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Yield stability in rice (*Oryza sativa*)–wheat (*Triticum aestivum*) system under long-term fertilizer use

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ABSTRACT

Field trials were conducted during 1978–79 to 1988–89 at Palampur and 1977–78 to 1994–95 at Pantnagar while at R S Pura from 1981–82 to 1994–95 to study the long-term effect of inorganic fertilizer application on yield sustainability and soil fertility in rice–wheat cropping system. The results showed that the system's productivity could be stable over years with the application of 40–80–40 kg NPK/ha at Palampur, 80–40–40 kg NPK/ha at R S Pura and 120–40–40 kg NPK/ha at Pantnagar. The soil fertility build-up was not observed at any of the sites with the application of NPK due to continuous cropping of rice (*Oryza sativa* L.) – wheat (*Triticum aestivum* L. emend. Fiori & Paol.) sequence except at Palampur and Pantnagar where increase in available phosphorus was noticed over the initial soil status.

Key words : yield stability, rice–wheat system, long-term fertilizer use

Rice (*Oryza sativa* L.) – wheat (*Triticum aestivum* L. emend. Fiori & Paol.) is an important cropping system in India occupying about 10.5 million ha area and contributing 75% to the total food grain production in the country. Nutrient uptake data in rice–wheat system from long-term fertilizer experiments indicate that there is negative balance of N, P and K even with recommended fertilizer use (Nambiar and Abrol 1989). Fertilizer recommendations for rice and wheat are used in sequential cropping system while fertilizer recommendations should be based on the crop sequences rather than for individual crops (Narain *et al.* 1990). Hence, a study was undertaken to find out the long-term influence of continuous application of inorganic fertilizers on yield stability and soil fertility in rice–wheat cropping system.

MATERIALS AND METHODS

The trials were conducted in permanent plots under the All-India Co-ordinated Research Project on Cropping Systems at Palampur (Himachal Pradesh) during 1978-79 to 1988-89, at Pantnagar (Uttar Pradesh) during 1977-78 to 1994-95 and at R S Pura (Jammu and Kashmir) from 1981–82 to 1994–95. The soil was red at Palampur, clay at R S Pura and fine silty at Pantnagar. The soil characteristics of 3 locations are given in Table 1. The treatments consisted of 3 levels each of N (40, 80 and 120 kg/ha) and P (0, 40 and 80 kg/ha) and 2 levels of K (0 and 40 kg/ha) with one control ($N_0P_0K_0$) in each block were tested in balanced factorial augmented design of 3 × 3 × 2 with 4 replications each having 3 blocks. Half N with full P and K were applied as basal to both rice and wheat crops and the remaining half N as top dressing at 25–30 and 45–50 days stage after irrigation. At Pantnagar, recommended varieties of rice were grown 'Jaya' from 1977–78, 1979–80 to 1985–86 and 'PD 4' from 1986–87 to 1994–95. The wheat variety 'RR 21' was taken from 1977–78 to 1981–83 while 'Sonalika' during 1982–83 and 1985–86. 'UP 2003 was taken from 1986–87 to 1987–88 and from 1989–90 to 1994–95 and in 1988–89 'HD 2285' was taken. At Palampur, rice varieties 'N 18' during 1978–79 and 1980–81 while 'R × T 42' from 1981–82 to 1983–84, 'HIM 1' from 1985–86 to 1986–87 and 'HPU 74' in 1987–88 and 'HPU 741' in 1988–89. In wheat, variety 'S 308' was used during all these years. At R S Pura, 'Jaya' variety was used from 1980–81 to 1994–95. However, wheat variety 'HD 2009' was used in 1981–82 and 'HD 2204' in 1982–83 while 'HD 2329' was used from 1985–86 to 1994–95. Rice was transplanted during first week of July in all the years and harvested in first fortnight of October. Land was prepared for wheat by taking care to prevent movement of soil from one plot to another. Wheat was sown during second fortnight of November and harvested during second fortnight of April. To study the stability of yield under each treatment, partial linear trend was worked out after eliminating environmental effects by following multiple regression equation treating yields as dependent variable and time and general mean (mean of all the 19 treatment combinations in an experimental year)

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as independent variables.

$$Y = a + b_1 t + b_2 y$$

where Y, average yield of a particular treatment combination in a year; y, general mean of all treatment combinations in that year defined as biological effect of the year (Katyal *et al.* 1998), a is a constant, b_1 and b_2 are partial regression coefficients.

Partial stability index of a treatment was computed as $\frac{1}{/b_2/}$ where $/b_2/$ stands for modulus of b_2 and partial stability index of a treatment has been computed after eliminating the effect of trend due to effect of treatment over time in the same plot.

RESULTS AND DISCUSSION

At Palampur both rice and wheat yields increased with increasing level of NPK and higher system's yield of 8.4 tonnes/ha was obtained under the treatment 120–40–40 NPK/ha wherein yields of both crops increased significantly due to the effect of treatment over years in the same plot (Fig 1). However, partial stability indices were 0.77 and 0.86 much below the value of 1. This indicates that environment affects upon the yields of both crops (Table 2). At Palampur yield of both rice and wheat did not increase in any of the treatments excepting in the treatment where 40 kg/ha each of NPK applied giving system's yield of 5.8 tonnes/ha. Interestingly the yield of both the crops increased further with the application of 40–80–40 kg NPK/ha giving system's yield of 6.5 tonnes/ha. The higher system yield under this treatment was associated with the application of higher dose of phosphorus as the application of 40 kg P_2O_5/ha was probably not sufficient to meet the requirement of rice–wheat system. Further, it was noticed that application of nitrogen beyond 80 kg/ha could not increase the yield of the system as experimental soil at Palampur was high in available nitrogen. Moreover, the higher dose of

Table 1 Site characteristics of 3 locations

Characteristics	Location		
	Pantnagar	Palampur	R S Pura
Latitude	29°N	32 6°'N	32 5°'N
Longitude	79° 5'E	76° 3'E	74° 8'E
Mean sea level (m)	243.8	1 290.8	270–2 000
Rainfall (mm)	1 400	2 500	1 058
Temperature (max)	42.5°C	32.9°C	32°C
Temperature (min)	3.6°C	2.9°C	2°C
Soil type	Coarse	Red	Clayey*
Textural class	Loamy and Udic fine silt Haplustalfs (very deep)		
Organic carbon (%)	0.986**	0.56	0.62
Available N (kg/ha)	0.104 (total N%)	769	365
Available P (kg/ha)	26.8	36	20.3
Available K (kg/ha)	148.3	121.6	162

* Eutrochrepts (very deep) and ** Haplusdolls (very deep, 90 cm depth)

Table 2 Stability indices and trend coefficients in Pantnagar, Palampur and R S Pura

Treatment (NPK level kg/ha)	Rice			Wheat		
	Average yield (kg/ha)	Partial *linear* trend	Partial *stability* index	Average yield (kg/ha)	Partial *linear* trend	Partial *stability* index
			Pantnagar			
N_{40} P_0 K_0	3 173	–68.01NS	1.580	2 340	–46.21NS	1.220
N_{40} P_0 K_{40}	3 059	–35.75NS	1.500	2 321	–25.47NS	1.270
N_{40} P_{40} K_0	3 210	–50.09NS	1.400	2 404	–7.22NS	1.410
N_{40} P_{40} K_{40}	3 319	–75.32NS	1.250	2 405	–40.95**	0.980
N_{40} P_{80} K_0	3 431	–45.72NS	1.430	2 433	–42.62**	1.050
N_{40} P_{80} K_{40}	3 311	–26.46NS	1.280	2 551	–29.25**	1.060
N_{80} P_0 K_0	3 809	–9.67NS	0.980	3 091	3.95NS	1.090
N_{80} P_0 K_{40}	3 839	3.07NS	1.000	3 176	–25.43NS	0.850
N_{80} P_{40} K_0	3 860	6.33NS	0.930	3 130	–4.02NS	0.960
N_{80} P_{40} K_{40}	3 952	–12.35NS	0.890	3 268	–5.64NS	0.960
N_{80} P_{80} K_0	4 211	–33.94NS	0.830	3 269	–1.69NS	0.890
N_{80} P_{80} K_{40}	4 156	5.93NS	0.810	3 387	20.58NS	0.970
N_{120} P_0 K_0	4 440	9.40NS	0.870	3 500	50.96*	1.010
N_{120} P_0 K_{40}	4 525	7.75*	0.860	3 455	40.34NS	0.930
N_{120} P_{40} K_0	4 419	5.73NS	0.710	3 538	61.55**	1.010
N_{120} P_{40} K_{40}	4 688	59.93*	0.770	3 655	57.72*	0.860
N_{120} P_{80} K_0	4 599	61.55NS	0.880	3 663	48.64NS	0.880
N_{120} P_{80} K_{40}	4 746	64.48NS	0.800	3 693	13.14NS	0.740
N_0 P_0 K_0	2 517	–73.13*	1.540	1 314	–72.47**	1.410

(*Continued*)

Table 2 (*continued*)

Treatment (NPK level kg/ha)	Rice			Wheat		
	Average yield (kg/ha)	Partial linear trend	Partial stability index	Average yield (kg/ha)	Partial linear trend	Partial stability index
			Palampur			
N_{40} P_0 K_0	3 341	53.81*	1.540	1 302	21.49NS	3.140
N_{40} P_0 K_{40}	3 185	–10.94NS	1.270	1 756	3.30NS	3.760
N_{40} P_{40} K_0	3 200	46.77NS	1.500	1 968	17.49NS	1.090
N_{40} P_{40} K_{40}	3 436	32.64NS	0.970	2 434	62.79**	0.660
N_{40} P_{80} K_0	3 558	23.78NS	0.980	2 115	26.72NS	0.900
N_{40} P_{80} K_{40}	3 834	23.98NS	0.950	2 631	67.98**	0.680
N_{80} P_0 K_0	3 749	–34.86NS	1.010	1 370	–5.84NS	1.280
N_{80} P_0 K_{40}	3 857	18.17NS	1.150	1 782	–35.84*	1.410
N_{80} P_{40} K_0	3 792	54.96**	1.010	1 971	–22.04NS	2.060
N_{80} P_{40} K_{40}	4 081	–23.45NS	0.960	2 903	52.15*	0.570
N_{80} P_{80} K_0	3 865	20.53NS	0.890	2 270	–21.34NS	0.950
N_{80} P_{80} K_{40}	3 861	37.91NS	0.860	2 836	40.56NS	0.630
N_{120} P_0 K_0	3 966	–12.00NS	0.990	1 306	–62.82NS	7.310
N_{120} P_0 K_{40}	4 368	–50.05*	0.940	1 580	–100.17NS	5.590
N_{120} P_{40} K_0	4 219	–26.10NS	0.810	1 952	–85.03**	1.740
N_{120} P_{40} K_{40}	4 153	–37.08NS	0.760	2 946	–8.98NS	0.480
N_{120} P_{80} K_0	3 962	–53.77NS	0.920	2 221	–49.57NS	1.620
N_{120} P_{80} K_{40}	4 342	–51.10NS	0.720	3 504	36.89NS	0.490
N_0 P_0 K_0	2 415	–5.56NS	1.760	1 332	31.85	0.950
			R S Pura			
N_{40} P_0 K_0	3 080	14.54NS	0.930	1 395	–38.55*	1.580
N_{40} P_0 K_{40}	3 288	–6.00NS	0.800	1 549	–24.56NS	1.620
N_{40} P_{40} K_0	3 467	–13.77NS	0.940	2 175	–21.02NS	0.980
N_{40} P_{40} K_{40}	3 640	54.81NS	0.930	2 329	40.05*	0.930
N_{40} P_{80} K_0	3 695	–2.27NS	0.900	2 375	17.60NS	0.760
N_{40} P_{80} K_{40}	3 875	24.85 NS	0.990	2 521	40.96**	0.830
N_{80} P_0 K_0	3 630	–49.51*	0.860	1 637	–87.78**	1.390
N_{80} P_0 K_{40}	3 783	–42.63*	0.810	1 779	–65.51**	1.370
N_{80} P_{40} K_0	4 020	–17.55NS	0.840	2 653	8.87NS	0.860
N_{80} P_{40} K_{40}	4 265	28.63*	1.270	3 008	85.29**	1.000
N_{80} P_{80} K_0	4 256	–16.66NS	1.060	2 858	–23.43NS	0.800
N_{80} P_{80} K_{40}	4 419	23.86NS	1.410	3 377	94.70**	0.820
N_{120} P_0 K_0	3 935	–48.23NS	0.740	1 724	–110.65**	1.320
N_{120} P_0 K_{40}	4 001	–40.65NS	0.910	1 835	–95.90**	1.400
N_{120} P_{40} K_0	4 578	70.56*	2.060	2 831	–52.01*	0.790
N_{120} P_{40} K_{40}	4 643	48.74NS	3.080	3 333	97.59**	0.960
N_{120} P_{80} K_0	4 562	–22.91NS	0.800	3 033	–19.40NS	0.660
N_{120} P_{80} K_{40}	4 666	90.47**	1.480	3 520	102.76**	0.840
N_0 P_0 K_0	2 085	59.12NS	1.870	1 074	–10.80NS	2.130

NS, Not significant, *, significant, **, highly significant

nitrogen application (120 kg N/ha) also recorded low stability index irrespective of levels of P and K. In case of 40–40–40 kg NPK/ha wheat yield increased highly significantly. On the other hand partial stability index in case of rice for this treatment was 0.97 quite close to 1 but for wheat it was only 0.66 much below 1. This implies that rice yields are not influenced by the change in environment while wheat yields are affected. The same trend was observed with 40–80–40 kg NPK/ha (Table 2).

At R. S. Pura yield of both rice and wheat increased in nutrient level of 80–40–40 kg NPK/ha producing the system's yield of 7.2 tonnes/ha. Increasing levels of N and P further resulted in higher yields of rice and wheat and higher system's productivity of 8.2 tonnes/ha was recorded under treatment 120–80–40 kg NPK/ha. In case of 80–40–40 kg NPK/ha yield of both rice and wheat increased significantly but stability indices were 1.27 for rice while 1.00 for wheat (Fig 1). Thus, yield for rice was unstable due to the influence of environment

while it was stable for wheat. In case of 120–80–40 kg NPK/ha both rice and wheat yields were influenced by environments (Table 2 and Fig 1).

Soil fertility

Soil analysis indicated that continuous cropping of rice–wheat system for 14 years at R S Pura and 11 years at Palampur decreased available soil N by 29.31 and 24.74%, respectively in unfertilized plots over its initial status. The decline was also recorded in all the fertilized plots. However, to some extent the decline was arrested due to application of higher doses of fertilizer N but increasing P application reduced the available soil N at R S Pura probably due to higher N uptake from the soil (Nambiar and Abrol 1989). The decline in available soil N under application of NPK may be attributed to the lack of association between organic carbon and available N as the soil submergence during rice cropping results in structural changes in organic carbon pool which become enriched with phenolic compound that may immobilize N containing compounds (Olka *et al.* 1996) and results in decline in available soil N.

A marked buildup in available soil P was observed at Pantnagar in both fertilized and unfertilized plots over its initial level after 18 years of continuous rice–wheat cropping. The increase in available soil P is due to applied P which is left out in the soil after harvest of crop, and gets accumulated over the years and contributes to the pool of available P in the soil. However, available soil P declined in all the fertilized plots at R S Pura and Palampur. This decline in available soil P at these centres may be due to high P fixing capacity of the soil.

Available soil K decreased at all the locations over its initial status due to continuous cropping of rice–wheat under fertilized and unfertilized plots (Table 3). This decrease in K is probably due to non release of non–exchangeable K for utilization of rice and wheat on one hand and higher uptake of K by these crops on the other (Singh *et al.* 1983).

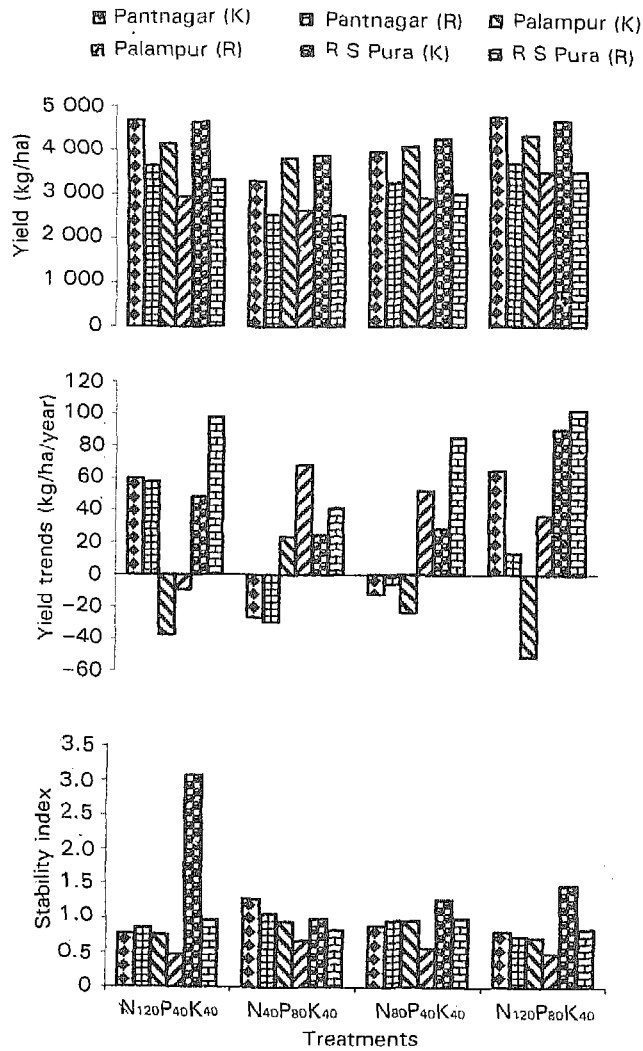

Fig 1 Pooled yield, yield trend and partial stability indices under selected treatments

Table 3 Effect of fertilizer use on soil fertility status under rice–wheat system

Treatment/ nutrient (kg/ha)	Available (N kg/ha)			Available (P kg/ha)			Available (K kg/ha)		
	Pantnagar (after 18 cycles)	Palampur (after 11 cycles)	R S Pura (after 14 cycles)	Pantnagar (after 18 cycles)	Palampur (after 11 cycles)	R S Pura (after 14 cycles)	Pantnagar (after 18 cycles)	Palampur (after 11 cycles)	R S Pura (after 14 cycles)
Control (absolute)	NA	578.7	258	17.38	10.5	12.0	106.1	121.6	129.0
Nitrogen									
40		703.6	239	39.0	23.0	20.0	112.0	128.0	123.0
80		704.3	238	40.0	23.0	21.0	110.0	124.4	122.0
120		756.6	298	37.0	26.9	21.0	101.0	123.5	121.0
Phosphorus									
0		672.9	285	29.0	12.7	18.0	103.0	123.5	126.0
40		687.9	247	39.0	28.9	24.0	110.0	123.2	120.0
80		717.9	244	48.0	33.2	19.0	111.0	126.3	127.0
Potash									
0		691.8	262	36.0	24.7	22.0	106.0	125.4	132.0
40		694.1	255	41.0	25.3	19.0	108.0	119.1	113.0
Initial	0.104 (Total N%)2	769.00	365.0	26.8	36.0	20.3	148.3	121.6	162.0

NA, Not availab[illegible]

REFERENCES

Katyal V, Sharma S K and Gangwar K S 1998. Stability analysis of rice–wheat cropping system in integrated nutrient management. *Indian Journal of Agricultural Sciences* **68** (2) : 51–3.

Nambiar K K M and Abrol I P. 1989. Long–term fertilizer experiments in India–an overview. *Fertilizer News* **34** (4) : 11–20.

Narain P, Soni P N and Pandey A K 1990. *Economics of long term fertilizer use and yield sustainability in soil fertility and fertilizer use*. Indian Farmer's Fertilizer Cooperative Organization, New Delhi, pp 251–64.

Olka D C, Cassman K G, Randall E W, Kinchesh P, Sangar L J and Anderson J M. 1996. Changes in chemical properties of soil organic matter with intensified rice cropping in tropical lowland soils. *European Journal of Soil Science* **47** : 293–303.

Singh R, Mittal S B, Singh A P and Singh M. 1983. Studies on depletion pattern of soil potassium in pearlmillet–wheat rotation. *Journal of Indian Society of Soil Science* **31** : 54–6.

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Performance of early and long-duration rice (*Oryza sativa*) varieties in pure and mixed cropping systems under intermediate lowland condition

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ABSTRACT

A field experiment was conducted during 1994 and 1995 at Cuttack to study the yield performance of rice (*Oryza sativa* L.) varieties of early-duration ('Annada' – dwarf, 105 days and 'Banaprabha' – semi-tall, 95 days) and long-duration ('Gayatri' – semi-dwarf, 170 days and 'CR 260–77' – semi-tall, 170 days) in pure (sole crops) and mixed row stand (1:1 and 1:2 ratio) under intermediate lowland condition. The conventional long-duration varieties gave more than double the grain yield obtained from the early varieties in pure stand. The tall varieties of both maturity groups ('Banaprabha' and 'CR 260–77') performed better than dwarf varieties ('Annada' and 'Gayatri') in pure as well as mixed stand. The total grain yield in mixed stand of 'Banaprabha' with long–duration varieties was significantly higher (16.1–16.9%) than pure crop of late variety alone. The increase in yield in mixed stand was due to long–duration varieties which gave 82.6–85.3% of their yield in pure stand due to higher panicle weight following wider row spacing after the harvest of early varieties in September. Land–equivalent ratio in mixed cropping of 'Gayatri' or 'CR 260–77' with 'Banaprabha' was 1.40–1.52 but only 1.14–1.21 with 'Annada'. An yield advantage of about 0.5 tonne/ha was achieved in the mixed cropping system which could be beneficial for avoiding risk and achieving sustainable production in the fragile lowland ecosystems.

Key words : competition, flooding, grain yield, growth duration, land equivalent ratio, mixed cropping, rice varieties

In eastern India, rainfed flooded lowlands are mostly monocropped with long-duration photosensitive rice (*Oryza sativa* L.) varieties, whereas early duration varieties are grown under upland conditions. In some waterlogged low-lying areas, the rice varieties of different maturity groups are grown together, eg *Udu* (autumn + winter rice) cultivation in Tamil Nadu, *Koottumundakan* in Kerala (Ramankutti *et al.* 1991), *ahu* + *bao* rices in Assam (Saikia *et al.* 1990) and *boro* + deepwater rices in Bangladesh (Rashid *et al.* 1988). These mixed cropping systems are known to result in higher productivity and provide stability in production in the risk–prone flooded lowland ecosystem. Besides tolerance to submergence, complementarity in growth habits between the varieties grown together is an important consideration under such conditions. The varieties compete with each other for resources and the vigorously-growing taller plants offer shade to the slow–growing dwarfer plants, thus affecting their growth and yield performance adversely. Studies have been conducted on mixed cropping systems using early and long-duration varieties in different row ratios (Reddy *et al.* 1991), plant populations (Sharma 1994) and fertilizer requirement (Sharma and Reddy 1991). However, the information on varying plant types differing in growth habits is lacking. Hence, a study was conducted to evaluate the performance of tall and dwarf rice varieties of varying growth duration in pure and mixed stand under intermediate lowland condition.

MATERIALS AND METHODS

An experiment was conducted at Cuttack during rainy season *kharif* (May–December) of 1994 and 1995 on an alluvial sandy-clay loam soil of Mahanadi delta having *p*H 6.2, organic carbon 0.83%, total N 0.09%, available P 22 kg/ha and available K 128 kg/ha. The conventionally-grown long-duration photosensitive lowland rice varieties, 'Gayatri' (semi-dwarf, 170 days) and 'CR 260–77' (semi–tall, 170 days) were grown along with early-duration upland types, 'Annada' (dwarf, 105 days) and 'Banaprabha' (semi-tall, 95 days). The long and early-duration varieties were grown as pure crops and in mixed stand in alternate rows (1:1 ratio) or 2 rows of late variety followed by 1 row of early variety (2:1 ratio). Eight treatment combinations of mixed crops and 4 of pure crops were arranged in a randomized block design with 3 replications. The plot size was 15 m^2.

Sowing of early and long-duration varieties was done simultaneously in dry soil on 18 May 1994 and in saturated

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soil on 5 June 1995. Seed rate was 400 seed/m² in pure stand, 300 seeds/m² of each variety in 1:1 ratio, and 400 seed/m² of late variety and 200 seed/m² of early variety in 2:1 ratio. The row spacing was 20 cm in pure stand and 15 cm in mixed cropping treatments. The varying seed rate and row spacing were adopted based on the results of an earlier study under similar conditions (Sharma 1994). A basal dose of 40 kg N and 8.7 kg P/ha was applied uniformly. The early varieties were harvested in September, after which the long-duration varieties grew in a wider space up to maturity in December. Observations were recorded on plant height, yield attributes and yield at maturity. Land-equivalent ratio was computed to compare the performance of different mixed cropping treatments.

Rainfall and flooding patterns

There was a large variation in the rainfall and flooding patterns in the field during the growth period of rice in 2 years (Fig 1). The 1994 was a normal year when the crop was sown in dry soil moistened with some pre-monsoon showers. The seed germinated with monsoon showers received after sowing but the young plants experienced drought conditions in the beginning of June for nearly 2 weeks. The regular rains started from June-end and water accumulated in the field from beginning of July (47 days after sowing). The water level remained < 10 cm in the initial 4–5 days but increased rapidly up to 66 cm at 60 days after sowing. The water level remained mostly between 30 and 45 cm during August but thereafter, flooding occurred up to a depth of > 70 cm coinciding with ripening and maturity of early varieties. The water level receded gradually from the last week of September to 0 in November-end.

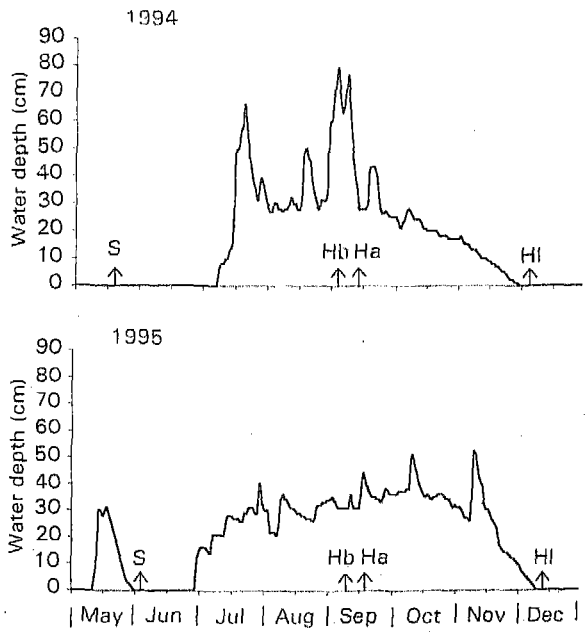

Fig 1 Daily variations in flooding patterns during growth period or rice. Arrows under S, Hb, Ha and HI indicate dates of sowing, and harvesting of 'Banaprabha', 'Annada' and long-duration varieties ('Gayatri' and 'CR 260–77') respectively.

In 1995, unusual heavy rains (603 mm) occurred from 10 to 17 May which resulted in accumulation of water in the field up to 30 cm. However, there were no rains thereafter for 1 month and the flood water receded completely by May-end. Sowing was done in saturated soil conditions and the seed were placed on the soil surface resulting in rapid germination. Flood water accumulated again from 20 days after sowing and rose gradually in the early stages. The water level fluctuated within a narrow range of 30 cm – 40 cm during major part of the crop growth period and did not rise to higher depth as in 1994. The late monsoon rains during October–November increased the water level up to 50 cm which receded to 0 by the second week of December.

RESULTS AND DISCUSSION

Growth parameters

The plant height of long-duration rice varieties 'Gayatri' and 'CR 260–77' was not affected significantly in mixed crop stand compared with that in pure stand (Tables 1 and 2). However, the height of early varieties 'Annada' and 'Banaprabha' was considerably less in mixed than in pure stand. This was because the early varieties had to compete for resources with the vigorously-growing long-duration varieties. The latter also had enough time to recover after the harvest of early varieties in September. The long-duration varieties grew taller in 1994 than in 1995 but the reverse was true for early-duration varieties particularly in the mixed crop stand. This was attributed to higher water depth in the early and middle growth stages in 1994 which resulted in elongation of plants of 'Gayatri' and 'CR 260–77' and thus suppressed the growth of 'Annada' and 'Banaprabha'. These variations in growth behaviour of the varieties could also be due to delayed sowing in saturated soil in 1995 compared with timely dry sowing in 1994.

Yield performance

In general, the yield performance of rice varieties was poor, particularly in 1995 (Tables 1 and 2). In 1994, the crop experienced drought in early stages followed by submergence of higher depths during tillering which reduced the crop stand. Further, excessive flooding in the first fortnight of September coincided with ripening of early varieties which adversely affected their performance. The crop performance was worse in 1995 because seeding in saturated soil condition although resulted in good germination but the plants remained weak due to early rise in water level from 20 days after sowing. The early varieties were affected more than the long-duration varieties as the former had no time to recover from the adverse effects of early flooding.

The conventional long-duration rice varieties gave nearly twice more grain yield than early varieties in pure stand (Tables 1 and 2). The variety 'CR 260–77' gave comparatively more

Table 1 Effect of pure and mixed cropping of rice varieties on growth and yield performance under intermediate lowland condition in 1994

Treatment	Plant height at maturity (cm)	Panicles/ m²		White head/m²		Panicle weight (g)	Grain yield (tonnes/ha)		Straw yield (tonnes/ha)	
Pure cropping										
'Gayatri'	139	169		35		2.48	3.34		5.10	
'CR 260–77'	146	207		24		2.56	3.72		5.67	
'Annada'	84	150		16		1.72	1.56		1.87	
'Banaprabha'	116	171		18		1.81	1.70		2.07	
Mixed cropping										
1:1 ratio										
'Gayatri'	133	119		21		2.65	2.70		4.03	
'Annada'	74	78	197+	15	36+	1.44	0.59	3.29+	1.43	5.46+
'Gayatri'	132	111		24		2.79	2.86		4.14	
'Banaprabha'	96	107	218+	11	35+	1.68	1.09	3.95+	1.67	5.81
'CR 270–77'	144	144		14		2.73	2.93		4.54	
'Annada'	73	79	223+	14	28+	1.48	0.68	3.61+	1.30	5.84+
'CR 260–77'	146	132		13		2.63	3.13		4.68	
'Banaprabha'	95	109	241+	12	25+	1.78	0.83	3.96+	1.53	6.21+
2:1 ratio										
'Gayatri'	139	133		19		2.75	2.96		4.28	
'Annada'	72	52	185+	18	37+	1.54	0.41	3.37+	0.91	5.19+
'Gayatri'	135	128		25		2.74	3.16		4.04	
'Banaprabha'	100	71	199+	16	41+	1.61	0.85	4.01+	1.59	5.63+
'CR 270–77'	146	166		13		2.76	3.25		4.73	
'Annada'	72	46	212+	9	22+	1.31	0.45	3.70+	0.86	5.59+
'CR 260–77'	147	172		15		2.79	3.06		4.49	
'Banaprabha'	101	76	248+	20	35+	1.59	0.95	4.01+	1.80	6.29+
SEm±	4.3		15.9		3.7	0.106		0.201		0.455
LSD (P=0.05)	12.7		48.9		11.4	0.313		0.619		1.402

+Total of both varieties

yield than 'Gayatri', and 'Banaprabha' was superior to 'Annada' in both years. This indicates that taller varieties of both maturity groups performed better than dwarfer varieties which had a greater portion of the plants submerged under water. In the mixed stand, 'Annada' performed miserably as its yield was only about one–third (28.0–33.9%) of the yield obtained in pure stand. On the other hand, the performance of 'Banaprabha' was better and it gave more than half of its pure crop yield in 1:1 ratio (57.4%) as well as in 2:1 ratio (54.7%). The greater decrease in yield of 'Annada' in mixed stand was due to its dwarf growth habit which was over-shadowed by the tall growing plants of the long–duration variety. The long–duration varieties also showed considerable recovery as they grew in a wider space (30 cm) after the harvest of early varieties. The yield of 'Gayatri' and 'CR 260–77' in the mixed stand was 80.3–83.2 and 83.6–86.9% of their pure crop yield in 1:1 and 2:1 ratio respectively. Accordingly, the contribution of these varieties in the total yield in mixed stand was 71.1–83.9 and 74.5–88.5% (Table 3). As expected, the contribution was higher when the long-duration variety was grown with 'Annada' (83.9–88.5%) than with 'Banaprabha' (71.1–76.4%) because of poor performance of the former early variety. In an earlier study, 'Gayatri' gave up to 82% of its pure crop yield and contributed up to 70% of the total yield in the mixed cropping system with 'Banaprabha' (Sharma 1994). The number and weight of panicles of early varieties was lower in the mixed stand than in the pure stand presumably due to competition effects. On the other hand in the case of long–duration varieties although the panicle number was lower in the mixed stand, the panicle weight increased conspicuously. This was understandable because after the harvest of early varieties in September, the row spacing became wider causing lesser inter-plant competition and thereby resulted in better performance of the long-duration varieties.

The total grain yield in mixed cropping system showed a variable trend with the two early varieties (Tables 1 and 2). Growing 'Annada' with either of the long-duration varieties resulted in either equal or even lower yield compared with sole crops of 'Gayatri' or 'CR 260–77'. However, the mixed cropping system of 'Banaprabha' with 'Gayatri' or 'CR 260–77' resulted in significantly more yield than with their sole crops. The yield advantage was higher with 'Gayatri' (19.3–20.9%) than with 'CR 260–77' (12.9%). However, the absolute yield in pure as well as mixed stands was higher with 'CR 260–

Table 2 Effect of pure and mixed cropping of rice varieties on growth and yield performance under intermediate lowland condition in 1995

Treatment	Plant height at maturity (cm)	Panicles/ m²		White head/m²		Panicle weight (g)	Grain yield (tonnes/ha)		Straw yield (tonnes/ha)	
Pure cropping										
'Gayatri'	116	167		18		2.11	2.32		3.74	
'CR 260–77'	120	214		12		2.04	2.48		3.82	
'Annada'	82	164		10		1.62	1.24		1.42	
'Banaprabha'	115	161		10		1.84	1.50		2.47	
Mixed cropping										
1:1 ratio										
'Gayatri'	116	127		19		2.40	1.91		2.55	
'Annada'	77	65	192+	10	29+	1.55	0.32	2.23+	0.81	3.36+
'Gayatri'	117	144		16		2.34	2.13		2.57	
'Banaprabha'	107	83	227+	6	22+	1.42	0.93	3.06+	1.70	4.27+
'CR 270–77'	117	135		14		2.42	2.15		2.55	
'Annada'	78	64	199+	6	20+	1.59	0.34	2.49+	1.10	3.65+
'CR 260–77'	119	151		15		2.25	2.30		2.77	
'Banaprabha'	110	74	225+	11	26+	1.67	0.82	3.12+	2.00	4.77+
2:1 ratio										
'Gayatri'	119	150		13		2.70	2.04		2.48	
'Annada'	81	53	203+	13	26+	1.70	0.48	2.52+	0.96	3.44+
'Gayatri'	118	162		18		2.81	2.04		2.54	
'Banaprabha'	105	75	237+	11	29+	1.55	0.90	2.94+	1.80	4.34+
'CR 270–77'	117	175		20		2.21	2.12		2.80	
'Annada'	79	52	227+	5	25+	1.46	0.26	2.38+	0.72	3.52+
'CR 260–77'	120	194		14		2.51	2.20		2.61	
'Banaprabha'	110	76	270+	17	31+	1.63	0.89	3.09+	1.92	4.53+
SEm±	3.6		12.1		2.6	0.098		0.157		0.333
LSD (P=0.05)	10.6		37.3		8.0	0.289		0.484		1.026

+Total of both varieties

Table 3 Contribution of long-duration rice variety in total grain yield and land-equivalent ratio under different mixed cropping treatments

Treatment	Contribution of late variety in total yield (%)			Land-equivalent ratio		
	1994	1995	Mean	1994	1995	Mean
1:1 ratio						
'Gayatri' : 'Annada'	82.1	85.7	83.9	1.19	1.08	1.14
'Gayatri' : 'Banaprabha'	72.4	69.7	71.1	1.50	1.54	1.52
'CR 260–77' : 'Annada'	81.2	86.3	83.8	1.22	1.14	1.18
'CR 260–77' : 'Banaprabha'	79.0	73.7	76.4	1.33	1.47	1.40
2:1 ratio						
'Gayatri' : 'Annada'	87.8	80.9	84.4	1.15	1.27	1.21
'Gayatri' : 'Banaprabha'	79.6	69.4	74.5	1.45	1.48	1.47
'CR 260–77' : 'Annada'	87.8	89.1	88.5	1.16	1.12	1.14
'CR 260–77' : 'Banaprabha'	76.3	71.2	73.8	1.38	1.48	1.43

77' because it had relatively fewer stem-borer infected white heads/m² than 'Gayatri'. Similarly, the land-equivalent ratio was low (1.14–1.21) when 'Annada' was grown with either of the long-duration varieties (Table 3). The land-equivalent ratio was much higher (1.40–1.52) with 'Banaprabha' suggesting its better compatibility and performance in the mixed cropping system. There was no greater difference in the grain yield and land-equivalent ratio between 1:1 and 2:1 ratio, which is in

agreement with the earlier results (Reddy *et al.* 1991). The trend in straw production was similar as in grain yield under different treatments.

