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Predicting crop growth and aphid incidence in *Brassica* under semi-arid environment

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ABSTRACT

A field experiment was conducted in the sandy loam soils to predict crop growth parameters and aphid incidence in *Brassica* using spectral reflectance and meteorological data. Three *Brassica* oilseed species, viz 'BO 54' (*Brassica napus* L.), 'Pusa Bold' Indian mustard (*Brassica juncea* L.) and 'T 9' toria (*Brassica campestris* L.) were sown on three dates at 14–day intervals starting from third week of October to create different photo-thermal environments during crop growth period. The intercepted photosynthetically active radiation and 4 spectral indices, viz (Infra red / red ratio, normalized difference, greenness index and brightness index) were derived to correlate plant growth parameters with these indices. The intercepted photosynthetically active radiation was found to be well correlated with biomass with the correlation coefficient varying from 0.71 to 0.92 in different cultivars and sowing dates. It was found from correlation study among different spectral and plant growth parameters that there was strong relationship (at 5% level of significance) between infra red / red ratio, normalized difference and leaf area index for all the 3 *Brassica* cultivars. On the other hand, the brightness and greenness indices were more closely correlated (at 5% level of significance) with above ground biomass as compared to infrared / red ratio and normalized difference. Model regression equations were also derived to forecast aphid incidence in *Brassica* with most significant weather variables. The aphid populations were found to be correlated with maximum temperature, minimum temperature and afternoon relative humidity with the correlation coefficients varying from 0.67 to 0.90 for different cultivars and sowing dates.

Key words : *Brassica,* intercepted photosynthetically active radiation, infrared /red ratio, normalized difference, greenness index, brightness index, aphid

The photosynthesis is the corner stone of crop production and hence it is important to be aware of the energy available to drive photosynthesis process and to know the relationship between intercepted photosynthetically active radiation with different plant growth parameters (Jefferies and Mackerran 1989, Jarwal and Singh 1990). Several vegetation indices derived from remotely sensed spectral reflectance data can also be used to make quantitative estimates of plant growth parameters (leaf area index, pod area index and above ground biomass) and hence find potential use of remote sensing techniques in agriculture for predicting crop growth (Wiegand and Richard 1984, Subba Rao and Sastry 1992, Smith *et al.* 1996). Each year considerable yield losses are caused by aphid (*Lipaphis erysimi* L.) which reduces the quality and quantity of crop produce each year. The study of variation of aphid population at different phenological stages in relation to favourable weather variables becomes absolutely necessary to improve crop production (Bishnoi *et al.* 1992, Rana *et al.* 1993).

MATERIALS AND METHODS

The experiment was conducted in the research station of the IARI, New Delhi (Longitude77° 10 'E, latitude 28°35 'N and altitude of 228.72 meter above mean sea-level). The soil was sandy loam in nature belonging to family Typic Ustocrepts. The climate of the station is semi-arid with dry hot summers and cold winters. The mean annual rainfall is about 710 mm of which 75% is received during south west monsoon and rest from December to February through the western disturbances The maximum temperature ranged between 40–46°C during May–June, while January is the coldest month with mean daily minimum temperature ranged from 6–8 °C. The treatments included 3 *Brassica* oilseed species, viz 'BO 54' (*Brassica napus* L.), 'Pusa Bold' Indian mustard (*Brassica juncea* L.) and 'T 9' toria (*Brassica campestris* L.) were sown during 2 *rabi* winter season of 1993–94 and 1994–95 following recommended package of practices. All the species were sown on 3 dates at 14 days interval starting from third week of

Based on complete Ph D thesis submitted to the IARI, New Delhi during 1996–97

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Table 1 Maximum leaf area index, pod area index and maximum biomass production in three cultivars as influenced by sowing dates

Cultivars	Leaf area index		Pod area index		Maximum biomass production(g/m^2)	
	I*	II**	I*	II**	I*	II**
'B O 54'						
1st sowing	6.9	7.1	2.1	2.3	1 690	1 852
2nd sowing	6.6	6.8	1.9	2.1	1 635	1 766
3rd sowing	5.6	5.9	1.6	1.7	1 361	1 473
'Pusa Bold'						
1st sowing	6.5	6.9	3.0	2.9	1 815	1 976
2nd sowing	5.8	6.1	2.5	2.7	1 664	1 696
3rd sowing	5.1	5.3	2.4	2.5	1 460	1 531
Toria 'T 9'						
1st sowing	3.9	4.1	1.9	2.0	1 206	1 293
2nd sowing	3.4	3.7	1.6	1.9	1 168	1 275
3rd sowing	2.5	3.4	1.5	1.6	1 165	1 187

*I, First crop year season (1993–94); **II, second crop year season (1994–95)

October to create different crop growth environment. Plant growth parameters and the plant samples were taken at weekly interval . The leaf area was measured using leaf area meter (LI 3100) and surface area of pod was determined by the formula (area $=\pi \times$ diameter $\times$ length). The sum of leaf area and pod area index were considered as green area index in this *Brassica* which is the most effective parameters for driving photosynthesis process specially in the later part of the growth. Because in oilseed species like *Brassica*, pods occupy reasonable space for interception of radiation and serve as main assimilating organ in the later stage of the crop. A line quantum sensor with an integrator (LI 188B) was used to measure the photosynthetically active radiation (400–700 nm) by the full canopy. Intercepted photosynthetic active radiation was determined as follows .

Intercepted photosynthetically active radiation for whole canopy = Incident photosynthetically active radiation on the canopy – reflected radiation by the canopy (obtained by keeping the sensor inverted 50 cm above the canopy) - transmitted radiation through the canopy (measured by keeping the sensors on the ground across the rows diagonally) + reflected radiation from the ground (measured by holding the sensors in the inverse position at 5 cm above the ground).

Spectral reflectance on crop was measured at weekly interval with the help of Spectroradiometer by keeping the sensor inverted at 50 cm above the canopy. After every 2 observations, irradiance was recorded. The data on measured reflectance were used to calculate the following 4 spectral indices for understanding the relationship of crop growth with spectral characteristics.

$$\text{Infra-red/red ratio (IR/R)} = \frac{\text{MSS7 (800–1100 nm)}}{\text{MSS5 (600–700 nm)}}$$

where MSS, multispectral scanner

$$\text{Normalized difference} = \frac{\text{MSS7 (800 to 1100 nm)} - \text{MSS5 (600 to 700 nm)}}{\text{MSS7 (800 to 1100 nm)} + \text{MSS5 (600 to 700 nm)}}$$

Table 2 Relationship between intercepted photosynthetically active radiation and above ground biomass production

Cultivars	Biomass
	Rabi 1993–94
'BO 54'	90.14 * Exp(0.035*IPAR), r = 0.73, N = 18
'Pusa Bold'	168.03 * Exp(0.028*IPAR), r = 0.77, N = 18
Toria 'T 9'	66.17 * Exp(0.035*IPAR), r = 0.69, N = 13
	Rabi 1994–95
'BO 54'	80.32 * Exp(0.036*IPAR), r = 0.71, N = 18
'Pusa Bold'	191.7 * Exp(0.025*IPAR), r = 0.69, N = 18
Toria 'T 9'	55.12 * Exp(0.038*IPAR), r = 0.92, N = 13
	Pooled data
'BO 54'	96.32 * Exp(0.039*IPAR), r = 0.72, N = 36
'Pusa Bold'	175.37 * Exp(0.029*IPAR), r = 0.81, N = 36
Toria 'T 9'	68.17 * Exp(0.036*IPAR), r = 0.82, N = 26

$$\text{Greenness vegetation index} = b1\ MSS4\ (400 \text{ to } 500\text{nm}) + b2\ MSS5\ (600 \text{ to } 700\text{ nm}) + b3\ MSS6\ (700 \text{ to } 800\text{ nm})) + b4\ MSS7\ (800 \text{ to } 1100\text{ nm}).$$

where b1, b2, b3 and b4 are the weightages to be given to the four MSS bands for a particular crop. For *Brassica* spp these values were found to be –0.283, –0.660, 0.577 and 0.388, respectively by Subba Rao (1987) and are used in the study.

$$\text{Soil brightness index} = a1\ MSS4 + a2\ MSS5 + a3\ MSS6 + a4\ MSS7$$

where a1, a2, a3 and a4 are derived (from bare soil) weightage coefficients and depend on the soil type. For the IARI soils, the these values were found to 0.332, 0.603, 0.675 and 0.262 respectively by Subba Rao (1987) and are used in the study.

To predict aphid incidence with significant weather variables in both the seasons, the aphids from 10 cm tip portion of the central shoot of a randomly selected plant were counted. Three plants in a plot were selected for counting aphid population at three days interval. The multiple correlation equations among different weather variables and aphid population were derived using SPSS statistical software. The infestation of aphids during both the *rabi* seasons were divided into three distinct phases, viz (i) Emergence phase: Appearance of first aphid on the plant, (ii) Establishment phase: In this phase population started multiplication and reached its peak population and (iii) Declining phase : In this phase population started decreasing and no aphid was noticed after three to four weeks.

