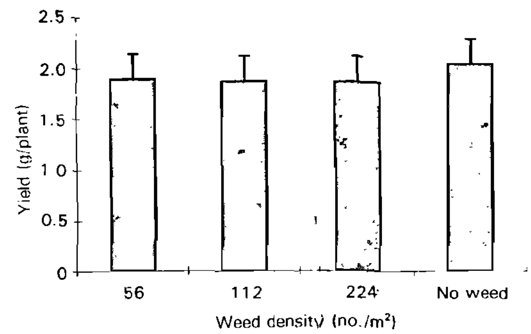


Fig. 3 Effect of *C. album* density on the dry matter of weed

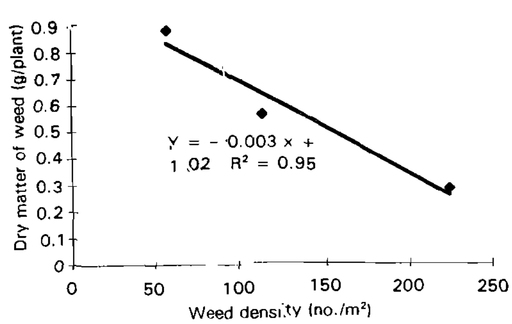


Fig. 4 Dry matter of *C. album* under different densities of wheat

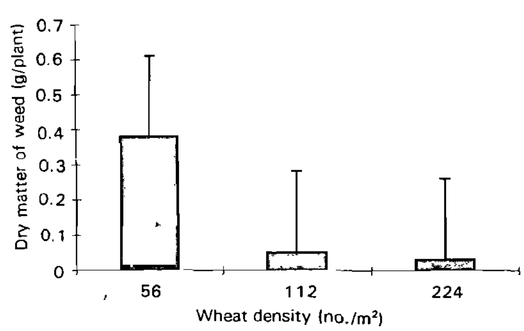


Fig. 5 Dry matter of wheat under different wheat densities

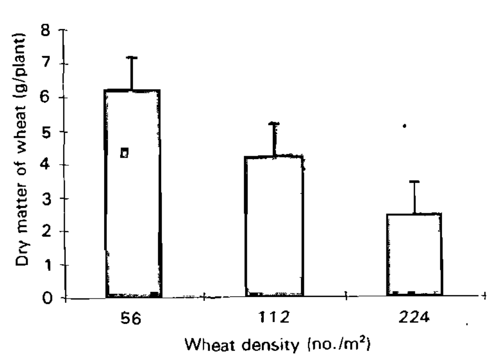


Fig. 6 Grain yield of wheat under different wheat densities

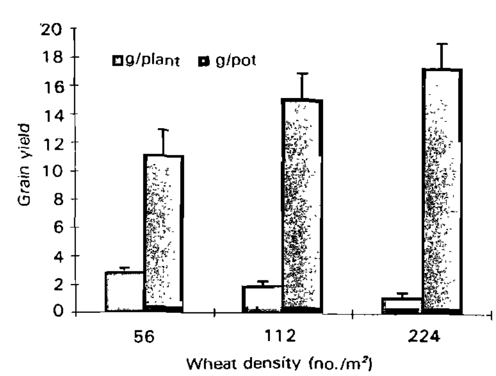


Fig. 7 Aggressivity of *C. album* under different weed densities

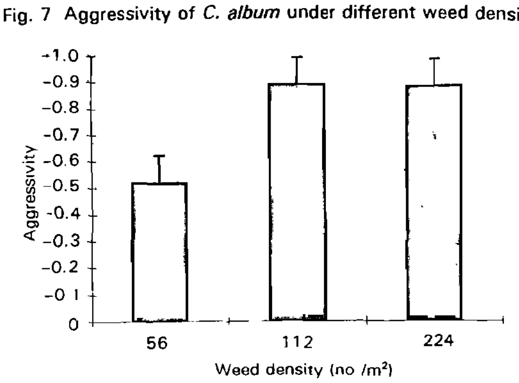
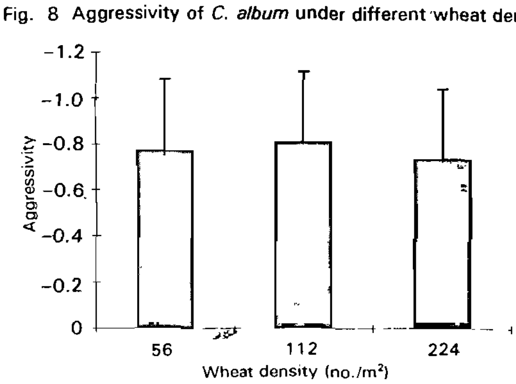


Fig. 8 Aggressivity of *C. album* under different wheat densities



density also related to better performance of wheat under the treatment. The optimum plant population of spring wheat was also reported as 150–300/m² in UK (Lockhart and Wiseman 1988). However, in Bangladesh comparatively less number of plants/m² is used.

The effects of different weed densities on dry matter production of wheat and grain yield was similar under different crop densities. The interaction effect of crop and weed densities was significant on dry matter accumulation of weed/plant when monoculture of weed was included but the effect was insignificant among 3 densities of weed.

Competitive ability of C. album

The competitive ability of *C. album* as measured by aggressivity varied under different weed densities, but it was unaffected under different crop densities (Fig 7). The weed was significantly more aggressive at low density. However, it was similar aggressive under population density of 112 and 224 plants/m². With higher weed density the intraspecific competition increased, which might make the weed weaker against the crop. Similar response of *C. album*, ie more competitive power at low density was also noticed by others (Frantik 1994).

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Effect of moisture-stress and phosphorus levels on the performance of gram (*Cicer arietinum*)

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ABSTRACT

An experiment was conducted during the winter season of 1991–92 and 1992–93 to study the effect of moisture-stress and phosphorus levels on the performance of 'Vishwas' gram or chickpea (*Cicer arietinum* L.) in a split-plot design. Six levels of irrigation (3 irrigations at 25, 50 and 75 days after sowing, 4 irrigations at 15, 30, 45 and 75 days, 2 irrigations at 25 and 50 days, 4 irrigations at 15, 30, 50 and 75 days, 2 irrigations at 45 and 75 days and 1 irrigations at 25 days), at different growth stages of gram were in main plots and 4 levels of phosphorus (0, 11, 22 and 33 kg P/ha) in subplots. Integrated effect of stress-free conditions due to 3 irrigations at 25, 50 and 75 days after sowing with P 22 kg/ha did not reduce seed yield (2.19 tonnes/ha) of gram significantly than the same moisture level with the P 33 kg/ha (2.25 tonnes/ha). Imposing water-stress throughout and providing stress relief only once at 25 days after sowing proved significantly superior (1.39 tonnes/ha) to that providing stress relief twice at 45 and 75 days after sowing (1.16 tonnes/ha) in respect of seed yield. Relief of moisture-stress twice at 25 and 50 days after sowing was equally effective (1.70 tonnes/ha) to stress relief 4 times at 15, 30, 45 and 75 days after sowing (1.74 tonnes/ha) as well as at 15, 30, 50 and 75 days after sowing (1.67 tonnes/ha) in respect of seed yield. The P stress from 22 kg/ha (1.75 tonnes/ha) to 11 kg/ha reduced the gram yield significantly (1.59 tonnes/ha).

Key words : moisture-stress, *Cicer arietinum*, phosphorus, water-stress

Gram or chickpea (*Cicer arietinum* L.) is usually grown on residual moisture in rice fallows on medium black soils of Konkan. In the absence of enough stored soil-moisture, the crop responds to supplemental irrigation (Nimje 1991). However, it is very sensitive to excess soil-moisture (Dahiya and Lather 1990). Only 1 irrigation at 60 days after planting generally increases the seed yield of gram (Patel *et al.* 1991). Gram responds positively up to 26 kg P/ha on soils having low P status (Dadhich and Mali 1991 and Singh and Ram 1991). Hence an experiment was conducted to study integrated effect of water-stress and phosphorus levels to find out judicious management of these factors in gram in rice-fallows on medium black soils of Konkan.

MATERIALS AND METHODS

The field experiment was conducted during winter season of 1991–92 and 1992–93 on medium black soil of Palghar, north Konkan coastal zone, in split-plot design with 3 replications.

The soil was clayey having organic carbon 1.03%, available N 188.16 kg/ha, available P 10 kg/ha (low), available K 147 kg/ha and *p*H 8.28. The field capacity of the soil was 32% and permanent wilting point was 20%, whereas the maximum water holding capacity was 52%. Six levels of irrigation at different growth stages, viz 3 irrigations at 25, 50 and 75 days after sowing, 4 irrigations at 15, 30, 45 and 75 days, 2 irrigations at 25 and 50 days, 4 irrigations at 15, 30, 45 and 75 days, 2 irrigations at 45 and 75 days and irrigation at 25 days, were allotted to main plots and 4 phosphorus levels (0, 11, 22 and 33 kg P/ha) in subplots. The gross and net plot size were 4.5 m x 3 m and 3.90 m x 2.70 m respectively. An uniform basal dose of 45 kg N/ha through urea and P as per the treatments through single superphsophate were applied. Treated seed (Thiram @ 4 g/kg seed) of 'Vishwas' gram was sown in the third week of November at 30 cm x 15 cm spacing and usual weed and pest control measures were followed. A common pre-sowing irrigation was given for all treatments and thereafter irrigations were applied as per the treatments. Quantity of water applied per irrigation was 60 mm. Harvesting of the crop was done during the third week of March and seed yield and other observations were recorded. The pooled analysis of data on seed yield, plant height, branches, pods and grain yield/plant was done and monetary evaluation of the treatment effect was made based on pooled seed yield data.

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RESULTS AND DISCUSSION

Effect of irrigation

Gram crop suffered significant yield loss due to water-stress at 25 days after sowing during 1991–92 as well as in pooled data. However, water-stress at 75 days after sowing was not as detrimental as that at 25 days after sowing. Stress relief at 25, 50 and 75 days after sowing proved significantly superior to rest of the treatments during 1991–92 and in pooled results. Removal of water-stress at 25 and 50 days after sowing only was as effective as that at 15, 30, 45 and 75 days after sowing or at 15, 30, 50 and 75 days after sowing. The stress relief at 15, 30, 45 and 75 days after sowing and at 15, 30, 50 and 75 days after sowing reduced yield due to excess moisture for the crop. The results confirm the finding of Dahiya and Lather (1990). The growth and yield attributing characters also showed similar trend (Table 1). Thus stress relief at 25, 50 amd 75 days after sowing was optimum for gram on medium black soils of Konkan for high yield, whereas providing stress relief at 15, 30, 45 or 50 and 75 days after sowing amounted to excess moisture for gram.

Effect of phosphorus

Application of P increased the yield of gram significantly up to 22 kg/ha beyond which the response was not significant in individual year as well as on pooled basis. Dadhich and Mali (1991) and Singh and Ram (1991) reported response of gram to P up to 26 kg/ha. Similar effect of P stress was evident on branches/plant and seed yield/plant. However, pods/plant showed significant and graded increase up to 33 kg P/ha. The P stress below 22 kg/ha did not reduce plant height markedly (Table 1). Thus P stress below 22 kg/ha

Table 2 Effect of different treatment combinations on seed yield of gram and their economics

Treatment combination	Pooled mean (tonnes/ ha)	Cost of cultiva-tion (Rs)	Gross return (Rs)	Net return (Rs)	Benefit: cost ratio
I_1P_0	1.65	5 432	8 663	3 231	1.60
I_1P_{11}	2.03	5 963	10 658	4 695	1.79
I_1P_{22}	2.19	6 305	11 498	5 193	1.82
I_1P_{33}	2.25	6 557	11 813	5 256	1.80
I_2P_0	1.41	5 238	7 403	2 165	1.41
I_2P_{11}	1.73	5 722	9 083	3 361	1.59
I_2P_{22}	1.85	6 030	9 713	3 683	1.61
I_2P_{33}	1.95	6 319	10 238	3 919	1.62
I_3P_0	1.45	5 229	7 613	2 384	1.46
I_3P_{11}	1.66	5 616	8 715	3 099	1.55
I_3P_{22}	1.84	5 970	9 660	3 690	1.62
I_3P_{33}	1.86	6 187	9 765	3 578	1.58
I_4P_0	1.37	5 209	7 193	1 984	1.38
I_4P_{11}	1.64	5 640	8 610	2 970	1.53
I_4P_{22}	1.84	6 016	9 660	3 644	1.61
I_4P_{33}	1.83	6 210	9 608	3 398	1.55
I_5P_0	0.88	4 731	4 620	-111	0.98
I_5P_{11}	1.15	5 170	6 038	868	1.17
I_5P_{22}	1.30	5 496	6 825	1 329	1.24
I_5P_{33}	1.30	5 701	6 825	1 124	1.20
I_6P_0	1.24	5 024	6 510	1 486	1.30
I_6P_{11}	1.34	5 309	7 035	1 726	1.33
I_6P_{22}	1.49	5 638	7 823	2 185	1.39
I_6P_{33}	1.50	5 852	7 875	2 023	1.35
SEm +	0.03				
CD (P=0.05)	0.09				

Details of treament are given under Table 1
Selling rate of gram seed Rs 5 250/tonne

Table 1 Effect of irrigation and phosphorus levels on growth , yield and yield attributing characters of gram (pooled mean)

Treatment	Seed yield (tonnes/ha)			Height/ plant (cm)	Branches/ plant	Pods/ plant	Seed yield/ plant (g)
	1991–92	1992–93	Pooled mean				
Irrigation levels							
I_1 (25, 50 and 75 days after sowing)	2.57	1.50	2.03	50.80	11.30	52.63	16.38
I_2 (15, 30, 45 and 75 days after sowing)	1.99	1.48	1.74	49.33	10.95	43.70	14.60
I_3 (25 and 50 days after sowing)	2.09	1.32	1.70	49.98	11.78	49.43	13.50
I_4 (15, 30, 50 and 75 days after sowing)	2.19	1.15	1.67	45.25	9.98	35.95	11.38
I_5 (45 and 75 days after sowing)	1.40	0.92	1.16	39.90	7.73	32.25	9.33
I_6 (25 days after sowing)	1.70	1.08	1.39	43.48	9.93	34.60	9.75
SEm ±	0.09	0.06	0.04	1.04	0.33	1.62	0.65
CD (P=0.05	0.28	0.18	0.13	3.77	1.20	5.90	2.38
Phosphorus levels (kg/ha)							
0	1.68	0.99	1.33	45.38	8.25	30.73	9.22
11	1.96	1.22	1.59	45.75	9.72	37.73	10.95
22	2.15	1.35	1.75	46.83	11.23	45.92	14.05
33	2.16	1.40	1.78	47.85	11.90	51.42	15.73
SEm ±	0.01	0.03	0.02	0.44	0.30	0.78	0.38
CD (P=0.05)	0.04	0.08	0.05	1.99	1.35	3.52	1.71

was detrimental to gram on medium black soils of Konkan.

Interaction and economics

Integrated effect of relief of water-stress at 25, 50 and 75 days after sowing and application of P @ 22 or 33 kg/ha proved significantly superior to the rest of the treatment combinations for yield, net return and benefit : cost ratio of gram, suggesting that the availabilty of moisture and P are synergistic for high production and profitability of gram on medium black soils of Konkan (Table 2).