These results suggested that 'Annada' was not suitable for mixed cropping with long-duration rice varieties in intermediate lowland condition. However, the combination of 'Banaprabha' with 'Gayatri' or 'CR 260–77' gave about 0.5 tonnes/ha more yield than the sole crop of conventional long-duration varieties. This system could be beneficial for avoiding risk and achieving sustainable production in fragile lowland ecosystems.

REFERENCES

Ramankutti N N, Bastine L and Nair R R. 1991. Fertilizer management for mixed cropping of rice in waterlogged areas. *Oryza* **28** : 277–8.

Rashid M A, Jabbar M A and Siddique S B. 1988. Maximizing productivity of deepwater rice land through ratooning and combining deepwater rice with high yielding *boro* rice. (*in*) *International Deepwater Rice Workshop,* held during 1987 at IRRI, Los Banos, Philippines, pp 513–6.

Reddy M D, Sharma A R and Panda M M. 1991. Effect of mixed row cropping of early and late-maturing rice varieties on crop productivity under intermediate deepwater conditions. *Experimental Agriculture* **27** : 79–85.

Saikia L, Chandra K, Patgiri D K and Mahanta T C. 1990. Mixed cropping of short and long-duration rice in *bao* (deepwater) areas of Assam. *Oryza* **27** : 337–8.

Sharma A R. 1994. Effect of seed rate and row spacing on the performance of early and late maturing rice cultivars in mixed crop systems under intermediate deepwater conditions (15–50 cm). *Journal of Agricultural Science, Cambridge* **122** : 201–5.

Sharma A R and Reddy M D. 1991. Mixed cropping of early-and late-duration rice (*Oryza sativa*) varieties at different fertilizer levels under intermediate deep-water conditions. *Indian Journal of Agricultural Sciences* **61** (9) : 659–61.

Indian Journal of Agricultural Sciences 70 (5) : 287–91, May 2000

Effect of tuber size, storage temperature and storage duration on sprout growth in seed potatoes (*Solanum tuberosum*)

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ABSTRACT

The influence of tuber weight and storage temperature on sprout growth of seed potatoes was studied during 1995–96 in 2 Indian varieties, 'Kufri Bahar' and 'Kufri Lalima' and a Dutch variety 'Desiree' at Modipuram. The number of sprouts/tuber showed a positive exponential relationship with the tuber weight while the length of the longest sprout showed a negative exponential relationship with it. The relationship between sprout weight and tuber weight was logarithmic. Low temperature (4°C) treatment for 5 or more months increased the sprout number/tuber and the practical significance of this effect for the north Indian plains is discussed. The number of sprouts developed on desprouting was more when the tubers were stored at 12°C prior to desprouting compared to 20°C. Irrespective of the variety, the length of the longest sprout showed a rectangular hyperbolic relationship with storage period and a linear relationship with accumulated day-degrees above 4°C when stored at 12°C. But at 20°C, this relationship varied with the variety. The weight loss due to respiration and evaporation was more at 20°C than at 12°C and the weight loss/unit sprout weight was higher in 'Kufri Lalima'.

Key words : tuber weight, sprout length, sprout weight, percentage weight loss, accumulated day-degrees

Potato (*Solanum tuberosum* L.) sprout growth is affected by several factors, (Allen *et al.* 1992). Tuber weight, storage temperature and storage duration are some of the important factors that influence sprout growth. Sprout growth in some European potato varieties has been studied in relation to seed weight (Wurr 1978a) and storage temperature (Burton 1978 and Mcgee *et al.* 1986). Wurr (1978a) observed a linear relationship between total sprout length and tuber weight. Allen *et al.* (1978) reported that the number and length of sprouts increased at ambient temperatures following low temperature (3°C) treatment. Burton (1978) reported that the rate of sprout growth increased up to 15–20°C. Measuring sprout growth over an extended period, McGee *et al.* (1986) found that 15–18°C is the optimum temperature for sprout growth in potato and sprout growth at above 23°C was arrested by sub–apical necrosis. Hartmans and van Loon (1987) studied sprout growth during prolonged storage at constant temperatures of 4 and 12°C and found that sprout growth and weight loss were higher at 12°C.

Studies on sprout growth at constant temperatures on Indian potato varieties is scarce. Though seed potatoes are stored in cold store in India, its significance on sprout number has not been investigated. An attempt has been made to study the sprout growth in 2 popular Indian potato varieties and to compare them with the Dutch variety 'Desiree' which has been used extensively in Europe in studies on sprout growth. The results of 3 experiments conducted to investigate the effect of tuber weight and storage temperature on the number of sprouts, the length of the longest sprout and sprout weight are reported here. The effect of desprouting and low temperature treatment on the number of sprouts/tuber and its importance in Indian context are also discussed.

MATERIALS AND METHODS

Sprout growth was studied in 2 Indian potato varieties 'Kufri Bahar' and 'Kufri Lalima' and one Dutch variety 'Desiree'. 'Kufri Bahar' a white tuber variety and 'Kufri Lalima' a red tuber variety belong to the same maturity group. Both are medium duration varieties which mature in 110 days and are popular in north Indian plains. Dutch variety 'Desiree' which is a red tuber variety and used extensively in experiments dealing with sprout growth in Europe was included for the sake of comparison. These experiments were conducted at Research Station, Modipuram during 1995 and 1996. The crop was grown in the experimental farm following recommended package of practices. Healthy tubers from the harvest were used in these experiments.

Experiment 1

The effect of seed tuber weight on sprout growth was

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studied in 1995. The crop was planted on 25.10.1994, dehaulmed after 110 days and harvested on 24.2.1995. Seed tubers weighing 5, 10, 20, 50, 75, 100 and 150 g were stored at 4°C for 90 days and then placed at 20°C to sprout. Low temperature (4°C) treatment was given, in order to induce maximum sprout growth. Each treatment was replicated thrice and each replicate consisted of 8 tubers. Observations were recorded on number of sprouts/tuber and length of the longest sprout/tuber after 40 days of storage at 20°C. The tubers were desprouted and the weight of sprouts and tubers was determined. Because of the large differences in tuber size, sprout weight was expressed as percentage of tuber weight and not on per tuber basis.

Experiment 2

Healthy seed tubers of 'Kufri Bahar', 'Kufri Lalima' and 'Desiree' weighing approximately 60 g grown at the research farm at Modipuram were used to study the effect of low temperature treatment for different periods on the number of sprouts tuber during 1996. Batches of 10 tubers of each variety were weighed and stored on 1 April at 4°C in darkness. No sprouting was observed in any variety at the time of storage. The tubers were stored in trays and each treatment was replicated thrice. On 1 May, 1 July, 1 August, 6 September and 4 October the tubers were withdrawn and placed in a walk–in–chamber maintained at 20°C (relative humidity 80–85%) for 4 weeks and the number of sprouts/tuber were recorded.

Experiment 3

Seed tubers of 'Kufri Bahar', 'Kufri Lalima' and 'Desiree' were used for studying the effect of storage temperature and duration on sprout growth during 1996. The crop was planted on 28 October 1995 and harvested on 1 March 1996. Healthy tubers weighing approximately 60 g were taken and stored at room temperature until March end. On 1 April batches of 10 tubers were weighed and stored at 12 and 20°C in darkness. The relative humidity during the storage period ranged from 80–85%. At the time of storage, no sprouting was observed in any variety. The seed tubers were stored in trays and each treatment was replicated thrice. The tubers were withdrawn on 1 May, 1 July, 1 August, 6 September and 4 October for recording observations on number of sprouts/tuber and the length of the longest sprout/tuber. After desprouting the tubers, the weight of sprouts and tubers was determined. The desprouted tubers were placed at 20°C (relative humidity 80–85%) for 4 weeks and the number of sprouts sprouted per tuber were recorded. The number of sprouts, the length of the longest sprout and the weight of sprouts are expressed on per tuber basis following Hartmans and van Loon (1987). The percentage total weight loss includes evaporation and respiratory weight loss of tubers and sprouts. Accumulated day-degrees were calculated following O'Brien *et al.* (1983).

Regression analysis was done and the best fit are shown in the graphs where ever applicable.

RESULTS AND DISCUSSION

Relationship between sprout growth and tuber weight

The number of sprouts/tuber increased with increase in tuber weight (Fig 1A) and the increase was marked when the tuber weight was more than 75 g. There was no significant difference in sprout number between tubers weighing 5 and 10 g. The longest sprout length showed no significant

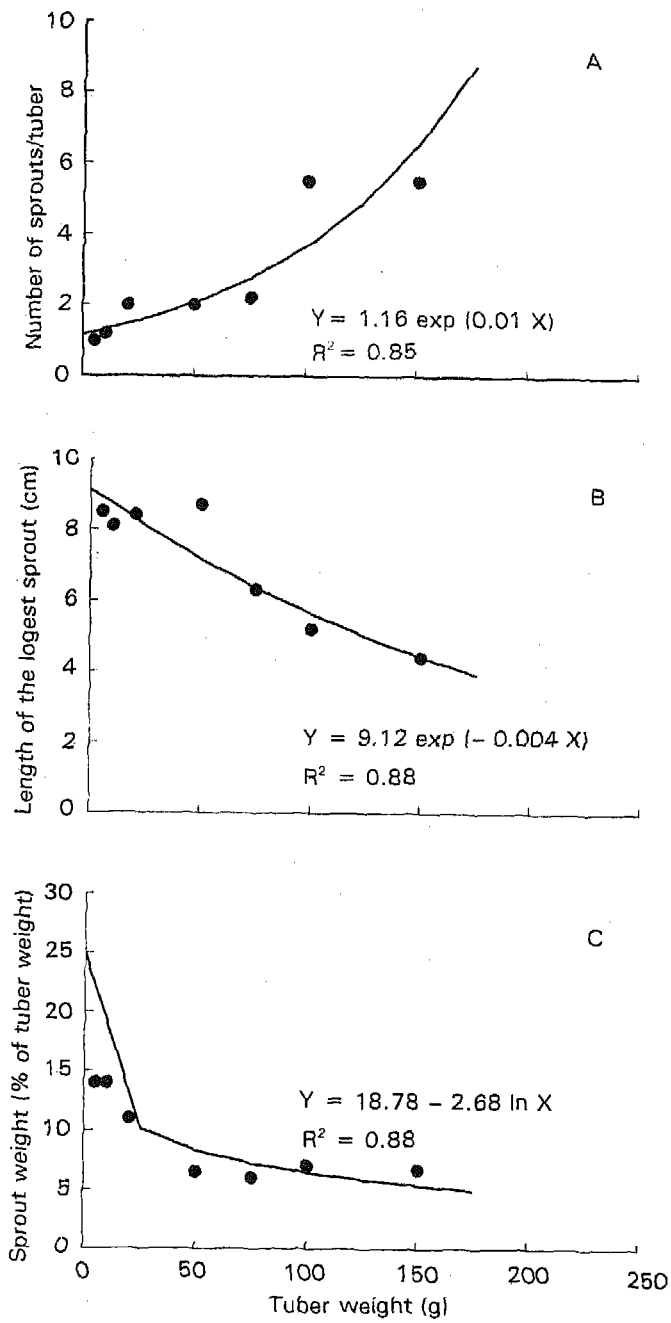

Fig 1 Relationship between [A] number of sprout/tuber [B] length of the longest sprout/tuber and [C] sprout weight (% of tuber weight) and tuber weight in the potato variety 'Kufri Bahar'

difference up to 50 g but declined with further increase in tuber weight (Fig 1B). Sprout weight expressed as percentage of tuber weight decreased with increase in tuber weight (Fig 1C). The number of sprouts/tuber showed a positive exponential relationship with tuber weight and the length of the longest sprout showed a negative exponential relationship with the tuber weight. The relationship between sprout weight and tuber weight was logarithmic.

Total sprout length and the length of the longest sprout have been shown to be the most useful measurements to estimate sprout development in potato tubers (Wurr 1978a). In this experiment we have taken the length of the longest sprout as the measure of sprout growth. In the first experiment which relates to tuber weight, in addition to the length of the longest sprout, sprout weight as per cent of tuber weight has also been shown.

The number of sprouts per tuber is primarily determined by the size of the tuber, and the temperature and duration of storage (Allen *et al.* 1992). We observed that the sprout number/tuber increased with increase in tuber weight. This is in conformity with the report of Allen *et al.* (1978). Larger tubers gave more number of sprouts because they carry more potential sprouts (Allen *et al.* 1978) and apical dominance diminishes with increase in tuber size (Goodwin 1967).

Wurr (1978a) observed a positive linear relationship between total sprout length per tuber and tuber weight. While studying the rate of growth of individual sprouts, Morris (1966) observed an inverse relationship between growth of sprouts and the number of growing sprouts/tuber. Our results are in agreement with that of Morris (1966) and the length of the longest sprout was inversely related to the number of sprouts/tuber. The length of the longest sprout showed a negative logarithmic relationship (R^2=0.84) with number of sprouts/tuber. The weight of sprouts expressed as percentage of tuber weight showed a weak linear relationship (R^2=0.36) with the length of the longest sprout.

Effect of low temperature treatment on sprout number

Tubers of all the 3 varieties stored at 4°C showed no

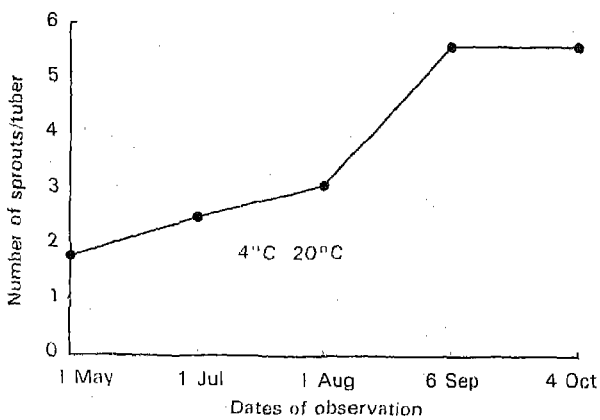

Fig 2 Effect of low temperature (4°C) treatment for different periods on the number of sprouts/tuber (tubers stored at 4°C for different periods were placed at 20°C to sprout. Values averaged over three varieties)

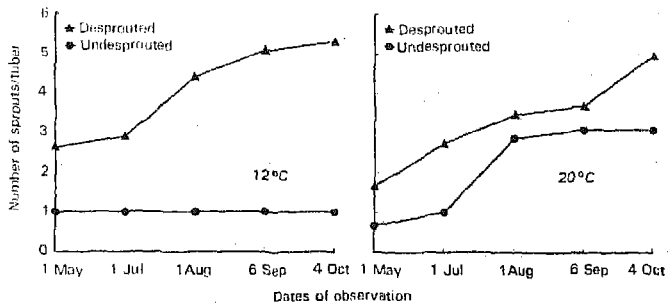

Fig 3 Effect of desprouting on the number of sprouts/tuber in seed tubers stored at 12 and 20°C (tubers stored at 12 and 20°C for different periods were desprouted and placed at 20°C to sprout. Values averaged over three varieties)

sprout growth. When the tubers were subjected to different periods of low temperature (4°C) treatment and then placed at 20°C to sprout, the number of sprouts/tuber increased (Fig 2). The increase in number of sprouts was more when the low temperature treatment was given for 5 or more months.

Low temperature (4°C) treatment for different periods led to increase in sprout number/tuber. The large increase in the number of sprouts/tuber following low temperature treatment has practical significance in north Indian plains where seed potatoes are stored at 4°C for about 7 months and pre-sprouted for 10–15 days at ambient temperatures before planting. The prolonged storage at 4°C helps in the development of maximum number of sprouts/seed tuber leading to more stems/seed tuber. Increase in sprout number following low temperature treatment has been reported by Toosey (1964) and Allen *et al.* (1978). The rate of sprout growth following removal from cold store has been found to increase (Wurr 1978a) and this increase was attributed to increase in gibberellin activity and reduction in inhibitor activity following cold storage (Thomas and Wurr 1976).

Effect of storage temperature and desprouting on sprout number

The seed tubers stored at 12°C gave single sprout (Fig 3) in all the 3 varieties throughout the storage period. In tubers stored at 20°C, the sprout number/tuber was one up to 3 months of storage and it increased to 3.3 in 'Kufri Bahar' and 'Kufri Lalima' after 4 months of storage. In 'Desiree', where sprouting started later, it was 2.7 at this stage.

When the tubers were desprouted after different periods of storage at 12 and 20°C and placed at 20°C for 4 weeks, the number of sprouts/tuber increased considerably in both the treatments (Fig 3). The number of sprouts developed on desprouting was more in the tubers stored at 12°C prior to desprouting compared to 20°C.

When stored at 12°C, only one sprout/tuber developed. Tubers placed in temperatures suitable for growth at dormancy break are known to give single sprouts because of the apical dominance. At the storage temperature of 12°C, the apical dominance was so strong that only the apical sprout grew and the growth of the other buds were completely suppressed. At 20°C also, up to 93 days after storage, only one sprout/tuber developed but after 124 days multiple sprouts were formed. This shows that though the apical dominance was

strong initially, it broke down after some time and other sprouts also developed. Desprouting the tubers had a beneficiary effect on sprout number, which increased on desprouting after storage at 12 or 20°C. Holmes and Gray (1971) also found that desprouting of tubers stored at high temperatures increased the number of sprouts but no more than did cool long-term storage.

Relationship between sprout length and, storage temperature and duration

Sprouts continued to grow up to about 200 days of storage (Fig 4). When stored at 12°C, the length of the longest sprout was maximum in 'Kufri Bahar' and minimum in 'Kufri Lalima'. But at 20°C, the sprout length was more in 'Kufri Lalima'. Initially, the sprout growth was slow in 'Desiree' but after 120 days it was similar to that in 'Kufri Lalima'. When stored at 12°C, irrespective of the variety, the length of the longest sprout showed a rectangular hyperbolic relationship with storage period and a linear relationship with accumulated day-degrees above 4°C (Fig 4). Whereas, at 20°C the relationship varied with the variety. The relationship between the length of the longest sprout and, storage period and accumulated day–degrees above 4°C was exponential in 'Kufri Bahar' and linear in 'Desiree'. But in the case of 'Kufri Lalima', the length of the longest sprout showed an exponential relationship with storage period and a rectangular hyperbolic relationship with accumulated day-degrees above 4°C.

Storage temperature affected sprout length differently in different varieties. Generally 'Kufri Bahar' showed higher rate of sprout growth as compared to the other 2 varieties. In

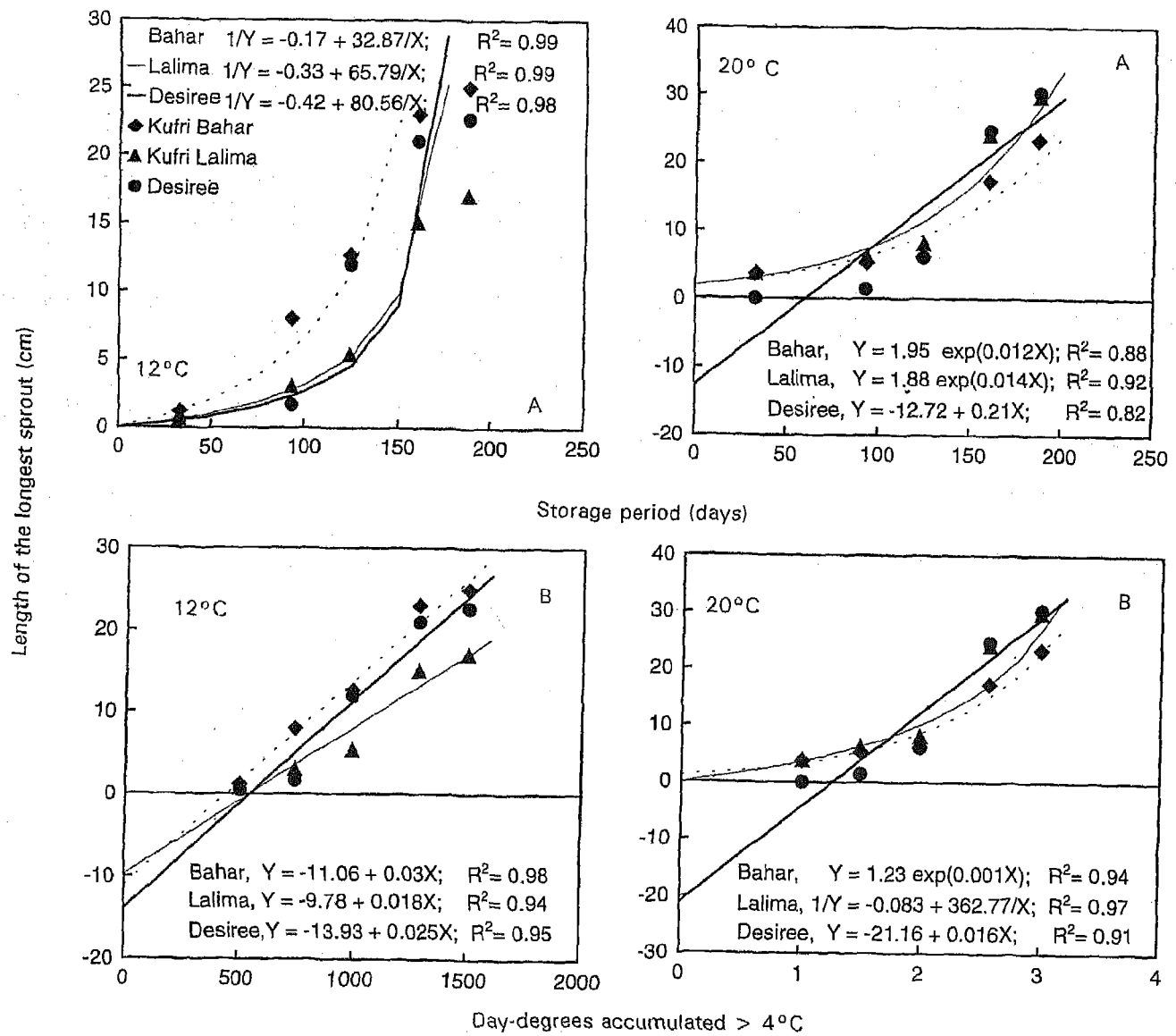

Fig 4 Relationship between [A] storage period and [B] day-degrees accumulated >4°C and the length of the longest sprout (cm) in three potato varieties stored at 12 and 20°C.

'Desiree', the growth of sprouts was slow initially but at later stages it was similar to that of 'Kufri Lalima'. The rate of sprout growth in dark is known to be a cultivar characteristic (Wurr 1979). The relationship between sprout length and storage period was found to be non-linear at temperatures above the optimum by McGee *et al.* (1986). We also observed a non-linear relationship except in 'Desiree' which showed a linear relationship at 20°C. There was a linear relationship between the length of the longest sprout and accumulated day-degrees at the storage temperature of 12°C. However, at 20°C it was linear only in the case of 'Desiree'. Wurr (1978b) reported a linear relationship between total sprout length/tuber and accumulated day-degrees above 0°C.

Relationship between weight loss and, storage period and sprout weight/tuber

During storage at 12°C, the weight loss increased with increase in storage period and was higher in 'Kufri Bahar'. When the percentage weight loss was calculated on the basis of sprout weight/tuber, the weight loss was minimum in 'Kufri Bahar' and maximum in 'Kufri Lalima'. During storage at 20°C, weight loss was more in 'Kufri Lalima' and minimum in 'Desiree'. The weight loss due to respiration and evaporation was more at 20°C than at 12°C in all the 3 varieties. The weight loss/unit sprout weight was higher in 'Kufri Lalima' at both the storage temperatures.

The weight loss due to evaporation and respiration was greater at 20°C than at 12°C. Weight loss in stored tubers has been related to degree of sprouting, and storage at high temperatures are reported to cause a high degree of sprouting combined with high respiration and evaporative weight loss (Burton and Hannan 1957, Hartmans and van Loon 1987). The relationship between sprout weight and evaporative and respiration weight loss was found to be linear by Krijthe (1962) and exponential by Hartmans and van Loon (1987). We found that this relationship varies with storage temperature and variety. For example, the relationship between sprout weight and evaporative and respiration weight loss in 'Kufri Bahar' was ractangular hyperbolic at 12°C while linear at 20°C, but in 'Kufri Lalima' it was exponential at 12°C and linear at 20°C and in 'Desiree' it was exponential at 12°C and logarithmic at 20°C. Varieties differed in their weight loss and this varied with storage temperature. During storage at 12°C the evaporative and respiration weight loss was more in 'Kufri Bahar' and this could be attributed to higher sprout growth in this variety because the weight loss per unit sprout weight was minimum in this variety as compared to the other two. However, during storage at 20°C, the evaporative and respiration weight loss was more in 'Kufri Lalima' and the weight loss/unit sprout weight was also higher in this variety. The differences in weight loss between varieties could be due to differences in size and shape of the sprouts, the number of sprouts and the amount of sprout branching (Hartmans and van Loon 1987) and loss of membrane integrity due to senescence (Simon 1977).

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REFERENCES

Allen E J, Bean J N and Griffith R L. 1978. Effects of low temperature on sprout growth of several potato varieties. *Potato Research* **21** : 249–55.

Allen E J, O'Brien P J and Firman D. 1992. Seed tuber production and management. (*in*) *The Potato Crop*. Harris PM (Ed.), pp 247–91. Chapman and Hall, London, UK.

Burton W G. 1978. The physics and physiology of storage. (*in*) *The Potato Crop*, pp 279–324. Harris P M (Ed.) Chapman and Hall, London, UK.

Burton W G and Hannan R S. 1957. Use of r–radiation for preventing the sprouting of potatoes. *Journal of the Science of Food and Agricuture* **12** : 707–15

Goodwin P B. 1967. The control of branch growth on potato tubers. *Journal of Experimental Botany* **18** : 78–86.

Hartmans K J and van Loon C D. 1987. Effect of physiological age on growth vigour of seed potatoes of two cultivars. 1.Influence of storage period and storage temperature on sprouting characteristics. *Potato Research* **30** : 397–409.

Holmes J C and Gray D. 1971. A comparison of de-sprouted and late sprouted seed potatoes in relation to apical dominance and tuber production. *Potato Research* **14** : 111–18.

Krijthe N. 1962. Observations on the sprouting of seed potatoes. *European Potato Journal* **5** : 316–33.

McGee E, Jarvis M C and Duncan H J. 1986. The relationship between temperature and sprout growth in stored seed potatoes. *Potato Research* **29** : 521–24.

Morris D A. 1966. Intersprout competition in the potato. *European Potato Journal* **9** : 69–85.

O'Brien P J, Allen E J, Bean J N, Griffith R L, Jones S A and Jones J L. 1983. Accumulated day-degrees as a measure of physiological age and the relationships with growth and yield in early potato varieties. *Journal of Agricultural Science, Cambridge* **101** : 613–31.

Simon, E W. 1977. Membranes in ripening and senescence. *Annals of Applied Biology* **21** : 417–56.

Thomas, T H and Wurr D C E. 1976. Gibberellin and growth inhibitor changes in potato tuber buds in response to cold treatment. *Annals of Applied Biology* **83** : 317–20.

Toosey R D. 1964. The pre-sprouting of seed potatoes. Factors affecting sprout growth and subsequent yield. *Field Crop Abstracts* **17** : 161–8.

Wurr D C E. 1978a. Studies of the measurement and interpretation of potato sprout growth. *Journal of Agricultural Science, Cambridge* **90** : 335–40.

Wurr D C E. 1978b. The effects of the date of defoliation of the seed potato crop and the storage temperature of the seed on subsequent growth. 1. Sprout growth. *Journal of Agricultural Science, Cambridge* **91** : 737–45.

Wurr D C E. 1979. The effect of variation in the storage temperature of seed potatoes on sprout and subsequent yield.*Journal of Agricultural Science, Cambridge* **93** : 619–22.

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Maturity indices for acid lime (*Citrus aurantifolia*) cultivar 'Kagzi' grown in central India

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ABSTRACT

Maturity indices of acid lime fruit cultivar Kagzi (*Citrus aurantifolia* Swingle) were standardized for agroclimatic conditions of central India. Fruit weight, volume and juice content increased significantly up to 160 days from anthesis. The respiration rate dropped from 159.65–80.11 mg CO_2/kg/hr during maturation. Peel colour changed from dark green (after 120 days) to greenish–yellow (after 160 days) with increase in brightness (L value) and colour intensity (chroma) and decrease in hue angle (115.630 after 120 days to 90.710 after 160 days). Height/diameter ratio decreased from 1.08 (after 140 days) to 1.02 (after 160 days) with round shape of fruit at maturity. Peel thickness decreased while firmness remained unchanged. Juice *p*H decreased with maturity. Acidity increased alongwith total soluble solids up to 150 days with slight decline after 160 days. Ascorbic acid content was highest (58.08 mg/100 ml) after 150 days and declined to 53.00 mg/100 ml after 160 days. Maturity period of 160 days from anthesis and juice content of 48 with 8.00% acidity were suggested as indices for harvesting.

Key words : acid lime, cultivar Kagzi, maturity indices, summer crop, central India

Acid limes (*Citrus aurantifolia* Swingle) are very important citrus fruits of daily consumption in almost every house hold and occupy 93 000 ha area with 746 000 tonnes of annual production in the country (Anonymous 1994). In central India particularly Vidarbha region of Maharashtra acid limes are grown on large acreage (5 000 ha) with annual production of nearly 50 000 tonnes. 'Kagzi' or 'Kagdi' with thin peel is the major variety widely utilized in processing for production of squashes, cordials and pickles besides culinary and salad purposes. In Vidarbha (20–23^0 N) under Nagpur climate, trees flower year round but three main flushes, ie spring blossom (*ambia*), monsoon blossom (*mrig*) and autumn blossom (*hasta*) are important. From marketing point of view, *hasta* or autumn flowering and early spring flowering are very important since it takes place in November, December and January with likely harvesting of fruit in dry months of April–May when demand is maximum. Fruits of monsoon blossom (June–July) grow in rainy season and are mostly affected by canker disease. Fruits of spring blossom (February–March) mature in July–August (in rainy season). Since the knowledge of fruit development and maturity with respect to physiological, physical and chemical parameters is a pre-requisite to harvesting for fresh fruit marketing, storage and processing, the detailed study was under taken to standardize maturity indices for acid lime cultivar 'Kagzi' grown under agroclimatic conditions of central India.

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MATERIALS AND METHODS

Uniformly growing eight-year-old seedling trees of Kagzi lime under normal agro climatic condition were identified in the Centre's orchard and fruit-lets were tagged at anthesis and fruit set during 1998 in January third week. Flowering of *hasta* season was delayed due to unseasonal heavy rains in October, November and December 1997. There were 10 (replicates) trees growing on medium black soil irrigated at alternate day with drip system (8 litre/hr; 3 dripper/plant, 8 hr/day). The weather data (temperature, humidity, sunshine and rainfall) during growing season were also recorded. Fifty fruits (5 fruits/tree) were taken from 4 th month (120 days from fruitset) onwards for recording observations on physical, chemical and physiological parameters. Sampling was done after 120 (18 May), 130 (28 May), 140 (8 June), 150 (18 March) and 160 (28 June) days after fruit set. Fruit length or height (stem end to stylar end), diameter and peel thickness was measured with vernier callipers and weight was recorded. Fruit volume was measured by water displacement. Firmness are determined with pressure tester in kg force and determined in Newton. Peel colour was measured with colour difference meter (colorgard systems/05, Pacific Scientific 1396–0987, USA) at the equatorial plane in CIE (Commission International del

Eclairage) System as L* (lightness or darkness 0, black; 100, white), a* (bluish–green/red–purple hue component) and b* (yellow/blue hue component). The a* and b* co-ordinates were transferred into hue angle (arc tangent b/a) and saturation index, ie chroma $\sqrt{a^2 + b^2}$ (McGuire 1992). The squeezed juice was weighed and expressed as per cent juice content. Total soluble solids in juice were measured with hand refractometer while titratable acidity (expressed as citric acid) and ascorbic acid content were estimated following titration methods described by Ranganna (1986). Juice *p*H was measured with *p*H meter (Accumet 950, pH/ion meter, Fisher Scientific). The respiration rate of fruits was measured with Infrared CO_2 analyser (Amtek model CD–3A) by flushing fresh air (100 ml/min.) over the approximately half kg fruit held in air tight glass jar to measure per cent CO_2 and estimated as mg CO_2/kg/hr.

