

CROP PRODUCTION

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Phenotypic stability of yield and related characters in *desi gram (Cicer arietinum)*

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ABSTRACT

A set of 22 advanced lines and 3 control varieties of gram or chickpea (*Cicer arietinum* L.) was evaluated in 4 environments during 1988-89 and 1989-90, to determine the stability for seed yield along with days to 50% flowering and to maturity, and 100-seed weight. Significant differences were observed among genotypes and environments along with significant genotype $\times$ environment ($G \times E$) interaction for means of these characters. Stability analysis showed that both linear and non-linear components significantly contributed towards $G \times E$ interaction for days to 50% flowering, whereas non-linear component predominantly contributed toward seed yield, days to maturity and 100-seed weight. 'K 850' and 'ICCV 89360' were found the most stable genotypes with high yield performance (1 985 and 1 850 kg/ha respectively). Absence of correlation between seed yield and the sensitivity of genotypes to different environments indicated the possibility of selection for high yield without compromising on its stability.

Instability of seed yield due to large genotype $\times$ environment ($G \times E$) interaction is a major reason for stagnation in production of gram or chickpea (*Cicer arietinum* L.) (Smithson *et al.* 1985). Therefore breeding programmes get high priority for stability in yield by multi-locational testing of advanced genotypes in different years. The lack of soil moisture and occurrence of biotic stresses, especially gram podborer [*Helicoverpa armigera* (Hübner)] and soil-borne diseases such as fusarium wilt [*Fusarium oxysporum* Schlecht. emend. Snyd. & Hans. f. sp. *ciceri* (Padwick) Snyd. & Hans.] and dry root rot

[*Rhizoctonia bataticola* (Taub.) Butler], are the major factors causing instable yield in gram (Singh 1987). Therefore an understanding of the response of different gram genotypes to irrigated and rainfed, and protected and unprotected (without application of fungicide and insecticide) conditions would be useful to gram breeders to identify genotypes with stable yield. Hence an experiment was conducted to determine the phenotypic stability of seed yield and related characters in a set of promising gram lines under different environments.

MATERIALS AND METHODS

Twenty-two advanced breeding lines of gram along with control varieties were

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evaluated at the main centre of the institute at Patancheru (18°N) and the subcentre at Gwalior (26°N), during 1988–89 and 1989–90. At Patancheru the crop was sown in 3 different environments, ie irrigated and protected, rainfed and protected, and rainfed and unprotected. The crop at Gwalior was irrigated and protected. All the trials were laid out in a 5 x 5 balanced lattice-square design with 3 replications and the crops were sown in October or November. Each plot consisted of 4 rows of 4 m length, spaced at 30 cm with plants at 10 cm within the rows. Total precipitation during the rainy season (June–October) in 1988–89 and 1989–90 was 900 and 937 mm at Patancheru and 641 and 535 mm at Gwalior respectively. Crop seasons were dry in both the years with total precipitation of 6.7 and 15.1 mm at Patancheru (October–February), and 28 and 20 mm at Gwalior (November–March). Besides the rain, 4 irrigations were provided to the crops sown under irrigated condition. The seeds sown in the protected trials were treated with thiram (Thiram) and benomyl (Benlate) before planting. Insecticides were sprayed in the protected trials to control the gram-podborer as and when needed. Days to 50% flowering and to maturity, 100-seed weight and seed yield were recorded in each plot. All the plots in unprotected environments were scored for pod-borer damage on 1–9 scale (1, resistant; 9, susceptible). The environments and genotypes were assumed to be fixed for statistical analysis. The phenotypic stability of genotypes was estimated using the parameters developed by Eberhart and Russell (1966). Rank correlations between the mean performance of genotypes and their regression coefficients on the environmental indices were also calculated for the characters under study.

RESULTS AND DISCUSSION

The mean seed yield for environments was 716–2 758 kg/ha (Table 1). The irrigated and

protected environments at both locations were favourable for gram production. Gwalior in particular was found more favourable because of longer crop duration, as indicated by environmental means for days to 50% flowering and to maturity. For 100-seed weight the means for different environments were 17.4–20.8 g.

The pooled analysis of variance revealed significant variation among genotypes and environments for all the 4 characters (Table 2). The presence of significant G x E interaction indicated that the relative rankings of genotypes were different in the 2 environments. Further partitioning of the G x E interaction into linear and non-linear (pooled deviation) components showed that both the components were significant for all the 4 characters. However, when linear component of G x E interaction was compared with the pooled deviation, it was found significantly different only for days to 50% flowering, indicating differences in linear response among genotypes in different environments. For the remaining characters a relatively high proportion of G x E interaction was non-linear, indicating that prediction of the performance of different genotypes for different environments will not be feasible. In this situation the deviation from regression (S^2_{di}) is a more important criterion for assessing the stability of genotypes. The result is in agreement with the reports of Jain *et al.* (1984), Singh and Bejiga (1990) and Singh and Singh (1990).

Eberhart and Russell (1966) defined stable genotypes as those having unit regression coefficient ($b = 1.0$) and non-significant deviation from the regression (S^2_{di}). A simultaneous evaluation of the stability parameters (b_i and S^2_{di}) and mean for seed yield showed that 8 genotypes had stable performance, as evident from their unit regression and a non-significant deviation from the regression (Table 3). Out of these, 'K 850' and 'ICC V

Table 1 Effect of location, irrigation and plant protection on performance of gram

Environment	Planting date	Mean performance			
		Days to 50% flowering	Days to maturity	100-seed weight (g)	Seed yield (kg/ha)
1988					
<i>Patancheru</i>					
Irrigated + protected	26 Oct	52	109	17.57	2 496 (14)
Non-irrigated + protected	9 Oct	56	111	18.52	1 386 (15)
Non-irrigated + unprotected	11 Oct	56	114	17.70	1 060 (11)
<i>Gwallor</i>					
Irrigated + protected	22 Nov	73	141	20.23	2 758 (12)
1989					
<i>Patancheru</i>					
Irrigated + protected	30 Oct	49	105	19.23	1 860 (12)
Non-irrigated + protected	3 Oct	53	112	17.36	1 089 (27)
Non-irrigated + unprotected	3 Oct	54	112	20.75	716 (12)
<i>Gwallor</i>					
Irrigated + protected	5 Nov	69	136	20.15	2 511 (15)
CD (P = 0.05)		1.32	1.58	0.59	163.9
Mean		58	118	18.94	1735

Figures in parentheses are coefficients of variation (%) for seed yield

Table 2 Pooled analysis of variance for different characters in gram

Source of variation	df	Mean squares			
		Days to 50% flowering	Days to maturity	100-seed weight (g)	Seed yield (kg/ha)
Genotypes (G)	24	272.2**	79.4**	103.43**	81 878**
Environment (E)	7	1 817.4**	4 299.1**	44.85**	15 214 811**
G × E	168	9.6**	8.6**	1.26**	91 921**
E (linear)	1	12 721.5**	30 094.6**	314.02**	106 503 512**
G × E (linear)	24	31.2**	8.8**	1.65**	89 741**
Pooled deviation	150	5.7**	7.9**	1.13**	87 368**
Pooled error	384	1.3	1.8	0.34	23 936

**P = 0.01

89360' were also among the 5 highest yielding genotypes. This indicates the possibility of identifying genotypes giving relatively high yields in different environments. Singh *et al.* (1986) also identified genotypes with high mean yield and stability in changing environ-

Table 3 Stability parameters for different characters in gram

Genotype	Days to 50% flowering			Days to maturity			100-seed weight (g)			Seed yield (kg/ha)		
	Mean	b _i	S ² _{di}	Mean	b _i	S ² _{di}	Mean	b _i	S ² _{di}	Mean	b _i	S ² _{di}
'ICCV 89342'	64	0.63**	11.92**	120	0.93	10.41**	24.69	1.37	0.14	1776	1.19	93156**
'ICCV 89343'	61	1.02	-0.35	119	1.04	5.66**	19.81	0.92	0.64**	1889	0.93	28556*
'ICCV 89345'	64	0.88	14.15**	121	0.92	-0.39	23.84	2.11**	1.89**	1819	1.25	132821**
'ICCV 89346'	61	0.94	1.57*	120	1.00	4.29**	20.42	1.49	0.24	1688	0.90	216756**
'ICCV 89347'	54	1.20	0.19	117	1.01	2.77*	24.37	1.43	1.10**	1626	0.98	8460
'ICCV 89348'	66	0.63**	5.10**	122	0.93	3.87**	19.28	1.35	1.04**	1600	1.34*	115286**
'ICCV 89349'	50	1.21*	2.94**	115	1.03	6.22**	15.65	0.67	0.05	1732	1.00	22667
'ICCV 89350'	53	1.22*	1.89*	114	1.11	1.45	14.82	0.74	0.32	1720	0.93	47061**
'ICCV 89351'	50	1.38**	3.91**	114	1.12	11.30**	21.67	0.77	0.31	1708	0.78	73952**
'ICCV 89352'	52	1.17	4.99**	111	1.15	12.82**	18.33	1.10	3.62**	1801	1.14	53881**
'ICCV 89353'	51	1.14	5.13**	112	1.16	10.54**	18.11	0.90	1.30**	1710	1.00	97919**
'ICCV 89354'	52	1.22*	2.26*	114	1.06	15.33**	20.88	0.62	0.52**	1636	0.95	21515
'ICCV 89355'	54	0.99	1.29	118	1.00	1.73	18.09	0.80	1.05**	1701	1.04	100660**
'ICCV 89356'	58	1.03	2.38*	117	0.97	3.80**	15.00	0.89	0.22	1695	1.01	38259*
'ICCV 89357'	62	0.86	1.45	120	0.94	6.10**	18.40	0.96	1.04**	1874	0.96	73203**
'ICCV 89358'	63	0.81	3.29**	120	0.93	9.16**	15.82	0.46	0.99**	1760	0.77	108673**
'ICCV 89359'	64	0.79*	-0.98	121	0.95	7.86**	18.74	1.08	0.09	1704	0.81	-3466
'ICCV 89360'	55	1.32**	5.22**	118	1.03	2.93*	19.66	1.18	0.27	1850	0.99	17206
'ICCV 89361'	60	0.85	2.19*	118	0.96	3.89**	15.50	0.38*	0.57*	1554	0.81	65878**
'ICCV 89362'	67	0.79*	14.46**	121	0.92	6.82**	16.44	1.12	0.08	1722	0.99	-3292
'ICCV 89363'	52	1.43**	5.05**	117	0.99	9.23**	15.76	0.81	0.20	1591	0.88	70444**
'ICCV 89364'	53	1.09	0.65	116	1.04	1.29	21.44	0.98	0.63**	1633	1.11	7745
'K 850'	61	0.76*	0.77	120	0.96	0.78	27.03	1.10	0.99**	1985	0.96	4074
'Annigeri'	52	1.14	1.89*	113	1.10	5.76**	19.19	0.91	2.11**	1866	1.16	75345**
'Pant G 114'	67	0.48**	19.09**	123	0.79**	8.95**	11.40	0.89	0.44*	1723	1.13	119050**
Mean	58			118			18.97			1735		
SE ±	0.9	0.106		1.0	0.081		0.38	0.300		104.5	0.143	
r between mean and b _i		-0.88**			-0.91**			0.60**			0.07	

*P = 0.05; **P = 0.01

b_i, Regression coefficient; S²_{di}, deviation from regression; r, correlation coefficient

ments. However, Singh and Bejiga (1990) reported that their stable lines were average yielders whereas the unstable lines were high yielders. Non-correlation of mean seed yield with regression coefficient (b_i) (Table 3) also indicated that selection for high seed yield is possible without affecting the ability of a genotype to perform well in every environment. 'ICCV 89347', 'ICCV 89364' and 'ICCV 89354' were stable ($b_i = 1$ and $S^2_{di} = 0$), but undesirable due to low yield. 'Annigeri' and 'ICCV 89357' gave high yield and showed average sensitivity to variation in the environments ($b_i = 1$) but their deviation from the regression was high, indicating that such genotypes were unpredictable in their performance. Similarly, 'ICCV 89348' was responsive to better growing conditions ($b_i > 1$) but its performance was not stable. 'K 850' showed stable performance for days to maturity in addition to seed yield. Kumar *et al.* (1994) also established 'K 850' as one of the most stable genotypes in International Chickpea Adaptation Trials conducted in 22 countries. 'ICCV 89360' with high and stable yield also showed stability for 100-seed weight. 'ICCV 89360' also combined resistance to wilt and root rots (16% total mortality) and moderate tolerance to gram podborer (5.3 in 1-9 scale). Therefore 'K 850' and 'ICCV 89360' can be suitable for environments characterized by irregular water availability and biotic stresses and may also be useful as donor parents for stability in future breeding programmes.

Five genotypes showed regression coefficient close to unity ($b_i = 1$) and the deviation from regression approaching 0 ($S^2_{di} = 0$) for days to 50% flowering. This indicated their average sensitivity to environmental fluctuation for time taken for flowering. Among these, 'ICCV 89347', 'ICCV 89355' and

'ICCV 89364' showed significantly earlier flowering than the mean. 'K 850' and 'ICCV 89359' also showed non-significant deviation from regression ($S^2_{di} = 0$) with $b_i > 1$, indicating that these genotypes tended to flower early in rainfed and unprotected environments.

Five genotypes ('ICCV 89345', 'ICCV 89350', 'ICCV 89355', 'ICCV 89364' and 'K 850') with unit regression and 0 deviation from regression showed phenotypic stability for days to maturity. Among these, 'ICCV 89350' and 'ICCV 89364' were the only genotypes maturing earlier than the average. 'ICCV 89355' and 'ICCV 89364', which showed stability for both days to 50% flowering and maturity, may be utilized as donors in the breeding programmes.

Ten genotypes had regression values closer to unity and non-significant deviation from regression for 100-seed weight, indicating their stable performance for this trait in different environments. Out of these, 'ICCV 89342', 'ICCV 89351' and 'ICCV 89346' had significantly higher 100-seed weight than the mean. Their use is desirable as donor parents for stabilizing seed size in the breeding programmes.

REFERENCES

- Eberhart S A and Russell W A. 1966. Stability parameters for comparing varieties. *Crop Science* 6 : 36-40.
- Jain K C, Pandya B P and Pande K. 1984. Stability of yield components of chickpea genotypes. *Indian Journal of Genetics and Plant Breeding* 44 : 159-63.
- Kumar J, Singh K B, Malhotra R S, Miranda J H and Dasgupta T. 1994. Genotype x environment interaction for seed yield in chickpea. *Indian Journal of Genetics and Plant Breeding* 54: (in press).
- Singh K B. 1987. Chickpea breeding. (in) *The Chickpea*, pp 127-62. Saxena M C and Singh K B (Eds). Commonwealth Agricultural Bureaux International, Wallingford.

- Singh K B and Bejiga G. 1990. Analysis of stability for some characters in kabuli chickpea. *Euphytica* **49** : 223-7.
- Singh R, Yadav H S and Singh P. 1986. Stability analysis for grain yield in gram (*Cicer arietinum* L.). *Science and Culture* **52** : 204-5.
- Singh V and Singh F. 1990. Stability of yield and harvest index in chickpea (*Cicer arietinum*). *Indian Journal of Agricultural Sciences* **60** (7) : 443-7.
- Smithson J B, Thompson J A and Summerfield R J. 1985. Chickpea (*Cicer arietinum* L.). (in) *Grain Legume Crops*, pp 312-90. Summer field R J and Roberts E H (Eds). William Collins Sons & Co. Ltd, London, the UK.

Long-term effect of continuous maize (*Zea mays*) – wheat (*Triticum aestivum*) cropping system and manuring on soil fertility and stability in crop yield

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ABSTRACT

A long-term field experiment was conducted since rainy and winter seasons of 1978-79 to 1987-88 on a clay-loam soil, to evaluate the effect of continuous maize (*Zea mays* L.)-wheat (*Triticum aestivum* L. emend. Fiori & Paol.) cropping system on soil fertility and stability in crop yield. Application of nitrogen @ 120 kg/ha and phosphorus @ 17.5 kg/ha to each crop significantly increased the grain yield of maize (2 025 and 1 803 kg/ha) and wheat (3 112 and 2 914 kg/ha) respectively. The fertilizer application resulted in building up the organic C, P and K status of the soil.

Management of soil fertility is gaining importance due to increase in the intensity of maize (*Zea mays* L.)-based cropping systems and continuous removal of plant nutrients. The knowledge of the status of soil nutrients is necessary for evaluating the impact of modern system of agriculture on sustained crop production. In Rajasthan the maximum area under maize-wheat (*Triticum aestivum* L. emend. Fiori & Paol.) sequence is concentrated in its south agro-climatic region. Therefore, to find out the optimum dose of nitrogen, phosphorus and potassium for this system, the present experiment was undertaken on the long-term effect of maize-wheat

cropping sequence and manuring on crops productivity and soil fertility.

MATERIALS AND METHODS

The field experiment was conducted during the rainy (*kharif*) and winter (*rabi*) seasons for 10 consecutive years (1978-79 to 1987-88) at Banswara, on clay-loam soil. The initial soil status was available N 166 kg/ha, available P 15 kg/ha, available K 252 kg/ha, and organic carbon 0.26%. The climate is subhumid to humid. The long dry spell is common in the rainy season. The average rainfall during 1978-88 was 556.6 mm, and the temperature was 21.6-40.8 and 6.0-38.0°C during the rainy and winter seasons respectively. The experiment was laid out in 3² × 2 factorial, partially confounded design in fixed plots, having 1 control plot in each block with 4 replications. N, P and K were applied through urea, single superphosphate and muriate of potash respectively. There

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were 19 treatment combinations consisting of 3 levels each of N (40, 80 and 120 kg/ha; N₄₀, N₈₀ and N₁₂₀ respectively), and P (0, 17.5 and 35 kg/ha; P₀, P_{17.5} and P₃₅) and 2 levels of K (0 and 33.3 kg/ha; K₀ and K_{33.3}), along with 1 control (N₀ P₀ K₀). Full dose of P and K and half of N were applied basal to both the crops at the time of sowing. The remaining N was applied 25–30 days after sowing to both the crops. 'Ganga 2' maize (rainfed) was sown at the onset of monsoon, followed by 'Kalyansona' wheat (irrigated) in the second fortnight of November each year. The yield of maize was poor during 1981–82 and 1986–87 due to uneven and erratic rainfall. Representative soil samples from a depth of 30 cm were drawn for analysis after harvesting the wheat crop of final year and were analysed for organic C, P and K.

RESULTS AND DISCUSSION

Response of maize to N, P and K

The grain yield of maize increased significantly with an increase in N level in all the seasons. Pooled analysis of data showed that N₁₂₀ gave significantly higher grain yield than N₄₀ and N₈₀ (Table 1). However, it was on a par with N₈₀ during 1978–79 and 1979–80. The finding confirms the result of Grewal *et al.* (1992). The yield prediction equation was found linear as:

$$Y = 993.3 + 8.94 X$$

$$R^2 = 0.96$$

where Y, expected grain yield (kg/ha) at a given unit of N(X), where unit of X is 40 kg N/ha.

The P application was effective in all the years except during 1978–79, 1979–80 and 1981–82. P_{17.5} and P₃₅ gave significantly higher grain yield of maize than P₀ in all the years. However, the difference between P_{17.5} and P₃₅ was not significant except during 1980–81 and 1983–84, perhaps due to low

P-fixing capacity of the soil. Yield response of maize to P was quadratic as:

$$Y = 1577 + 5.525 X - 0.03375 X^2$$

$$R^2 = 0.99$$

The optimum dose of P was worked out to 19.7 kg/ha and grain yield at this dose was 1757.3 kg/ha.

Potassium application did not increase the grain yield of maize significantly, owing to sufficient K reserve and high K-buffering capacity. Patel *et al.* (1985) also reported that K application increased its uptake but not the yield of sorghum [*Sorghum bicolor* (L.) Moench].

Response of wheat to N, P and K

The response of wheat to N increased significantly with increase in N level. Linear response to it was observed up to 120 kg/ha in all the 10 years except during 1978–79 where N₈₀ and N₁₂₀ were at par. Pooled analysis showed that N₁₂₀ gave 42 and 12% more grain yield of wheat than N₄₀ and N₈₀ respectively.

The regression equation worked out was:

$$Y = 1776.6 + 11.48 X$$

$$R^2 = 0.97$$

The optimum dose was more than 120 kg N/ha for wheat. An increase in P level from 0 to 35 kg P/ha increased the grain yield of wheat correspondingly. However, significant increase in yield was observed only up to P_{17.5}, except during 1985–86, 1986–87 and 1987–88 where P₃₅ was better. Godyani and Tiwari (1985) and Raghuwanshi *et al.* (1988) also reported beneficial effect of P on wheat.

The yield response of wheat to P was quadratic as:

$$Y = 2395.03 + 12.51 X - 0.075 X^2$$

$$R^2 = 0.99$$

The average optimum yield was 2902.2 kg/ha at P_{30.5}. K application did not increase the

Table 1 Grain yield (kg/ha) of maize and wheat and soil-fertility status as influenced by continuous cropping and fertilizer application (pooled data of 1978-79 to 1987-88)

Treatment	Grain yield (kg/ha)		Organic carbon (%)	Available nutrient (kg/ha)	
	Maize	Wheat		P	K
<i>N (kg/ha)</i>					
40	1 310	2 193	0.26	14	302
80	1 790	2 780	0.30	18	343
120	2 025	3 112	0.33	18	347
CD (P = 0.05)	76	153			
<i>P (kg/ha)</i>					
0	1 577	2 395	0.28	16	320
17.5	1 744	2 775	0.30	17	332
35.0	1 803	2 914	0.30	18	333
CD (P = 0.05)	76	153			
<i>K (kg/ha)</i>					
0	1 702	2 678	0.29	17	323
33.3	1 715	2 712	0.29	17	338
CD (P = 0.05)	NS	NS			
Control (NoPoK ₀)	827	1 085	0.21	10	247

grain yield of wheat significantly, similar to maize.

Soil analysis

The soil analysis (Table 1) revealed an increase in organic carbon (%) from the initial value of 0.26 to 0.33%. The available P (though medium) also increased but remained in the medium range from 14 to 18 kg P/ha. The available K (which was initially high) remained high (300-347 kg K/ha. The result confirms the findings of Singh and Nambiar (1986), Raghuwanshi *et al.* (1988) and Patel *et al.* (1991). It was concluded that under maize-wheat cropping sequence both the crops should be fertilized with 120 kg N/ha along with 17.5 kg P/ha.

REFERENCES

- Godyani B R and Tiwari B P. 1985. Effect of irrigation and fertilizers on growth and yield of wheat. *Indian Journal of Agronomy* 30 (3) : 342-4.
- Grewal H S, Kolar J S and Kang J S. 1992. Effect of combined use of green manure and nitrogen on the productivity of maize (*Zea mays*)-wheat (*Triticum aestivum*) system. *Indian Journal of Agronomy* 37 (4) : 635-8.
- Patel P V, Mehta P M, Patel M L and Patel M G. 1985. Efficient utilization of potassic fertilizer by sorghum on a vertisol. *Journal of Potassium Research* 1 (2) : 129-32.
- Patel S K, Patel M M, Kerelia G N, Patel D M, Upadhyaya S M and Patel B A. 1991. Long-term effect of continuous pearl millet (*Pennisetum glaucum*)-wheat (*Triticum aestivum*) cropping system and manuring on soil fertility and yield stability. *Indian Journal of Agronomy* 36 (suppl) : 86-90.
- Raghuwanshi R K S, Nema M L, Dubey D D, Umat R and Thakur H S. 1988. Manurial requirement of a long term hybrid sorghum-wheat cropping sequence. *Indian Journal of Agronomy* 33 (3) : 295-9.
- Singh G B and Nambiar K K M. 1986. Crop productivity and fertility under intensive use of chemical fertilizer in long term field experiments. *Indian Journal of Agronomy* 31 (2) : 115-7.

Effect of preceding crops on growth, nitrogen concentration and uptake in rice (*Oryza sativa*)

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ABSTRACT

A field experiment was conducted during early rainy season (*kharif*) of 1989 and 1990 to study the effect of preceding crop and crop combinations and N levels on growth and nutrient uptake of rice (*Oryza sativa* L.). Rice sown after sole blackgram (*Phaseolus mungo* L.) had tallest plant (94.8 cm), higher dry matter (1.26 kg/m²) and leaf-area index (1.87) than when sown after early rainy-season or *aus* (March–April) rice and maize (*Zea mays* L.) alone. N content in rice plant at all the growth stages was significantly higher when it was followed by blackgram as sole and intercrop with maize. Similar trend was noticed for nutrient content in grain and straw and nutrient uptake. An increase in N level increased the plant height, dry matter, leaf-area index and nutrient uptake. The grain yield of rice was significantly highest when the crop was grown after sole blackgram.

Growth and nutrient uptake in a plant vary according to natural condition of soil, climate and cultural practices, i.e. method of cultivation and amount of nutrients applied (Ishizuka 1971). Fertilizer application, however, may be based on nutrient uptake, as the crop yield is directly related to the amount of nutrients absorbed. The manner of nutrient uptake is also useful in determining the peak period of its uptake for maximizing the efficiency of the applied fertilizers. Hence the present investigation was carried out to study the effect of preceding crop, crop combinations and nitrogen levels on growth and nutrient uptake by rice (*Oryza sativa* L.).

MATERIALS AND METHODS

The field experiment was conducted during early rainy season (*kharif*) of 1989 and 1990 at Joydebpur (240.0' N, 92.25' E, 8 m above sea-level). The soil was silty clay with pH 6.3, belonging to Chitta series of Grey Terrace soil, having moderately slow permeability. The soil was low in organic matter (1.10%), nitrogen (14 mg/kg), phosphorus (15 mg/kg) and potassium (66 mg/kg) and S (16 mg/kg). The trial during early rainy season (*aus*) (March–April) was set up in randomized block design with 4 replications. The treatments tested were: T₁, broadcast sole early rainy-season rice (periodically fixed-maturity rice variety, grown in March–April); T₂, row-seeded early rainy-season rice sole; T₃, row-seeded blackgram (*Phaseolus mungo* L.) sole; T₄, uniform maize (*Zea mays* L.) in sole; T₅, maize in paired row (100%) + blackgram rows

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(33%); T₆, row-seeded early rainy-season rice (67%) + prickly sesban [*Sesbania cannabina* (Retz.) Pers., syn *S. aculeata* Pers. var *cannabina* Baker)] broadcast in strip (33%); T₇, row-seeded early rainy-season rice (100%) + prickly sesban broadcast (50%); and T₈, row-seeded early rainy-season rice (67%) + blackgram in rows (33%). At full-growth stage (45 days after sowing) plants of prickly sesban were incorporated into the soil. Blackgram pods were picked once only at 70 days and the plant residues were incorporated into the soil. After harvest of early rainy-season (*kharif*) crops, *aman* (photoperiod-sensitive rice variety transplanted in July–August and harvested in November–December) rice was grown under 4 N levels (0, 40, 80, and 120 kg N/ha; N₀, N₄₀, N₈₀, and N₁₂₀ respectively). The N treatments were superimposed over the preceding crop and crop combination. Treatment combinations were arranged in split-plot design with 4 replications. The preceding crop and crop combination constituted the main-plot treatment. Seeds of 'BR 11' *aman* rice were sown in the seed-bed and the seedlings at 25 days were transplanted, maintaining 2 seedlings/hill with a spacing of 25 cm x 15 cm. Fertilizers P @ 29 kg/ha and K @ 33 kg/ha were given basal, as per recommended dose, and N as per treatment, into subplots. N was top-dressed in 3 equal splits at 15, 30 and 45 days after transplanting.