The 2 year pooled results shows that, providing moisture-stress-relief at 25, 50 and 75 days and application of P at 22 kg/ha gives high yield and monetary returns in gram on medium black soils of north Konkan costal Zone.

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Effect of cane trash management on soil-moisture conservation, soil fertility and yield of sugarcane (*Saccharum officinarum*)

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ABSTRACT

A study was taken up on cane trash management through use of compost culture, urea, single superphosphate in relation to soil moisture conservation during ealy part of crop growth, recycling of nutrients and soil fertility improvement in the later part of the sugarcane cultivation. Trash mulching at 3 tonnes/ha and use of composting microbial culture, urea and single superphosphate conserved soil mositure under sugarcane (*Saccharam officinarum* L.) cultivation. Cane trash management helped in conserving soil-moisture in the initial stages of crop growth, which decomposed subsequently by the action of compost culture, urea and superphosphate leading to improvement in soil nitrogen and phosphorus. However, the potassium removal by the crop was higher than the added potassium, thereby leading to depletion of soil reserves. Trash mulching at 3 tonnes/ha and urea application at 10 kg/ha gave highest cane and sugar yields.

Key words : cane trash managment, soil moisture conservation, cane and sugar yields, soil fertility.

Sugarcane is crushed for extraction of juice and sugar manufacture or jaggery making only after removing the cane trash and green tops. On an average the cane trash available is 9–10 tonnes/ha. Generally the trash is burnt in the field itself or used as fuel in jaggery making or for thatching huts. It is estimated that the sugarcane trash contains 0.4% nitrogen, 0.13% phosphorus, 0.12% potassium, 4.65% moisture and 50% organic matter. However, loss of entire nitrogen and part of phosphorous, potassium, magnesium, calcium, sodium and micronutrients due to burning of cane trash was recorded by Ramakrishna Rao and Ramalinga Swamy (1980). In the context of shortage of bulky organic manures and need for integrated nutrient managment in sugarcane; cane trash management is highly important for soil-moisture conservation, fertility improvement and thus increase cane production. It is well known that trash mulching in rainfed areas/areas with limited irrigation facilities conserves soil moisture, especially during the formative phase which conincides with dry summer period in North Coastal Andhra Pradesh. Though recycling of nutrients present in the trash through incorporation into the soil during grand growth period (in the presence of sufficient moisture during rainy season) is practised, the wide C : N ratio, high cellulose and lignin contents make the decomposition process very slow. Shinde *et al.* (1992) indicated that composting microbial culture containing a mixture of five cellulolytic fungi, viz *Aspergillus flavus, Pencellium chrysojenum, Cochilobolus spicifer, Rhizophus oryzae* and *Trichoderma viridi*, was very effective in decomposing the cane trash.

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MATERIALS AND METHODS

Field experiments were conducted at Regional Agricultural Research Station, Ankapalle during 1994-95 to 1996-97 to study the cane trash management effects on soil moisture and nutrient changes and their effect on sugarcane yield and quality. The treatments comprised control (no cane trash application) (T_1), cane trash @ 3 tonnes/ha (T_2), cane trash @ 3 tonnes/ha + compost culture @ 1 kg/tonne of trash immediately after spreading trash and wetting the same with water (T_3), cane trash @ 3 tonnes/ha + compost culture @ 1 kg/tonne of trash immediately after spreading trash + urea at 10 kg/ha sprinkled on the trash at the time of earthing up (T_4), cane trash @ 3 tonnes/ha + urea at 10 kg sprinkled on the trash at the time of earthing up (T_5), cane trash @ 3 tonnes/ha + single superphosphate at 10 kg/ha sprinkled on the trash at the time of earthing up (T_6), cane trash @ 3 tonnes/ha + ureas at 10 kg/ha + single superphsophate at 10 kg/ha sprinkled on the trash at the time of earthing up (T_7), cane trash @ 3 tonnes/ha + compost culture @ 1 kg/tonne of trash along with dung slurry sprinkled on the trash at the time of earthing up (T_8). The experimental soils is a clay loam in texture, neutral in reaction (pH 7.21), normal in conductivity (EC 0.05 m.mhos/cm), low in available nitrogen (223 kg N/ha), high in available phosphorus (64 kg P_2O_5/ha) and potash (362 kg K_2O/ha).

Sugarcane variety 'Co 7219' was planted during February and the treatments were replicated thrice using randomised block design. Trash mulching was done on the third day after planting and compost culture was applied in T_3 immediately after spreading the trash. In rest of the treatments compost culture was applied at the time of earthing up, with the early onset of monsoon. The compost culture was supplied by Agricultural Bacteriologist, College of Agriculture, Pune. Since this is a microbial culture, urea/single superphosphate was applied to energise the microbes and as there was a risk of their survival at higher temperature during summer as well as chances of loss of nutrients from the applied single superphosphate, the compost culture and the energy agents were applied at the time of earthing up. Further the crop had to take the twin advantages of soil moisture conserved during summer due to trash mulching, and, nutrients derived through decomposition of trash. The crop was harvested at 12 months age. Yield data and quality characters were recorded at harvest. The initial and final soil available nitrogen, phosphorus and potassium status was determined by following standard procedures given by Jackson (1973). The soil moisture content to a depth of 30 cm was recorded at monthly intervals from the date of planting till onset of monsoon. The moisture content in soil was determined using the formula :

$$\frac{\text{Loss in weight of soil on drying}}{\text{Oven dry weight of soil}} \times 100$$

The balance sheet of nutrients was worked out as the difference between added nutrients (through fertilisers and trash) and uptake by the crop as well as the difference between intial and final available NPK status of the soil. The balance of added and uptake of nutrients as well as soil nutrients was considered as the change in soil reserves.

RESULTS AND DISCUSSION

The effect of cane trash management on the uptake of nutrients and soil fertility is presented in Table 1. Uptake of nitrogen, phosphorus and potassium increased due to trash mulching @ 3 tonnes/ha (20.30, 1.99 and 24.93 kg/ha respectively). Addition of compost culture immediately after spreading trash resulted in higher uptake of major nutrients than compost culture application at the time of earthing up. Urea application at 10 kg/ha on the cane trash at the time of earthing up, in the absence of compost culture (T_5) resulted in additional uptake of nitrogen, phosphorus and potassium (9.37, 0.52 and 17.45 kg/ha respectively than trash mulching alone. Use of compost culture and urea on cane trash (T_4) resulted extra uptake of 6.31, 4.32 and 3.71 kg/ha of NPK respectively than trash mulching alone (T_2). Phosphorous application as single superphosphate either singly or in combination with urea appear to have no appreciable effect on uptake of major nutrients. When the post harvest soil test value were compared with intial soil test values, depletion in available nitrogen, phosphorous and potassium was recorded in the absence of trash mulching. Cane trash management resulted in either maintainance or addition of nutrients to the soil. When the balance-sheet of nutrients applied and removed in relation to soil test values are considered; lowest amounts of nitrogen (+ 11.56) and phosphorus (+ 69.17) were added to soil reserves and maximum amount of potassium (–16.96) was removed from soil reserves when trash mulching was not done. In case of N and P, added nutrients are higher than the nutrients removed and hence the nutrients were added to soil reserve. However, in case of potassium, the uptake is greater than addition of nutrient and hence depletion from soil reserve was recorded. Sundara and Subramanian (1989) reported that the removal of K was higher than the amount of K applied, whereas lesser N and P were removed than the amount applied in sugarcane based crop rotation. Swamy and Raju (1996) found that despite regular addition of K to all crops in rotation, the applied K was lower than uptake and hence potassium was removed from soil reserves.

The soil moisture content was recorded at monthly intervals from date of planting till onset of monsoon and the data (Table 2) indicate that soil moisture per cent was lower in non trash mulched plots (T_1). Trash mulching at 3 tonnes/ha and different trash management practices resulted in higher moisture content in the soil indicating conservation of soil moisture. Though the moisture content in different cane trash management plots vary much, application of urea at 10 kg/ha on cane trash (T_4) resulted in higher moisture content in the soil. Soil moisture conservation and reduction in weed growth due to trash mulching was reported by Anonymous (1989).

The effect of cane trash management on the yield and quality of sugarcane is furnished in Table 3.

The cane yield obtained due to cane trash management (86.16 tonnes/ha) was significantly superior to no cane trash treatment (77.40 tonnes/ha). Among the cane trash treatments : cane trash @ 3 tonnes/ha + urea @ 10 kg/ha gave highest cane yield (T_5) which was on par with cane trash @ 3 tonnes/ha + compost culture @ 1 kg/tonnes of trash + urea @ 10 kg/ha (T_4) and cane trash @ 3 tonnes/ha + urea @ 10 kg/ha + single superphosphate @ 10 kg/ha. Cane trash @ 3 tonnes/ha + compost culture @ 1 kg/tonne of trash + urea @ 10 kg/ha either immediately after spreading (T_3) or at the time of earthing up (T_8) though on par with each other, found to be superior to trash mulching @ 3 tonnes/ha alone (T_2).

The sugar yield increased due to trash mulching alone (1.03 tonnes/ha), trash mulching + compost culture (1.65 tonnes/ha), trash mulching + compost culture + urea (2.48 tonnes/ha), trash + urea (2.98 tonnes/ha), trash + single

Table 1 Balance sheet of available N, P and K after sugarcane crop

Treat-ment	Uptake of nutrient (kg/ha)	Applied nutrient (kg/ha)	Balance	Soil test before expt.	Post harvest STV	Balance	Change in soil reserve
Nitrogen							
T_1	71.44	112.0	+40.56	223	194	-29.0	+11.56
T_2	91.74	124.0	+32.26	223	228	+5.0	+37.26
T_3	90.09	124.0	+33.91	223	230	+7.0	+40.91
T_4	98.05	134.0	+35.95	223	236	+3.0	+38.95
T_5	101.11	134.0	+32.89	223	238	+5.0	+37.89
T_6	90.19	124.0	+33.81	223	220	+3.0	+36.81
T_7	79.55	134.0	+54.45	223	230	+3.0	+57.45
T_8	73.30	124.0	+50.70	223	225	+2.0	+52.70
CD (P=0.05)	2.48						
Phosphorus							
T_1	28.83	100.0	+71.17	64	62	-2.0	+69.17
T_2	30.82	103.9	+73.08	64	64	-	+73.08
T_3	33.19	103.9	+70.71	64	66	+2.0	+72.71
T_4	35.14	103.9	+68.76	64	66	+2.0	+70.76
T_5	33.71	103.9	+70.19	64	65	+1.0	+71.19
T_6	29.51	113.9	+84.39	64	68	+4.0	+88.39
T_7	31.09	113.9	+82.81	64	69	+5.0	+87.81
T_8	28.49	103.9	+75.41	64	64	-	+75.41
CD (P=0.05)	0.96						
Potassium							
T_1	113.96	120.0	+6.04	362	339	-23.0	-16.96
T_2	138.89	123.6	-15.29	362	370	+8.0	-7.29
T_3	134.11	123.6	-10.51	362	373	+1.0	-9.51
T_4	142.60	123.6	-19.00	362	378	+16.0	-3.00
T_5	156.34	123.6	-32.74	362	380	+18.0	-14.74
T_6	126.66	123.6	-3.06	362	362	-	-3.06
T_7	145.80	123.6	-22.20	362	375	+13.0	-9.20
T_8	107.65	123.6	-15.95	362	370	+8.0	-7.95
CD*	1.15				16.70		

+ Added to soil reserve, removed from soil reserve

Table 2 Effect of cane trash management on the soil moisture content

Treatment	One month after planting	Two months after planting	Three months after planting
T_1	23.37	23.22	23.43
T_2	24.84	23.92	24.90
T_3	25.22	23.85	24.73
T_4	25.45	24.67	24.48
T_5	25.97	24.87	26.88
T_6	24.53	25.72	23.45
T_7	24.89	24.85	22.85
T_8	25.10	24.36	26.42
CD @ P=0.05	0.74	1.20	

Table 3 Effect of cane trash management on the yield and quality of sugarcane

Treatment	Cane yield (tonnes/ha)	Sugar yield (tonnes/ha)	Sucrose (%)
T_1	77.40	9.25	16.56
T_2	81.59	10.28	17.37
T_3	85.18	10.90	17.63
T_4	89.09	11.73	18.11
T_5	90.91	12.23	18.46
T_6	84.48	10.80	17.53
T_7	88.54	11.37	17.76
T_8	83.33	10.61	17.61
CD (P=0.05)	3.22	0.74	0.88

superphosphate (1.55 tonnes/ha), trash + urea + single superphoshate (2.12 tonnes/ha) over that of no trash mulching (T_1). Similarly, the improvement in juice sucrose per cent due to trash mulching alone was (0.81%), trash + compost culture (1.07%), trash + urea + compost culture (1.55%), trash + urea (1.90%), trash + single superphosphate (0.97%), trash + urea + single superphosphate (1.20%) over that of no trash mulching. However, application of compost culture either immediately after spreading trash (T_3) or at the time of earthing up (T_8) were on par with each other with respect to cane and sugar yields as well as sucrose per cent. Jadhav *et al.* (1985) concluded that direct incorporation of chopped trash @ 10 tonnes/ha + urea @ 8 kg/tonne of trash + cellulose decomposing organism @ 1 kg/tonnes of trash gave significantly higher yield. The millable canes, girth and cane height increased due to incorporation of either chopped or unchopped trash supplemented with 8 kg urea, 10 kg single superphosphate and 1 kg fungal culture with no adverse effect on juice quality (Shinde *et. al*, 1993). The trash mulching has conserved the soil moisture in the initial stages of crop growth, which was decomposed during grand growth period due to the action of micro-organisms (either native or applied) energised by urea and single superphosphate; leading to higher release of nutrients and absorption by cane plants, finally resulting in higher cane and sugar yields as well as juice quality. Thus these results indicate that trash mulching @ 3 tonnes/ha and urea sprinkled on the trash @ 10 kg/ha at the time of earthing up not only conserve soil moisture but also improve soil fertility, cane yield and juice quality.

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Evaluation of soils of Jalgaon district of Maharashtra for cotton (*Gossypium hirsutum*) cultivation

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ABSTRACT

Major soils of Jalgaon District of Maharashtra were evaluated for their suitability for cotton (*Gossypium hirsutum* L.) cultivation and their irrigation requirement. Umarti soil series was found permanently unsuitable (N_2ts) while Lasur and Pimpri series were rated as presently unsuitable (N_1ts). Bodvad and Bhod series were marginally suitable (S_3s) for cotton, while Hingona, Bhava and Dhupa series were evaluated as moderately suitable (S_2ts and S_2t). Slope, soil depth and coarse fragments were the major determining parameters for suitability class. Net irrigation water requirement of different soils was varied between 142–255 mm based on soil depth, plant available water capacity and length of growing period.

Key words : land evaluation, soil suitability, net irrigation water requirement, length of growing period.

Cotton (*Gossypium hirsutum* L.) a major cash crop of central and southern region of India is mainly cultivated on swell-shrink soils (Vertisol and its associated soils) under rainfed conditions. The neglect of surface drainage, inefficient soils, water and crop managment and low input of nutrients in the region resulted in low yield and their stagnation at lower level (Kanwar 1995). Higher level of productivity of cotton can be achieved primarily by proper consideration of soil-site properties (Sehgal 1991) and expanding area under irrigation in central and southern region of India (Anonymous 1994). Therefore, a need is felt to evaluate soil-suitability and irrigation-water requirement for better utilization of soil and water resources for cotton cultivation. Thus, a case study of Jalgaon district representing variety of soils and landforms has been undertaken to evaluate these soils for cotton cultivation.