RESULTS AND DISCUSSION

Changes in respiration and physical parameters of the developing fruit

Fruit weight increased significantly at each interval up to 160 days (Table 1). The respiration rate of harvested fruit was quite high (159.65 mg CO_2/kg/hr) initially (after 120 days) as the fruits were small indicating very high metabolic activity in rapidly growing fruit (Fig 1). After 160 days, as the fruits matured respiration rate reduced to 80.11 mg CO_2/kg/hr at 32°C (room temperature in summer) indicating completion of growth. Respiration rate of the harvested limes decreased gradually thereafter to 40 mgCO_2/kg/hr at 29–31°C during a span of 8–10 days. These findings corroborate with the trend of respiration (450, 140 and 40 mg CO_2/kg/hr after 30, 120 and 180 days respectively) in developing acid limes at Mysore (Subramanyam *et al.* 1965). Similar to most perishable commodities, respiration rate of limes and lemons has been found to be temparature dependent. Eureka lemons gave 80.5 mg CO_2/kg/hr at 37.7°C and 22.7 mg CO_2/kg/hr at 21.1°C (Murata 1997). Fruit length or height increased rapidly as compared with diameter during 120 and 140 days from fruit set thus increasing height/diameter ratio resulting in slightly oblong fruit shape. With advancement of maturity, diameter increased and height/diameter ratio decreased and fruit became round in shape. This development pattern towards maturity also indicated completion of fruit growth. Under Dharwad (north Karnataka) condition, Kagzi lime fruit weight increased upto 195 days with final weight of 39 g and diameter of 42 mm at maturity (Rao *et al.* 1981). On the other hand, under Bangalore condition (south Karnataka), Kagzi lime fruit weight, volume and diameter were at maximum after 165 days from fruit set (Mustafa and Kumar 1997). In another study, acid lime (Kagzi) fruits took 6 months (180 days) for maturation from anthesis at Mysore (Subramanyam *et al.* 1965). These

Table 1 Changes in Physical quality attributes during growth and maturity of acid lime fruit cultivar Kagzi'

Days after fruit set	Fruit weight (g)	Fruit height (mm)	Fruit diameter (mm)	H/D ratio	Fruit volume (ml)	Peel colour			Peel thickness (mm)	Juice (%)
						L*	C*	h°		
120	20.24	33.25	32.25	1.03	18.41	42.92	27.64	115.63	1.57	28.92
130	28.10	39.13	36.25	1.07	25.86	43.29	32.65	114.32	1.41	35.19
140	30.15	40.41	37.38	1.08	28.29	49.82	35.68	110.45	1.30	38.77
150	37.41	43.55	40.87	1.06	37.68	58.17	42.65	100.49	1.24	43.59
160	45.30	45.55	44.09	1.03	44.35	61.66	51.46	90.71	1.19	47.93
SE for Means ±	0.67	2.09	0.33	0.02	0.79	1.20	1.15	1.30	0.05	1.42
CD (P=0.05)	2.03	2.96	1.02	NS	2.39	3.60	3.46	3.90	0.16	4.26

H/D, Height to diameter ratio; L*, lightness or darkness; C*, chroma (0 – lowest intensity, 100 – greatest intensity); h°, hue angle (0° – red purple, 90° – yellow, 180° – green, 270° – blue)

Table 2 Monthly mean temperature, relative humidity, sunshine and rainfall during growth and maturity of acid lime in summer

Month (1998)	Temperature (°C)		Relative humidity (%)	Sunshine (hr/day)	Rainfall (mm)
	Maximum	Minimum			
Jan	26.65	12.73	84.80	8.00	3.80
Feb	28.63	14.28	80.80	9.58	7.00
Mar	32.33	16.23	66.53	9.87	7.30
Apr	38.83	21.95	55.05	10.75	0.75
May	41.63	25.08	47.03	10.08	8.88
June	41.90	28.88	51.50	8.82	9.43

reports and present findings indicated that duration of fruit growth and maturity period from fruit set varied depending on agroclimatic conditions. Relatively shorter period for maturity of fruit in present study under agroclimatic conditions of Central India could be attributed to the ample of sunshine with high temperature (Table 2) during growth and maturity of lime fruits.

Fruit volume increased significantly at each interval with similar trend as that of weight. Peel thickness decreased gradually as fruit matured with significant difference between 130 days (1.41 mm) and 160 days (1.19 mm). The cultivar Kagzi derived name from its thin paper like peel and peel became thinner with advancement of maturity.

Fruit peel colour changed from deep green to greenish-yellow during the maturity. Increasing L* indicated brightness of colour with change in colour shade from dark-green to light-green, then to greenish–yellow. The increase in C* indicated increased colour intensity. Maximum hue angle 115.63° after 120 days indicated deep green colour along with minimum L* value showing darkness of colour. As the peel colour changed from light green to yellow, there was significant decrease in hue angle. The 90.71° hue angle on colour plain indicated yellow colour with light green spots and could be attributed to rise in carotenoids and drop in chlorophyll. In lemons, carotenoids concentration in the rind increased to 1.00–1.1 mg/100 g while chlorophyll dropped almost to zero at maturity (Soni and Randhawa 1969).

The juice content of fruit went on increasing during the course of development and maturity. There was significant rise in juice content after 140 days at each interval up to 160 days with 47.93% juice. There was no change in fruit firmness during the period of analysis from 120 to 160 days. Higher firmness could probably be due to turgidity of developing fruit. Firmness was more than 49.05 Newton after 120 days when fruits were green and remained so after 160 days even though colour changed to greenish–yellow. In study, with change of colour fruits could be easily detached from the plant particularly after 160 days while plucking indicating onset

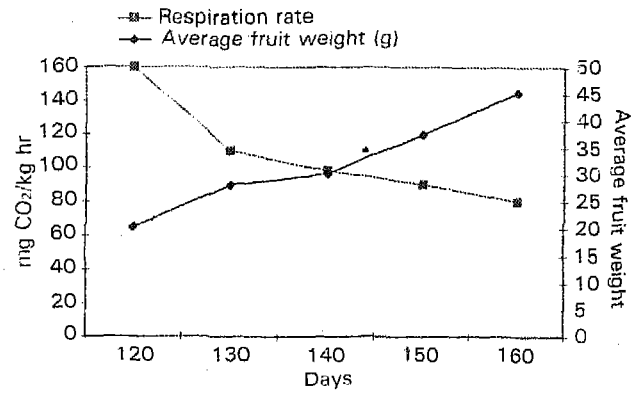

Fig 1 Fruit weight and respiration rate of developing acid lime fruits

of process of abscission and natural ceassation of growth. Murti (1998) reported that abscissic acid concentration increased in fruit at maturity and ripening with changes leading to abscission and senescence. The drop of lime fruits at turning stage and yellow colour stage could be seen in the field further suggesting completion of natural growth of the fruit.

Changes in chemical constituents of the developing fruit

Total soluble solids increased up to 150 days and recorded slight decline after 160 days. In acid lime, major constituent of total soluble solids are organic acids mainly citric acid and *changes in acidity were reflected in TSS content. Juice acidity* went on increasing upto 150 days (8.15%) with very marginal decline (0.09%) thereafter (Table 3). Ascorbic acid content increased significantly upto 150 days (58.08) and then declined (53.00 mg/100 ml). The juice *p*H declined from 2.21 to 2.01 during maturity indicating increase in acidity. Rao *et al.* (1981) reported that acidity content in mature Kagzi lime was 9.30% with 9.6% TSS and 2.50 *p*H under North Karnataka conditions. The chemical composition seems to vary according to weather conditions. At Parbhani (Marathwada, Maharashtra), Kagzi lime fruits had 8.8% TSS with 7.11% acid in *mrig* blossom crop

Table 3 Changes in chemical constituents of acid lime (cv Kagzi) during growth and maturity

Days after fruit set	TSS (%)	Titratable acid (% citric acid)	Ascorbic acid (mg/100 ml)	pH*
120	7.84	7.02	37.45	2.21
130	8.20	7.81	38.18	2.19
140	8.28	7.98	48.73	2.18
150	8.68	8.15	58.08	2.13
160	8.12	8.06	53.00	2.01
SE for means ±	0.02	0.16	1.28	
CD(*P*=0.05)	0.08	0.50	3.84	

* After analysis, juice under different replicates within the treatments combined to record the *p*H

while 8.00% TSS and 6.45% acidity was recorded in *ambia* crop (Chakrawar 1978). In Andhra Pradesh, quality standards for acid lime (Kagzi) fruits have been suggested as 45–58% juice and 6.7–7.7% acid (Satyanarayan and Rama Subba Reddy 1994). The minimum maturity standard for *C. aurantifolia* (acid lime) fruits grown in Florida, is 42% juice content. There is no minimum size requirement for these limes as in case of 'Tahiti' lime (*Citrus latifolia*) which has minimum requirement of 44 mm (diameter) size. Colour break on the fruit, acid content and brix : acid ratio were not the factors considered in determining minimum quality of acid limes in Florida (Jackson 1991).

Although acid content declined marginally between 150 and 160 days, significant increase in fruit weight and juice content during that period could result into significantly higher recovery of acids and juice from processing and fresh fruit utilization point of view. The acid limes are grown mainly for their acidic juice and hence duration of 160 days appeared appropriate for completion of growth and maturity under conditions of central India during summer crop. Duration of growth (i e 160 days from fruit set) and 48% juice content with 8.00% acidity are the reliable maturity indices for this economically important crop in summer.

The size of acid lime fruit cannot be a reliable criteria for maturity since fruit size may remain small depending on bearing and nutritional status of the plant (Goldweber *et al.* 1957). Sidappa (1952) reported that acid limes grown in South India, average yield of juice varied from 45–58% and acidity from 6.27–7.69%. The fruit size and weight did not bear any definite relationship to the percentage of juice and acid content.

To meet Indian grade standards of Extra Special, lime fruit should have minimum diameter of 44 mm (1.75 inches) which resembles grade I recommended for fruit with diameter of 45 mm in Andhra Pradesh (Rajput and Haribabu 1993). For Special and A grades of Indian standards corresponding to grade II and III of acid limes in Andhra Pradesh recommended sizes are 40 mm and 35 diameter, respectively. Grade would depend on fruit size but whatever may be the grade, acid lime fruit should meet minimum internal standard of juice content and acidity to a reasonable extent. There is a need to fix the grade standards which are not only based on fruit size and appearance but important internal quality parameters also.

Thus, it can be stated that, since flowering and fruit set continue for 2–4 weeks during blossom season, acid lime maturity can best be judged from duration and external fruit characters, viz colour and shape besides internal quality parameters such as juice (nearly 48%) and acidity (nearly 8%) content so as to phase harvesting of fruits to get required quality.

REFERENCES

Anonymous.1994. *Area and Production of Citrus*. Horticultural Information Service, National Horticulture Board.

Chakrawar V R. 1978. Physico-chemical characters of seedless lemon and Kagzi lime fruits in different seasons. *Journal of Maharashtra Agricultural Universities* **3** (2) : 136–7.

Goldweber S, Boss M and Lynch SJ. 1957. Some effects of nitrogen, phosphorous and potassium fertilization on growth, yield and fruit quality of Persian limes. *Proceedings of Florida State Horticulture Society* **69** : 328–32.

Jackson L. 1991. *Citrus Growing in Florida*, pp 230–31. University of Florida Press. Gainesville.

McGuire R G. Reporting of objective colour measurements. *Hort Science* **27** : 1254-9.

Murata T. 1997. Citrus. (*in*) *Post-harvest Physiology and Storage of Tropical and Sub-tropical Fruits*, pp 21–47. Mitra S K (Ed). CAB International.

Murti G S R. 1998. Changes in abscisic acid content during fruit development of acid lime. *Plant Physiology and Biochemistry* **15** (1) : 138–43.

Mustafa M M and Kumar V. 1997. Studies on growth and development of Kagzi lime fruits. *Paper presented in National Symposium on Citriculture*, held during 17–19 November 1997 at National Research Centre for Citrus, Nagpur .

Rajput C B S and Haribabu. 1993. *Citriculture*, pp 228–35. Kalyani Publishers, New Delhi.

Ranganna S.1986. *Handbook of Analysis and Quality Control for Fruits and Vegetables*. pp 9–10.Tata McGraw Hills Publishing Company Limited, New Delhi.

Rao M M, Hittalmani S V and Bojappa K M. 1981. A comparative study of the developmental physiology of Kagzi and Tahiti lime fruits. *Proceedings of International Citrus Symposium*, Chadha K L and Pal R N. (Eds). Horticulture Society of India, Bangalore, pp 211–6.

Satyanarayana G and Ramasubba Reddy M. 1994. *Citrus Cultivation and Protection*, pp 66. Willey Eastern Ltd. New Delhi.

Sidappa G S. 1952. Quality standards for south Indian citrus fruits. *Indian Journal of Horticulture* **9** (4) : 7–24.

Soni S L and Randhawa G S 1969. Changes in pigments and contents of lemon peel during growth. *Indian Journal of Horticulture* **26** : 21–6.

Subramanyam H, Narasimhan P and Srivastava H C. 1965. Studies of the physical and biochemical changes in limes (*Citrus aurantifolia* Swingle) during growth and development. *Journal of Indian Botanical Society* **44** : 105–8.

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Distribution of nitrate–nitrogen in ground water and in some soils of Bihar

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ABSTRACT

A study was conducted during 1996 at Pusa to evaluate the potential toxicity hazards of nitrate–N in ground water, the nitrate–N content was estimated in water samples from different sources like wells, hand pumps, ponds and tube wells located in areas receiving domestic sewage–sludge of low intensity (Pusa), municipal sewage–sludge (Patna), fertilizer factory effluents (Barauni) and intensive chemical fertilization (Samastipur). The NO_3–N contents of the soils of these areas were also estimated to evaluate the mobility of NO_3–N. Most of the water samples collected from Barauni contained more than 10 mg/litre nitrate–N making them unsafe for potable use. Water samples from the wells situated in the city sludge disposal area of Patna was also judged unsafe. The water from tube wells and pumps was, however, safe for consumption. A good deal of nitrate–N enrichment was observed up to 90 cm soil depth in the cases where organic wastes were continuously disposed and nitrogenous fertilizers were applied in heavy doses. Implications of continuous disposal of organic wastes and application of high levels of N fertilizers in relation to nitrate–N of ground water contamination with nitrate–N is discussed.

Key words : organic wastes, soil profile, ground water pollution

Water containing more than 10 mg/litre nitrate–N becomes unsafe for potable use (WHO, Geneva 1963). Ground water reservoirs are the main sources of potable water in our country but they are constantly being polluted in various ways. Excessive use of nitrogenous fertilizers for crop production and disposal of city and industrial organic wastes in crop land are the main source of nitrate–N that may contaminate ground water with nitrate (Nightingale 1972, Bauder and Schneider 1979, Conway 1992). The levels of irrigation, amount of rainfall together with water transmission characteristics of the soil profile determine the extent of transportation of nitrate from the surface of the soil to the ground water reservoir (Burns and Dean 1964, Choudhary and Bhatnagar 1976, Singh and Sekhon 1976). Unfortunately, data on ground water pollution due to nitrate in eastern India is scanty. Hence, an investigation was conducted on the distribution of nitrate–N in soil profiles, ground water and other water bodies in different areas receiving town wastes and intensive N fertilization.

MATERIALS AND METHODS

Water

Water samples from four study areas at different depths were collected. The samples were kept at 4°C in referigerator till analysis. The *p*H and EC of water samples were estimated by pH meter (APHA, New York 1975) and conductivity meter respectively. The CO_3^{2-} and HCO_3^- were estimated by simple acidimetric titration method (Richard 1954). The Ca^{2+} and Mg^{2+} were estimated by versenate titration method as described by Cheng and Bray (1951). The total N and nitrate–N content in water samples were carried out by phenol disulphonic acid method (APHA, New York 1975) and ammonical–N was calculated through subtraction of the values of nitrate–N from the values of total N.

Soil

Soil samples were taken from soil profiles of same study area as that for water samples. Soil profiles were dug in cropped and fallow sites of Pusa (Calciorthents–young alluvium, calcareous, sandy loam); highly fertilized and moderately fertilized soils of Masina (Calciorthents–young alluvium, calcareous, loamy sand); fertilizer factory effluent receiving and not receiving areas of Barauni (Udifluvents–recent alluvium, calcareous, loam) and sewage sludge disposal areas of Patna (Pellusterts–Tal land soils, light–grey–dark grey, medium to heavy textured clay loam). The nitrate–N in soils was estimated colorimetrically by phenol disulphonic acid method (Jackson 1978). The total N in soil was estimated by the modified Kjeldahl method as described by Jackson (1978).

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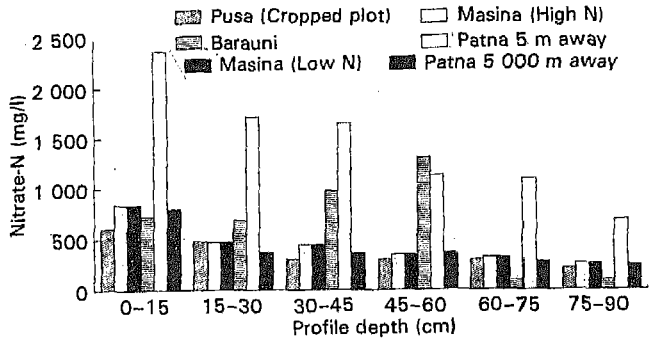

Fig 1 Distribution of nitrate–nitrogen in soil profiles of Pusa farm, Masina farm, Barauni and Patna by-pass canal

RESULTS AND DISCUSSION

Distribution of nitrate–N in ground water and other water bodies

The results of analysis of nitrate–N concentration and other physico–chemical properties of water samples of various sources and various locations are presented Table 1 and 2. The data analyses such as geometric mean (GM), arithmetic mean (AM), standard deviation (SD) and coefficient of variance (CV) revealed comparative and useful information on physico–chemical properties of water (Table 2 and 3). In general, concentration of nitrate–N was found to be higher in wells in comparison to other sources. The data (Table 3) reveals that GM, AM, SD values and pH, EC, CO_3^{--}, HCO_3^-, $Ca^{++} + Mg^{++}$,

Table 1 General physico–chemical properties of water samples of Pusa, Masina farm, Barauni and Patna

Source	Site	Depth meter	pH	EC dsm^{-1}	CO_3^{--} $meqL^{-1}$	HCO_3^- $meqL^{-1}$	Ca+Mg $meqL^{-1}$	RSC me/litre	Cl^- mg/litre	No_3–N mg/litre	NH_4–N mg/litre	Total–N mg/litre
					Pusa farm							
Pond	Pusa	9.0	8.1	0.90	1.2	5.7	4.5	2.4	1.3	0.46		
Well	Pusa Bharav	10.0	7.8	1.40	0.6	7.3	6.2	1.7	4.1	10.00	7.5	17.5
Hand pump	Pusa Bharav	18.0	7.9	0.95	0.8	4.3	4.4	0.7	0.7	0.14		
Hand pump	Poultry farm	20.0	7.6	1.00	0.8	6.5	5.9	1.4	2.5	5.25		
Hand pump	Dairy farm	25.0	7.8	0.95	1.0	6.8	5.7	2.1	1.8	0.20		
Tube-well	Jhilli field	30.0	7.9	0.85	1.0	4.5	4.6	0.9	0.7	0.12		
Tube-well	CIRI Campus	60.0	7.9	0.7	0.8	4.4	4.0	1.2	0.6	0.11		
Disposal canal	Pusa		7.7	0.90		8.7	7.0		0.08	0.39	21.61	22.0
					Masina farm							
Pond	Field	11.0	7.6	0.8		8.5	3.5		1.1	0.41		
Well	Field	9.0	8.2	0.8	1.8	13.4	8.0	7.2	2.1	0.45		
Well	Village	8.0	8.3	0.9	2.0	13.2	8.2	7.0	2.0	2.50		
Hand pump	Field	12.0	8.3	0.8		5.7	8.0		1.5	0.36		
Hand pump	Village	12.0	8.2	0.8		5.8	8.0		1.6	1.75		
Tube-well	Field	24.0	8.1	0.5		6.0	6.0		0.5	0.31		
Tube-well	Masina Farm	32.0	8.2	0.6		7.4	7.4		0.6	0.32		
					Barauni Borrow Pit No. 1							
Effluent of Fertilizer factory	Pit no. 1		9.2	3.2	23.2	14.5	4.1	33.6	4.2	25.63	645.0	671.63
Water effluent	Borrow pit no.1		8.4	0.55		7.5	4.8		0.3	0.21		
HFCL Well	Borrow pit no. 1	10.0	7.6	2.0		9.4	10.7		4.4	45.63	17.37	63.0
Hand pump (Govt.)	Borrow pit no. 1	30.0	8.0	0.40		4.7	4.0		0.5	0.25		
					Patna by pass canal							
Sawage	Main canal		7.8	0.90	1	12.3	6.7		2.92	0.49	29.51	30.00
Well	Bari pahari	10.0	7.6	1.45		4.4	7.5		3.52	31.88	8.30	40.18
Well	Mahabir	15.0	7.5	1.40		1.4	7.1		3.04	15.63	2.62	18.25
Hand pump	Bari pahari	30.0	7.8	0.55		3.2	2.9		1.44	3.19		
Hand pump	By-pass road	45.0	7.7	0.40		3.6	2.8		0.46	0.33		
Hand pump	BVC Patna	25.0	7.7	1.00		6.1	5.9		2.64	3.56		
Tape water	BVC Patna		8.0	0.5		3.9	3.3		1.16	1.19		

Total–N and NH_4–N concentration of Barauni and Patna samples were estimated only when NO_3–N concentration >10 $mgl.^{-1}$ except sewage sample. (–) indicates absence of CO_3^{--} and residual sodium carbonate (RSC)

and RSC ranges were higher in water samples of the Pusa and Masina farm followed by the water samples of Barauni and were least in case of Patna. This might be attributed to the nature of soils. Pusa and Masina farm soils are calcareous with 40% free $CaCO_3$ whereas Barauni soil profile contained less than 7% free $CaCO_3$. There was total absence of free $CaCO_3$ in Patna soil profiles (Table 3). The GM of EC of water samples were found to be in the order : Barauni > Pusa > Masina farm > Patna by-pass canal area. This may be attributed to the heavy texture of surface and sub-surface horizons. The highest Cl^- concentration in water samples of Patna by-pass canal area may be due to (i) seepage and leaching of C^- from the sewage (Table 2) and (ii) due to the residues of bleaching powder used by the farmers. The effluent of Barauni (borrow pit no.1) contained 4.2 meq/litre Cl^- (Table 2). The area adjoining the reservoir showed a higher content of Cl^- than that of Pusa and Masina farm. The geometric and arithmetic mean values of nitrate–N concentration in water samples of area adjoining Barauni's reservoir was higher (3.79 and 9.90 mg/litre) in comparison to that (2.0 and 5.89 mg/litre) in area near Patna by-pass canal (Table 3) and were minimum (0.55 and 1.45 mg/litre) in cultivated areas of Pusa and Masina farm. Though the average value of nitrate–N concentration in water sample of cultivated area (Pusa and Masina farm) is far below the safe limit, ie 10 mg/litre nitrate–N but, the well at Pusa Bharav located at meeting border of village and a hand-pump located just near to poultry farm at Pusa and kitchen garden showed 10 mg/litre and 5.25 mg/litre nitrate–N respectively (Table 1). This may be attributed to the excessive use of N–based fertilizer (500–550 kg N/ha/year) and manures in the field near the well. Light texture of the location helped in leaching of the nitrate up to the ground water–table at relatively shallow depth.

Nitrate–N content in water samples collected from all sources of Masina farm did not exceed the safe limit although almost every farmer of Masina used 500–550 kg N/ha annually. This shows that the farmers utilized the proper management and judicious irrigation practices, to check leaching of nitrate–N. The hydrology and texture of the soils are possibly important components in determining the nitrate–N contamination of ground water. The water–table at Masina is quite deep round the year and the soil is medium textured. The water application through surface irrigation and rainfall may not join ground water in sufficient quantities in the given situation. Thus nitrate–N leached to the sub-surface horizons in rainy seasons is again brought to the surface due to capillarity in dry periods. The area near the reservoir of Barauni falls in the influence of borrow pit no.1 containing effluent having 25.63 mg/litre NO_3–N, 646 mg/litre NH_4–N and 671.6 total N (Table 2). The most interesting observation was, that the water samples from the well located just 20 m away from the reservoir of effluent disposal along the slope had low NO_3–N (8.56 mg/litre) content in comparison to the same in well located nearly 500 m away (45.63 mg/litre). In other words, nitrate–N contamination increased with distance of the well from the reservoir, when the wells are located on slopes. Similar observation was reported by Engberg (1967). More or less similar results were observed in water samples of hand–pump

Table 2 Study of statistical parameters for various physico–chemical properties of water of different sources in relation to cultivated, fertiizer effluent and town sewage disposal area

Sampling sites	Statistical parameters	No. of observations	pH	EC dSm^{-1}	Co_3^- meq/litre	HCO_3^- meq/litre	Ca^{++}+Mg meq/litre	RSC meq/litre	Cl^- meq/litre	NO_3–N mg/litre
Cultivated	GM	17	8.0	0.61	0.00	6.60	6.00	0.00	1.10	0.55
area (Pusa +	SD		8.0	0.81	0.59	6.99	6.23	1.45	1.39	1.45
Masina farm)	SD		0.22	0.22	0.65	2.54	1.55	2.21	0.92	2.49
	CV		0.23	0.27	1.09	0.36	0.25	1.52	0.66	1.72
	Range of values		7.6–8	0.5–1.4	0–2.0	4.3–13.4	4.0–8.2	0–7.0	0.5–4	01.–10
Fertilizer	GM	7	7.8	0.75	0.00	6.00	5.90	0.00	1.30	3.67
effluents	AM		7.8	0.89	0.00	6.24	6.31	0.00	2.11	9.30
HFCL	SD		0.15	0.55	0.00	1.79	2.41	0.00	1.82	14.82
Barauni	CV		0.02	0.66	0.00	0.28	0.38	0.00	0.86	1.50
	Range of values		7.6–8	0.4–2.0	0–0	4.8–9.4	4.0–10.7	0–0	0.5–4.5	0.25–46
Town sewage	GM	15	7.7	0.71	0.00	4.20	4.10	0.00	1.80	2.00
disposal area	AM		7.7	0.79	0.00	4.60	4.53	0.00	2.19	5.89
(Patna by-pass)	SD		0.14	0.40	0.00	1.79	2.41	0.00	1.82	14.82
canal)	CV		0.02	0.50	0.00	0.37	0.40	0.00	0.57	1.46
	Range of values		7.6–8	0.4–1.5	0–0	1.4–7.8	2.1–7.1	0–0	0.46–4.7	0.3–32

GM, Geometric mean; AM, arithmetic mean; SD, standard deviation; CV, coefficient of variance

Table 3 Study of statistical parameters for various physico-chemical properties of water in relation to different sources of water

Sampling sites	Statistical parameters	No. of observations	pH	EC dSm^{-1}	CO_3^{--} meq/litre	HCO_3^- meq/litre	Ca^{++}+Mg meq/litre	RSC meq/litre	Cl^- meq/litre	NO_3–N mg/litre
Pond	GM	2	7.85	0.84	0.00	6.96	3.97	0.00	1.20	0.43
Average depth	AM		7.86	0.85	0.60	7.10	4.00	1.20	1.20	0.44
(10 m)	SD		0.26	0.05	0.650	1.40	0.50	1.20	0.10	0.03
	CV		0.03	0.60	4.00	0.20	0.13	1.00	0.08	0.06
	Range of values		7.6–8.1	0.8—9	0–1.2	5.7–8.5	3.5–4.5	0–2.4	1.1–1.3	0.4–0.41
Well	GM	11	7.75	1.23	0.00	6.31	7.04	0.00	3.37	7.75
Average depth	AM		7.75	1.27	0.40	7.29	7.18	1.45	3.50	13.50
(10.9 m)	SD		0.25	0.32	0.73	3.48	1.67	2.71	0.92	13.11
	CV		0.03	0.25	1.82	0.48	0.23	1.87	0.26	0.97
	Range of values		7.5–8.3	0.8–2	0.6–2	1.4–13.4	4.3–10.7	0–7.2	2–4.9	.45–45.6
Handpump	GM	18	7.89	0.61	0.00	5.06	4.65	0.00	1.16	0.92
Average depth	AM		7.90	0.65	0.14	5.26	5.02	0.23	1.39	1.67
(28.1 m)	SD		0.21	0.22	0.33	1.38	1.86	0.57	0.78	1.69
	CV		0.026	0.34	2.32	0.26	0.37	2.47	0.56	1.01
	Range of values		7.6–8.3	0.4–1.0	0.8–1.0	2.6–7.8	21.–8.2	0–2.1	0.46–3	0.14–5.2
Tube-well	GM	6	8.02	0.59	0.00	5.85	5.75	0.00	0.56	0.22
Average depth	AM		8.02	0.60	0.30	5.97	5.86	0.35	0.57	0.24
(34.3 m)	SD		0.11	0.14	0.43	1.16	1.121	0.50	0.08	0.09
	CV		0.01	023	1.43	0.19	0.21	1.43	0.13	0.38
	Range of values		7.8–8.2	0.5–85	0.8–1.0	4.4–7.4	4.0–7.4	0–1.2	0.5–7	0.11–0.32

GM, Geometric mean; AM, arithmetic mean; SD, standard deviation; CV, coefficient of variance

situated near the reservoir yielding 0.25 mg/litre NO_3–N as compared to other hand–pump located at larger distance from the reservoir (Table 1).

The main source of high NO_3–N content in ground water of the area in the vicinity of Patna by–pass canal is the town sewage flowing through this canal. Though NO_3–N level in sewage is very low (0.49 mg/litre the presence of NH_4–N (29.51 mg/litre) high amounts makes them pollutant besides its undecomposed organic matter (Table 1). In this area nitrate–N content varies 9.5 to 15.63 mg/litre in four wells which is beyond the safe limit for potable use. Nitrate–N concentration in water of hand-pump was well within to the safe limit.

Distribution and accumulation of NO_3–N, NH_4–N and total N in soil profiles

The profile farthest from the waste canal of Pusa had higher nitrate-N content at all depth in comparison to those in the vicinity (Fig 1). In general, the nitrogen content in all forms except NO_3–N declined with depth. The N leaching rate was higher in cropped profile than that in fallowed one. At Masina, the distribution and accumulation of NO_3–N was higher and deeper in case of profiles receiving higher dose of N fertilization than those receiving low N-fertilization. Similar trend was observed in case of upland soil profiles in comparison to low lands. At Barauni, the soil profile nearer to HFCL effluent reservoir had lowest NO_3–N content (2.64–15.16 mg/litre), highest NH_4–N (trace–15.99 mg/litre) and total N (94–1364 mg/litre) throughout the profile. The profile away from the effluent reservoir showed reverse results. Nitrogen content was highest in surface horizon due to the presence of high organic carbon content (Fig 1). All profiles in a direction perpendicular to the Patna by–pass canal contained highest amount of all forms of N in comparison to soil profiles along it (Fig 1). Another interesting result was, that the soil profile nearer to discharge point of sewage contained higher amount of all forms of N in comparison to the farthest one in both cases. The amount of nitrate–N content in soil profiles was found to be in the order : Patna by–pass canal > Barauni > Masina Farm.

The findings from the studies indicate that the probability of the occurrence of nitrate–N will be greater in wells than that of any other sources of water like hand–pump, tube well, ponds etc. The concentration of nitrate–N in ground water is greatly governed by the depth of water sources. The distribution and accumulation of nitrate–N will be higher in the soils away from discharge point of effluents in comparison to those nearer to it. Thus, it seems that the water transmission characteristics of the soil profiles and the depth of water table

are the two properties that determine the accumulation of nitrate–N in water sources abnormally high nitrogen sources accumualte on the soil surface.

REFERENCES

APHA. New York 1975. *American Water Works Association and Water Pollution Control Federation, Standard methods for Examination of Water and Waste Water,* 14th edn. American Public Health Association, New York, USA.

Bauder J W and Schneider R P. 1979. Nitrate–nitrogen leaching following urea fertilization and irrigation. *Soil Science Society of American Journal* **43** : 348–52.

Burns G R and Dean L A. 1964. The movement of water and nitrate around bands of sodium nitrate in soils and glass beads. *Proceedings of the Soil Science Society of America* **28** : 470–4.

Choudhary P C and Bhatnagar V K. 1976. The leaching of nitrates as influenced by rates of irrigation and the timing of fertilizer application to wheat on a sandy soil. *Indian Journal of Ecology* **3** : 125–31.

Cheng K L and Bray R H. 1951. Determination of calcium and magnesium in soil and plant material. *Soil Science* **72** : 449–58.

Conway G R. 1992. Agriculture too can pollute. *Intensive Agriculture* 6–8.

Jackson M L. 1978. *Soil Chemical Analysis,* Prentice Hall of India Pvt. Ltd., New Delhi.

Nightingale H I. 1972. Nitrates in soil and ground water beneath irrigated and fertilized crops. *Soil Science* **114** : 300–11.

Richard L A. 1954. *Diagnosis and Improvement of Saline–alkali Soils. Agriculture Handbook, United States Department of Agriculture,* 160 pp.

Singh B and Sekhon G S. 1976. Nitrate pollution of ground water from nitrogen fertilizers and animal wastes in the Punjab. *Indian Journal of Environment* **3** : 57–67.

WHO, Geneva 1963. *International Standard for Drinking Water,* second edn. World Health Organization, Geneva.

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Incidence, varietal preference and control of fruit borer, *Conopomorpha cramerella* (Lepidoptera: Gracillariidae) on litchi (*Litchi chinensis)* in Himachal Pradesh

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ABSTRACT

In a two year study conducted during 1996 and 1997 on the occurrence of litchi fruit borer, *Conopomorpha cramerella* Snell. in 8 different blocks of district Kangra, it was observed that pest attack varied between 13.6 and 64.9%. Incidence of the borer on 9 cultivars indicated maximum attack on 'Mclean' (85.7%) while 'Seedless Early' had minimum incidence (33.3%) of the pest. The information on the borer control using 6 different insecticides revealed that the highest efficacy was obtained by using monocrotophos (@ 0.036% and 0.072%) and cypermethrin (@ 0.01 and 0.02%) during both the years. The benefit: cost analysis indicated that delayed single spray (15 days before harvest) with endosulphan 0.05%, monocrotophos 0.036%, methyl parathion 0.05% and cypermethrin 0.01% resulted in high returns with a ratio of 1:35.9, 1:35.7, 1:35.1 and 1:33.5 respectively. Methyl demeton proved to be the least effective insecticide.

Key words : incidence, varietal preference, control, litchi fruit borer, *Conopomorpha cramerella,* benefit: cost ratio

Litchi (*Litchi chinensis* Sonn.) is one of the most important fruits recently identified for export purpose by the Government of India. After Bihar, Himachal Pradesh is the largest producer of litchi in the country. In the state the crop is grown over an area of over 1915 ha in low hills and valley areas. The average yield of 7-10 year-old plant is about 50 kg which is far below than that obtained in Bihar. A host of factors have been found responsible for the lower yields, of which, occurrence of litchi fruit borer, *Conopomorpha cramerella* Snell. (Lepidoptera: Gracillariidae) is the most important. The larvae of this gracillarid bore into the fruit at the pedicel end and feed on the crown portion of the nut just below the stalk at the time of ripening . The affected fruits drop off from the trees towards harvest. Only 1 larva is generally found/fruit. The last instar full fed larvae bore out of the fruits and pupate in a roundish dirty white pupal case, generally on the upper surface of the leaves. The adults cut one end of the cocoon and come out.

Insufficient information is available on this pest. Lall and Sharma (1978) found 15.84% incidence in Bihar, Huang *et al.* (1994) reported 96.1–100% infestation of this pest in Taiwan. In Himachal Pradesh, the pest was recorded for the first time during the 1991 (Anonymous 1991) when it occurred in large numbers.In the next 4 years, its infestation remained low. However, in 1996 and 1997 its incidence was high when studies on occurrence , survey and control of this borer were undertaken.

MATERIALS AND METHODS

The survey work was done in 8 different developmental blocks of major litchi growing areas of District Kangra at harvest (last week of June to first fortnight of July) during 1996 and 1997 cropping seasons. Ripening/ripened fruits (40–50 in number) were randomly harvested from each orchard site and put in separate polythene bags to record the presence of larva in the fruits by peeling it off from the pedicel end and to work out per cent fruit infestation.

Varietal preference

For this study, 25–30 ripening/ripened fruits of different varieties being grown at Litchi and Mango Research Station, Nagrota Bagwan were screened for the presence/ absence of borer larvae.