Twenty plants were collected from each plot. Observations were taken on plant height, dry matter and leaf-area index at harvest. The plant samples of rice were collected for N analysis at 4 stages of growth, i.e. active tillering, panicle initiation, flowering and harvest; N content was determined by the wet digestion method (Hunter 1983); and the total N content in grain by autoanalyser (AOAC, Washington 1960). Nutrient uptake was determined by using the estimate of present nutrient in the plant tissue divided by total dry-matter yield.

RESULTS AND DISCUSSION

Plant height

Plant height of rice was significantly affected by the preceding crop and crop combination. It was more when sole blackgram preceded it, and was equal to that of maize intercropped with blackgram and prickly sesban and blackgram with rice. The lowest plant height of rice was recorded when early rainy-season rice or maize was the preceding crop. The plant height increased with an increase in N level (Table 1).

Dry matter

Highest dry matter of rice was recorded with preceding sole blackgram. When sole broadcast early rainy-season rice was the preceding crop, it gave the lowest dry matter, followed by maize and row-seeded sole rice (Table 1). The rate of increase was more in rotation with a legume than in that of cereal. An increase in N level increased the dry matter. The result confirms the finding of Wankhade *et al.* (1988).

Leaf-area index

The leaf-area index was the highest when rice was grown after sole blackgram. It differed significantly from the other treatments. The lower leaf-area index was recorded when sole early rainy-season rice or maize was grown before rice than with legumes. The increase in dry matter increased the leaf-area index, as also the increase in N level (Table 1).

Grain yield

The grain yield of rice was significantly affected by the preceding crop and crop combination. The preceded sole blackgram gave the significantly highest yield of rice, followed by preceded maize in paired row + blackgram (Table 1). Ahlawat *et al.* (1981) also reported beneficial effect of including legume in the crop rotation. The lowest grain yield was obtained when rice was followed by

Table 1 Effect of preceding crop, crop combination and N level on growth attributes, grain yield, nitrogen content in grain and straw yields of rice (pooled data)

Treatment	Growth attributes at harvest				N (%) at growth stages				N content (%)		N uptake (kg/ha)		
	Plant height (cm)	Dry matter (kg/m ²)	Leaf area index	Grain yield (tonnes/ha)	Active tillering	Panicle initiation	Flowering	Harvest	Grain	Straw	Grain	Straw	Total
Main plot													
T ₁	91.38	1.16	1.65	3.51	2.49	1.51	0.91	0.50	1.08	0.50	37.93	16.99	54.92
T ₂	92.15	1.15	1.69	3.56	2.53	1.54	0.94	0.53	1.11	0.53	39.53	18.34	57.87
T ₃	94.80	1.26	1.87	3.92	2.81	1.62	1.05	0.73	1.21	0.73	47.50	28.72	76.22
T ₄	91.39	1.15	1.67	3.43	2.51	1.49	0.90	0.47	1.06	0.47	36.52	15.65	52.17
T ₅	94.21	1.25	1.81	3.86	2.71	1.59	1.00	0.68	1.18	0.68	45.61	26.38	71.99
T ₆	93.60	1.24	1.77	3.65	2.67	1.57	0.98	0.65	1.15	0.65	41.99	24.28	66.27
T ₇	93.53	1.23	1.75	3.69	2.63	1.56	0.96	0.63	1.13	0.63	41.94	23.50	65.43
T ₈	94.01	1.24	1.76	3.74	2.65	1.58	0.99	0.66	1.16	0.66	43.39	24.73	68.12
CD (P = 0.05)	1.30	0.07	0.03	0.04	0.05	0.04	0.05	0.04	0.05	0.04	1.42	1.44	1.40
CV (%)	1.62	1.15	1.11	1.62	1.05	1.60	2.38	1.85	2.97	1.85	2.37	2.28	2.36
Subplot													
N ₀	86.67	1.08	1.46	2.85	2.27	1.21	0.65	0.37	1.01	0.38	28.95	10.13	39.08
N ₄₀	91.93	1.16	1.74	3.52	2.59	1.47	0.94	0.63	1.11	0.63	39.21	22.35	61.56
N ₈₀	95.37	1.28	1.85	4.11	2.76	1.71	1.08	0.73	1.18	0.73	48.76	28.90	77.66
N ₁₂₀	98.51	1.33	1.94	4.22	2.88	1.82	1.19	0.79	1.24	0.79	52.33	33.58	85.91
CD (P = 0.05)	0.82	0.06	0.02	0.03	0.04	0.03	0.04	0.03	0.02	0.03	1.15	1.35	1.38
CV (%)	1.51	1.12	1.08	1.58	1.02	1.57	2.30	1.77	2.58	1.50	2.29	2.19	2.25

Details of treatments are given in text

early rainy-season rice or maize. It indicates that a cereal alternating either with maize or rice in sole situation considerably reduces the grain yield. Incorporation of prickly sesban *in situ* was not as effective as blackgram for increasing the grain yield of rice, because prickly sesban was incorporated 45 days after sowing and drought prevailed during the period of its decomposition. Besides, when blackgram was incorporated at 70 days after sowing, after taking pods once; heavy rainfall at that time helped decomposition of the blackgram plants, which got mixed well with the soil. Grain yield was significantly influenced by the N level. Rice yield increased with increase in N level. The result confirms the findings of De (1983) and Antil *et al.* (1988).

N content

In general, higher N content in rice was observed when it was preceded by sole blackgram and intercropped with maize or early rainy-season rice. Nitrogen content in rice plant was significantly higher after sole blackgram at active tillering stage, but sole blackgram was at par with intercropped blackgram in maize at panicle-initiation stage and at flowering stage. At harvest stage, higher N content was recorded from the treatment in which sole blackgram crop preceded, which was significantly higher than other treatments. When broadcast early rainy-season rice sole was the preceding crop, it gave the lowest N content, closely followed by sole maize or row-seeded rice.

An increase in N level increased the N content at all the growth stages. Significantly highest N content was observed at active tillering stage with higher N level (120 kg/ha) and lower at harvest with no nitrogen (Table 1).

Higher N content in rice grain was observed when legumes (blackgram) were incorporated into the soil during the preceding

early rainy season. There was no significant difference of N content in rice among sole blackgram and maize intercropped with blackgram. The lowest N content in grain was recorded from the preceded sole maize, which was at par with that of sole broadcast or row-seeded rice (Table 1). The increase in N content in the succeeding crop was due to the addition of N to the legume in the soil. Nitrogen content in rice grain increased significantly up to 120 kg N/ha. The result confirms the findings of Antil *et al.* (1988).

Significantly highest N content in rice straw was found when it was preceded by sole blackgram. The lowest N content was observed after sole maize, which was on a par with that obtained with broadcast early rainy-season rice. The higher N content in rice straw was recorded with highest N level (Table 1).

N uptake

Higher uptake of N in rice grain was observed when it was preceded by blackgram, grown either as sole or intercrop compared with sole maize and early rainy-season rice. Nitrogen uptake in grain increased with increase in N level up to 120 kg/ha (Table 1). Nitrogen uptake in rice straw also followed a similar trend as that in grain. The result confirms the finding of Antil *et al.* (1988). The uptake of N in straw increased significantly with increase in N level up to 120 kg/ha.

Total N uptake by rice at harvest showed a similar trend as that of grain and straw. The highest total N uptake by rice was observed when it was preceded by sole blackgram and the lowest when it was preceded by sole maize or early rainy-season rice. An increase in N level increased the total N uptake (Table 1).

Thus crop combination involving blackgram proved better than other combinations in terms of yield, nitrogen content and nutrient uptake in the succeeding *aman* rice.

REFERENCES

- Ahlawat I P S, Singh A and Saraf C S. 1991. Effect of winter legumes of the nitrogen economy and productivity of succeeding cereal. *Experimental Agriculture* 15 : 57-62.
- Antil R S, Dalal S, Kumar V and Mahendra S. 1988. Effect of different preceding crops on yield and N uptake by rice. *Indian Journal of Agronomy* 33 (4) : 380-4.
- AOAC, Washington. 1960. *Official Methods of Analysis of the Association of Official Agricultural Chemists*, edn 9. Association of Official Agricultural Chemists, Washington DC.
- De R. 1983. Grain and fodder legumes as preceding crops affecting the yield and N economy of rice. *Journal of Agricultural Science, Cambridge* 101 : 463-6.
- Hunter A H. 1983. *Monograph of Analysis of Plant Tissue Sample*, Agro-Services International Inc., Washington, the USA.
- Ishizuka Y. 1971. Physiology of the rice plant. *Advances in Agronomy* 23 : 241-310.
- Wankhade S G and Pandranji R B. 1988. Growth and nutrient uptake behaviour of upland paddy as influenced by N and P fertilization. *Annals of Plant Physiology* 2 (1) : 30-6.

Effect of tillage, weed-control practices and nitrogen fertilization on performance of rice (*Oryza sativa*) under intermediate deep-water condition

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ABSTRACT

A field experiment was conducted during 1990 and 1991 at Cuttack to study the effect of tillage practices (autumn, summer and pre-monsoon ploughings) along with weed-control methods [manual, chemical and post-establishment inter-crop cultivation (*beushen*)] and N levels (0-60 kg N/ha) on direct-sown 'Gayatri' rice (*Oryza sativa* L.) under intermediate deep-water condition (0-50 cm). In 1991 the grain yield of rice increased significantly with frequency of ploughing, but in 1990 (when weed infestation was less) the yield was more with 2 ploughings [summer (March) and pre-monsoon (May)] than with 3 ploughings [autumn (January), March and May] or 1 ploughing (just before sowing in May). Hand-weeding at 20 and 40 days after germination, early application of butachlor @ 2 kg/ha followed by hand-weeding at 40 days and inter-crop cultivation (*beushen*) provided equally good weed control and increased the yield up to 15.5% in 1990 and 25.9% in 1991 compared with the unweeded control. The effect of weed-control measures was more pronounced with less number of ploughings, particularly in 1991 due to higher weed biomass. Further, in 1991 (when crop-weed competition was allowed unchecked) N application increased the yield up to 20 kg/ha under 3 ploughings but not under 2 ploughings. Moreover, the grain yield decreased linearly with N application under 1 ploughing due to considerable increase in dry weight of weeds. Therefore off-season tillage particularly in summer along with mechanical or chemical weed control was found essential for improving the N-use efficiency and productivity of rainfed lowland rice.

Rainfed lowland areas in eastern India are monocropped with long-duration rice (*Oryza sativa* L.) and the fields remain fallow after crop harvest. Ploughing starts with the receipt of pre-monsoon showers in May for establishing the crop in the following season. In the intermediate deep-water lowlands (0-50 cm), timely sowing is important for obtaining a good initial crop stand and higher productivity (Sharma 1994). However, sowing of seeds often gets delayed due to the limited time available from mid-May to early June. Fur-

ther, increased pressure on draught power results in inadequate land preparation, which causes not only poor germination but also severe weed infestation from the early stages, resulting in low efficiency of applied N fertilizer. Annual grasses and aquatic weeds are controlled effectively with butachlor application (Moody *et al.* 1986, Sharma and Reddy 1992), but the perennial species including sedges are not checked by chemical methods. Post-establishment inter-crop cultivation (*beushen*) is followed predominantly in the broadcast-sown shallow lowland rice for controlling weeds, optimizing crop stand and

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promoting tiller production (Moorthy and Rao 1991). But this practice might also reduce plant population and thus prove harmful under excess water condition (Sharma 1992). In the present study the effect of tillage, weed-control practices and N fertilizer on weeds and rice was investigated under intermediate deep-water condition.

MATERIALS AND METHODS

The field experiment was conducted at Cuttack during the rainy seasons of 1990 and 1991 on the alluvial sandy clay-loam soil of Mahanadi delta, having pH 6.4, organic carbon 0.83%, total N 0.09%, available P 22 kg/ha and available K 128 kg/ha. Off-season tillage involving ploughing of fields after the harvest of previous winter crop in January, summer ploughing in March, ploughing after the receipt of pre-monsoon showers in May (farmer's practice) and no ploughing were combined with treatments of hand-weeding, herbicide application, *beushen* and unweeded control. Weed population in the field was less in 1990 and therefore the experiment was conducted in 1991 in another adjoining weedy field. Based on the results obtained in 1990, another trial was planned in 1991 to find out the effect of N dose on rice with increase in number of ploughings. The tillage treatments were combined with basal application of 0, 20, 40 and 60 kg N/ha without following any weed-control measure. A split-plot design keeping tillage in the main plots and treatments of weed control or N fertilizer in sub-plots (18 m²) with 3 replications was followed.

The fields were ploughed with a tractor-drawn cultivator each time up to a depth of 15–18 cm. The seed was sown in a plough furrow 4–5 cm deep @ 400 seeds/m² at 20 cm row spacing, using a semi-dwarf, long-duration, photo-sensitive rice variety 'Gayatri'. A common basal dose of 8.7 kg P/ha and 16.7 kg K/ha along with N @ 40

kg/ha in the tillage x weed-control trial and as per treatment in the tillage x N trial were applied. Hand-weeding comprised manual uprooting of weeds twice at 20 and 40 days after germination. Herbicide butachlor was sprayed @ 2 kg/ha within a week of germination in moist soil and was also combined with hand-weeding at 40 days. *Beushen* operation, consisting of inter-culturing with a country plough followed by removal of weeds and redistribution of uprooted rice plants, was done at 40 days after germination. By this time, 25 and 40 cm water had accumulated in the field in 1990 and 1991 respectively. Under no ploughing, paraquat was sprayed @ 2 litres/ha before sowing to kill the existing weeds (mainly sedges). But this treatment was discontinued in 1991, as sowing in the unploughed plots was found difficult.

RESULTS AND DISCUSSION

Variation in water depth in field

The crops germinated with the premonsoon showers received after sowing. In 1990, water accumulated from 18 days after germination and rose gradually to 27 cm at 35 days after germination. However, it decreased to 10 cm at 50 days and thereafter rose to a peak depth of 46 cm at 120 days, and again after some recession to 42 cm at 147 days after germination. In 1991 water accumulation started at 22 days after germination and increased rapidly to 32 cm at 30 days and to a maximum of 54 cm at 60 days after germination. Thereafter there was a gradual recession of water to 0 by the end of November (Fig 1).

Crop and weed growth

The predominant weeds in the field were: the broad-leaved species like tropical spiderwort (*Commelina benghalensis* L.), joyweed [*Alternanthera sessilis* (L.) DC.], *mundari* (*Ludwigia perennis* L.) and jointvetch (*Aeschynomene indica* L.); grasses like barnyard

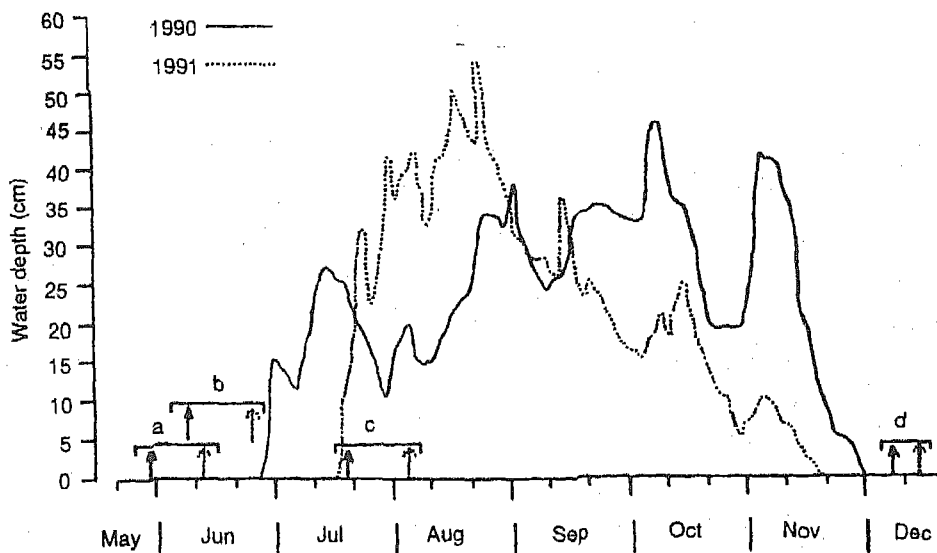


Fig 1 Daily variation in water depth in field during crop-growth period (arrows under a, b, c and d indicate dates of sowing, germination, beushen and harvesting respectively)

grass (*Echinochloa crus-galli* Retz.) and sprangletop [*Leptochloa chinensis* (L.) Nees]; sedges like umbrella sedge (*Cyperus iria* L.) and bulrush (*Scirpus maritimus* L.); and algal aquatic weeds like musk grass (*Chara zeylanica* Willd.) and *Eriocaulon sieboldianum* L.

Plant height was more in 1991 due to abrupt rise in water level to higher depths in the early stages compared with the gradual and slow rise of water in 1990. Further, greater weed infestation in 1991 resulted in more crop-weed competition for light, leading to increased plant height. There were no significant differences in plant height among different weed-control treatments except beushen, which recorded the lowest height due to reduced plant population and better weed control.

The effect of tillage and weed-control practices varied in the 2 years due to variable

pattern of water accumulation and intensity of weed infestation in the field. Increased tillage operations reduced the weed infestation and promoted the growth of rice plants in the early stages. With the off-season ploughing, the exposed weeds dried and decayed in the sun. The dry weight of weeds at harvest decreased significantly by 55.5–85.5% with increase in the number of ploughings; the greater effect appeared to be that of summer ploughing in March (Table 1). Butachlor provided a good early control of grassy and aquatic weeds, confirming our earlier finding (Sharma and Reddy 1992). However, a satisfactory season-long weed control was achieved only when hand-weeding was combined with herbicide application.

Seedling emergence was similar (195–209/m²), but the initial vigour of the rice plants was better with increasing tillage operations. In 1990 the crop plants grew significant-

ly taller with increase in the number of ploughings, but in 1991 the difference between 2 and 3 ploughings were nil (Table 1).

Yield performance of rice

The loss in grain yield of rice due to weeds was 2.5–10.5% in 1990 and 11.5–34.2% in 1991, depending on the number of ploughings (Table 2). Higher loss in yield during 1991 was due to greater weed infestation in the field. In 1990 although there was considerable decrease in weed biomass at harvest with increase in ploughing, highest grain yield was obtained with 2 ploughings in March and May. It may be attributed to the weed population below the required threshold level, causing no adverse effect on grain yield under 2 and 3 ploughings. The taller rice plants under 3 ploughings lodged around the flowering

time, resulting in lower panicle weight and greater sterility due to poor grain filling. However, the shorter plants under the 2 ploughings did not lodge until maturity and thus gave the highest yield (4.30 tonnes/ha). The yield under 1 ploughing (4.07 tonnes/ha) was equal to that under 3 ploughings (4.02 tonnes/ha), although dry weight of weeds at harvest under the former treatment (50.2 g/m^2) was significantly more than that under the latter (7.3 g/m^2). No-ploughing treatment resulted in the lowest yield (1.93 tonnes/ha) due to the highest weed biomass (189.4 g/m^2). This treatment was not found practical due to difficulty in sowing in the unploughed plots and more labour consumption for weeding. In 1991 the grain yield increased significantly with increase in number of ploughings, which was associated with progressive decrease in

Table 1 Effect of tillage and weed-control method on growth and yield attributes of rice and dry weight of weeds at harvest

Treatment	Plant height at harvest (cm)		Panicles/ m^2		Panicle weight (g)		Straw yield (tonnes/ha)		Dry weight of weeds (g/m^2)	
	1990	1991	1990	1991	1990	1991	1990	1991	1990	1991
<i>Tillage</i>										
3 ploughings (Jan, Mar and May)	117	129	207	174	2.29	3.23	11.36	8.27	7.3	74.4
2 ploughings (Mar and May)	110	126	230	145	2.40	3.30	10.22	8.06	12.0	119.6
1 ploughing (May)	107	120	211	115	2.40	2.96	8.55	6.60	50.2	167.0
No ploughing	96		153		1.84		3.86		189.4	
SEm +	2	2	5	5	0.05	0.07	0.32	0.30	3.4	5.0
LSD (P = 0.05)	6	8	17	18	0.15	0.29	1.09	1.16	11.6	19.5
<i>Weed-control method</i>										
No weeding	109	127	198	117	2.13	2.89	8.16	6.24	139.6	219.3
Hand-weeding twice	107	127	223	154	2.26	3.52	9.03	8.06	23.8	91.7
Butachlor @ 2 kg/ha	107	124	200	134	2.15	3.16	8.61	7.61	84.1	124.0
Butachlor + hand- weeding once	110	125	217	149	2.28	3.03	8.90	8.40	26.0	70.0
<i>Beuschen</i>	104	122	165	168	2.35	3.20	7.78	7.92	50.5	96.7
SEm +	1	2	6	5	0.07	0.08	0.33	0.31	3.7	4.5
LSD (P = 0.05)	4	NS	18	15	0.19	0.24	0.95	0.91	10.7	13.1

dry weight of weeds. The yield of straw was more in 1990 than in 1991 and there was significant increase with number of ploughings in both the years.

Interaction between tillage and weed-control treatments on grain yield of rice was significant in both the years (Table 2). The effect of weed-control methods was more pronounced with less number of ploughings. In 1990 the weed-control methods had no effect on grain yield under 2 and 3 ploughings due to insufficient weed biomass (7.3–12.0 g/m²). However, under 1 ploughing, hand-weeding alone or butachlor + hand-weeding increased the yield significantly (10.5–11.6%), whereas under no ploughing the effect of weed-control practices except

butachlor alone was significant (74.3–116.5%) compared with unweeded control. Panicle number decreased under *beushen* operation due to its adverse effect on tillering under the excess water regime (Sharma 1992), but the resultant increase in panicle weight gave a similar grain yield as obtained under hand-weeding. In 1991 hand-weeding and *beushen* effectively controlled the weeds and increased the grain yield significantly (12.8–45.1%) under all tillage treatments. Hand-weeding twice or once along with butachlor application proved equally effective. The effect of butachlor applied alone was not observed under 3 ploughings due to lower dry weight of weeds at harvest (105 g/m²). But under 1 and 2 ploughings, butachlor provided

Table 2 Interaction between tillage and weed-control method on grain yield (tonnes/ha) of rice

Treatment (weed-control method)	Tillage				Mean
	3 ploughings (Jan, Mar and May)	2 ploughings (Mar and May)	1 ploughing (May)	No ploughing	
1990					
No weeding	3.97	4.20	3.80	1.21	3.30
Hand-weeding twice	4.07	4.31	4.24	2.62	3.81
Butachlor @ 2 kg/ha	3.95	4.32	4.10	1.45	3.46
Butachlor + hand- weeding once	4.05	4.35	4.20	2.24	3.71
<i>Beushen</i>	4.05	4.30	4.03	2.11	3.62
Mean	4.02	4.30	4.07	1.93	
1991					
No weeding	3.62	3.03	2.17		2.94
Hand-weeding twice	4.09	3.70	3.30		3.70
Butachlor @ 2 kg/ha	3.82	3.52	2.77		3.37
Butachlor + hand- weeding once	4.08	3.84	3.00		3.64
<i>Beushen</i>	3.92	3.97	3.15		3.68
Mean	3.91	3.61	2.88		
	<i>SEm</i> ±		<i>LSD</i> (<i>P</i> = 0.05)		
	1990	1991	1990	1991	
Tillage	0.13	0.12	0.46	0.46	
Weed-control method	0.10	0.13	0.30	0.39	
Interaction	0.13	0.18	0.39	0.55	

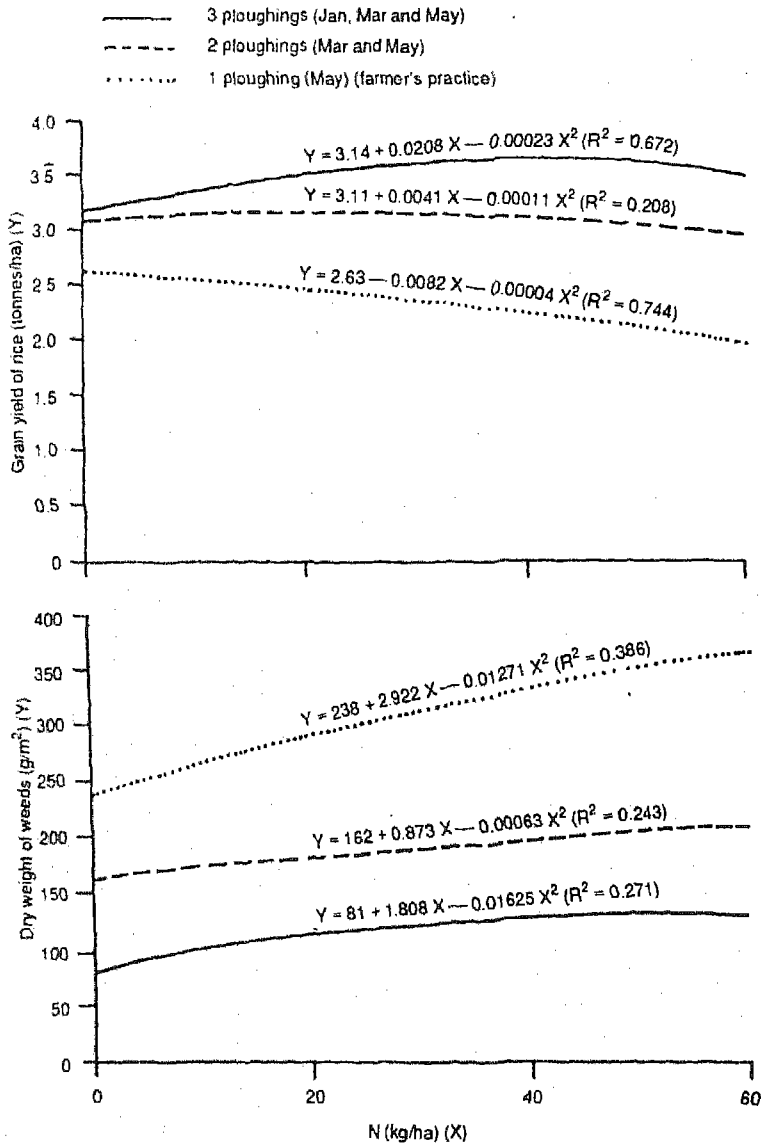


Fig 2 Grain yield of rice and dry weight of weeds at harvest as affected by different levels of N fertilizer under unweeded conditions in 1991

good early control of weeds and thereby gave higher yield (16.2–27.7%) than under unweeded control. Nevertheless, such a yield was lower than that under the treatments where the late flushes of weeds were controlled at 40 days. Moody *et al.* (1986) also

reported that butachlor is quite effective in controlling most annual grassy weeds in lowland rice fields.

Interaction between tillage and N fertilizer in 1991 revealed that when no weed-control measures were adopted, basal N fertilization increased the weed biomass, but the trend in grain yield varied with the number of ploughings. Response to N was less with reduced number of ploughings due to the corresponding increase in dry weight of weeds (Fig 2). Under 3 ploughings, N application was beneficial up to 20 kg/ha, beyond which the yield remained unchanged. Moreover, there was no effect of N under 2 ploughings; rather the grain yield decreased linearly with successive increase in N level under 1 ploughing. This may be attributed to more beneficial effect of basal N application to the weeds in the initial stages, resulting in their vigorous growth and thus adversely affecting the performance of rice. Although weed biomass decreased with more frequent ploughings, it increased significantly with N application. It indicates that fertilization with N would be beneficial if the weeds are controlled, so that the crop-weed competition is minimized, particularly in the early stages. De Datta and Barker (1977) reported that weed control was more important under high- than under low-fertility condition.