RESULTS AND DISCUSSION

Intercepted photosynthetically active radiation by whole canopy

Results of intercepted photosynthetically active radiation revealed that the cultivar 'BO 54' and 'Pusa Bold' with relatively broader leaves intercepted 90–96 % photosynthetic active radiation by whole canopy during siliqua seed filling stage, where as in narrow leaved cultivar 'T 9' the maximum interception was 81–86 %. In cultivar 'BO 54' the maximum interception of photosynthetically active radiation which occurred on 107, 106 and 110 days after sowing, respectively coincided with siliqua seed filling to early maturity periods of crop growth. Thereafter, the values declined as the pods started turning yellow. In other cultivars also peak values of intercepted radiation were observed during siliqua seed filling to early maturity phases of crop growth. The long duration cultivar 'BO 54' and medium duration cultivar 'Pusa Bold' intercepted higher amount of photosynthetically active radiation as compared with the 'T 9' which may be attributed to the higher value of leaf are index, higher biomass production and longer crop duration of the former cultivars (Table 1). It was also noted that though leaf area index in 'Pusa Bold' was less than in 'BO 54', the radiation interception was higher in the former because of profuse podding habit (pod area index

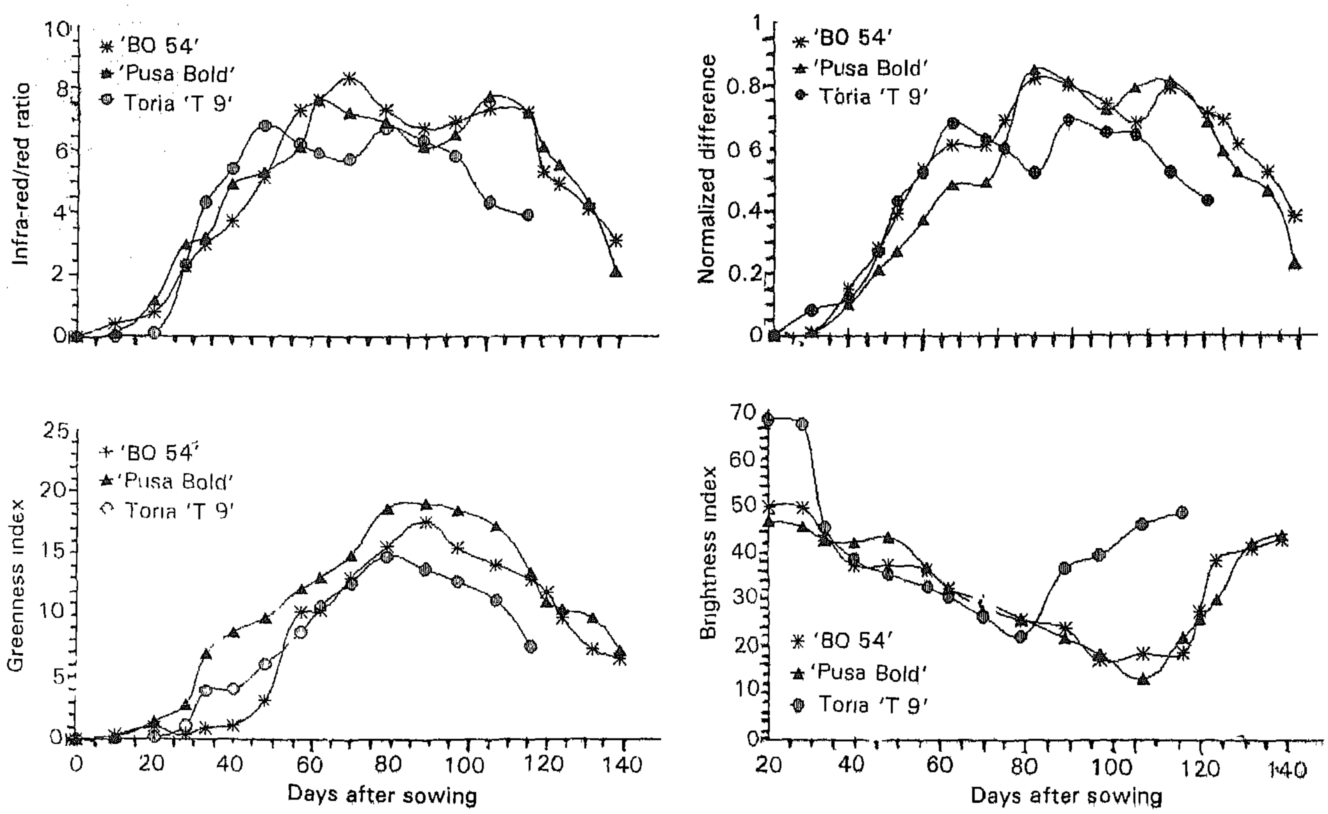

Fig 1 Variation of spectral indices in *Brasssica* during crop growth period

was higher in 'Pusa Bold' (Table 1) which plays a significant role in interception of photosynthetically active radiation even after occurrence of leaf senescence.The relationships between intercepted photosynthetically active radiation and above ground biomass production were derived and presented (Table 2). The relationships were found to be significantly correlated with the correlation coefficients varying between 0.69 and 0.92 in different sowing dates and cultivars.

Variation of spectral indices throughout the crop growth period

To understand the variation of spectral indices (infrared / red ratio, normalized difference, greenness index, brightness index) at different growth stages, the spectral reflectance was measured through out the crop growth period and 4 spectral indices were calculated as per methodology. The results of four spectral indices were pooled for different cultivars and sowing dates and variation of these indices throughout the growth period are presented in Fig 1. From the results of variation of spectral indices it was observed that peaks of infrared / red and normalized difference occurred, one before the canopy turned yellow due to flowers and another during seed filling period when no flowers were found in the plants. The greenness index followed the pattern of growth, it increased as the plants grow and declined with the crop canopy coverage. The depression due to flowers was not prominent in this index unlike infrared / red ratio and normalized difference. On the other hand, in contrast to other indices, *viz.* infrared/red, nomalized difference, greeness index, the brightness index showed a reverse pattern. It decreased as the canopy developed and attained minimum values during the maximum canopy coverage.

Table 3 Regression equations between leaf area index, above ground dry biomass and different spectral indices

'BO 54'			
LAI	=	0.521 - 0.351(IR/R)²	N = 36, r = 0.92
	=	0.518 + 0.203 (ND) - 0.847(ND)2	N = 36, r = 0.91
Biomass	=	0.88* Exp(-0.0016*GN)	N = 36, r = 0.98
	=	0.033 - 163.5(BNI) + 2.70(BNI)	N = 36, r = 0.64
'Pusa Bold			
LAI	=	0.634 - 0.259(IR/R)²	N = 36, r = 0.87
	=	0.518 + 0.403 (ND) - 0.847(ND)²	N = 36, r = 0.85
Biomass	=	0.81* Exp(-0.0071* GN)	N = 36, r = 0.87
	=	0.045 - 175.3(BNI) + 2.43(BNI)²	N = 36, r = 0.72

Table 4 Correlation coefficients between aphid population and weather parameters

	Maximum temperature	Minimum temperature	Relative humidity (%), noon
'BO 54'			
1st sowing	–0.852*	–0.853*	–415
2nd sowing	–0.195	–0.884*	–677*
3rd sowing	–0.193	–0.052	–0.866*
'Pusa Bold'			
1st sowing	–0.903*	–0.389	–0.291
2nd sowing	–0.759*	–0.629	–0.713*
3rd sowing	–0.802*	–0.709	–0.591*
Toria 'T 9'			
1st sowing	–0.586	–0.782*	–0.019
2nd sowing	–0.793*	–0.805*	–0.333
3rd sowing	–0.704*	–0.519	–0.667*

*Significant at $P = 0.05$

Table 5 Multiple regression equations between aphid population and significant weather variables

Emergence phase		
'BO 54'	Pa = 772.13 - 40.9 (TMX) + 0.179 (TMN) + 0.47 (RHN)	r = 0.67
'Pusa Bold'	Pa = 75.9 - 31.05 (TMX) + 14.13 (RHN)	r = 0.86
Toria 'T 9'	Pa = 194.63 - 17.4 (TMN) + 0.23 (RHN)	r = 0.90
Establishment phase		
'BO 54'	Pa = 19.7 + 4.69 (RHN) + 0.21 (TMN)	r = 0.86
'Pusa Bold'	Pa = 269.12 - 5.05 (TMX) - 0.40 (TMN + 0.12 (RHN)	r = 0.90
Toria 'T 9'	Pa = 194.63 - 17.4 (TMN) + 0.23 (RHN)	r = 0.79
Declining phase		
'BO 54'	Pa = -182.39 + 4.3 (RHN) + 3.9 (TMX)	r = 0.81
'Pusa Bold'	Pa = 245.93 - 32.45 (TMN) + 4.49(TMX)	r = 0.83
Toria 'T 9'	Pa = 598.61 - 31.05 (TMX) + 12.13(RHN)	r = 0.83

Pa, Number of aphids/10 cm; TMX, maximum temperature (°C) ; TMN, minimum temperature (°C), RHN , afternoon relative humidity (%)

Vegetation indices, crop growth parameters and intercepted photosynthetically active radiation

The leaf area index and above ground dry biomass are important parameters which govern crop growth and yield. Since the direct measurement of these parameters are time consuming, destructive and tedious, an attempt has been made to make the quantitative estimates of these parameters using different remotely sensed spectral indices. To understand the relationships between plant parameters like leaf area index and dry biomass and different spectral indices, viz infrared / red, nomalized difference, greeness index, the brightness index, correlation matrix was computed from pooled data of both the seasons separately for all the cultivars. It is revealed from the correlation matrix table that there was strong relationship between infrared / red ratio, normalized difference and leaf area index for all the cultivars where as these spectral indices were not significantly correlated with above ground dry biomass. On the other hand, the brightness and greenness indices were closely correlated with above ground dry biomass as compared to infrared / red ratio and normalized difference. The crop growth parameters were found to well correlated with spectral parameters (Table 3) as the correlation coefficients ranged between 0.64 and 0.92.