Based on the extent of damage/ infestation observed during the survey studies, control trials were laid out during 1997 and 1998 at a farmer's field at Dadhamb situated at an elevation of 835 MSL to evaluate the efficacy of different insecticides against the borer larvae on cultivar 'Dehradun'. In order to find out the best insecticide and time of spray for the effective control of the fruit borer larvae, 6 insecticides each at 2 concentrations were applied as a single spray on 10

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or 24 June (during 1997) and 12 or 24 June (during 1998), or as a double spray on all these dates during the 2 years, respectively. All these treatments were replicated thrice including control with single tree/replication /spray in a randomised block design. The per cent infestation was calculated by recording the number of infested fruits from the total fruits in all the treatments (including control) at the time of harvest.

Benefit: cost analysis

Assuming that the attacked fruits are worthless in the market,the cost of spray per plant and added returns were worked out for all the treatments to find out the most economical spray. The cost of spray included the cost of insecticide and labour charges, whereas added returns were calculated by working out the increase in yield/plant over the control treatment. Net returns from each of the insecticides were also worked out and benefit: cost ratio were calculated.

RESULTS AND DISCUSSION

The fruit borer infestation was prevalent in almost all the major litchi growing belts of District Kangra (Table 1). Among 54 orchards in 8 surveyed blocks, orchards in Rait had highest (63.7%) attack on fruits followed by those in Nagrota Bagwan (46.4%). However, minimum borer infestation (20%) was found in Bhawarna block. There was 2.3–12.9 % increase in the borer incidence during 1997 as compared with 1996 indicating thereby that it may become more menacing in future on this crop in the area. Lall and Sharma (1978) reported 7.1–72.5% infestation of *Acrocercops cramerella* Snellen on leaves of litchi, whereas Sharma (1985) reported 24–32% fruit loss alone in Muzzafarpur district of Bihar due to this pest. Huang *et al.* (1994) reported 96.1–100% fruit damage by a closely related species *C. sinensis* Bradley in untreated orchards.This gives an indication that the pest is capable of causing large scale damage to the litchi fruit crop. Relatively lower degree of damage under present situation may be due to the fact that this pest is of recent appearance in this area as it was not known to cause any damage till 1991 (Anonymous 1991). However, since 1996 it has established as a regular pest resulting in economic losses.

Varietal preference

The data on the incidence of borer larvae arranged in ascending order on the cultivars growing at the station indicated that fruit infestation varied from 33.3–85.7 % on 'Seedless Early', 'Dehradun' (61.1%), 'Large Red' (73.7%), 'Muzzafarpur' (75%), 'Saharanpur' (76.5%), 'Rose scented' (78.6%), 'Calcuttia' (78.8%), 'Seedless Late' (81%) and 'McLean'. There is no earlier information available on this aspect of study. However, on the bases of the data it can be inferred that mid and late maturing varieties were most preferred ones than early maturing cultivars (except Muzzafarpur).

Control of the borer reveals that its minimum incidence was observed in the trees sprayed with monocrotophos (0.072%) and cypermethrin (0.02%) (Table 2). All other insecticides were relatively less effective. Effectiveness of pyrethroids against *Cryptophlebia* sp has been reported earlier by Hofmeyr (1984). Lall and Sharma (1978) and Sharma and Lall (1983) reported methyl demeton beside other insecticides as the most effective insecticide for the control of this pest which does not agree with the present findings in which it was found to be least effective. Higher concentrations of the insecticides were statistically superior in all the cases.When the sprays were compared (Table 3), it was found that double sprays in all the treatments were far superior to single sprays. However, second single (delayed second) spray was relatively far better than first single spray in all the cases during both the years and closer to double spray in efficacy. This information indicates that probably the insect attack starts late in the month of June at the time of fruit ripening in these areas that is why second single spray has been able to provide sufficient pest control. Similar observations regarding the attack of this pest have been made by Huang *et al.*(1994) who reported fruit maturing period (early to mid June) as the period of highest incidence of this pest in Taiwan.

Benefit: cost analysis

The information on the cost– benefit analysis (Table 3)

Table 1 Incidence of litchi fruit borer in different blocks of District Kangra

Name of block	Orchards surveyed (no.)	Per cent incidence during		Mean of two years	Per cent increase over 1996
		1996	1997		
Bhawarna	6	13.6	26.5	20.1	12.
Baijnath	8	32.2	36.9	34.5	4.7
Indora	4	24.5	33.3	28.9	9.0
Kangra	7	21.2	29.4	25.3	8.2
Nagrota Bagwan	10	41.2	51.6	46.4	10.4
Nurpur	7	35.5	39.2	37.4	3.7
Panchrukhi	6	39.6	43.5	41.6	3.9
Rait	6	62.6	64.9	63.7	2.3

Table 2 Efficacy of insecticides against litchi fruit borer

Insecticides	Concentration (%)	Percent borer incidence		
		SI	S2	S3***
Cypermethrin	0.01	27.7 (31.72)**	10.2 (18.63)	8.8 (17.20)
(Ripcord)	0.02	17.1 (24.41)	7.1 (15.41)	5.4 (13.38)
Decamethrin	0.0028	30.3 (33.42)	23.7 (29.15)	13.1 (21.18)
(Decis)	0.0056	27.3 (31.47)	9.6 (26.27)	11.5 (19.83)
Endosulphan	0.05	39.3 (38.82)	11.3 (19.60)	10.1 (18.50)
(Endocil)	0.10	28.7 (32.36)	10.3 (18.76)	8.0 (16.42)
Methyl demeton	0.025	40.4 (39.48)	28.4 (32.18)	12.8 (20.96)
(Metasystox)	0.05	34.9 (36.19)	24.7 (29.79)	12.3 (20.55)
Methyl parathion	0.05	26.0 (3.66)	15.2 (22.95)	9.6 (18.00)
(Metacid)	0.10	22.2 (28.12)	11.6 (19.92)	7.9 (16.34)
Monocrotophos	0.036	25.3 (30.16)	8.6 (17.06)	5.4 (13.69)
(Monocil)	0.072	14.1 (22.03)	5.2 (13.21)	3.8 (11.26)
Control		70.7 (57.24)	70.7 (57.24)	70.7 (57.24)
CD (P=0.05)		2.41	1.15	1.08

* Pooled data for two years (1997,1998),** Figures in parentheses are angular transformation values
***S1, 1st single spray; S2, 2nd single (delayed) spray; S3, double spray

Tabel 3 Benefit: cost analysis of different insecticidal sprays** for the control of litchi fruit borer

Insecticide	Concentration (%)	Cost of spray	Added returns*			Net returns*			Cost:benefit ratio		
			1	2	3	1	2	3	1	2	3
Cypermethrin	0.01	9.00	228.25	301.25	308.50	219.25	292.25	290.50	1:25.4	1:33.5	1:17.1
	0.02	13.00	258.25	317.00	325.50	245.25	304.00	299.50	1:19.9	1:24.4	1:12.5
Decamethrin	0.0028	10.75	200.50	235.25	287.00	189.75	224.50	265.50	1:18.7	1:21.9	1:13.3
	0.0056	17.50	215.75	254.50	294.75	198.25	237.00	259.75	1:12.3	1:14.5	1:8.4
Endosulphan	0.05	8.25	156.50	296.00	302.50	148.25	287.75	286.00	1:18.9	1:35.9	1:18.3
	0.10	12.50	208.75	300.50	312.00	196.25	288.00	287.00	1:16.7	1:24.1	1:12.5
Methyl demeton	0.025	7.36	150.25	210.50	287.50	142.89	203.14	272.78	1:20.4	1:28.6	1:19.5
	0.05	10.72	178.25	229.00	290.75	167.53	218.28	269.31	1:16.6	1:21.4	1:13.6
Methyl parathion	0.05	7.88	222.25	276.25	304.50	214.37	268.37	288.74	1:28.2	1:35.1	1:19.3
	0.10	11.76	241.00	294.00	312.75	229.24	282.24	289.23	1:20.5	1:25.1	1:13.3
Monocrotophos	0.036	8.69	226.00	310.25	324.25	217.31	301.56	306.87	1:26.0	1:35.7	1:18.7
	0.072	13.38	274.50	325.25	333.25	261.12	311.87	306.49	1:20.5	1:24.4	1:12.5

* Values per plant in rupees
** 1, Ist single spray; 2, 2nd single (delayed) spray; 3, double spray

reveals that 0.05% endosulphan gave the best ratio (1 : 35.9) followed by 0.036%monocrotophos (1: 35.7) when applied as second single spray. The lowest ratio (1:14.6) was obtained in decamethrin (0.0056 %) spray. Singh *et al.* (1990) reported cost : benefit ratio of 1:44, 1:33 and 1:25 for 1-, 2- and 3- spray treatments for the control of nut borer (*Gatesclarkeana erotias*) of litchi. Although, endosulphan and methyl parathion yielded better cost : benefit ratio, yet they proved less effective when compared with monocrotophos and cypermethrin. Net returns per plant were found to be maximum (Rs 311 and 301) in case of monocrotophos when applied as 0.072 and 0.036% sprays, respectively. These values were followed by cypermethrin (Rs 292 and 304) when applied at 0.01 and 0.02%, respectively. The net returns/plant and benefit ratio were less for both first single spray and double spray treatments in case of all the insecticides.

From the above discussion, it can be concluded that second single spray timings of insecticides like monocrotophos (0.036%) and cypermethrin (0.02%) should be standardised to get maximum control of this pest. Although, delayed single spray gives satisfactory control of the pest, the data need to be developed from residue point of view. The zero day samples which were got analysed from the pesticide residue laboratory, Department of Entomology Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan, showed no residues in the fruit pulp at both the concentrations of these insecticides.

REFERENCES

Anonymous. 1991. *Annual report*. Regional Horticultural Research Station, Jachh, 98 pp.

Hofmeyr J H. 1984. False codling moth: evaluation of synthetic pyrethroids applied against various developmental stages. *Citrus Subtropical Fruit Journal* **599** : 10–11.

Huang C C Chang K S and Chu Y I. 1994. Damage and population fluctuation of the litchi fruit borer, *Conopomorpha sinensis* Bradley, in Chia–Nan district, Taiwan. Plant Protection Bulletin, Taipei **36** (2) : 85–95.

Lall B S and Sharma D D. 1978. Studies on the bionomics and the control of cacao moth, *Acrocercops cramerella* Snellen (Lepidoptera: Gracillariidae). *Pesticides* **12** (12) : 40–2.

Sharma D D.1985. Major pests of litchi in Bihar. *Indian Farming* **35** (2) : 25–6.

Sharma D D and Lall B S. 1983. Comparative toxicity of insecticides to *Acrocercops cramerella* Snellen (Lepidoptera: Gracillariidae). *Indian Journal of Agricultural Science* **53** (3) : 187–8.

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Soil solarization for controlling soil-borne pathogens in vegetable crops

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ABSTRACT

A study was conducted during 1995–98 at Jachh to find out the effect of transparent polyethylene mulch on soil temperature, incidence of soilborne diseases, plant growth and yield of vegetable crops. Solar heating with transparent polyethylene mulch of a infected field in summer for 40 days under irrigated conditions reduced the incidence of soilborne diseases. Mulching with transparent polyethylene resulted in 14°C higher temperature at 8 cm soil depth with an average maximum temperature of 50° C which was found lethal to soilborne pathogens. Incidence of different soil-borne diseases in solarized plots ranged between 0 and 6 % in different crops in comparison to 10–21 % in unsolarized plots.

Key words : broccoli, cabbage, cauliflower, Chinese sarson, lettuce,onion, tomato, wilt, soil solarization, mulching, *Fusarium, Phoma, Sclerotium* and *Sclerotinia sclerortionum*

Soil-borne pathogens cause huge crop losses due to repeated cultivation of a crop in the same land (Singh 1987, Kapoor 1988, Raj and Gupta 1996). Soil-borne pathogens are more difficult to control than the foliar pathogens because of the complex soil ecosystem. There are many approaches (chemical, biological, cultural, use of resistant cultivars, etc.) to control soil-borne pathogens but each method has its own limitations. Soil solarization is an effective method to control soil-borne pathogens in tropical and subtropical areas. Soil solarization uses transparent polyethylene mulch for capturing solar energy for heating the soil and increasing soil temperature. The high temperature is lethal agent for controlling pests in the soil (Raj and Kapoor 1993, Katan 1981). Among different polyethylene mulches used in earlier studies, thin transparent polyethylene (25 µm) is most effective in killing soil-borne pathogens since it transmits most of the solar radiations that heat the soil (Raj and Kapoor 1993, Katan 1981). We report the effect of transparent polyethylene mulch (25 µm) on soil temperature, incidence of soil-borne diseases, plant growth and yield of vegetable crops.

MATERIALS AND METHODS

A study was conducted at experimental farm, Jachh (75°55 E, 32°18 N, 428 m above MSL) during 1995–98 at 2 different fields, where different vegetables were grown for last 8 years and there was high incidence of soil-borne diseases caused by *Fusarium* spp (wilt), *Sclerotinia sclerotiorum* (stalk rot), *Phoma* spp and *Sclerotium* sp (root rots). The plots were 2 m × 2 m. Soil type was clay loam and *p*H of the soil was 6.8. On 1 June 1995 and 1997 each plot was irrigated to saturation level and half of the plots were covered with thin transparent polyethylene mulch (25 µm) for 40 days. Temperature of solarized and unsolarized plots was recorded at depth of 8, 15 and 30 cm daily at 2 PM. Vegetable crops transplants of broccoli (*Brassica oleracea* var *italica* L.) 'Italian Green', 'Red Holland' cabbage (*Brassica oleracea* var *capitata* L.), 'Early Kanwari' cauliflower (*Brassica oleracea* var *botrytis* L.), 'Solan Selection' Chinese sarson (*Brassica chinensis* L.), 'Alamo 1' lettuce (*Lactuca sativa* L.), 'Nasik Red' onion (*Allium cepa* L.) and 'Pusa Ruby' tomato (*Lycopersicon esculentum* L. Mill.) were grown in the first week of October in solarized nursery beds. The vegetables were transplanted in the first week of November to 21 solarized and 21 unsolarized plots in randomised block design with 3 replication. Standard practices were followed in all the vegetable crops with respect to spacing and manurial requirements. Effect of soil solarization was observed on incidence of soil-borne diseases, plant growth and yield of vegetable crops. The disease incidence was computed by adopting a 0–5 scale to cover all the broad symptoms and disease index (%) was calculated using the formula given by Raj and Kapoor (1993).

RESULTS AND DISCUSSION

Mulching with transparent polyethylene (25 µm) resulted in increase in the soil temperature. The average soil temperature was highest at 8 cm soil depth in the solarization

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treatment (Table 1). The temperature was 14°C higher in the solarized beds during 1995. During this period, the warmest temperature of 58°C was recorded at 8 cm soil depth in solarized plots. In contrast, the warmest temperature in unsolarized plots at the same depth was only 44°C. However, the differences in temperature was less at 15 and 30 cm soil depth. The average daily air-temperature was 37°C. During 1997, the average soil temperature at 8 cm depth was also highest (44°C) in the solarized plots, which was 12°C higher than the unsolarized plots. In earlier studies, using polyethylene of different colours and thicknesses, a thin transparent polyethylene mulch (25μm) caused the greatest

Table 1 Effect of solarization on soil temperature at various soil depth

Treatment	Depth (cm)	Maximum soil temperature (°C) during 1 June–10 July			
		Range 1995	Average 1995	Range 1997	Average 1997
Solarized*	8	34–58	50	32–54	44
Unsolarized		30–44	36	23–38	32
Solarized	15	34–50	43	29–50	40
Unsolarized		28–41	35	21–37	30
Solarized	30	27–42	35	26–43	36
Unsolarized		26–39	33	20–35	29
Air temperature		25–43	37	24–39	34

*Plots covered with transparent polyethylene mulch (25 μm)

average maximum temperature (Raj and Kapoor 1993). Pullman *et al.* (1979) reported that 25 μm thick transparent polyethylene mulches were more effective in heating soils and in killing soil–borne fungi than 100 μm thick mulches.

In earlier studies, soil solarization with transparent polyethylene mulch (25 μm) for 40 days under irrigated conditions has been found effective to eradicate the propagules of *Fusarium* spp and *Pythium* spp up to 30 cm soil depth (Raj *et al.* 1997). Porter and Meriman (1983) also reported that soil solarization for 4 weeks was effective in reducing soil-borne pathogens and nematodes when average maximum temperature during solarization under transparent mulches was 50°C. In the present study, the increased soil temperature was found lethal to soil-borne pathogens, reducing the incidence of soil-borne diseases. Incidence of soil–borne diseases was 0–6 % in solarized plots compared with the 10–21 % in unsolarized plots (Table 2). Cabbage, cauliflower, chinese sarson and lettuce grown in solarized plots had no plant mortality in comparison with the 10–19% plant mortality in unsolarized plots. Soil solarization was effective in other crops too. Broccoli, onion and tomato grown in solarized plots had 87, 68 and 80% reduction in disease incidence respectively. Soil solarization is effective in reducing the wilt incidence of *Verticillium dahliae* by 65 % in tomato and 95 % in potato (Katan *et al.* 1976).

Soil solarization also had a significant effect on plant growth and vegetable yield. During 1995, Vegetable yield was 35–161 % higher in the solarized plots than in the unsolarized plots (Table 3). In 1997, significant increase (35–86 %) in vegetable yield was recorded in solarized plots compared to unsolarized plots. Broccoli grown in solarized plots had the highest increase in yield (161 %) in 1995 followed by tomato (132 %). However, in 1997, tomato grown in solarized plots had the highest increase in yield (86 %) followed by broccoli (73 %). Katan *et al.* (1980) also reported an increase of 60–125 % in onion yield in solarized fields which were earlier infested with pink root rot (*Pyrenochaeta terrestris*). Soil solarization was found effective in reducing the incidence of *Fusarium* wilt of cotton to 0 along with an increase of 225 % in yield (Katan 1981). Soil solarization also had a better effect on plant growth. Plant height of vegetables grown in solarized plots was 20.8–35.6 % higher than the vegetables grown in unsolarized plots (Table 3). Increase in plant height was the highest in onion (35.6 %) followed by tomato (31.2 %) and chinese sarson (28.6 %). In earlier studies, saplings of mango grown in solarized plots had a better growth in comparison with unsolarized plots (Raj and Gupta 1996). Similarly, the

Table 2 Effect of soil solarization on incidence of wilt in different vegetable crops caused by different soil borne pathogens

Crop	Disease index (%)									
	Solarized plots					Unsolarized plots				
	F.spp	S.s.	S.spp	P.spp	Total	F.spp	S.s.	S.spp	P.spp	Total
Broccoli	1.4				1.4	10.8				10.8
Cabbage	0	0		0	0	11.4	4.3		3.3	19.0
Cauliflower	0	0		0	0	8.3	6.5		2.9	17.7
Chinese sarson					0		8.4		4.2	12.6
Lettuce		0			0		10.0			10.0
Onion	2.1		3.9		6.0	12.1		6.7		18.8
Tomato	4.2				4.2	21.0				21.0

F.spp. *Fusarium* spp; S.s.. *Sclerotinia sclerotiorum*; S.spp. *Sclerotium* spp; P. spp. *Phoma* spp

Table 3 Effect of soil solarization on plant height and yield of vegetable crops

Crop	Yield (tonnes/ha)				Per cent increase in plant height over unsolarized plots
	1995		1997		
	Solarized plots	Unsolarized plots	Solarized plots	Unsolarized plots	
Broccoli	20.44	7.29	21.6	12.5	20.8 (26.89)
Cabbage	15.36	8.59	14.9	9.1	23.4 (28.90)
Cauliflower	9.13	6.27	10.2	7.4	22.9 (27.83)
Chinese sarson	19.86	16.53	20.2	13.3	28.6 (32.29)
Lettuce	15.44	10.33	14.7	11.2	25.2 (30.02)
Onion	20.57	13.14	22.4	13.1	35.6 (36.60)
Tomato	42.71	20.14	45.8	24.6	31.2 (33.88)
CD(P=0.05)	Solarization	1.50		1.40	(4.17)
Crop	2.82		2.72		
Interaction (Solarization crop)	3.98		3.78		

*Figures in the parentheses are square root transformation values

growth of seedlings of 10 vegetables grown in solarized nursery beds was significantly better compared to unsolarized nursery beds (Raj *et al.* 1997).

Soil solarization using transparent polyethylene mulch (25 µm) with pre-irrigation resulted in higher temperature which killed soil-borne pathogens. Soil solarization reduced disease incidence and caused 35–161 % increase in vegetable yield.

REFERENCES

Kapoor I J. 1988. Fungi involved in tomato wilt syndrome in Delhi, Maharashtra and Tamil Nadu. *Indian Phytopathology* **41** : 208–18.

Katan J 1981. Solar heating (solarization) of soil for control of soil-borne pests. *Annual Review of Phytopathology* **19** : 211–36.

Katan J, Greenberger A, Alon H and Grinstein A. 1976. Solar heating by polyethylene mulching for the control of diseases caused by soil-borne pathogens. *Phytopathology* **66** : 683–8.

Katan J, Grinstein A, Fishler G, Frank Z R, Rabinowitch H D, Greenberger A, Alon H and Zig U 1981. Long-term effects of solar heating of the soil. *Phytoparasitica* **9** : 236.

Katan J, Rotem Y, Finkel Y and Daniel J. 1980. Solar heating of the soil for the control of pink root and other soilborne diseases in onions. *Phytoparasitica* **8** : 39–50.

Porter I J and Merriman P R 1983. Effect of solarization of soil on nematode and fungal pathogens at two sites in Victoria. *Soil Biology and Biochemistry* **15** : 39–44.

Pullman G S, DeVay J E, Garber R H and Weinhold A R. 1979. Control of soil-borne pathogens by plastic tarping of soil. (*in*) *Soil-borne Plant Pathogens*, pp 439–46. Schippers B and Garns W (Eds). Academic Press, London.

Raj H and Kapoor I J. 1993. Soil solarization for the control of tomato wilt pathogen (*Fusarium oxysporum* Schl.). *Zeitschrift fur Pflanzenkrankheiten und Pflanzenschutz* **100** : 652–61.

Raj, Harender, Bhardwaj M L and Sharma N K.1997. Soil solarization for the control of damping-off of different vegetable crops in the nursery. *Indian Phytopathology* **50** : 524–8.

Raj, Harender and Gupta V K. 1996. Soil solarization for controlling mango wilt (*Fusarium solani*) in nursery. *Indian Journal of Agricultural Sciences* **66** (4) : 258–62.

Singh R S. 1987. *Diseases of Vegetable Crops*, pp 362. Oxford and IBH Co. Pvt Ltd, New Delhi.

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Indirect-ELISA technique for the detection of the red rot pathogen in sugarcane (*Saccharum* spp hybrid) and resistance screening

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ABSTRACT

A study was conducted during 1995–97 on the possibility of identifying resistance to red rot pathogen *Colletotrichum falcatum* Went in sugarcane based on serological technique. Large number of genotypes are screened for red rot resistance in sugarcane every year. To identify the disease resistance at an early stage a new serological technique, enzyme linked immunosorbent assay was developed based on antiserum developed against the fungus. Early detection of the pathogen well before the symptom development was possible in this technique. When different tissues in the infected sugarcane plant were screened for antigen titre, root eyes and bud in the nodal region and internodal samples from pith and white spot gave higher values showing more pathogen colonisation. When 20 different sugarcane varieties were subjected to ELISA test after pathogen inoculation, it showed a clear variation in disease resistance among them as in field testing. Further this technique was found reliable to screen sugarcane genotypes for red rot resistance at an earlier stage.

Key words : sugarcane, red rot pathogen, ELISA, detection

The methods to quantify resistance of plants to fungal pathogens differ widely. Very often lesion size or sporulation are used to quantify the external manifestation of disease several days after inoculation (Ferris 1995) but these lack rigour. Resistance to red rot disease of sugarcane caused by *Colletotrichum falcatum* is assessed based on internodal symptoms such as lesion width, nodal transgression, presence of white spots and drying of tops (Srinivasan and Bhat 1961). Field screening takes more time to assess the resistance by plug and nodal methods of evaluation (Viswanathan *et al.* 1998). Resistance assessed by the above methods are grossly influenced by environmental factors such as temperature and relative humidity. Since the current method is time consuming and inconsistent a controlled condition evaluation was deviced to assess the host reaction under optimum environmental conditions (Mohanraj *et al.* 1997).

Another ideal measure to evaluate resistance during the early phase of host–pathogen interaction is the ability of the host to restrict or fungal growth. By measuring the amount of fungal colonisation in the infected host the resistance can be assessed. A direct microscopic method was standardized to quantify red rot resistance in the inoculated sugarcane tissues (Mohanraj *et al.* 1994). Estimation of fungal biomass by serological methods such as enzyme-linked immunosorbent assay (ELISA) has been attempted in other host pathogen systems (Aguelon and Dunez 1984, Mullen and Hagan 1989). In order to circumvent the time consuming field testing an ELISA technique was attempted to detect the pathogen in the host using polyclonal antiserum developed against the fungus during earlier stages of disease development. The same technique is standardized to assess the disease resistance in sugarcane clones. Possibility of using this technique to screen large population of sugarcane clones for red rot resistance is discussed.

MATERIALS AND METHODS

Fungal cultures from the national type culture collection for red rot, maintained at the plant pathology laboratory of the Institute were used for the studies. After isolation from the host tissues single conidial cultures of the 3 pathotypes, viz Cf1148, Cf7717 and Cf671 were maintained on oat meal agar medium. The fungus was grown on Czapeck's Dox liquid culture medium (28 ± 2°C) to harvest the mycelium for serological studies. Six to eight–month–old sugarcane (*Saccharum* spp hybrid) plant of hybrid varieties maintained at the Institute farm were used for inoculation. Polyclonal antiserum was raised against the pathotypes as followed by Alexander and Jothi (1995).

Mycelia harvested from liquid medium were ground in ice cold phosphate buffered saline (PBS) 0.1M (*p*H 7.2) and extracted by centrifugation at 5000 g for 10 min at 4°C and

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protein concentration was assessed using Brilliant Blue dye R–250 (Sigma) (Bradford 1976). Later the homogenate was diluted with carbonate buffer, pH 9.6 to a concentration of 10–50 mg/ml. The protein adjusted extracts were used as antigen in the first set of experiment. The antigen dilutions in carbonate buffer of 200 µl were incubated overnight at 4°C in micro-titre plates. The wells were then emptied, washed thrice with phosphate buffered saline, *p*H 7.2 containing 0.05% (v/v) Tween–20 (Mowat and Dawson 1987). The emptied wells were loaded with 200 µl antiserum raised against *C. falcatum* diluted to 1:1000 or 1:2000 in PBS, *p*H 7.2 containing 0.05% (v/v) Tween 20, 2% (w/v) polyvinylpyrrolidone (PVP) and 0.2% (w/v) ovalbumin (PBSTPO) and incubated at 37°C for 3 hr. After rewashing, the plates were incubated for 3 hr at 37°C with 200 µl per well of goat anti-rabbit gamma globulin alkaline phosphatase conjugate diluted to 1:8000 in PBSTPO. After final washing, the wells were loaded with 200 µl of a solution containing 1mg/ml para nitrophenyl phosphate substrate (Sigma, phosphatase reagent) in 10% diethanolamine buffer, pH 9.8. Colour development was monitored periodically at 405 nm with a Biotek ELISA Reader.

To standardise the detection of *C. falcatum* in the infected host 8–month–old sugarcane stalks were brought from the field, leaf sheaths removed and fungal spore suspension (10^6 conidia/ml) was applied on the young nodes just below the spindle covered with thick cotton pads and polythene strips. Inoculated canes were incubated under 90% relative humidity and the temperature was maintained at 32°C (Mohanraj *et al.* 1997). Later tissue samples of 10 mm depth were drawn from the inoculated nodal region using an 8 mm cork borer over a period of 15 days after inoculation. Tissue samples were ground in carbonate buffer *p*H 9.6, diluted to concentration ranging from 1:10 to 1:500 and used as antigen and the ELISA test performed as in previous assays with antiserum concentrations of 1:1000 and 1:2000. Likewise about 20 cultivars showing different levels of resistance were screened to standardize the ELISA technique for *in-vitro* screening of sugarcane genotypes.

RESULTS AND DISCUSSION

Detection of C. falcatum *by ELISA*

Direct antigen coating–ELISA tests showed that there was progressive increase in absorbance values for antigen concentrations from 10µg/ml (2µg well) to 50µg /ml (10µg/well) against antiserum concentration of 1:1000 and 1:2000 and conjugate dilutions of 1:8000 (Fig 1). When antiserum dilutions of 1:1000 and 1:2000 were compared against antigen extract (from naturally infected stalks) dilutions from 1:10 to 1:500 there was a decrease in absorbance upon dilution. The same assay showed fast colour development in wells after substrate addition in extracts diluted to concentration of 1:10 to 1:50 (Fig 2).

Quantification of pathogen antigen in the naturally infected nodal and internodal tissues showed clear variations in antigen titre among the tissue samples. Although extracts

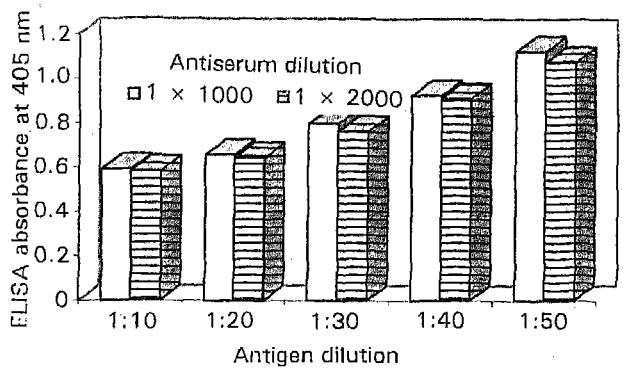

Fig 1 Specific reaction of *C. falcatum* antiserum against fungal antigen

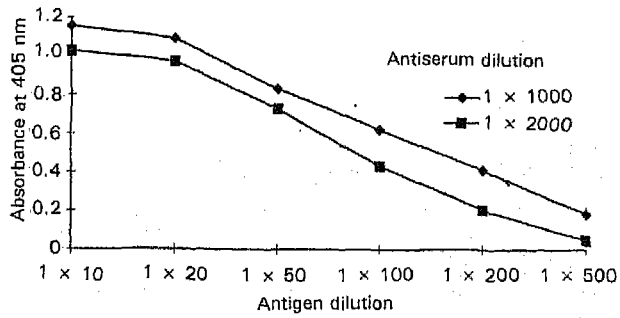

Fig 2 Detection of *C. falcatum* infection in sugarcane tissues by ELISA

from different parts of the internodal and nodal tissues reacted well with pathogen antiserum, extract from rind with root eyes, root eyes and bud, internodal pith tissue, ground tissue (white spot) and bud tissues recorded more ELISA values than those from other tissue parts. Extracts from bud tissue showed highest titre and the values were higher than those of the mycelial extracts (20µg/ml) used as check (Table 1).

The purpose of the study was to determine whether or not ELISA based detection of red rot pathogen using polyclonal antiserum during the earliest stages of fungal invasion were feasible. The concentration of antigen (1:100), antiserum (1:1000) and enzyme conjugate (1:8000) used in the study were found optimum to detect *C. falcatum* in the infected host.

Dormant infection by the pathogen at the nodal region and on the bud tissues has been known (Srinivasan and Alexander 1964) such colonization of the pathogen as thickened hyphae and mycelial mass at the root primordia, leaf scar region and buds of the cane can lead to development of disease in subsequent generations if such infected setts were used for planting. In such situations identification of the pathogen colonization in the planting sugarcane setts assumes greater significance. In the present study colonisation of the pathogen on different parts of sugarcane stalk revealed the marked difference in their ELISA titre values. The maximum signal for pathogen colonization by ELISA was detected in root eyes, buds, white spot region of ground tissue region

Table 1 Assessment of fungal colonization in the naturally infected sugarcane nodal and internodal tissues by ELISA test

Sugarcane tissue	Absorbance 405nm*
Nodal Region	
Rind with root eyes	0.935 ± .101
Rind with root eyes + bud	1.167 ± .101
Inner layer to ring	0.782 ± .056
Growth ring	0.656 ± .034
Bud	1.921 ± 158
Leaf scar	0.574 ± .034
Internodal region	
Internode tissue with rind (12 mm depth)	0.829±.68
Pith tissue	1.364 ± .097
Rind (discoloured)	0.543 ± .051
Rind (acervuli)	*0.606 ± .056*
Inner layer to rind	0.912 ± .087
Pith tissue with mycelial growth	1.513 ± .129
Ground tissue (white spot)	1.450 ± .110
Mycelium (20 mg/ml)	0.451 ± .022
Healthy control	0.039 ± .002
CD (*P*=005)	0.244

* Mean of 4 replications.

Table 2 Comparison of host reaction to the pathogen in relation to ELISA values

Genotype	Disease reaction	Absorbance 405 nm
Co 7704	MR	0.049 ± .003
CoSi 86071	MR	0.040 ± .004
CoS 767	MR	0.040 ± .003
BO 91	MR	0.032 ± .002
Co 7717	MS	0.073 ± .006
Co 8013	MS	0.055 ± .003
Co 8014	MS	0.062 ± .003
Co 8338	MS	0.062 ± .002
Co 7805	MS	0.056 ± .003
Co 997	S	0.145 ± .003
Co 1148	S	0.159 ± .006
Co 8341	S	0.197 ± .007
Co 8011	HS	0.408 ± .010
Co 62175	HS	0.538 ± .023
Co 85004	HS	0.457 ± .015
CoC 671	HS	0.597 ± .016
CoC 86062	HS	0.463 ± .020
CoC 90063	HS	0.312 ± .011
CoJ 64	HS	0.267 ± .004
CoC 8001	HS	0.512 ± .012
Healthy Control		0.030 ± .002
Fungal mycelium		0.521 ± .023
CD (P=0.05)		0.048

Mean of 4 replications; MR, moderately resistant; MS, moderately susceptible; S, susceptible; HS, highly susceptible.

indicating the pathogen colonization which had been earlier observed microscopically (Srinivasan and Alexander 1964). Hence, ELISA technique may be highly useful in detection of the pathogen in the infected host for purposes of seed indexing and quarantine.

Evaluation of host-resistance through ELISA

Twenty sugarcane cultivars with known red rot reactions were artificially inoculated and ELISA tests performed using the method described. The samples from different sugarcane cultivars showed variation in their ELISA values reflecting the level of pathogen colonization. Samples from cultivars which were showing susceptible and highly susceptible reactions recorded absorbance values of more than 0.100. Cultivars with moderately susceptible reaction had values between 0.05 and 0.100. Moderately resistant clones had titre values equal to healthy cane extracts or slightly more (Table 2).