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Table 1 Site characteristics of soils

Soil Series	Physiography	Elevation (m MSL)	Slope (%)	Erosion	Surface drainage	PAWC* (mm)	LGP** (days)
Umarti	Hill ridge	318	8–15	Very severe	Well drained	38	107
Bodvad	Table land	390	1–3	Moderate	Moderately well drained	45	108
Lasur	Upper pediment	250	3–5	Moderately severe	Moderately well drained	40	107
Bhod	Lower pediment	230	0–1	Slight	Moderately welldrained	92	117
Hingona	pedimont plain	197	1–3	Moderate	Moderately welldrained	216	172
Dhupa	Piedmont plain	167	1–3	Moderate	Moderately welldrained	150	141
Bhava	River terraces	158	1–3	Moderate	Moderately welldrained	192	161
Pimpri	Dissected flood plain	152	3–15	Severe	Well drained	215	172

*PAWC, plant available water capacity; **LGP, length of growing period

MATERIALS AND METHODS

The study area Jalgaon District is located in between 20°15' to 20°30' N latitutde and 74°55' to 76°25' E longitude with total area of 1.16 million ha. The mean annual temperature of the area is 27.2°C (mean maximum summer temperature 37.6°C and mean minimum winter temperature 13.0°C) with average rainfall of 840 mm, thus qualify for semi-arid sub-tropical climate.

Exploratory soil survey in Jalgaon district was carried out to classify different soils (NBSS & LUP 1984). Evaluation of identified soil series for their suitability to cotton cultivatation was done during 1993–94. The important soil-site characteristics and physico-chemical properties of the major identified soil series are presented in Table 1 and Table 2 respectively.

Suitability of the soil for cotton cultivation (Table 3) was assessed by comparing different land qualities with crop requirement (Cys 1985, Sehgal 1991, NBSS & LUP 1994). The soil-site characteristics were expressed in terms of degree of limitations (0, 1, 2, 3, 4) as per the definitions of the criteria of FAO, Rome (1978). Soils found suitable for cotton cultivation were analysed for water requirement for a crop of 180 days duration based on the procedure laid by FAO, Rome (1977) and Anonymous (1971).

RESULTS AND DISCUSSION

Soil suitability

Temperature (mean, maximum and minimum), and relative humidity are optimum for cotton cultivation, however only 740 mm of rainfall during cotton growing season along

Table 2 Physico-chemical characteristics of the soils

Horizon	depth (cm)	Sand (%)	Silt (%)	Clay (%)	Texture	Structure	pH	EC (dS/m)	OC (%)	$CaCO_3$ (%)	CEC cmol (+p/kg)	Coarse fragments (%)	Bulk density (mg/m^3)
Umarti Series-Fine-loamy, mixed, hyperthermic family of Lithic Ustorthents													
Al	0-9	39.2	27.3	33.5	g Cl	ml sbk	6.9	0.20	0.83		30.6	4	1.60
Ac	9-25	37.4	26.0	36.6	g Cl	m2 sbk	7.0	0.20	0.50		31.2	31	1.60
R	25+		Basalt rock										
Bodvad Series-Very fine, montmorillonitic, hyperthermic family of Vertic Ustochrepts													
Ap	0-14	10.7	22.5	66.6	C	m2 sbk	7.1	0.25	0.57	2.9	52.2	3	1.90
Bw2	14-30	12.4	22.2	65.4	C	c2 sbk	7.2	0.20	0.54	2.8	55.4	3	1.90
Cr	30+Weathered basalt												
Lasur Series-Fine, mixed, hyperthermic, family of Typic Ustochrepts													
Ap	0-10	30.7	25.5	43.8	C	m2 sbk	7.5	0.20	0.55		38.2	12	1.82
Bw2	10-26	39.6	19.5	40.9	gC	m2 sbk	7.4	0.30	0.29		37.6	53	1.87
C	26-55+	40.1	17.2	42.7	gC	massive	7.3	0.25	0.26		37.8	65	1.90
Bhod Series- Fine, montmorillonitic, hyperthermic family of Vertic Ustochrepts													
Ap	0-15	13.9	32.4	53.7	C	fl gr	7.8	0.30	0.65	12.1	47.8	12	1.82
Bw2	15-50	19.7	30.5	49.8	C	c2 sbk	7.9	0.25	0.50	12.1	41.4	3	1.87
C	50-75	22.6	29.1	48.3	gC	ml sbk	8.1	0.20	0.39	18.7	40.4	43	1.88
Hingona Series- Fine, montorillonitic, hyperthermic family of Typic Haplusterts													
Ap	0-15	22.6	26.8	50.6	C	fl gr	8.1	0.20	0.44	9.0	47.2	10	1.80
A12	15-40	25.8	18.6	55.6	C	m3 sbk	8.2	0.30	0.43	9.7	50.2	8	1.82
Acl	40-85	22.3	18.1	58.0	C	c3 abk	8.5	0.35	0.40	9.1	52.6	10	1.86
Ac2	85-125	23.8	18.1	58.1	C	c3 abk	8.5	0.30	0.35	9.5	50.2	12	1.86
AC3	125-190	27.5	25.4	47.1	gC	msbk	8.7	0.14	0.28	14.0	43.8	26	1.92
Dhupa Series-Fine, montomorillonitic, hyperthermic family of Chromic Haplusterts													
AP	0-16	27.0	24.6	48.4	C	m2 sbk	7.4	0.20	0.41	0.7	46.0	7	1.80
Acl	16-53	23.0	23.2	53.8	C	m2 sbk	7.6	0.20	0.32	0.6	48.0	2	1.80
AC2	53-75	39.9	23.1	37.0	C	m2 sbk	7.1	0.20	0.25	7.1	36.2	12	1.80
Cr	75-150+	54.9	18.1	27.0			8.9	0.20	0.31	6.4	33.0		
Bhava Series- Fine, mixed, hyperthermic family of Typic Ustochrepts													
Ap	0-15	43.0	23.7	33.3	Cl	ml sbk	7.8	0.20	0.49	3.9	30.2	11	1.70
Bwl	15-50	29.3	34.7	36.0	C	m2 sbk	7.6	0.20	0.36	6.1	33.0	11	1.70
Bw21	50-95	31.0	32.1	36.9	C	m2 sbk	7.7	0.20	0.35	6.1	33.2	2	1.70
Bw22	95-145+	27.9	35.5	36.6	C	m2 abk	7.7	0.20	0.31	6.4	33.0		1.70
Pimpri Series- Fine loamy, mixd, hyperthermic family of Fluventic Ustochrepts													
Ap	0-15	27.2	38.5	34.3	Cl	ml sbk	8.6	0.20	0.16	7.7	31.1	2	1.71
Bwl	15-30	35.7	32.4	31.9	gCl	ml sbk	8.9	0.25	0.15	18.8	28.0	4	1.69
Bw2	30-67	44.4	25.0	30.6	Cl	m2 sbk	8.9	0.35	10.13	13.3	25.2	2	1.70
Bw22	67-115	49.9	23.8	26.3	sCl	m2 sbk	8.9	1.70	11.11	13.6	23.2	1	1.70

Table 3 Soil-site suitability for cotton cultivation

Parameters	Soils							
	Umarti	Bodvad	Lasur	Bhod	Hingona	Dhupa	Bhava	Pimpri
Climate (c)								
Total Rainfall (mm)	1	1	1	1	1	1	1	1
Rainfall during growing season (mm)	2	2	2	2	2	2	2	2
Mean temp (°C)	0	0	0	0	0	0	0	0
Mean max. temp (°C)	0	0	0	0	0	0	0	0
Mean min. temp (°C)	0	0	0	0	0	0	0	0
Mean RH (%)	1	1	1	1	1	1	1	1
Soil characteristic								
Topography (t)								
Slope	4	1	3	0	1	1	1	3
Wetness (w)								
Flooding	0	0	0	0	0	0	0	0
Drainage	0	1	1	1	1	1	0	0
Physical characteristics (s)								
Texture	1	0	0	0	0	0	0	0
Structure								
Coarse fragments								
• with in 50 cm	2	0	3	1	1	0	1	0
• below 50 cm	3	2	2	2	0	0	0	0
Depth (cm)	3	3	2	2	0	0	0	0
$CaCo_3$ (%)	0	0	0	2	1	0	1	2
Gypsum (%)	0	0	0	0	0	0	0	0
Fertility characteristics (f)								
CEC (cmol (+p)/kg)	0	0	0	0	0	0	0	0
BSP	0	0	0	0	0	0	0	0
Org. carbon (%)	1	1	1	1	1	1	1	1
Salinity/sodicity (n)								
EC (dS/m)	0	0	0	0	0	0	0	0
ESP	0	0	0	0	0	0	0	0
pH	0	0	0	0	0	0	0	0
Soil suitability classification	N_{2ts}	S_{3s}	N_{1ts}	S_{3s}	S_{2ts}	S_{2t}	S_{2ts}	N_{1ts}

with low plant available water capacity, thus marginal limitations of length of growing period makes Umarti, Bodvad, Lasur and Bhod soils climatically marginally suitable for cotton. Similarly, due to moderate plant available water capacity (100.2 to 143.9 mm) with moderate length of growing period (141 to 172 days) makes Hingona, Dhupa, Bhava and Pimpri soils moderately suitable. Suitability of these soils, however, can be improved by providing supplementary protective irrigation during the critical stages of the crop after withdrawal of monsoon.

Pimpri soils developed on dissected flood plain, with deep wide and numerous gullies due to severe erosion are presently unsuitable (N_{1t}) for cotton cultivation. These soils can be improved to moderately suitable (S_{2s}) by levelling of land and stabilizing gullies by adopting suitable soil and water conservation measures.

Umarti soils formed on moderately sloping (8–15%) hilly ridge are subjected to severe erosion. These shallow soils with high amount of coarse fragments have been evaluated as permanently unsuitable (N_{it}) for cotton cultivation.

Lasur soils developed on gently sloping (3–5%) upper pediment are subjected to moderately severe erosion. These medium deep soils with high content of coarse fragments are presently unsuitable (N_{it}). However after terracing and removal of coarse fragments/stones from the surface soils, which restricts tillage operations, these soils can be upgraded to moderately suitable (S_{2s}).

Bodvad soils developed on very gently sloping tableland and Bhod soils on lower pediment are moderately well drained and subjected to moderate erosion. These marginally deep soils are moderately suited for root growth of cotton. In addition to this Bhod soils have 7% coarse fragments in surface soil while it increase to 43% in sub-surface along with moderately high amount of $CaCO_3$ and thus these soils are marginally suitable (S_{3s}) for cotton cultivation.

Hingona and Dhupa soils occurring on very gently sloping piedmont plain and Bhava soils on river terrace are deep, well drained to moderately well drained and slightly eroded with good plant available water capacity and fertility status except moderate content of organic matter. Therefore, these soils are moderately suitable (S_2) for cotton cultivation.

Net irrigation water requirement

Due to occurrence of these soils in the same climatological region and of some crop duration, the total crop water requirement is almost same. The minor difference is due to the soil depth. Shallow soils restricts penetration of roots to deeper layers and thus plant growth is adversely affected. Out of suitable soils, the maximum net irrigation water requirement of 255 mm was estimated for Lasur soils, while minimum net water requirement of 142 mm was for Bhava soils. The irrigation requirements for other soils are 236 mm, 216 mm, 183 mm, 241 mm and 183 mm for Bodvad, Bhod, Hingona, Dhupa and Pimpri soils respectively. The major reasons for this is the soil depth, PAWC and length of growing period of the soils. In general, with an increase in soil depth, plant available water capacity and length of growing period, the net irrigation water requirement is reduced. The date of first irrigation is estimated to be 19 September for Lasur soils, 26 September for Bodvad soils, 8 November for Hingona and Pimpiri soils. The number of irrigation varies from only one in Hingona, Bhava and Pimpri soils to 8 in Lasur soils with an irrigation intervals of 12 to 52 days depending upon the type of soils. The relationship between the net irrigation requirement and major soils-site factors can be presented as-

$$N = 1.12 \times d - 1.86 \times PAWC + 1.25 \times LGP + 160.05$$
$$R^2 = 0.81$$

where N, Net irrigation water requirement (mm); d, effective soil depth (cm); PAWC, plant available water capactiy of soil (mm); LGR, length of growing period (days).

Crop management

Soils studied have high amount of exchangeable cations (CEC > 30 cmol (+p)/kg) along with high base saturation percentage (BSP>90) which shows high inherent capacity of soils for crop production. However, exchange complex is dominated by Ca and Mg, which shows excess of these cations but the ratio between Ca and Mg is less than 3:1 which results in less availability of Ca to plant and inhibiton of P in all soils (Landon 1984 and Murthy *et al.* 1996). Therefore, phosphate fertilizers application in splits at 50 cm below soil surface (Basu 1992) and as foliar spray (Venugopalan *et al.* 1995) may increase the P-fertilizer use efficiency. Similarly, the exchange complex is low in exchangeable potassium (Gajbhiye *et al.* 1992). Therefore, there is likelihood of positive response of potassic fertilisers (Zende 1978 and Gajbhiye *et al.* 1994). These soils are formed from the basaltic parent material or basaltic alluvium and thus develop cracks when deficient in moisture, which further accelerate water loss from the soil. This water loss can be minimised by adopting broad base furrows to increase the cotton yield (Sagare and Bhongle 1993). The findings show that as the suitability of soil-site for cotton cultivation decreases the net irrigation requirement and number of irrigations increases to produce optimum/maximum production. It makes cotton cultivation uneconomic on marginally suitable soils. Therefore soils like Umarti, Lasur and Bodvad should be put under cultivation of some other less water requiring land use like pasture, agro-forestry, sorghum, soybean and groundnut cultivation, etc.

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Population dynamics and growth of *Galinsoga ciliata* in relation to method of cultivation, crop type and altitude

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ABSTRACT

Population dynamics and growth (dry-matter yield) of *Galinsoga ciliata* (Rafin.) Blake a serious weed in hill agroecosystem of Meghalaya was studied for two years in radish (*Raphanus sativus* L.) and maize (*Zea mays* L.) fields under slash and burn agriculture (*jhum*) and terrace cultivation situated at high and low altitudes of Meghalaya, north-east India. Two to three seedling cohorts were recruited in the crop fields at the low altitude, while at high altitude seedlings were recruited invariably in three successive cohorts. Seedling emergence in the first cohort was significantly higher than in the second and/or third cohort. Associated crop, method of cultivation and altitudinal variation significantly influenced seedling recruitment and survivorship and half lives of cohorts of *G. ciliata*.