Correlation coefficients between aphid population and weather parameters

In order to develop a suitable predictive equation for estimating aphid population using weather data, correlation coefficients between different weather parameters and aphid population (pooled data) were derived and it was found that maximum and minimum temperatures, afternoon relative humidity were significantly correlated with aphid population with few exceptions. This correlation analysis also showed that the aphid population had a negative correlation with temperature conditions, whereas afternoon humidity had a positive correlation with aphid infestation. The correlation coefficients obtained with each of the variables for different treatments are given in the Table 4 .

Development of predictive model of aphid population

From the analysis of correlation coefficients (Table 4), it is revealed that there is a strong relationship of aphid population with maximum and minimum temperatures and afternoon relative humidity. Hence, a multiple regression analysis was build up at different phases and is summarised in the Table 5. These regression equations might be useful for forecasting aphid population in *Brassica* using meteorological parameters.

It was concluded from the present study that siliqua seed filling stage is the most vital stage of crop growth to intercept maximum amount of photosynthetically active radition . Though the leaf area index is maximum in cultivar 'BO 54', the maximum interception occurred in 'Pusa Bold' for both the seasons. The regression equations between remotely sensed spectral indices, viz infrared/red, normalized difference, greenness index, the brightness index and crop growth parameters and intercepted photosynthetically active radiation are useful in prediction of leaf area index, above ground biomass in advance without destroying the crop and find potential use of remote sensing technique in agriculture. The equations between aphid population and weather parameters can also be incorporated in the algorithms of a forecasting model to predict the incidence of aphid in agro-advisory services.

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Early evaluation of sugarcane for quality improvement as an effective approach for varietal selection in subtropical climate

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ABSTRACT

A study was conducted during 1994–96 to evaluate 16 early maturing high sugar genotypes in plant crops for 3 quality traits — brix, purity and sugar content at 4 sampling dates in October, November, December and January to assess the genetic variances, heritability, genetic advance over the mean, correlation coefficient among the characters at each sampling date and repeatability of quality traits between sampling time and maturity. Results showed that the genetic variances for these traits were largest at the early maturity stage (October). The broad sense heritability, genetic advance over the mean and correlation between 3 sucrose related traits were also highest at early maturity stage (October) and lowest at late maturity stage (January/February). Repeatability of quality traits between sampling time and maturity was smallest but highly significant at early maturity stage and highest at the late maturity stage. The study indicates that selection for the sucrose related traits will have higher expected genetic gains at the early maturity stage than selection done at other maturity stages. Genotypic differences between clones were more pronounced during this(October) for quality traits and this is very important and critical time for selection of period desirable early maturing high sugar genotypes in Uttar Pradesh which lies in the subtropical part of India .

Key words : early evaluation, sugar content, maturity stages, heritability

Selection of early maturing high sugar genotypes is major objective in breeding sugarcane for subtropical areas. In subtropical climate of Uttar Pradesh sugarcane ripening is influenced by climatic conditions and the interaction between cultivars and the environment causing the variability in the period required for ripening often ranges from 9–10 month in early varieties. To speed up the breeding process especially for early maturity combined with high tonnage, quality and resistance to diseases and other stresses, early diagnosis is useful in the selection of desired sugarcane hybrid progenies (Singh and Singh 1994). Early diagnosis depends upon the effectiveness of genes that manifest themselves in the early phases of sucrose synthesis because it is genetically correlated with those operating in the late maturity phase. Early rejection of useless genotypes from the population reduces the breeding cost and intensifies the selection.

Genes with pleiotropic effects can also be successfully used in early diagnosis. The use of pleiotropy in the selection rests on the assumption that a complex of characters is controlled by one or several closely linked genes (Kuckuck *et al.* 1991). Moreover, the pleiotropic effect of a gene can be dissipated through storage in a different genetic background. The modifying changes in quantitative characters, through environmental factors will occur particularly in the case of characters with low grades of heritability. Genetic advances from selection are largely determined by the heritability of the selection traits, their genotypic variability and the selection pressure applied by the breeder. In Uttar Pradesh it was observed that in spite of the relatively high heritability of quality traits of sugarcane advances from selection were poor, this was attributed to low genotypic variabilities observed for these traits at their maturity (Singh and Singh 1994).

The earlier reports have indicated that the environ-ment could enhance or attenuate the expression of population parameters (Mariotti 1979) but the information on the usefulness of pleiotropy for quality improvement, especially for selecting early genotype is fragmentry and insufficient. It was therefore,considered desirable to conduct intesive studies on this aspect and the result obtained during last 3 years on the selection for quality traits (brix, purity and sugar content) at 4 sampling dates commencing from early to late stages of maturity are presented.

MATERIALS AND METHODS

The experiment was conducted with 16 early maturing high sugar genotypes (clones) at selection stage IV (standard

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varietal trial-early). These genotypes were planted in spring season of 1994–95, 1995–96 and 1996–97 at the Institute farm, Shahjahanpur. Randomized block design was followed with plot size 8.0 m × 3.7 m replicated thrice. Nitrogenous fertilizer was applied @ 150 kg N/ha uniformly in 3 equal doses during February, April and May. The plant protection measures and interculture operations was done as per research recommendations. For juice analysis 1 clump from each plot was harvested randomly and analysed on monthly basis in early (November), mid-early (December), mid (January) and late (February), maturity stages for juice brix , pol % juice (sugar content) and purity. The data collected from 3 successive crop years 1994–95, 1995–96, 1996–97 were subjected to statistical analysis.

RESULTS AND DISCUSSION

Genetic evaluation of characters

The results obtained for 3 successive years show the estimation of several population parameters (Table 1,2). For simplicity year-wise data for pol % juice (sugar content) were included in Table 1 although the same trends were observed for brix and purity (Table 2).

Variability

Genotypic coefficient of variations for brix , purity and sugar content are largest at the early maturity stage (5.63, 2.94, 10.63 respectively) and lowest at the late maturity stage (1.35, 0.51, 2.16 respectively) (Table 2). The magnitude of genetic vriance for these 3 sucrose related traits decreased with monthly maturity, so did the phenotypic variance. It indicated that the variation of sucrose related traits among varieties would decline with the increase of maturity. As shown in Fig 1, environmental coefficient of variation increased almost linearly throughout the crushing season, but it was very low in October and increased rapidly up to January whereas genotypic coefficient of variation decreased more

Table 1 Population parameters estimated for pol per cent juice (sugar content) at different sampling months in early maturing sugarcane varieties

Estimate	Year	October	November	December	January
Population mean (%)	1994–95	14.38	15.63	18.18	18.87
	1995–96	14.25	15.64	17.72	18.37
	1996–97	14.15	15.74	17.75	18.52
	Pooled	14.19	15.65	17.55	18.22
Standard error (SE ±)	1994–95	0.39	0.17	0.14	0.11
	1995–96	0.42	0.40	0.31	0.17
	1996–97	0.27	0.22	0.19	0.12
	Pooled	0.32	0.18	0.11	0.09
CD (P=0.05)	1994–95	0.80	0.35	0.29	0.24
	1995–96	0.86	0.87	0.59	0.35
	1996–97	0.56	0.45	0.36	0.25
	Pooled	0.67	0.38	0.24	0.19
Coefficients of variation (%)					
Genotypic	1994–95	10.38	9.34	2.42	2.11
	1995–96	10.88	9.69	2.72	2.53
	1996–97	11.26	9.56	3.85	1.89
	Pooled	10.63	9.19	2.52	2.16
Phenotypic	1994–95	11.57	10.62	5.21	4.91
	1995–96	12.14	11.37	5.73	5.56
	1996–97	12.79	11.22	5.90	4.48
	Pooled	11.65	10.93	4.90	4.65
Environmental	1994–95	1.19	1.27	2.75	2.83
	1995–96	1.26	1.68	3.01	3.04
	1996–97	1.53	1.66	2.05	2.64
	Pooled	1.02	1.73	2.38	2 48
Heritability (%)	1994–95	89.73	87.99	46.54	42.81
	1995–96	89.66	85.22	47.44	45.45
	1996–97	88.03	85.23	65.26	42.16
	Pooled	91.23	84.10	51.45	46.52
Genetic advance for 10% selection pressure	1994–95	18.28	16.44	4.26	3.72
	1995–96	19.15	17.12	4.78	4.45
	1996–97	19.83	16.83	6.78	3.32
	Pooled	18.70	16.18	4.44	3.80

Table 2 Population parameters estimated for brix and purity coefficient at different maturity stages (pooled data of three successive years)

Estimate	Trait	October	November	December	January
Population mean (%)	Brix	17.57	18.34	19.83	20.76
	Purity	79.80	85.03	87.50	87.87
Coefficients of variation (%)					
Genotypic	Brix	5.63	4.14	2.41	1.35
	Purity	2.94	1.98	1.01	0.51
Phenotypic	Brix	5.80	4.40	2.87	2.55
	Purity	3.38	2.70	2.32	2.29
Environmental	Brix	1.41	1.46	1.59	2.20
	Purity	1.65	1.84	2.10	2.24
Heritability (%)	Brix	96.96	94.17	84.03	52.83
	Purity	87.03	73.39	45.34	22.12
Genetic advance for 10% selection pressure	Brix	9.90	7.29	4.25	2.37
	Purity	5.18	3.49	1.77	0.89

rapidly in November–December (Fig 1) and the genotypic variances had more influence on phenotypic variances than environmental variances. Mariotti (1979) in Argentina, Chang (1997) in Taiwan reported that genotypic variabilities in observed sugar content were more pronounced during October and less influenced by environmental conditions. During (1994–95 to 1996–97), the phenotypic coefficient of variation was higher compared with the genotypic coefficient of variation,but the magnitude of variability was higher only in October during all the 3 years. It implied that the selection for early high sugar varieties will be most effective at the early maturity stage (October) and low at the late maturity stage (February). It might be due to the genotypic differences in quality among genotypes which trend to be counters balanced by expression of traits at late maturity. This indicated that there was good scope for making selection for these characters at early maturity stage.