Currently sugarcane clones are evaluated by the plug and nodal methods of evaluation under field conditions (Viswanathan *et al.* 1998). The plug method of evaluation is used to evaluate parenchymatous resistance based on a 0–9 scale developed by Srinivasan and Bhat (1961). This was found highly injurious since it breaks the natural barriers of resistance. Similarly, time and again serious doubts have been expressed about the reliability of the field nodal method of testing for red rot. Field nodal testing had resulted in high levels of disease escape because of lack of proper environmental condition essential for infection. Hence a controlled condition testing was developed to screen genotypes under optimal environmental conditions to the pathogen with minimum injury to the host (Mohanraj *et al.* 1994, 1997, Viswanathan *et al.* 1998). This method takes lesser time (10 days) for disease evaluation as compared to field testings which require more time (60 days). In addition to the advantages of time, space and precision, this method enables us to use the ELISA technique to screen genotypes against red rot disease. Highly susceptible and susceptible clones or moderately susceptible and moderately resistant clones can be clearly distinguished by ELISA. Moreover, there was a clear matching of host reaction evaluated by controlled condition testing and ELISA titre values. This suggests that sugarcane genotypes evaluation can be effectively evaluated for red rot reaction using the ELISA technique with much more precision and quantification of pathogen colonisation was also possible in this technique. This is the first report on the possibility of using ELISA technique to detect red rot pathogen in the infected host and such studies to detect plant

pathogens in other host species have already been reported (Barker and Pitt 1988, Harrison *et al.* 1990, Mohan 1988).

Serological techniques for the detection of red rot pathogen colonisation in the sugarcane host will be highly useful in studies related to seed indexing, quarantine, biochemistry and molecular biology studies of resistance mechanisms and resistance screening. Further, this technique was found to be simple and feasible to quantify the amount of fungal colonisation in the infected host at a very early stage of host-pathogen interaction. Such quantification would be highly useful in early screening of sugarcane genotypes for red rot pathogen.

REFERENCES

Aguelon M and Dunez J. 1984. Immunoenzymatic techniques for the detection of *Phoma exigua* in infected potato tissues. *Annals of Applied Biology* : 463–9.

Alexander K C and Jothi R. 1995. Current status of race flora of *Colletotrichum falcatum* Went. (*in*) *Sugarcane Production Constraints and Strategies for Research and Management of Red rot*. Part II, pp 273–84. Agnihotri V P, Sinha O K and Singh R P (eds). IISR, Lucknow.

Barker I and Pitt D. 1988. Detection of the leaf curl pathogen of anemones in corms by enzyme linked immunosorbent assay (ELISA). *Plant Pathology* 37 : 417–22.

Bradford M M. 1976. A rapid and sensitive method for the quantification of microgram quantities of protein utilising the principle of protein-dye binding. *Analytical Biochemistry* 72 : 248–54.

Ferris V R. 1995. Histological study of pathogen–suspect relationship between *Phytophora infestans* and derivatives of *Solanum denissum*. *Phytopathology* **85** : 546–52.

Harrison J G, Barker H, Love R and Rees E A. 1990. Estimation of amounts of *Phytophthora infestans* mycelium in leaf tissue in enzyme-linked immunosorbent assay. *Plant Pathology* 39 : 274–7.

Mohan S B. 1988. Evaluation of antisera raised against *Phytophthora fragariae* for detecting the red core disease of strawberries by enzyme-linked immunosorbent assay (ELISA). *Plant Pathology* **37** : 206–16.

Mohanraj D, Padmanaban P, Viswanathan R and Alexander K C. 1994. Rapid evaluation of resistance against red rot disease of sugarcane under controlled conditions. *Proceedings of National Symposium on Ultrastructure, Cytology, Sexuality and Variability in Plant Pathogens*, held during 24–27th January by Indian Phytopathological Society, at Tamil Nadu Agricultural University, Coimbatore, pp 8–9.

Mohanraj D, Padmanaban P, Viswanathan R and Alexander K C. 1997. Sugarcane screening for red rot resistance. *Sugarcane* **3** : 18–23.

Mowat W P and Dawson S. 1987. Detection and identification of plant viruses by ELISA using crude sap extracts and unfractionated antisera. *Journal of Virological Methods* **15** : 233–47.

Mullen J M and Hagan A K. 1989. Use of ELISA kits for diagnosis of *Phytophthora* crown and root rot of Azalea (Abst.) *Phytopathology* **79** : 113.

Srinivasan K V and Alexander K C. 1964. A study of mode of infection and occurrence of dormant infections of red rot. *Proceedings of 5th All India Conference of Sugarcane Research and Development Workers*, pp 675–84.

Srinivasan K V and Bhat N. 1961. Red rot of sugarcane – Criteria for grading resistance. *Journal of Indian Botanical Society* **40** : 566–77.

Viswanathan R, Padmanaban P and Mohanraj D. 1998. Comparison of three testing methods for evlauation of resistance to red rot caused by *Colletotrichum falcatum* in sugarcane. *Indian Journal of Agricultural Research* **68** : 226–30.

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Acceptance and bioefficacy of difethialone as rodenticide and its suitability in the fields

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ABSTRACT

Difethialone (25 ppm) cereal bait was tested against *Bandicota bengalensis, Mus musculus* and *M. booduga* in laboratory both in no choice and choice feeding for its acceptance and bioefficacy and was found to be effective against all the 3 species. Male and female *B. bengalensis* consumed 0.228 and 0.280 mg a i/100 g body weight respectively in 1 day and 0.390 and 0.404 mg a i respectively in 2 days of no choice feeding and died beween 4 and 10 days after treatment. In the various choice feeding experiments, these animals consumed 0.143 to 0.201 mg a i and died between 4 and 9 days after treatment. In the fields, defethialone proved to be very effective when employed through burrow baiting resulting in 54.38–57.93% success during mild rainy season and up to 76.96% success in absence of rains in terms of reduction in rodent activity as manifested by reduction in active burrows and plain bait consumption. In pulse baiting, the success was more than 90% in different crops including cereal, vegetable and fruit crops.

Key words : difethialone, rodenticide, *Bandicota bengalensis, Mus musculus, Mus booduga,* surface baiting, burrow baiting

Killing the rodents with the help of chemicals (rodenticides and fumigants) is till date the most widely used single method of rodent control though non-chemical methods such as trapping (Sheikher and Jain 1992, Tobin *et al.* 1993) and habitat manipulation (Engeman *et al.* 1995) have also been advocated. Difethialone is a second generation anticoagulant rodenticide which holds promise on account of its low LC_{50} against various rodent species and also its low toxicity to non-target species. Therefore, this chemical was used in the study, viz sub-temperate, sub-humid mid-hills of Himachal Pradesh to assess its acceptance and bioefficacy against rodents and its usefulness in the fields for containing rodent menace.

MATERIALS AND METHODS

Difethialone– [(Bromo–4'–[biphenyl–1–1']–yl–4)–3, tetrahydro– 1– 2– 3– 4–naphthyl–1]–3–hydroxy–4–2H–1–bentothiopyran– one– 2, supplied by Hoechst Schering, Mumbai as a liquid concentrate containing 0.125% a i was used to prepare 25 ppm cereal bait.

Laboratory studies

Prepared cereal bait was tested for its acceptance and bioefficacy against field collected and laboratory acclimatized test species, viz *Bandicota bengalensis, Mus musculus* and *M. booduga*, the 3 most prevalent species inhabiting sub-temperate, sub-humid and mid-hills of Himachal Pradesh (altitude: 915 to 1,523 m above MSL). The animals of each species were divided into four sets, each comprising 10 males and 10 females, and were subjected to the following feeding experiments:

No choice feeding

The animals of set I and II were housed individually in cages (45 cm × 30 cm × 30 cm). The animals of set I were provided with the prepared difethialone bait for 1 day only and those of set II for 2 days @ 20 g/animal/day and subsequently were shifted to normal laboratory feed.

Choice feeding

The animals of set III and IV were housed individually in cages (90 cm × 30 cm × 30 cm) and were provided with prepared difethialone bait and normal laboratory feed @ 20 g each/animal/day for 1 (set III) and 2 days (set IV) before shifting them to normal feed.

The amount of difethialone bait alone (set I and II) and of difethialone bait as well as normal feed consumed (set III and IV) by individual animal during feeding trial period was calculated and the animals were kept under observation. The treated animals were dissected after their death. The consumption data in choice test were subjected to t–test to find out the preference of the animal to difethialone bait if any. Water was provided *ad libitum* to all the animals (set I to IV)

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during the study.

Field studies

The fields were treated with 25 ppm difethialone in cereal bait through (i) broadcasting, ie the bait was scattered manually in the field @ 3 kg/ha from the edges of the fields, (ii) surface baiting i e the bait was placed on a piece of paper in the fields in a grid, with bait to bait distance of 10 m @ 20–40 g/location, (iii) bait stations, ie 40 g of bait was placed in cylindrical metallic containers having openings at both the ends, with station to station distance of 10 m, and (iv) burrow baiting, ie 20–40 g of bait material was placed on a piece of paper and inserted 20–30 cm deep in each active burrow.

Pulsed treatment through burrow baiting was also employed wherein 2 treatments with the cereal bait were given at an interval of 30 days.

The success of the rodenticide application was worked out on the basis of active burrow count as well as on bait consumption data at pre- and post-treatment census in the experimental fields (receiving rodenticide treatment) vis-a-vis reference field (receiving no rodenticide treatment) using the method of Buckle *et al.* (1984) and employing the formula

$$\text{Success (\%)} = 100\ [1-(r_1t_2/r_2t_1)]$$

where r and t refer to reference and experimental fields and 1 and 2 to pre– and post–treatment census (of either active burrows or bait consumption) respectively. The post-treatment census was carried out a fortnight after treatment (0 day) and pre-treatment census 1 day before employing rodenticide in the fields.

RESULTS AND DISCUSSION

It was observed that 25 ppm difethialone bait was effective against all the test species. In no choice trials, male and female bandicoot rats (*B. bengalensis*) consumed 0.228 and 0.280 mg a i/100 g body weight respectively in 1 day and 0.390 and 0.404 mg a i respectively in 2 days (Table 1). Further it was observed that the animals consumed maximum bait on the first day itself and the consumption was relatively less on the second day of exposure in no choice feeding for 2 days. All the treated animals died between 4 and 10 days after treatment and showed internal haemorrhage especially in axillary and groin regions. Necrotic lesions along with haemorrhage were also observed in liver and kidney.

When a choice was given *B. bengalensis* consumed more poison bait than plain food. This preference was however, significantly evident in males (both in 1 and 2 days choice trial) and females in 1 day choice experiment, while it was non-significant in females in 2 days choice experiment. Both the sexes consumed 0.143 mg a i/100 g body weight in 1 day whereas the consumption by males and females was 0.201 and 0.157 mg a i/100 g body weight respectively in 2 days trials (Table 1).

M. musculus was observed to consume relatively more quantity of a i/100 g body weight; the males and females ingesting 0.413 and 0.420 mg respectively in 1 day and 1.028 and 1.023 mg respectively in 2 days exposure to poison bait without any alternative food. Given a choice, the males and females consumed 0.295 and 0.365 mg a i/100 g body weight respectively in 1 day and 0.574 and 0.529 mg a i respectively in 2 days exposure (Table 1); the consumption of poison bait and normal food differing only non-significantly. *M. booduga* males and females, on the other hand, consumed 0.467 and 0.449 mg a i respectively in 1 day and 0.8323 and 0.794 mg a i/100 g body weight respectively in 2 days in no choice set up. The consumption by males and females, however, was 0.198 and 0.206 mg a i/100 g body weight respectively in 1 day and 0.311 and 0.292 mg a i respectively in 2 days choice feeding, ie in presence of alternate food (Table 1). The consumption of poison bait differed non-significantly from that of normal food but for by males in 2 days choice feeding where plain food was significantly preferred over poison bait.

Further it was observed that though there was no rejection of poison bait on the second day of exposure, the overall consumption reduced on the second day in all the species in as much as the *B. bengalenis* consumed approximately 9–11 g bait/100 g body weight in 1 day against 15–16 g in 2 days in no choice; 9–10 g in 1 day against 12 g in 2 days in choice experiments. Subsequently when the animals were shifted on to normal food, the consumption was around 6–9 g/day till death. A slight decline in the total consumption was also recorded in *M. booduga* in no choice and in *M. musculus* in choice (Table 1). All the treated animals died between 3 and 10 days of post–treatment period barring 1 female *B. bengalensis* which succumbed to poison after 17 days. Its autopsy revealed poisoning symptoms such as lesions in liver and kidney and internal haemorrhage.

Earlier, Saravanan and Kanakasabai (1996) reported that the adult *B. bengalensis* consumed on an average 4.1 mg difethialone/kg body weight and sub–adults consumed 4.5 mg/kg during 1 day exposure and took 9.8 and 8 days respectively before succumbing to poison in no choice tests. They, however, recorded only 80% mortality in choice test after 1 day and 100% mortality after 2 days exposure. Further, they reported that *M. booduga* males and females consumed 1.5 and 1.2 mg/kg and died relatively in shorter period after treatment, i e took 4 and 6 days respectively to death. They recorded that the adult and sub–adult mice consumed more poison bait in choice tests, i e 2.3 and 2.2 mg/kg respectively and also took longer to death, i e 11.2 and 10.5 days respectively. The study, however, has revealed that the mice consumed more poison/unit body weight as compared with the consumption by *B. bengalensis*, and also that difethialone (25 ppm = 0.0025%) in an accepted and effective rodenticide against not only *B. bengalensis* but also against mice (*M. musculus* and *M. booduga*) which are perhaps more hardy and difficult murids to be controlled, and as such it can be employed in rodent management programmes.

The field studies, revealed that 25 ppm difethialone was

Table 1 Efficacy of 25 ppm difethialone against *B. bengalensis*, *M. musculus* and *M. booduga*

Species	Sex	Average weight (g ± SD)	Treatment	Bait consumption/100 g body weight (g ± SD)			a i consumed per 100 g body weight (mg ± SD)	Time taken to death		Mortality (dead/ treated)
				Poison bait	Plain bait	Total		Average (days ± SD)	Range (days)	
	Male	140.00±8.165	1 day, no choice	9.121±1.038		9.121±1.038	0.228±0.026	6.6±1.35	4–9	10/10
	Female	142.00±13.166	1 day, no choice	11.193±0.855		11.193±0.855	0.280±0.021	6.7±1.64	5–10	10/10
	Male	166.00±35.340	2 days, no choice	15.607±1.845		15.607±1.845	0.390±0.046	6.0±0.82	5–7	10/10
	Female	166.00±20.656	2 days, no choice	16.149±1.981		16.149±1.981	0.404±0.050	5.4±0.70	4–6	10/10
B. bengalensis	Male	149.00±8.756	1 day, choice	5.707±0.873	3.612±0.878	9.919±1.116	0.143±0.022	6.2±1.14	4–8	10/10
	Female	173.00±9.487	1 day, choice	5.730±0.485	4.254±0.739	9.984±0.587	0.143±0.012	5.6±0.70	5–7	10/10
	Male	186.00±32.159	2 days, choice	8.055±2.494	4.175±1.297	12.230±3.343	0.201±0.062	6.0±1.63	4–9	10/10
	Female	207.00±40.566	2 days, choice	6.257±1.635	5.715±1.080	11.972±2.395	0.157±0.040	7.1±3.76	4–17*	10/10
	Male	11.47±1.29	1 day, no choice	16.521±2.160		16.521±2.160	0.413±0.054	5.3±1.34	4–8	10/10
	Female	11.40±1.49	1 day, no choice	16.815±2.731		16.815±2.731	0.420±0.068	5.4±1.27	4–8	10/10
	Male	10.89±1.18	2 days, no choice	41.098±8.047		41.098±8.047	1.028±0.201	4.7±0.82	4–6	10/10
	Female	10.87±0.95	2 days, no choice	40.825±6.806		40.825±6.806	1.023±0.167	5.3±1.48	4–9	10/10
M. musculus	Male	11.02±1.34	1 day, choice	11.804±3.778	14.707±5.928	26.511±4.571	0.295±0.095	5.1±1.10	3–7	10/10
	Female	11.73±1.57	1 day, choice	14.597±2.503	13.269±3.122	27.866±3.972	0.365±0.063	4.9±1.20	4–8	10/10
	Male	10.62±0.72	2 days, choice	22.954±2.881	23.244±3.937	46.198±3.423	0.574±0.072	4.8±0.79	4–6	10/10
	Female	11.75±0.94	2 days, choice	21.145±2.673	23.517±5.585	44.662±3.692	0.529±0.067	5.1±0.07	4–6	10/10
	Male	19.22±1.35	1 day, no choice	18.662±1.717		18.662±1.717	0.467±0.043	5.7±1.34	4–8	10/10
	Female	20.82±2.03	1 day, no choice	17.937±1.227		17.937±1.227	0.449±0.031	5.6±1.27	4–8	10/10
	Male	17.72±1.61	2 days, no choice	33.303±1.830		33.303±1.830	0.833±0.046	5.2±1.40	4–8	10/10
	Female	19.18±1.86	2 days, no choice	31.772±1.904		31.772ñ1.904	0.794±0.047	5.4±1.17	4–7	10/10
M. booduga	Male	17.62±3.60	1 day, choice	7.911±2.586	7.184±2.322	15.095±4.282	0.198±0.065	5.9±1.85	4–10	10/10
	Female	21.99±2.92	1 day, choice	8.252±2.151	6.400±2.875	14.652±4.472	0.206±0.054	6.1±1.73	4–9	10/10
	Male	19.31±2.18	2 days, choice	12.451±2.110	17.963±4.905	30.414±4.472	0.311±0.053	5.8±1.10	4–8	10/10
	Female	21.42±2.39	2 days, choice	11.692±2.768	16.156±4.007	27.848±2.020	0.292±0.069	6.0±1.33	4–8	10/10

* Range 4–9 days with the exception of one where the animal died after 17 days

Table 2 Efficacy of 25 ppm difethialone against rodents in the fields

Mode of treatment	Crop	Number of active burrows				Bait consumed (g)				% success=100 [1–($t_1 r_2/t_2 r_1$)]		
		Treated field		Reference field		Treated field		Reference field		Active burrow basis	Bait consumption basis	Average
		A (t_1)	B (t_2)	A (r_1)	B (r_2)	A (t_1)	B (t_2)	A (r_1)	B (r_2)			
Broadcasting	Cauliflower	16	14	14	14	24.4360	20.4354	18.1512	17.9438	12.50	15.41	13.95
Broadcasting	Tomato	18	14	13	13	27.0524	21.3975	16.8732	17.3640	22.22	23.14	22.68
Surface baiting (1 day)	Apple	21	18	12	13	15.9234	14.0166	12.8450	13.7832	20.88	17.97	19.42
Surface baiting (2 days)	Apple	15	11	12	13	13.6472	10.8514	12.8450	13.7832	26.67	25.90	26.28
Bait boxes (1 day)	Tomato	17	13	11	12	26.1376	19.9220	11.7251	12.0834	29.90	26.04	27.97
Baix boxes (2 days)	Cauliflower	18	11	17	17	26.5601	17.0088	24.8902	25.5978	38.89	37.73	38.31

A, Pre-treatment census; B, post-treatment census

most effective when used through burrow baiting. Broadcasting of the cereal bait did not prove to be effective as it reduced rodent activity by 22.68% maximal, calculated as the average of the 2 assessment methods employed, ie reduction in active burrow count and reduction in plain bait consumption (Table 2). Since vegetable crops are not very dense (the plant to plant distance being 45 cm × 45 cm in cauliflower and 30 cm × 90 cm in tomato), the rodents are probably unable to spend much time in absence of shelter or cover during their forays in search of food above ground. Secondly in broadcasting, the bait might have got scattered throughout the field in such a manner that its contents at any given place visited by rodents were not in enough quantity to prove lethal when ingested. This might be the cause of low success rate with broadcasting. This suggests that broadcasting should be normally avoided in vegetable crops, as it results in low rodent control success rate and at the same time increases the chances of ingestion of rodenticide by non–target animals especially granivorous birds. However, Byers *et al.* (1982) had achieved excellent control of pine voles (*Microtus pinetorum*) and meadow voles (*M. pennsylvanicus*) through a single broadcasting treatment in apple orchards. Even the surface baiting for 1 or 2 days did not prove to be efficient in reducing rodent activity in the fields; the reduction being 26.28% maximally (Table 2). Lack of ground cover (Sheikher and Jain 1996), and also the nature of the bait offered (which was in the form of loose cereal bait) may be the reasons for low efficacy of the rodenticide when employed through surface baiting since the rodents fail to spend enough time on the bait to consume or to carry it to their burrow in a quantity which may prove lethal if ingested. Rodenticide application through bait boxes yielded better success, ie up to 38.31% (Table 2) probably because the rodents could spend relatively more time on the poison bait in the safe confines of the box and thereby could have consumed lethal dose of the rodenticide.

Burrow baiting was, however, recorded to be the most effective means of rodenticide application resulting in 54.38–76.96% success in different crops in different seasons. Even during mild rainy days, it was able to reduce rodent activity by at least 58.80% in terms of reduction in the number of active burrows and by at least 53.48% in terms of reduction in

Table 3 Efficacy of 25 ppm difethialone against rodents in the fields employed through burrow baiting

Crop	*Number of active burrows*				*Bait consumed (g)*				*% success=100 [1–($t_1 r_2/t_2 r_1$)]*		
	Treated field		Reference field		Treated field		Reference field		Active burrow basis	Bait consumption basis	Average
	A (t_1)	B (t_2)	A (r_1)	B (r_2)	A (t_1)	B (t_2)	A (r_1)	B (r_2)			
Cauliflower *	17	7	21	21	28.0945	12.4422	17.8734	17.0143	58.82	53.48	56.15
Cauliflower	21	5	19	20	26.6681	7.3288	15.3911	16.0025	77.38	73.57	75.47
Tomato	15	4	18	19	25.6174	7.1358	12.6518	13.1020	74.74	73.10	73.92
Tomato	19	5	19	21	26.0982	6.4522	9.4792	9.9660	76.19	76.49	76.34
Wheat	32	7	26	26	27.9573	7.2984	14.3326	15.4559	78.13	75.79	76.96
Wheat *	49	19	17	16	34.8804	13.1396	12.3750	10.8644	58.80	57.09	57.93
Apple	16	4	14	14	23.4165	7.1052	8.1624	9.0532	75.00	72.64	73.82
Apple *	29	9	18	17	35.3006	12.5190	18.4512	15.7208	67.14	58.38	54.38

* Treatment during mild rainy period

A, Pre-treatment census; B, post-treatment census

Table 4 Efficacy of pulsed burrow treatment with 25 ppm difethialone in the fields

Crop	Number of active burrows				Bait consumed (g)				% success=100 [1–($t_2 r_1/t_1 r_2$)]		
	Treated field		Reference field		Treated field		Reference field		Active burrow basis	Bait consumption basis	Average
	A (t_1)	B (t_2)	A (r_1)	B (r_2)	A (t_1)	B (t_2)	A (r_1)	B (r_2)			
Wheat	33	2	25	26	21.3406	1.8471	14.1523	15.2716	94.17	91.98	93.07
Cauliflower	26	1	18	18	24.5219	1.6602	17.3519	16.9825	96.15	93.08	94.61
Apple	25	2	19	20	23.7220	2.4556	19.2468	20.0360	92.40	90.06	91.23

A, Pre-treatment census; B, post-treatment census

bait consumption (Table 3). In absence of rains, the reduction in the active burrows was between 74.74 and 78.13% and reduction in rodent activity as revealed by reduction in bait uptake was 72.64 and 76.49% (Table 3). Byers and Carbaugh (1991) have successfully employed defethialone to control pine and meadow voles in orchards. Similarly, Vuksa *et al.* (1995) recorded difethialone to be effective in controlling both *Microtus arvalis* and *Apodemus sylvaticus* in apple and peach orchards. Pulsed treatment with difethialone (ie 2 burrow treatments spaced at 30 days) gave over 90% success (Table 4). Superiority of burrow baiting over surface baiting, and of pulsed baiting over single treatment in vegetable crops had been reported earlier by Shiekher and Jain (1996), and in orchards by Malhi *et al.* (1993). Burrow baiting perhaps reduces the chances of leaching of the poison from the bait material due to rain water. Plugging of the burrows with clod prevents to a great extent, the free access of rain water to the bait placed inside the burrow.

The studies have clearly demonstrated that difethialone (0.0025%) is an effective rodenticide in the fields, and that it should be employed through burrow baiting either as a one time treatment or in pulsed baiting treatment.

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REFERENCES

Buckle A P, Rowe F P and Husin A. 1984. Field trials of warfarin and brodifacoum wax block baits for the control of rice field rat, *Rattus argiventer*, in Penninsular Malaysia. *Tropical Pest Management* **30** : 51–8.

Byers R E and Carbaugh D H. 1991. Rodenticides for the control of pine and meadow voles in orchards. *Journal of Environmental Horticulture* **9** : 167–72.

Byers R E, Merson M H and Palmateer S D. 1982. Control of orchard voles with broadcast baits. *Journal of American Society for Horticultural Sciences* **107** : 613–9.

Engeman R M, Barnes V G Jr, Anthony R M and Krupa H W. 1995. Vegetation management for reducing mortality of ponderosa pine seedlings from *Thomomys* spp. *Crop Protection* **14** : 505–8.

Malhi C S, Ahmad N and Parshad V R. 1993. Management of rodents on the floor of small-sized orchard. *Quarterly Newsletter* FAO/APPPC **36** : 10–6.

Saravanan K and Kanakasabai R. 1996. Evaluation of 0.0025% difethialone against *Bandicota bengalensis* and *Mus booduga* under laboratory conditions. *Rodent Newsletter* **20** : 6–7.

Sheikher C and Jain S D. 1992. Efficacy of live-trapping as a rodent control technique in vegetable crops. *Tropical Pest Management* **38** : 103–5.

Sheikher C and Jain S D. 1996. Mode of application and performance of rodenticides in vegetable crops. *Indian Journal of Agricultural Sciences* **66** : 437–40.

Tobin M E, Koehler A E, Sugihara R T, Ueunten G R and Yamaguchi A M. 1993. Effect of trapping on rat population and subsequent damage and yield of macadamia nuts. *Crop Protection* **12** : 243–6.

Vuksa M, Dimic N, Injac M, Peric P, Krnajaic S, Polensy F, Muller W and Olszac R W. 1995. Optimalisation of rodenticide application in orchard protection. *Proceedings of the International Conference on Integrated Fruit Production*, held during August 28 to September 2 1995 at Cedzyna, Poland. (*fide Acta Horticulturae* **422** : 389–91).

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Gene effects for maydis leaf blight (*Drechslera maydis*) resistance and grain yield in white maize (*Zea mays*)

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ABSTRACT

A study was conducted during 1996–98 on the gene effect for maydis leaf blight (*Drechslera maydis*) disease resistance and grain yield in exotic and indigenous white maize grain (*Zea mays* L.) from line × tester analysis. The experiment was conducted under artificial inoculation conditions. Combining ability analysis revealed that non-additive genetic variances were more important in the expression of disease resistance and high grain yield. There was no similarity in ranking between *per-se* performance and its corresponding sea effects of the crosses. In general, it was found that resistance level of the crosses to maydis leaf blight disease was increased where both the parents were having disease reaction resistant/least susceptible followed by resistant × susceptible irrespective of incidence of male parents. Lines L_1, L_2, L_3 and tester T_1 were the best general combiners for disease resistance and high yield. $L_2 \times T_1$ and $L_3 \times T_1$ were the most desirable combinations having both high *per-se* performance and high sea effects for the traits under study.

Key words : gene effect, *Zea mays, Drechslera maydis*, yield

Diseases are the major constraints in the development of high-yielding cultivars. A large number of diseases are evident to cause reduction in maize (*Zea mays* L.) yield particularly during rainy season (*kharif*). However, maydis leaf blight [(*Drechslera maydis*) Nisikado and Miyaki] is the commonly occurring disease in many parts of the maize growing area of India and rest of the world. It can cause reduction in yield up to 30% when appears at an early stage of crop growth (Gregory *et al.* 1978). So far, no single cross white maize hybrid with better resistance is released. Only a few resistant lines with respect to white maize are available. Thus, line × tester with limited number of lines was undertaken for the present study.

MATERIALS AND METHODS

One hundred five white maize lines collected from International Maize and Wheat Improvement Center (CIMMYT, Mexico) and the material generated at Regional Research Station, Karnal were evaluated for diseases and other traits during rainy season (*kharif*) 1996. Most of the lines from CIMMYT did not flower due to temperature sensitivity and susceptibility to maydis leaf blight disease under Indian conditions. Among them, 9 contrasting lines for disease reaction (resistance/susceptibility) were selected during *kharif* 1996 (Table 2). Experiment consists of 6 genetically diverse females (lines), namely HKIW 1346, HKIW 1348 (Karnal) ST 27, CML 85, CML 110, Pop 590–65 (CIMMYT, Mexico) and males (tester) HKIW 1351 (Karnal), ST 21, CML 87 (CIMMYT, Mexico) were crossed in line × tester mating design during winter 1996–97. A complete set of 28 genotypes (18 F_1's, 9 parents and check 'GS 2') were grown at Karnal in a randomized block design with 3 replication during *kharif* 1998. All the recommended cultural practices for maize cultivation were followed. The distance between rows and plants were 70 cm and 20 cm respectively in 5 m plot.

Preparation of inoculum and method of inoculation

During 1997, the pathogen (*D. maydis*) was isolated and maintained on the potato dextrose agar (PDA) medium. The multiplication of the pathogen was done on sorghum grains. Five–week–old culture was grinded in sterilized distilled water and the contents were filtered through muslin cloth. This inoculum prepared was used for artificial inoculation. First inoculation was done by spraying the inoculum after 24 days of planting the crop. Some inoculum was also placed in the central whorl of the plants. The humidity was maintained by perfo-sprinkler system for providing the congenial conditions for disease development. Second inoculation was done 10 days after the first inoculation by repeating the same process.

For disease prevalence, all the plants in the plots were taken into consideration where as for grain yield data 10 competitive plants were recorded. Disease data was subjected to angular transformation before analysis. For carrying out

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the analysis of variance F_1 parents and check were included for testing the significance of genotypic differences. Line × tester analysis was carried out according to the method suggested by Kempthorne (1957).

RESULTS AND DISCUSSION

The mean squares due to genotypes were significant for disease and grain yield suggesting the existence of sufficient variability among the parents and hybrids, that is a pre-requisite for line × tester analysis to study the nature and magnitude of gene effects (Table 1). The line × tester analysis revealed that mean squares due to lines and testers were significant for both the characters. This indicated that lines and testers were of diverse in nature because the lines and testers involved in the study was from both indigenous and exotic sources. The interaction was also found significant for disease resistance as well as grain yield. The sca variances were higher in magnitude than gca for both the traits. This indicated that non-additive genetic variances played an important role. These findings though not in white maize but in yellow maize have already been reported by Khera *et al* (1984), Debnath and Sarkar (1987) and Ceballos and Gracen (1988).

Table 1 Analysis of variance for combining ability and estimates of genetic component for disease prevalence and yield

	df	Disease prevalence	Yield/plant
Replication	2	0.81	7.89
Treatments	26	1157.36*	1650.57*
Parents	8	2157.61*	1012.00*
Parents vs crosses	1	178.06*	2629.01*
Crosses	17	744.26*	1893.52*
Lines	5	1603.91*	2232.70*
Testers	2	2146.63*	8957.48*
Lines × testers	10	33.97*	311.14*
Error	52	3.19	33.08
σ^2D sca		334.28	1077.14
^{2}A gca		42.58	94.88
^{2}D/A		2.80	3.37

$P = 0.05$

Combining ability effects of lines and testers were estimated to evaluate their worth in hybrid combinations. While examining the gca effects of lines and testers (Table 2), it was observed that among lines, viz L_1, L_2, L_3 were the best general combiners for both yield and maydis leaf blight disease resistance as they possessed favourable genes (significant negative gene effects for disease resistance and significant positive gene effects for grain yield). These lines can be of great use in combination breeding. Among testers, only 1 tester (T_1) contributed maximum favourable genes for disease resistance and high grain yield. The examination of sca effects revealed that of the 18 crosses, as many as 7 cross combinations were found desirable for disease resistance. The highest negative value for sca effects was obtained in cross combination $L_6 \times T_3$ (Table 3).

For convenience, two cross combination in each category (resistant × resistant, resistant × susceptible, susceptible × resistant, susceptible × susceptible) were taken for better conclusion (Table 4). In general, it was found that resistance level was increased where both the parents were resistant/least susceptible to maydis leaf blight followed by resistant × susceptible. Irrespective of incidence of male, disease level was increased wherever susceptible female was involved.

Table 2 *Per-se* performance and estimates of general combining ability effects of LXT for disease prevalence and yield

Genotype	*Per-se performance*		Source	gca effects	
	Disease prevalence (%)	Disease reaction		Disease prevalence	Yield/plant
Female (line)					
HKIW 1346	0.90 (5.44)	R	Karnal	−12.62*	15.38*
HKIW 1348	0.90 (5.44)	R	Karnal	−12.12*	5.88*
ST 27	14.30 (22.20)	R	CIMMYT	−11.64*	17.88*
CML 85	78.50 (62.41)	S	CIMMYT	12.70*	−3.45*
CML 110	90.10 (71.82)	S	CIMMYT	9.86*	17.99*
POP 590–65	43.10 (41.03)	S	CIMMYT	13.82*	−17.70*
SE (gi)			0.85	2.71	
Male (tester)					
HKIW 1351	0.90 (5.44)	R	Karnal	−11.74*	23.44*
ST 21	30.20 (33.22)	S	CIMMYT	1.89*	−2.47*
CML 87	80.30 (63.70)	S	CIMMYT	9.85*	−20.97*
SE (gi)				0.60	1.91

Figures in parenthesis is transformed value
R, Resistant, S, susceptible

Table 3 Five desirable crosses on the basis of sca effects and *per se* performance for disease prevalence and grain yield in white maize

Five top crosses on the basis of sca effects			Five top crosses on the basis of *per-se* performance		
Cross	sca effect	*per-se* performance	Cross	*per-se* performance	sca effect
		Disease prevalence (%)			
$L_1 \times T_1$	–1.60	0.90 (5.44)	$L_1 \times T_1$	0.90 (5.44)	–1.60
$L_2 \times T_1$	–2.10	0.90 (5.44)	$L_1 \times T_2$	11.78 (20.00)	–0.67
$L_3 \times T_1$	–2.58	0.90 (5.44)	$L_2 \times T_1$	0.90 (5.44)	2.27
$L_4 \times T_2$	–3.15	46.24 (42.84)	$L_2 \times T_2$	13.84 (21.76)	0.59
$L_6 \times T_3$	–5.76	47.80 (49.31)	$L_3 \times T_1$	0.90 (5.44)	–2.58
SE (sij)	1.46				
		Grain yield/plant (g)			
$L_2 \times T_1$	16.22	142.20	$L_1 \times T_1$	132.33	–3.15
$L_3 \times T_1$	11.77	149.75	$L_1 \times T_2$	109.67	0.20
$L_4 \times T_2$	4.26	95.00	$L_2 \times T_1$	142.20	16.22
$L_5 \times T_2$	8.37	84.57	$L_3 \times T_1$	149.75	11.77
$L_6 \times T_3$	7.83	65.84	$L_4 \times T_1$	110.67	–5.98
SE (sij.)	4.69				

Possibly, there is a role of cytoplasm/maternal effects alongwith few major genes in determining the inheritance of resistance for maydis leaf blight as expressed by Dass *et al.* (1996). Present study also revealed that female must be resistant for the development of disease free/least susceptible hybrids. For better conclusion, five cross combinations with respect to *per-se* performance, sca effects were compared. The results are presented in (Table 3). Baring 2 cross combinations ($L_2 \times T_1$, $L_3 \times T_1$) remaining crosses did not show any correlation between high sca effects and disease prevalence. $L_2 \times T_1$ which gave resonable values for sca effects was the next high yielding F_1 hybrid. The cross combination ($L_3 \times T_1$) which gave the highest yield was the next best combination for sca effects.