Key words : *Galinsoga ciliata*, population dynamics, cultivation, crop type, altitude

Galinsoga ciliata (Rafin.) Blake is a serious weed, and it is found abundantly in the crop fields of Meghalaya state. As its seeds lack dormancy (Ivany and Sweet 1973), seedling recruitment takes place whenever temperature and moisture conditions become favourable (Usami 1976). Consequently, within a given crop cycle several cohorts of seedling emerge at different time intervals in the Meghalaya region (Rai and Tripathi 1984). Although *G. ciliata* has been the subject of many recent studies (Rai and Tripathi 1982, Rai and Tripathi 1983 and Rai and Tripathi 1985), the effects of associated crops, cultivation method and altitudinal variation on growth and population behaviour of this weed are unknown. Therefore, a study was undertaken on the population dynamics and growth of *G. ciliata* in two different crops cultivated at high and low altitudes in Meghalaya.

MATERIALS AND METHODS

The study was carried out in crop fields under slash and burn (*jhum*) and terrace cultivation at high altitude at Upper Shillong (1825 m above mean sea-level 25°34 N, 91°56 E) and at low altitude in experimental fields of the Farming System Research Project, Barapani (952 m above mean sea-level 25°28 N, 91°53 E). The Farming System Research Project in micro-watersheds was initiated in 1984, when bench terraces were introduced along the slope of the watersheds. Study at higher altitude was conducted in 20 years old terrace fields of the Central Potato Research Station (CPRS) farm and in *jhum* fields owned by a local farmer (4 km away from CPRS). The *jhum* fields were left fallow for a period of four years before the start of recropping in 1987.

The soil of the study site at Upper Shillong was sandy loam and acidic in nature (pH 5.1-6.6), and at Barapani it was clay loam and acidic (pH 5.5). Average annual rainfall is 2500 mm, of which about 65-90 per cent occurs during summer months (May-September). The maximum and minimum temperatures during summer ranged between 24°C and 9°C at Upper Shillong and 28° and 14°C at Barapani. Winter (November-February) is characterised by low temperature (maximum 11°C and minimum 2°C at Upper Shillong and 16°C at Barapani), with occasional light showers and frost.

Three replicates of radish and maize fields, each of 2500 m^2 size, were randomly selected at Upper Shillong and Barapani during August 1988 for the study. Radish was planted on 14 September 1988 and 14 August 1989 at Upper Shillong; and 7 November 1988 and 1989 at Barapani. Maize was planted on 14 April 1989 and 1990 at Upper Shillong; and 28 February, 1989 and 14 February 1990 at Barapani.

In each field, seven permanent quadrats of 50 x 50 cm were randomly laid immediately after crop sowing. The size and number of quadrats were determined according to Misra (1968). *G. ciliata* seedlings, which emerged in different clear-cut batches at different times were marked with waterproof paints in their cotyledons as well as on the first eophyll as done by Yadav and Tripathi (1981) in an earlier study. The first batch of *G. ciliata* seedlings emerged within 8-10 days of crop sowing along with the crop seedlings, while the second and third batch emerged after 15 and 45 days later than the

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first batch in all fields, except in radish at Barapani, where only two batches of weed seedlings were identified and the second batch emerged 45 days later than the first. Seedlings of different batches were marked with waterproof pains of different colours. Batches were designated as cohort I, II and III. Survival of marked seedlings in each cohort was monitored fortnightly until crops were harvested. Half-life (time from emergence to 50% survival) (Rai and Tripathi 1984) and mortality pattern of cohorts were studied using time series density data.

For growth studies, ten additional quadrats of 1 m^2 size were randomly laid in each field after crop sowing. Each quadrat was divided into four 50 x 50 cm small quadrats. Weed biomass was determined fornightly by collecting plants of different cohorts from four randomly selected small quadrats up to crop maturity. In each small quadrat shoots were clipped and roots were extracted from soil down to 25 cm depth and separated from soil by washing. Dry weight was determined by oven-drying the shoots and roots at 80°C to a constant weight. Data on percentage emergence of *G. ciliata* and half-life of cohorts were analysed using three-way ANOVA (fixed effects model) (Zar 1974). Survivorship curve slopes for different cohorts were compared by using procedure of covariance analysis followed by Tukey's test for multiple comparison among slopes (Zar 1974). Data on dry matter production as influenced by cultivation and type of crop were analysed through two-way ANOVA (Zar 1974).

RESULTS AND DISCUSSION

Seedling emergence

At Upper Shillong, 45-66 per cent of the *G.ciliata* seedlings emerged in the first cohort, 22–39 per cent in the second cohort and 7–27 per cent in the third cohort (Table 1). The differences between cohorts were significant ($P<0.01$) during both years; however, variation between crops, and between *jhum* and terrace fields were not significant. Seedling emergence (%) in the first cohort was significantly higher at lower altitude than at higher altitude. There were three cohorts of seedlings in maize fields at both the altitues, but in radish fields only two seedling cohorts could be recognised at lower altitude (Table 1). Seedling emergence in the first cohort was always significantly higher than the second cohort. At higher altitude, recruitment of *G. ciliata* seedlings in radish under terrace cultivation (394 plants/m^2) was significantly (ANOVA $P<0.01$) higher than *jhum* (210 plants/m^2) as well as in the radish fields located at lower altitude (61 plants/m^2) ($P<0.01$). This trend was reversed in the maize fields. Seedling emergence is greatly influenced by many factors such as burial depth (Benjamin 1990), light (Van der Toorn and Pons 1988, Baskin and Baskin 1990), soil moisture (Eddleman and Romo 1988 , Fernandez-Quintanilla *et al* 1990), soil temperature (Eddleman and Romo 1988, Egley 1990) and their direct and/or indirect interactions (Schwaegerle and Levin 1990).

A market decrease in size of successive cohorts in *G. ciliata* conforms with the results of Rai and Tripathi (1984) on two species of *Galinsoga*, Ballare *et al.* (1987) on *Datura ferox* and Pandey and Dubey (1989) on *Parthenium hysterophorus* who attributed decline in the population density of successive cohorts to the depletion of non-dormant fraction of seeds in soil.

Table 1 Seedling emergence (%) of *G. ciliata* in different cohorts at higher and lower altitude.

Crop	High altitude			Low altitude
	Cohort	Jhum 1988–90	Terrace 1989–90	Terrace 1988–90
Radish	I	53.0	61.5	81.5
	II	37.0	25.0	21.5
	III	10.0	13.5	0
Maize	I	48.5	58.5	69.0
	II	25.0	35.0	12.0
	III	26.5	9.5	19.0

Survival and half-life of seedling cohorts

A comparison of slopes of survivorship curves for different cohorts revealed significant differences between crops an cultivation practices (Table 2). At higher altitude, all the cohorts in radish fields both under *jhum* as well as terrace cultivation showed higher mortality during first fortnight after emergence than in the later periods, but the third cohort showed more or less uniform mortality throughout its life. High mortality of seedlings within 30 days of their emergence confirms the findings of Hawthorn and Cavers (1976) and Yadav and Tripathi (1981), who assigned this common phenomenon in most colonizing species to keen competition for resources during the active growth phase. At lower altitude, however, mortality in the first and second cohorts was greater during the last fortnight of the cohort-life. In maize all the three cohorts under *jhum* at higher altitude showed greater mortality towards the end of their life. At lower altitude also the mortality pattern towards the end of cohort-life was the same. All cohorts under terrace cultivation at higher altitutde exhibited more or less constant mortality throughout their lives (Fig 1). Larger population density of *G. ciliata* at higher altitude than at lower altitude could be ascribed to the sandy loam nature of soil at the former site, since an increased proportion of sand in soil has been reported to enhance the seed germination of this species (Rai and Tripathi 1982). Higher plant density of *jhum* fields than in terraces was due to greater seed input to the soil seed bank because of inappropriate weeding operations, wherein seed bearing weed plants are uprooted and often buried in the field (Misra *et al.* 1992).

The half-life of *G. ciliata* significantly (ANOVA $P<0.01$) declined in successive cohorts in both radish and maize fields. In radish fields the cohorts had significantly longer (ANOVA $P<0.01$) half-life in terraces (3.0–10.0 weeks) than in *jhum* fields (2.5–9.5 weeks) at higher altitude. In maize fields,

Table 2 Covariance of slopes of the survivorship curves *G. ciliata* under *jhum* and terrace cultivation at higher and lower altitude

Crop	High altitude				Low altitude Terrace	
	Jhum		Terrace		1988–90	1989–90
	1988-89	1989–90	1988-89	1989–90		
Radish F	2.56	4.95	4.91	1.44	7.14	17.02
DF	8	8	8	8	5	5
P	0.25	0.05	0.05	NS	0.05	0.01
Cohorts compared	$I^{a}II^{ab}III^{b}$	$I^{a}II^{a}III^{b}$	$I^{a}II^{a}III^{b}$	I II III	I II	I II
Maize F	0.39	1.73	0.60	3.89	16.81	1.06
DF	14	14	3	4	14	14
P	NS	NS	NS	NS	0.01	NS
Cohorts compared	I II III	I II III	I II III	I II III	$I^{b}II^{a}III^{a}$	I II III

The cohorts with same letters did not differ significantly, while those marked with different letters differed significantly (P<0.05) among themselves.

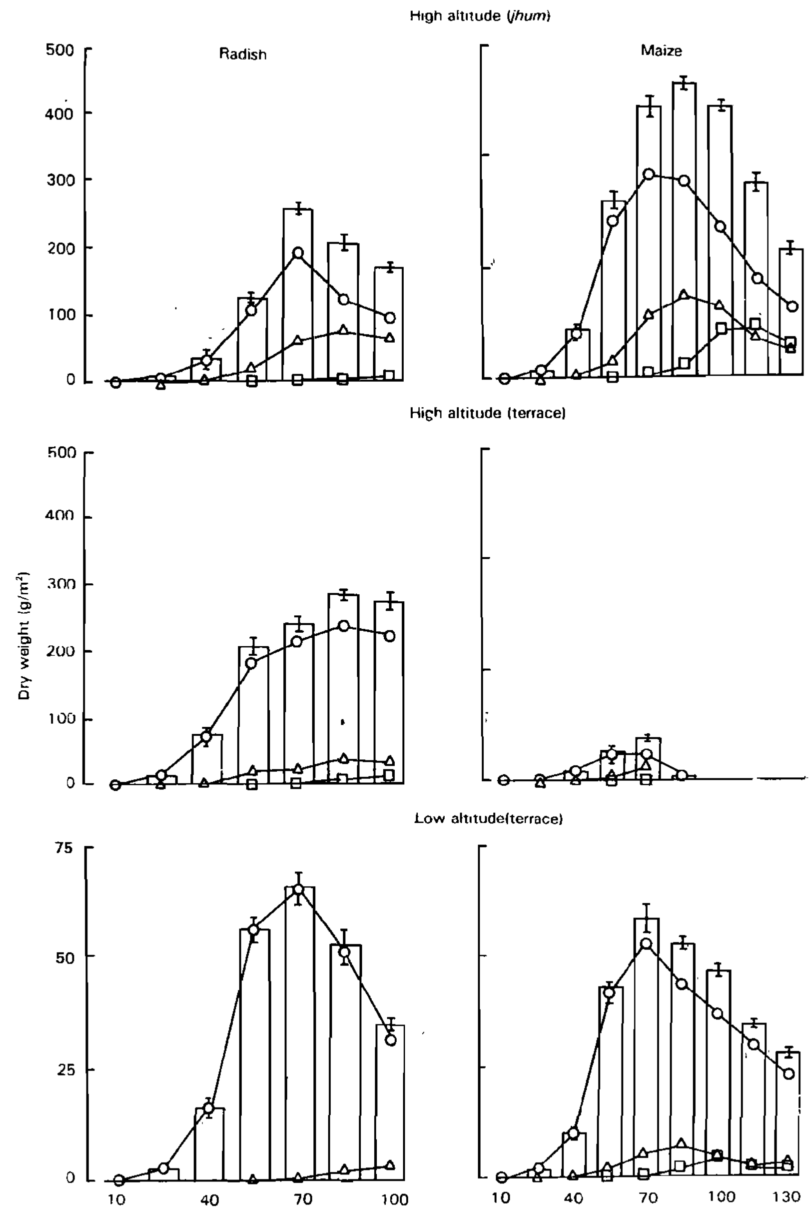

Fig 1 Survivorship curves of different seedling cohorts I, (-0-); II (-▲-) and III (-■-) of *G. ciliata* in radish and maize fields under *jhum* (—) and terrace (--) cultivation at higher altitude and terrace (—) cultivation at lower altitude. Vertical lines indicate ± SE

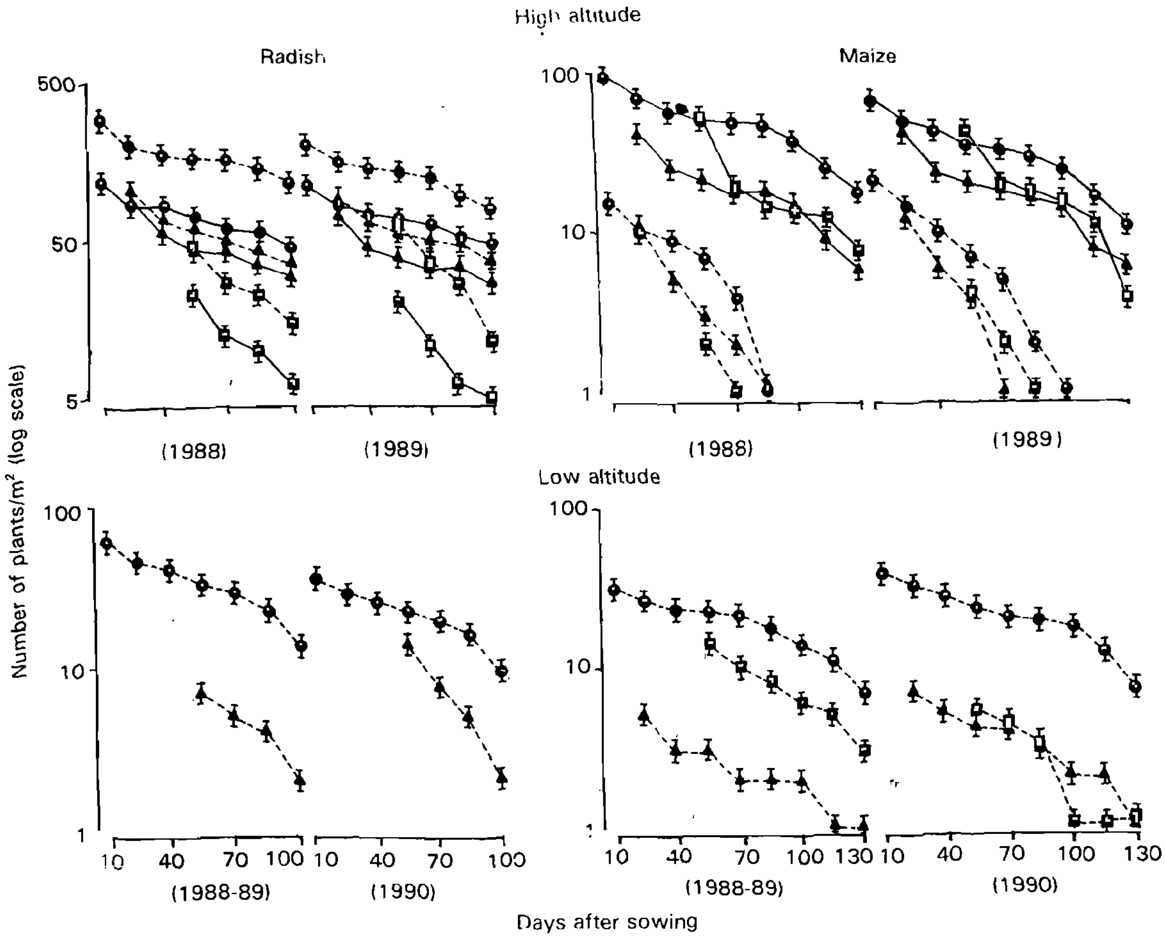

Fig 2 Dry matter yield (g/m²) of different cohorts I, -0-; cohort II, (-▲-) --; cohort III, (-◘-) and total dry matter production (bars) of *G. ciliata* in radish and maize fields under *jhum* and terrace cultivation at high altitude, and terrace cultivation at low altitude. The figure is based on pooled data for 1988-89 and 1989-90. Vertical bars indicate ± SE

Table 3 Half-life (weeks) of seedling cohorts of *G. ciliata* under *jhum* and terrace cultivation at higher and lower altitude

Crop	Cohort	High altitude				Low altitude Terrace	
		Jhum		Terrace		1988–89	1989–90
		1988–89	1989–90	1988–89	1989–90		
Radish	I	9.5	9.5	10.5	9.5	8.0	9.0
	II	7.5	5.5	5.0	8.5	4.5	2.5
	III	2.5	2.5	4.0	3.0		
Maize	I	8.0	7.0	5.0	3.5	11.0	9.5
	II	4.0	3.0	2.0	2.0	5.0	7.0
	III	1.5	2.0	2.0	2.0	5.0	4.5

however, half lives of the first and second cohorts were large in *jhum* than in terraces. Half-lives of different cohorts in maize fields at lower altitude were significantly longer (ANOVA $P<0.01$) than those at higher altitude (Table 3).