Therefore off-season tillage, particularly in summer along with pre-emergence butachlor

application followed by 1 hand-weeding or *beushen* alone proved effective for controlling weeds and increasing the productivity of direct-sown lowland rice. Further, weed control was important for better response and efficient utilization of applied N fertilizer in the intermediate deep-water regime.

REFERENCES

- De Datta S K and Barker R. 1977. Economic evaluation of modern weed control techniques in rice. (in) *Integrated Control of Weeds*, pp 205-28. Fryer J D and Matsunaka S (Eds). University of Tokyo Press, Tokyo, Japan.
- Moody K, De Datta S K, Bhan V M and Manna G B. 1986. Weed control in rainfed lowland rice. (in) *Progress in Rainfed Lowland Rice*, pp 359-70. International Rice Research Institute, Los Baños, Manila, Philippines.
- Moorthy B T S and Rao K S. 1991. Influence of method of stand establishment, and cultural and weed-control practices on performance of rainfed lowland rice (*Oryza sativa*) in coastal Orissa. *Indian Journal of Agricultural Sciences* 61 (8) : 588-90.
- Sharma A R. 1992. Adverse effects of beushaning on intermediate deepwater rice (DWR). *International Rice Research Newsletter* 17 (2) : 21-2.
- Sharma A R. 1994. Effect of different methods and timings of stand establishment on performance of rainfed lowland rice under 0-50 cm water depth. *Journal of Agronomy and Crop Science* 172 : 38-51.
- Sharma A R and Reddy M D. 1992. Effect of method of sowing and weed-control practice on performance of rice (*Oryza sativa*) under intermediate deep-water condition. *Indian Journal of Agricultural Sciences* 62 (1) : 24-8.

Influence of boron on yield and grain quality of pearl millet (*Pennisetum glaucum*)

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ABSTRACT

An experiment was conducted during the rainy season of 1991 to study the effect of 7 concentrations of boron on 'WCC 75' pearl millet [*Pennisetum glaucum* (L.) R. Br. emend. Stuntz]. Boron @ 0.33 mg/litre gave the highest weight of inflorescence (69.8 g/plant), grain yield (50.9 g/plant), 100-grain weight (1.0 g) and biomass (117.1 g/plant). However, deficient or excess supply of B application adversely affected these characters. Its deficiency decreased the grain yield (1.3 g/plant) compared with its excess supply (19.0 g/plant) and the effect was more marked on grain yield than on biomass. B @ 0.66 mg/litre resulted in a minimum phenol (0.008%) and nitrate-N (0.10%) in the grain, which increased under its deficient (< 0.33 mg/litre) or excess (> 0.66 mg/litre) supply. Though B decreased the concentration of protein (6.48 and 9.25%) and starch (5.87 and 6.52%) both at low as well as excess supply, at former level it had a greater accumulation of sugars (0.352%) compared with that at the latter level (0.194%). An increase in B supply increased its content in grain; however this increase was much less (3 µg/g dry weight) than that in the leaves. Its deficiency or excess symptoms were apparent on young leaves under low (6.5 µg/g dry matter) or excess (268 µg/g dry matter) content of B.

Boron deficiency in plants decreases the biomass and disturbs the carbohydrate and phenol metabolism (Dugger 1983). In many plant species including cereals inadequate supply of B decreases the economic yield (Misra and Patil 1987), mainly because of the marked reduction and retardation in flowering and fruit development under B deficiency. Sufficient information is, however, not available on the effect of deficiency and toxicity of B on yield and quality of the grains of pearl millet [*Pennisetum glaucum* (L.) R. Br. emend. Stuntz]. An experiment was therefore undertaken to study the influence of different

levels of B on yield and concentration of carbohydrates, proteins, nitrate-nitrogen and phenols in pearl millet grains.

MATERIALS AND METHODS

The experiment was conducted during the rainy season (*khari*) 1991 at Lucknow. 'WCC 75' pearl millet was grown in glass-house at ambient temperature (25-35°C) in purified sand in clay pots of 20 kg capacity lined with alkathene. Each pot had a central drainage hole, whose rim was covered with glass-wool, over which a clean watch-glass was inverted. The method of purification of sand was as per Hewitt (1966). Just after the emergence of the seedlings, 500 ml nutrient solution (including B at desired levels) was applied daily (except

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on Sunday) in each pot, which was increased to 1 litre after 40 days. The excess solution was drained through the drainage hole. On Sunday the sand was flushed with B-free distilled water to remove the salts and other deleterious substances.

The composition of the nutrient solution excluding B was the same as described by Chatterjee *et al.* (1990). Boron as H_3BO_3 was supplied @ 0.0033, 0.011, 0.165, 0.33, 0.66, 1.32 and 3.3 mg/litre. Contribution of B from pots, refined sand, purified nutrients and distilled water was less than 0.003 mg/litre, which was taken into account while supplying the B. There were 4 replications for each treatment. Initially 3 plants were maintained in each pot, which were decreased to 1 at 70 days after sowing.

Dry matter and grain yields were recorded at harvest, at 129 days after sowing. In leaves and air-dried grains the concentrations of B, sugars, starch and water-soluble protein were estimated (Chatterjee *et al.* 1990). Phenols (Swain and Hillis 1959) and nitrate-N (Richards and Templeman 1936) were estimated in air-dried grains.

RESULTS AND DISCUSSION

When pearl millet was grown at 0.0033 and 0.011 mg B/litre, the decrease in growth was apparent at 24 days after sowing, and became pronounced at 30 days onward. The young leaves developed interveinal chlorotic spots, initiating from the tip of the lamina. The B-deficient plants showed marked condensation of internodes and enlarged chlorotic spots on young leaves, which coalesced and later formed streaks. At higher levels of boron (> 0.33 mg/litre) the growth was depressed and old leaves showed apical marginal chlorosis, which became intense at 50–60 days. Necrosis developed on chlorotic spots and the apex of leaves curled outward. These symptoms due to excess B were similar to those reported in maize (*Zea mays* L.) and wheat (*Triticum aestivum* L. emend. Fiori & Paol.) (Marschner 1986).

The biomass was highest at 0.33 mg B/litre, but it decreased by 65, 52 and 32% at 0.0033, 0.011 and 0.165 mg B/litre respectively (Table 1). The beneficial effect of B on the grain yield could be expected, because it plays an important role not only in carbohydrate

Table 1 Influence of different levels of boron on biomass, grain yield and boron concentration in leaves of pearl millet (129 days after sowing)

Boron (mg/litre)	Biomass/ plant (g)	Inflorescence weight/plant (g)	Total grains/plant (g)	100-grain weight (g)	B conc (µg/g dry matter) in young leaves
0.0033	39.5	6.6	1.3	0.79	6.5
0.011	56.5	18.6	4.8	0.85	10.5
0.165	79.8	36.5	25.9	0.99	22.2
0.33	117.1	69.8	50.9	1.00	47.2
0.66	82.6	39.9	28.4	0.96	67.2
1.32	60.3	30.5	19.9	0.96	92.0
3.3	46.9	24.7	19.0	0.88	268.0
LSD (P = 0.05)	2.09	1.46	1.70	0.30	4.2

metabolism but also in protein formation (Mengel and Kirkby 1987). At higher levels of boron, i.e. 0.66, 1.32 and 3.3 mg B/litre, the decline in biomass was 30, 49 and 60% respectively.

At high B levels, its concentration in leaves and grains was high and toxic, leading to decreased biomass. The concentration of B in pearl millet leaves from the plants receiving it in excess was almost similar to that observed in grasses under similar conditions of excess B (Mengel and Kirkby 1987).

The weight of total grains decreased significantly at all the levels of B compared with that at adequate B supply. The lowest grain

weight was recorded at 0.0033 mg B/litre (1.3 g) and the highest (50.9 g) at 0.33 mg B/litre. The decline in grain production under B-deficiency and toxicity conditions confirms the reports of Sherrill (1983) in red clover (*Trifolium pratense* L.) and of Misra and Patil (1987) in lucerne (*Medicago sativa* L.). It may be attributed to the production of aborted and malformed embryo-sacs (Hewitt 1983) or low viability of pollen-grains under B deficiency (Agarwala *et al.* 1981). The present study reports that the deficiency of boron is a serious problem for seed production and seed quality, as also suggested by Shorrocks (1991).

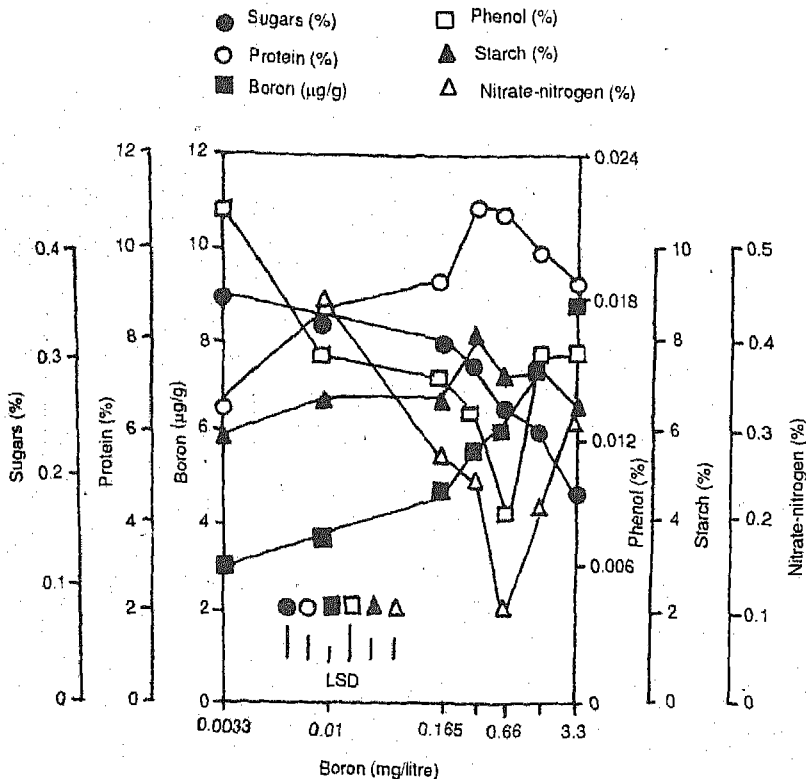


Fig 1 Effect of variable boron on concentration of sugars, protein, tissue B, phenols, starch and nitrate-nitrogen in pearl millet grains

The reduction in inflorescence weight and grain yield under B deficiency was more marked than in total biomass, which may be ascribed to reduced sink activity of shoots suffering from B deficiency (Marschner 1986).

The accumulation of sugars in B-deficient pearl millet grains (Fig 1) might be due to improper utilization of sugar, eg in starch formation (Dugger 1983, Mengel and Kirkby 1987).

The decrease in starch content in grains deficient in B might be due to lowered availability of uracil (Marschner 1986), which resulted in reduced formation of uridine diphosphate glucose (UDPG) — a substrate for starch synthesis. Alternatively, the reduction could be explained by decreased activity of starch synthetase (Dugger 1983).

Nitrate-nitrogen not only accumulated in leaves of B-deficient plants but also in grains, indicating that nitrate reduction was inhibited by decrease in nitrate-reductase activity (Bonilla *et al.* 1980). Birnbaum *et al.* (1977) reported that some phenols accumulate in the B-deficient seeds, which inhibit the oxidizing activity of indole acetic acid. This abnormal increase in indole acetic acid might have caused anatomical changes in seeds, resulting in the formation of damaged, malformed fruits under low amounts of B. The accumulation of phenols in edible parts causes poor digestibility of proteins, thus adversely affecting the quality of pearl millet grains (Sikka *et al.* 1989).

The water-soluble proteins in pearl millet grains increased with an increase in boron supply from 0.0033 to 0.33 mg B/litre. Our finding is in consonance with the results on rice (*Oryza sativa* L.) and wheat (Swamy 1980, Esteban *et al.* 1985).

It was concluded that the seed production and the quality of pearl millet grains depend on adequate B supply.

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REFERENCES

- Agarwala S C, Sharma P N, Chatterjee C and Sharma C P. 1981. Development and enzymic changes during pollen development in boron deficient maize plant. *Journal of Plant Nutrition* **3** : 329-36.
- Birnbaum E H, Dugger W M and Bud C A. Beasley. 1977. Interaction of boron with components of nucleic acid metabolism in cotton ovules cultured *in vitro*. *Plant Physiology, Lancaster* **59** : 1 034-8.
- Bonilla I, Cadahia C and Hernado V. 1980. Effect of boron on nitrogen metabolism and sugar levels of sugarbeet. *Plant and Soil* **57** : 3-9.
- Chatterjee C, Sinha P and Agarwala S C. 1990. Boron nutrition of cowpea. *Proceedings of Indian Academy of Sciences (Plant Sciences)* **100** (5) : 311-5.
- Dugger W M. 1983. Boron in plant metabolism. (in) *Encyclopedia of Plant Physiology* (new series) 158, pp 626-50. Springer-Verlag, Berlin-New York.
- Esteban R M, Collado J G, Lopez A F J and Fernandez H M. 1985. Effect of boron on soluble protein and sugar contents of tomato roots. *Plant and Soil* **88** : 149-51.
- Hewitt E J. 1966. *Sand and Water Culture Methods Used in the Study of Plant Nutrition*, edn 2, pp 15-24. Commonwealth Agricultural Bureaux, England.
- Hewitt E J. 1983. The essential and functional mineral elements. (in) *Diagnosis of Mineral Disorder in Plants: Principles*, vol 1, pp 7-55. Bould C, Hewitt E J and Needham P (Eds). Her Majesty's Stationery Office, London.
- Marschner H. 1986. *Mineral Nutrition of Higher Plants*, pp 321-34. Academic Press, New York.
- Mengel K and Kirkby E A. 1987. *Principles of Plant Nutrition*, edn 4, pp 533-43. International Potash Institute, Berne, Switzerland.
- Misra S M and Patil B D. 1987. Effect of boron on seed yield in lucerne (*Medicago sativa* L.). *Journal of Agronomy and Crop Science* **158** (1) : 34-7.
- Richards F I and Tompleman W G. 1936. Physiological studies in plant nutrition. IV. Nitrogen metabolism in relation to nutrient deficiency and age in leaves of barley. *Annals of Botany, London* **50** : 367.
- Sherrell C G. 1983. Boron deficiency and response in white clover (*Trifolium repens*) and red clover (*Trifolium pratense*) and lucerne (*Medicago sativa*).

- New Zealand Journal of Agricultural Research* 26 : 197-204.
- Shorrocks V M. 1991. Thailand - boron first amongst micronutrients. *Micronutrient News and Information* 11 (4) : 4-6.
- Sikka K C, Lodha M L and Mehta S L. 1989. Nutritional quality of cereal and grain legume proteins. (in) *Recent Advances in Plant Biochemistry*; pp 305-88. Mehta S L, Lodha M L and Sane P V (Eds). Publications and Information Division, Indian Council of Agricultural Research, Krishi Anusandhan Bhavan, Pusa, New Delhi.
- Swain T and Hillis W E. 1959. The phenolic constituents of *Prunus domestica*. I. The quantitative analysis of phenolics constituent. *Journal of Science for Food and Agriculture* 10 : 65-8.
- Swamy M N. 1980. Effect of boron on the nutritive value of rice. *Oryza* 17 : 142-3.

Response of long melon (*Cucumis melo* var *utilissimus*) to foliar application of plant-growth substances

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ABSTRACT

An experiment was conducted during summer season of 1991 and 1992 to study the effect of foliar sprays of ethephon, gibberellic acid (GA₃), maleic hydrazide (MH) and naphthalene acetic acid (NAA) on vegetative growth, flowering and yield of 'Hisar Local Selection' long melon (*Cucumis melo* L. var *utilissimus* Duth. & Full.). GA₃ @ 25 mg/litre applied at the stage of 2 and 4 true leaves improved the main vine length (3.97 m), whereas MH @ 200 mg/litre suppressed it to minimum (2.11 m). NAA @ 25 mg/litre, ethephon at all the concentrations and MH @ 50 and 100 mg/litre also suppressed the main vine length compared with the untreated control. Ethephon @ 250 mg/litre, which effectively increased the branches/plant (10.8) compared with the control (5.2), reduced the internodal length (8 cm) and male : female ratio (3.1), and gave the earliest (68 days) and the maximum number of female flowers (27), fruits (17.7) and total yield (1.36 kg/plant). Ethephon @ 250 mg/litre gave the maximum fruit yield (29.76 tonnes/ha) and GA₃ @ 25 mg/litre the minimum (11.08 tonnes/ha).

As information on the effect of plant-growth substances on long melon (*Cucumis melo* L. var *utilissimus* Duth. & Full.) is lacking, a study was conducted on the efficacy of ethephon, gibberellic acid (GA₃), maleic hydrazide (MH) and naphthalene acetic acid (NAA) at different concentrations.

MATERIALS AND METHODS

The experiment was conducted at farmer's field at Hisar during summer season of 1991 and 1992. The seeds of a local cultivar ('Hisar Local Selection') of long melon were sown from a single side on 3 January 1991 and 6 January 1992 at 50 cm plant spacing on 75 cm wide and 20 m long raised beds. In a plot of 2.25 m x 20 m, 120 plants per treatment were

raised. The treatments comprised ethephon @ 50, 100 and 250 mg/litre; gibberellic acid (GA₃) @ 5, 10 and 25 mg/litre; maleic hydrazide (MH) @ 50, 100 and 200 mg/litre; and naphthalene acetic acid (NAA) @ 25, 50 and 100 mg/litre, including a control (sprayed with canal water). Randomized complete-block design was followed with 3 replications. Two aqueous sprays of each treatment, added with 4 drops of polyoxyethylene sorbitan monolourate (Tween-20) per litre solution were made at the stage of 2 and 4 true plant leaves. Observations were recorded on main vine length, internodal length, node and days to first male and female flower appearance, total number of male and female flowers/plant, male : female (sex) ratio, days to harvest of first 5 fruits, fruit length, number and weight of fruits/plant from first 5 pickings made up to middle of April (early yield) and

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sum total of all the 12 pickings/plant made up to the end of May (total yield) in both the years.

The usual analysis of variance for the design of experiment was carried out on the average of 2-year data.

RESULTS AND DISCUSSION

Foliar application of various plant-growth substances significantly influenced all the growth, flowering, fruiting and yield characteristics.

Growth characteristics

GA₃ @ 25 mg/litre showed maximum length of main shoot and internodes and ethephon @ 250 mg/litre gave maximum branches/plant (Table 1). However, MH @

200 mg/litre, untreated control and ethephon @ 250 mg/litre recorded the least main shoot length, branches/plant and internode length respectively. The result confirms the finding of Arora *et al.* (1985). This response may possibly be due to the promotory effect of GA₃ and inhibitory effect of ethephon on growth, confirming the finding of Arora and Partap (1988) in pumpkin [*Cucurbita moschata* (Duchesne) Duchesne ex Poiret].

Flowering characteristics

GA₃ @ 25 mg/litre resulted in appearance of staminate flowers at the lowest nodes and in maximum number, whereas NAA @ 100 mg/litre delayed their appearance (Table 1). Ethephon @ 100 mg/litre reduced the number of staminate flowers to minimum and 250

Table 1 Effect of plant-growth substances on growth and flowering behaviour in local long melon (average data of 2 years)

Treatment (mg/litre)	Main vine length (m)	Branches/plant	Inter-nodal length (cm)	Node to 1 male flower	Node to 1 female flower	Days to 1 male flower	Days to 1 female flower	Male flowers/plant	Female flowers/plant	Male : female
Control	2.82	5.2	14	9	13	46	78	169	14	12.1
<i>Ethephon</i>										
50	2.66	6.7	10	10	8	46	71	87	15	5.8
100	2.50	8.8	9	12	7	48	69	79	17	4.6
250	2.34	10.8	8	14	5	50	68	84	27	3.1
<i>GA₃</i>										
5	3.27	8.0	16	7	14	43	80	160	11	14.6
10	3.47	6.1	18	6	14	42	83	152	9	16.9
25	3.97	5.7	20	5	16	41	91	181	8	22.6
<i>MH</i>										
50	2.40	6.7	11	8	11	44	80	165	13	12.7
100	2.23	9.4	10	9	10	45	77	151	15	10.1
200	2.11	10.5	9	11	9	51	72	161	16	10.1
<i>NAA</i>										
25	2.57	8.9	14	8	11	49	79	146	10	14.6
50	2.83	7.8	17	9	13	51	84	167	12	13.9
100	2.97	7.5	17	11	14	54	88	179	13	13.8
CD (P = 0.05)	0.38	1.3	2.1	2.1	1.8	3.5	5.1	15.5	3.3	2.1

mg/litre shifted their position at higher nodes. However, pistillate flowers appeared maximum late at highest nodes with GA₃ @ 25 mg/litre and in maximum number with ethephon @ 250 mg/litre compared with all other treatments. The ratio of male : female flowers was highest with GA₃ and lowest with ethephon at these concentrations. The result confirms the finding of Arora *et al.* (1985). The effect of ethephon in modifying flower sex may be due to auxin production (El-Zawily and Arafa 1981) or to its persistence on leaf surface (Hume and Lovell 1983). Kabir *et al.* (1989), Vadigeri and Madalageri (1989) and Karim *et al.* (1990) also reported modified sex expression in cucurbits by use of plant-growth substances. However, Suleiman and Suwvan (1990) did not find any effect of NAA on sex

expression in summer squash (*Cucurbita pepo* L.).

Fruiting characteristics

The number of days required from seed sowing to harvest of first 5 fruits/plant, their fruit length, total of first 5 harvests (early yield) and sum total of all the 12 harvests (total yield) both by number and weight of fruits/plant and fruit yield/ha were maximum with ethephon @ 250 mg/litre; whereas fruit length and early yield in terms of fruit number and weight/plant were least with MH @ 50 mg/litre and in the control respectively (Table 2). GA₃ @ 25 mg/litre gave the least total fruit yield by number and weight/plant. The result confirms the findings of El-Kholy and Hafez (1982), Vadigeri and Madalageri (1989),

Table 2 Effect of plant-growth substances on fruiting and yield characteristics in local long melon (average data of 2 years)

Treatment (mg/litre)	Days to harvest of 15 fruits	Fruit length (cm)	Early yield		Total yield		Early yield (tonnes/ ha)	Total yield (tonnes/ ha)
			Fruits/ plant	Yield/ plant (g)	Fruits/ plant	Yield/ plant (kg)		
Control	96	25	2.1	156	8.9	0.69	4.01	18.24
<i>Ethephon</i>								
50	93	26	4.1	313	11.2	0.90	7.51	20.40
100	89	28	4.7	347	13.3	1.03	8.69	23.04
250	83	30	9.7	767	17.7	1.36	17.86	29.76
GA ₃								
5	93	22	3.1	243	8.4	0.61	5.76	16.32
10	96	24	2.3	179	7.9	0.63	4.30	12.48
25	101	27	2.3	179	6.7	0.48	4.30	11.08
<i>MH</i>								
50	90	18	3.2	235	9.7	0.77	5.52	16.56
100	86	19	3.8	281	10.9	0.85	6.95	22.80
200	84	21	4.3	311	12.4	0.88	7.74	20.16
<i>NAA</i>								
25	90	25	2.3	160	7.3	0.56	4.12	14.16
50	94	27	2.9	209	7.4	0.58	5.13	13.44
100	96	27	3.4	258	9.9	0.72	6.03	18.24
CD (P=0.05)	4.3	2.5	1.2	29	2.8	0.12	0.65	1.18

Karim *et al.* (1990) and Singh and Choudhary (1990). An increase in fruit yield of long melon due to ethephon application applied at early stages of plant growth was caused by triggering a process that stimulated the development of lateral shoots thereby increasing the number of nodes/plant, as well as increased the production of female flowers that resulted in greater fruit yield.

Thus the application of ethephon @ 250 mg/litre proved most effective in production of early marketable fruits and total yield/plant as well as productivity (tonnes/ha) of long melon.

REFERENCES

- Arora S K and Partap P S. 1988. Effect of plant-growth regulators on vegetative growth, flowering and fruit yield in pumpkin (*Cucurbita moschata* Duch. ex Poir). *Journal of Research, Haryana Agricultural University, Hisar* 18 (4) : 284-90.
- Arora S K, Pandita M L, Partap P S and Sidhu A S. 1985. Effect of ethephon, gibberellic acid, and maleic hydrazide on vegetative growth, flowering, and fruiting of cucurbitaceous crops. *Journal of American Society for Horticultural Sciences* 110 (3) : 442-5.
- El-Kholy E and Hafez H. 1982. Response of snake cucumber (*Cucumis melo* var *pubescens*) to some plant regulators. *Journal of Agricultural Science, Cambridge* 99 : 587-90.
- El-Zawily A I and Arafa A E. 1981. Effect of ethephon on growth, flowering and fruiting of summer squash (*Cucurbita pepo* L.). *Research Bulletin* 240, Zagazig University, Cairo, pp 1-12.
- Hume R J and Lovell P H. 1983. The control of sex-expression in cucurbits by ethephon. *Annals of Botany* 52 : 689-95.
- Kabir J, Chatterjee R, Biswas B and Mitra S K. 1989. Chemical alteration of sex expression in *Momordica charantia*. *Progressive Horticulture* 21 (1-2) : 69-72.
- Karim A J, Splittstoesser W R and Skinvin R M. 1990. Ethephon and gibberellic acid influence on sex expression of glass house grown cucumbers. *Bulletin of Plant Growth Regulators Society of America* 18 (2) : 67-72 (fide *Horticultural Abstracts* 60 : 835, abstr 7253; 1990).
- Singh R K and Choudhary B. 1990. Differential response of three genera of cucurbits to boron and plant-growth regulators. *Indian Journal of Horticulture* 46 (2) : 215-21.
- Suleiman F A S and Suwwan M A. 1990. Effect of agritone on fruit set and productivity of summer squash (*Cucurbita pepo* L.) under plastic house condition. *Advances in Horticultural Sciences* 4 (2) : 83-9.
- Vadigeri B G and Madalageri B B. 1989. Response of cucumber genotypes to ethrel and GA₃. *Karnataka Journal of Agricultural Sciences* 2 (3) : 176-8.

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Water requirement of vegetables in a dryland watershed

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To minimize the risk in dryland crop production, Sharma and Mishra (1992) advocated harvesting of watershed run-off in a farm pond and its re-use in areas with an average rainfall of 750 mm. Establishment of water requirement of each crop helps in effective utilization of water under scarcity condition, besides facilitating the estimation of land area that could be irrigated by limited water supply. Crop-water requirement is normally expressed by the rate of evapo-transpiration, which is related to the evaporative demand of the atmosphere. Therefore an attempt was made to determine the water requirement of high-value vegetable crops of the region as a percentage of open pan-evaporation value in a dryland watershed by utilizing the pond water.