Development of high grain yielding and better disease resistant single cross hybrids, the choice of females having high degree of disease resistance as well as high *per-se* performance along with good combining ability is essential for exploiting the heterosis (Alvarez *et al.* 1993 and Dass *et al.* 1998). L_1, L_2, L_3 were the most desirable parents which fulfilled most of these requirements and may be used in future breeding programme for the development of white maize single cross hybrids. In breeding programme, the role of tester is equally important. T_1 can serve as good tester parent for evaluating large number of lines. It can also be used as good pollen parent of single cross hybrids. A base population from these lines and pollen parent can be generated for extraction of new breeding lines. The crosses $L_2 \times T_1$ and $L_3 \times T_1$ possessed high sca effects and high *per-se* performance for disease resistance and grain yield can be directly used for general cultivation after confirming its potential through multi-locational testing. These crosses can be further exploited in breeding programme.

Table 4 Disease reaction of two crosses in each category (R × R, R × S, S × R, S × S) with their *per-se* and sca effect

Cross	Disease reaction	sca effects	*per-se* performance
$L_1 \times T_1$	R × R	–1.60	0.90 (5.44)
$L_2 \times T_1$	R × R	–2.10	0.90 (5.44)
$L_1 \times T_2$	R × S	–0.67	11.78 (20.00)
$L_3 \times T_3$	R × S	–0.11	24.29 (29.50)
$L_5 \times T_1$	S × R	2.65	28.37 (32.17)
$L_6 \times T_1$	S × R	3.91	36.90 (37.39)
$L_6 \times T_2$	S × S	1.87	48.95 (56.87)
$L_4 \times T_3$	S × S	3.42	70.88 (57.37)

Figures in parenthesis is transformed value

R × R, resistance × resistant; R × S, resistant × susceptible; S × R, susceptible × resistant and S × S, susceptible × susceptible

REFERENCES

Alvarez A, Garay G, Gimanez J and Ruiz de Gaterrete J I. 1993. Heterosis in two synthetic varieties of maize based on morphological and reproductive traits. *Investigation Agaria, Production and Protection Vegets* **8** : 333–48.

Ceballos H and Gracen V E. 1988. A new source of resistance to *Bipolaris maydis* race – T in maize. *Maydica* **33** : 233–46.

Dass, Sain, Ahuja V P and Dhanju K S. 1996. Genetics of resistance to *Helminthosporium maydis* in maize (*Zea mays* L.) *Proceedings of Second International Crop Science Congress*, held during 17–23 November 1996 at New Delhi,

Dass, Sain, Arora Pawan and Dhanju K S. 1998. Heterosis for maydis leaf blight disease resistance and grain yield in maize. *Indian Journal of Genetics and Plant Breeding* **58** (3) : 313–7.

Debnath S C, Sarkar K R. 1987. Genetic analysis of grain yield and some of its traits in maize (*Zea mays* L.). *Thailand Journal of Agricultural Sciences* **20** : 263–7.

Gregory L V, Ayers J E and Nelson R R. 1978. Predicting yield losses in corn from Southern corn leaf blight. *Phytopathology* **68** : 517–21.

Kempthorne O. 1957. *An Introduction to Genetic Statistics*. John Wiley and Sons Inc., London.

Khera A S, Rao A V B S, Day S K, Dhillon B S and Malhi N S. 1984. Inheritance of resistance to maydis leaf blight in maize. *Indian Journal Agricultural Sciences* **54** (10) : 881–3.

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Response of greengram (*Phaseolus radiatus*) cultivars to dates of sowing during winter*

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Key words : disease incidence, greengram, varieties, dates of sowing, yield

Greengram (*Phaseolus radiatus* L.) is the most important pulse crop of Orissa. It is grown largely as a winter (*rabi*) crop in rice fallows in the coastal districts. Lack of suitable cold tolerant variety restricts its cultivation during *rabi* season in the inland districts where winter is comparatively more severe. To meet the growing pulse requirement, it is necessary that besides increasing productivity, more area should be brought under the crop. The scope exists in the inland districts both in rainfed lands as a second crop in rice fallows and in irrigated lands as a catch crop in between the 2 principal crops of rice. Performance of greengram genotypes vary as per their photothermal requirement (Rawson and Craven 1979, Faroda *et al.* 1983, Saini and Jaiswal 1991). Hence, a study was undertaken for identification of suitable cold tolerant varieties for cultivation during *rabi* season in the inland districts.

The investigation was carried out at the University's Regional Research Station, Chiplima, Sambalpur during *rabi* season of 1995–97. Eight improved ('TARM 2', 'PDM 54', 'WGG 35', 'MGG 329', 'Dhauli', 'Sujata', 'Pusa 9071', 'K 851' and 4 local ('Banapur local', 'Nayagarh local', 'Rairakhol local' and 'Badelia local') varieties of greengram were evaluated under 2 dates of sowing (1 and 16 November) in factorial randomised block design with 3 replications. The soil was sandy loam with total N of 0.06% and available P and K of 13.6 and 186.4 kg/ha respectively. Sowing was done in line with row spacing of 25 cm using seed rate of 30 kg and fertilizer dose of 20 kg N and 18 kg P/ha. The crop was raised under unprotected condition to study the reaction of varieties to powdery mildew and yellow mosaic virus.

Days to 50% flowering and maturity of the varieties varied in between 50 and 57 and 78 and 90 days respectively (Table 1). 'WGG 35' and 'MGG 329' were the longest duration (90 days) and 'K 851' shortest duration (78 days) to mature. All the 4 local varieties matured in 80–85 days after sowing. Duration of the varieties was not influenced by the dates of sowing. Although days to 50% flowering was more by one week due to delayed sowing on 16 November but the total duration of the different varieties remained practically unchanged irrespective of the dates of sowing.

Yield attributing characters

Yield attributing characters, viz pods/plant, seeds/pod and test weight of seeds varied significantly due to varieties but not due to dates of sowing. 'Nayagarh local' recorded the maximum pods/plant and was significantly superior to rest of the varieties. Next in order were 'Rairakhol local' and 'Banapur local' which were at par and recorded significantly more pods/plant than all the improved varieties. 'MGG 329' recorded the maximum seeds/pod and was at par with 'WGG 35', 'Sujata', 'Banapur local' and 'Nayagarh local'. Variety 'Dhauli' had the least pods/plant and seeds/pod. Test weight of seeds of 'Dhauli', however, was the highest closely followed by those of 'MGG 329', 'PDM 54', 'WGG 35', 'TARM 2' and 'K 851'. Test weight of all the local varieties was significantly lower than those of the improved varieties. The lowest test weight of seeds was recorded with the variety 'Nayagarh local'.

Yield

Different varieties varied significantly in respect of seed yield (Table 1). 'Nayagarh local' being at par with 'Rairakhol local' and 'Banapur local' recorded the highest seed yield. All the three local varieties significantly outyielded the improved ones indicating that the local varieties are comparatively less thermosensitive than the improved varieties. Pods/plant is an important yield attributing character in pulses. Several workers (Sandhu *et al.* 1980, Rahman 1982, Shamsugyaman *et al.* 1982) reported significant positive correlation between pod/plant and seed yield in greengram. Higher seed yield of the local varieties over the improved ones in the study has been due to more pods/plant of the former than the latter. Performance of 'Badelia local', however, was not satisfactory in November sowing. Among the improved varieties 'Sujata' and 'TARM 2' performed comparatively better than the rest. Sowing date had no significant effect on the seed yield of different varieties.

*Short note

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Table 1 Duration, yield components and yield of greengram varieties as influenced by dates of sowing (average of 3 years)

Treatment	Days to 50% flowering	Days to maturity	Pods/plant	Seeds/pod	1000-seed weight (g)	Seed yield (tonnes/ha)
Variety						
'TARM 2'	52	87	10.6	9.5	26.2	0.58
'PDM 54'	53	85	9.9	8.7	28.5	0.47
'WGG 35'	57	90	10.0	10.1	27.3	0.45
'MGG 329'	57	90	9.9	10.3	28.7	0.52
'Dhauli'	55	86	9.8	8.2	29.0	0.50
'Sujata'	54	87	11.3	9.7	24.5	0.63
'K 851'	50	78	10.1	9.4	26.2	0.54
'Pusa 9071'	53	85	10.7	9.5	25.0	0.59
'Banapur local'	51	85	14.2	10.0	23.0	0.96
'Nayagarh local'	52	82	16.5	10.1	21.5	1.01
'Rairakhol local'	52	80	15.0	9.3	22.8	0.97
'Badelia local'	52	83	11.0	9.6	22.0	0.61
SEM ±			0.4	0.2	1.0	0.03
CD ($P = 0.05$)			1.1	0.6	2.8	0.09
Sowing date						
1 November	50	84	11.8	9.5	26.0	0.64
16 November	57	86	11.4	9.6	25.3	0.66
SEM ±			0.2	0.1	0.4	0.01
CD ($P = 0.05$)			NS	NS	NS	NS

Table 2 Incidence of powdery mildew and yellow mosaic virus as influenced by variety and date of sowing

Variety	Incidence of powdery mildew		Incidence of yellow mosaic virus	
	1 Nov sowing	16 Nov sowing	1 Nov sowing	16 Nov sowing
'TARM 2'	Mild	Moderate	Trace	Mild
'PDM 54'	High	High	Trace	Trace
'WGG 35'	High	High	Moderate	Moderate
'MGG 329'	High	High	Mild	Mild
'Dhauli'	High	High	Trace	Trace
'Sujata'	High	High	Trace	Mild
'K 851'	High	High	Trace	Mild
'Pusa 9071'	High	High	Trace	Mild
'Banapur local'	Mild	Mild	Mild	Mild
'Nayagarh local'	Mild	Mild	Trace	Mild
'Rairakhol local'	Moderate	Moderate	Mild	Moderate
'Badelia local'	Mild	Mild	Mild	Moderate

Trace < 2% mild 2–10%, moderate 11–25%, high > 25%

Disease incidence

Incidence of powdery mildew was mild in 'Banapur local', 'Nayagarh local' and 'Badelia local' and moderate in 'Rairakhol local' and 'TARM 2' irrespective of the dates of sowing. All the improved varieties except 'TARM 2' recorded high incidence of powdery mildew in both the dates of sowing (Table 2).

Incidence of yellow mosaic virus, however, has been influenced by the dates of sowing. The crop sown on 16 November, in general was more susceptible to the disease than the crop sown on 1 November. In the crop sown on 1 November, yellow mosaic virus incidence was mild in

'Banapur local', 'Rairakhol local', 'Badelia local' and 'MGG 329', moderate in 'WGG 35' and trace in rest of the varieties. But in the crop sown on 16 November the disease incidence was trace only in 'PDM 54', mild in 'TARM 2', 'Banapur local', 'Nayagarh local', 'MGG 329', 'Sujata', 'K 851' and 'Pusa 9071' and moderate in rest of the varieties.

REFERENCES

Faroda A S, Tomar D P S and Singh R C. 1983. Performance of mungbean varieties under different sowing dates during summer season. *Indian Journal of Agronomy* **28**(1) : 144–7.

Rahman A R M S. 1982. Correlation of path coefficient studies in some quantitative character of mungbean (*Phaseolus aureus* Roxb). *Proceeding of 6–7th Annual Conference of Bangladesh Association for Advancement of Science,* held during 7–11 February 1982 at BARI, Joyedebpur, Dhaka.

Rawson H M and Craven C L. 1979. Variation between short duration moong cultivars (*Vigna radiata* L.) in response to temperature and photoperiod. *Indian Journal of Plant Physiology* **22** : 127–35.

Saini S S and Jaiswal V P. 1991. Response of summer greengram to date of planting. *Indian Journal of Agronomy* **36** (3) : 427–8.

Sandhu T S, Bhuller B S, Cheema H S and Brar J S. 1980. Path coefficient analysis for grain yield and its attribute in greengram. *Indian Journal of Agricultural Sciences* **50** (7) : 541–4.

Shamsugyaman K M, Khan M H R and Sahaikh M A Q. 1980. Genetic variability and character association in mungbean. *Proceeding of 6–7th Annual Conference of Bangladesh. Association for Advancement of Sciences*, held during 7–11 February 1982 at BARI, Joyedebpur, Dhaka.

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Effect of spacing and fertility levels on upland cotton (*Gossypium hirsutum*) in Sundarbans*

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Key words : cotton, *Gossypium hirsutum*, spacing, fertility levels, growth, productivity, net return

Upland cotton (*Gossypium hirsutum* L.) was established in Sundarbans under rainfed conditions during winter (*rabi*) season in rice fallow and saline lands (Samui *et al.* 1993) as this crop has inherent potential to draw moisture from deeper zone by its long tap roots (Reddy *et al.* 1989) and tolerance to soil salinity (Hebbara *et al.* 1996). Spacing and fertility level greatly influence growth and productivity of cotton (Sharma and Tomar 1994. Singh and Nagda 1996). Information regarding spacing and fertility level on growth and productivity of transplanted cotton is meagre with reference to the agro–climatic conditions of Sundarbans. Therefore, the present study was conducted.

A field experiment was conducted at instructional farm of the Kendra during *rabi* season of 1996–98 on clay-loam soil (Entisols) having *p*H 7.1., EC 5.4 dS/m, low organic C (0.47%), medium available N (221 kg/ha), high available P (32 kg/ha) and high available K (276 kg/ha). The treatment comprised of 4 plant spacings (45 cm × 30 cm, 45 cm × 45 cm, 60 cm × 30 cm and 60 cm × 45 cm) and 4 N:P:K levels (40:12.9:16.6, 60:17.2:24.9, 80:21.5:33.2 and 100:25.8:41.5 kg NPK/ha). The experiment was laid out in factorial randomised block design and replicated thrice. The sources of N, P and K were urea, single superphosphate and muriate of potash respectively. Half quantity of N and full of P and K were applied as basal dose and remaining half of N was top-

*Short note

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Table 1 Growth attributes, yield components, seed–cotton yield and net return of upland cotton as affected by spacing and fertility levels (Pooled data of 1996–98)

Treatment	Growth attributes			Yield components		Seed cotton yield (kg/ha)	Net return (Rs/ha)	Benefit : cost ratio
	Monopodia/ plant	Sympodia/ plant	Plant height (cm)	Harvested bolls/plant	Boll weight (g)			
Plant spacings (cm)								
45 × 30	1.58	13.10	70.20	6.90	3.02	1 108	7 071	1.55
45 × 45	1.63	16.20	71.40	11.80	3.11	1 392	12 184	1.95
60 × 30	1.74	16.80	71.80	9.00	3.18	1 436	12 975	2.01
60 × 45	1.76	19.60	73.90	12.50	3.27	1 502	14 164	2.10
SEm±	0.10	0.90	0.73	0.36	0.08	66		
CD (*P*=0.05)	NS	2.54	2.07	1.02	0.23	186		
N:P:K levels (kg/ha)								
40:12.9:16.6	1.57	12.70.	69.20	9.20	2.96	1 146	8 497	1.80
60:17.2:24.9	1.64	16.30	71.90	9.90	3.09	1 309	10 960	1.87
80:21.5:33.2	1.70	17.80	72.80	10.20	3.20	1 421	12 364	1.94
100:25.8:41.5	1.80	18.90	74.30	11.70	3.33	1 562	14 573	2.08
SEm±	0.10	0.90	0.73	0.36	0.80	66		
CD (*P*=0.05)	NS	2.54	2.07	1.02	0.23	186		

The cost of N, P and K was taken as Rs 9.24, Rs 47.24 and Rs 9.96/kg respectively. Price of seed cotton was Rs 18/kg

dressed at pre-flowering stage. Cotton seedlings were raised in polyethylene packets measuring 12.5 cm × 7.5 cm with 150 gauge thickness. Sun-dried and pulverised field soil having above mentioned nutrient status was used as nursery media to fill the packets. 30-day-old seedlings of 'LRA 5166' cotton was transplanted during last week of December in both the years. The crop received 387 mm and 428 mm rainfall during 1996–97 and 1997–98 respectively.

Variation in plant spacing did not influence monopodia/plant, however, sympodia/plant and plant height were significantly higher under 60 cm × 45 cm (Table 1). Harvested bolls/plant was maximum with a spacing of 60 cm × 45 cm and it was closely followed by 45 cm × 45 cm. These treatments were significantly superior to others in increasing number of harvested bolls/plant. Wider spacing of 60 cm × 45 cm gave the maximum boll weight followed by 60 cm × 30 cm. The highest seed cotton yield was obtained under wider spacing of 60 cm × 45 cm and it was closely followed by 60 cm × 30 cm and 45 cm × 45 cm. These treatments recorded significantly more seed cotton yield than closer spacing of 45 cm × 30 cm. Low productivity with closer spacing might be recorded due to over crowding that increased competition among plants. The results are in conformity with the findings of Sharma and Tomar (1994) and Singh and Nagda (1996). Wider spacing of 60 cm × 45 cm increased the net return and gave maximum benefit : cost ratio.

Fertility levels did not increase the number of monopodia /plant. Application of 100:25.8:41.5 kg N:P:K/ha recorded the maximum plant height and sympodia/plant. Harvested bolls/plant, boll weight and seed cotton yield were more with 100:25.8:41.5 kg N:P:K/ha, though it was statistically at par with 80:21.5:33.2 kg N:P:K/ha and they gave significantly higher seed cotton yield than other fertility level (Table 1). High fertility levels of 100:25.8:41.5 or 80:21.5:33.2 kg N:P:K/ha increased the growth attributes and yield components and these ultimately reflected into crop productivity. The results corroborate with the findings of Sharma and Tomar (1994) and Singh and Nagda (1996). The fertility level of 100:25.8:41.5 kg N:P:K/ha recorded the maximum net return and benefit : cost ratio.

REFERENCES

Hebbara M, Patil S G, Majunatha M V and Gupta R K. 1996. Performance of cotton (*Gossypium* species) genotypes under different salinity and water table conditions. *Indian Journal of Agricultural Sciences* **66** (8):446–56.

Reddy K C, Rao G V M M and Sathe A 1989. Active root distribution of different cotton cultivars in Vertisols under rainfed and irrigated conditions. *Journal of Indian Society for Cotton Improvement* **14** (2):121–3.

Samui S K, Barik A, Das S, Pal R and Majumdar R C. 1993. Promotion of cotton and oilseed cultivation under saline Sundarban conditions of West Bengal during *rabi* season. *Journal of Indian Society of Coastal Agricultural Research* **11** (2):119–25.

Sharma R K and Tomar R S S. 1994. Response of upland cotton (*Gossypium hirsutum*) to plant spacing and nitrogen under rainfed condition. *Indian Journal of Agronomy* **39** (2):274–6.

Singh I and Nagda B L 1996. Effect of sowing date, spacing and nitrogen level on upland cotton (*Gossypium hirsutum*). *Indian Journal of Agricultural Sciences* **66** (5):293–4.

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Effect of mango trees on germination, growth and yield of *gobhi sarson* (*Brassica campestris*)

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Key words : gobhi sarson, mango, intercropping

Agroforestry is a sustainable land management system which combines trees and crops simultaneously on same unit of land. It has the potential to increase the productivity of land by bringing it under multiple land-use. Of the various agroforestry systems, agri-horticultural system is most prevalent in Himachal Pradesh. In subtropical zone , mango and citrus are the important cash crops. Since land holding is very small in Himachal Pradesh, therefore, farmers grow field crops as intercrops in mango orchards. *Gobhi sarson* is common intercrop in mango orchards in Kangra district, which comprises of more than 80 % area under mango in the state. As both, the trees and crops share a common environment, interactions which result in competition for moisture, light, nutrients etc. are inevitable (Tomar and Shrivastva 1986). Chemical influence of trees on agricultural crops is least studied in many agroforestry systems. Toxic substances called allelochemicals are released through leachates from leaf litter during irrigation or rainfall. These phytotoxins affect seed germination and growth of understorey crops. Keeping above facts in view, a study was conducted to study the allelopathic and shade effect of mango on germination, growth and yield of *gobhi sarson.*

The studies were conducted at Progeny cum demonstration orchard, at Jachh (420 m above MSL with 32° 18' N latitude and 75° 55' E longitude). The mean annual rainfall is about 1 500 mm. The mean winter and summer temperature was 13.6–29.3°C. Soil was loamy clay, neutral in reaction and medium in available N, P and K. The mango plants of different height classes H_1 (1.00 – 2.00 m), H_2 (2.00 – 4.00 m) and H_3 (4.00 – 6.00 m) respectively growing in east to west direction in rows spaced 9 m apart were selected for present studies. The distance between plant to plant was 4 m. Plots of 2 m × 2 m were marked in already sown *gobhi sarson* crop at distances of 0.5 – 2.5 m (D_1) and 2.5 – 4.5 m (D_2) in North (N) and South (S) directions at right angle to mango tree line leaving 1 m wide strip (0.5 m on each side) as tree basin. The trial consisted of 12 possible combinations of 3 height classes, 2 directions, 2 distances and a control (pure isolated *gobhi sarson* plot) with 2 replications. At the time of *gobhi sarson* maturity, data were recorded on plant growth and yield.

Leaf leachate of mango was prepared by immersing 100 g fresh leaves in 1.0 l water for 24 hr. The solution was filtered through Whatman filter paper and the filtrate was kept in refrigerator at 2–4°C to avoid any fungal growth. Ninety seeds (30 in each replication) of *gobhi sarson* were germinated in petri-dishes lined with filter paper. The seeds were saturated daily with 2 ml leachate and distilled water was used as control. Per cent seed germination, seedling growth and fresh weight were recorded 14 days after seed sowing (Koul *et al.* 1991). Vigour index was calculated as a product of seedling length and germination (Abdul Baki and Anderson 1973). The data were analysed statistically using a computed analysis of variance, ANOVA and t-test (Panse and Sukhatme 1976).

Growth and yield parameters, viz plant height, branches/ plant, pods/plant and yield/plot were found to be affected significantly by mango tree height, direction and distance from mango trees (Table 1).

The height of *gobhi sarson* plants growing in the vicinity of smallest mango trees (H_1) was reduced. However, other growth parameters except pod length were the highest under H_1. Similarly, the plants growing on southern side of the mango trees were smaller in height in comparison to those growing on northern side. The *sarson* plants bordering mango trees were taller . Harmful effects of trees on agricultural crops have been increasingly noticed with increase in size and age of trees (Harsh and Tiwari 1993) and decrease in distance from the trees (Sharma and Sharma 1994).

Contrary to height, *gobhi sarson* plants growing with small mango trees gave more number of branches as well as pods/plant than those plants growing with tall trees. The plants facing south gave more branches and pods than those facing the north. With increasing distance from mango trees, the number of branches and pods increased significantly. Pod length did not reveal any consistent and significant effect with height and distance from the mango trees. However, it was significantly higher in the plants growing southwards.

Yield of *gobhi sarson* was affected drastically by height, direction and distance from mango trees. It was 80 % higher

Table 1 Effect of mango tree height, direction and distance from tree trunk on growth and yield of *gobhi sarson*

Treatment	Height (m)	Growth		Pod length (cm)	Yield (g/plot)
		Branches/plant (Number)	Pods/pant (Number)		
Tree Height (m)					
1.00–2.00	1.08	3.91	89.32	5.82	67.87
2.00–4.00	1.16	2.74	81.17	5.91	51.88
4.00–6.00	1.27	2.60	53.20	5.83	37.62
CD (P=0.05)	0.03	0.18	1.91	NS	3.46
Direction (m)					
North	1.20	2.82	60.72	5.80	40.75
South	1.14	3.35	88.41	5.90	64.17
CD (P=0.05)	0.02	0.15	1.56	0.09	2.82
Distance (m)					
0.5–2.5	1.19	2.84	64.30	5.86	45.58
2.5–4.5	1.15	3.33	84.83	5.84	59.33
CD (P=0.05)	0.02	0.15	1.56	NS	2.82

Table 2 Effect of leaf leachates of mango on germination and growth of *gobhi sarson*

Treatment	Germination (%)	Growth parameters				
		Height (cm)	Root length (cm)	Seedling weight (mg/plant)		Vigour index
				Fresh	Dry	
Tap water	86.66 ± 10.00	6.9 ± 1.0	6.4 ± 1.8	50.8 ± 6.0	3.0 ± 1.0	11525.8 ± 1771.1
Mango leaf Leachate	93.33 ± 5.77	6.7 ± 1.0	4.8 ± 2.0	40.0 ± 9.0	3.0 ± 1.0	11323.6 ± 2286.2
't' 0.05	2.24	NS	2.31	3.58	NS	NS

under the smaller mango trees (H_1) compared with the tall trees (H_3). Like-wise, yield was 57 % higher in south direction. The yield increased by about 30 % with the increase in distance from D_1 to D_2. This could be ascribed to shade effect for longer period which becomes more pronounced with increase in height and crown spread of mango trees. Significant negative effect of tree shade on crop yield have been reported by Jama and Getahun (1991). Higher yield/plot in south direction may be due to the longer photosynthetic activity of *gobhi sarson* plants as the south direction faces sun for a longer period in a day as compared to the north direction.

Germination was enhanced significantly by leaf leachate of mango (Table 2). Leaf leachate had no significant effect on height, dry weight and vigour index of *gobhi sarson* plants, however, root length and seedling dry weight were found to be substantially reduced. Sharma *et al.* (1997) have observed significant reduction in growth, fresh as well as dry weights and vigour index of wheat seedlings with leaf leachates of several tree species. It is evident from the findings that not only mango tree size, shade and direction affect the yield of *gobhi sarson* plants yet leaf leachate of mango is also responsible for hampering growth and development of *gobhi sarson*.

Thus, *gobhi sarson* can be successfully grown with young mango trees on southern side at a distance of 2.5 m from mango trees without adverse effects on growth and yield of *gobhi sarson*.

REFERENCES

Abdul Baki A and Anderson, J D . 1973. Vigour determination in soybean seed by multiple criteria. *Crop Science* **13** : 630 – 3.

Harsh L N and Tiwari J C. 1993. Tree crop interactions in agroforestry practices. (in) *Agroforestry for Rural Needs*, pp 535–41. Khurana D K and Khosla P K (Eds). Indian Society of Tree Scientist, Solan.

Jama B and Getahun A. 1991. Intercropping *Acacia albida* with maize (*Zea mays*) and green gram (*Phaseolus aureus*) at Mtuapa, Coast province, Kenya. *Agroforestry Systems* **14** : 193–205.

Koul V K, Raina A, Khanna Y P, Tickoo M L and Singh H. 1991. Evaluation of allelopathic influence of certain farm grown tree species on rice (*Oryza sativa* L.c.v. PC 19). *Indian Journal of Forestry* **14** (1) : 54–7.

Panse V G and Sukhatme P V. 1976. *Statistical Methods for Agricultural Workers*. ICAR, New Delhi, pp 359.

Sharma K, Dhiman R C and Joshi N K. 1997. Allelopathic effect of some tree species on wheat (*Triticum aestivum* L.). *Journal of Research, BAU* **9** (1) : 101 – 5.

Sharma K and Sharma I M. 1994. Performance of wheat under shade of boundary - planted grey gum (*Eucalyptus tereticornis*). *Indian Journal of Agricultural Sciences* **64** (8) : 574–5.

Tomar G S and Shrivastava S K. 1986. Preliminary studies of rice cultivation in association with trees. *(in) Agroforestry Systems – A New Challenge*, pp 207–11. Khosla P K, Puri S and Khurana D K (Eds). Indian Society of Tree Scientists, Solan.

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Leaf nutrients limit for optimum yield of Nagpur mandarin (*Citrus reticulata*)*

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Key words : leaf nutrient limits, optimum yield, quadratic response, Nagpur mandarin

Nagpur mandarin (*Citrus reticulata* Blanco) one of the most important citrus cultivars grown in India with a total citrus production of 3.9 million tonnes from an acreage of 0.45 million ha (Srivastava and Singh 1999). No systematic fertilizer schedule based on the current nutrient constraints of orchards is followed due to absence of information on leaf nutrient limit *vis–a–vis* optimum productivity. Resultantly, as low as 2% mandarin orchards receive recommended doses of fertilizers in the central India (Deshmukh *et al.* 1988) which induces not only nutrient deficiency in the orchards year after year owing to wide gap between the quantum of nutrients applied and removed but the longevity of these orchards is also limited to a considerable extent.

Unstability in the production due to nutritional constraints is another problem usually associated with the mandarin orchards of central India which can be effectively streamlined through the judicious use of fertilizers via suitable leaf nutrient standards suiting to the nature of soil, climate and growth habit of the cultivar having distinct agro–ecological preference of hot sub-humid tropical climate. Hence, an investigation was made to determine the leaf nutrients limit for optimum productivity of Nagpur mandarin grown in central India.

A survey of 48 Nagpur mandarin orchards was carried out during 1995–96 in six major citrus growing tehsils of Nagpur district, namely Kalmeshwar, Katol, Narkhed, Ramtek, Saoner and Hingna. The leaf samples from non-fruiting terminals on all the 4 directions at an height of 1.5–1.8 m from the ground were collected from the earmarked trees following the leaf sampling technique as described by Srivastava *et al.*(1994). The soil samples (0–15 cm depth) were collected simultaneously from the periphery of the selected trees, fruit yield/tree was also recorded.

Thoroughly cleaned and dried (65°C for 48 hrs) leaf samples were digested in diacid having three parts H_2SO_4 plus 1 part $HClO_4$. The N in soil (Subbiah and Asiza 1956) and leaf samples was determined titrimetrically using alkaline permanganate method, P was determined colorimetrically using vanadomolybdo phosphoric acid in leaf samples (Kitson and Mellon 1944) and stannous molybdophosphoric acid method in soil samples (Olsen *et al.* 1954) and K flame photometrically. The Ca and Mg were determined using the versene titration method (Cheng and Bray 1951). The micronutrients in soil was determined using atomic absorption spectrophotometer after extracting the samples with DTPA (*p*H 7.3) following the procedure of Lindsay and Norvell (1978), while acid digests of leaf samples were directly analysed for micronutrients. The reliability of soil or leaf analysis versus fruit yield was compared through bivariate linear and quadratic correlation analyses based on which multivariate quadratic response models were developed to find out the optimum nutrient limit in relation to fruit yield of Nagpur mandarin.

Variation in soil fertility and leaf nutrient composition

The data on orchard age, fruit yield, fertility status of soil and leaf nutrients composition (Table 1) showed large variation except soil/leaf K, Ca and Mg since the soils were derived from Ca + Mg rich parent material having uniform montmorillonitic mineralogy.

Relationship of leaf nutrient content and soil available nutrients with fruit yield

A significant correlation of leaf N (r =0.831), P (r =0.461), Fe (r = 0.716), Mn (r = 0.624) and Zn (r = 0.761) with fruit yield was observed in quadratic than non-significant linear correlations except Ca and Mg. Using the linear and quadratic correlation coefficients, the fruit yield was better correlated with soil available Ca + Mg (r = 0.446 and 0.728) than leaf Ca (r = 0.082 and 0.061) or Mg content (r = 0.091 and 0.121). These observations indicated leaf analysis, a better tool of identifying the nutritional problems. While to find out Ca and Mg nutrition, soil analysis proved better than leaf analysis. The studies in the past have shown the better reliability of leaf than soil analysis for diagnosing the nutrient constraints of citrus orchards (Embleton *et al.* 1973, Srivastava *et al.* 1993).

*Short note

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Table 1 Variation in soil fertility and leaf nutrient content mandarin orchards

Orchards parameters	Range	Coefficient of variation (%)
Orchard age (years)	8–30	24.6
Fruit yield		
Fruit/tree	86–100	72.5
kg/tree	11.6–123.3	52.8
Soil fertility status		
Available N (mg/kg)	68.7–229.2	48.4
Available P (mg/kg)	4.8–18.7	28.2
Available K (mg/kg)	180–280	18.0
NH4OAC (pH 7.0), Ca+Mg	1562.4–3477.6	42.5
DTPA–Zn (mg/kg)	0.34–1.04	32.0
DTPA–Fe (mg/kg)	6.4–18.4	28.9
DTPA–Mn (mg/kg)	9.1–24.3	24.2
DTPA–Ca (mg/kg)	0.9–4.1	27.2
Leaf nutrient content		
Nitrogen (%)	1.78–2.67	20.6
Phosphorus (%)	0.06–0.17	42.4
Potassium (%)	0.56–1.92	24.2
Calcium (%)	1.0–2.0	20.0
Magnesium (%)	0.20–0.54	24.4
Zinc (ppm)	1.2–19.1	72.0
Iron (ppm)	88.8–483.7	68.1
Manganese (ppm)	8.1–128.6	71.6
Copper (ppm)	2.0–50.0	72.5

Nutrient constraints of mandarin orchards

The nutrient constraints of mandarin orchards were identified using soil and leaf analysis.

Soil analysis: Considering optimum level of available N and P as 126–250 ppm (Subbiah and Asiza 1956) and 12.6 – 22.5 ppm (Olsen *et al.* 1954) respectively, available N and available P in 45.8 and 8.3% orchards was in optimum range. Another 54.2 and 91.7% orchards were low in available N and P respectively. On the other hand, all the orchards were high in available K considering 90–100 ppm (Du Plessis 1977) as an optimum limit of available K.

Soil micronutrient analysis further showed that all the orchards were optimum in available Fe, 89.6 % in available Mn, 100% orchards in available Cu and 31.3% orchards in available Zn using critical levels of Fe 4.0 ppm (Jones 1980), Mn 10.0 ppm (Lindsay and Norvell 1978), Cu 0.5 ppm (Jones 1980) and optimum limit of available Zn as 0.60 to 1.00 ppm (Reisenaur 1978). The other 10.4 and 68.7% orchard were low in available Mn and Zn respectively. In the absence of any well defined and acceptable soil available nutrient standards, the nutritional problems of mandarin orchards are often erratically identified, unless it is supplemented by soil test-crop response studies.

Leaf analysis: The leaf nutrient standards developed by the University of California (Embleton *et al.* 1973) are used worldwide for identifying the nutrient constraints of citrus orchards. They suggested the optimum values of N as 2.4–2.6%, P 0.12–0.16%, K 0.70–1.09%, Ca 3.5–5.5%, Mg 0.26–0.60%, Fe as 60–120 ppm, Mn 25–200 ppm, Cu 5–16 ppm and Zn 25–100 ppm. On the basis of the above limits, 45.8% orchards were deficient in N and P, while 64.6% orchards were high in K but the crop response studies have indicated response of K fertilization to Nagpur mandarin @ 300 g K_2O/tree/year in Typic Chromustert soil (Kohli *et al.* 1995). Amongst micronutrients, 81.2, 16.7 and 54.2% orchards were optimum in Fe, Mn and Cu respectively while as much as 63.4% orchards were Cu deficient level. These observations revealed that the above standards were not entirely applicable to Nagpur mandarin under the sub-humid tropical climate of central India.

Considering the better correlationship of leaf nutrients content with fruit yield than soil available nutrients, 2 multivariate quadratic response models were developed using leaf nutrients content and fruit yield.

Leaf nutrient limit in relation to optimum yield: The optimum leaf macronutrients were fixed using the following multivariate quadratic response model :

$$Y \text{ (fruit yield)} = -2001.52 - 652.72\times1 \text{ (Leaf N)} + 100012.00\times2 \text{ (Leaf P)} - 432.51\times3 \text{ (Leaf K)} + 3024.12\times4 \text{ (Leaf Ca)} + 5023.21\times5 \text{ (Leaf Mg)} + 382.27\times12 + 56123.25\times22 + 132.42\times32 - 920.24\times42 - 3612.62\times52 \qquad (R^2 = 0.876)$$

Using the above model, the optimum level of N was observed as 2.24, P 0.072, K 1.42, Ca 1.32 and Mg 0.48% for optimum fruit yield of 675.17 fruits. The earlier studies on Coorg mandarin have shown optimum level of leaf N and K as 2.91 to 3.15 and 1.51 to 1.10% respectively (Anonymous 1980). Chahill *et al.* (1991) suggested optimum value of leaf N as 2.28, P 0.15% and K as 1.57% for Kinnow mandarin.