Weed biomass

The first cohort contributed maximum (74% biomass), whereas the second and third cohorts contributed 24 and 1% respectively to the total weed biomass. The total weed biomass followed more or less a sigmoid growth curve in all fields attaining peak values between 70–85 days after crop sowing.

The study reveals that at higher altitude *G. ciliata* was more successful as indicated by its higher population density, longer half life of its first and second cohorts and greater biomass production in the crop fields under terrace cultivation than in jhum fields. Seedling recruitment and survivorship and half life of cohorts were significantly influenced by the mode of cultivation, crop type and altitude. The growth of the weed too was affected by altitude and crop type as indicated by its poor performance in radish field at lower altitude than at higher altitude where the effect of crop type was not prominent.

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A comparison of soil enzyme activities in forest and tea (*Camellia sinensis*) plantation soil samples

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ABSTRACT

Soil-enzyme activities with respect to rhodanese, phosphatase, and cellulase of samples obtained from land under tea [*Camellia sinensis* (L.) O. Kuntze] cultivation and neighbouring forest land form 3 major tea growing areas of India were evaluated in 1992. The study showed a decreasing trend in cellulase activity in the plantation samples of Assam and Nilgiris compared with the forest samples of that region. Rhodanese activity in the Dooars region was higher in plantation samples but lower in Assam and Nilgiri samples. For phosphatase, the samples from forest of Assam showed a higher activity than the corresponding plantation samples of the region. In all others the phosphatase activity was higher in the plantation samples. Organic carbon values did not appear to have any relationship with cellulase activity detected in the samples. Grouping the samples on basis of yield of tea did not bring about any relationship between yield of tea and enzyme activity pertaining to the enzymes evaluated.

Key words : soil enzyme activity, tea plantations, rhodanese, phosphatase and cellulase

Soil fertility is directly proportional to the type of microbial activity present in the soil. Conventional most probable number counts in a single plating medium as is done for bacterial contamination of food products does not provide information necessary for determining microbial diversity. Therefore, to assess microbial populations in soil under tea [*Camellia sinensis* (L.) O. Kuntze] cultivation, we used earlier (Bezbaruah and Barua 1985, Bezbaruah *et al.* 1995 a & b) enrichment media to determine the population counts of different types of soil bacteria. While this method provides valuable information about the proportion of the bacterial strains which are viable in the enrichment media used for the most probable number counts, it does not provide information about the actual status of microbial transformations possible in the soil environment particularly when the soil is being exposed continuously to an array of agrochemicals. To assess the influence of agrochemicals on the soil microflora, evaluation of enzyme activity in freshly collected soil samples can be considered suitable because most of the influence present in the field can be expected to be present in the soil sample. We therefore analysed cellulase, phosphatase and rhodanese activities of soil samples from forest and land under tea cultivation from 3 major tea growing regions of India. As commercial tea cultivation follows highly organized, preplanned cropping systems including chemical fertilizer and pesticide application programmes, plucking and pruning cycles and maintain accurate records of yield in individual sections grouped on the year of planting of the tea plant, the soil under tea cultivation was considered as the ideal material to study the effects of long term cultivation.

[1] Project Leader and Head,, [2,3] Scientists

MATERIALS AND METHODS

Soil samples from forests and land under tea cultivation were collected from the same regions and statictically analysed (Bezbaruah *et al* 1997). Series as in figures are: A; Assam *B*: Dooars and *C*:Nilgiris forest samples used for comparison were from the respective regions similarly collected.

Agrochemicals were applied in the 3 plantations as described by Bezbaruah (1994).

Cellulase assay was performed by incubating 5 g soil overnight at 30°C with 1 g cellulose powder and 5 ml of sterile water for 24 hr. The samples were then filtered and the quantity of glucose present in the filtrate was taken as a measure of cellulase activity. Control values in samples without cellulose powder were substracted from the experimental values in each case. The values were expressed as μg of sugar in 5 g soil samples. Sugar was estimated according to the method of McCready *et al.* (1950).

Phosphatase assay was performed according to the method of Tabatabai and Bremner (1969). The values were expressed as μ moles of nitrophenyl from nitrophenol phosphate cleaved by phosphatases in 5 g soil samples. *Rhodanese assay* was performed according to the method of Tabatabai and Singh (1976). The values were expressed as μ moles of thiocyanate from 4 g soil samples. *Organic carbon* was estimated according to the method of Jackson (1973). The *p*H was determined with a *p*H electrode by soaking 10 g soil samples in 25 ml distilled water overnight.

RESULTS AND DISCUSSION

The significantly low *p*H values found in the plantation samples in comparison to the forest samples particularly of the Dooars and Nilgiri region which in no way related to the age of the section from where the samples were obtained, suggested that the cultural practice of maintaining the plantation samples in the range of 4.5–5.5 was responsible for the soil acidity rather than a change introduced through root exudates of the tea plant. As the soil in Assam is naturally acidic, the slightly higher *p*H values found in plantation samples of Assam are likewise attributable to the measures undertaken to reduce acidity in those plantations (Fig 1).

The carbon source is an important factor for microbial activity in soils. In forest ecosystems the source of carbon comprises almost entirely of plant residues and there is a rapid turnover of both above-and below-ground sources of organic carbon through microbial activity which is not subjected to influences of xenobiotics. But in soils under tea cultivation, the source of organic carbon originates from weeds and insects killed through plant protection chemicals, tea bush prunings which might also contain residues of insecticidal sprays. In addition to this, the organic pesticides applied as fungicides, soil fumigants, herbicides and insecticides also contribute to the organic carbon content of the soil. Horner *et al.* (1988) and Taylor *et al.* (1989) reported that assimilation of carbon compounds by microorganisms is influenced by the structure of the compound. Lignin degradation products, such as catechol are also formed from the degradation of 2,4-D, and both 2,4-D and paraquat incorporated into soil biomass (Stott *et al.* 1983, Ogram *et al.* 1985). Therefore the values of organic carbon concentration in plantation samples may not entirely represent the readily assimilable carbon substrate of all heterotrophs present in the soil environment (Fig 1).

The high values of organic carbon in the Nilgiri samples, which showed reduced enzyme activity in comparison to the forest samples of the region, with respect of rhodanese (Fig 2), cellulase (Fig 3) and urease (Bezbaruah *et al.* 1995) confirms that amendment of organic carbon alone is insufficient to overcome the influences created through cultural practices. The cropping practices followed in the Nilgiri plantations, such as covering the soil with tea bush pruning which is rich in lignin and use of heavy dosage of chemical nitrogen are known to retard lignin degradation (Reid 1983, Zadrazil and Brunnert 1980).

Phosphatases which were higher than the respective forest samples in both Nilgiri and Dooars samples (Fig 4) are also influenced by the cropping practices being followed in the plantations. Perucci and Scarponi (1985) have shown

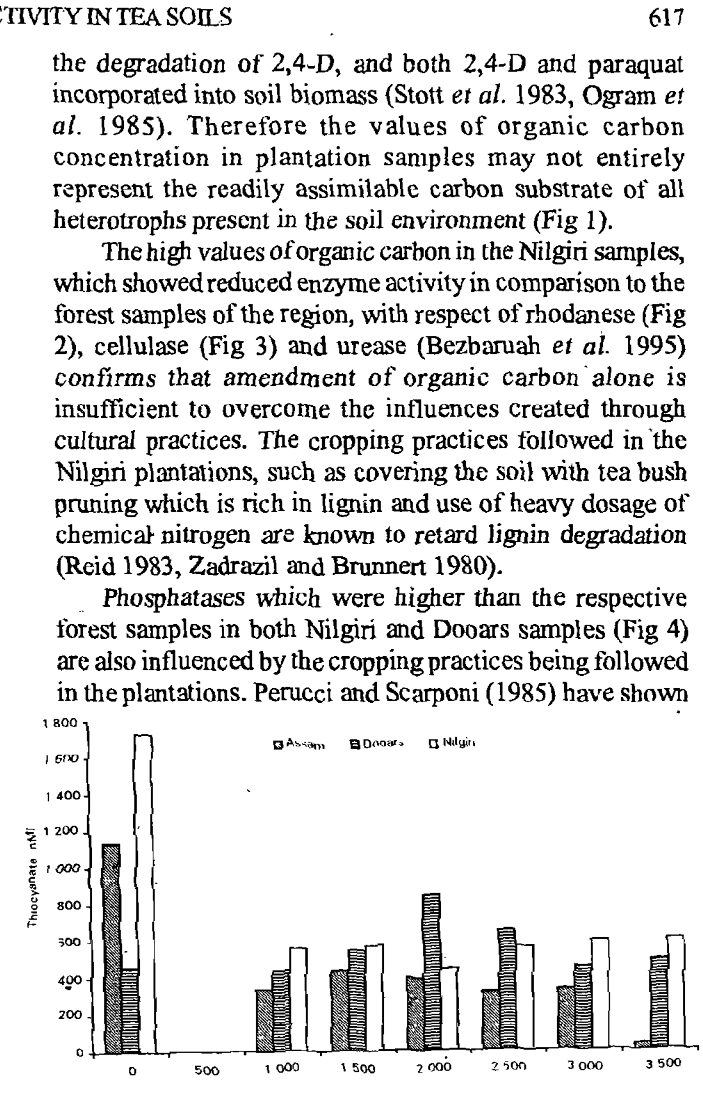


Fig 2 Rhodanese activity

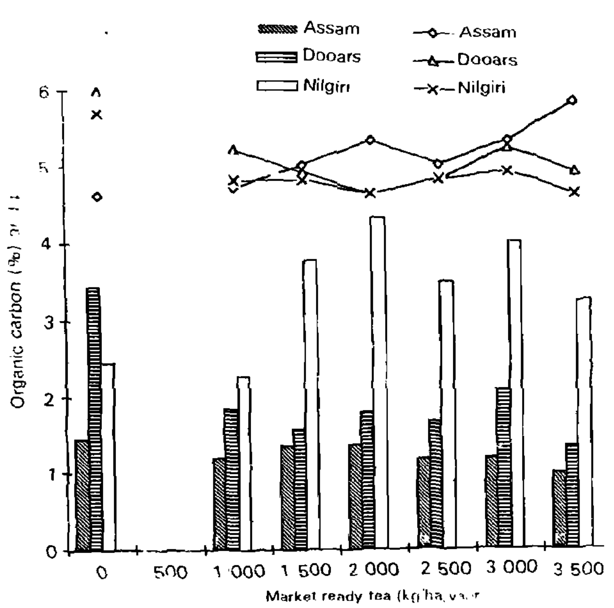


Fig 1 Per cent organic carbon and pH

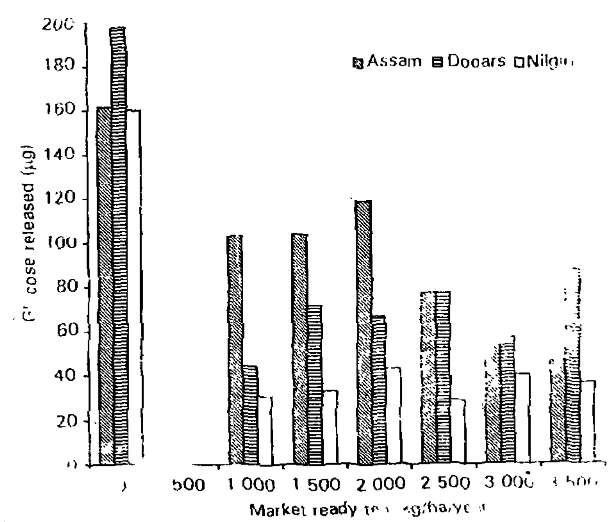


Fig 3 Cellulose activity

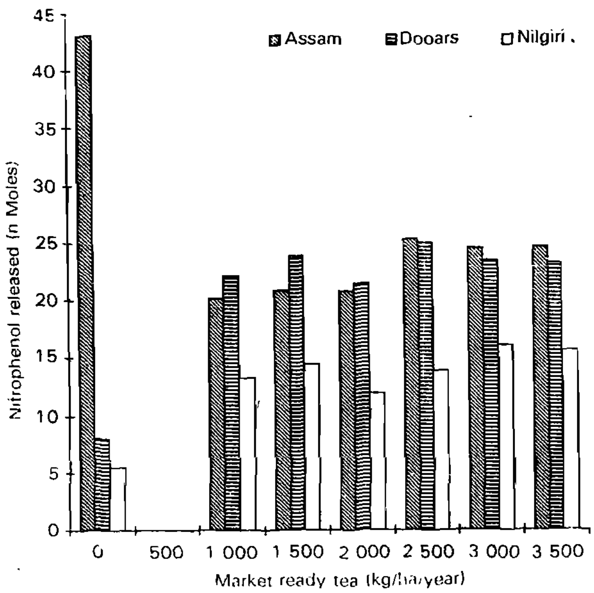


Fig 4 Phosphatase activity

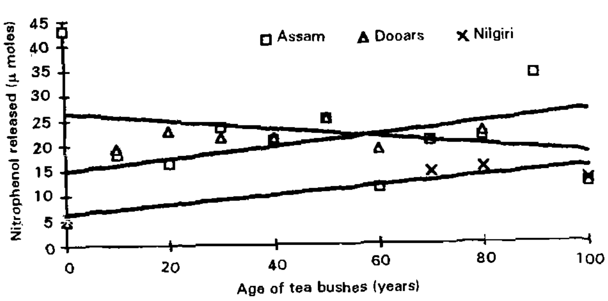


Fig 5 Phosphatase activity

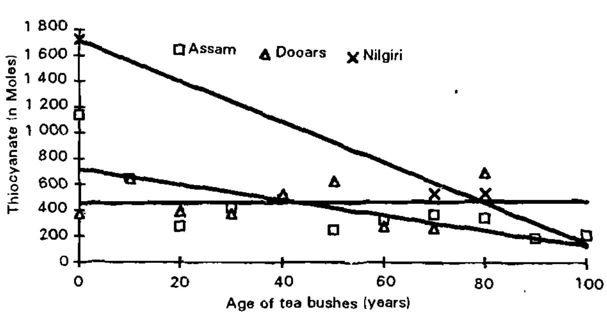
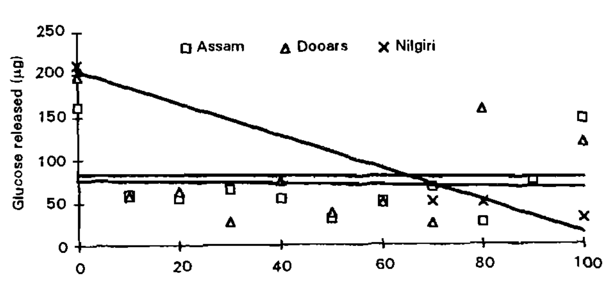


Fig 6 Rhodanese activity



that the organic amendments used in the soil, influence phosphatase activity. As Gogoi and Devchowdhury (1990) have confirmed tea bush pruning are likely to show enhanced phosphatase activity. Since the values of organic carbon in Assam plantation samples were lower than those found in Nilgiris or Dooars and the phosphatase activity in the plantation samples from Assam was lower than the corresponding forest samples of the region, it is likely that lack of organic matter amendment in Assam plantation samples was responsible for the reduction in phosphatase activity of the plantation samples. However, as phosphatases play an important role in the detoxication processes of organophosphorus pesticides which were frequently being used in both Nilgiris and Dooars, increase in phosphatase activity in samples can also mean proliferation of pesticides degrader microbial strains.