Heritability

Broad sense heritability for brix, sugar content and purity was quite high and very similar at the early (October) and mid-early (November) maturity stages but numerically decreased as maturity proceeded and was not affected significantly by sampling dates in all the three successive years (Table 1, 2). This may be owing to the presence of high genetic variance coupled with low environmental variance at early dates of sampling (October). Thus high value of heritability indicated the possibility of improvement of these characters through selection (Mariotti 1979, Gravois *et al.* 1991), which may be indirectly helpful in quality improvement.

Genetic advance

Sugar content had the largest expected genetic gain at the early maturity stage (October) for 10% selection pressure; similar trend was also observed for brix and purity (Table 1,2). Three years expected genetic gain for selection for sugar content at the early maturity stage was 18.70% higher than that for selection for brix (9.90%) and purity (5.18%). Since the expected genetic gain decreased with monthly maturity, selection for brix, purity and sugar content is better than at early maturity stage for a higher genetic advancement. A correct selection time will result in higher genetic gain. The high genotypic coefficient of variation and heritability for sugar content were reflected in its higher genetic advance value in October followed by lower value in November due to the presence of moderate genotypic coefficient of variation. These results suggest that the genes that control sucrose accumulation at early stage (October) are governed by additive gene action (Singh and Singh 1994), whereas the high heritability with lower genotypic coefficient of variation and genetic advance were observed in November–January, which is an indication of non additive gene action but it may be possibly due to greater influence of environmental factors on sugar content during this period. Thus, the mass selection for sucrose content in mid-October appears to be desirable while this traits seems to be governed by additive gene in early maturing sugarcane population (Gravois *et al.* 1991, Chang 1997). This may be improved through selection to the maximum extent only during these days.

The 3 successive years means as well as pooled data for sugar content at the early maturity stage (October) were 14.38, 14.25, 14.15, 14.19% respectively but at the maturity stage (January) these were as high as 18.87, 18.37,18.52, 18.22% respectively. The early varieties mature at the early maturity stage, so the means for quality traits were low at the early maturity stage as compared to other maturity stages. Since all varieties come to maturity at the late maturity stage the difference among varieties in quality traits becomes small and genetic variation also becomes minimum as sown in Table 1. The study showed that smaller genetic variance resulted in less genetic gain therefore, more precise selection should be conducted at the time when the trait of interest has the higher genetic variance.

Table 3 Pooled data on repeatability of quality traits between sampling time and maturity

Character	Sampling time(month)		
	October	November	December
Juice brix	0.72**	0.86**	0.92**
Pol% juice (sugar content)	0.69**	0.77**	0.88**
Purity	0.60**	0.68**	0.78**

** Denotes significant at P=0.05

Repeatability

Highly positive and significantly increasing trend of pooled temporal repeatability was observed between sampling dates and maturity, and expressed by phenotypic correlation coefficients (Table 3). Repeatabilities of quality traits - brix, sugar content and purity increase significantly as maturity approaches: possibly due to active sugar accumulation and predominant environmental correlation. Mariotti (1979) also reported similar repeatability between sampling time and maturity in Argentina.

Association between sugar content and brix

The results presented in Table 4 clearly indicated that the genotypic correlations between sugar content and brix were higher than the corresponding phenotypic and environmental correlations in October and November and almost equal in December but environmental correlations between sugar content and brix were possitive, significant and highest in January (Fig 2). Gravois *et al.* (1991) also reported similar association between sucrose content and brix in Louisiana at genotypic level in plant cane and first 2 ratoons. Genetic association of sugar content was more strongly correlated with brix in October and November than in December and January: possibly due to linkages of genes and pleiotropy as genetic causes for such correlations at early maturity stage

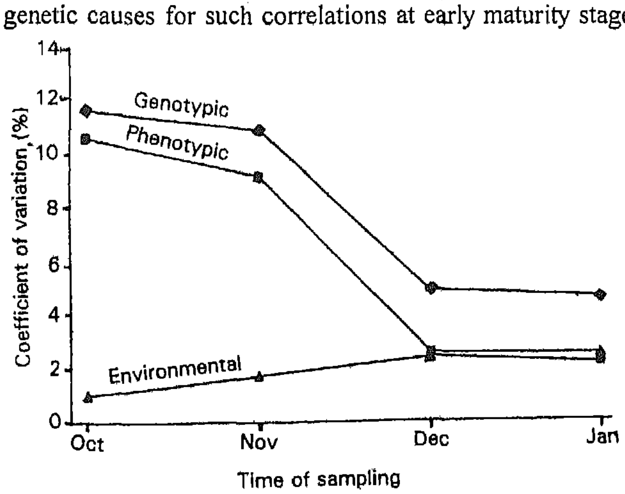

Fig 1 Effect of sampling time on pooled co-efficient of variation for sugar content

Table 4 Pooled data on genetic association of quality traits among pol percent juice (sugar content) and juice brix at different sampling time

Pol% juice(sugar content) VS Juice brix	Sampling time (month)			
	October	November	December	January
Correlation coefficient				
Genotypic	0.99**	0.89**	0.84**	0.79**
Phenotypic	0.96**	0.83**	0.78**	0.73**
Environmental	0.71**	0.78**	0.83**	0.90**

** Denotes significant at P=0.05

(Kuckuck *et al.* 1991). Thus it decreased with intensity of association as maturity approached. However, environmental correlation was also high and significant but intensity of association was lowest in October and was highest in January (Fig 1), possibly due to maturity effect, which led to positively significant correlation. These genetic correlations, in broad sense are not easily changable and are therefore, better suited for the early diagnosis or selection of secondary characters at early maturity stage (October) for sugar content and brix.

Results obtained in this study suggested that the selection of early maturing cultivars with high sugar content would be advantageous, if the selection is made in October in a clonal population of sugarcane genotypes under north Indian conditions especially in Uttar Pradesh because at this stage, most of components involved in sucrose synthesis are highly heritable and genetically independent as indicated by less environmental association values between October sampling and maturity and highly positive correlation of quality characters at genotypic level.

The study suggests that selection for sucrose related traits (brix, purity, and sugar content) done at the early maturity stage is more effective than that practiced at other maturity stages, since genetic variances, heritability, expected genetic gain and genotypic correlation between sugar content and brix were found largest at the early maturity stage (October). Considering the cost, time and labour involved in the selection process for

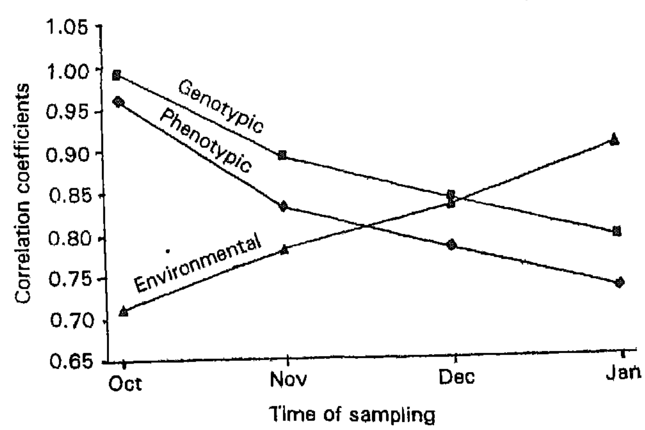

Fig 2 Effect of sampling time on pooled co-efficient of variation for association of sugar content and brix

quality improvement in sugarcane, this period (October) is critical for rejection of useless genotypes from the population. This may be useful in intensifying the selection of early maturing high sugar genotypes with reduced breeding cost.

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Estimation of sensible heat flux from radiometric temperature over crop canopy

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ABSTRACT

A numerical experiment was conducted during the harvesting period of potato crop by Lhomme to estimate sensible heat flux from radiometric surface temperature over the canopy. The model of Lhomme was in terms of the characteristics of the crop and meteorological profiles within the canopy. In the model, Lhomme introduced an additional resistance so called canopy aerodynamic resistance. Hence the total resistance to the heat transfer from canopy to the air is the sum of canopy aerodynamic resistance and usual classical aerodynamic resistance. It is not very easy to work out analytical solutions for the additional aerodynamic resistance. In this paper, an attempt is made to reformulate the model and present the simplified mathematical procedures to calculate the canopy aerodynamical resistance. Finally, the predidictions of the reformulated model were compared with those of Lhomme's model.

Key words : sensible heat flux, latent heat flux, radiometric surface temperature, aerodynamic resistance

Radiometers and scanners mounted in aircrafts and satellites provide high resolution digital images in the infrared portion of the spectrum so that the terrestrial surface temperature may be estimated on both the local and regional scales. During the past decade, infrared thermometry was extensively used to the remote sensing of the surface heat balance and associated fluxes of heat and water vapour from soil and vegetation (Choudhary and Monteith 1986).

Remotely sensed surface temperature was used over crop canopies to determine sensible heat and latent heat fluxes from the energy balance equation. These studies are generally based on the assumption that the measured infrared surface temperature is same as aerodynamic surface temperature, defined as the temperature of apparent source or sink of heat at this level. The aerodynamic surface temperature is computed from the extrapolation of temperature and velocity profiles over the top of canopy down to the level of source or sink (Kalma and Jupp 1990, Baldocchi 1991).