The optimum leaf micronutrients were worked out following the multivariate quadratic response model as given below :

$$Y \text{ (fruit yield)} = 2890.45 + 8.62\times1 \text{ (Leaf Fe)} + 44.20\times2 \text{ (Leaf Mn)} + 192.82\times3 \text{ (Leaf Cu)} - 348.10\times4 \text{ (Leaf Zn)} - 0.042\times12 - 0.62\times22 - 9.10\times33 + 6.04\times42 \qquad (R^2 = 0.721)$$

Using the above model, optimum levels of leaf Fe content was noted as 132.12, Mn 32.26, Cu 12.12 and Zn 18.60 ppm for optimum fruit yield of 692.00 fruits. The studies by Chahill *et al.*(1991) have indicated optimum limits of leaf Fe, Mn, Zn and Cu as 61, 20, 18 and 4 ppm respectively for Kinnow mandarin. While, Singh and Tripathi (1985) recorded 20 ppm leaf Zn level as critical limit for delineation between declining and healthy orchards.

The 60.4, 39.6 and 58.3% orchards were observed to contain sub-optimum level of leaf N, P and K respectively

Table 2 Nutrient constraints of Nagpur mandarin orchards using different indices

Nutrient	Leaf nutrient indices*					Nutrient constraints based on suggested optimum leaf nutrient limit	
	Deficient	Low	Optimum	High	Excess	Optimum	Sub-optimum
N	22 (45.8)**	14 (29.2)	7 (14.6)	5 (10.4)		19 (39.6)	29 (60.4)
P	22 (45.8)	12 (25.0)	12 (25.0)	2 (4.2)		29 (60.4)	19 (39.6)
K		6 (12.5)	11 (22.9)	31 (64.6)		20 (41.7)	28 (58.3)
Ca	17 (35.4)	31 (64.6)				42 (87.5)	6 (12.5)
Mg		9 (18.8)	39 (81.2)			2 (4.2)	46 (95.8)
Fe			8 (16.7)	11 (22.9)	29 (60.4)	36 (75.0)	12 (25.0)
Mn		10 (20.8)	38 (79.2)			29 (60.4)	19 (39.6)
Cu			26 (54.2)	8 (16.7)	14 (29.1)	16 (25.0)	32 (75.0)
Zn	40 (63.4)	4 (8.3)	4 (8.3)			8 (16.7)	17 (83.3)

* Based on standards developed by Embleton *et al.*(1973)

** Figures in paranthesis indicate percentage of orchards

(Table 2). While rest of the 39.6, 60.4 and 41.7% orchards were optimum in leaf N, P and K respectively. Similarly, 87.5% orchards were found to be optimum in leaf Ca and 95.5% orchards sub-optimum in leaf Mg content. While 25.0, 39.6, 75.0 and 83.3% orchards were having sub-optimum level of leaf Fe, Mn, Cu and Zn respectively. The optimum levels of leaf Fe, Mn, Cu and Zn were observed in 75.0, 60.4, 25.0 and 16.7% orchards respectively. Kharkar *et al.*(1991) observed deficient to low range of phosphorus, optimum to high range of manganese as well as iron and excessive level of copper in mandarin orchards of Vidarbha region.

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REFERENCES

Anonymous. 1980. *Mandarin Cultivation*. Extension Bulletin. Citrus Experiment Station. Indian Institute of Horticultural Research, Bangalore, pp 9.

Chahill B S, Dhatt A S, Singh, Raghbir and Dhillon D S. 1991. Studies on the leaf nutrient standards in Kinnow. *Indian Journal of Horticulture* **48** : 315–20.

Cheng K L and Bray R H. 1951. Determination of calcium and magnesium in soils and plant materials. *Soil Science* **50** : 239–52.

Deshmukh P P, Bagde T R, Deshpande V B and Damle S B. 1988. *Two decades of Research on Fruits in Vidarbha.* (1969–1987). Directorate of Research, Punjabrao Krishi Vidyapeeth, Akola, Maharashtra, pp 2.

Du Plessis 1977. Soil analysis as a necessary compliment to leaf analysis for fertilizer advisory purposes. *Proceeding of International Society of Citriculture* **1** : 15–19.

Embleton T W, Jones W W, Labananskas C K and Reuther W. 1973. Leaf analysis as a diagnostic tool and guide for fertilization. (*in*) *Citrus Industry*, Vol III, pp 183-210. Reuther W (Ed) University of California, Division of Agriculture Science, Berkeley, California, USA.

Jones J B. 1980. *Handbook on Reference Methods for Soil Testing*, pp 82. Council for Soil Testing and Plant Analysis, Athens, Georgia, USA.

Kharkar P T, Deshmukh P P, Bagde T R and Zade K B. 1991. Nutritional status of healthy and declined orchards of Nagpur mandarin in Vidarbha region. *Annals of Plant Physiology* **5** : 24–9.

Kitson R E and Mellon M G. 1944. Colorimetric determination of phosphorus as molybdivana-do-phosphoric acid. *Industrial Engineering and Chemical Analysis* **16** : 379–83.

Kohli R R, Lallan Ram, Huchche A D and Srivastava A K. 1995. *Nutrient management studies in Nagpur mandarin.* Annual Report. National Research Centre for Citrus, Nagpur, pp 13–25.

Lindsay W L and Norvell W A. 1978. Development of DTPA test for zinc, iron, manganese and copper. *Soil Science Society of American Journal* **42** : 421–8.

Olsen S R, Cole C V, Watanabe F S and Dean L A. 1954. *Estimation of available phosphorus in soils by extraction with sodium bicarbonate.* United States Department of Agriculture Circulation, pp 639.

Reisenaur H M. 1978. *Soil and plant tissue testing in California.* Bulletin 1879. California Corporation of Extension Service, Davis, USA pp 42.

Singh, Vinay and Tripathi B R 1985. Studies on chlorosis in sweet orange in Agra region of Uttar Pradesh. *Journal of Indian Society of Soil Science* **33** : 333-8.

Srivastava A K, Kohli R R, Dass H C, Huchche A D and Lallan Ram 1993. Role of leaf analysis in citrus cultivation. *VIII Biennial Workshop on Tropical Fruits*, Periyakulam, Madurai, Tamil Nadu.

Srivastava A K, Lallan Ram, Huchche A D, Kohli R R and Dass H C. 1994. Standardization of leaf sampling technique in Nagpur mandarin under sub-humid tropical climate. *Indian Journal of Horticulture* **51** : 32–6.

Srivastava A K and Singh, Shyam. 1999. Recent trends in citrus production research. Souvenir. *International Symposium on Citriculture*, held during 23–27 November, at Nagpur (Maharashtra), pp 174–91.

Subbiah B V and Asiza G L. 1956. A rapid procedure for determination of available nitrogen in soils. *Current Science* **25** : 259.

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Production of lignolytic enzymes and degradation of paddy husk by *Cyathus* spp*

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Key words : paddy husk, *Cyathus* spp, lignin degradation, weight loss, lignolytic enzymes

It is known that the white rot fungi are the most capable microorganisms to degrade lignin (Kirk 1983). Abbott and Wicklow (1984) have observed that *Cyathus* spp have unique substrate preference but differ in their ability to attack the substructures of the native lignin as well as other lignocellulosic complexes. Most of the studies on the mechanism of degradation of lignin have been made using *Phanerochaete chrysosporium*. However, no economically acceptable process is presently available (Wood 1985). Keeping this in view, it was decided to screen 4 species of *Cyathus*, a white rot fungus, for their ability to produce extracellular lignolytic enzymes and thereby, bring about decomposition of paddy husk.

Organisms: Cyathus bulleri (Brodie 195062), *Cyathus africanus* (Brodie 196686), *Cyathus striatus* (Huds.). wild.ex.pers. (196675) and *Cyathus stercoreus* (Schw) de Toni (196676) were used for the study. The cultures were grown and maintained on Brodie's agar medium (BAM) (Brodie 1975) at 4°C and subcultured every month . Growth rate for each of the fungal cultures was estimated by dividing the average colony diameter (three colonies) by the number of days (at 10 days) for which colony growth on individual plates of BAM was recorded.

Paddy husk was obtained from paddy processing mills. It was first dried in an oven at 80°C for 1–2 hr and then crushed with high speed grinder. A modified version of Brodie's medium (Brodie 1975) as described by Chander (1984) was used containing/litre: KH_2PO_4, 0.5 g ; $MgSO_4$ .7 H_2O, 0.5 g; $Ca(NO_3)_2.4H_2O$, 0.5 g; $FeSO_4.7H_2O$, 3.0 mg; asparagine, 0.2 g; peptone, 0.2 g; yeast extract, 2.0 g. The *p*H of the medium was adjusted to 6.5.

Fifty ml of the basal medium was poured in a 250 ml erlenmeyer flask containing 5.0 g paddy husk and sterilized. The flasks were inoculated with 2 inoculum discs (8 mm dia.) and incubated at 26 ± 1°C for 40 days. The uninoculated media incubated in a similar manner served as the control. After incubation the cultures were harvested by filtering through pre-dried and pre-weighed whatman filter paper. The mycelium and undegraded substrate (mycohusk) along with the filter paper was dried at 70°C. The culture filtrate was used for the assay of enzymatic activities.

Enzyme assays: Laccase (p–diphenol oxygen oxidoreductase) activity was determined spectrophotometrically by the oxidation of guaiacol as described by Froehner and Eriksson (1974). Catechol oxidase (polyphenol oxidase) was assayed by the method of Mayer and coworkers (1965). Peroxidase activity was determined spectrophotometrically by oxidation of pyrogallol to purpurogallin in presence of H_2O_2.

One enzyme unit was defined as the amount of enzyme which causes an absorbance change of 0.01/min under the assay conditions. Tannic acid oxidase production was assayed by the method of Davidson and coworkers (1938). Total phenols in the culture filtrates were estimated using the Folin Ciocalteu method (Bray and Thorpe 1954). Lignin content of paddy husk was determined by modified Klason Lignin Assay method. Ash yield was determined by combusting a known amount of substrate in a muffle furnace at 750°C in an oxygen atmosphere. Combustion was carried out until there was complete oxidation of the organic carbon present. All the results are an average of 3 replicates.

The growth rate and biomass production by all the 4 species of *Cyathus* grown on paddy husk are given in Table 1. *C.striatus* and *C.africanus* gave higher biomass yield of 4.420 and 4.399 g compared with the 4.308 and 4.205 g by *C.stercoreus* and *C.bulleri* respectively. *C.bulleri* exhibited highest rate of growth, whereas *C. stercoreus* showed least growth rate. Though *C.bulleri* has highest growth rate, biomass production was least as compared to other species of *Cyathus*.

A perusal of data in Table 1 indicates total weight loss, lignin loss and ash yield of paddy husk. *C. striatus* brought about highest lignin loss but effected comparatively less total weight loss. The reason could be that it produced more of lignin-degrading enzymes and other components of paddy husk were not degraded. Reverse was true for *C. bulleri*; it effected maximum weight loss but minimum lignin loss.

*Short note

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Table 1 Growth rate (on BAM), biomass production, phenol content, total weight loss, lignin loss and ash yield during lignolysis of paddy husk

Organism	Growth rate (mm/day)	Biomass (mycelium +residual substrate) (g)	C.F.left/ flask (ml)	Final *p*H of fermentation broth	Final phenol content (µg/ml)	Weight loss (%)	Lignin loss (%)	Ash yield (%)
Control (Uninoculated)	(±0.008)	4.899 (±0.0)	50.0 (±0.0)	6.5 (±0.0)	130			13.2
C. bulleri	8.1	4.205 (±0.09)	23.0 (±2.02)	5.9 (±0.14)	31.5 (±1.76)	15.9 (±0.91)	10.47	20.7
C. africanus	6.5	4.399 (±0.12)	20.0 (±1.04)	5.9 (±0.17)	41.0 (±4.94)	12.02 (±0.82)	12.41	21.0
C. striatus	6.1	4.420 (±0.089)	19.5 (±0.7)	5.6 (±0.00)	37.0 (±4.6)	11.6 (±0.79)	15.52	19.3
C. stercoreus	3.1	4.308 (±0.029)	22.0 (±0.98)	7.5 (±0.29)	125 (±2.62)	13.84 (±0.82)	11.2	22.0

CF, Culture filtrate

Table 2 Lignolytic enzymes by *Cyathus* spp growing on paddy husk

Organism	Laccase activity		Catechol oxidase activity		Peroxidase activity		Tannic acid oxidase activity after 12 days incubation (zone dia in mm)
	I U	Production/litre	I U	Production/litre	I U	Production/litre	
C.bulleri	37.1 (±1.48)	37 100	4.1 (±0.10)	4100	5.4 (±0.042)	5 400	80.0 (±5.2)
C.africanus	43.5 (±1.76)	43 500	11.0 (±0.2)	11000	10.0 (±0.28)	10 000	67.0 (±3.6)
C.striatus	92.0 (±12.79)	92 000	40.5 (±4.0)	40500	9.1 (±0.32)	9 100	58.0 (±2.2)
C.stercoreus	59.2 (±5.96)	59 200	33.0 (±3.8)	33000	14.2 (±0.92)	14 200	56.0 (±2.5)

IU= International unit
Values in parentheses represent standard deviation

At less alkaline *p*H, the loss in dry weight was low (i e low degradation rate) while at more alkaline *p*H, the weight loss was greater. Maximum ash yield was observed with *C. stercoreus* (22%) which also corresponds with more alkaline *p*H. *C. striatus* recorded lowest ash yield which also corresponded with maximum lignin loss (15.52%) because it showed considerably higher production of lignin degrading enzymes. Though *C.stercoreus* produced fairly good amount of laccase, peroxidase and catechol oxidase, it was not reflected in terms of per cent lignin loss. Abbott and Wicklow (1984) have also observed that *Cyathus* spp have unique substrate preference but also differ in their ability to attack the substructures of the native lignocellulosic complexes.

All the four species of *Cyathus* were found to produce lignolytic enzymes such as laccase, peroxidase, catechol oxidase and tannic acid oxidase (Table 2). Maximum laccase and catechol oxidase activity were recorded in case of *C.striatus* (92 and 40.5 enzyme units/ml respectively) followed by *C. stercoreus* (59.2 and 33 enzyme units/ml respectively) which also corresponds with highest lignin loss. Peroxidase activity was also found to be highest in case of *C.stercoreus* (14.2) followed by *C. africanus* (10) and *C.striatus* (9.1 enzyme units). *C.bulleri* was found to secrete high activities of tannic-acid oxidase but showed least laccase, catechol oxidase and peroxidase activities.

C. striatus and C.stercoreus may be used for degrading the lignocellulosic substrates like paddy husk.

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REFERENCES

Abbott T P and Wicklow D T. 1984. Degradation of lignin by *Cyathus* species. *Applied and Environmental Microbiology* **47** : 585–7.

Bray H G and Thorpe W V. 1954. Analysis of phenolic compounds of interest in metabolism. *Methods in Biochemical Analysis* **1** : 27–52.

Brodie H J. 1975. *The Bird's Nest Fungi*, pp 199. University of Toronto Press, Toronto.

Chander R. 1984. 'Decomposition of lignocellulose by species of white–rot fungus *Cyathus*'. Ph D thesis, Bhopal University, Bhopal.

Davidson R W, Campbell W A and Blaisdell D J .1938. Differentiation of wood–decaying fungi by their reactions on gallic or tannic acid medium. *Journal of Agricultural Research* **57** : 683–95.

Froehner S C and Eriksson K E. 1974. Induction of *Neurospora crassa* laccase with protein synthesis inhibitors. *Journal of Bacteriology* **120** : 450–7.

Kirk T K. 1983. Degradation and conversion of lignocelluloses. (*in*) *The Filamentous Fungi. Fungal Technology*, Vol 4, pp 265–95. Smith J E, Berry D R and Kristiansen B (Ed). Edward Arnold, London.

Mayer A M, Harel E and Benshaul R. 1965. Assay of catechol oxidase – a critical comparison of methods. *Phytochemistry* **5** : 783–9.

Wood D A.1985. Useful biodegradation of lignocellulose. *Annual Proceedings of Phytochemical Society of Europe* **26** : 295–309.

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Gene effects for some quantitative characters in soybean (*Glycine max*) crosses*

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Key words : *Glycine max*, soybean, gene effects, epistasis

Soybean [*Glycine max* (L.) Merr.] is a major oilseed crop in the world and has occupied third place in India among the 9 oilseed crops, next to groundnut and rapeseed–mustard. In India it has been grown on about 5.8 million ha area during 1997–98 season with 6.53 million tonnes annual production and 1 126 kg/ha average productivity. Recently, India has achieved self-sufficiency in oilseed production during VIII plan. However, to meet the demand of increasing population in the country, oilseed production programme needs to be augmented through breeding for economically important characters with high yield potential. For increasing the productivity it is necessary to evolve high yielding varieties with resistance to biotic and abiotic stresses and value added characters. Success in breeding for desirable genotypes depends on knowledge of genetic architecture of different characters. Hence, an attempt was made to study the genetic analysis of some important quantitative characters in three soybean crosses.

Three soybean crosses, viz 'Hardee' × 'MACS 13', 'Hardee' × 'MACS 124' and 'Hardee' × 'MACS 346' were made and subsequent generations were raised in the following rainy season *kharif*. Three separate replicated trials of respective crosses consisting of parents, F_1, F_2 and F_3 generations were grown at the Institute's experimental farm at Hol (District Pune) during 1994–95 in *kharif* season. In each trial, parents and F_1's were represented by one row, F_2 by 4 rows and F_3 by 20 rows/replication. Each row consisted of 30 plants with 10 and 45 cm distance within and between rows, respectively. Data were recorded on five randomly selected

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Table 1 Estimates of gene effects for seven characters in three crosses of soybean

Cross	Parameter	Characters						
		Plant height (cm)	Pods/ plant	Seeds/ plant	Yield/ plant (g)	Oil content (%)	Seeds/ pod	100-seed weight (g)
'Hardee '×' MACS 13'	m	47.72	104.16	174.69	25.54	18.83	1.72	14.48
	d	4.24**	2.10	7.14	2.98*	0.83**	–0.01	–1.48**
	h	21.51**	63.19**	106.30**	18.13**	0.08	0.02	1.35
	l	–25.97*	6.99	41.84	4.35	1.44	0.08	–1.63
	i	22.76**	11.26	33.01	9.65*	0.89**	0.15	3.21**
'Hardee '×' MACS 124'	m	–57.60	93.10	156.28	–22.59	19.64	1.72	14.45
	d	–10.37**	1.24	–10.40	–1.92	–0.74**	–0.15*	–0.24
	h	4.04	22.47	53.74**	8.72**	2.41**	0.14	–0.41
	l	59.68**	22.99	72.40	40.32**	–4.77**	0.24	16.61**
	i	–37.04**	–4.71	–15.24	–10.46**	3.65**	–0.08	–5.24**
'Hardee '×' MACS 346'	m	66.60	88.36	163.06*	25.97	19.85	1.87	16.12
	d	–2.04	–9.00	–15.63	–3.28	–1.00**	–0.01	–0.49
	h	36.47**	–4.35	21.86	4.41	1.18**	0.30**	0.79
	l	–100.53**	161.65**	266.32**	49.47**	–5.20**	–0.40	1.71
	i	23.86**	–57.55**	–90.87**	–17.98**	2.70**	0.10	–1.75

**, *Significant at P=0.01 and 0.05 respectively

plants per row on seven quantitative characters (Table 1). Gene effects were estimated by using 5 parameter model given by Hayman (1958).

Analysis of variance for generation means indicated significant differences among the means for most of the characters. Scale tests and joint scaling test revealed epistatic gene interaction in 12 cross-character combinations out of 21 combinations. Gene effects showed additive gene effects to be significant in the inheritance of plant height in 'Hardee' × 'MACS 13' and 'Hardee' × 'MACS 124', oil content in all the 3 crosses and 100-seed weight in 'Hardee' × 'MACS 13' (Table 1). Dominance gene effects were significant for plant height, pods/plant, seeds/plant and yield /plant in 'Hardee' × 'MACS 13', for seeds/plant, yield/plant and oil content in 'Hardee' × 'MACS 124' and for plant height, oil content and seeds/pod in 'Hardee' × 'MACS 346'.

Dominance × dominance (l) and additive × additive (i) types of epistatic gene action were significant for plant height, yield/plant,oil content and 100-seed weight in 'Hardee' × 'MACS 124' and for plant height, pods/plant, yield/plant and oil content in 'Hardee' × 'MACS 346'. Only 'i' type of epistatic gene interaction was significant for plant height, oil content and 100-seed weight in 'Hardee' × 'MACS 13' and only 'l' type of interaction was significant for seeds/plant in 'Hardee' × 'MACS 346'. It is obvious that these interactions along with dominance gene effects indicated duplicate type of epistasis for oil content in 'Hardee' × 'MACS 124' and 'Hardee' × 'MACS 346' and for plant height in 'Hardee' × 'MACS 346'. Complementary epistasis was evident for yield/plant in 'Hardee' × 'MACS 124'.

Tawar *et al.* (1989) have reported additive gene effects to be important for most of the traits studied and dominance gene effects for plant height, number of fruiting nodes, seed yield and pods/plant. Li *et al.* (1991) observed that additive gene effects account for more than 50% of the variation in these traits. They reported dominant gene effects to be important in the inheritance of pods/plant, seeds/plant and yield/plant and epistatic interaction for almost all 9 traits.

Complementary epistasis for yield/plant is desirable and will be helpful in further improvement in the yield. However, duplicate epistasis observed for oil content might cause hindrance in the improvement of this trait by simple breeding methods to exploit additive gene effects. In such cases breeding methods like reciprocal recurrent selection might be useful.

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REFERENCES

Hayman B I. 1958. The separation of epistatic from additive and dominance variation in generation means. *Heredity* **12**: 371–90.

Li X H, Chen W M and Li Z L. 1991. Analysis of gene effects for some important agronomic characters in summer soybean. *Acta Agronomica Sinica* **17**: 453–60.

Tawar M L, Mishra A K and Rao S K. 1989. Gene action in soybean. *Indian Journal Heredity* **21**: 10–6.

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Unusual early flowering in Komadan: a natural cross hybrid of coconut (*Cocos nucifera*)

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Key words : coconut , early flowering , natural cross hybrid , Komadan

Coconut (*Cocos nucifera* L.) is considered the most useful and economic palm in the world. These palms fall into 2 groups, the tall and the dwarf. Coconut cultivars are usually known by the name of the location where they are commonly grown. Tall palms grown in the western coast of India are known as 'West Coast Tall'. When 'West Coast Tall' is adopted and cultivated in a specific area of a state for a considerable period, they develope certain specific characters and minor differences leading to a separate identity of the sub-group named after the locality such as 'West Coast Tall' (Kuttiadi). The palm shows a high degree of variability because of its long history of cross-pollination. The complex genetic make up of the today's tall population of coconut sometimes display unusual characters.

The type 'Komadan' is an off type from the progeny of 'Chowghat Orange Dwarf' open pollinated by the 'West Coast Tall'. Careful selection of the F_2 progeny of this naturally occurring hybrid was made over a long period by Tharavadu family of Aranmula village situated at Central Travancore area of Kerala.

Shylaraj *et al.* (1991) reported superior mother palm character in terms of stem girth, number of fronds, number of bunches, percentage fruit set and annual nut yield and better seedling vigour in terms of germination percentage, high collar girth and number of leaves in Komadan in comparison to 'West Coast Tall'. According to Satyabalan (1993) 'West Coast Tall' starts bearing in 5–8 years (ie flowers by 48–84 months), 'Chowghat Orange Dwarf' and tall × dwarf hybrids flowers by three and a half to four years (42–48 months). In farmers garden

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Table 1 Performance of different cultivars of coconut.

Cultivars	'West Coast Tall' (Kasaragod)	Natural Cross Hybrid (Komadan)	'West Coast Tall' (Kuttiadi)	Tripur tall	Lakshadweep ordinary
Date of Planting	July 94	July 94	Aug 94	Aug 94	Aug 95
Seedlings planted	121	187	130	235	60
Trunk height (cm)	33.8	35.0	20.0	27.5	
Range	(05–69)	(10–55)	(15–35)	(08–57)	
Leaves	19	19	15	17	12
Range	(14–26)	(12–25)	(11–18)	(13–23)	(10–13)
Date of first flowering	25.3.98	18.12.96			
Palms flowered so far	5	31			
(%)	(4.13%)	(16.58%)			
Date of last harvest		4.7.98			
Bunches harvested		4			
Nuts harvested		23			

under identical conditions, dwarf × tall (natural cross) hybrids gave higher yield than tall × dwarf and pre-bearing period of dwarf × tall (natural cross) hybrid was slightly more than tall × dwarf hybrids (Anonymous 1979).

Planting programme in the demonstration cum seed production farm initiated in 1994. Five cultivars of coconut were planted at a distance of 8.5 × 9.0 m in the farm between July 1994 and August 1995 as detailed in Table 1.

The average annual rainfall recorded in the farm during 1994 to 1996 was 2849 mm (2218 – 3522 mm) relative humidity was 73.47% (53–91%) and maximum and minimum temperature was 32.4–22.7°C (37.6–21.3 °C). The average *p*H value of the farm soil was 5.5, organic carbon content was 1.11% and available P and K content was 7.0 and 9.6 ppm respectively. All the seedlings transplanted were provided with recommended dose of manure and fertilisers following standard application schedules. Pitcher irrigation was provided by placing 12 litre mud pots in the basin, twice a week from January–May. Need based plant protection measures were adopted.

On 18 December 1996 after 28 month of transplanting first flowering was observed in 1 plant of Komadan and 2 nuts were harvested from that bunch after 1 year. On 5 May 1997 after 33 month of transplanting, 3 more plants flowered and 21 nuts were harvested from these three bunches on July 1998. As on 31 December 1998 54 months after transplanting, 27 more plants gave flowers. In 'West Coast Tall' (Kasaragod), first flowering was observed in March 1998, after 45 months of transplanting and as on December 1998 after 54 months, flowering was noticed only on 5 plants, whereas other 4 cultivars did not flower till 54 months of planting.

That first flowering to occur in a natural cross hybrid of coconut within 28 months after transplanting and the next flowering to occur by 33 month under rainfed condition with only life saving irrigation was an unusual and rare incidence. Early flowering plants of Komadan were separately demarcated and regularly observed for further studies.

REFERENCES

Anonymous. 1979. *Survey report on the performance of coconut varieties and hybrids in Kerala state.* Directorate of Coconut Development, Cochin. Government of India, Ministry of Agriculture.

Satyabalan K. 1993. *Coconut Palm : Botany and Breeding,* First edn. Asia Pacific Coconut Community, Indonesia.

Shylaraj K S, Bindu M, Gopakumar K and Gopimoni R. 1991. Comparing Komadan coconut type with West Coast Tall. (*in*) *Coconut Breeding and Management,* pp 106–08. Silas E G, Aravindakshan M and Jose A J (Eds). Kerala Agricultural University, Trichur, Kerala.

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Management of stem gall of coriander (*Coriandrum sativum*) incited by *Protomyces macrosporus*

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Key words : fungicide stem gall, seed treatment, disease severity, irrigation

Stem gall of coriander (*Coriandrum sativum* L.) incited by *Protomyces macrosporus* Unger is a destructive and versatile disease. It was first reported by Sydow and Butler (1911) from Pusa, Bihar. The disease is frequently referred as tumour of coriander. The disease manifests itself in the form of tumours on stems, branches, leaf stalks, petioles, peduncles, leaves and fruits. Systemic infection causes greater distortion (hypertrophy and hyperplasia) to plant and plant parts including seeds. It is a seed as well as soil borne disease, survives in the form of chlamydospores. The disease may cause severe yield loss and quality of seeds as reported by Singh *et al.* (1984) and Lakra (1995). No systematic study with regard to disease management has been conducted. The present investigation is a comprehensive endeavour in this direction.

The effect of seed treatment, foliar application of chemicals, date of sowing, NPK combinations and level of irrigation were tried under field conditions for the disease management during 1996–97 and 1997–98. The susceptible variety 'Hisar Anand' was sown in 3 replications in randomized block design in 5 m × 4 m plots with at a spacing of 30 cm × 20 cm. The mericarps (splitted seeds) were sown adopting a seed rate of 30 kg/ha in the first week of November in infested field where the stem gall disease has been occurring year after year. In seed treatment trial, the seeds were treated with bavistin, captan, thiram and vitavax @ 2 and 4 g/kg seed each before sowing. In chemical control trial, 6 chemicals, viz carbendazim, carboxin, copper oxychloride, mancozeb, streptomycin and tridemorph were sprayed at the rates as mentioned in Table 2. Three sprays of test chemicals were given at 15 days interval started from 30, 45, 60 and 75 days after sowing. For evaluating the effect of date of sowing on disease management, 7 staggered plantings were done at 15 days interval starting from 15 September during both the years. For seeing the impact of N, P and K, a topographical uniform field infested with stem gall disease was selected. The field soil was low in N (72 kg/ha) and P (30 kg/ha) and rich in K (595 kg/ha) contents. The soil has high *p*H (8.5). In all, 8 NPK combinations as given in Table 1 were tried. The fertilizers were properly applied in the soil prior to sowing. To find out the effect of irrigation on stem gall development, the crop was implied different levels of irrigation. The level of irrigation water : cumulative pan evaporation (IW : CPE mm) studied were, viz 40: 30, 35: 30, 40: 40, 35: 40, 40:50 and 35:50. At crop maturity, the data on disease severity and yield/ha were recorded in each experiment and analysed statistically to determine the selective effectiveness of treatments in managing the disease. The disease indices were scored with the scoring scale proposed by Lakra (1991), where a healthy plant scores 0, while a fully diseased plant scores 100 points divided into 4 parts: main stem (30 points), leaves (20 points), pedicels (20 points) and fruits (30 points). The total score will count for the total disease intensity.

An overall perusal of data from Table 1 suggests that thiram gave best management of the disease followed by vitavax when used @ 4 g/kg seed. Seed treatment @ 2 g/kg seed was found too low concentration to control the disease effectively. The disease control in thiram, vitavax, bavistin, and captan were obtained 53.5, 50.0, 35.7 and 32.1% respectively in comparison to the control. Significant yield differences were observed in all the treatments in comparison to the control. Three sprays of streptomycin, carboxin and tridemorph could control the disease 66.6, 62.5 and 58.3% respectively when spray schedule was adopted 30 days after sowing. Delay in adopting spray schedule resulted in less disease control and more yield losses. Contact fungicides (mancozeb and copper oxychloride) were found least effective against the disease. None of the fungicide was found effective when spray schedule was adopted late (75 days after sowing). The incidence of stem gall was observed less in early and late sown plantings in comparison to 16 October sown crop (Table 1). First November sown crop has highest yield potential besides high disease incidence (40%). The 16 September and

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Table 1 Management of stem gall of coriander through seed treatment, dates of sowing, NPK combinations and irrigation levels

Treatment			Disease intensity	Yield (tonnes)
Seed treatment (g/kg seed)				
Bavistin	2	(0.2%)	38	0.70
Bavistin	4	(0.4%)	36	0.65
Captan	2	(0.2%)	40	0.60
Captan	4	(0.4%)	40	0.60
Thiram	2	(0.2%)	26	0.80
Thiram	4	(0.4%)	20	0.90
Vitavax	2	(0.2%)	35	0.70
Vitavax	4	(0.4%)	28	0.70
Control	(Untreated)		56	0.25
CD (*P*=0.05)			2.1	0.1
Date of sowing				
16 Sept			30	0.40
1 Oct			38	0.50
16 Oct			45	0.65
1 Nov			40	0.75
16 Nov			28	0.50
1Dec			12	0.40
16 Dec			10	0.25
CD (*P*=0.05)			2.0	0.1
NPK combinations				
NoPoKo			16	0.35
NoPoK			16	0.35
NoPKo			32	0.20
NoPK			31	0.25
N PoKo			22	0.70
N PoK			21	0.65
N PKo			25	0.85
NPK (control)			24	0.90
CD (*P*=0.05)			1.0	0.1
Irrigation levels(IW/CPE)				
1.33			46	0.40
1.16			33	0.70
1.00			30	0.90
0.87			24	0.95
0.80			23	0.90
0.70			22	0.85
CD (*P*=0.05)			1.8	0.1

N, 62 kg/ha; P, 50 kg/ha; K, 25 kg/ha

IW, Irrigation water (mm); CPE, cumulative pan evaporation (mm)

16 December crop have less disease incidence but also resulted in drastic reduction in yield. In December sown crop the disease score on fruits were observed more in comparison to early plantings. The effect and interaction of N, P and K were noticed with respect to stem gall infection and yield. It is obvious from the result (Table 1) that application of K has no impact on disease intensity. More disease incidence were observed when P was applied in absence of N. Application of balance N, P and K created middle order disease and yielded high. Per cent yield losses were observed as high as 77.0 and 71.5% in N_0. P_{50}, K_{25} treatment respectively in comparison to the balance fertilizers (N, 62; P, 50; K, 25 kg/ha). Lowest disease intensity (16%) was observed in $N_0P_0K_0$ anf $N_0P_0K_{25}$ combinations but had adverse effect on yield. Coriander crop has low requirement of water. A concomitant increase in irrigation provided high disease indices. The heaviest soil moisture (IW/CPE = 1.33) resulted in 46 % disease intensity whereas lowest soil moisture (IW/CPE = 0.70) created 22 % disease intensity with 57.2 and 10.4% yield losses.

The results from these studies indicated that stem gall can not be efficiently managed by any single mean/mode and a collective approach in this regard needs to be exploited. None of the seed dresser could bring the disease below 20 % even if applied at higher doses (@ 4 g/kg seed). Earlier also, reduction in disease through seed treament with thiram has been documented by Nene *et al.* (1966). Among all the fungicides/antibiotics tested as foliar application, maximum disease control (66.6%) was found in streptomycin followed by carboxin (62.5%) and tridemorph (58.3%). A considerably high amount of disease remained uncontrolled in this aspect too. Gupta and Sinha (1963) also found good results of penicillin and streptomycin when used at 400 ppm. Bhardwaj and Shreshtha (1985) reported foliar application of thiram (0.2%), captafol (0.2%) or carboxin (0.1%) giving better results than seed treatment. It was demonstrated that once stem gall caused infection in plants it become systemic and becomes difficut to control. So delay in adopting spray schedule ought to be avoided otherwise it will be merely wastage of fungicides. Stem gall incidence can not be managed through shifting different dates of sowing because reduction in disease also results in reduction in seed yield due to adverse environmental effects. The disease can be managed up to 25% by applying balanced fertilizers. The similar trend of application of fertilizers on disease development was also observed by Gupta (1976). Disease serverity was observed to be positively correlated with the amount of soil moisture in the field. Thus, for tackling such a dreaded disease all collective practices, viz seed treatment with thiram @ 4 g/kg seed before sowing spray the crop with streptomycin (500 ppm) or carboxin (0.1%) or tridemorph (0.1%) at 30 days after sowing, apply balance fertilizers (N, 62; P, 50; K, 25 kg/ha) and avoid heavy and frequent irrigation, needs to be exploited for efficient management and harvesting good seed yield.