Grouping the soil samples on basis of age of the bushes revealed no significant trend in decrease or increase in any of the enzymes evaluated in relation to age (Fig 5, 6 and 7). From this observation, one can conclude that the differences in enzymes activity observed in plantation samples and the corresponding forest samples with respect to the enzymes studied was introduced through the cultural practices being followed in the plantations and was not an artifact produced by the tea plant. Likewise, as no correlation between extent of enzyme activity and the yield of tea harvested form the sections (Fig 2,3,4) emerged, it is further confirmed that the enzymes studied were clearly an index of the soil conditions which was not reflected on the yield of tea leaves per hectare. Since all the sections under tea showed a similar type of activity which was characteristic of the region and the cropping practices in the respective regions varied from one another, it is further confirmed that all the 3 enzymes studied were subjected to influences of the cultural practices of the respective plantations.

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Hybrid vigour among newly evolved bivoltine hybrids of silkworm (*Bombyx mori*) under Hill conditions

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ABSTRACT

Heterosis studies on rearing and cocoon characters of 23 new bivoltine hybrids revealed that manifestation of heterosis was highly significant for all the silk yield contributing characters especially cocoon yield by weight among all the hybrids. Ten new bivoltine hybrids were highly promising over the existing check hybrid ('KA' x 'NB 4 D 2'). Four hybrids namely 'CNR 14' x 'NB4 D2', 'CNR 12' x 'NB 4D2', 'CNR 16' x 'NB 4D2' and 'CNR 13' x 'NB 4D2' exhibited significantly positive heterobeltosis and standard heterosis for most of the characters.

Key words : silkworm, *Bombyx mori*, heterosis, hybrid vigour, bivoltine hybrids

India is the second largest raw silk producing country in the world (13 518 metric tonnes) and the foreign exchange earnings of the silk industry during 1993–94 was Rs 8 000 million (Datta 1994, Menon *et al.* 1994).

The domesticated silkworm *Bombyx mori* L. has about 2000 breeds in the world which differ in their silk production both quantitatively and qualitatively (Bhargava *et al.* 1996). Introduction of silkworm hybrids revolutionised the world silk production. Most of the silkworm hybrids in China and Japan are productive bivoltine hybrids with superior quality silk filament of International standards. It has been proved that the silk yield from hybrids is better than that of their parents (Bhargava *et al.* 1993, 1996; Harda 1949, 1961). Much of Indian silk is from multivoltine x bivoltine hybrids which have less shell content and inferior quality of silk filament compard with the bivoltines. The productivity of bivoltine silkworm breeds is 800–1 250 kg of cocoons/ha of mulberry and that of polyvoltines is 160–440 kg/ha (Jayaswal *et al.* 1994). Bivoltine hybrids have the potential to improve the silk production and quality of silk filament competable in International silk market (Aruga 1994, Aurea *et al.* 1994). Hence, an attempt was made to study the extent of hybrid vigour among hybrids of the new bivoltine silkworm genotypes evolved at this station for the economically important cocoon as well as silk yielding characters.

MATERIALS AND METHODS

Thirteen newly evolved promising bivoltine silkworm genotype ('CNR 3', 'CNR 4', 'CNR 5', 'CNR 6', 'CNR 7', 'CNR 8', 'CNR 9', 'CNR 10', 'CNR 11', 'CNR 12', 'CNR 13', 'CNR 14', 'CNR 15', 'CNR 16') of this station and 2 popular bivoltines 'KA' and 'NB4 D2' was selected based on their performance in the laboratory. A total of 23 hybrids were reared along with their 15 parents in randomised block design with 3 replications each during November/December 1995 following the standard rearing method 23–28°C, 70–80% relative humidity and 12 hr photoperiod (Bhargava *et al.* 1993). The popular bivoltine hybrid 'KA' x 'NB4 D2' was reared as a check hybrid.

The observations were recorded on cocoon yield by number and weight, single cocoon weight, single shell weight, shell ratio percentage, filament length and silk productivity.

Mid-parent heterosis, heterobeltiosis, better parent heterosis and standard check heterosisi of the hybrids over standard hybrid were calculated by the methods already in application (Ashoka and Govindan 1990, Bhargava *et al.* 1993, 1996). The significance of heterosis was marked by least significant difference at 5% (P=0.05) and 1% (P=0.01) levels.

RESULTS AND DISCUSSION

Cocoon yield by number

The extent of better parent heterosis exhibited by all the 23 hybrids was positive and significant (0.427 to 9.633%). Highly significant better parent heterosis values in percentage were recorded by 'CNR 12' x 'NB4 D2' (9.63), 'CNR 13' x 'KA' (9.45), 'CNR 13' x 'NB4 D2' (9.44), 'CNR 11' x 'NB 4D2' (9.12), 'CNR 16' x 'NB4D2' (8.70), 'CNR 15' x 'NB 4D2' (7.97) and 'CNR 16' x 'KA' (7.04) (Table 1).

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Ten hybrids registering significant standard hybrid values were 'CNR 10' x 'CNR 14' and 'CNR 10' x 'CNR 5' (2.54), 'CNR 12' x 'NB4 D2' and 'CNR 13' x 'KA' (2.43), 'CNR 9'x 'KA', 'CNR 13' x 'NB4 D2' and 'CNR 14' x 'NB4 D2' (2.25), 'CNR 11' x 'NB4 D2' (2.14), 'CNR 10' x 'KA' (2.08) and 'CNR 14' x 'KA' (1.73).

Cocoon yield by weight

All the hybrids recorded positive better parent heterosis values (4.14 to 39.34%). Seven hybrids namely, 'CNR 16' x 'NB4 D2' (39.34%), 'CNR 15' x 'KA' (35.01), 'CNR 10' x 'KA' 33.28), 'CNR 12' x 'NB4 D2' (30.56), 'CNR 12' x 'KA' (30.26), 'CNR 14' x 'NB4 D2' (27.98) and 'CNR 13' x 'KA' (27.33) expressed highly significant better parent heterosis values.

Sixteen hybrids registered positive standard hybrid values (0.48–15.22%), out of which 7 had highly significant values. They were 'CNR 16' x 'NB4 D2' (15.22), 'CNR 14' x 'NB4 D2' (9.08), 'CNR 13' x 'KA (8.82)', 'CNR 15' x 'KA' (8.13), 'CNR 12' x 'NB4 D2' (7.44), 'CNR 10' x 'KA' (6.75) and 'CNR 13' x 'NB4 D2' (6.23), 'CNR 14' x 'KA' (5.62%) and 'CNR 3' x 'CNR 16' (5.30%) showed significane at 5% level (Table 1).

Cocoon weight

Though twenty hybrids registered positive better parent heterosis values for single cocoon weight, they were highly significant only among 'CNR 16' x 'NB4 D2' (20.79), 'CNR 3' x 'CNR 16' (19.50), 'CNR 3' x 'CNR 14' (12.50), 'CNR 15' x 'KA' (10.80) and 'CNR 13' x 'KA' (10.10%).

CNR 16 x NB4 D2 (14.38), CNR 15 x KA (6.97), CNR 3 x CNR 16 (6.92), CNR 13 x KA (6.29), CNR 13 x NB4 D2 (3.46), CNR 12 x KA (3.17), CNR 14 x NB4 D2 (2.97) and CNR 12 x NB4 D2 (2.92) expressed significant positive standard hybrid values at 1% level (Table 1).

Shell weight

Seventeen hybrids recorded positive BPH values ranging from 0.08 to 21.71% for single shell weight. CNR 3 x CNR 16 (21.71), CNR 16 x NB4 D2 (20.79), CNR 12 x KA (19.42), CNR 3 x CNR 14 (16.50), CNR 15 x KA (14.59), CNR 14 x NB 4D2 (14.25), CNR 12 x NB4 D2 (12.52) and CNR 14 x KA (11.90) recorded significant (P=0.01) positive better parent heterosis values (Table 2).

Eight hybrids yielded significant (P=0.01) standard hybrid values. They were 'CNR 16' x 'NB4 D2' (17.32), 'CNR 12' x 'KA' (12.67), 'CNR 14' x 'NB4 D2'.(10.98), 'CNR 12' x 'NB4 D2' (9.29), 'CNR 3' x 'CNR 16' (8.85), 'CNR 3' x 'CNR 14' (8.22), 'CNR 15' x 'KA' (8.11) and 'CNR 13' x 'NB4 D2' (7.84)

Table 1 Heterosis percentage for cocoon yield by number and weight and single cocoon weight in silkworm

Hybrid	Cocoon yield			Cocoon yield (g)			Single cocoon weight (g)		
	Mid parent	Better parent	Check	Mid parent	Better parent	Check	Mid parent	Better parent	Check
'CNR 3' x 'CNR 12'	4.60	2.62	-2.76	9.89	4.73	-13.21	6.49	2.05	-12.48
'CNR 3' x 'CNR 14'	4.80	2.69	1.39	21.44	19.76	2.08	13.63	12.50**	-3.51
'CNR 3' x 'CNR 16'	1.70	0.43	-4.84	24.22	21.49	5.30*	22.02**	19.50**	6.92
'CNR 10' x 'CNR 4'	3.80	2.78	2.54**	18.36	4.14	3.23	10.18	1.61	-4.53
'CNR 10' x 'CNR 5'	5.34	4.84	2.54**	18.14	11.23	-5.13	4.44	-1.52	-11.79
'CNR 10' x 'CNR 6'	7.84	3.30	1.04	21.23	17.77	-5.94	4.75	0.28	-13.01
'CNR 10' x 'CNR 8'	1.60	0.83	-1.38	18.82	13.07	-5.71	11.51	8.14	-8.67
'CNR 9' x 'KA'	6.18	3.26	2.25**	24.35	19.88	3.46	10.04	3.99	0.39
'CNR 9' x 'NB4 D2'	4.46	1.51	0.52	21.91	19.08	2.77	8.58	3.55	-1.95
'CNR 10' x 'KA'	6.67	4.36	2.08**	37.38**	33.28**	6.75**	15.21**	4.95	1.32
'CNR 10' x 'NB4 D2'	3.95	1.62	-0.60	23.49	18.26	-2.68	9.94	1.03	-4.34
'CNR 11' x 'KA'	6.11	6.10	-0.69	16.35	15.41	-6.06	0.77	-4.14	-7.46
'CNR 11' x 'NB4 D2'	9.22**	9.12**	2.14**	22.77	22.11	0.48	-0.62	-4.58	-9.65
'CNR 12' x 'NB4 D2'	7.32	5.93	-0.86	34.46**	30.26**	4.32	17.81**	6.87	3.17**
'CNR 12' x 'KA'	10.98**	9.63**	2.43**	36.53**	30.56**	7.44**	18.79**	8.70*	2.92**
'CNR 13' x 'KA'	11.92**	9.45**	2.43**	31.46**	27.33**	8.82**	10.91	10.10	6.29**
'CNR 13' x 'NB4 D2'	11.82**	9.44**	2.25**	26.64	24.29	6.23**	9.01	8.76*	3.46**
'CNR 14' x 'KA'	5.80	3.04	1.73*	27.77	23.92	5.62*	12.20	4.95	1.32
'CNR 14' x 'NB4 D2'	6.42	3.56	2.25**	30.23**	27.98**	9.08**	15.21**	8.75*	2.97**
'CNR 15' x 'KA'	12.35**	7.23**	0.35	41.89**	35.01**	8.13**	20.11**	10.80**	6.97**
'CNR 15' x 'NB4 D2'	13.03**	7.97**	0.87	27.35	19.63	-1.56	8.16	0.67	-4.68
'CNR 16' x 'KA'	7.73	7.04**	0.18	21.38	16.77	1.21	4.64	0.81	-2.68
'CNR 16' x 'NB4 D2'	9.33**	8.70**	1.56	36.38**	32.93**	15.22**	24.21**	20.79**	14.38**
CD (P=0.05)	1.40	1.28	0.81	3.32	3.77	2.73	2.75	2.76	3.00
CD (P=0.01)	1.90	1.74	1.10	4.51	5.12	3.72	3.74	3.75	4.08

*Significant at 5% level (P=0.05), ** significant at 1% level (P=0.01)

Table 2 Heterosis percentage for single shell weight and shell ratio in silkworm

Hybrid	Single shell weight (mg)			Shell ratio (%)		
	Mid parent	Better parent	Check	Mid parent	Better parent	Check
'CNR 3' x 'CNR 12'	0.33	-3.12	-13.36	-3.68	-3.88	1.27
'CNR 3' x 'CNR 14'	18.71	16.50**	8.22**	3.68	0.70	12.10**
'CNR 3' x 'CNR 16'	21.98**	21.71**	8.85**	1.58	-1.01	3.86
'CNR 10' x 'CNR 4'	15.26	-2.42	5.84*	4.68**	-5.71	11.67**
'CNR 10' x 'CNR 5'	12.85	-3.41	2.03	6.78**	-4.40	14.79**
'CNR 10' x 'CNR 6'	1.61	-7.44	-15.32	-2.83	-8.17	-2.06
'CNR 10' x 'CNR 8'	12.00	2.39	-7.06	2.09	-3.91	3.38
'CNR 9' x 'KA'	7.29	0.26	-5.41	-1.02	-2.29	-3.01
'CNR 9' x 'NB4 D2'	11.11	2.46	-0.48	2.67	-0.41	2.48
'CNR 10' x 'KA'	14.74	3.09	-2.74	0.38	-1.81	-2.54
'CNR 10' x 'NB4 D2'	12.82	0.08	-2.79	4.99**	0.92*	3.86
'CNR 11' x 'KA'	2.75	-1.25	-6.84	0.96	-1.02	2.27
'CNR 11' x 'NB4 D2'	5.23	-0.26	-3.12	6.10**	5.88**	9.40**
'CNR 12' x 'KA'	26.85**	19.42**	12.67**	7.97**	4.85**	10.46**
'CNR 12' x 'NB4 D2'	21.15**	12.52**	9.29**	3.90*	2.69**	8.19**
'CNR 13' x 'KA'	12.06	11.25*	6.51*	0.74	-0.11	0.85
'CNR 13' x 'NB4 D2'	11.83	11.03*	7.84**	3.65	2.67**	5.65
'CNR 14' x 'KA'	12.77	11.90**	5.58	-0.01	-5.42	5.28
'CNR 14' x 'NB4 D2'	16.80*	14.25**	10.98**	2.09	-1.77	9.35**
'CNR 15' x 'KA'	18.57**	14.59**	8.11**	0.61	-3.79	4.65
'CNR 15' x 'NB4 D2'	13.09	7.78	4.69	5.27**	2.43**	11.41**
'CNR 16' x 'KA'	8.31	5.26	-0.69	3.93*	3.77**	3.33
'CNR 16' x 'NB4 D2'	26.04**	20.79**	17.32**	3.21	1.54**	4.49
CD (P=0.05)	3.01	3.64	3.53	1.23	1.52	2.08
CD (P=0.01)	4.09	4.95	4.79	1.68	2.08	2.83

*Significant at 5% level (P=0.05), ** significant at 1% level (P=0.01)

Shell ratio percentage

Seven hybrids, viz 'CNR 11' x 'NB4 D2' (5.88), 'CNR 12' x 'KA' (4.85), 'CNR 16' x 'KA' (3.77), 'CNR 12' x 'NB4 D2' (2.69), 'CNR 13' x 'NB4 D2' (2.67), 'CNR 15' x 'NB4 D2' (2.43) and 'CNR 16' x 'NB4 D2' (1.54) showed significance at 1% level.