Lhomme (1988) gave an analytical model to calculate sensible heat flux over homogeneous crop canopy from the classical equation:

$$H = Pc_p(T_R - T_a) \quad \text{(eq 1)}$$

where T_R is infrared surface temperature, P is the mean air density, c_p is the specific heat of air at constant pressure, T_a is the air temperature at reference height z_r (a point of observation taken above the top of canopy), and r_a is the resistance to the heat transfer from canopy to the air. They showed that this resistance r_a is the sum of 2 components:

$$r_a = r_{aa} + r_{ac} \quad \text{(eq 2)}$$

where r_{aa} is the classical aerdynamic resistance of air stream between the height (h) of canopy and the reference height z_r, and r_{ac} is additional resistance, called the canopy aerodynamic resistance, accounting for the heat transfer within the canopy between the exchange surfaces (soil surface and leaves) and top of the canopy. This canopy aerodynamic resistance, defined by the mathematical expression (eq 3 of the next section) is not easy to calculate because it involves micrometeorological and physiological profiles within the canopy.

In this paper, an attempt was made to simplify the calculations for the additional resistance to make model (Lhomme 1988) more operational. Complete procedural details about the mathematical treatment are presented.

MATERIALS AND METHODS

Mathematical expressions for r_{ac} and r_{aa}

The additional resistance appearing in eq (2) is given by the following expression (Lhomme 1988):

$$r_{ac} = (X + Y)/Z \quad \text{(eq 3)}$$

where

$$X = \int_0^h s(z)l(z)r_A(z)dz \quad \text{(eq 3.1)}$$

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$$Y = s(0)r_A(0) \quad \text{(eq 3.2)}$$

$$Z = \int_0^h s(z)l(z)dz + s(0) \quad \text{(eq 3.3)}$$

where l(z) is the leaf area density, and s(z) is a function representing the fraction of surface viewed by the radiometer at any horizontal level within the crop. For a small viewing angle of the radiometer, this function can be approximated. $r_A(z)$ can be defined by the following expression:

$$r_A(z) = [(da(z)/dz).(r_b(z)/2l(z)] + \int_0^h (a(z)/K(z))dz \quad \text{(eq 4)}$$

where a(z) is the normalized available energy defined by:

$$a(z) = [Rn(z) - G]/[Rn(h) - G] \quad \text{(eq 5)}$$

where Rn(z) is the net radiation at the level z within the crop and G is the soil heat flux. $r_b(z)$ is the boundary resistance of leaves at the level z and K(z) is the eddies diffusivity at the same level.

At soil surface:

$$r_A(0) = a(0)r_b(0) + \int_0^h (a(z)/K(z))dz \quad \text{(eq 6)}$$

where $r_b(0)$ (to be denoted as r_{b0} later) is the boundary layer resistance of soil surface.

In the neutral conditions, assuming the roughness lengths for momentum and heat to be equal, the aerodynamic resistance r_{an0} above the canopy can be expressed as:

$$r_{an0} = \ln[(z_r - d)/(h - d)].\ln[(z_r - d)/z_0]/k^2u \quad \text{(eq 7)}$$

where u is the wind velocity at reference height z_r, k is the von Karman constant (0.4), d is the zero-displacement height, and z_0 is the roughness length. The values of d and z_0 for most of the crops can be obtained from empirical relationship (Campbell 1977).

$$d = 0.64h, \; z_0 = 0.13h \quad \text{(eq 8)}$$

In the non-neutral conditions, the ratio between stability-corrected aerodynamic resistance and r_{an0} is generally expressed as a function of the bulk Richardson number:

$$(r_{aa}/r_{an0}) = F(Ri_b) \quad \text{(eq 9)}$$

Ri_b is defined as

$$Ri_b = -g(z_r - d)(T_s - T_a)/(T_a u^2) \quad \text{(eq 10)}$$

where g is the accleration due to gravity.

Under the stable condition ($Ri_b > 0$), the form of F consistent with log-linear profile is given by :

$$F(Ri_b) = 1 - \alpha Ri_b \quad \text{(eq 11)}$$

where is the coefficient of linear term set at 5. The use of (eq 11) is inconvenient because $F(Ri_b)$ decreases to zero when Ri_b reaches a critical value $Ri_c = 1/\alpha$ Louis (1979) proposed the expression :

$$F(Ri_b) = (1 + \beta Ri_b)^{-1} \quad \text{(eq 12)}$$

which remains positive for the whole stable domain. Eq (11) fits the data for $Ri_b < 0.1$. Eq (12) with $\beta = 10$ gives a better representation of data in the range $0.1 < Ri_b < 0.2$. Louis (1979) used eq (12) with $\beta = 5$, which overestimates flux gradient ratio except for small values of Ri_b. Equations (11) and (12) can be combined together to give:

$$F(Ri_b) = 1 - Ri_b/[Max(Ri_c, Ri_b + 1/\beta \quad \text{(eq 13)}$$

$F(Ri_b)$ is given by eq (3.11) for $Ri_b \leq Ri_b - 1/$ and by eq (12) for $Ri_b \geq Ri_c - 1/\beta$

Under the unstable conditions ($Ri_b < 0$), only the approximate solutions can be obtained.

Calculations for r_{ac}

The calculations for r_{ac} involve determination of each function appearing in expression eq (3). The evaluation of each function is step-wise is given below:

The area viewed by the radiometer at any level within the canopy is expressed as an exponential function of cummulative leaf area index L(z) (Ross 1975):

$$s(z) = \exp[-\gamma L(z)] \quad \text{with } \gamma = G(\gamma_0)/\sin\gamma_0 \quad \text{(eq 14)}$$

where γ_0 is the inclination angle of the radiometer to the horizontal and $G(\gamma_0)$ is a function giving the projection of unit foliage area in the direction of radiometer. Goudriaan (1977) gave following expression for $\gamma_0 > 15^0$:

$$G(\gamma_0) = G_1 + 0.877/(1 - 2G_1)\sin\gamma_0 \quad \text{(eq 15)}$$

with

$$G_1 = 0.5 - 0.633X_L - 0.33X_L^2 \quad \text{(eq 16)}$$

where X_L is the inclination index of the foliage; where $X_L = 1$ corresponds to the foliage having horizontal leaves and $X_L = -1$ to the foliage having vertical leaves. Ross (1975) gave values of X_L for different crops.

The cummulative leaf area index L(z) is related leaf area density l(z) by the expression:

$$L(z) = \int_z^h l(z)dz \quad \text{(eq 17)}$$

Using a constant leaf area density profile defined by l(z)

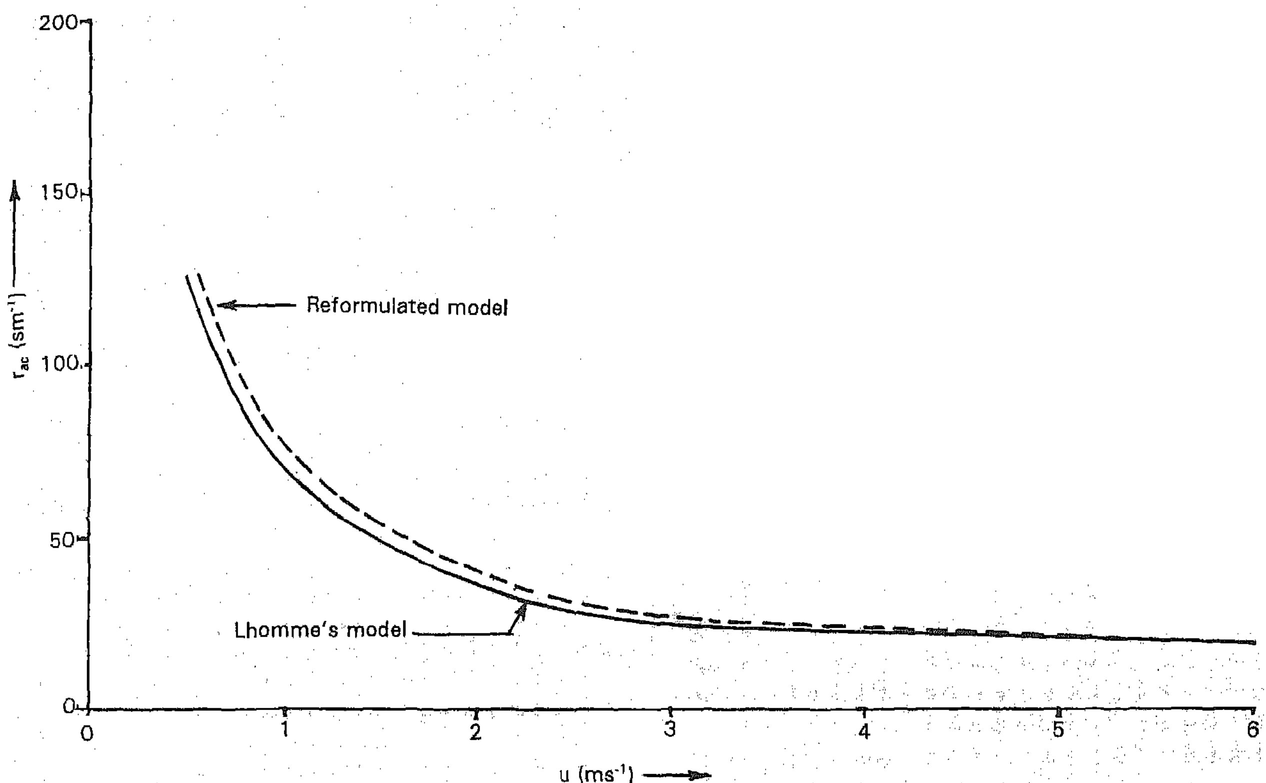

Fig 1 Variation in canopy aerodynamic resistance r_{ac} (calculated for neutral condition) as a function of wind velocity at a reference height of 3m The characteristics of the crop are: h=0.7m, L_0=3, X_L=0.4, view angle radiometer is 90°

$= L_0/h$; L_0 being the total leaf area index, the integration (17) gives:

$$L(z) = L_0(1 - z/h) \quad \text{(eq 18)}$$

The extinction of net radiation within the canopy can be described by the Beer's law:

$$Rn(z) = Rn(h)\exp[-\alpha_r L(z)] \quad \text{(eq 19)}$$

The extinction coefficient α_r depends upon the structure of canopy. $_r$ is generally taken as 0.6 for most of agricultural crops with dense canopies. The soil heat flux G is generally taken as a proportion of the net radiation reaching the ground; $G = \mu Rn$ with $\mu = 0.1$ (Campbell 1977).