The experiment was conducted during winter (*rabi*)–summer season of 1991–92 at Hyderabad in an Alfisol. The varieties used were 'Pusa Sawani' okra (*Hibiscus esculentus* L.), 'Pusa Jwala' red pepper (*Capsicum annuum* L.) and 'Pusa Ruby' tomato (*Lycopersicon esculentum* Miller nom. cons.). The experiment was laid out in split-plot design

with 3 replications. The crops were in the main plots and 3 irrigation levels in the subplots. The irrigation levels were designed to meet 50% (I₁), 75% (I₂) and 100% (I₃) of weekly evaporative demand of atmosphere (Table 1). The irrigation treatments were given soon after establishment of the crops as per average pan evaporation of the corresponding standard week and the water requirement was calculated by adding the amount of water given for each irrigation.

In okra total pod yield did not differ significantly when the amount of water applied increased from I₁ to I₃, though the yield increased from 6.69 to 7.51 tonnes/ha particularly at I₃. It indicates that under water-scarcity condition, meeting 50% evaporative demand of atmosphere through irrigation is profitable, as is reflected by highest water-use efficiency (213.7 kg/ha-cm). Further increase in the supply of moisture (Table 1) reduced the water-use efficiency (134.7 kg/ha-cm) significantly.

In red pepper irrigation treatments did not show significant differences, which were reflected in water-use efficiency also. The irrigation at I₃ decreased the yield (2.01 tonnes/ha) compared with that at I₁ level (2.20 tonnes/ha). This might be due to the water stagnation, creating problem of aeration immediately after irrigation. As the crop is

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Table 1 Effect of irrigation on fruit yield and water-use efficiency of 3 vegetables

Treatment	Water applied (ha-cm)	Total fruit yield (tonnes/ha)	Water-use efficiency (kg/ha-cm)
<i>Okra</i>			
I ₁	31.3	6.69	213.7
I ₂	43.5	6.71	154.4
I ₃	55.7	7.51	134.7
'F' test		NS	*
CD (P = 0.05)			22.2
<i>Red pepper</i>			
I ₁	41.4	2.20	53.2
I ₂	58.6	2.22	37.9
I ₃	76.2	2.01	26.4
'F' test		NS	NS
<i>Tomato</i>			
I ₁	34.5	2.94	850.9
I ₂	48.3	3.99	826.8
I ₃	62.2	3.79	609.3
'F' test		*	**
CD (P = 0.05)		6.70	
CD (P = 0.01)			120.4

I₁, Irrigation at 50% of open pan evaporation; I₂, irrigation at 75% of open pan evaporation; I₃, irrigation at 100% of open pan evaporation

known for its drought tolerance and susceptibility to water stagnation, it did not respond favourably to the higher amounts of irrigation water. The result confirms the finding of Tiwari (1990).

Fruit yield of tomato increased sharply from 29.4 to 39.9 tonnes/ha with increase in irrigation from I₁ to I₂. However, further increase in irrigation to I₃ decreased the fruit yield by 5%, indicating an option of irrigating at 75% of evaporative demand of atmosphere. The water-use efficiency was the highest under I₁. This was at par with I₂ and significantly higher than I₃ for water-use efficiency. Further, the crop duration of tomato was delayed by a week under I₃ compared

with I₁ due to delayed flowering and increased vegetative growth. Therefore it is beneficial to schedule irrigation that meets up to 50% evaporative demand of atmosphere under situations of harvested water in farm pond during the off-season. }

The cumulative pan evaporation and total evaporation from pond surface depends on the duration of the crop. From a farm pond of size 500 m³ capacity (catching water from 4 ha) vegetable crops of 4-month duration (November–February) can be irrigated in 0.1 ha, considering 50% evaporative demand as the irrigation requirement. The 500 m³ storage accounts for a total evaporation of 94.8 m³ and availability of irrigation water of 405.2 m³ during the crop season (CRIDA, Hyderabad 1993).

Crops such as okra give high yield in a short span of time, allowing a large area to be irrigated. In view of this advantage, besides having stable price, okra is a profitable vegetable crop for harvested farm-pond water situation. However, if market prices are assured, tomato may be more profitable due to its higher yield potential unlike that of red pepper. Scheduling of irrigation to meet 50% evaporative demand of atmosphere in these vegetables is more stable under limited water-availability situation. If sufficient water is available in the pond, tomato can be irrigated at 75% level of pan evaporation for higher yield.

REFERENCES

- CRIDA, Hyderabad. 1993. *Annual Report of the Central Research Institute for Dryland Agriculture, Hyderabad*, 45 pp.
- Sharma S and Mishra P K. 1992. Watershed development for drought proofing. (in) *Dryland Agriculture in India: State of Art of Research in India*, pp 493–517. Somani L L, Vittal K P R and Venkateswarlu B (Eds). Scientific Publishers, Jodhpur.
- Tiwari R S. 1990. Pungent chillies and sweet bell peppers. *Indian Farmers Digest* 23 (2) : 21–5.

Water requirement of pea (*Pisum sativum*) in Inceptisol of mid-Himalayas

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When water is at a premium, vegetable will usually get the first priority. The judicious management of water needs adequate knowledge on crop-water requirement and the correct timing of irrigation. Off-season vegetable crops in north-western Himalayas give low yield, mainly due to their cultivation under rainfed condition. Hence the crops experience periodical moisture stress during their life-cycle, leading to reduction in yield. Since detailed information on the effect of different irrigation regimes on the crop yield, water expense and water-expense efficiency in pea (*Pisum sativum* L. sensu lato) in hilly regions is still meagre, an experiment was conducted on these aspects.

A field experiment was conducted with 'Lincoln' pea during 1989-90 and 1990-91 at Solan. The soil samples were collected before laying out the experiment and were analysed for their physico-chemical characteristics by using standard methods (Jackson 1973). There were 7 irrigation treatments, viz T₁, 6 cm irrigation common to all at 50% germination; T₂, 6 cm irrigation at IW : CPE 1.0 (IW, irrigation water depth; CPE, cumulative pan evaporation) ratio; T₃, 4 cm irrigation at IW :

CPE 1.0; T₄, 6 cm irrigation at IW : CPE 0.8; T₅, 4 cm irrigation at IW : CPE 0.8; T₆, 6 cm irrigation at IW : CPE 0.6; and T₇, 4 cm irrigation when IW : CPE ratio 0.4. All these treatments were replicated 4 times in randomized block design. The soil was Inceptisol, having pH 6.9-7.1, electrical conductivity in 1 : 2 soil-water suspension 0.19-0.39 dS/m, organic carbon 0.37-0.58% and bulk density 1.3-1.5 g/cm³ in 0-90 cm profile zone. The soil was loamy sand, medium in available N and K and low to medium in available P. The field-capacity moisture (0.3 bar) and wilting point moisture were 30.4-32.4% and 8.9-9.3% (by weight) respectively in different layers of profile.

'Lincoln' pea was sown in 3.0 m x 3.5 m plots, with a spacing of 30.0 cm x 7.5 cm on 3 November 1989 and 5 November 1990. A basal dose of 100 kg N/ha, 375 kg P/ha and 100 kg K/ha was applied through urea, single superphosphate and muriate of potash respectively at the time of sowing. Urea was applied in 2 splits, 1 month after sowing and at the time of flowering. One common post-sowing irrigation of 6 cm was applied uniformly to ensure better germination. Later on 6 and 4 cm depths of water were applied at IW : CPE ratios of 1.0, 0.8, 0.6 and 0.4. For computing the total water requirement, irrigation-water requirement, effective rainfall and available

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soil-moisture content were taken into consideration. As only the green-pod yield was recorded, 4–5 pickings were done each year and the last picking for green-pod yield was done on 4 May 1990 and 7 May 1991.

During the cropping season total rainfall received in 1989–90 was 62.5 cm and in 1990–91 it was 59.3 cm. The depth of irrigation water applied in different treatments varied from 6.0 cm to 24.0 cm and it was maximum (24.0 and 18.0 cm) in T₂ treatment during 1989–90 and 1990–91 respectively. Water expense was computed as the total of seasonal effective rainfall, seasonal irrigation water applied and seasonal soil-moisture use.

All the irrigation treatments had significant effect on pod yield (Table 1). The highest yield was obtained under T₅, mainly due to higher number of effective pods and greater green-pod yield. The highest total water expense was observed under T₂, followed by T₄, T₆, T₅, T₇ and T₁. But the response in yield to irrigation was maximum in T₅ during both the

years. Bhowmik *et al.* (1983) and Mandal *et al.* (1986) also reported similar observations in pulse crops.

The water-expense efficiency of pea was different not only under different irrigation inputs, but also with irrigation timing (Table 1). The mean water-expense efficiency varied from 92.8 to 166.3 kg/ha-cm during both the years, whereas the highest was obtained under T₅. It decreased with increase in frequency of irrigation. Green-pod yield of pea also behaved similarly except under T₁, where only 1 irrigation was applied. This result corroborates the finding of Nayar and Singh (1983).

Maximum water-expense efficiency of 166.3 kg/ha-cm was obtained with 4 cm irrigation water depth (IW) at IW : CPE 0.8. This may be due to better utilization of irrigation water. But in higher irrigation regime of IW : CPE 1.0, the rate of water loss as evapotranspiration was very high and relative increase in yield was not proportional to the increase in consumptive use of water. This

Table 1 Effect of irrigation regime on water-expense components, water-expense efficiency and pod yield of pea (mean data of 2 years)

Treatment	Effective rainfall (cm)	Irrigation water applied (cm)	Soil-moisture use (cm)	Total water expense (cm)	Pod yield (kg/ha)	Water-expense efficiency (kg/ha-cm)
T ₁	42.6	6.0	2.1	50.1	4 650	92.8
T ₂	38.1	21.0	1.9	60.0	5 960	99.4
T ₃	40.4	14.0	2.0	56.4	6 790	120.4
T ₄	42.1	15.0	2.0	59.1	7 570	128.1
T ₅	42.4	12.0	1.8	56.2	9 350	166.3
T ₆	42.6	12.0	1.8	56.4	8 270	146.9
T ₇	42.9	8.0	1.7	52.6	7 040	133.8

T₁, 6 cm irrigation at 50% germination; T₂, 6 cm irrigation at IW : CPE 1.0; T₃, 4 cm irrigation at IW : CPE 1.0; T₄, 6 cm irrigation at IW : CPE 0.8; T₅, 4 cm irrigation at IW : CPE 0.8; T₆, 6 cm irrigation at IW : CPE 0.6; T₇, 4 cm irrigation at IW : CPE 0.4

result is in close association with the finding of Grewal *et al.* (1984).

Hence for proper utilization of applied irrigation water and higher water-expense efficiency in pea, the crop should be irrigated with 4 cm depth of irrigated water at IW : CPE ratio 0.8.

REFERENCES

- Bhowmik N N, Ghosh N and Chowdhury P. 1983. Effect of irrigation on growth and yield of pigeonpea (*Cajanus cajan* L.). *Indian Agriculturist* 27 : 343-47.
- Grewal S S, Sud A D, Singh, Kehar and Singh, Prahlad. 1984. Effect of minimal irrigation on profile-water use, water expense and yield of chickpea as modified by seasonal rainfall in Siwalik region. *Indian Journal of Agricultural Sciences* 54 (7): 576-81.
- Jackson M L. 1973. *Soil Chemical Analysis*, pp 111-272. Prentice Hall of India Pvt. Ltd, New Delhi.
- Mandal B K, Ray P K and Dasgupta S. 1986. Water use by wheat, chickpea and mustard grown as sole crops and intercrops. *Indian Journal of Agricultural Sciences* 56 (3) : 187-93.
- Nayar R R and Singh N P. 1985. Consumptive use and soil moisture use pattern of late sown chickpea (*Cicer ardetinum* L.) as influenced by irrigation and phosphorus. *Indian Journal of Agronomy* 30 : 192-8.

Effect of foliar application of nitrogen on morpho-physiological traits of pea (*Pisum sativum*)

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Leguminous crops meet their nitrogen requirement from the inherent soil as well as through root nodules by biological nitrogen fixation. Senescence of nodules, however, starts after profuse flowering, resulting in deficiency symptom of nitrogen during reproductive stage (Minchin *et al.* 1981). Such deficiency leads mainly to flower abortion and insufficient pod filling. Foliar application of N is easier and economical than other methods like top-dressing. Since information is meagre on foliar nutrition of nitrogen on morpho-physiological traits of pea (*Pisum sativum* L. sensu lato), an attempt was made to find out a suitable concentration and time (stage) of foliar application of N in pea to improve its yield.

The field experiment was conducted during the winter season 1992-93 at Jorhat. The soil was sandy loam with pH 6.3, low available nitrogen (243 kg/ha) and available phosphorus (16.02 kg/ha) and medium available potassium (101.91 kg/ha). N @ 20 kg/ha and P @ 46 kg/ha were applied basal uniformly in all plots as per package of practices. Three concentrations of N (0.5, 1.0 and 2.0%) were sprayed on to leaves as urea at 3 stages of growth, viz first flowering, post-flowering (15 days after the first foliar spray) and first

flowering + post-flowering, keeping water spray as the control. Thus there were 10 treatments, viz T₁, 0.5% N at first flowering, T₂, 0.5% N at post-flowering stage; T₃, 0.5% N at first flowering and post-flowering; T₄, 1% N at first flowering; T₅, 1% N at post-flowering; T₆, 1% N at first flowering and post-flowering; T₇, 2% N at first flowering; T₈, 2% N at post-flowering; T₉, 2% N at first flowering; and post-flowering; and T₁₀, the control. The treatments were replicated thrice in randomized block design. The net plot size was 4 m x 1 m, and the row-to-row and plant-to-plant distances were 30 and 10 cm respectively. The samples were taken at 15-day intervals from 30 days after sowing. For every sampling, 5 plants were uprooted, cleaned and dried at 70°C. The activity of leaf-nitrate reductase was assayed at 50% flowering and pod-filling stage by standard method. Mean relative growth rate, net assimilation rate, leaf-area index and leaf-area duration were calculated by standard methods. For recording the fresh weight of pods/plant, 5 plants were randomly selected in each plot and the fruits were picked (harvested).

Foliar spray of 2% N at first flowering and at post-flowering showed significantly higher leaf-area index than the control (Table 1). It may be attributed to the promotive effect of applied N in leaf growth and in turn on leaf area. The finding agrees with the result of Sati

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Table 1 Effect of foliar spray of nitrogen on morpho-physiological traits and yield of pea

Treatment	LAI at 50% F	LAI at PF	LAD between FF and 50% F (days)	LAD between 50% F and PF (days)	RGR between FF and 50% F (g/g/day)	RGR between 50% F and PF (g/g/day)	NAR between FF and 50% F (g/cm ² /week)	NAR between 50% F and PF (g/cm ² /week)	NRA at 50% F (μ mole NO ₃ ⁻ /g fresh weight/hr)	NRA at PF (μ mole NO ₃ ⁻ /g fresh weight/hr)	Pods/plant	Seeds/pod	Fresh weight of pod/plant (g)
T ₁	1.65	1.17	16.63	20.87	0.084	0.033	0.005	0.003	0.229	0.136	15.40	4.51	75.99
T ₂	1.39	1.28	14.70	19.63	0.080	0.037	0.004	0.004	0.205	0.147	17.22	4.85	78.62
T ₃	1.61	1.32	16.33	21.60	0.087	0.040	0.005	0.004	0.234	0.156	19.58	4.93	80.58
T ₄	1.69	1.21	16.93	21.33	0.089	0.035	0.005	0.003	0.244	0.148	16.00	4.71	77.07
T ₅	1.53	1.34	15.77	21.85	0.082	0.041	0.004	0.004	0.208	0.159	17.96	4.98	81.23
T ₆	1.75	1.42	17.40	23.33	0.091	0.043	0.005	0.004	0.246	0.176	21.16	5.13	84.23
T ₇	2.05	1.30	19.57	23.03	0.095	0.041	0.006	0.003	0.257	0.164	16.91	4.94	81.05
T ₈	1.52	1.44	15.70	24.50	0.081	0.050	0.004	0.005	0.204	0.180	18.82	5.40	85.66
T ₉	2.11	1.58	20.10	27.70	0.097	0.053	0.006	0.005	0.255	0.188	21.44	5.52	90.33
T ₁₀	1.42	1.11	15.07	18.97	0.080	0.029	0.004	0.003	0.207	0.119	15.33	4.19	71.48
SEd	0.19	0.09	1.44	1.57	0.005	0.005	0.001	0.001	0.023	0.016	1.83	0.36	4.20
CD (P = 0.05)	0.40	0.19	2.96	3.24	0.01	0.01	0.001	0.001	NS	0.033	3.78	0.74	8.66

Details of treatments are given in text

LAI, Leaf-area index; LAD, leaf-area duration; RGR, relative growth rate; NAR, net assimilation rate; NRA, nitrate-reductase activity; 50% F, 50% flowering; PF, pod filling; FF, first flowering

et al. (1991). Leaf-area duration increased in the plants treated with 2% N, between first flowering and 50% flowering and between 50% flowering and pod filling compared with the control, indicating maintenance of significantly higher leaf area under treatments. Similarly, mean relative growth rate was found significantly higher under 1 and 2% N between first flowering and 50% flowering and under 0.5, 1.0 and 2.0% between 50% flowering and pod filling than the control. The foliar spray of 0.5% N was less effective in increasing the relative growth rate than 1.0 and 2.0% N. The increased relative growth rate might be due to higher accumulation of biomass in response to applied N given at sensitive stages of plant growth. Net assimilation rate was found highest at 2% N during both the stages and was significantly higher than the control (Table 1). Foliar spray of 2% N at post-flowering stage alone and at first flowering + post-flowering showed significantly higher net assimilation rate between 50% flowering and pod filling. This increased the net assimilation rate under foliage-sprayed plants, perhaps due to increased supply of nitrogen to leaf cells, which is essential for photosynthesis. Sekhon *et al.* (1988) also reported increased NO₃ content in leaf with increase in N application in gram (*Cicer arietinum* L.). There was no significant difference in the activity of leaf-nitrate reductase among various treatments and between treatments and control at 50% flowering. But at pod filling the treated plants showed significantly higher nitrate-reductase activity compared with the control, except under 0.5% N (applied at first flowering and at pod filling alone) and under 1.0% N (applied at first flowering alone). However, nitrate-reductase activity declined in general at pod-filling stage than that at 50% flowering (Table 1), which may be due to translocation of NO₃ and carbohydrate from leaf to developing pods.

Mahadkar *et al.* (1991) also recorded higher nitrate-reductase activity in blackgram (*Phaseolus mungo* L.) with top-dressing of N at 30 days after sowing. Fresh weight of pods/plant increased significantly in the treated plants compared with the control, highest being 90.33 g/plant under 2.0% N sprayed at first flowering and post-flowering. Highest number of pods/plant was also found at 2.0% N, applied at first flowering and post-flowering (Table 1). Seeds/pod were significantly higher in the treated plants than in the control, highest being 5.52 under 2% N sprayed at first flowering and post-flowering. This promotive effect of foliar applied N may be attributed to the removal of N stress, which otherwise, cause a major reduction in pod and seed number towards the end of flowering or pod filling. Application of 2.0% N at first flowering and post-flowering increased the fresh weight of pods/plant by 26.37% compared with the control, which may be attributed to the increase in physiological efficiency. It was concluded that N stress both at flowering and pod-filling stages was likely responsible for decline in yield performance of pea.

REFERENCES

- Mahadkar U V and Saraf C S. 1991. Nitrate reductase in relation to nodulation and nitrogen nutrition of blackgram. *Journal of Maharashtra Agricultural Universities, Pune* 16 (3) : 395-7
- Minchin F R, Summerfield R J and Neves M C P. 1981. Nitrogen nutrition of cowpea (*Vigna unguiculata*). Effect of timing of inorganic nitrogen application on nodulation, plant growth and seed yield. *Tropical Agriculture, Trinidad* 58 (1) : 1-12.
- Sati P C, Srivastava B K and Ram B. 1991. Response of garden pea (*Pisum sativum*) to nitrogen under lower hills and foot-hills region of Uttar Pradesh. *Indian Journal of Agricultural Sciences* 61 (1) : 51-3.
- Sekhon B S, Sandhu H S and Thapar S. 1988. Effect of nitrogen at sowing and post flowering stage on nitrogen assimilation and seed yield of chickpea. *Plant Physiology and Biochemistry, India* 15 (1) : 92-6.

Production potential of rice (*Oryza sativa*)-based intercrops in hills zone of Assam

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The productivity of direct-seeded upland rice (*Oryza sativa* L.) is very low and quite unstable due to undulating topography, poor moisture and nutrient retentivity of the soil, occasional drought, weed problem and sub-optimal management adopted by the farmers. Sengupta *et al.* (1985) and Ghosh *et al.* (1986) reported that intercropping of rice with pulses is a more productive and profitable system than sole cropping of rice. Owing to shorter maturity period, greengram (*Phaseolus radiatus* L.) and blackgram (*P. mungo* L.) may prove suitable for intercropping with direct-seeded rice. Since such an information is lacking for this zone, an experiment was planned to study the feasibility of intercropping greengram and blackgram with direct-seeded rice.

A rainfed experiment was conducted during summer season of 1991-93 at Diphu (25°50'N; 93°30'E). The soil was sandy-loam with pH 6.2, organic carbon 1.42% and the available N, P and K 275, 6.6 and 224 kg/ha respectively. The treatments were: T₁, sole rice; T₂, sole greengram; T₃, sole blackgram; T₄, rice + greengram (2 : 1); T₅, rice + greengram (4 : 1); T₆, rice + greengram (2 : 2); T₇, rice + greengram (4 : 2); T₈, rice + blackgram (2 : 1); T₉, rice + blackgram (4 : 1);

T₁₀, rice + blackgram (2 : 2); and T₁₁, rice + blackgram (4 : 2). 'ML 56' greengram and 'T 9' blackgram were intercropped with 'Maibee' (local hill variety) direct-seeded rice as per treatment. Fertilizer was applied @ 20, 4.4 and 8.3 kg/ha N, P and K respectively to sole rice and intercropped treatments. Greengram and blackgram each were fertilized with 15 kg N/ha and 15.4 kg P/ha. Seeds were sown simultaneously with a row spacing of 20 cm between rice, 25 cm between rice and greengram or blackgram and 30 cm between greengram or blackgram on 11 March 1991, 14 March 1992 and 15 March 1993. The experiment was laid out in randomized block design with 3 replications. The total rainfall received during the crop period (March-August) was 734.7, 973.7 and 1 056.9 mm in the respective years.

Intercropping did not influence plant height, panicles/m, panicle length and grains/panicle of rice compared with sole rice, indicating its compatibility with greengram or blackgram (Table 1). Differences between intercrops for plant height, branches/plant, pods/plant, pod length and seeds/pod were significant. However, these parameters did not affect the individual crop under different row proportions.

Intercropping reduced the grain yield of rice by 35-74% compared with sole crop, depending on crop and row proportion

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(Table 2); the highest rice yield being under 4 : 1 proportion. In greengram and blackgram also, grain yield decreased significantly compared with that of their respective sole crops. Unlike in rice, the yield in both the pulses decreased by intercropping and was highest under 2 : 2 proportion. The difference in grain yield of rice and component crops was due to variation in row arrangement.

The rice-equivalent yield of all the treatments was superior to that of sole rice except rice + greengram (4 : 1), rice + blackgram (4 : 1) and rice + blackgram (4 : 2), and was equal to that of sole rice. Rice + greengram showed a maximum increase in rice-equivalent yield (97%) in 2 : 1 proportion and rice + blackgram (4 : 1) the minimum. The highest rice-equivalent yield recorded by sole greengram was due to higher market price.

Among the intercropping combinations, the best treatment rice + greengram (2 : 1) was on a par with that of rice + greengram in 2 : 2 and 4 : 2 ratios, rice + blackgram in 2 : 1 and 2 : 2 ratios. The superiority of 2 : 1 ratio is also supported by higher land-equivalent ratio, as it had 17–19% advantage in yield compared with sole crops.

Intercropping treatments showed higher gross income, net income and benefit : cost ratio compared with sole rice. Rice + greengram in general recorded higher income as well as benefit : cost ratio than rice + blackgram irrespective of the row ratio. These differences were due to the variation in market price of these pulses. Among the intercropping treatments rice + greengram (2 : 1) showed the highest income and benefit : cost ratio. The result confirms the findings of Sarma and Shyam (1992).

Table 1 Growth and yield-attributing characters of rice, greengram and blackgram as influenced by treatments (pooled data of 3 years)

Treatment	Rice				Intercrop				
	Plant height (cm)	Panicles/ m row	Panicle length (cm)	Grains/ panicle	Plant height (cm)	Branches/ plant (cm)	Pods/ plant	Pod length (cm)	Seeds/ pod
T ₁	124	22.5	27.5	119					
T ₂					70.0	2.60	17.5	8.86	12.5
T ₃					43.0	4.96	46.8	4.73	6.7
T ₄	121	23.0	24.4	116	71.3	2.70	14.5	8.80	12.2
T ₅	118	22.5	23.9	11.5	72.3	2.50	14.2	8.80	12.2
T ₆	115	20.4	24.2	113	69.6	2.90	18.5	8.70	12.4
T ₇	118	21.9	25.3	114	71.3	3.20	19.5	8.86	12.8
T ₈	121	21.5	25.8	118	45.3	4.70	48.3	4.50	6.5
T ₉	116	21.9	23.5	114	43.3	4.76	46.3	4.43	6.4
T ₁₀	115	20.5	24.5	116	41.3	4.83	45.5	4.46	6.6
T ₁₁	120	21.7	23.6	113	43.6	5.03	52.7	4.46	6.6
CD (P = 0.05)	NS	NS	NS	NS	8.7	1.42	10.8	0.61	0.7

Details of treatments are given in text

Table 2 Grain yield, rice-equivalent yield, land-equivalent ratio and economics as influenced by treatments (pooled data of 3 years)

Treatment	Grain yield (kg/ha)		Rice- equivalent yield* (kg/ha)	Land- equivalent ratio	Gross income (Rs/ha)	Net income (Rs/ha)	Benefit : cost ratio
	Rice	Intercrop					
T ₁	1 630		1 630	1.00	4 239	1 403	1.82
T ₂		952	3 847	1.00	10 002	7 657	4.26
T ₃		1 012	3 386	1.00	8 804	6 413	3.68
T ₄	985	551	3 210	1.19	8 347	5 637	2.74
T ₅	1 200	246	2 197	1.00	5 714	2 784	1.95
T ₆	670	584	3 032	1.03	7 884	4 886	2.62
T ₇	924	466	2 806	1.06	7 233	4 214	2.39
T ₈	1 052	532	2 711	1.17	7 054	4 011	2.31
T ₉	1 183	293	2 171	1.01	5 644	2 714	1.92
T ₁₀	579	607	2 621	0.96	6 814	3 816	2.27
T ₁₁	765	452	2 286	0.92	5 943	2 917	1.96
CD (P = 0.05)	316	189	739	NS	1 819	1 807	0.65

Details of treatments are given in text

*Cost of produce (Rs/100 kg): Rice, 260; greengram, 1 050; blackgram, 875

It was concluded that both greengram and blackgram can be grown as an intercrop profitably with direct-seeded, upland, summer rice under rainfed condition. Intercropping of greengram and blackgram with summer rice in 2:1 and 2:2 ratios may be followed in the hills zone of Assam considering its production potential and economics.