Highly significant standard hybrid values were recorded by 'CNR 10' x 'CNR 5' (14.79), 'CNR 3' x 'CNR 14' (12.10), 'CNR 10' x 'CNR 4' (11.68), 'CNR 15' x 'NB4 D2' (11.41), 'CNR 12' x 'KA' (10.46), 'CNR 11' x 'NB4 D2' (9.40), 'CNR 14' x NB4 D2' (9.35) and 'CNR 12' x 'NB4 D2' (8.19%) (Table 2).

Filament length

Fifteen hybrids expressed positive better parent heterosis (1.98 to 34.27%) but it was significant (P=0.01) only among 'CNR 10' x 'KA' (34.27), 'CNR 10' x 'NB4 D2' (27.56), 'CNR 14' x 'KA' (23.92), 'CNR 9' x 'KA' (23.34), 'CNR 9' x NB4 D2' (22.66), 'CNR 15' x 'KA' (17.80) and 'CNR 14' x 'NB4 D2' (17.07%).

The hybrids, namely 'CNR 14' x 'KA' (27.10), 'CNR 13', 'KA' (20.57), 'CNR 14' x 'NB4 D2' (20.08), 'CNR 12' x 'KA' (18.60), 'CNR 10' x 'CNR 4' (18.00), 'CNR 15' x 'KA' (17.80) and 'CNR 13' x 'NB4 D2' (15.33) recorded significant (P=0.01) standard hybrid values (Table 3).

Silk productivity

All the hybrids except 'CNR 3'x 'CNR 12' recorded positive better parent heterosis values for silk productivity day (6.56–65.76%). 'CNR 12' x 'NB4 D2' (65.76), 'CNR 16' x 'NB4 D2' (49.53), 'CNR 12' x 'KA' (42.86), 'CNR 15' x 'KA' (38.74) and 'CNR 10' x 'NB4 D2' (33.16) and 'CNR 11' x 'NB4 D2' (32.32%) also expressed significance at 5% level.

'CNR 13', x 'NB4 D2' (35.73), 'CNR 12' x 'NB4 D2' (34.33), 'CNR 16' x 'NB4 D2' (27.15), 'CNR 14' x 'NB4 D2' (20.96) and 'CNR 12' x 'KA' (17.76) showed significant (P=0.01) standard hybrid values for this character (Table 3).

Heterosis is the function of dominance effect and genetic distance between parents. When two completely genetically diversed homozygous parents are crossed, maximum heterozygosity can be achieved and this in turn leads to significant heterosis (Falconer 1989). The study clearly reveals significant heterosis for all the silk yield contributing characters. Better parent heterosis was highly significant for cocoon yield by weight in all the hybrids. This can be

Table 3 Heterosis percentage for filament length and silk productivity/day in silkworm

Hybrid	Filament length			Silk productivity/day		
	Mid parent	Better parent	Check	Mid parent	Better parent	Check
'CNR 3' x 'CNR 12'	-2.24	-10.95	-2.67	4.12	-0.23	-11.78
'CNR 3' x 'CNR 14'	15.78	8.58	11.37	24.00	19.46	13.97
'CNR 3' x 'CNR 16'	4.50	-5.20	4.55	11.62	9.48	-3.19
'CNR 10' x 'CNR 4'	8.65	-10.84	18.00**	29.72	15.03	14.57
'CNR 10' x 'CNR 5'	-21.87	-35.25	-16.42	28.02	16.92	8.98
'CNR 10' x 'CNR 6'	-9.56	-11.14	-21.86	11.93	6.56	-9.18
'CNR 10' x 'CNR 8'	-14.23	-24.38	-15.92	15.48	6.83	-3.19
'CNR 9' x 'KA'	26.84**	23.34**	8.21	31.45	23.97	2.20
'CNR 9' x 'NB4 D2'	23.78**	22.66**	7.62	36.41	28.50	6.19
'CNR 10' x 'KA'	35.85**	34.27**	13.95*	31.16	26.88	4.59
'CNR 10' x 'NB4 D2'	28.51**	27.56**	9.89	28.50	24.15	2.59
'CNR 11' x 'KA'	13.94	2.48	6.33	20.15	17.68	-2.99
'CNR 11' x 'NB4 D2'	17.71	7.72	11.77	29.38	26.57	4.59
'CNR 12' x 'KA'	23.42**	8.51	18.60**	44.08**	42.86**	17.76**
'CNR 12' x 'NB4 D2'	9.41	-2.17	6.92	64.15**	62.56**	34.33**
'CNR 13' x 'KA'	27.51**	13.50*	20.57**	23.93	10.90	15.77*
'CNR 13' x 'NB4 D2'	19.90	8.57	15.33**	45.14**	30.02	35.73**
'CNR 14' x 'KA'	37.07**	23.92**	27.10**	26.60	17.99	12.57
'CNR 14' x 'NB4 D2'	27.25**	17.07**	17.80**	51.19**	38.74**	14.37
'CNR 15' x 'KA'	28.83**	17.80**	17.80**	51.19**	38.54**	11.18
'CNR 15' x 'NB4 D2'	9.56	1.98	1.98	46.77**	34.54**	11.18
'CNR 16' x 'KA'	3.84	-9.06	0.30	25.63	23.71	5.19
'CNR 16' x 'NB4 D2'	16.52	3.77	14.44*	51.67**	49.53**	27.15**
CD (P=0.05)	6.61	7.22	5.27	6.11	6.42	5.25
CD (P=0.01)	8.98	9.82	7.17	8.31	8.73	7.14

*Significant at 5% level (P=0.05), ** significant at 1% level (P=0.01)

attributed to the significant positive heterosis for cocoon yield by number and also single cocoon weight as cocoon yield by weight is positively correlated with the number and weight of cocoons. The hybrids 'CNR 16' x NB4 D2, 'CNR 13' x 'NB4 D2', 'CNR 12' x 'KA', 'CNR 15' x 'NB4 D2', 'CNR 10' x 'NB4 D2' and 'CNR 3' x 'CNR 14' were most promising and expressed positive better parent beterosis for all the 7 economically important characters. 'CNR 16' x 'KA', 'CNR 12' x 'NB4 D2' and 'CNR 15' x 'KA' recorded significant better parent heterosis for all characters except filament length in the fomer two and shell ratio in the latter, 'CNR 14' x 'NB4 D2' also showed positively significant better parent heterosis for 4 characters.

The hybrid 'CNR 14' x 'NB4 D2' recorded positively significant standard hybrid values for al 7, while 'CNR 12' x 'NB4 D2', 'CNR 13' x 'NB4 D2' and 'CNR 13' x 'KA' for 6 and 'CNR 16' x 'NB4 D2' for 5 characters. This shows the more superiority of these new bivoltine hybrids to the existing popular hybrids.

Four hybrids, namely 'CNR 14' x 'NB4 D2', 'CNR 12' x 'NB4 D2', 'CNR 16' x 'NB4 D2' and 'CNR 13' x 'NB4 D2' expressed significantly positive better parent heterosis and standard hybrid values for most of the characters and found to be promising. All the female parents involved in these hybrids, ie 'CNR 14', 'CNR 12', 'CNR 16', 'CNR 13' are oval cocoon producing ones and are genetically distant from the male counter parts, ie 'NB4 D2' which is a dumbbell cocoon producing genotype. This in addition to the high general combining ability of these 4 CNR breeds as well as the high specific combining ability of their hybrids with 'NB4 D2' can be easily and successfully exploited in the field and to a greater extent under hill condition to increase the raw silk production.

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Yield performance of soybean genotypes*

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Key words : climatic variables, minimum and maximum temperature, relative humidity, rainfall, bright sunshine, sugarcane yield, regression equation, *Saccharum officinarum*

[*Glycine max* (L.) Merr.] is one of the important oil seed crops in India and its acreage and production are substantial in world but its productivity is quite low. Various biotic and abiotic factors play important role to decrease its productivity. Forty eight national varieties have been released, there is scope to add more genotypes. Sixteen germplasm lines were selected to evaluate for their yield performance with comparison to 3 local checks, viz 'Punjab 1', 'PK 472' and 'JS 335'. These 16 lines were chosen from the material screened earlier for resistance to major insects and diseases by the author and his associate (Shukla and Prabhakar 1991, Sharma and Shukla 1993a and 1993b).

The experiment was conducted with randomised block design in 4 replications during rainy seasons 1993 and 1994 at Indore. Each genotype was grown in 5 m x 4.95 m plot. Fertilizers (N:P:K:S) were also applied as per the recommendation, ie @ 20:60–80:20:20 kg/ha and all the recommended practices for the crop were followed throughout.

Yield performance of 3 lines, viz 'EC 251311' (2 770 kg/ha), 'PK 442 (2 475 kg/ha) and 'EC 241412' (2 166 kg/ha) was found better or at par with check varieties 'Punjab 1' (2 276 kg/ha) and 'JS 335' (2 422 kg/ha) during *kharif* 1993. During *kharif* 1994 yield of some genotypes like 'EC 34500' (1 955 kg/ha), 'EC 251311' (1 683 kg/ha), 'JS 79-420' (1 592 kg/ha) and 'MACS 13' (1 570 kg/ha) was good and at par with checks, viz 'Punjab 1' (1 631 kg/ha) and 'PK 472' (1 565 kg/ha). Rains were more during 1994 because of that actual potential of the genotypes were not observed. 100-grain weight of 3 lines, viz 'EC 241412' (15.4 g), 'EC 251311' (13.5 g) and 'EC 34500' (13.3) is highest among all the genotypes. Earlier 'PK 472' and 'JS 335' varieties of soybean were scored resistant to bacterial pustule while 'Punjab 1' was susceptible to the disease (Bhatnagar and Tiwari 1990, Bhatnagar 1994) but at present these 2 varieties are not showing true resistance therefore true resistant genotypes with better yield potential will be good for cultivation. Based on 2-year performance 'EC 2513311' cultivar was included in intial varietal trail (IVT) of AICRP on soybean in the name of 'NRC 27' during *kharif* 1995. This was tested under the coordinated project and ranked 7th in the list of top 10 entries on the basis of yield for promoting further evaluation in higher trials.

Table1 Performance of soybean genotypes

Genotypes	Yield (kg/ha)		Disease reaction		100-seed-weight (g)
	1993	1994	NP	LS	
AGS 109		797	MR	M	6.5
EC 34500		1955	R	T	13.3
EC 241412	2166		R	L	15.4
EC 251311	2770	1683	R	T	13.5
EC 251844		1009	R	T	7.5
Ec 251867	1010	R	L	9.2	
IQ 5186		672	R	L	7.9
L 450	1037	M	R	S	7.2
L 537		1247	R	T	7.6
JS 335	2422		R/MR	M	11.1
JS 79-420		1592	R M	12.5	
MACS 13		1570	R L	10.5	
PK 442	2475		1525	R L	11.3
PK 472		1565	MR/MS	S	11.9
Punjab 1	2276	1631	HS	S	9.7
TK 5	993		S	L	8.0
TG 8-11-27D	1291		R	M	7.0
TG 1073-30E	1680		MR	L	7.2
TG 1073-55E		689	MR	T	8.2
C.D at 5%	690	245			

BP, Bacterial pustule; LS, leaf spot; I, immune; R, resistant; T, traces; L, light; MR, moderately resistant, M, moderate, MS, moderately susceptible; HS, highly susceptible.

*Short note

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Effect of *in-situ* moisture conservation practices on runoff, soil loss and productivity of sorghum (*Sorghum bicolor*)*

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Key words : vetiver grass hedge, contour line, strip cropping, runoff

Undulating topography along with faulty agricultural practices result in more runoff and soil-loss of top fertile soil. Mechanical structures reduce run off and erosion and has their limitation in small and irregular fields. Bathkal *et al.* (1992) reported the use of vegetative barriers on contour for *in-situ* soil-and-moisture conservation and productivity of crops. Greenfield (1987) introduced the concept of vetiver grass [*Vetiveria zizanioides* (L.) Nash (2n=20) Khus] hedges on contour to achieve higher in-situ soil-and-moisture conservation and crop productivity. Hence, a study was conducted to find out the effect of vegetative system on contour for *in-situ* soil-and-moisture conservation and productivity of sorghum [*Sorghum bicolor* (L.) Moench].

A monitoring block having 5 plots with different practices was developed at Kotri (district Bhilwara, Rajasthan) for estimation of runoff, soil-loss and productivity of sorghum crop during the rainy season (*kharif*) of 1992, 1993 and 1994. The soil was sandy clay loam with *p*H 8.2, having organic carbon 0.32%, ECe 0.07 dS/m at 25°C, P 9.7 kg/ha and K 265.6 kg/ha. There were 5 treatments, viz T_1, sowing along the slope; T_2, sowing along contour bund in cross section of 0.2 m^2 at 30 m horizontal interval; T_3, contour cultivation across the slope; T_4, contour sowing along the vetiver grass key-line with V-ditch cross-section of 0.09 m^2 at 30 m horizontal interval; and T_5, contour-strip cropping of sorghum and greengram (*Phaseolus radiatus* L.) in 3:1 proportion. The plot size of each treatment was 2 400 m^2 with the slope length of 90 m having almost a uniform slope of 1.2%. A monitoring device coshocton wheel silt sampler 30 cm diameter with H-flume was set up with each treatment. Rainfall was measured by self-syphon-type recording rainguage installed at the site. 'CSH 6' hybrid sorghum and 'K 857' greengram (as strip in strip-cropping treatment) were sown at the onset of monsoon in all the years. The total rainfall received during July-October in 1992, 1993 and 1994 was 625.8, 391.3 and 1 030.8 mm respectively.