The wind velocity and eddies diffusivity can be assumed to decrease exponentially within the canopy:

$$u(z) = u(h)\exp[-\alpha_w(1 - z/h)] \quad \text{(eq 20)}$$
$$K(z) = K(h)\exp[-\alpha_w(1 - z/h)] \quad \text{(eq 21)}$$

A typical value of α_w for agricultural crops is 2.5. From traditional theory of eddies diffusivity, K(h) can be expressed as a function of u(h):

$$K(h) = K_0 u(h) \quad \text{(eq 22)}$$

where K_0 is the eddy diffusivity at the reference height level above the top of canopy given by:

$$K_0 = k^2(h - d)/\ln[(h - d)/z_0] \quad \text{(eq 23)}$$

The wind velocity at canopy level u(h) can be calculated from the wind velocity u measured at the reference height z_r

$$u(h) = \{\ln[(h - d)/z_0]/\ln[(z_r - d)/z_0]\}\, u \quad \text{(eq 24)}$$

The boundary layer resistance of the leaves $r_b(z)$ can be related to local wind velocity u(z):

$$r_b = r_{b0}/(u(z))^n \quad \text{(eq 25)}$$

where r_{b0} is the boundary layer resistance of the soil surface. The parameters r_{b0}, and n are considered to be respectively equal to 50 and 0.8.

Using analytical profiles described right from Equations (4) to (25), solutions for $r_A(z)$, X, Y, and Z can be worked to give:

$$r_A(z) = \Delta.[B.\exp(n\alpha_w - \alpha_r L_0)t + C.\exp(\alpha_w - \alpha_r L_0)t + D.\exp(\alpha_w t) - (C + D)] \quad \text{(eq 26)}$$

where, $t = 1 - z/h$; $\Delta = 1/[1 - \mu.\exp(-\alpha_r L_0)]$; $B = \alpha_r r_{b0}/2(u(h))^n$; $C = h/[K(h)(\alpha_w - \alpha_r L_0)]$;
and $D = -h\mu/(K(h)\alpha_w)$

$$X = \Delta.L_0[B.\{\exp(b) - 1\}/b + C.\{\exp(c) - 1\}/c + D.\{\exp(d) - 1\}/d + (C + D).\{\exp(-\gamma L_0) - 1\}/\gamma L_0] \quad \text{(eq 27)}$$

where, $b = n\alpha_w - (\alpha_r + \gamma)L_0$; $c = \alpha_w - (\alpha_r + L_0)$; $d = \alpha_w - \gamma L_0$

$$Y = \Delta^*.[B^*.\exp(n\alpha_w - \alpha_r L_0) + C.\exp(\alpha_w - \alpha_r L_0) + D.\exp(\alpha_w) - (C + D)] \quad \text{(eq 28)}$$

where, $\Delta^* = \Delta^*.\exp(-\gamma L_0)$; $B^* = 2(1 - \mu)B/\alpha_r$

$$Z = [1 + (\gamma - 1).\exp(-\gamma L_0)]/\gamma \quad \text{(eq 29)}$$

RESULTS AND DISCUSSION

The model developed by Lhomme (1988) could be made more operational by simplifying the additional resistance r_{ac} (eq 3) appearing in the equation of sensible heat flux (eq 1). The additional resistance involves 3 quantities: X, Y, and Z (eqs 3.1 – 3.3) which were formulated in terms of wind velocity (u) at the reference height (z_r), inclination of radiometer (γ_0), crop height (h), leaf area index [L_0(= LAI)], surface boundary layer resistance (r_{b0}), and inclination index of foliage (X_L). The simplified explicit expression for r_{ac} can be used to calculate more readily the sensible heat flux than the previous expression given by Lhomme (1988). This model can even be applied to sparse canopies for which a major portion of soil below the canopy can be viewed by the radiometer.

Lhomme (1988) computed r_{ac} for potato crop ($L_0 = 3$, h = 0.7m, z_r = 3m) in the neutral condition shown in the Fig. (solid curve) as a function of wind velocity at reference height. As a comparison, numerically evaluated r_{ac} from this model is presented in the Fig 1 (dotted curve) using a standard agricultural crop canopy; the characteristcs of which are close to those of a potato crop (h = 0.7m, z_r = 3m, L_0 = 3, X_L = 0.4). A close agreement was found.

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Management of *Ralstonia* wilt through soil disinfectant, mulch, lime and cakes in tomato (*Lycopersicon esculentum*)

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ABSTRACT

The study was conducted during the winter season of 1992–1995 on soil amelioration in sick plot having mean *Ralstonia solanacearum* population 6.23×10^5 cfu/g soil (ranging from 3.64×10^5 to 8.38×10^5cfu/ g soil) with 8 treatments, viz (i) bleaching powder, (ii) rice straw, (iii) rice straw + bleaching powder, (iv) mustard cake, (v) Indian beech (karanj) cake, (vi) lime, (vii) formaldehyde and (viii) untreated control ; applied 15 days before transplanting, revealed that *Ralstonia* wilt in tomato (*Lycopersicon esculentum* Mill. nom cons.) could be significantly managed by soil disinfectant, lime and cakes. The results revealed that the plant survival was maximum in plots receiving Indian beech (karanj) cake (69.7%) follwed by bleaching powder (68.2%) and lime (60.0%). Maximum yield increase over the control was noted in lime application (128.7%.) followed by that of mustard cake (69.7%)and formaldehyde (52.7%), the bacterial population was reduced to 53.7% over the initial in plots receiving bleaching powder folloed by 53.3% in formaldehyde and to 51.1% in rice straw + bleaching powder. Soil amelioration by Indian beech (karanj) cake, bleaching powder and lime may be used to manage the bacterial wilt of tomato.

Key words : *Ralstonia solanacearum*, soil amelioration, tomato

Bacterial wilt of tomato (*Lycopersicon esculentum* Mill. nom cons.) caused by *Ralstonia solanacearum* Smith (Yabuuchi *et al.* 1995) is one of the most destructive bacterial diseases of plants and the most widespread in tropical, sub-tropical and warm temperate region. The status of disease in India has been reviewed (Sinha 1985, Ram Kishun 1987, Rao and Ram Kishun 1988.) The pathogen is serious on solanaceous vegetable in several states (Rao and Sohi 1977). High temperature play an important role in increasing wilt (Rema Devi and Menon 1980). The disease attack at flowering stage (Gowda *et al.* 1974) and cause severe loss in yield. Very meagre information on management of this disease is available through crop rotation (Sohi *et al.* 1981, Rao and Ram Kishun 1988) and soil amendments in India (Jaya Prakash and Rajan 1975) and abroad (Yao *et al.* 1994). Paucity of information on the disease management through cultural practices in the Alfisols of eastern plateau prompted us to undertake the present investigation.

MATERIALS AND METHODS

The experiment was conducted at the experimental station, Ranchi during 1992–95 on a sandy loam soil (Ultric Haplustaf) with pH 5.3 having organic carbon 0.45% and status of NPK as high, low and high respectively. The population of *Ralstonia solanacearum* was monitored in different seasons and the soil was found to contain a high of $11.33 \times 10^5$and a low of 2.94×10^5 cfu bacteria/g of soil with a mean population of 6.23×10^5 cfu/g soil.

Three-old seedlings of bacterial wilt susceptible cultivar 'Pusa Ruby' were transplanted in post-monsoon season at 15 days after the application of treatments. Treatments included (i) bleaching power (3 g/m^2), (ii) rice straw (250 g/m^2), (iii) rice straw (250g/m^2) plus bleaching powder (3 g/m^2), (iv) mustard (*Brassica juncea* L. Czernj & Cosson) cake (92.5 g/m^2), (v) Indian beech (karanj) (*Pongamia glabra* Vent. Jardi and Malm.) earlier reported as *P. pinnata L.*) cake (92.5 g/m^2), (vi) lime (finely meshed calcium carbonate dust 250 g/m^2), (vii) formaldehyde (0.1%) and (viii) untreated control. A recommended dose of NPK fertilizer (100: 70:50) along with organic manure was applied and usual crop husbandary measures were taken.

Soil samples taken at the intial and final stage (36 month) of experiment were quantitatively assayed by dilution plate technique on TTC medium for determining the bacterial population. Plant survival at 30-days interval and yield/plot were recorded. Mean values of 3 years data on plant survival and yield were statistically analysed (Panse and Sukhatme 1978).