REFERENCES

- Ghosh R K, Dasgupta B and Basal K. 1986. Intercropping of direct-seeded upland rice with legumes. *Indian Journal of Agronomy* 31 (4) : 785-6.
- Sarma D and Shyam N N. 1992. Intercropping of summer pulses with direct-seeded rice (*Oryza sativa*). *Indian Journal of Agronomy* 37 (4) : 785-6.
- Sengupta K, Bhattacharyya K K and Chatterjee B N. 1985. Intercropping of upland rice with blackgram (*Vigna mungo* L.). *Journal of Agricultural Science, Cambridge* 104 : 217-21.

Soil-nitrogen status under summer legumes — maize (*Zea mays*) sequence

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Intensive agriculture demands maintenance of higher soil fertility. The practice of cereal-cereal rotation continuously might have an adverse effect on physico-chemical properties and fertility status of soil (Deka and Singh 1984). Inclusion of legumes in the sequence improves the soil fertility better than cereal-cereal sequence (Yadav 1985). Hence an experiment was conducted to study the relative efficiency of different summer legume crops with respect to change in total nitrogen content in the soil.

The field experiment was conducted under summer and rainy seasons of 1991 and 1992 at Pantnagar. The soil was neutral, sandy loam, having 0.0673% total N, 21.1 kg P/ha and 339.1 kg K/ha in the top 0–15 cm soil. The treatments comprised 5 summer crops, viz blackgram (*Phaseolus mungo* L.), greengram (*P. radiatus* L.), cowpea [*Vigna unguiculata* (L.) Walp.] for fodder, cowpea for grain and maize (*Zea mays* L.) for fodder and fallow as the main plot; and 4 levels of N (0, 30, 60 and 90 kg/ha) applied to subsequent maize as the subplot. The design of experiment was split plot with 4 replications. Summer crops during summer season were sown in the first fortnight of March and harvested in the first fortnight of June. A basal application of 18 kg

N/ha through diammonium phosphate was made to all the crops including maize (fodder) at the time of sowing. 'Sweta' composite maize was sown with pre-sowing irrigation at a spacing of 60 cm row to row and 20 cm plant to plant in the last week of June during both the years and harvested on 3 October 1991 and 25 September 1992. N was applied to maize through urea in 3 equal splits, one-third each at sowing, 30 days after sowing and tasselling stages. P was applied basal @ 26.6 kg/ha through single superphosphate. Composite soil samples were taken from 0–15 cm depth before sowing summer crops each year. Soil samples were also collected from each plot after harvest of summer crops, including fallow as well as rainy-season maize crop. Soil samples were analysed for total nitrogen by macro-Kjeldahl method (Jackson 1967). To minimize the fertility gradient in the experimental plots, a general crop of oat (*Avena sativa* L.) was raised (without any fertilizer use) after harvesting maize.

The grain yield of maize was reported at 14% moisture. The plots seeded with legumes before maize maintained a higher level of soil fertility with respect to total N than fallow and maize fodder (Table 1), probably due to dinitrogen fixation. The total N content in the plot where maize was grown for fodder decreased from the initial value of 0.0673 to 0.0653%. Perhaps this is the reason of lower

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Table 1 Grain yield of maize and total nitrogen content in soil as influenced by preceding summer crops and nitrogen applied to maize (pooled data of 2 years)

Treatment	Grain yield (kg/ha)	Total N (%)	
		After summer crop	After maize harvest
<i>Summer crop</i>			
Blackgram	3 920	0.069	0.068
Greengram	4 208	0.071	0.069
Cowpea (fodder)	4 404	0.075	0.070
Cowpea (grain)	3 594	0.071	0.070
Maize (fodder)	3 477	0.065	0.066
Fallow	3 946	0.068	0.068
CD (P = 0.05)	504		0.0008
<i>N to maize (kg/ha)</i>			
0	2 790		0.063
30	3 775		0.066
60	4 451		0.067
90	4 684		0.070
CD (P = 0.05)	279		0.0008

yield of rainy-season maize grown after maize fodder. Among summer pulses, cowpea for fodder was more potent in improving soil N, perhaps because of its long growing period, incorporation of high amount of biomass (5.86 tonnes/ha) and being rich in nitrogen (2.1%). Ramshe and Patel (1987) also reported significantly higher residual N, when wheat (*Triticum aestivum* L. emend. Fiori & Paol.) was preceded by cowpea for fodder and followed by greengram. The total N status even after the harvest of rainy-season maize

was higher in the plot having legumes as the preceding crop than maize fodder. The result confirms the finding of Ahlawat *et al.* (1981). The total N content in maize field at harvest grown after cowpea for grain was higher than when grown after cowpea for fodder (Table 1). An increase in N level up to 90 kg/ha to maize resulted in higher total N content of soil even after harvest of maize (Table 1). The reason are (i) N stimulates the activity of soil micro-organisms, and (ii) root portion of legumes left after harvesting having narrow C : N ratio serves as a source of proliferation for microbes, which helps in greater mineralization of N in the soil system.

It was concluded that cowpea for fodder is more potent among summer pulses in improving the soil-N status, which improved the productivity of subsequent maize crop.

REFERENCES

- Ahlawat I P S, Singh A and Saraf C S. 1981. Effect of winter legumes on nitrogen economy and productivity of succeeding cereals. *Experimental Agriculture* 17 (1) : 57-62.
- Deka J C and Singh Y. 1984. Studies on rice-based multiple crop sequence. Effect of crop rotation on fertility status of soil. *Indian Journal of Agronomy* 29 (4) : 490-4.
- Jackson M L. 1967. *Soil Chemical Analysis*, pp 183-214. Prentice Hall of India Pvt. Ltd, New Delhi.
- Ramshe D G and Patel B R. 1987. Studies on nutrient status of soil in different crop sequence. *Journal of Maharashtra Agricultural Universities, Pune* 12 (2) : 214-6.
- Yadav H L. 1985. Changes in soil fertility as a result of different cropping systems. *Indian Journal of Agronomy* 30 (1) : 84-5.

Response of rainfed pearl millet (*Pennisetum glaucum*) to water harvesting, moisture conservation and plant population in light soils

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Pearl millet [*Pennisetum glaucum* (L.) R. Br. emend. Stuntz] like other rainy-season crops generally encounters moisture stress during its growing period, resulting in low yield. Collection of rain water in simple land lay-outs (Kaushik and Gautam 1991), use of various mulches and transpiration suppressants (Pandey *et al.* 1988; Lal *et al.* 1992) and reduction of final plant stand in the wake of mid-season drought (Venkateswarlu 1983) increase the productivity and water-use efficiency of dryland crops. Hence an experiment was conducted to assess the performance of various *in-situ* water-harvesting and moisture conservation practices and plant population on productivity and water-use efficiency of pearl millet.

The field experiment was conducted during the rainy season of 1988 and 1989 at New Delhi. It was laid out in split-plot design replicated thrice. In main plot treatments were 6 *in-situ* water-harvesting and moisture conservation practices (flat seed-bed, ridge and furrow seed-bed, banded seed-bed, flat seed-bed + straw mulch @ 5 tonnes/ha, flat seed-bed + 6% kaolin spray and flat seed-bed + seed treatment with 0.2% Supersorb) and in subplot treatment were 3 final plant stands (normal plant population of 200 000 plants/ha

removal of every third row, ie 150 000 plants/ha and removal of alternate rows, ie 100 000 plants/ha). Hybrid 'BK 560-230' was sown on 6 July 1988 and 12 July 1989. Other cultural operations were carried out as per recommendation. The total rainfall during the crop season was 845.2 mm in 1988 and 172.2 in 1989. The maximum rainfall was received during August in 1988 and during September in 1989.

Straw mulch and kaolin-spray treatments were applied when the drought occurred in the second week of September in 1988 and the first week of August in 1989. Seeds were treated with Supersorb before sowing as per treatment. Normal plant stand was maintained at 200 000 plants/ha (with 50 cm row spacing). Every third and alternate rows were removed with the onset of mid-season drought during 1988 and 1989 cropping seasons respectively. Seasonal consumptive use of water was computed by pan-evaporation method. Daily soil-moisture use was worked out by dividing the seasonal consumptive use of water with crop duration and water-use efficiency by dividing the grain yield with seasonal consumptive use of water.

In general, the yield was higher in 1988 than in 1989, owing to more favourable rainfall during the crop-growth period in the first year. However, the impact of water harvesting and conservation practices on the growth and

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Table 1 Growth and yield characteristics, yield, consumptive use, rate of water use and water-use efficiency of pearl millet as affected by water harvesting and moisture-conservation practices and plant stand

Treatment	Plant height (cm)		Tillers/plant		1 000-grain weight (g)		Grain yield (tonnes/ha)		Stover yield (tonnes/ha)		Consumptive water use (mm)		Rate of water use (mm/day)		Water-use efficiency (grain kg/ha-mm)	
	1988	1989	1988	1989	1988	1989	1988	1989	1988	1989	1988	1989	1988	1989	1988	1989
Water harvesting and conservation																
T ₁	186	106	3.45	2.15	6.80	5.80	2.44	0.76	7.05	2.70	280	180	3.01	2.02	8.71	4.22
T ₂	191	122	3.56	2.65	6.73	6.35	2.73	1.32	7.34	4.32	286	204	3.07	2.29	9.54	6.47
T ₃	188	118	3.47	2.50	6.57	6.20	2.46	0.90	7.20	3.29	287	198	3.08	2.22	8.57	4.54
T ₄	187	115	3.52	2.35	6.68	6.10	2.68	1.17	7.52	3.75	285	203	3.06	2.28	9.40	5.76
T ₅	190	108	3.57	2.20	6.70	6.05	2.50	0.97	7.03	3.37	281	192	3.02	2.15	8.90	5.05
T ₆	191	108	3.42	2.16	6.65	5.75	2.60	0.80	7.60	2.64	284	178	3.05	2.00	9.15	4.50
CD (P = 0.05)	NS	7	NS	0.33	NS	0.24	NS	0.19	NS	0.48						
Plant stand																
P ₁	188	111	3.40	2.29	6.60	6.00	2.95	1.13	9.06	4.24	290	200	3.11	2.24	10.17	5.65
P ₂	189	112	3.50	2.33	6.59	6.05	2.57	0.98	7.38	3.34	285	193	3.06	2.16	9.01	5.07
P ₃	190	116	3.58	2.38	6.77	6.07	2.18	0.85	5.42	2.44	275	184	2.95	2.06	7.92	4.61
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	0.23	0.11	0.43	0.32						

T₁, Flat seed-bed; T₂, ridge-and-furrow seed-bed; T₃, banded seed-bed; T₄, flat seed-bed + straw mulch; T₅, flat seed-bed + kaolin spray; T₆, flat seed-bed + seed treatment with 0.2% Supersorb

P₁, Normal plant stand (200 000 plants/ha); P₂, removal of every third row (150 000 plants/ha); P₃, removal of alternate rows (100 000 plants/ha)

yield of pearl millet was observed only in 1989 (Table 1). Ridge-and-furrow seed-bed and flat seed-bed + straw mulch outyielded significantly all other treatments. The next best treatment was flat seed-bed + kaolin spray. These 3 practices increased the grain yield by 73.6, 54.0 and 27.6% respectively compared with flat seed-bed. Kaushik and Gautam (1991) also reported 27.4, 14.5 and 14% increase in pearl millet yield by the use of straw mulch, sowing in furrows and kaolin spray respectively. However, banded seed-bed and flat seed-bed + seed treatment with 0.2% Supersorb did not increase the grain yield much compared with flat seed-bed. Stover yield showed the trend almost similar to that of grain yield.

Reduction in plant stand with the onset of drought significantly decreased the grain and stover yields in both the years (Table 1). The maximum reduction in grain yield was recorded with removal of alternate rows (35.3 and 33.0% in 1988 and 1989 respectively) followed by removal of every third row (14.8 and 15.3%). The result confirms the finding of Kaushik and Gautam (1984).

Significantly higher plant height, tillers/plant as well as 1 000-grain weight were recorded in ridge-and-furrow seed-bed than in flat seed-bed, followed by banded seed-bed and flat seed-bed + straw mulch. Flat seed-bed + kaolin spray improved only 1 000-grain weight.

All the growth and yield attributes remained unaffected due to mid-season removal of every third row as well as alternate rows in both the years.

Ridge-and-furrow, flat seed-bed + straw mulch and flat seed-bed + kaolin spray recorded higher consumptive use, moisture-use rate and water-use efficiency compared with flat seed-bed, particularly in 1989 (Table 1). These high values could be attributed to

vigorous crop growth resulting from increased availability of soil moisture. Though banded seed-bed also recorded higher consumptive use and moisture-use rate, it did not improve the water-use efficiency because of lower grain yield.

Nominal plant stand (200 000 plants/ha) showed higher consumptive use, moisture-use rate and water-use efficiency compared with lower plant densities (removal of either every third row or alternate rows) in both the years. In spite of higher consumptive use, the higher water-use efficiency under higher plant density could be attributed to the beneficial effect of increased evapo-transpiration on yield (Arnon 1975).

It may be inferred that higher yield of rainfed pearl millet can be obtained by planting in furrows and maintaining a population of 200 000 plants/ha.

REFERENCES

- Arnon I. 1975. Physiological principles of dryland crop production. (in) *Physiological Aspects of Dryland Farming*, pp 3-8. Gupta U S (Ed). Oxford & IBH Publishing Co. Pvt. Ltd, New Delhi.
- Kaushik S K and Gautam R C. 1984. Drought evading studies in pearl millet. *Indian Journal of Agronomy* 29 (2) : 254-6.
- Kaushik S K and Gautam R C. 1991. Effect of dryland practices and plant population on the productivity and moisture-use efficiency of pearl millet. *Indian Journal of Agronomy* 36 (2) : 228-33.
- Lal B, Kaushik S K and Gautam R C. 1992. Response of rainfed pearl millet (*Pennisetum glaucum*) to nitrogen fertilization and moisture conservation. *Indian Journal of Agricultural Sciences* 62 (7) : 476-8.
- Pandey S K, Kaushik S K and Gautam R C. 1988. Response of rainfed pearl millet (*Pennisetum glaucum*) to plant density and moisture conservation. *Indian Journal of Agricultural Sciences* 58 (7) : 517-20.
- Venkateswarlu J. 1983. Contingent crop production strategy in rainfed areas under different weather conditions. Project Bulletin 5. All-India Coordinated Research Project for Dryland Agriculture, Hyderabad. Andhra Pradesh.

Response of foxtail millet (*Setaria italica*) genotypes to levels of nitrogen and phosphorus under rainfed condition

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Foxtail millet or italian millet [*Setaria italica* (L.) P. Beauv.] is cultivated in marginal lands with low nutrient status under limited moisture condition. Subramanian and Ganesaraja (1992) reported a grain yield of 1 360 kg/ha with 20 kg N/ha and 10 kg P/ha compared with 1 295 kg/ha in the control (without N and P). Since information on agronomic requirement of this crop is meagre, an investigation was undertaken on nitrogen and phosphorus requirements of rainfed foxtail millet.

The field experiment was conducted during the wet season of 1993 at Chittorgarh. The soil was medium black, low in available N (207 kg/ha), medium in available P (15.5 kg/ha) and high in available K (343 kg/ha) and organic carbon content 0.45%, with pH 8.4. The treatments consisted of combinations of 3 foxtail millet genotypes ('SR 11', 'SR 16' and 'SIA 326'), 4 levels of N (0, 20, 40 and 60 kg N/ha) and 2 levels of P (0 and 12.9 kg P/ha). Randomized block design was adopted with 3 replications. The crop was sown on 7 July 1993 after receipt of the first rain, by keeping a row spacing of 23 cm. Nitrogen through urea and phosphorus through single superphosphate were applied basal at 10 cm depth.

Genotype 'SIA 326' produced taller plant with higher dry-matter accumulation/plant compared with 'SR 11' and 'SR 16' at 30 and 60 days after sowing (Table 1). 'SIA 326' also recorded significantly higher leaf-area index 60 days after sowing. It showed significantly more ear girth, 1 000-seed weight and grain yield than other genotypes. 'SR 11' proved significantly superior to 'SR 16' in ear length, ear girth and grain yield.

Nitrogen up to 60 kg/ha increased the plant height and dry-matter accumulation/plant 30 and 60 days after sowing (Table 1). Application of 40 and 60 kg N/ha increased the leaf-area index significantly at 60 days after sowing compared with 0 and 20 kg N/ha. However, the crop fertilized with 40 and 60 kg N/ha increased the ear length, ear girth and 1 000-seed weight significantly compared with 0 and 20 kg N/ha. N @ 60 kg/ha did not influence the yield attributes significantly compared with 40 kg N/ha. The grain and straw yields increased significantly with 40 and 60 kg N/ha compared with 0 and 20 kg N/ha (Table 1). However, the difference in crop performance among 0 and 20 kg N/ha and 40 and 60 kg N/ha was non-significant. This increase in yield may attributed to the greater ear length, ear girth, 1 000-seed weight, dry-matter accumulation/plant and leaf-area index on N application. Unirradiated

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Table 1 Effect of N and P on growth and yield attributes and yield of foxtail millet genotypes

Treatment	Plant height (cm)		Dry-matter accumulation/		Leaf-area index at days*	Ear		1 000-seed weight (g)	Yield (kg/ha)	
	at days*		plant at days*			Length (cm)	Girth (cm)		Grain	Straw
	30	60	30	60	60					
<i>Genotype</i>										
'SR 16'	37.5	75.0	3.3	10.4	1.8	15.9	3.1	2.3	730	2 576
'SR 11'	36.1	84.3	3.6	10.4	2.2	21.2	4.4	2.4	922	2 527
'SIA 326'	46.8	93.8	4.7	13.4	2.5	22.4	4.7	2.7	1 085	2 729
CD (P = 0.05)	3.2	4.1	0.3	1.0	0.3	2.6	0.3	0.1	105	NS
<i>N (kg/ha)</i>										
0	34.6	76.5	2.6	7.9	1.8	15.7	3.5	2.2	682	2 055
20	39.1	82.8	3.3	9.8	2.0	18.5	3.8	2.3	790	2 441
40	41.6	88.7	4.7	13.6	2.4	22.5	4.5	2.6	1 074	2 952
60	45.4	89.5	5.0	14.3	2.5	22.7	4.6	2.6	1 104	2 994
CD (P = 0.05)	3.7	4.7	0.3	1.2	0.3	3.0	0.3	0.2	120	350
<i>P (kg/ha)</i>										
0	39.7	84.0	3.8	11.3	2.7	19.8	4.1	2.4	908	2 605
12.9	40.6	84.7	3.9	11.5	2.8	19.9	4.1	2.5	917	2 616
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

* Days after sowing

Bhoi (1982) also observed a linear response in foxtail millet to N under rainfed condition.

The response of the crop to P application was not significant in growth, yield attributes and yield. The soil contained 15.5 kg P/ha, and showed no response to its additional application. The result confirms the finding of Umrani and Bhoi (1982).

The interaction of N and P was not found statistically significant in all the characters.

REFERENCES

- Subramanian P and Ganesaraja V. 1992. Response of *Setaria italica* to different management practices under dryland farming. *Annals of Arid Zone* 31 (4): 269-71.
- Umrani N K and Bhoi P G. 1982. Response of *Setaria italica* to N and P under two rainfall situations. *Indian Journal of Agronomy* 27 (1): 61-3.

Yield and water-use efficiency of rainfed lentil (*Lens culinaris*) as influenced by boron, zinc and molybdenum

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Foot-hill soils of northern part of West Bengal are light in texture and acidic in nature. High rainfall (3 000 mm) of this region favours high rate of leaching of plant nutrients from such soils, often causing micronutrient deficiency that needs to be corrected for sustained crop production. Zinc is an important nutrient influencing growth and yield of lentil (Takkar and Mehta 1984, Gangwar and Singh 1991). Molybdenum is required in greater amount for symbiotic nitrogen fixation, and it increases seed yield of lentil (Khirwar and Singh 1991). Plants grown on acid soils also show response in yield to boron application (Dwivedi *et al.* 1990). No information is available on the effect of boron, molybdenum and zinc on lentil (*Lens culinaris* Medikus) grown on foot-hill soils of West Bengal. Hence an experiment was conducted to study the effect of these nutrients on lentil grown under rainfed condition.

The experiment was conducted during the winter season (*rabi*) of 1986-87 and 1987-88 on sandy-loam soil at the University farm at Pundibari in Cooch Behar district. The soil had organic carbon 0.87%, available N and P 13.5 and 20.6 kg/ha respectively, exchangeable K 28.1 kg/ha, total B 0.55 ppm, total Mo

0.11 ppm, available DTPA-extractable Zn 0.72 ppm and pH 5.5. The experimental site was situated at 26°N and 89°E, 43 m above mean sea-level. The average maximum temperature was 25.8-29.6°C during the crop season and minimum temperature 13.4-17.9°C. The relative humidity was 65.5-75.8%. The crop received 81.4 mm rainfall during 1986-87 and 82.0 mm during 1987-88 crop seasons.

The treatments comprised 2 levels of boron (0.6 and 1.2 kg/ha as borax), 1 level each of zinc (4.4 kg/ha as zinc sulphate) and molybdenum (0.5 kg/ha as sodium molybdate) and their combinations, ie [control, boron 0.6 kg/ha (B_{0.6}) and 1.2 kg/ha (B_{1.2}), zinc 4.4 kg/ha (Zn_{4.4}), molybdenum 0.5 kg/ha (Mo_{0.5}), B_{0.6} + Mo_{0.5}, B_{1.2} + Mo_{0.5}, B_{0.6} + Zn_{4.4}, B_{1.2} + Zn_{4.4}, and Mo_{0.5} + Zn_{4.4}]. These were replicated 3 times in randomized block design. Every year all the treatments received 20 kg N/ha, 25.8 kg P/ha and 33.2 kg K/ha as urea, rock phosphate and muriate of potash respectively. All the nutrients were applied basal to the soil. The test crop 'B 77' lentil was sown in rows spaced 25 cm apart, on 20 November 1987 and 22 November 1988, and harvested on 25 March 1987 and 28 November 1988.

Soil moisture from 0-120 cm layer at 15-day interval, was periodically determined gravimetrically. Consumptive use was calcu-

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lated from the soil-moisture content and the water-use efficiency was worked out by dividing the seed yield with corresponding seasonal consumptive use recorded under the respective treatment.

Economics of production was calculated on the basis of prevailing rates [labour wage @ Rs 19/8 hr, seed @ Rs 6/kg, urea @ Rs 2.24/kg, rock phosphate @ Re 1.00/kg, muriate of potash @ 1.34/kg, borax @ 15.00/kg, sodium molybdate @ Rs 800/kg, zinc sulphate @ Rs 10.00/kg and insecticide endosulfan (Thiodan) @ Rs 180/litre].

Primary branches/plant and pods/plant increased significantly with an application of boron, zinc and molybdenum either alone or

in combination (Table 1). Secondary branches/plant and seeds/pod were not affected by boron alone, but increased significantly when it was applied in combination with zinc and molybdenum, and by zinc or molybdenum alone. Boron @ 1.2 kg/ha, zinc and molybdenum alone or in combination increased the 1 000-seed weight significantly compared with the control. The channelization of photosynthates during reproductive stage might have been influenced by zinc with its involvement in electron transfer and activation of various enzymes (Backer *et al.* 1982). Gangwar and Singh (1991) also reported improved growth of lentil by zinc application. Beneficial effect of molybdenum in symbiotic

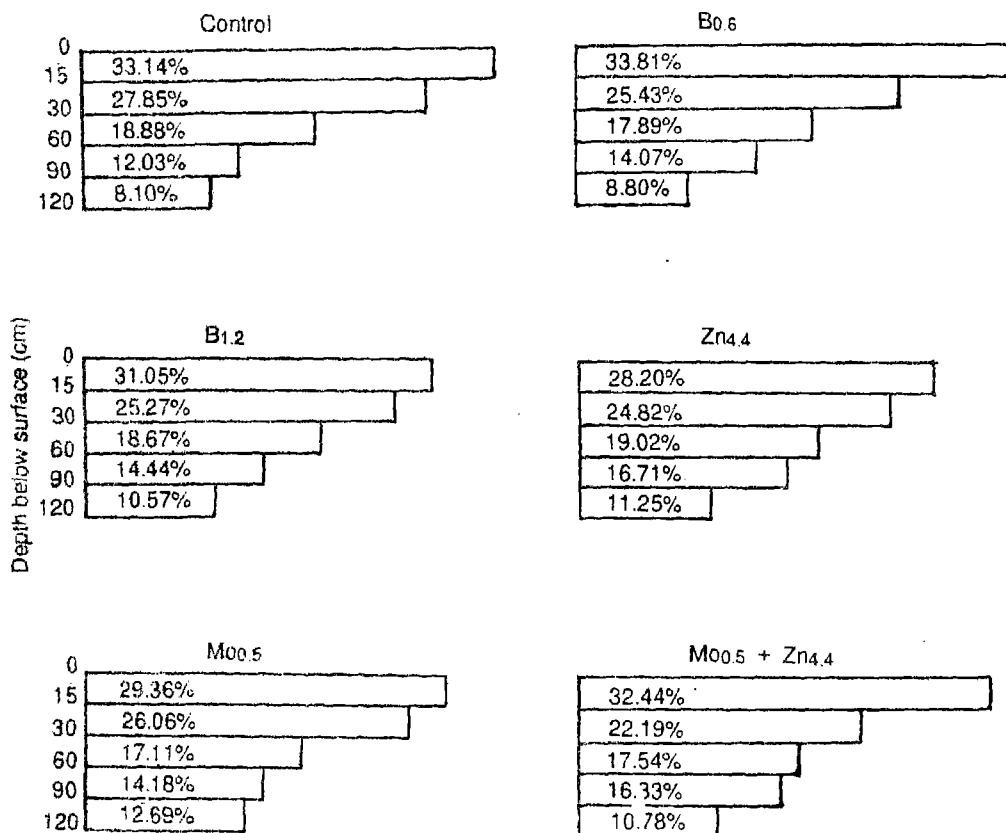


Fig 1 Moisture-depletion pattern in lentil under different micronutrient treatments

Table 1 Effect of micronutrients on yield attributes, seed yield, consumptive use and water-use efficiency of lentil and economics of fertilizer application (pooled data of 1986-87 and 1987-88)

Micro-nutrient (kg/ha)	Pods/ plant	Seeds/ pod	1 000- seed weight (g)	Seed yield (tonnes/ha)		Increase (%) over control	Total produc- tion (Rs/ha)	Net income (Rs/ha)	Bene- fit : cost	Consump- tive use (cm)	WUE (kg/ha- cm)
				1986-87	1987-88	Pooled					
Control	52.9	1.8	14.65	1.42	1.54	1.48	1 995	6 885	3.45	21.64	68.43
B _{0.6}	68.6	1.9	15.23	1.66	1.72	1.69	2 070	8 070	3.90	21.95	76.95
B _{1.2}	73.4	2.0	15.97	1.73	1.85	1.79	2 145	8 595	4.00	22.72	79.09
Zn _{4.4}	78.9	2.1	15.60	1.69	1.83	1.76	2 195	8 365	3.81	22.35	79.15
M _{00.5}	84.2	2.2	15.75	1.78	1.86	1.82	2 395	8 525	3.56	23.60	76.91
B _{0.6} + M _{00.5}	90.1	2.0	16.43	2.03	2.09	2.06	2 470	9 890	4.00	26.71	77.27
B _{1.2} + M _{00.5}	96.4	2.1	17.19	2.09	2.17	2.13	2 545	10 235	4.02	26.32	80.97
B _{0.6} + Zn _{4.4}	92.5	2.1	16.62	1.83	1.95	1.89	2 270	9 070	3.99	25.20	74.80
B _{1.2} + Zn _{4.4}	94.1	2.1	16.81	1.89	1.97	1.93	2 345	9 235	3.94	26.45	73.04
M _{00.5} + Zn _{4.4}	105.7	2.1	17.92	2.23	2.35	2.29	2 595	11 145	4.29	27.86	82.32
CD (P = 0.05)	10.7	0.2	0.70	0.32	0.36	0.19		1 298	0.54		

WUE, Water-use efficiency.

nitrogen fixation might have contributed to greater yield attributes of lentil.