Table 2 Efficacy of fungicides in controlling stem gall of coriander through foliar sprays

Treatment	Disease intensity with spray schedules			
	30 DAS	45 DAS	60 DAS	75 DAS
Carbendazim (0.2%)	40 (0.6)	42 (0.5)	45 (0.45)	47 (0.35)
Carboxin (0.1%)	18 (1.10)	23 (0.90)	31 (0.80)	36 (0.70)
Copper oxychloride (0.3%)	46 (0.45)	47 (0.35)	47 (0.40)	48 (0.30)
Mancozeb (0.25%)	46 (0.40)	47 (0.35)	48 (0.30)	48 (0.30)
Streptomycin (500 ppm)	16 (1.20)	21 (1.00)	28 (0.90)	37 (0.65)
Tridemorph (0.1%)	20 (1.05)	25 (0.85)	31 (0.80)	38 (0.65)
Control	48 (0.30)	48 (0.35)	48 (0.30)	48 (0.30)

Figures in parentheses are yield tonnes/ha DAS, days after sowing
CD for yield (Y) = 0.1, CD for disease intensity (DI) = 1.9, CD for DI with time (T) = 0.1, CD for DI × T = 0.2, CD for Y × T = 0.1

REFERENCES

Bhardwaj L N and Shreshtha S M. 1985. Efficacy of fungicide application in the control of stem gall of coriander. *Agriculture Ecosystems and Environment* **13** (3/4) : 319–23.

Gupta J S and Sinha S. 1963. Some therapeutic control on the stem gall disease of coriander (abst). *Indian Phytopathology* **16** : 104.

Gupta R N. 1976. Impact of nitrogen, phosphorus and manganese on the stem gall disease of coriander. *Acta Botanica* **4** (1) : 30–5.

Lakra B S. 1995. Evaluation of dormancy and viability of the chlamydospores of *Protomyces macrosporus* and its effect on seed health of coriander. *Haryana Journal of Horticultural Sciences* **24** (3–4) : 325–7.

Nene Y L, Siddqui I A and Kharbanda P D. 1966. Control of stem gall of coriander by fungicides. *Mycopathologia et Mycologia Applicata.* **29** : 142–4.

Singh S P, Gupta J S and Sharma A K. 1984. Disease appraisal and crop loss estimates in coriander attacked by *Protomyces macrosporus* Unger in Uttar Pradesh. *Geobios* **11** (6) : 276–8.

Sydow H and Butler E J. 1911. Fungi Indiae Orientalis. *Annales Mycologici.* **9** : 372–421.

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Susceptibility of *Plutella xylostella* to the entomopathogenic fungus *Paecilomyces farinosus**

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Key words : *Paecilomyces farinosus, Plutella xylostella,* susceptibility

Plutella xylostella, commonly called diamondback moth of cabbage, is a serious pest on cruciferous crops like cabbage (*Brassicae oleracea* var *capitata* L.), cauliflower (*Brassica oleracea* var. *botrytis* L.), knol-khol (*Brassicae oleracea* L.var *caulorapa* DC.), radish (*Raphanus sativus* L.), etc. The larval stage of the insect causes extensive damage to the primordium especially in cabbage and cauliflower and thereby causes economic loss (Nagarkatti and Jayanth 1982, Krishnakumar *et al.*1986). Entomopathogenic fungus *Paecilomyces farinosus* (Holmskiold) Brown and Smith which is considered to be a potential biological control agent (Prenerova 1994) was isolated from the field population of *P. xylostella* (Gopalakrishnan 1998). All the stages of the insect were tested for its susceptibility to *P. farinosus*. The different stages, viz larval instars (I–IV), pupae and eggs of *P. xylostella* were obtained from the host culture maintained on cabbage leaves in the laboratory. First instar 50 larvae, second instar 60 larvae, third 80 instar larvae, fourth 70 instar larvae, 80 pupae and 896 eggs were treated with fungal spore suspension of 1.7×10^8 spores/ml concentration.

The fungal spore suspension was obtained form the culture maintained on Sabouraud maltose agar yeast slants. The spores were washed with sterile distilled water + triton ×–100 (0.01%) with a sterile glass rod and the suspension filtered through double layered muslin cloth. The stock suspension of 1.7×10^{10} spores/ml was diluted to 1.7×10^8 spores/ml for inoculating different stages of *P. xylostella*. Counting of the spores was made using double ruled Neubauer haemocytometer under phase–contrast microscope.

The larval and pupal stages were dipped into the suspension with forceps and brush and the excess removed by mearly touching them on whatman filter paper. The inoculated larval instars were released separately in plastic containers of 13.5 cm × 11.0 cm provided with tender cabbage leaves whose petiole wrapped in cotton swab to prevent desiccation. Thin layer of cotton in water covered with tissue paper at the bottom of the container provided required moisture. The containers were closed with meshed lids to provide aeration to the growing larvae. The pupae inoculated with fungal spore suspension were kept on moist filter paper in petri-dishes.

The eggs obtained from the insect culture on tissue paper were counted through stereo zoom microscope. Fungal spore suspension was smeared with camlin hair brush on to the surface of the eggs gently. The tissue paper along with the treated eggs was kept for drying for sometime and then placed on cabbage leaf in plastic container provided with moisture and aeration as described above. The experiment was carried out under room temperature of 27 ± 2°C.

Daily observations on larval mortality, pupal mortality, hatching of the eggs, mortality to neonate larvae, mycelial growth and sporulation on diseased larvae and pupae were recorded.

The fungus was highly infective in causing an average percentage mortality of 56.3–100% to the larval instars and to the pupae in 3–5 days of incubation (Table 1). The I instar showed cent per cent mortality in 3–4 days of incubation followed by 93.0% in II instar, 91.0 in III instar and 88.6 in IV instar. Pupal stage recorded 56.3% mortality. Results also showed that the fungus could inflict 41.3 – 88.0 mortality to the larval instars and pupae in 72 hr after inoculation (Table 1).

The fungus did not have any effect on the eggs of *P. xylostella*. However, 100% mortality was noticed to the neonate larvae that hatched out from the treated eggs (Table 1). The incubation period from hatching to death was 2–3 days. The fungal infection was evident when the dead larvae produced white mycelial growth and sporulation on moist surface. The symptomatology of the fungal infected *P. xylostella* generally resembled those described for the other fungal affected lepidopterous larvae (Madelin 1966, Ferron 1978). The initial signs of the disease were visible 48 hr after the inoculation.

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Table 1 Susceptibility of different stages of *P. xylostella* to the fungus @ 1.7×10^8 spores/ml concentration

Stage	Inoculated (no.)	mortality (%)	Incubation (days)	Mortality (%) on the III day
I instar	50	100.0	3–4	88.0
II instar	60	93.0	3–5	63.3
III instar	80	91.0	3–5	67.5
IV instar	70	88.6	3–5	68.6
Pupae	80	56.3	3–5	41.3
Eggs*	896	00.0		

* *All the neonate larvae hatched from the treated eggs died in 2–3 days after hatching*

All the larval stages and pupae of *P. xylostella* inoculated with fungal spore suspension of 1.7×10^8 spores/ml concentration were susceptible (Table 1). As the larvae matured, a decrease in susceptibility was observed. Earlier in the case of larval instars of certain noctuids, similar phenomenon was observed in their responses to *Beauveria. bassiana*, *Nomuraea rileyi* and *P. fumosoreseus* (Gardner and Noblet 1978, Ignoffo *et al.* 1978, Fargues and Rodriguez–Rueda 1980).

The higher susceptibility of younger instars to the fungal infection observed is advantageous as pests controlled in the early stages are less likely to cause economic injury to the crop plants (Devaprasad *et al*. 1990).

Like other fungal pathogens which affects the pupal stage of the lepidopterous insects (Gopalakrishnan and Narayanan 1990), *P. farinosus* is also infective to pupal stage of *P. xylostella*. The adult emerged form the treated pupae that escaped death was malformed. *P. farinosus* infecting pupae of *Heteronygonia dissimilis* (Schabel *et al.* 1988), *Eligma narcissus* (Mohanan and Varma 1988) and *H. armigera* (Alma 1975) confirms the findings of investigation on susceptibility of pupae to *P. farinosus*.

Some of the fungal pathogens are also known to inflict diseases on insect eggs (Caroll 1988, Patel *et al.* 1988, Gopalakrishnan and Narayanan 1990). Unlike the other fungal pathogens, *P. farinosus* did not infect at egg stage. But the neonate larvae emerged from the treated eggs contracted the disease and caused cent per cent mortality in 2–3 days after hatching (Table 1). The lepidopterous larvae eat their way through chorionic membrane during exclusion. Thus it is possible for the larvae to contract the disease when they eat the contaminated egg shell as they hatch. Similar result was reported by Poprawski *et al.* (1985) for black wine weevil *Otiorhynchus sulcatus*, that the grubs hatching from treated and unaffected eggs were susceptible for *P. farinosus* confirms the findings.

The fungus infecting the neonate larvae hatching from the treated eggs is an advantage because the neonate larvae are bound to be killed by the fungal spray at the egg stage itself, as the eggs are laid on the leaf surface and the microclimate existing inside the crop canopy is ideal for the fungus to act under field condition. Similarly, the mortality of the pupae is also an added advantage because the insect pupates invariably on the leaves.

REFERENCES

Alma P J. 1975. Infection of pupae of *Heliothis armigera* by *Paecilomyces farinosus*. *New Zealand Journal of Forestry Science* **5** : 42–4.

Caroll G C. 1988. Facultative fungal egg parasites as agents of gypsy moth mortality. *Northwest Environmental Journal* **4**: 345–6.

Devaprasad V. Jayaraj S and Rabindra R J. 1990. Susceptibility of gram caterpillar, *Heliothis armigera* Hbn. (Noctuidae : Lepidoptera) to certain entomogenous fungi. *Journal Biological Control* **4**: 44–7.

Fargues J. and Rodriguez–Rueda D. 1980. Susceptibility of the larvae of *Spodoptera littoralis* (Lep. Noctuidae) to the entomopathogenic hypomycetes *Nomuraea rileyi* and *Paecilomyces fumoroseus*. *Entomophaga* **25**: 43–54.

Ferron. 1978. Biological control of insect pests by entomogenous fungi. *Annual Review of Entomology* **23** : 409–42.

Gardner W A. and Noblet R. 1978. Effects of host age, root of infection and quantity of inoculum on the susceptibility of *Heliothis virescens*, *Spodoptera eridania* and *S. frugiperda* to *B. bassiana*. *Journal of Georgia Entomological Society* **13**: 214–22.

Gopalakrishnan C. 1998. 'Studies on the entomopathogenic fungus *Paecilomyces farinosus* (Homskiold) Brown and Smith for the control of cabbage diamondback moth *Plutella xylostella* L.' Ph D thesis, Bangalore University, Bangalore.

Gopalakrishnan C and Narayanan K. 1990. Studies on dose–mortality relationship between the entomofungal pathogen *Beauveria bassiana* (Bals.) Vuillemin and *Heliothis armigera* Hubner (Lepidoptera: Noctuidae). *Journal of Biological Control* **4** (2): 112–5.

Ignoffo C M, Hostetter D L, Biever K D, Garcia C, Thomas G D, Duckerson W A and Pinnell R E. 1978. Evaluation of an entomopathogenic bacterium, fungus and virus for the control of *Heliothis zea* on soybeans. *Journal of Economic Entomology* **71**: 165–78.

Krishnakumar N K, Srinivasan K, Ramachandar P R and Suman C L. 1986. Optimum control strategy of cabbage pests from a chemical control trial. *Progressive Horticulture* **18**: 104–10.

Madelin. 1966. Fungal parasites of insects. *Annual Review of Entomology* **11** : 423–48.

Mohanan C and Varma R V. 1988. *Paecilomyces farinosus* a potential biocontrol agent of some lepidopterous tree pests in India. *Transaction of British Mycological Society* **90** (1) : 119–22.

Nagarkatti S and Jayanth K P. 1982. Population dynamics of major insect pests of cabbage and of their natural enemies in Bangalore district (India), *Proceedings of the International conference on Plant Protection Society*, Kuala Lumpur, Malaysia, pp 325–47.

Patel K C, Patel A G, Yadav D N, Dube H C and Patel R J. 1988. Preliminary studies on the pathogenicity of *Metarhizium anisopliae* (Metschn.) Sorokin var *anisopliae* to cutworm *Agrotis segetum* (Shiff.). *Journal of Biological Control* **2**: 32–4.

Poprawski T J, Robert P H, Majchrowicz I and Bovin G. 1985. Susceptibility of *Delia antiqua* (Diptera: Anthomyiidae) to eleven isolates of entomopathogenic Hypomycetes. *Environmental Entomology* **14**: 557–61.

Prenerova E. 1994. Pathogenicity of *Paecilomyces farinosus* toward *Cephalcia abietis* Econymphs (Insecta, Hymenoptera): Enhancement of bioactivity by *in vivo* passaging, *Journal of Invertebrate Pathology* **64**: 62–4.

Schabel H G, Schabel A and Msanga H P. 1988. Bioecological aspects of the mahogany defoliator *Heteronygonta dissimilis* in Morogoro, Tanzania. *Insect Science and Application* **9**: 179–84.

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Effect of vermi-compost and vermi-casting on the damage of sucking pests to groundnut (*Arachis hypogaea*)*

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Key words : Vermi-casting, vermi-compost, groundnut, sucking pests

It has become necessary to use organic manures to recoup the soil health which has deteriorated due to indescriminate use of chemical fertilizers over the years. There have been several reports (Rao 1994 and Kale 1996) that the use of vermi-compost is a mean to combat the ill-effect of chemical fertilizers on soil health. Use of vermi-compost in addition to improving soil health also imparts pest tolerence to plants. Hence, study was conducted to investigate the effect of vermi-compost and vermi-castings on the damage caused by the sucking pests, viz jassids and thrips to groundnut crop, as no information is available.

A trial was conducted during winter (*rabi*) season of 1994 and 1995 with a susceptible 'JL 24' groundnut in randomised block design, replicated 4 times with 4 treatments, viz recommended dose of chemical fertilizers (20 kg N, 40 kg P_2O_5, 0 kg K_2O/ha), vermi-castings @ 2 tonnes/ha, vermi-compost @ 2 tonnes/ha and a control. Sowing was done in 16 m × 16 m plot by dibbling the seeds at a spacing of 30 cm in between and 10 cm within the rows. Number of leaves damaged by the jassid (*Empoasca kerri* Pruthi) and thrip (*Scirtothrips dorsalis* Hood and *Caliothrips indicus* (Bagnall) counted on 10 randomly selected plants in each plot, 45 days after sowing and subjected to statistical analysis.

Results obtained clearly suggested that the jassid and thrips damage to groundnut crop was significantly low in the vermi-casting and vermi-compost applied plots in comparison to fertilizer applied and control plots. The difference in the damages might be attributed to the presence of higher levels of K_2O (5–7 fold) in the vermi-compost and vermi-castings

Table 1 Leaf damage by jassids and thrips to groundnut crop

Treatment	Mean damaged leaves/plant			
	1994		1995	
	Jassids	Thrips	Jassids	Thrips
Fertilizer	28.39	17.71	20.729	13.65
Vermi-castings	17.64	14.94	14.78	9.74
Vermi-compost	9.82	12.27	10.76	7.39
Control	32.58	19.93	28.86	16.49
SEm±	2.3565	1.279	1.716	1.047
CD ($P > 0.05$)	7.2609	3.9409	5.29	3.227

(Bhatnagar and Palta 1996 and Kale 1996). The higher levels of K_2O increases the turgidity of plant cell and as a result most of the sucking pests find difficulty in probing their mouth parts into the plant cell while feeding on such plants. It suggests that the application of vermi-compost and vermi-castings in groundnut reduced the damage caused by jassid and thrips in groundnut.

*Short note

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REFERENCES

Bhatnagar R K and Palta R K. 1996. Earthworm – vermiculture and vermicomposting. (*in*) *Advantages of Vermiculture*, pp 44. Kalyani Publishers, New Delhi.

Kale Radha D. 1996. Earthworms – The significant contributions to organic farming and sustainable agriculture. *Proceedings of National Seminar on Organic Farming and Sustainable Agriculture*, organised by Association for Promotion of Organic Farming held during 9–11 October 1996 at UAS, Bangalore, pp 52–7.

Rao N S. 1994. Model scheme on financing vermi-compost. *National Bank Newsletter* 5 (3–4) : 1–5.

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Stability in resistance against wilt in chickpea (*Cicer arietinum*)*

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Key words : chickpea, dry root rot, collar rot, stability

Chickpea (*Cicer arietinum* L.) suffers from several soil-borne diseases. Among them, fusarium wilt (*Fusarium oxysporum* f sp *ciceri*), dry root rot (*Rhizoctonia bataticola*), collar rot (*Sclerotium rolfsii*), black root rot (*Fusarium solani*) and foot rot (*Operculella padwickii*) are in order of their importance. Sources of resistance have been identified for fusarium wilt (Kumar *et al.* 1985) and dry root rot (Nene 1988). The information on resistance against rest of the soil borne diseases is rarely available. Similarly, limited number of genotypes having stable resistance against fusarium wilt are identified based on their-multi environment testing. Hence, a study was carried out to identify the genotypes possessing multiple resistance against wilt and root rots along with stability in resistance in chickpea.

Eighty one diverse genotypes of chickpea were evaluated for their reaction to wilt and root rot in randomized complete block design with 2 replications in sick plot having Vertisol soil with available N, P, K and organic carbon of 210, 6.62, 383 kg/ha and 0.51% respectively along with 7.5 *p*H during 3 years (1995–96 to 1997–98). The sowing was done on 30 October 1995, 13 November 1996 and 23 October 1997. Each genotype

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Table 1 Meteorological data for crop period (*1995–98*)

Month/year	Temperature (°C)		Rainfall (mm)	Rainy days	Relative humidity (%)
	Maximum	Minimum			
			1995–96		
October 95	32.1	15.4	72.7	2	70
November 95	29.3	9.4			61
December 95	26.5	8.5	13.1	2	74
January 96	29.8	8.5	2.5	4	82
February 96	28.1	8.7	2.2	3	70
March 96	39.9	14.4	2.4	2	58
			1996–97		
October 96	31.7	15.7	69.9	7	87
November 96	30.2	10.1	12.4	1	81
December 96	27.7	8.5			80
January 97	26.5	8.5	13.4	2	85
February 97	28.8	8.3			67
March 97	36.7	16.8	15.5	5	60
			1997–98		
October 97	34.4	15.5	28.5	5	84
November 97	30.5	13.5	4.2	2	80
December 97	28.5	7.5			80
January 98	27.0	6.0	0.3	1	84
February 98	28.5	8.0	48.0	3	89
March 98	35.1	12.7			64

was grown in single row plot of 4.0 m length with row to row spacing of 30 cm. The sick plot is having abundant population of *Fusarium oxysporum* f sp *ciceri* (race 1), *Sclerotium rolfsii* and *Rhizoctonia bataticola*. The sick plot is 6-years-old and sickness was enhanced by adding the wilted plant residue and growing the susceptible 'JG 62' genotype in rainy season and ploughing them in field every year. The population of pathogens were optimum as 85.0% mortality occurred in susceptible check on an average of 3 years. The observations on total plant emergence and wilted plants were recorded in each genotype and each replication to determine the per cent incidence of wilt/root rots. Angular transformed values of per cent incidence was used for statistical analysis. Stability analysis was carried out according to Eberhart and Russell (1966).

Stability analysis of variance revealed highly significant differences among genotypes and soil environments as influenced by ambient environmental conditions. It indicated the presence of genetic variability among the genotypes for their reaction to wilt/root rot and significant variation in the ambient environmental conditions prevailed in different years and their influence on disease incidence in the soil (Table 1). Highly significant mean squares due to environment (linear) indicated the genetic control of response of genotypes for disease incidence under variable environmental conditions. Significant mean squares due to genotype – environment (linear) indicated that the genotypes interacted considerably with environmental condition that existed in different years even at same location for their reaction to wilt/root rot incidence. Hence, prediction of resistant genotypes based on stability analysis is reliable. The estimate of environmental indices was 2.1, –1.3 and –0.8 in 1995–96, 1996–97 and 1997–98 respectively. It indicated that environmental conditions prevailed during 1995–96 were more favourable in comparison to rest of the years for the incidence of wilt/root rot in chickpea in Madhya Pradesh.

Several measures have been adopted by various workers to determine the stability of genotype. Finlay and Wilkinson (1963) considered linear regression as a measure of stability whereas Eberhart and Russell (1966) emphasised that both linear (bi) and non-linear (S^2di) components of genotypes – environment interaction be considered while judging the phenotypic stability of a genotype. Breese (1969), Paroda and Hayes (1971) and Jatasra and Paroda (1979) suggested that linear regression is simply a measure of response of a particular genotype, whereas deviation from regression is a measure of stability. The genotypes with least deviation from regression being most stable and *vice-versa*. In the present study, the mean disease incidence (x), regression coefficient (bi) and deviation from regression (S^2di) are together considered for judging the varietal response and stability. The genotypes having resistant reaction, unit regression coefficient and least deviation from regression are considered as stable resistant genotypes for wilt/root rots incidence in chickpea.

The mear incidence, regression coefficient and deviation

Table 2 Stability parameters for wilt/root rot incidence in chickpea

Genotype	Mean wilt/root rot incidence	bi	S^2di
'BG 369'	18.0 (24.9) H	2.14	1.67
'BG 387'	17.4(24.7)	–0.53	–1.39
'BG 1008'	21.0 (26.9)	3.20	14.72
'BG 1032'	23.5 (29.0)	2.27	–0.59
'BG 1033'	22.8 (28.0)	4.30	13.88
'BG 1035'	13.1(21.0)	1.84	1.42
'BG 1039'	20.7 (26.8)	2.91	–1.49
'BGD 74'	16.3(23.6)	2.41	–1.85
'BGD 78'	18.0 (24.9)	0.46	42.07
'BGM 417'	18.4 (25.2)	2.27	9.57
'BGM 481'	14.2 (22.1)	1.33	–1.44
'BGM 498'	16.0 (23.5)	1.11	11.66
'BGM 501'	20.3(26.6)	2.42	–1.73
'BKG 21'	13.6 (21.4)	2.41	0.63
'C 235'	13.9 (21.8)	–2.34	3.73
'COG 29'	13.5 (21.4)	2.05	1.19
'BCP 9203'	14.2(22.1)	–0.58	–1.64
'FG 541'	12.3 (20.5)	0.25	5.56
'FG 89–135'	15.5 (23.2)	0.87	–1.27
'GG 588'	17.7 (24.8)	1.89	–1.53
'GI 92228'	13.1 (21.2)	0.98	–1.46
'GNG 718'	13.8(21.8)	0.74	–0.51
'GNG 737'	13.0 (21.0)	1.51	0.92
'GNG 968'	13.6 (21.6)	–0.55	0.92
'GNG 1000'	13.9 (22.7)	–0.64	2.79
'GNG 1028'	13.7 (21.8)	0.38	0.57
'H 86 – 18'	13.8 (21.8)	–0.45	–0.48
'H 86 – 170'	19.9 (26.4)	1.53	9.95
'H 90 – 21'	12.8 (20.9)	0.87	10.32
'H 90 – 61'	12.7(20.8)	0.85	–1.65
'H 90 – 64'	15.7 (23.0)	–0.29	51.86
'H 90 –201'	19.9 (26.2)	3.17	2.77
'H 91 – 47'	17.1 (25.4)	2.52	–1.62
'H 92 – 67'	14.8 (22.4)	1.03	27.63
'H 100 – 2'	15.8 (23.2)	2.45	–1.24
'ICC 35'	11.7 (20.0)	–0.32	1.67
'ICC 491'	11.1 (19.4)	–0.36	–1.39
'ICC 5003'	10.3 (18.7)	1.04	14.72
'ICC 13099'	14.7 (22.5)	0.06	–0.59
'ICC 16975'	13.7 (21.6)	1.38	13.88
'ICC 16989'	11.0 (19.4)	0.48	1.42
'ICCL 87411'	14.4 (21.9)	3.05	–1.49
'ICCX 850621'	20.3 (27.2)	–0.78	–1.82
'IPC 94–8'	14.0 (21.8)	1.35	42.07
'IPC 94–18'	9.6 (17.9)	1.30	9.57
'JG 89–2'	18.1 (25.0)	2.28	–1.44
'JG 89 – 6'	8.8 (17.1)	1.30	11.78
'JG 89 – 7'	8.1 (16.4)	–0.04	–1.73
'JAKI 9218'	11.8 (19.9)	0.64	0.63
'JAKI 9226'	18.9 (25.7)	1.14	3.73
'KGB 1174'	14.7 (22.5)	–0.96	1.19
'KGB 1176'	16.0 (23.6)	0.43	–1.64
'Khajawa 91–4'	12.7 (20.6)	0.35	5.56
'Khajawa 183'	15.2 (22.9)	1.31	–1.27

(*Continued*)

Table 2 (*Continued*)

Genotype	Mean wilt/root rot incidence	bi	S²di
'KPG 316'	6.8 (15.0)	0.22	−1.53
'KW 104'	14.6 (22.4)	0.91	−1.46
'KW 80 – 3'	16.4 (23.9)	1.47	−0.51
'KW 109'	10.7 (19.0)	0.02	0.92
'Phule G 92–4'	13.4(21.4)	1.17	0.92
'Pusa 362'	14.4 (22.3)	0.56	2.79
'Pusa 372'	14.6 (22.4)	0.20	0.57
'RG 9210'	12.6 (20.7)	1.13	−0.38
'RG 9218'	16.6 (24.0)	1.33	9.95
'SCP 1'	12.6 (20.4)	0.57	10.32
'SCP 4'	12.4 (20.6)	−0.88	−1.65
'SCP 5'	13.4 (21.4)	−0.22	51.86
'SCP 7'	17.5 (24.7)	0.92	2.77
'SCP 15'	14.2 (21.9)	1.24	−1.62
'SKG 1'	11.4 (19.6)	−0.47	27.63
'SKG 2'	11.4 (19.6)	0.52	−1.24
'SKG 3'	13.9 (21.9)	−0.08	−1.79
'KPG 59'	12.0(20.2)	−0.68	−2.39
'KPG 143–2'	6.4 (14.4)	1.86	0.15
'KPG 229–4'	7.7 (15.8)	1.67	−0.04
'JG 9'	10.1(18.5)	0.05	−1.66
'JG 11'	7.4 (15.7)	1.21	−0.50
'JG 22'	6.3 (14.2)	0.68	−2.39
'JG 23'	14.9 (22.7)	0.15	−1.56
'JG 33'	8.1 (16.1)	1.17	−0.54
'SAKI 93130'	11.1 (19.1)	1.04	−0.64
'JG 62'	85.0 (71.3)	8.40	6.69
Mean	15.02 (22.4)	1.0	
SEm±	2.19		

H, Angular transformed values

from regression varied from genotype to genotype (Table 2). Out of 81 tested genotypes, only 10 namely 'IPC 94–18', 'JG 89–6', 'KPG 143–2', 'KPG 229–4', 'JG 11', 'KPG 316', 'JG 22', 'JG 33', 'SAKI 93130' and 'JG 89–7' have shown resistant reaction against wilt/root rot based on pooled analysis of 3 years. Among them, 'KPG 316', 'JG 22', 'JG 23' and 'SAKI 93130' were average responsive and stable for their reaction (Table 2). Sixty three genotypes have shown moderately resistant reaction against wilt/root rot, out of which 'BGM 498', 'FG 541', 'GF 89–135', 'GI 92228', 'GNG 718', 'GNG 1028', 'H 90–21', 'H 90–61', 'ICC 5003', 'ICC 16989', 'JAKI 9218', 'JAKI 9226', 'KGB 1176', 'Khajwa 919', 'KW 104', 'Pusa 362', 'Pusa 372', 'RG 9210', 'SCP 1', 'SCP 7', 'SKG 2' and 'JG 23' were average responsive and stable for their reaction having unit regression coefficient and deviation from regression approaching to 0. Twenty five genotypes were responsive to favourable environments having greater than one regression coefficient, while 16 genotypes with negative estimates of regression coefficients were responsive to unfavourable environments (Table 3). Genotypes 'BGD 78' and 'H 92–67' were average responsive and unstable with moderately resistant reaction. Highly susceptible genotype 'JG 62' exhibited maximum estimate of positive regression coefficient (8.40) indicating that it is highly responsive to favourable environmental conditions for wilt.

It was concluded that genotypes 'JG 22', 'JG 33', 'KPG 316' and 'SAKI 93130' showing stable resistant reaction could be used as donors in breeding programme for developing high yielding lines with stable multiple resistance to wilt/root rots in chickpea. The study further suggests the vigourous

Table 3 Grouping of genotypes based on disease reaction and stability parameters in chickpea

Reaction	Stability	Responsiveness	Genotypes
Resistant	Stable	Average responsive	KPG 316, JG22, JG 33 and SAKI 93130
		Responsive to favourable environment	IPC 94–18, JG 89–6, KPG 143–2, KPG 229–4 and JG 11
		Responsive to unfavourable environment	JG 89–7
Moderately resistant	Stable	Average responsive	BGM 498, FG 541, GF 89–135, GI 92228, GNG 718, GNG 1028, H 90–21, H 90–61, ICC 5003, ICC 16989, JAKI 9218, JAKI 9226, KGB 1176, Khajwa 919, KW104, Pusa 362, Pusa 372, RG 9210, SCP 1, SCP 7, SKG 2 and JG 23
		Responsive to favourable environment	BG 369, BG 1008, BG 1032,BG 1035, BG 1039, BGD 74, BGM 417, BGM 481, BGM 501, BKG 21, COG 29, GG 588, GNG 737, H 86–170, H90–201, H 91–47, H 100–2, ICC 16975, ICCL 87411, IPC 98–18, JG 89–2, Khajwa 183, KW 80–3, Phule G 92–4 and RG 9218
		Responsive to unfavourable environment	BG 387, C 235, BCP 9203, GNG 968, GNG 1000, H 86–18, ICC 35, ICC 491, ICC 13099, ICCX 850621, KGB 1174, KW 109, SCP 4, SKG 3, KPG 59 and JG 9
	Unstable	Average responsive	BGD 78 and H 92–67
		Responsive to favourable environment	IPC 94–8
		Responsive to unfavourable environment	H 90–64, SCP 5 and SKG 1
Susceptible	Stable	Responsive to favourable environment	JG 62

testing of large number of genotypes over years and locations for identification of stable multiple resistance against soil borne diseases in chickpea.

REFERENCES

Breese E L. 1969. The measurement and significance of genotype–environment interactions in grasses. *Heredity* **24** : 27–44.

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

Finlay K W and Wilkinson G N. 1963. The analysis of adaptation in plant breeding programme. *Australian Journal of Agricultural Research* **14** : 742–54.

Jatasra D S and Paroda R S. 1979. Stability for synchrony traits in wheat. *Indian Journal of Genetics and Plant Breeding* **39** : 378–82.

Kumar J, Haware M P and Smithson J B. 1985. Registration of four short duration fusarium wilt resistant Kabuli chickpea germplasm. *Crop Science* **25** : 576–7.

Nene Y L. 1988. Multiple disease resistance in grain legumes. *Annual Review of Phytopathology* **26**: 203–17.

Paroda R S and Hayes J D. 1971. An investigation of genotype–environment interactions for rate of ear emergence in spring barley. *Heredity* **26** : 157–76.

BOOK REVIEW

Indian Journal of Agricultural Sciences **70** (5) : 349, May 2000

Dictionary of Gardening. 1999. Somani L L. Agrotech Publishing Academy, I–G–24, Sector 5, Gayatri Nagar, Hiran Magri, Udaipur 313 002. Edn 1, 592 pp. 22.0 cm × 14.5 cm. Hardcover. Rs 980. ISBN 81–85680–33–7.

The book *Dictionary of Gardening* is intended to be useful as a handbook of ready reference and is to fill the communication gap of the vocabulary of science and technology in common dictionaries of the English language. The book covers more than 11000 entries and covers entire range of terms related with gardening like garden layouts, types of gardens, lawns, bonsai, nursery, pot culture, etc. It also covers terms used in breeding, cultivation, propagation, processing, marketing, plant protection, modern field, industrial and laboratory techniques.

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The book will be of immense use for research workers, teachers and students who are engaged in horticulture and related disciplines.

P P Reddy
Dir, IIHR, Bangalore 560 089

ANNOUNCEMENT

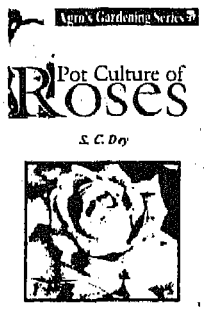
The Indian Association of Soil and Water Conservationists, Dehradun, is organizing a National Conference on Resource Conservation and Watershed Management (RCWM-2000) at Dehradun during October 2000. For details contact Er K P Tripathi, Principal Scientist and Organising Secretary (RCWM-2000), Central Soil and Water Conservation Research and Training Institute, 218, Kaulagarh Road, Dehradun 248 195; Telephone (O): 0135-757213, 758564, (R) 0135-621549; Telegram: SOILCONS; Fax: 0135-754214; E-mail: cswrti@400.nicgw.nic.

CORRIGENDUM

In article entitled Response to sowing dates and performance of different sunflower (*Helianthus annuus*) hybrids during rainy season in high-intensity cropping systems by H S Sur and A R Sharma published in October 1999 issue carried some errors. These may be read as follows:

Page	Incorrect	Correct
683	Heat units (26%)	Heat units (2.6%)
684 (para 2 and 5)	Bajra	Pearlmillet
686	Girth for 1997 under 6 August sowing date : 7.60	7.00
687	Fig 2 – Yield (kg/ha)	Yield (kg/ha) (Y)
	Response of sunflower of different sowing dates	Response of sunflower to different sowing dates
680	Table 3 – Plant stand at maturity of 'SH 3322': 5.69	5.6
Last para	20 tonnes	2.0 tonnes
	tonne	tonnes

Popular *Agro's Gardening Series* by S. C. Dey from Agrobios (India)



Pot Culture of Roses

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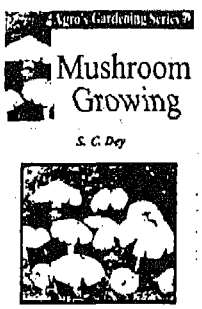

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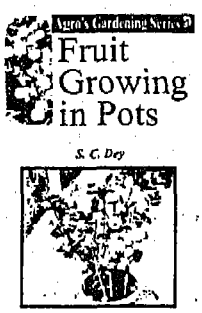

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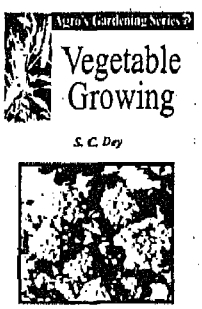

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Introduction, Why Vegetable?, Soil and Its Fertility, Manures and Fertilizers, Soil Reaction, Soil Preparation and Drainage, Raising Seedlings and Transplanting, Cultural Operations, Cole Vegetables, Legume Vegetables, Cucurbits, Fruit Vegetables, Root Vegetable, Tuber Vegetable, Bulb Vegetable, Malvaceous Vegetable, Salad Vegetable, Perennial Vegetable, Leafy Vegetable, Kitchen Gardening, Pest and Disease Control, **Appendixes:** A. The Role of Vegetable and Other Foods In Preventing Diseases, B. Some Preparations, C.Seedsmen, D. Preservation of Vegetables, E. Sowing Calendar

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