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Table 1 Effect of soil amelioration on population of *R. solanacearum*, plant survival and yield of tomato

Treatment	Dose (g/m^2)	Population of After 36 months cfu ($\times 10^5$)/g of soil	*R. solanacearum* % reduction over initial	Plant survival percentage	Disease control (%)	Yield (tonnes/ha)	Yield increase over control (%)
Bleaching Powder	3.0	2.88	53.7	68.2(56.68)	82.8	6.08	35.9
Rice straw	250.0	3.49	43.9	55.0(47.88)	47.5	6.38	42.6
Rice straw + bleaching powder	250.0 +3	3.05	51.0	52.1(46.21)	39.7	6.35	41.9
Mustard cake	92.5	4.11	34.0	37.1(37.52	0.0	7.59	69.7
Karanj cake	92.5	3.41	45.2	69.7(58.11)	86.9	6.06	35.5
Lime	250.0	3.50	43.8	60.0(50.79)	60.9	10.23	128.7
Formaldehyde	0.1%	2.91	53.3	52.5(46.45)	40.0	6.83	52.7
Control		4.03		37.3(37.67)		4.47	
CD (P=0.05)		0.68		9.60(18.01)		10.9	
CV (%)				15.40		9.63	

RESULTS AND DISCUSSION

Ralstonia *population*

The pooled analysis of data on bacterial assay carried out from soil samples collected 15 days before and 36 months after the soil amendments are presented in Table 1. Bacterial population (mean) on initial as well as at final stage (after 36 months) varied significantly. The initial mean population in control plot was 6.23×10^5 cfu/g soil ranging from 2.94 to 8.38×10^5 soil. At the end of 36 months the mean bacterial population in treated plots declined to 3.3×10^5 cfu/g soil showing an average 46.4% reduction over the mean initial population in control. The low bacterial populations in polts treated with bleaching powder (2.88×10^5 cfu/g soil), formaldehyde soil desinfectant (2.91×10^5 cfu/g soil), rice straw + bleaching powder (3.05×10^5 cfu/g soil) and Indian beech (karanj) cake *(Pongamia glabra)* (3.41×10^5 cfu/g soil) were noted. These treatments were at par among themselves but significantly different from other treatments showing 53.7, 53.3, 51.0 and 45.2% reduction in bacterial population respectively over the intial population in control plot, whereas in the soil amended with lime, rice straw and mustard cake, the bactetial population was 3.5×10^5, 3.49×10^5, 4.11×10^5 cfu/g soil respectively, thereby showing 34.0, 43.9 and 34.0% reduction in the mean population, The effect on the reduction of bacterial population due to soil ammendments with bleaching powder and rice straw, either singly or in combination were at par and no added advantage due to the synergistic effect was noted.

Plant survival

The pooled data of 3 years (Table 1) revealed that the maximum plant survival was recorded in Indian beech cake ammended plots (69.7%) followed by bleaching powder (68.2%) and lime (60.0%) applied plots. These treatments but stood significantly different from control (37.3%). In these treatments disease control could be achieved up to 86.9, 82.8 and 60.9% respectively. On the other hand the mulch treatment with rice straw *(Oryza sativa)* alone showed 55% plant survival followed by formaldehyde soil disinfectant (52.5%) and rice straw + bleaching powder (52.1%) showing moderate disease control of 39.7–47.5% only.

However, in mustard (*Brassica juncea*) cake treated plot plant survival (37.1%) was at par with control (37.3%).

The correlation coefficient between plant survival and bacterial population was determined (r= – 0.6841). This significant relationship showed that bacterial population plays an important role in plant survival. the co-efficient of determinative showed 66.23% relationship, and the following quadratic equation was derived:

$$Y = 909765.18 - 19569.48\,X + 160.49\,X^2 \quad (R^2 = 0.6623)$$

where Y, expected bacterial population in cfu/g soil; X, plant survival (%).

Fruit yield

A significant effect of treatments on yield was noted. The maximum, response in yield was noticed in lime treated plot (10.23 tonnes/ha) (Table 1) which yielded 128.7% more than control. Mustard cake boosted the yield (7.59 tonnes/ha), ie 69.7% more than the control, whereas the formaldehyde treated plot recorded 6.83 tonnes/ha yield sowing 52.7% increase over the control. Yield increase between 35.5 – 42.6% over that of control was found in the other treatments.

Thus the best treatment in reducing the *Ralstonia* population to 53.7 and 82.8% disease control was found through bleaching powder alone which resulted in 35.9% more yield over the control. This result was in conformity with various workers (Rao and Ram Kishun 1985, Mazumder 1998). This was followed by *Pongamia* cake showing 45.2%

reduction in bacterial popoulation giving 86.9% disease control with 35.6% more yield. Lime showed 43.9% reduction in bacterial population with 60.9% disease control and 128.7% more yield over the control. Mustard (*Brassica juncea)* cake showed toxic effect on plant survival which may be due to the (toxic principle to plant) (Anonymous 1984) but reduction in bacterial population was 23.5% only. *Pongamia* cake was used as manure and has been reported to reduce to incidence of root knot nematode (*Meloidogyne javanica)* which is closely related with *Pseudomonas* wilt (Anonymous 1982). In this investgation the yield increase may be due to increase in available nutrients after cakes application. Besides this due to toxic principle present in cake might have decreased the bacterial population (Singh 1991). The heat is generated due to cake application which might also affect plant survival and pathogen (Yao *et al.* 1994). bleaching powder ($CaOCl_2$)@50 g/m^2 is reported to reduce bacterial wilt by 68.4% in potato (Verma and Shekhawat 1991) 10 g and 5 g/litre in tomato (Mazumder 1998), whereas in the present invesigation it was used @3 g/m^2 which resulted in significant reduction of the pathogen and increased yield in tomato.

Lime ($CaCO_3$) application showed maximum response on plant survival and fruit yield (2.3 times over the control) as well as reduction in pathogen population which might be due to increase in pH of soil. The result was in corroboration with Yuan *et al.* 1997 who reported that the susceptible soil amended with 2.67% calcium carbonate having pH 7.8 resulted in 41.67% disease frequency. The change of pH towards neutral increases the availability of nutrients like calcium (Yamazaki *et al.* 1996), magnesium, phosphorus, boron and molybdenum which may improve plant health and increase the yield (Singh 1991). It may be noted that the soil ammending agents have acted differently. It has helped reduction in bacterial population (bleaching power, rice straw, formaldehyde), enhancement of plant survival (karanj cake) and the yield increase by improving the plant vigour (lime). The advantage of the treatments is therefore requried to be viewed accordingly. The present investigation is in confirmity with the results of Locascio *et al.* (1988), Jaya Prakash and Rajan (1975) and Michel *et al.* (1997).

It was concluded that the soil amelioration with bleaching powder, lime and Indian beech (karanj) cake were effective in the management of bacteial wilt and the yield increase in tomato in plateau area of Bihar. Mustard cake however did not control the bacterial population in soil but it boosted the yield by 69.7%.

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Effect of paclobutrazol on yield and quality of different cultivars of ber (*Zizyphus mauritiana*)

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ABSTRACT

A study was conducted during 1995–96 to evaluate the suitable dose of paclobutrazol on fruit production and quality of ber (*Zizyphus mauritiana* L.) and results showed highest dose of paclobutrazol (200 ppm) was effective to minimize the fruit drop and fruit craking in each cultivars of ber. Fruit quality in terms of fruit weight, pulp:stone ratio, TSS (%) and storage life of fruit increased at lower concentration (150 ppm) of paclobutrazol. Only highest does of paclobutrazol reduced the fruit weight and its size. However, high does of paclobutrazol were increased the fruit yield and proved economical.

Key words : paclobutrazol, cracking, fruit drop

Ber (*Zizyphus mauritiana*) is one of the most important subrtopical fruit crop of Rajasthan. A 10-year-old bearing tree gave average fruit yeild of 80–200 kg/tree. This variation in yield was depends on the type of cultivars and orchard management (Pareek 1995). Plant growth regulators have long been recognized as important tool in the integral development activities which are concerned with response of plant to the external physical environment besides being the main agent, which otherwise regulated expression of intrinsic genetic potential of the plant (Moore 1979). An attempt was, therefore, made to the use of paclobutrazol, a gibberellin biosynthesis inhibitor in tackling the problem of lower yield of poor fruit quality.

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MATERIALS AND METHODS

The present investigations were carried out on fully grown 10 - year - old ber cultivars 'Gola' ,'Seb' and 'Umran' at Government Agriculture Research Station, Hanumangarh Town in Rajasthan during 1995 – 96. Trees selected for studies were uniform size and vigour and were receiving uniform cultural

Table 1 Effect of paclobutrazol sprays on fruit drop and fruit cracking in different cultivars of ber

Treatment (PBZ ppm)	Total fruit drop (%)	Direction-wise fruit cracking				Total fruit cracking (%)
		East	West	North	South	
'Gola Control'	90.00	2.06	4.24	2.83	6.93	16.06
'Gola 100'	88.50	1.97	3.84	2.71	6.55	15.06
'Gola 150'	87.63	1.85	3.33	2.45	6.20	13.83
'Gola 200'	84.13	1.81	3.13	2.25	5.31	12.50
'Seb Control'	91.96	2.15	4.78	2.97	6.89	16.79
'Seb 100'	89.76	2.11	4.50	2.74	6.99	16.34
'Seb 150'	86.66	1.84	3.98	2.41	5.96	14.19
'Seb 200'	86.03	1.76	3.10	2.19	5.50	12.55
'Umran Control'	91.30	1.97	4.30	2.64	6.18	15.09
'Umran 100'	89.96	1.88	4.05	2.38	6.08	14.39
'Umran 150'	87.90	1.73	3.87	2.19	5.63	13.42
'Umran 200'	85.00	1.71	3.02	2.05	5.26	12.04
Mean		1.90	3.84	2.48	6.12	14.35

PBZ , Paclobutrazol

Table 2 Effect of paclobutrazol sprays on fruit quality of different cultivars of ber