Boron, molybdenum and zinc alone increased the seed yield in both the years and in pooled data, but the effect was significant in the latter only (Table 1).

There was no significant difference in seed yield on application of boron, zinc or molybdenum. B_{0.6}, B_{1.2}, Zn_{4.4} and Mo_{0.5} applied alone increased the seed yield by 14.0, 21.3, 19.4 and 22.5% respectively compared with the control. Combined application of any 2 of these nutrients increased the seed yield significantly compared with the control in both the years and in pooled data (Table 1). Mo_{0.5} + Zn_{4.4} recorded the highest seed yield of 2.29 tonnes/ha (54.9% more than the control). This treatment was, however, on a par with B_{1.2} + Mo_{0.5}. The increase in seed yield was due to the improvement of yield attributes. There are reports on the increase in seed yield of lentil on the application of boron (Dwivedi *et al.* 1990), zinc (Takkar *et al.* 1985) and molybdenum (Khirwar and Singh 1991).

Consumptive use of water by lentil and its water-use efficiency were the lowest in the control, and increased on application of boron, zinc and molybdenum either alone or in combination (Table 1). The micronutrients increased the growth and development of lentil plants, which increased transpiration and ultimately consumptive use. Improvement in water-use efficiency was due to the increase in seed yield on application of micronutrients.

Moisture-extraction pattern decreased with depth of soil in all the treatments (Fig 1).

Lentil extracted 56–60% moisture from 0–30 cm soil layer, and only 6.6–12.7% moisture from 90–120 cm soil layer. The control plants extracted more moisture (61%) from surface 30 cm layer and less (8%) from deeper (90–120 cm) layer than the plants receiving micronutrients (53–59% from 30 cm layer and 9–12.7% from 90–120 cm layer).

The crop receiving a dressing of molybdenum (0.5 kg/ha) in combination with zinc (4.4 kg/ha) gave the highest net return Rs 11 145/ha and benefit : cost ratio (4.29) due to maximum seed yield of lentil.

REFERENCES

- Backer N R, Fernyhough P and Meek T T. 1982. Light dependent inhibition of photosynthetic electron transport by zinc. *Plant Physiology* 56 : 217–22.
- Dwivedi B S, Ram, Munna, Singh B P, Das, Madhumita and Prasad R N. 1990. Differential response of crops to boron fertilization in acid Alfisols. *Indian Journal of Agricultural Sciences* 60 (2) : 122–7.
- Gangwar K S and Singh N P. 1991. Growth and development behaviour of lentil (*L. culinaris* Medic) in relation to zinc fertilization. *Indian Journal of Agricultural Research* 25 (1) 38–42.
- Khirwar H S and Singh V. 1991. Effect of nitrogen, molybdenum and liming on yield and uptake of N and Mo by lentil. *Journal of Indian Society of Soil Science* 39 (4) : 699–702.
- Takkar P N and Mehta S K. 1984. 17th Annual Report (1983–84), All-India Co-ordinated Scheme on Micronutrients in Soils and Plants, Indian Council of Agricultural Research, New Delhi.
- Takkar P N, Chhibba I M and Mehta S K. 1985. 18th Annual Report (1984–85), All-India Co-ordinated Scheme on Micronutrients in Soils and Plants, Indian Council of Agricultural Research, New Delhi.

Effect of A and B genome chromosomes on seedling characters in tetrasomics of 'Chinese Spring' wheat (*Triticum aestivum*)

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Seedling characters such as coleoptile length and seedling height have significance in germination and establishment of good stand of wheat (*Triticum aestivum* L. emend. Fiori & Paol.) crop. Similarly, more number of roots and length of the longest root give an indication of tolerance to drought, as its root absorbs water and nutrients from deeper soil. Location of genes for these characters on particular chromosome in wheat will be useful in transferring the desired genes to otherwise promising wheat variety.

Sears (1954) developed a series of aneuploids such as monosomics, trisomics, nullisomics, ditelosomics and tetrasomics in 'Chinese Spring' wheat. These aneuploids help in the location of genes to individual chromosomes. Out of these aneuploids, tetrasomics were used to study the effect of additional pair of chromosomes on seedling characters, viz root length, root number, coleoptile length and seedling height, in wheat.

Pre-soaked seeds (16 hr) of 14 tetrasomic lines of A and B genomes along with the parent variety 'Chinese Spring' as the control were grown at Pune during January 1993 in petri-dishes, which were randomized in 3 replications at 22 + 1°C. After 11 days, data

were recorded on 10 plants of each variety from each replication for root number, root length, coleoptile length and seedling height. The experiment was repeated again during February 1993 and pooled data were processed statistically by completely randomized design (Singh and Chaudhari 1985). Normal disomic 'Chinese Spring' was used as the control for comparison.

Significant increase in number of roots compared with parent variety 'Chinese Spring' was observed in 'Chinese Spring Tetrasomic 1A', 'Chinese Spring Tetrasomic 5A', 'Chinese Spring Tetrasomic 6A' and 'Chinese Spring Tetrasomic 2B' (Table 1).

For root length, 'Chinese Spring Tetrasomic 2A' and 'Chinese Spring Tetrasomic 7A' showed reduction in root length compared with disomic 'Chinese Spring'. On the basis of monosomic analysis, Sears (1954) reported chromosomes 3B and 3D responsible for root development. Variation in root length in tetrasomics might be due to the presence of additional chromosomes in the tetrasomic lines under study.

'Chinese Spring Tetrasomic 2A' and 'Chinese Spring Tetrasomic 7A' showed maximum and minimum values for coleoptile length respectively. However, no significant deviation was observed in comparison with the disomic 'Chinese Spring'. It indicates that the presence of additional pair of chromo-

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somes did not have any effect on coleoptile length. Thus the earlier reports and our result indicate that this character is polygenically controlled.

Out of the 14 tetrasomic lines, 9 lines ('Chinese Spring Tetrasomic 2A', 'Chinese Spring Tetrasomic 3A', 'Chinese Spring Tetrasomic 4A', 'Chinese Spring Tetrasomic 6A', 'Chinese Spring Tetrasomic 7A', 'Chinese Spring Tetrasomic 2B', 'Chinese Spring Tetrasomic 4B', 'Chinese Spring Tetrasomic 5B' and 'Chinese Spring Tetrasomic 6B') showed significant reduction in total length compared with 'Chinese Spring' disomic.

Such a reduction in seedling height is difficult to explain, because the same chromosome in tetrasomic line carries genes similar to that in the disomic line. It is perhaps owing to the presence of additional genes or chromosome, which might have activated or partly suppressed the expression of seedling height.

Addition of a pair of chromosomes in tetrasomics generally results in additive gene effect. In the present study, out of the 4 seedling characters, only root number showed significant increase, whereas root length and seedling height showed significant reduction compared with disomic 'Chinese Spring' in

Table 1 Pooled data of seedling characters of 14 tetrasomics lines of 'Chinese Spring'

Genotype	No. of roots	Root length (cm)	Coleoptile length (cm)	Seedling height (cm)
'Chinese Spring Tetrasomic 1A'	3.85 ⁺	12.98	6.58	10.83
'Chinese Spring Tetrasomic 2A'	3.22	8.93 ⁻	7.12	9.63 ⁻
'Chinese Spring Tetrasomic 3A'	3.38	12.35	6.60	10.45 ⁻
'Chinese Spring Tetrasomic 4A'	3.20	11.15	6.12	9.37 ⁻
'Chinese Spring Tetrasomic 5A'	3.78 ⁺	12.78	6.70	12.02
'Chinese Spring Tetrasomic 6A'	4.10 ⁺	10.80	6.27	9.27 ⁻
'Chinese Spring Tetrasomic 7A'	3.10	10.33 ⁻	5.95	10.32 ⁻
'Chinese Spring Tetrasomic 1B'	3.38	11.50	6.78	10.87
'Chinese Spring Tetrasomic 2B'	3.73 ⁺	12.22	6.70	9.73 ⁻
'Chinese Spring Tetrasomic 3B'	3.46	12.88	6.55	11.02
'Chinese Spring Tetrasomic 4B'	3.35	12.15	6.23	9.95 ⁻
'Chinese Spring Tetrasomic 5B'	3.22	11.98	6.32	9.93 ⁻
'Chinese Spring Tetrasomic 6B'	3.10	10.73	6.00	9.05 ⁻
'Chinese Spring Tetrasomic 7B'	3.42	12.67	6.77	11.95
'Chinese Spring'	3.12	12.97	6.65	12.03
SE ±	0.14	0.65	0.22	0.38
CD (P = 0.01)	0.53	2.43	0.84	1.43

⁺Significant increase over 'Chinese Spring' at P = 0.01

⁻Significant decrease from 'Chinese Spring' at P = 0.01

chromosomes 2A and 7A. For root number, significant increase was observed in 'Chinese Spring Tetrasomic 1A', 'Chinese Spring Tetrasomic 5A', 'Chinese Spring Tetrasomic 6A' and 'Chinese Spring Tetrasomic 2B', whereas for root length decrease was observed in 'Chinese Spring Tetrasomic 2A' and 'Chinese Spring Tetrasomic 7A'. It indicates that these 2 characters are governed by genes located on different chromosomes. Out of the 7 chromosomes each of A and B genomes, 6A and 2B simultaneously increased the root

number with subsequent reduction in the seedling height when present in tetrasomic condition. Thus 2A, 6A, 7A and 2B are the most important chromosomes for seedling characters.

REFERENCES

- Sears ER. 1954. Aneuploids of common wheat. *Research Bulletin 572, Missouri Agricultural Experimental Station*, Columbia, USA, pp 1-59.
- Singh R K and Chaudhari B D. 1985. *Biometrical Methods in Quantitative Analysis*, 318 pp. Kalyani Publishers, New Delhi.

Genotype x environment interaction in blackgram (*Phaseolus mungo*)

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The area under blackgram (*Phaseolus mungo* L.) is increasing every year in Orissa. But its production is not commensurate with area because of large variation in its yield. The low yield is mostly due to genotype x environment interaction (Sood and Saini 1989, Chopra and Sinha 1994). This interaction can be exploited either by breeding varieties separately for different zones or identifying stable varieties over environments. Hence 6 promising lines were selected from a group of 15 genotypes of blackgram tested under co-ordinated varietal trial to study their interaction with different environments along with a state control.

The experiment was conducted at Regional Research Station, Berhampur, and in the University at Bhubaneswar during winter and rainy seasons of 1985-88. The material consisted of 7 genotypes, 'UH 80-4', 'UH 80-7', 'UH 80-9', and 'UH 87-11' from Haryana; 1 released variety 'LBG 17' from Andhra Pradesh, 1 promising line 'B 3-8-8' from Orissa, and 'Sarala', a released variety of Orissa. The entries were tested at 2 different locations in 6 seasons (5 seasons ie winter season of 1985, 1986 and 1987, and rainy season of 1986 and 1987 at Berhampur; and only 1 rainy season of 1988 at Bhubaneswar).

The experiment was conducted in randomized block design with 4 replications during the 6 seasons, with net plot size of 9.0 m². Seeds were sown in line 10 cm apart, with line-to-line spacing 30 cm. N and P were applied @ 20 kg/ha and 18.7 kg/ha respectively at the time of sowing. The trials were conducted under rainfed situation during rainy season and with 1 life-saving irrigation during the winter. Plant-protection measures were followed as per schedule. The data on grain yield were analysed for each season, and thereafter pooled analysis was also carried out. Stability parameters were computed following Eberhart and Russell (1966).

Analysis of variance for grain yield indicated highly significant differences among the genotypes for all seasons, except during winter 1987 where the genotypes were significant at 5% level (Table 1). Pooled analysis in all the environments indicated that mean squares due to genotypes were significant when tested against both pooled error and pooled deviation, indicating the presence of variation among the genotypes. The environmental indices of all the locations and seasons for the grain yield varied from -902.69 to 1 083.02. The mean squares due to genotype x environment (G x E) interaction were significant only when tested against pooled error, indicating differential response of genotypes to different environments. Pooled deviation

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Table 1 Grain yield and stability parameters of 7 genotypes of blackgram (mean data)

Genotype	Overall mean (kg/ha)	Stability parameter	
		bi	S^2_{di}
'B 3-8-8'	1 542.1	0.9271**	37 819.25**
'LBG 17'	1 427.8	0.9225**	6 759.25**
'UH 80-4'	1 576.6	1.0629**	4 118.52**
'UH 80-7'	1 386.0	1.0065**	12 355.12**
'UH 80-9'	1 399.0	1.0136**	16 560.05**
'H 87-11'	1 321.3	1.0757**	590.02
'Sarala' (control)	1 220.8	0.7615**	58 195.65**

*P = 0.05, **P = 0.01

was also significant, indicating that linear and non-linear components were responsible for the stability of grain yield in blackgram.

Both regression and deviation from regression were significant for all the genotypes except 'UH 87-11', indicating that both linear and non-linear components were responsible for genotypes x environment interaction among the genotypes. However, for 'UH 87-11' the regression was significant and close to 1, but deviation from regression was not sig-

nificant, indicating good fit of the linear model. Different genic systems are responsible in controlling linear and non-linear functions of a genotype (Sood and Saini 1989). Hence mean, regression coefficient and deviation from regression were considered for assessing stability of genotypes. 'Sarala', the state control showed above-average stability and was suitable for low-yielding environments, as the regression estimate was less than 1 and deviation from regression was significant. But 'UH 87-11' with below-average stability was found suitable for high-yielding environments only. The remaining genotypes showed under-average stability, out of which 'LBG 17', 'UH 80-4' and 'B 3-8-8' were better adapted but 'UH 80-7 and 'UH 80-9' were poorly adapted to different situations.

REFERENCES

- Chopra R K and Sinha S K. 1994. *Proceedings of International Symposium on Pulses Research*, held during 2-6 April 1994 at New Delhi, (abstract, p 13).
- Eberhart S A and Russell W A. 1966. Stability parameters for comparing varieties. *Crop Science* 6 : 36-40.
- Sood B C and Saini G C. 1989. Stability for yield and maturity in mash [*Vigna mungo* (L.) Hepper]. *Indian Journal of Genetics and Plant Breeding* 49 (3) : 309-11.

Identification of suitable soybean (*Glycine max*) varieties for non-traditional regions of India

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Soybean [*Glycine max* (L.) Merr.] presently covers 4.0 million ha in India, an 80% of which is in Madhya Pradesh alone. Recently, feasibility of soybean cultivation has been demonstrated in non-traditional areas of peninsular India, north-east hills and Bundelkhand region of Uttar Pradesh. No suitable varieties have yet been identified based on consistent yield performance for different locations and years in these regions. Hence multi-locational trials were undertaken to identify suitable soybean varieties for these new areas.

The trials were conducted in randomized block design with 3 replications during 3 years, viz 1988, 1989 and 1990, at 3 representative locations of 1 each in the non-traditional regions, ie Shillong in north-east hills, Ugarkhurd in Karnataka, and Orai (Jalaun) in Bundelkhand. Yield values (kg/ha) obtained were first analysed in randomized block design to see varietal significance and to identify superior varieties for each location. On confirmation of homogeneity of error variances, yield values of environments (3 locations x 3 years) were used for pooled analysis. The suitability of the varieties was adjudged using the regression and deviation parameters (Eberhart and Russell 1966).

The mean yield varied from 906.8 kg/ha of 'Hardee' at Shillong to 2 806.6 kg/ha of 'PK

262' at Ugarkhurd (Table 1). An overall mean yield of 1 656.2 kg/ha was obtained during different years and at different locations (Table 2). This confirmed the feasibility of soybean cultivation in these non-traditional regions.

Significant varietal and environmental differences were observed. The effect of location was highly significant, being more pronounced than that of year. Ugarkhurd gave the highest yield (Table 1). The year-to-year variation in yield was also significant (Table 2), being the lowest in 1988 (1 270.9 kg/ha)

Table 1 Location-wise yield performance of soybean varieties during 1988-90 (mean data)

Variety	Yield (kg/ha)		
	Shillong	Orai	Ugarkhurd
'PK 472'	1 410	1 501	2 704
'Gaurav'	1 138	1 279	2 303
'MACS 58'	955	1 275	2 275
'Hardee'	907	1 032	2 238
'Punjab 1'	1 188	1 523	2 101
'Durga'	1 283	1 058	2 172
'MACS 13'	1 129	953	2 667
'JS 80-21'	2 034	1 505	2 437
'PK 262'	1 045	1 798	2 807
Mean	1 232	1 325	2 411

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and the highest in 1990 (1 995.0 kg/ha). Among the interaction effects, the variety $\times$ environment interaction was significant. Further, variety $\times$ location effects were highly significant. The variety $\times$ years interaction within each location was highly significant for Shillong and Ugarkhurd and near-significant for Orai.

Location-wise varietal superiority for high mean yield was obtained for 'JS 80-21' at Shillong; for 'PK 262' and 'Punjab 1' at Orai; and for 'PK 262', 'PK 472' and 'MACS 13' at Ugarkhurd. The environmental indices (Table 2) showed that Ugarkhurd in north Karnataka was the most favourable location for the highest expression of soybean yield.

Pooled analysis for stability in 9 environments showed significant effects of varieties and highly significant effects of environments as well as variety $\times$ environment interaction. Linear component of variety $\times$ environment interaction was also highly significant. Stability of a variety, judged on the basis of high mean yield (X), almost unit regression coefficient (b_i) and non-significant deviation from regression (S^2_{di}) (Table 3), showed that 'PK 472', 'Gaurav', 'MACS 58' and 'Hardee' had almost unit regression coefficient, but only 'PK 472' and 'Punjab 1' showed non-significant deviation from regression. Thus only 1 variety ('PK 472') showed both unit regression coefficient and non-significant deviation from regression. It was also high yielder, with an average yield of 1 871.7 kg/ha. Thus 'PK 472' was identified as the most stable for the non-traditional areas studied. Though 'JS 80-21' and 'PK 262' also gave yield almost equal to that of 'PK 472', they had undesirable features, viz regression coefficients away from unity and highly significant deviation from regression.

Earlier studies have identified stable varieties for the central zone and other tradi-

Table 2 Mean yield and environmental indices of soybean for each location and year

Location	Mean yield (kg/ha) during			Location-wise mean
	1988	1989	1990	
Shillong	1 059.4 (-596.7)	1 547.1 (-109.1)	1 089.8 (-566.4)	1 232.1
Orai	685.5 (-970.7)	1 200 (-456.2)	2 089.6 (433.4)	1 324.9
Ugarkhurd	2 067.9 (411.7)	2 360.6 (704.4)	2 805.7 (1 149.5)	2 411.3
Year-wise mean	1 270.9	1 702.6	1 995.0	1 656.2

Figures in parentheses represent environmental indices

Table 3 Mean yield and regression-deviation parameters of soybean varieties over 9 environments

Variety	Mean yield (X)	Regression (b_i)	Deviation (S^2_{di})
'PK 472'	1 872	1.07	119 930
'Gaurav'	1 573	1.07	578 236**
'MACS 58'	1 502	1.02	417 829**
'Hardee'	1 392	1.04	327 158**
'Punjab 1'	1 604	0.70	158 513
'Durga'	1 504	0.83	411 845***
'MACS 13'	1 584	1.23	928 340**
'JS 80-21'	1 992	0.54	1 303 697**
'PK 262'	1 883	1.48	2 338 664**

**P = 0.01

tional areas (Bhatnagar and Tiwari 1989, Nigam *et al.* 1990, Harer and Shaw 1991, Bhatnagar *et al.* 1994).

The present study thus identifies the soybean varieties for each of 3 non-traditional zones, and points out yield stability of 'PK 472' in all these regions during the 3 years of study.

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REFERENCES

- Bhatnagar P S and Tiwari S P. 1989. Phenotypic stability analysis of yield in soybean [*Glycin max* (L.) Merrill]. *Biovigyanam* 15 : 90-3.
- Bhatnagar P S, Tiwari S P and Kamra S K. 1994. Stability for grain yield of soybean varieties in the predominant soybean belt of India. *Tropical Science* 34 : 48-50.
- Eberhart S A and Russell W A. 1966. Stability parameters for comparing varieties. *Crop Science* 6 : 36-40.
- Harer P N and Shaw B S. 1991. Stability for seed yield in some soybean varieties. *Legume Research* 14 : 195-6.
- Nigam P K, Sharma R A, Mishra V K, Holkar S and Billore S D. 1990. Phenotypic stability of seed yield, dry matter and water-use efficiency of soybean (*Glycine max*) under rainfed conditions. *Indian Journal of Agricultural Sciences* 60 (3) : 185-8.

Stability analysis of seed-cotton yield in upland cotton (*Gossypium hirsutum*)

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Upland cotton (*Gossypium hirsutum* L.) is grown mainly under rainfed condition in Maharashtra as a rainy-season crop and shows great fluctuation in yield. One reason is the sensitivity of the varieties to different growing seasons or conditions. The genotypes showing the least genotype $\times$ environment interaction are considered desirable. Hence it is necessary to identify stable varieties for different environments. In this study 9 promising genotypes of upland cotton were evaluated for stability in seed-cotton yield.

The material consisted of 9 promising genotypes, viz 'NH 422', 'NH 418', 'NH 452', 'NH 450', 'NH 439', 'NH 459', 'PH 93', 'LRA 5166' and 'NHH 44'. These varieties were grown in 2 seasons (1990-91 and 1991-92) at 4 locations (Somnathpur, Badnapur, Nanded and Parbhani), thus comprising 8 environments. The genotypes were grown in randomized block design with 4 replications in each environment. Seed-cotton yield was recorded on the basis of net plot consisting of 4 rows of 20 dibbles each. The analysis proposed by Eberhart and Russell (1966) was used to study both the linear (bi) and non-linear (S^2_{di}) parameters of phenotypic stability.

Pooled analysis of variance for seed-cotton yield indicated highly significant difference among the genotypes and among the environments. It indicates the presence of variability among the genotypes and among environments in different years and locations. The significant environment + (genotype $\times$ environment) interaction indicated that seed-cotton yield was unstable. Mean sum of squares due to genotype $\times$ environment (linear) was non-significant when tested with pooled deviation, indicating the absence of genetic difference among the genotypes for their regression on environmental index.

The result confirms the findings of Singh and Yadav (1983) and Singh *et al.* (1991). Mean sum of squares due to pooled deviation when tested with pooled error was found highly significant, indicating important role of unpredictable component of $G \times E$ interaction. Bhandari (1980), Singh (1981) and Bhatade *et al.* (1991) also reported similar results.

Paroda and Hays (1971) and Jatasara and Paroda (1980) emphasized that linear regression (bi) could simply be regarded as a measure of response of a particular genotype, whereas the deviation around the S^2_{di} as the most suitable measure of stability, i.e. the genotypes with least deviation around the

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Table 1 Mean seed-cotton yield (kg/ha) and stability parameters of different genotypes of upland cotton in 8 environments

Genotype	Seed-cotton yield (kg/ha)	b_i	S^2_{di}
'NH 422'	1 329	1.0466	0.0137
'NH 418'	1 250	0.9716	0.0186
'NH 452'	1 545	1.0858	0.0072
'NH 450'	1 519	1.0047	0.0015
'NH 439'	1 479	1.0897	0.0297*
'NH 459'	1 339	0.8548	0.0099
'PH 93'	1 359	1.0052	0.0080
'LRA 5166'	1 290	1.0469	-0.0500
'NHH 44'	1 541	0.8931	0.0089
Population mean (kg/ha)	1 405		
SE +	49.84		

b_i , Linear regression; S^2_{di} , deviation from regression

regression line are the most stable, and *vice versa*.

The mean seed-cotton yield of 9 genotypes was 1 250–1 545 kg/ha (Table 1). 'NHH 44' gave the highest overall yield and 'NH 418' the lowest. Considering the response of genotypes to environmental changes, most of the genotypes had unit regression coefficient, as indicated by non-significant b_i value from unit. Therefore these genotypes could perform well under normal environmental conditions. 'NH 452', 'NH 439', 'NH 422' and 'LRA 5166' had b_i value > 1. Therefore these genotypes were good in response and could be expected to give better yield under good environmental conditions. 'NHH 44', 'NH 459' and 'NH 418' had b_i value less than 1, indicating their high degree of adaptability to unfavourable environments. S^2_{di} value was significant in 'NH 439', indicating its unstable performance in fluctuating environments.

Table 2 Performance of upland cotton genotypes in different environments

Genotype	Seed-cotton yield (kg/ha)								Mean
	E ₁	E ₂	E ₃	E ₄	E ₅	E ₆	E ₇	E ₈	
'NH 422'	2 392	951	1 302	405	2 111	1 486	1 285	702	1 329
'NH 418'	2 151	1 255	1 344	415	2 040	1 305	918	575	1 250
'NH 452'	2 456	1 202	1 514	424	2 358	2 059	1 439	906	1 545
'NH 450'	2 436	1 379	1 525	486	2 110	1 853	1 583	783	1 519
'NH 439'	2 311	1 201	1 553	627	2 507	1 637	1 335	658	1 479
'NH 459'	2 064	1 441	1 228	466	2 028	1 463	1 152	871	1 339
'PH 93'	2 174	1 223	1 327	349	2 033	1 920	1 084	737	1 356
'LRA 5166'	2 215	1 204	1 263	314	2 059	1 636	1 034	596	1 290
'NHH 44'	2 334	1 510	1 618	583	1 977	1 951	1 498	856	1 541
Environmental index	1.098	-0.224	-0.034	-1.271	1.199	0.347	-0.226	-0.895	
SE +	107.02	74.07	94.13	91.74	169.94	98.3	108.8	52.5	
CD	9.51	216.04	NS	NS	470.9	272.6	301.6	145.4	

E₁, Nanded (1991–92); E₂, Parbhani (1991–92); E₃, Somnathpur (1991–92); E₄, Badnapur (1991–92); E₅, Nanded (1992–93); E₆, Parbhani (1992–93); E₇, Somnathpur (1992–93); E₈, Badnapur (1992–93)

'LRA 5166' possessed negative S^2_{di} and therefore showed stable performance and wider adaptability. Considering all the 3 parameters of stability (mean, b_i and S^2_{di}), 'NH 452', 'NH 450' and 'NHH 44' had better mean performance than population mean with unit regression coefficient and the least deviation from regression. Therefore these genotypes have greater stability. Owing to excellent performance in different environments, 'NH 452' is being utilized for general cultivation of upland cotton. 'NH 452' and 'NH 450' may be utilized in future breeding programme to develop stable genotypes of upland cotton having better performance.