The runoff recorded under the contour cultivation along vetiver grass key-line was the lowest during all the years, ie 8.4% in 1992, 7.6% in 1993 and 7.0% in 1994 (Table 1). This can be attributable to more uniform spread of surface runoff all over the toposequence. Further, high velocity of flowing water was considerably reduced by vetiver grass key-line and crop lines on contour. Vetiver key-line obstructs the

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Table1 Surface runoff, soil-loss and grain yield of sorghum as influenced by various contour systems

Treatment	Runoff producing storm of rainfall			Surface runoff (%)			Soil loss (tonnes/ha)			Yield (kg/ha)		
	1992	1993	1994	1992	1993	1994	1992	1993	1994	1992	1993	1994
T_1	220	140.7	524.1	36.2	37.8	39.4	1.74	1.92	2.05	160	620	390
T_2	220	140.7	524.1	13.3	11.5	10.6	1.10	0.90	0.87	380	1130	750
T_3	220	140.7	524.1	33.6	35.4	36.0	1.65	1.50	1.45	320	900	610
T_4	220	140.7	524.1	8.4	7.6	7.0	0.78	0.68	0.61	460	1240	850
T_5	220	140.7	524.1	9.0	8.4	7.8	0.85	0.78	0.72	260	1020	640
										(500)	(460)	(480)
CD (P=0.05)										065	205	102

Figures in parentheses show yield of strip crop

(In 1993 the crop failed due to prolonged drought)

T_1, Sowing along the slope; T_2, sowing along contour bund; T_3, contour cultivation across the slope; T_4, contour sowing along the vetiver key-line; T_5, contour strip-cropping flowing water for a shorter period, thereby achieving higher and uniform recharge (Greenfield 1987). However, this treatment was followed by contour strip-cropping where surface runoff was 9.0, 8.4 and 7.8% and contour bunding where surface runoff was 13.3, 11.5 and 10.6% respectively during 1992, 1993 and 1994. Sowing along the slope and contour farming resulted in highest runoff during all the seasons. The result confirms the findings of Bharad *et al.* (1991) and Patil and Singh (1987).

The seasonal soil-loss was also highest in sowing along the slope and contour farming, i e 1.90 and 1.53 tonnes/ha respectively. Seasonal loss in soil was lowest under vetiver grass key-line, ie 0.78, 0.68 and 0.61 tonne/ha during 1992, 1993 and 1994 respectively, followed by contour-strip cropping and contour bund. Establishment of vegetative bund on contour conserves *in-situ* soil and gives more time for infiltration of water into the field (Greenfield 1987). The reduction in soil-loss in vetiver grass key-line treatment may probably be due to low velocity of flowing water and setting down of soil particles along the line.

The yield of sorghum was significantly influenced by contour cultivation (Table 1). Vetiver grass key-lines on contour gave highest grain yield of sorghum during 1992 and 1994. Yield recorded from the vetiver key-line was 850 kg/ha which was significantly higher by 117.9, 39.3 and 32.8% respectively compared with the sowing along slope, contour farming and contour strip cropping but closely followed by contour bund. The productivity trend was in consonance with runoff and soil-loss.

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Response of tuberose (*Polianthes tuberosa*) with increasing dose of NPK*

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Key words : nutrients, *Polianthes tuberosa*, potassium, phytohormones

Considering the importance of nutrients particularly N, P and K and the role of K in improving the quality of flowers, it is essential to determine an optimum dose of K for quality flower production. However, at constant level of N and P, increasing levels of K adversely affect as N and P become limiting factor. Thus it is needed for study the effect of increasing dose of K with corresponding increase in N and P on tuber (*Polianthes tuberosa*).

The experiment was conducted at Jorhat during 1995–96 with 7 treatments of N:P:K, viz T_1 (40:20:0, control), T_2 (40:20:20), T_3 (40:20:20), T_4 (80:40:60), T_5 (80:40:80), T_6 (120:60:100) and T_7 (120:60:120) laid out in randomized block design with 3 replications per treatment. The plot size was 3.5 m x 2.0 m with spacing 30 cm x 20 cm. The *p*H of the soil was 5.2.

Out of all the treatments (Table 1) T_4 (80N : 40P : 60K) recorded the highest mean performance for yield of spike (692.86 g/m^2), self (22.16 days) and vase (17.47 days) life, size of floret (3.88 cm), number of pairs of florets/spike (17.47) and plant height (101.13 cm). In addition, the treatment also exhibited high performance for length of spike (104.89 cm) and rachis (33.67 cm). Days to emergence of shoot (19.30 days), days to emergence of spike (97.60 days) and days to opening of flower (98.33 days) exhibited by the treatment clearly indicated that 60 g K along with moderate levels of N and P (80 : 40) not only increased the yield and quality of flower but also induced earliness. It was observed that at 40 g K along with low levels of N and P (40 : 20), the yield of spike (66.429g/m^2) was not significantly lower than the best treatment but exhibited the longest spike (106.35cm) and rachis (35.27cm), the treatment resulted in reduced plant height (95.80cm) and moderate duration for emergence of spike (102.47 days) and opening of flower (103.53 days).

The level of 60 g K could be optimum for production of cytokinin and promotion of flower morphogenesis resulting in increased number of florets/spike as reported by Brunisma (1977). Mukhopadhyaya and Bankar (1986) also reported similar findings. The increase in flower size by this treatment could also be due to enhanced translocation of metabolits required for growth. The treatment could be a balanced supply of NPK, promoting translocation of phytohormones resulting in early flower initiation (Marchner 1983).

*Short note

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Table 1 Effect of potassium on shoot emergence, growth and flower characters

Treatment	Days to emergeence of shoot	Plant height (cm)	Days to emergence of spike	Days to opening of flower	Length of spike (cm)	Length of rachis (cm)	No. of pairs of florets /spike	Size of floret (cm)	Self-life of spike (days)	Vase-life of spike (days)	Yield of spike (g/m^2)
T_1	21.83	93.42	114.93	116.27	94.63	31.07	10.93	2.44	17.13	11.47	530.95
T_2	20.70	94.68	110.93	111.20	96.72	33.13	12.47	3.00	18.13	11.67	576.19
T_3	19.94	95.80	102.47	103.53	106.35	35.27	15.27	3.30	19.13	15.60	664.29
T_4	19.30	101.13	97.60	98.33	104.89	33.67	17.47	3.88	22.26	17.47	692.86
T_5	19.40	100.54	96.80	97.66	100.76	32.33	15.47	3.62	20.33	17.00	645.24
T_6	20.47	98.56	98.87	99.33	89.77	29.87	12.07	3.38	19.53	14.13	635.72
T_7	20.63	97.21	99.13	99.63	86.55	28.73	11.33	3.16	18.40	12.47	604.76
CD (P=0.05)	1.05	1.46	1.90	1.09	1.50	2.66	0.78	0.26	1.02	1.13	32.23

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Torulospora globosa : A unique strain solubilizing tricalcium phosphate

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Key words : *Torulospora globosa*, phosphorus solubilizing microorganisms, phosphorus, yield

Phosphate solubilizing microorganisms (PSM) are group of microoorganisms, which include bacteria, fungi and yeast have got the capacity to convert insoluble phosphatic compounds into soluble forms. This includes *Bacillus, Pseudomonas. Micrococcus. Penicillium, Aspergillus, Fusarium* and others (Gaur 1990).

During routine screening for the presence of efficient strains of PSMs, a yeast *Torulospora globosa* with a capacity to use calcium, iron and aluminium phosphates was found for the first time in India (Vora and Shelat 1996). This organism produced a clear zone around its colonies on Pikovskaya's agar plate incorporated with insoluble tricalcium phosphate. The culture was then repeatedly plated and finally from pure culture, a series of morphological and biochemical tests were performed. The culture was identified as *Torulospora globosa* strain PBA 22. The identification was confirmed by Institute of Microbial Technology, Chandigarh. This strain has all the biochemical tests identical to type culture of *Torulospora globosa*, but it differs in one test, that is, it produces acetic acid. The strain has been deposited at Microbial Type Culture Collection Centre, Chandigarh as MTCC 2707.

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Field experiments were laid out during 1994–95, 1995–96 and 1996–97 on different crops, viz pearlmillet, sorghum, wheat, mustard, chickpea and pigeonpea at different locations in Gujarat, viz Anand, Jamnagar, Surat and Bharuch. The effect of seed inoculation with carrier based (vermiculite) culture of *T. globosa* was tested at all locations. Nitrogen was applied as urea in two split doses. Phosphorus was not applied in any of the treatment. The treatments were replicated two times in randomized block design. Yield was determined at the time of crop maturity. The mean data are presented in Table 1.

The results indicate that seed inoculation with *T. globosa* increased yield of all the crops tested. The grain yield increase due to seed inoculation over the non-inoculated control was 17.6 –55.2% in pearlmillet at Jamnagar; 5.1–17.0% in sorghum at Surat; 19.1–32.2% in wheat at Anand, 22.1% in chickpea at Anand and 36.4–88.5% in mustard at Anand.

Table 1 Response to inoculation with *Torulospora globosa* (PBA 22) in different crops.

Crop	Season	Year	Yield (kg/ha)		Per cent increase
			T. globosa (PBA 22)	Absolute control	
Pearlmillet*	*Kharif*	1994	2 274	1 465	55.2
	Kharif	1995	1 561	1 206	29.4
	Kharif	1996	3 097	2 634	17.6
Sorghum*	*Kharif*	1994	3 539	3 025	17.0
	Kharif	1995	3 694	3 444	7.3
	Kharif	1996	3 639	3 463	5.1
Wheat*	*Rabi*	1994-95	1 764	1 481	19.1
	Rabi	1995-96	2 072	1 567	32.2
Chickpea*	*Rabi*	1994-95	1 275	1 044	22.1
Mustard*	*Rabi*	1994-95	1 939	1 422	36.4
	Rabi	1995-96	3 206	1 701	88.5
Sorghum**	*Kharif*	1996	7 461	5 793	28.8
Pegeonpea***	*Kharif*	1995-96	2 521	1 111	127.0
	Kharif	1996-97	6 536	3 522	85.6

*Grain yield, **dry stover yield, ***fresh pod yield

Similarly, seed inoculation increased dry stover yield in sorghum by 28.8% at Anand. At Bharuch, a significant increase in green pod yield could be obtained due to seed inoculation.

This report has shown positive effects of *T.globosa* inoculations to all the crops studied. Several workers reported increase in yield due to inoculation with PSMs (Gaur 1972, Gaur *et al.* 1980)

Further assessment of the effect of this strain on yield increase of other crops is warranted.

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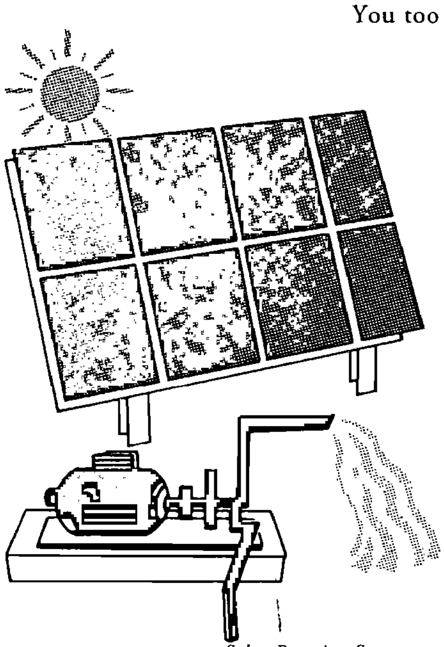

Solar Pumping System

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Ministry of Non-Conventional Energy Sources, Govt. of India

E N E R G Y F O R E V E R

MOVING FROM DECADE, AIMING THE SILVER

THE INDIAN JOURNAL OF AGRICULTURAL SCIENCES

GUIDELINES TO AUTHORS

The Indian Journal of Agricultural Sciences is published every month. The following types of material is considered for publication on meeting the style and requirements of the journal (details in December 1996 issue).

1.1 ARTICLES ON ORIGINAL RESEARCH COMPLETED, not exceeding 4 000 words (up to 15 typed pages, including references, table etc) should be exclusive for the journal. They should present a connected picture of the investigation and should not be split into parts. Complete information of Ph D thesis should preferably be given in 1 article.

1.2 SHORT RESEARCH NOTES, not more than 1 300 words (total 5 typed pages), which deal with (*i*) research results that are complete but do not warrant comprehensive treatment, (*ii*) descriptions of new material or improved techniques or equipment, with supporting data, and (*iii*) a part of thesis or study. Such notes require no headed sections.

1.3 CRITICAL RESEARCH REVIEW ARTICLES, showing lacunae in research and suggesting possible lines of future work. These are mostly invited from eminent scientists.

1.4 The research article or note submitted for publication should have a direct bearing on agricultural production or open up new grounds for productive research. Articles on agricultural engineering are also considered. Basic type of articles and notes relating to investigation in a narrow specialized branch of a discipline may not form an appropriate material for this journal, nor do the articles of theoretical nature, or those of local importance, repetitive, based on old data, with no positive significance, or on extension education.

1.5 Author should note: (*a*) period (years) of conducting the experiment must be indicated, (*b*) article should preferably be submitted soon after completion of experiment, (*c*) articles on genetics and plant breeding and on plant crops should be based on data of minimum 2 years, (*d*) contribution involving a former or present student must clarify that it is not based/based on complete M Sc thesis, or complete or a part of the Ph D thesis, indicating its year of submission, and (*e*) Article Certificate must be signed by all the authors.

2.1 TITLE should be short, specific and informative. It should be phrased to identify the content of the article and include the nature of the study and the technical approach, essential for key-word indexing and information retrieval.

2.2 A SHORT TITLE not exceeding 35 letters should also be provided for running headlines.

2.3 BY-LINE should contain, in addition to the names and initials of the authors, the place (organization) where research was conducted. Change of address should be given as a footnote and correspondence address separately.

3. ABSTRACT, written in complete sentences, should not have more than 150 words. It should contain a very brief account of the materials, methods, results, discussion and conclusion, so that the reader need not refer to the article except for details. It should not have references to literature, illustrations and tables.

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4.2 Relevant details should be given of the MATERIALS AND METHODS including experimental design and the techniques used. Where the methods are well known, citation of the standard work in sufficient. Mean results with the relevant standard errors should be presented rather than detailed data. The statistical methods used should be clearly indicated.

4.3 RESULTS AND DISCUSSION should be combined, to avoid repetition.

4.4 The results should be supported by brief but adequate tables or graphic or pictorial materials wherever necessary. Self-explanatory tables should be typed on separate sheets, with appropriate titles.

4.5 The tables should fit in the normal lay-out of the page. All weights and measurements must be in SI (metric) units. Tables and illustrations (up to 20% of text) should not reproduce the same data.

4.6 The discussion should relate to the limitations or advantages of the author's experiment in comparison with the work of others. All recent relevant literature should be discussed critically.

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