REFERENCES

- Bhandari D R. 1980. Studies on stability parameters in parents and hybrids of *Gossypium hirsutum*. *Journal of Indian Society of Cotton Improvement* 5 : 61-4.
- Bhatade S S, Rajewar S R, Reddy V G and Guthe V D. 1991. Phenotypic stability in upland cotton (*Gossypium hirsutum*). *Indian Journal of Agricultural Sciences* 61(11) : 829-30.
- Eberhart S A and Russell W A. 1966. Stability parameters for comparing varieties. *Crop Science* 6 : 36-40.
- Jatasara D S and Paroda R S. 1980. Phenotypic stability analysis for synchrony traits in wheat (*Triticum aestivum* L.). *Indian Journal of Genetics and Plant Breeding* 40 : 132-9.
- Paroda R S and Hays J D. 1971. Investigation of genotype-environment interaction for rate of ear emergence in spring barley. *Heredity, London* 26 : 157-76.
- Singh J V and Yadav T P. 1983. Stability studies for yield and its components in sunflower (*Helianthus annuus* L.). *Indian Journal of Agricultural Research* 17 : 213-8.
- Singh J V, Paroda R S, Arora R N and Saini M L. 1991. Stability analysis for green and dry fodder yield in cluster bean. *Indian Journal of Genetics and Plant Breeding* 51(3) : 345-8.
- Singh P. 1981. Phenotypic stability in upland cotton. *Current Science* 50 (23) : 1 034.

CROP PROTECTION

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Integrated management of mushroom nematode (*Aphelenchoides composticola*)

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ABSTRACT

An experiment was conducted during 1991-92 to standardize the method of management of mushroom nematode (*Aphelenchoides composticola* Franklin). Neemark (containing azadirachtin) 0.5 and 1.0% was found effective in the management of the nematode, giving significantly more yield of mushroom [*Agaricus bisporus* (Lange) Singer]. Incorporation of dry leaf of margosa or neem (*Azadirachta indica* A. Juss.) @ 5% during composting proved as effective as application of phenamiphos @ 0.01%. Supplementation of phenamiphos @ 0.005% along with the margosa leaf @ 1 or 2% was very effective. Margosa oil and indian beech tree or *karanj* [*Pongamia pinnata* (L.) Pierre] oil @ 0.5 and 1% reduced the nematodes by 70-76% in the compost but did not increase the yield.

Mushroom nematode (*Aphelenchoides composticola* Franklin) is highly pathogenic, causing 33-100% damage to the mushroom [*Agaricus bisporus* (Lange) Singer], depending on the initial inoculum level (Khanna and Sharma 1988). Treatment of rice-straw compost with 200 ppm phenamiphos reduces the population of mushroom nematodes (*Aphelenchoides composticola* and *A. sacchari* Hooper) by 70-75% in the compost (Rao *et al.* 1991 c). Incorporation of dry leaf powder of margosa or neem (*Azadirachta indica* A. Juss.) in the compost suppresses the population of mushroom nematode, resulting in higher yield of *Agaricus bisporus* (Grewal

1989). Keeping the cost of chemicals and residue problems in view, an effort was made to evaluate the efficiency of phenamiphos, margosa leaf and their combinations, commercially available Neemark (containing azadirachtin) along with margosa oil and indian beech tree or *karanj* [*Pongamia pinnata* (L.) Pierre] oil for the management of mushroom nematode.

MATERIALS AND METHODS

An experiment was conducted during 1991-92 in the mushroom laboratory at Bangalore. For the experiment margosa and indian beech tree oils and Neemark solutions of 0.5 and 1% concentrations were prepared. Solutions of the former 2 oils were emulsified by adding 0.25-0.5 ml Teepol/1 litre solution. These solutions were sprinkled separately on

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the rice (*Oryza sativa* L.)-straw compost during the second turning @ 1 litre/10 kg compost.

Similarly, rice-straw compost (during the third turning) was thoroughly mixed separately with phenamiphos @ 0.005% (50 ppm) and 0.01% (100 ppm) or dry margosa leaf powder @ 1, 2 and 5% or combinations of low dose of chemical and leaf, ie phenamiphos 0.005% + margosa leaf 1% and phenamiphos 0.005% + margosa leaf 2%. In the control compost was not treated. Compost from each treatment was filled in polythene bags @ 4 kg and each treatment was replicated 5 times. Spawn of mushroom *Agaricus bisporus* strain-310 was used. Observations on spawn run were recorded 25 days after spawning. Afterwards these were put in a case by spreading pasteurized soil (25% sand mixed with chalk powder, pH 7-7.5) in 3-4 cm layer on top of spawned compost.

Data on yield of mushroom were recorded. The compost was mainly harbouring *A. composticola*. It also harboured nematodes of *Rhabditis* sp. These nematodes are saprophytic and are not as harmful as *A. composticola*, particularly when they are in small

number. Hence the focus of the experiment was concentrated on the management of *A. composticola* whose density was $218 \pm 16/1$ kg compost. Observations on final population of *A. composticola* were recorded by drawing 10 samples from each bag.

RESULTS AND DISCUSSION

Though all the treatments proved significantly effective in reducing the population of the nematode, compost with Neemark (0.5 or 1.0%) significantly increased the yield of mushroom compared with other treatments (Table 1). Treatments with margosa and indian beech tree oils were not effective in increasing the yield of mushroom. The increase in yield by Neemark could be due to the reduction of pathogenic nematode population and partly to its favourable effect in increasing the growth of mushroom mycelium. Siddiqui and Alam (1990) also reported the toxicity of margosa compounds (azadirachtin, nimbin and nimbicidin). Some of these compounds present in margosa formulation (Neemark) could be responsible for reduction in population of mushroom nematode. Fungal antibiosis character of these compounds might

Table 1 Effect of margosa oil, indian beech tree oil and Neemark on *Aphelenchoides composticola* on spawn run and yield of *Agaricus bisporus*

Treatment		Nematode population [*]	Spawn run [†] (%)	Yield (g)/4 kg
Margosa oil	0.5	6 546	Good	200
	1.0	6 025	Good	185
Indian beech tree oil	0.5	8 734	Poor	172
	1.0	5 788	Poor	187
Neemark	0.5	7 505	Very good	408
	1.0	5 637	Very good	439
Control		24 348	Very poor	227
CD (P = 0.05)		785.33		30.52

* At termination of experiment

† Visual observations recorded 25 days after spawning

Table 2 Comparative efficacy of phenamiphos and margosa leaf on management of *Aphelenchoides composticola* and yield of *Agaricus bisporus*

Treatment	Nematode population*	Spawn run (%)	Yield (g)/4 kg
Phenamiphos 0.005%	5 356	58	373
Phenamiphos 0.01%	3 251	60	400
Dry margosa leaf 1%	7 498	61	352
2%	6 247	61	365
5%	3 659	64	376
Phenamiphos 0.005% + dry margosa leaf 1%	4 378	66	447
Phenamiphos 0.005% + dry margosa leaf 2%	3 132	65	453
Control	21 448	41	232
CD (P = 0.05)	756.32	5.5	30.73

* At termination

be responsible for the production of some antagonistic fungi, which in turn can control the nematode population to some extent and also a similar nature of compounds might be responsible for the growth of some useful microflora in the compost (Grewal 1989, Rao *et al.* 1991a, Rao and Pandey 1992).

Incorporation of margosa leaf powder in the compost increased the useful microflora and reduced the harmful microflora, resulting in suppression of nematodes and increase in yield (Sohi *et al.* 1987, Grewal 1989). Margosa leaf 5% was as effective as chemical treatment both in reducing the nematode population and increasing the yield, though at low concentration of 1% it could not reduce the nematode population significantly compared with phenamiphos (Table 2). Spawn run was more in the compost mixed with margosa leaf. Grewal (1989) also reported increased mycelial growth due to application of margosa leaf powder. Incorporation of the leaves of margosa, slipper-plant (*Pedilanthus tithymaloides* Poit.), castor (*Ricinus communis* L.) and eucalyptus (*Eucalyptus hybrida* L.) increases the physico-chemical properties

of the compost (Sohi *et al.* 1987, Rao *et al.* 1991 b, Rao and Pandey 1991). Treatment of compost with phenamiphos (0.005%) + margosa leaf (1 or 2%) proved significantly superior to the chemical or margosa leaf treatments individually in suppressing the *A. composticola* population and increasing the yield of *A. bisporus* because of their complementary effect. Phenamiphos + margosa leaf did not affect the spawn run. Use of plant products not only increased the yield but also helped in avoiding the use of chemicals.

REFERENCES

- Grewal P.S. 1989. Effects of leaf-matter incorporation on *Aphelenchoides composticola* (Nematoda), mycoflora composition mushroom compost quality and yield of *Agaricus bisporus*. *Annals of Applied Biology* 115 : 299-312.
- Khanna A.S. and Sharma N.K. 1988. Pathogenicity of various *Aphelenchoides* species on *Agaricus bisporus*. *Indian Phytopathology* 41 : 472-3.
- Rao M.S. and Pandey, Meera. 1991. Comparative efficiency of karanj and carbofuran on the management of *Aphelenchoides composticola*. *Indian Journal of Nematology* 21 (2) : 158-9.
- Rao M.S. and Pandey, Meera. 1992. Integrated management of mushroom nematodes. *Mushroom Research* 1 : 137-8.

- Rao M S, Parvatha Reddy P and Tewari R P. 1991a. Comparative efficacy of certain oil cakes against mushroom nematodes *Aphelenchoides sacchari* and their effect on yield of *Agaricus bisporus*. *Indian Journal of Nematology* 21 (2): 101-6.
- Rao M S, Tiwari R P, Parvatha Reddy P and Pandey, Meera. 1991b. Comparative efficacy of *Glyricidia maculata*, *Pedilanthus tithymaloides* and carbosulfan in the management of nematodes *Aphelenchoides sacchari*. (in) *Proceedings of National Symposium on Mushrooms*, held during 22-24 January 1991 at Kerala Agricultural University, Trivandrum, pp 245-7.
- Rao M S, Tiwari R P, Reddy P P, Pandey, Meera and Khan R M. 1991c. Efficacy of some new chemicals on the management of myceliophagous nematodes *Aphelenchoides sacchari* and *A. composticola* and on the production of *Agaricus bisporus*. (in) *International Symposium on Mushroom*, held during 1-6 September 1991, at Trinity College, Dublin, Ireland (abstr.).
- Siddiqui M A and Alam M M. 1990. Control of root-knot, reniform and stunt nematodes by nimbin seed dressing. *Nematologia mediterranea* 18: 19-22.
- Sohi H S, Grewal P S and Seth A. 1987. Preliminary studies on the effect of plant extracts on the mycelial growth and yield of *Agaricus bisporus* (Lange) Singer and fungal flora in compost. (in) *Cultivating Edible Fungi*, 121-8. Wuest P J, Roysee D J and Bedam R D (Eds). Elsevier Science Publishers, Amsterdam.

Influence of weather factors on light-trap catches of groundnut leafminer (*Aproaerema modicella*) (Lepidoptera : Gelechiidae)

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ABSTRACT

The relationship between weather factors and light-trap catches of leafminer (*Aproaerema modicella* Deventer) of groundnut (*Arachis hypogaea* L.) was studied during 1987, 1988 and 1989 at Vridhachalam. The number of moths attracted to light-trap was significantly high in second fortnight of August and September in 1987 (11 peak catches), in first fortnight of October in 1989 (7 catches) and in March and first fortnight of April 1988 (6 catches). Pooled analysis of data revealed that the light-trap catches had a negative association with maximum temperature ($r = -0.18$), minimum temperature ($r = -0.01$) and sunshine hours ($r = -0.18$), and a positive association with relative humidity ($r = 0.24$) and rainfall ($r = 0.41$). The correlation studies indicated that rainfall alone exerted a significant positive influence, and an increase of 1 mm rainfall would increase the leafminer adults by 8.9.

Leafminer (*Aproaerema modicella* Deventer), a key pest of groundnut (*Arachis hypogaea* L.), causes damage by mining the leaves and feeding on green matter. Attempts were made by many workers to study the influence of weather factors on light-trap catches of lepidopteran pests (Lewin *et al.* 1979, Logieswaran *et al.* 1982, Mahadevan and Chelliah 1985, Balasubramanian *et al.* 1985). Ghule *et al.* (1989) studied the correlation between field incidence of groundnut leafminer and weather factors. However, studies were made only for the particular season, that too correlated with field incidence of leafminer. In the present attempt light-trap

catches of leafminer adult were recorded throughout the year for 3 years and correlated with weather factors.

MATERIALS AND METHODS

The experiment was conducted from January 1987 to December 1989 with light trap using 125 W mercury lamp, set up at Vridhachalam. Only the moths of the leafminer caught were recorded. The weather factors, viz maximum and minimum temperatures, sunshine hours, rainfall and relative humidity for 52 standard weeks, were recorded in the meteorological observatory of the research station. The data on weather factors of 3 years were correlated with light-trap catches and the correlation coefficient was calculated. Finally pooled analysis was done.

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RESULTS AND DISCUSSION

During 1987 the attraction of leafminer adults to light-trap was high 1 180–2 006 adults) during meteorological weeks 34, 43 and 45, which coincided with fourth week of August to fourth week of October and second week of November respectively (Fig 1). Similar trend with slight change was observed in 1989, during which only 7 peak catches were obtained compared with 11 peak catches in 1987 (Fig 1). The meteorological weeks 36–42 of 1989 recorded high number of catches, ie 268, 264, 297, 247, 250, 294 and 226 leafminer adults respectively, coinciding with first week of September to third week of October. The trap attraction was generally low during 1989 compared with that during 1987. Though disparity was minor, and could be attributed to low night temperature during 1989, leading to low field incidence of leafminer and the resultant less trap attraction. During 1988, however, the peak attraction (590–2 003 adults) was recorded during meteorological weeks 10–15, coinciding with

first week of March to second week of April, with 6 peak catches (Fig 1).

The reduction in trap attraction during September–October 1988 was due to high sunshine hours (9 hr) compared with only 5 hr during 1987 and 1989. Peak catches during March–April were recorded in many lepidopteran pests, including in tobacco caterpillar (Balasubramanian *et al.* 1985). The highest number of 2 006, 2 003 and 297 leafminer adults were attracted in last week of August and April and third week of September during 1987, 1988 and 1989 respectively.

Simple correlations between light-trap catches and weather factors showed consistent trend except for maximum and minimum temperature. During 1987, significant positive association of catches was observed with maximum temperature ($r = 0.07$), minimum temperature ($r = 0.35$), rainfall ($r = 0.40$) and relative humidity ($r = 0.54$), and negative with sunshine hours ($r = -0.17$), minimum temperature ($r = -0.08$) and sunshine hours ($r = -0.13$), and a positive correlation with

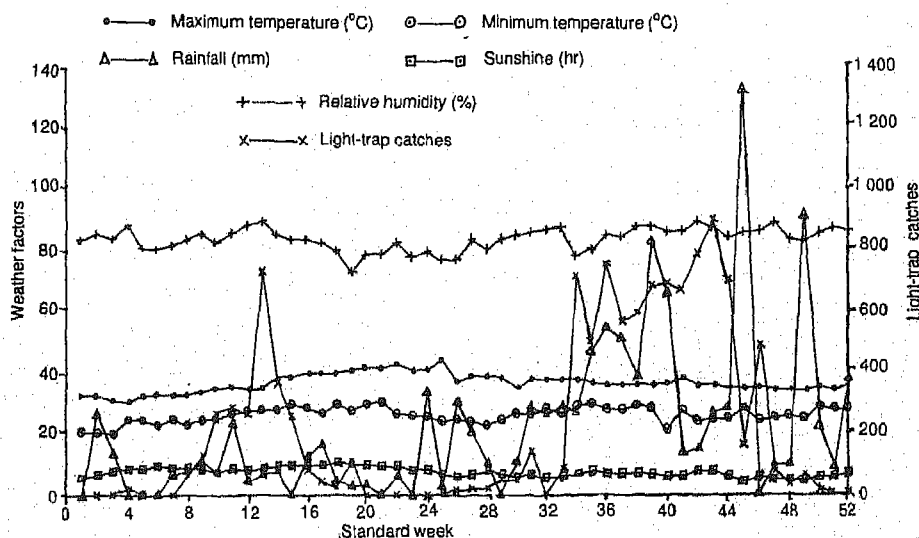


Fig. 1 Light-trap catches of groundnut leafminer as affected by weather factors during 1987, 1988 and 1989

Table 1 Correlation coefficient between weather factors and light-trap catches of groundnut leafminer (pooled analysis)

Parameter	Correlation coefficient	Equation
Maximum temperature (°C)	-0.18	$Y = 976.8 - 20.9 X$
Minimum temperature (°C)	-0.01	$Y = 247.3 - 1.1 X$
Sunshine hours (hr)	-0.18	$Y = 523.8 - 40.5 X$
Relative humidity (%)	0.24	$Y = -1398.7 + 19.3 X$
Rainfall (mm)	0.41**	$Y = 148.0 + 8.9 X$

*P = 0.05; **P = 0.01

relative humidity ($r = 0.31$) and rainfall ($r = 0.42$) were recorded. Negative relationship of light-trap catches with maximum and minimum temperatures and sunshine hours as well as positive relationship with relative humidity and rainfall was observed during 1989. The relationship of relative humidity and rainfall with catches was uniformly positive in all years.

Pooled analysis indicated that the relationship between trap catches and weather factors was statistically non-significant except with rainfall (Table 1). Mahadevan and Chelliah (1985) reported trap catches of maize-borer [*Chilo partellus* (Swinhoe)]. The rainfall alone exerted significant positive influence ($r = 0.41$) and an increase of 1 mm rainfall increased the number of leafminer adults to 8.9.

Our study contradicts that of Logieswaran *et al.* (1982), who recorded that all weather factors including rainfall had non-significant relationship with light-trap catches except wind velocity. Ghule *et al.* (1989) reported significant positive correlation of pest incidence with sunshine hours and negative correlation with relative humidity. Positive relationship of relative humidity with trap catches in this study confirms that of Maheswara Reddy (1981), perhaps because of increased relative humidity, which might have favoured the adult emergence and flight ac-

tivity. The rainfall had a positive influence on the trap catches, supporting the finding of Pandey (1977). The negative relationship of sunshine hours with trap catches confirms the results of Maheswara Reddy (1981), who reported very little or no influence of sunshine hours on the catches of lepidopteran moths.

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REFERENCES

- Balasubramanian G, Chelliah S and Balasubramanian M. 1985. Influence of weather factors on the attraction of moths of *Spodopteralitura* Fabricius to light trap. (in) *Proceedings of National Seminar on Behavioural and Physiological Approaches in Pest Management*, held during 21-23 June 1984 at Tamil Nadu Agricultural University, Coimbatore, pp 110-3.
- Ghule B D, Jagtap A B, Dhumal V S and Dlokar A B. 1989. Influence of weather factors on the incidence of leafminer (*Aproaerema modicella* Deventer) on groundnut. *Journal of Oilseeds Research* 6 : 17-25.
- Lewin H D, Saroja R, Sundaraju D and Padmanabhan S. 1979. Influence of sowing time and weather on the incidence of groundnut leaf-miner. *Indian Journal of Agricultural Sciences* 49 (2) : 886-91.
- Logieswaran G, Rao Mohan S, Vasudevan G and Kannan V. 1982. Incidence of leafminer *Aproaerema modicella* Deventer (*Stomopteryx subsecivella*

- Zell.) on groundnut in relating to time of sowing and weather factors. *Madras Agricultural Journal* 69 : 491-7.
- Mahadevan N R and Chelliah S. 1985. Population dynamics of the sorghum stemborer, *Chilo partellus* (Swinhoe) in light-trap. (in) *Proceedings of National Seminar on Behavioural and Physical Approaches in Pest Management*, held during 21-23 June 1984 at Tamil Nadu Agricultural University, Coimbatore, pp 104-6.
- Maheswara Reddy A. 1981. 'Studies on the biology, ecology and control of tobacco cutworm, *Spodoptera litura* Fabricius (Noctuidae : Lepidoptera)'. M Sc (Agriculture) thesis, Tamil Nadu Agricultural University, Coimbatore (unpublished).
- Pandey S N. 1977. Ecological studies on *Spodoptera litura* (F.). II. Outbreak. *Indian Journal of Entomology* 38 : 106-9.

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Sources of resistance in soybean (*Glycine max*) to frog-eye leaf-spot caused by *Cercosporidium sojinum*

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Frog-eye leaf-spot caused by *Cercosporidium sojinum* (Hara) Liu & Guo is a major disease of soybean [*Glycine max* (L.) Merr.], causing severe damage to the crop in North-Eastern Hills region including Sikkim (Vishwadhari *et al.* 1980, Maiti *et al.* 1983, Verma *et al.* 1988). The present investigation was undertaken to study the reaction of germplasm lines of soybean to this disease under natural epiphytotic conditions and to identify the source of resistance for future improvement programme.

The experiment was conducted during rainy season of 1991 and 1992 at Tadong. The material comprising 74 and 84 lines was evaluated during 1991 and 1992 respectively for their reaction to the leaf-spot. The experiment was laid out in randomized block design with 3 rows of 2 m length, at 30 cm row-to-row and 10 cm plant-to-plant spacings. Disease reaction was recorded 80 days after sowing on 10 random plants when the disease build-up was at its peak. Disease index (%) was calculated according to McKinney's (1923) formula using 0–5 scale. On the basis of disease index (%), lines were grouped into 5 categories, viz resistant (0–5), moderately

resistant (5.1–10.0), moderately susceptible (10.1–20.0), susceptible (20.1–40.0) and highly susceptible (above 40).

Out of the 74 germplasm lines screened during rainy season 1991, only 19 were found resistant and 9 moderately resistant to the leaf-spot. Among the 84 germplasm lines screened during rainy season 1992, 15 were found resistant and 3 moderately resistant. The remaining lines during both the years were found moderately susceptible to highly susceptible.

The varieties found resistant in 1991 were 'PK 472', 'P 9', 'P 8', 'EC 161466', 'EC 39802', 'IC 13754', 'IC 18383', 'IC 18753', 'IC 10689', 'EC 9574', 'JS 76-20', 'JS 81-608', 'JS 80-291', 'JS 80-21', 'NL 812', 'Alankar', 'Kandhaghat', 'KHSF 6' and 'Cucumberland'. In 1992 these were 'IC 13053', 'IC 13050', 'IC 2716', 'IC 18383', 'JS 80-61', 'JS 79-22', 'JS 76-259', 'JS 76-257', 'Piso 9', 'Piso 10', 'BR 11', 'BR 12', 'BR 7', 'PK 472' and 'Kandhaghat'.

Moderately resistant varieties in 1991 were 'P 84-34', 'EC 100779', 'EC 16694', 'JS 74-46', 'Himso 1520', 'MACS 56', 'NA 2', 'NH 615', and 'DS 76-16'; and in 1992 were 'IC 18384', 'Piso 36' and 'Soymax'.

Only 3 germplasm lines, viz 'PK 472', 'IC 18383' and 'Kandhaghat', were found resis-

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tant in both the years. These lines may be used in future breeding programme for developing disease-resistant lines in soybean. 'PK 472' was also found promising in yield-evaluation trials conducted in Sikkim.

REFERENCES

- Maiti S, Kumar S, Verma R N and Vishwadhar. 1983. Current status of soybean diseases in north-east India. *Soybean Rust Newsletter* 6(1): 14-21.
- McKinney H H. 1923. Influence of soil temperature and moisture on infection of wheat seedlings by *Helminthosporium sativus*. *Journal of Agricultural Research* 26: 195-216.
- Verma R N, Kumar S, Chandra S, Sharma S K and Chauhan S. 1988. Diseases of soybean in north eastern states of India. (in) *Proceedings of National Symposium on Insect Pests and Diseases of Soybean*, held during 1-3 November 1988 at College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Sehore, Madhya Pradesh, pp 30-1.
- Vishwadhar, Maiti S, Srivastava L S and Saimbhi H S. 1980. Studies on soybean diseases in Meghalaya. (in) *Proceedings of Symposium on Plant Disease Problems Under Diversifications of Crop Production in India*, held during 10-12 November 1980 at Punjab Agricultural University, Ludhiana, 34 pp.

Effect of herbicides on bacteria, fungi and actinomycetes in sesame (*Sesamum indicum*) soil

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The microbial equilibrium is disturbed by change in soil fertility, temperature, pH, organic matter, moisture and succession of crops. Moreover, the frequent use of pesticides (including herbicides) may be harmful to them (Saler and Gangawane 1980). An experiment was therefore conducted to study the relative efficacy of marketed herbicides on soil bacteria, fungi and actinomycetes in sesame (*Sesamum indicum* L.).

The field experiment was conducted during pre-winter 1991 at Bhubaneswar. There were 10 treatments including 8 herbicides, viz T₁, unweeded control; T₂, traditional practice of hand-weeding at 20 days after sowing; T₃, fluchloralin @ 1.0; T₄, pendimethalin @ 0.5; T₅, anilophos @ 0.3; T₆, butachlor @ 0.75; T₇, oxyfluorfen @ 0.03; T₈, metolachlor @ 0.5; T₉, thiobencarb @ 1.0; and T₁₀, alachlor @ 1.0 kg/ha. All the herbicides except fluchloralin were used 1 day after sowing, whereas fluchloralin was used 1 day before sowing. The trial was laid out in randomized block design with 4 replications. The soil was sandy loam, acidic (pH 5.8), low in available N (21 kg/ha), but the available P and K were 23.7 and 53.75 kg/ha respectively. Initially the microbial population of bacteria,

fungi and actinomycetes was 3 120 000, 183 000 and 940 /g soil respectively.

A composite sample was collected from furrow slice of 0-15 cm depth from 20 spots by random sampling to assess the initial microbial population of the site. Further samples were collected from various treatments at 25, 50 and 75 days after application of herbicides for studying the dynamics of the microbes.

The dilution-plate method (Goss 1972) was followed to enumerate the total bacterial, fungi and actinomycetes population. The nutrient agar medium suggested by Goss (1972) for bacteria and actinomycetes population and the medium suggested for fungal population by Johnson *et al.* (1959) were used for estimation of various populations.

In the control and anilophos-treated plots the bacterial population increased by 10.9 and 5.4% respectively at 25 days after treatment compared with the initial population of 3.12 million/ha soil, whereas it decreased by 11.5-70.2% in all other treatments (Table 1). The maximum decline in bacterial population was noticed in alachlor-treated plots, followed by thiobencarb, butachlor and metolachlor. The adverse effect on the bacterial population was probably due to the lethal action of these herbicides at the applied rates. The finding con-

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Table 1 Effect of herbicides on population ('000/g) of soil bacteria, fungi and actinomycetes in sesame

Treatment	Bacteria at			Fungi at			Actinomycetes at		
	25 days*	50 days	75 days	25 days	50 days	75 days	25 days	50 days	75 days
T ₁	3 460	810	540	160	40	13	14.0	5.3	2.6
T ₂	2 430	660	670	80	43	36	7.3	4.0	4.3
T ₃	1 460	750	390	100	123	20	9.3	11.3	3.0
T ₄	1 360	820	560	130	50	73	11.0	6.3	8.3
T ₅	3 290	520	470	116	40	56	10.0	5.6	3.3
T ₆	1 300	430	510	60	33	26	7.6	3.6	5.3
T ₇	2 760	750	1 230	93	46	30	9.3	7.3	2.6
T ₈	1 330	440	580	63	76	13	7.3	6.3	3.0
T ₉	1 020	580	410	63	36	36	6.6	6.6	2.3
T ₁₀	930	750	530	63	73	73	8.6	6.3	4.6
SEm +	0.2	0.09	0.1	0.019	0.016	0.013	0.006	0.0008	0.0006
CD (P = 0.05)	0.61	0.27	0.3	0.056	0.048	0.036	0.0018	0.0023	0.0017

*Days after treatment

Details of treatments are given in text

firmes the result of Atlas *et al.* (1978). However, the lost bacterial population was recovered to some extent in the plots treated with butachlor, oxyfluorfen and metolachlor 50 days after the treatment, as the toxic effect of these herbicides nullified due to their degradation in the soil. Jaryal *et al.* (1989) reported similar result.

Maximum fungal population was recorded with unweeded control, followed by pendimethalin and anilophos, probably due to their less toxic effect on fungal growth. Alachlor, thiobencarb and metolachlor reduced the fungal population to the minimum (63 000/g soil), whereas at later stages they increased it.

Actinomycetes population 25 days after treatment increased in the unweeded control and under pendimethalin and anilophos compared with the initial population, perhaps due

to the stimulatory effect of herbicides. This corroborates the finding of Sandhu *et al.* (1978). Pre-emergence application of alachlor, metolachlor, butachlor, oxyfluorfen and thiobencarb and pre-planting application of fluchloralin reduced the actinomycetes population by 29.8, 22.3, 19.1, 1.06 and 1.06% respectively compared with the initial population due to their adverse toxic effect. At later stage, however, conspicuous effect was observed among the various weed-control methods with respect to actinomycetes population. In general, the use of herbicides reduced the microbial population.

REFERENCES

- Atlas R M, Pramer D and Bartha R. 1978. Assessment of pesticide effects on non-target soil microorganisms. *Soil Biology and Biochemistry* 10 (3) : 231-9.
Goss R C. 1972. *Experimental Microbiology Guide*, pp 73-1. Kalyani Publishers, Ludhiana.

- Jaryal R R, Bhardwaj R B L, Ahuja K N and Kulshrestha, R N. 1989. Herbicide persistence in soil and its effect on soil microflora. *Indian Journal of Agronomy* 34 (4) : 482-4.
- Johnson L F, Curl E A, Bond L H and Fribourg H A. 1959. *Methods of Studying Soil Microflora Plant Disease Relationships*, pp 89-6. Burgess Publications Co., Minneapolis, the USA.
- Saler R S and Gangawane L V. 1980. Tolerance of target and non-target spermosphere microfungi of groundnut to fungicides. *Pesticides* 14 : 22-6.
- Sandhu K S, Randhawa K S and Chahal V P S. 1978. The effect of some herbicides on the rhizosphere microflora in the seed crop of okra [*Abelmoschus esculentus* (L.) Moench.]. *Indian Journal of Ecology* 5 : 61-6.

Anti-sporulant activity of fungicides on downy mildew (*Peronospora parasitica*) of cabbage (*Brassica oleracea* convar *capitata* var *capitata*)

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Downy mildew of cabbage [*Brassica oleracea* L. convar *capitata* (L.) Alef. var *capitata* L.] incited by *Peronospora parasitica* (Pers.) Fr. occurs occasionally in a destructive form in Himachal Pradesh. It spreads rapidly during cool and moist weather and causes substantial seedling mortality and extensive damage to the foliage at post-transplanting stage of the crop. To prevent such a damage, it is necessary to use fungicides that have the capability to reduce the secondary inoculum for achieving effective disease management with minimum number of sprays. Since information on this aspect is meagre (White *et al.* 1984), a study was conducted to evaluate the anti-sporulant activity of systemic and non-systemic fungicides in comparison with a standard fungicide mancozeb (Indofil M-45) on the established infection of downy mildew.

The experiment was conducted during 1993 in green-house of the Department of Plant Pathology, at Nauni. Cabbage seedlings (25 days old) of 'Pride of India' were transplanted in earthen pots filled with soil. Established plants were inoculated with sporangial suspension (adjusted to 90 000

sporangia/ml with the help of haemocytometer) prepared by harvesting sporangia from incubated cabbage leaves infected with the fungus (Bains and Jhooty 1976). The inoculated plants were kept under high relative humidity (90-100%) for 24 hr at 20°C, transferred to natural conditions, and were sprayed with water in the morning and evening. After the appearance of symptoms, the sporangia present on the leaf lesions were washed. To evaluate the anti-sporulant activity of different fungicides, the plants were subsequently subjected to 7 fungicide spray treatments, viz metalaxyl + mancozeb (Ridomil MZ 72 WP, 0.25%), cymoxanil (Curzate 50 WP, 0.03%), cymoxanil + mancozeb (Curzate 50 WP, 0.03% + Indofil M-45 75 WP, 0.20%), mancozeb (Indofil M-45 75 WP, 0.25%), copper oxychloride (Blitox-50 WP, 0.25%), captan (Hexacap 50 WP, 0.25%) and a control (only water). At 5, 10 and 15 days after single spray, sporangia were washed into 5 ml water from 5 leaves in the morning with the help of hypodermic syringe (Bains and Jhooty 1976). One drop (0.1 ml) of sporangial solution was observed under 3 microscopic fields (120X) for counting the number of sporangia and reduction (%) in the number of sporangia was calculated compared with the control. The data on reduction (%) were transformed by

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arc-sine transformation and were statistically analysed, using randomized block design with treatments as combination of fungicides and days of interval.

Metalaxyl + mancozeb 5 days after the first spray caused maximum reduction in the number of sporangia in comparison with the control, followed by copper oxychloride, cymoxanil alone and in combination with mancozeb, which were statistically at par. But the reduction (1%) in sporangia formation was significantly lesser in spray treatments of mancozeb, captan and chlorothalonil than the other treatments. On day 10, though all the fungicides continued to reduce the number of sporangia, metalaxyl + mancozeb proved the best treatment because it reduced the number of sporangia significantly more than the other treatments, whereas chlorothalonil was the least effective. On day 15, the anti-sporulant activity was considerably reduced

in all the fungicides spray applications, except metalaxyl + mancozeb which still maintained 50.06% reduction of sporangial formation, closely followed by cymoxanil + mancozeb (36.76%); both being statistically at par with each other.

On the basis of overall mean production of sporangia, maximum reduction occurred in metalaxyl + mancozeb, and thus it was the most superior treatment. However, the reduction in sporangial formation caused by cymoxanil and its combination with mancozeb and copper oxychloride was statistically non-significant and equieffective, whereas treatments with mancozeb, captan and chlorothalonil were least effective. The overall means of reduction of sporangial formation at the 3 durations indicate that there was no significant decrease in reduction in it up to 10 days, but a significant decrease was observed on day 15.

Table 1 Effect of fungicides on sporangial production on established downy mildew of cabbage plants

Fungicide	Reduction (%) in no. of sporangia at day			Overall mean
	5	10	15	
Metalaxyl + mancozeb 0.25%	100.00 (90.00) ^P	89.49 (71.13) ^P	50.06 (44.17) ^q	79.85 (68.43) ^a
Cymoxanil 0.03%	81.55 (63.69) ^P	76.30 (58.73) ^q	31.78 (34.34) ^r	63.21 (52.97) ^b
Cymoxanil 0.03% + mancozeb 0.20%	81.55 (63.69) ^P	78.98 (60.88) ^P	36.42 (36.76) ^q	65.65 (53.06) ^b
Mancozeb 0.25%	55.55 (38.78) ^q	47.39 (43.26) ^q	27.28 (29.93) ^r	43.40 (37.32) ^c
Copper oxychloride 0.25%	81.55 (63.69) ^P	60.50 (50.71) ^q	13.64 (18.66) ^r	51.89 (44.35) ^b
Captan 0.25%	51.81 (44.39) ^q	44.70 (41.72) ^q	31.78 (34.34) ^r	42.78 (40.15) ^c
Chlorothalonil 0.2%	40.77 (41.09) ^q	31.59 (32.78) ^r	18.14 (19.49) ^r	30.16 (31.12) ^c
Overall mean	70.39 (57.90) ^x	61.27 (51.31) ^x	29.87 (31.09) ^y	
CD (P = 0.05)				
Fungicide (F)	= 15.2316			
Interval (I)	= 9.9723			
F x I	= 26.3829			

Figures in parentheses are arc-sine transformed values

The result indicates that the residues of metalaxyl + mancozeb and cymoxanil + mancozeb showed higher degree of antispore activity for a longer period and thus checked the build up to secondary inoculum. Jawarski *et al.* (1982), White *et al.* (1984) and Davies and Wafford (1988) also reported the efficacy of metalaxyl in the control of this disease, whereas the anti-sporulant activity of cymoxanil + mancozeb observed in this study confirms the finding of Thind *et al.* (1982). The reduction in sporangial formation by mancozeb and copper oxychloride also corroborate the findings of Thind *et al.* (1982) and Singh (1985), who observed that these fungicides proved effective in controlling the downy mildew of cabbage. The least antispore activity of chlorothalonil recorded in our investigation supports the finding of Davies and Wafford (1988), who also reported the ineffectiveness of chlorothalonil spray.

It was concluded that even a single spray of metalaxyl + mancozeb or cymoxanil + mancozeb may effectively manage the downy-mildew disease of cabbage.

ACKNOWLEDGEMENT

We are thankful to Dr Ravinder Malhotra for helping in statistical analysis.

REFERENCES

- Bains S S and Jhoo J S. 1976. Host range and possibility of pathological races in *Pseudoperonospora cubensis*: cause of downy mildew of muskmelon. *Indian Phytopathology* 29(2) : 214-16.
- Davies J M L and Wafford J D. 1988. *Control of Downy Mildew in Module-raised Cauliflower*, pp 379-86. Monograph 39, British Crop Protection Council, the UK.
- Jawarski C A, Phatak S C and Csino S A. 1982. Effects of metalaxyl on phycomycetous fungi and yield of pepper, tomato and cabbage transplants. *Journal of American Society for Horticultural Science* 107(5): 91-13.
- Singh R S. 1985. *Diseases of Vegetable Crops*, 346 pp. Oxford & IBH Publishing Co. Pvt. Ltd, New Delhi.
- Thind T S, Kaur J and Jhoo J S. 1982. Efficacy of DPX 3217/mancozeb against some phytopathogenic fungi. *Indian Journal of Mycology and Plant Pathology* 12 (1) : 21-5.
- White J G, Crute I R and Wynn E C. 1984. A seed treatment for the control of *Pythium* damping-off diseases and *Peronospora parasitica* on brassicas. *Annals of Applied Biology* 104 : 241-7.

Fungicidal control of floury leaf-spot of french bean (*Phaseolus vulgaris*) caused by *Mycovellosiella phaseoli*

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Floury leaf-spot [*Mycovellosiella phaseoli* (Drummond) Deighton; syn *Ramularia phaseoli* (Drummond) Deighton] occurs in french bean (*Phaseolus vulgaris* L.) growing at high-altitude areas bordering north-western Himalayas. The disease was first reported from Solan by Sohi *et al.* (1965). Tripathi (1985) reported it from hilly areas of Uttar Pradesh. Singh and Sharma (1976) reported effectiveness of benomyl for chemical management of the disease. Since there is no other report available on its management aspects, an experiment was conducted during rainy season in 1989 and 1991 to manage the disease through chemicals.

The experiment was conducted during July 1989 and 1991 at Kandbari. A susceptible french bean cultivar 'Contender' was sown in plots measuring 2.5 m x 2.5 m, in randomized block design with 3 replications of each treatment. Four systemic fungicides, viz carbendazim (Bavistin), bitertanol (Baycor), tridemorph (Calxin 80) and benomyl (Benlate), and 4 non-systemic fungicides, viz captafol (Difolatan), mancozeb (Dithane M-45), copper oxychloride (Blitox 50) and captan (Cap-

taf), were evaluated in the field. The first spray was given at the initial appearance of disease symptoms when the crop had just entered the 10% flowering stage. Three sprays were applied at 7-day intervals (water for the control).

An 8-point scale was prepared to record disease severity on the basis of number of lesions and leaflet area infected (%). Grades 1-8 were assigned when the number of lesions on a leaflet was 1, 3, 5, 10, 20, 30, 40, and 50 respectively, with the corresponding leaflet area (%) 1.5, 4.5, 7.5, 15.0, 30.0, 45.0, 60.0 and 75.0. Yield of dry bean seeds was recorded per hectare 20 days after the spray.

All the fungicides proved significantly superior to the control in suppressing the disease (Table 1). Carbendazim @ 0.05% followed by copper oxychloride @ 0.2% and mancozeb @ 0.2% showed maximum control of the disease. However, they were statistically at par with each other. Tridemorph was least effective, where leaf area infected was 21.53% in 1989 and 11.97% in 1991 and 27.07% respectively compared with 37.35% in the control. Bitertanol, benomyl and captafol were statistically at par with each other in reducing the disease severity. However, the performance of bitertanol was superior to that of benomyl and captafol during both the years. Carbendazim increased the seed yield, apart from giving the best control. Mancozeb and biter-

¹ Based on complete information of M Sc thesis of the first author submitted to Himachal Pradesh Krishi Vishvavidyalaya, Palampur, in 1990 (unpublished)

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Table 1 Effect of fungicides on disease severity and yield of french bean in field

Fungicide	Concentration (%)	Disease severity (%)		Yield (kg/ha)	
		1989	1991	1989	1991
Mancozeb	0.2	6.44	5.83	3 456	2 896
Tridemorph	0.05	21.53	11.97	2 256	1 904
Captan	0.2	16.78	8.43	2 912	2 736
Captafol	0.2	12.08	9.60	3 072	2 672
Carbendazim	0.05	3.32	0.46	3 872	3 568
Benomyl	0.05	11.42	6.93	2 960	2 560
Copper oxychloride	0.2	3.49	3.87	2 960	2 496
Bitertanol	0.05	10.52	8.20	3 296	2 784
Control		37.35	27.07	2 032	1 680
CD (P = 0.05)		5.17	4.07	0.21	0.13

tanol increased the yield considerably. Copper oxychloride, although most effective in checking the disease after carbendazim, did not increase the yield as much as carbendazim, mancozeb and bitertanol. The yield was least under tridemorph treatment, where the increase in yield was not significantly different compared with that of the control. Singh and Sharma (1976) found benomyl highly effective in controlling the disease. In our study also it was almost equally good. Simbwa-Bunnya (1972) also reported the efficacy of mancozeb in controlling the disease.

It was concluded that 3 sprays of carbendazim (0.05%) or mancozeb (0.02%) are the

most effective in checking the floury leaf-spot of french bean.

REFERENCES

- Simbwa-Bunnya M. 1972. Fungicidal control of bean diseases at Kawanda, Uganda. *Plant Disease Reporter* 50 : 901-3.
- Singh B M and Sharma Y R. 1976. Screening of fungicides to control angular and floury leaf spots of beans. *Indian Journal of Mycology and Plant Pathology* 6 : 148-51.
- Sohi H S, Sharma S L, Verma B R and Sachdeva K B. 1965. Floury leaf spot of bean caused by *Ramularia phaseolina* Petrak. *Indian Phytopathology* 18 : 384.
- Tripathi K C. 1985. Occurrence of floury leaf spot of french bean in Uttar Pradesh hills. *Indian Botanical Reporter* 4 : 175.

BOOK REVIEWS

Indian Journal of Agricultural Sciences 64 (12) : 896, December 1994

Hybrid Rice: Food Security in India. 1993. Barwale B R (Ed). Macmillan India Ltd, 2/10 Ansari Road, Daryaganj, New Delhi 110 002. xii + 181 pp. 22.5 cm x 15.0 cm. Rs 260. ISBN 033392-245-X (hardcover).

The book under review compiles the proceedings of the seminar on hybrid rice held in India during August 1992 and covers important aspects of hybrid rice under 5 sessions.

Session 1 gives a comprehensive position about the global status and development of hybrid rice, highlighting the constraints and future needs. The Chinese experience in the development of 3-line and 2-line system of hybrid rice helps in understanding the subject matter. The feasibility of introducing hybrid rice in India based on national network programme has been discussed elaborately.

Session 2 is on seed production. Involvement of public and private sectors in seed production has been discussed. The example of spread of hybrid maize in the United States of America in 10 years is worth adoption, along with additional strategies given for spread of hybrid rice in India. Production of hybrid rice seed by both public and private sectors is needed to achieve productivity targets in addition to quality.

Session 3 gives the economics of hybrid rice cultivation and seed production. The comparative advantages of hybrid rice over other high-yielding varieties have been discussed. The former gives adequate returns to farmers for the time spent and investment made. Good grasp of seed-production techniques and greater care to retain purity of A-lines and hybrid seed are stressed. Economic analysis of hybrid rice-seed production in India also has been presented. Stress is laid on identification of suitable areas for seed production through multi-location trials.

Session 4 is on the progress of hybrid rice programme. Need was felt to accelerate activities relating to hybrid rice research, to utilize the strengths of public and private sectors in research, and to evolve suitable packages of practices for different agro-climatic zones. Privatization of public research in less-developed countries, especially on breeding hybrid rice, has been suggested for attractive returns. The success of the hybrid rice-programme finally depends on the effective transmission of the technology to the farmers through the extension wing of the Department of Agriculture.

Session 5 deals on the role of rice in the national food-security system. Intensification of rice research in India is needed to achieve 50% rice of the total food budget in the early part of the next century. The food security in India depends very much on crop improvement in east India by developing new breeds of rice and adopting improved technologies. Biotechnology can play an important role in agriculture. The three-fold advantages of hybrids, viz increase in average yield, opportunities for more skilled jobs, and better crop-management practices, are very important for attaining food security in India.

In each session, at the end a useful, lively discussion part gives a better understanding and clarification of the subject.

This publication is useful to all interested in hybrid rice development and its commercialization.

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Hormonal Regulation of Plant Growth and Development, vol VI. 1993. Purohit S S (Ed). Agro Botanical Publishers (India), 4E-176 J N Vyas Nagar, Bikaner 334 003. viii + 197 pp. 25 cm x 16 cm. Rs 400, US \$ 120, ISBN 81-85031-57-6.

It is a good attempt by the publishers to review recent advances in plant-hormone research in the light of vast literature accumulated during the last 30 years. This volume presents 6 contributed articles written by authorities in the subject. It includes mechanism of hormone action, use of hormones on post-harvest aspects of citrus, biochemistry and physiology of abscisic acid, reproductive abscission of grain legumes, regulation of dwarfism, hormonal role on crop productivity and its prospects in India.

First 64 pages are devoted to illustrating the mechanism with flow charts and figures. It gives comprehensive information on the line of action of various hormones including gibberellins, cytokinins, abscisic acid (ABA) and ethylene. The information is useful for the beginners, covering all aspects of the mechanism available up to 1987 including various hypotheses. Authorities need to be quoted for technical reports from page 10 to page 21. Regulation of dwarfism by hormones is another contribution that gives basic information about different behaviour of species in response to exogenous gibberellins. The manner of the effect of dwarfism in improvement of crop productivity should be included in the revised edition. Detailed review of hormone research on post-harvest aspects of citrus fruits deserves special compliments, because this information was lacking on horticultural crops in earlier volumes (vols I-V), though it is the first area where the use of hormones began in the last 2 decades and the use of hormones is seen first in the developed

countries. Residue analysis of fruits may further be of interest to the readers in view of international quality standards as envisaged in the General Agreements on Tariffs and Trade (GATT). Efforts are needed on this aspect as well in the changing global scenario, because refusal of the product by a buyer country due to substandard quality may not be a remote probability in agricultural marketing.

The review on abscisic acid (ABA) is presented well. The review on reproductive abscission in the grain legumes by Dr Clifford and Dr Baylis is quite informative and excellent. The physiology of abscission and its possible control by hormones is explained briefly. However, crop-wise response in tabular form could be more beneficial to the readers. Their hypothesis on hormonal response in relation to plant density in the field could prove thought provoking. The review on the role of growth-regulators in increasing crop productivity by Dr C P Malik and co-workers deserves special mention. This is the area where scientists have different views, because there is no consistency in responses over a wide range of environments. Authors have attempted to detail the role and effects in 37 pages. It needs substantiation of authorities. Authors are of the opinion that 'biocheminisation' may improve the peak potential of field crops, with 10-15% increase in yield, without affecting the cost : benefit ratio. The conclusions should be given. A majority of the hormones are costly, with optimum doses 50-200 ppm. The 'yield gaps' given by the authors for different states in

India appear unconvincing. The wheat productivity in Maharashtra can never be comparable to that in Punjab, because of cold temperature requirement of the crop. The author's view is hard to digest. Since increase in yield by hormones is marginal, the peak potential cannot be exceeded solely with the hormone technology. Authors should attend the exercise of crop-wise response along with doses and specific conditions to facilitate the readers in microplanning the increase in yield at various locations in India. Environment plays a significant role in monitoring the yield, rather than plant-growth response alone. The efforts on evaluation of constraints limiting the yield are, however, much appreciated.

There are several books on hormonal regulation of plant growth and development such as by S M Sircar (1971), L J Audus

(1972), W K Jacob (1979), Letham *et al.* (1979), P F Wareing (1982) and M Bopp (1985), besides 5 volumes published by S S Purohit (1983 and onward) and others. The presentation, depth of information and language used are good and easy to understand by the Indian students. The book whets the appetite of the readers; a commendable task indeed!

There are a few spelling errors and some references are missing in bibliography. Mistakes creep in despite the efforts, but these should be kept to the minimum. The book is recommended for researchers and post-graduate teachers.

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Indian Journal of Agricultural Sciences 64 (12) : 899-900, December 1994

Mollicute Diseases of Plants. 1993. Raychaudhuri S P and Mitra D K. Oxford & IBH Publishing Co. Pvt. Ltd, 66 Janpath, New Delhi 110 001. x + 81 pp. 25.25 cm x 15.75 cm. Rs 365. ISBN 81-204-075908.

Since the discovery of plant mycoplasma (mollicutes) in 1967, they have been found to cause yellow disease of plants. These smallest-known free-living prokaryotes lack cell-wall and are pleomorphic in nature, infecting many agricultural, horticultural, ornamental and plantation crops. The present publication was planned to bring together most of the relevant scattered information on mycoplasma diseases of crops, particularly those occurring in India.

The book has 9 chapters. In the introductory chapter mycoplasma and spiroplasma are described in detail. Ch 2 deals with symptoms, transmission, host range, causal agents and control measures of rice yellow dwarf, corn (maize) stunt and sesame phyllody.

Ch 3 provides information on diseases of potato and brinjal. Out of the 6 mycoplasma diseases of potato, 4 (purple top roll, marginal flavesence, witches' broom and potato phyllody) have been reported from India. Their symptoms, loss in yield caused by them, morphology and ultrastructure, transmission, host range, effect on host physiology, source of resistance and control measures are discussed together. The information on little leaf disease of brinjal is quite useful.

A detailed account is provided in ch 4 on symptoms, causal agents, transmission and control of grassy shoot and white-leaf diseases of sugarcane, along with pathophysiology of the former disease.

The next chapter deals with diseases of fruit trees. There is no 1 set of symptoms that can typify mycoplasma-associated diseases

of fruit trees. The most recurrent symptom is witches' broom (shortening of stem and leaf internodes, resulting in loss of apical dominance). Important diseases (rubbery wood apple, peach 'X' disease, *phalsa* bushy stunt, citrus stubborn, citrus greening and grapevine yellow) along with their symptoms and control measures are described lucidly.

Lethal yellowing and root (wilt) diseases of coconut are discussed in detail in ch 6, along with their symptoms, causal agents, transmission and control measures.

Symptoms, transmission and control measures of marigold phyllody, phlox phyllody and *Hydrangea* virescence are dealt with in ch 7. Yellows of periwinkle and china aster are also covered in this chapter.

Ch 8 on diseases of plantation crops deals with spike disease of sandal, little leaf of eucalyptus, mulberry dwarf and *Paulownia* witches' broom, along with their symptoms and control measures.

The last chapter is extremely useful, as it provides detailed information on the control measures. The diseases can be controlled through integrated programme, utilizing measures of resistance, protection, eradication, quarantine, chemotherapy, heat therapy, white light, lower temperature and seed-bed covering with polythene gauze. Among these measures, chemotherapy has been tried most widely but none of the chemicals tested could control mycoplasma effectively. Host-plant resistance is the best method to control these diseases. Though eradication of diseased plants never checks the disease spread, rapid

removal of affected plants is able to slow the apparent rate of disease spread to healthy ones. Quarantine approach is currently recommended practice for their control.

The references (including recent ones) are given with each chapter. The text is written well, supported by relevant colour and black-and-white photographs. The photographs should have been given with particular disease of the crop. It is essential to maintain unifor-

mity in describing the different aspects of diseases of crops. The diseases of coconut should have been covered under diseases of plantation crops and the chapter should precede that of ornamental plants.

The book is timely and useful for students and plant-protection specialists. The price is high.

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(Assistant Editor)

Indian Journal of Agricultural Sciences 64 (12): 901, December 1994

Proceedings of National Seminar on Natural Farming, 1992. L L Somani, Totawat K L and Baser B L. Rajasthan College of Agriculture, Udaipur 313 101. xx + 577 pp. 22.5 x 14.5 cm. Rs 220, US \$ 25.

The book presents the proceedings of the National Seminar on Natural Farming, organized jointly by Rajasthan Agriculture University and State Department of Agriculture (Rajasthan) during 18–20 February 1991 at Rajasthan College of Agriculture, Udaipur.

It has 8 sections, covering 42 papers or presentations on various aspects of natural farming, contributed by leading specialists and practising farmers. Two papers are in Hindi and the rest in English. It covers natural farming prospects and constraints, tillage vs earthworm farming and conservation system, soil microbes, organic matter and plant growth, waste recycling, integrated plant protection and mixed cropping, experiences, observations and reports, and conclusions.

Natural farming is a system of agriculture that seeks to maintain and increase productivity of land by encouraging natural biological processes and avoids the use of synthetic agro-chemicals. Though the maintenance of current level of agricultural production through natural farming from the available land resources is questionable, the importance of intergrating sound traditional practices with the modern intensive agriculture needs no emphasis.

The book critically reviews the existing information on various aspects of natural farming. It also documents certain negative effects of modern agricultural practices that lead to unsustainable development. Most of the presentations are review-type papers, which stress the need for initiating systematic

research so that natural farming practices have a sound scientific foundation. Many experiences of natural farming by practising farmers make very interesting reading.

Though it is a refreshing and interesting collection of information as a whole, the book is not without its limitations. One would particularly wish that the treatment of various aspects was more in depth and clear cut. A more detailed presentation of reasons for better sustainability with natural farming would have been fascinating and convincing. There are also many repetitions of same information in different papers. Although some amount of overlapping of information in a proceedings of this type cannot be avoided, it could certainly have been minimized by the editors.

The book is also weak in proper editing. There are unusually large number of spelling errors, which sometimes convey entirely different meanings. A definite format could have been followed for all the papers, which would have definitely helped in better presentation of the information.

These limitations of the book can easily be overlooked, as the reader is rewarded by ample insight into various aspects of natural farming. It definitely succeeds in arousing the interest in natural farming. The publication is also moderately priced and will be of great use to the research workers, teachers, development agencies and progressive farmers.

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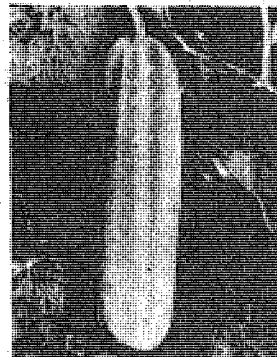
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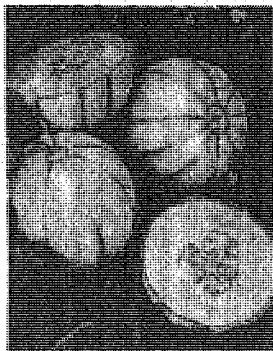
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