Treatment (PBZ ppm)	Fruit weight (g)	Seed weight (g)	Pulp : stone ratio	Fruit length (cm)	Fruit (g) weight	TSS (%)	Storage life (days)
'Gola Control'	23.33	5.13	4.64	4.40	3.40	15.06	3.66
'Gola 100'	23.66	4.86	5.54	4.10	3.30	15.40	5.00
'Gola 150'	26.33	4.46	5.92	3.76	3.10	15.60	5.33
'Gola 200'	22.66	4.06	5.59	3.46	2.86	15.60	5.33
'Seb Control'	27.33	5.06	5.39	4.06	3.66	15.03	4.00
'Seb 100'	31.33	4.63	6.75	3.86	3.40	15.56	5.33
'Seb 150'	31.66	4.13	7.67	3.66	3.20	15.73	6.33
'Seb 200'	25.00	3.80	6.95	3.46	2.90	15.90	5.66
'Umran Control'	29.66	4.96	5.96	4.60	3.86	15.46	4.33
'Umran 100'	34.33	4.50	7.62	4.30	3.76	15.73	5.66
'Umran 150'	28.33	3.73	8.28	4.10	3.46	15.93	6.66
'Umran 200'	35.66	4.10	9.43	3.76	3.06	15.93	6.66
CD (P=0.05)	2.154	0.369	1.008	0.431	0.549	0.371	1.170

PBZ, Paclobutrazol

Table 3 Effect of paclobutrazol sprays on different cultivars of ber yield and cost effectiveness of the treatment applied

Treatment (PBZ ppm)	Fruit yield		Increasing in yield over cont -rol (kg/ha)	Cost of applying treatment/ha (Rs)	Value of increased yield over control/ha (Rs)*	Profit (Rs/ha)
	kg/tree	kg/ha				
'Gola Control'	75	7 500				3 750
'Gola 100'	84	8 450	950	350	4 625	4 275
'Gola 150'	95	9 500	2 000	475	10 000	9 525
'Gola 200'	98	9 825	2 325	600	11 625	11025
'Seb Control'	72	7 250				3 625
'Seb 100 '	82	8 225	975	350	4 875	4 525
'Seb 150 '	92	9 200	1 950	475	9 750	9 275
'Seb 200 '	95	9 500	2 250	600	11 250	10 650
'Umran Control '	76	7 625				3 812
'Umran 100'	80	8 050	425	350	2 125	1 775
'Umran 150'	96	9 600	1 975	475	9 875	9 400
'Umran 200'	97	9 700	2 075	600	10 375	9 775

PBZ, Paclobutrazol ; * wholesale price of ber fruit Rs 5/kg

practices like manures, fertilizers, irrigation and tillage etc. Foliar sprays of 100, 150 and 200 ppm paclobutrazol were applied in each cultivars at fruit set and 15 days interval thereafter. Tween - 20, 0.1 % was used as surfactant.These were compared with the unsprayed, ie control in experiment laid out as per randomized blrck design with 3 replications. One tree served as a unit of treatment in each replication.

In all replications, 20 flowering panicles (5 in each direction) were tagged on each tree for studying the percentage of fruit drop and fruit cracking. The data on the fruit weight were recorded in gram and yield in kg/tree. Size of fruit were measured and TSS % was recorded by hand refractometre. The precentage of edible proportion of fruits (pulp:stone ratio) were calculated on weight basis. Profit was calculated by substracting the total cost of treatment from total earning on per hactare basis.

RESULTS AND DISCUSSION

Fruit drop in various treatment significantly varied from 84.13% in 200 ppm paclobutrazol sprayed on 'Gola' cultivar (minimum) to 91.96 % in control (Table 1). Teotia and Chauhan (1963) reported that fruit drop in ber was due to embryo abortion besides hormonal imbalance (Singh *et al.* 1970 and Singh *et al.* 1987). Present findings indicated that paclobutrazol sprays helped only to a very limited extent in reducing the severity of fruit drop in 'Gola', 'Seb' and 'Umran' under Hanumangarh conditions and confirm the earlier findings of Sankhala *et al.* 1989. Highest dose of paclobutrazol (200 ppm) sprays effectively minimized cracking incidence in each cultivars of ber. Minimum cracking of 12.04% was with 200 ppm of paclobutrazol sprays while lowest concentration (100 ppm) gave slightly higher cracking percentage (14.39). Maximum fruit cracking of 16.79 % was observed in control trees. Seb cultivar of ber was responded to most sensitive to cracking than 'Gola' and 'Umran' respectively. These findings confirm the earlier finding of Sankhala *et al.* (1989) who found that soil appliction of 8 mg paclobutrazol / tree reduced the fruit cracking in ber. Maximum fruit cracking observed on southern and western sides of the tree was due to the high temperature and more light intensities including the longer duration of exposure to sunlight (on the western sides specially) is in full agreement with the earlier observation of Kumar (1988) and Dutta (1988) in litchi.

Poaclobutrazol reduced the seed weight and size of fruit with the increase of fruit quality in terms of pulp:stone ratio, TSS % and storage life of fruit (Table 2). High pulp:stone ratio was probably due to the reduced seed weight. Only highest concentration of paclobutrazol reduced the fruit weight along with pulp:stone ratio. Generally, paclobutrazol increased 2 days longer shelf life of fruit in each cultivars. Similar results were also brought out by Kurian and Iyer (1993) in mango (*Mangifera indica* L.)

High concentration of paclobutrazol sprays war effective to encrease the fruit yield in each cultivars of ber than the low doses (Table 3). Such an improvement in production has been reported by several workers (Burondkar and Gunjate 1991), in mango. The data on the cost effectiveness of various doses of paclobutrazol sprays indicated that the 2 075 – 2 325 kg/ha increased yield in 200 ppm paclobutrazol sprays over the control with the value of Rs 9 775 – 11 025.

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Infection process of take-all causing fungus (*Gaeumannomyces graminis* var *tritici*) on wheat (*Triticum aestivum*) and oat (*Avena sativa*) roots

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ABSTRACT

The infection process of take-all causing fungus *Gaeumannomyces graminis* (Sacc.) Arx & Oliver var *tritici* J. Walker on the seminal roots of wheat (*Triticum aestivum* L. emend Fiori and Paol.) and oat (*Avena sativa* L.), cultured at 15±1°C under 12 hr intervals of light and dark, was shown by microscopic observations to consist of 4 stages, viz pre-infection, invasion of epidermis, invasion of cortex and invasion of stele stages. In the pre-infection stage, fungus spreads mainly as runner hyphae on the root and root hair surface. Sister hyphae matted and brown kidney- or fork-shaped hyphopodia formed on wheat and oat roots were observed, respectively. After 48 hr (wheat) and 120 hr (oat) of inoculation, the runner hyphae producing hyaline infection hyphae penetrated into the epidermal cells of roots through intercellular spaces. However, the invasion of infection hyphae on oat roots was hindered. After 60 hr (wheat) and 132 hr (oat) of inoculation, the take-all fungus penetrated epidermal cells into the cortical cells and spread radially in the cortex. Some infection hyphae in the cortex of oat roots were dissolved. After 120 hr (wheat) and 240 hr (oat) of inoculation, *G. graminis* var *tritici* reached stele tissue resulting in the blockage of the vascular cells and making the transport system abnormal.

Key words : pathogenesis, *Gaeumannomyces graminis* var *tritici*, wheat and oat

The soil-borne ascomycete *Gaeumannomyces graminis* (Sacc.) Arx & Oliver var *tritici* J. Walker is the etiologic agent of take-all, a root-rotting disease that causes large economic losses in wheat and barley production worldwide (Zengel *et al.* 1993). Since 1970s, it is one of the major factors threatening wheat production in China. The disease can be managed by cultural practices and chemical treatments (Huber 1989, Huber and MacCay-buis 1993, Penrose 1995), however, a degree of resistance in wheat would further enhance its control where these options are restricted.

Strong resistance to *G. graminis* var *tritici* has not been detected in cultivated wheat (Scott 1981). Even though some wild cereal grasses may have take-all resistance genes that could be transferred to wheat (*Triticum aestivum* L. emend Fiori and Paol) (Conner *et al.* 1988), no resistant wheat cultivars have been released yet. Oat (*Avena sativa* L.) having antifungal saponin avenacin in the roots, is resistant to *G. graminis* var *tritici* (Crombie and Crombie 1986, Crombie *et al.* 1987, Osbourn and Clarke 1994). The physico-chemical properties and the distribution in the plant and the toxicity of avenacin to *G. graminis* var *tritici* are known (Crombie and Crombie 1986, Crombie *et al.* 1987), however, few reports are available about the infection process of *G. graminis* var *tritici* on the seminal roots of cereals and whether avenacin is the only factor determining resistance of oat to *G. graminis* var *tritici*.

A study conducted during 1995–98 to focus on the cytological and morphological reactions of wheat and oat roots to *G. graminis* var *tritici* to understand the mechanism of take-all resistance further.

MATERIALS AND METHODS

Fungal culture and cultivars

Culture of *G. graminis* var *tritici* isolated from infected wheat roots in Shaanxi and maintained on potato dextrose agar medium in petri-dish for 10 days at 25±1°C served as inoculum. Seeds of '76120' wheat and 'Canada 73–7' oat were kindly provided by Dinxi Agricultural Science, Dinxi, Gansu Province of China.

Inoculation and observation

Samples of seminal root sections of wheat and oat seedlings grown in sand culture technique were prepared following Penrose (1985). Seeds were surface sterilized with 70% ethanol rinsed thrice with sterile water germinated aseptically in incubator at 25±1°C and placed singly on inverted disc of 1 cm diameter inoculum cut from the edge of actively

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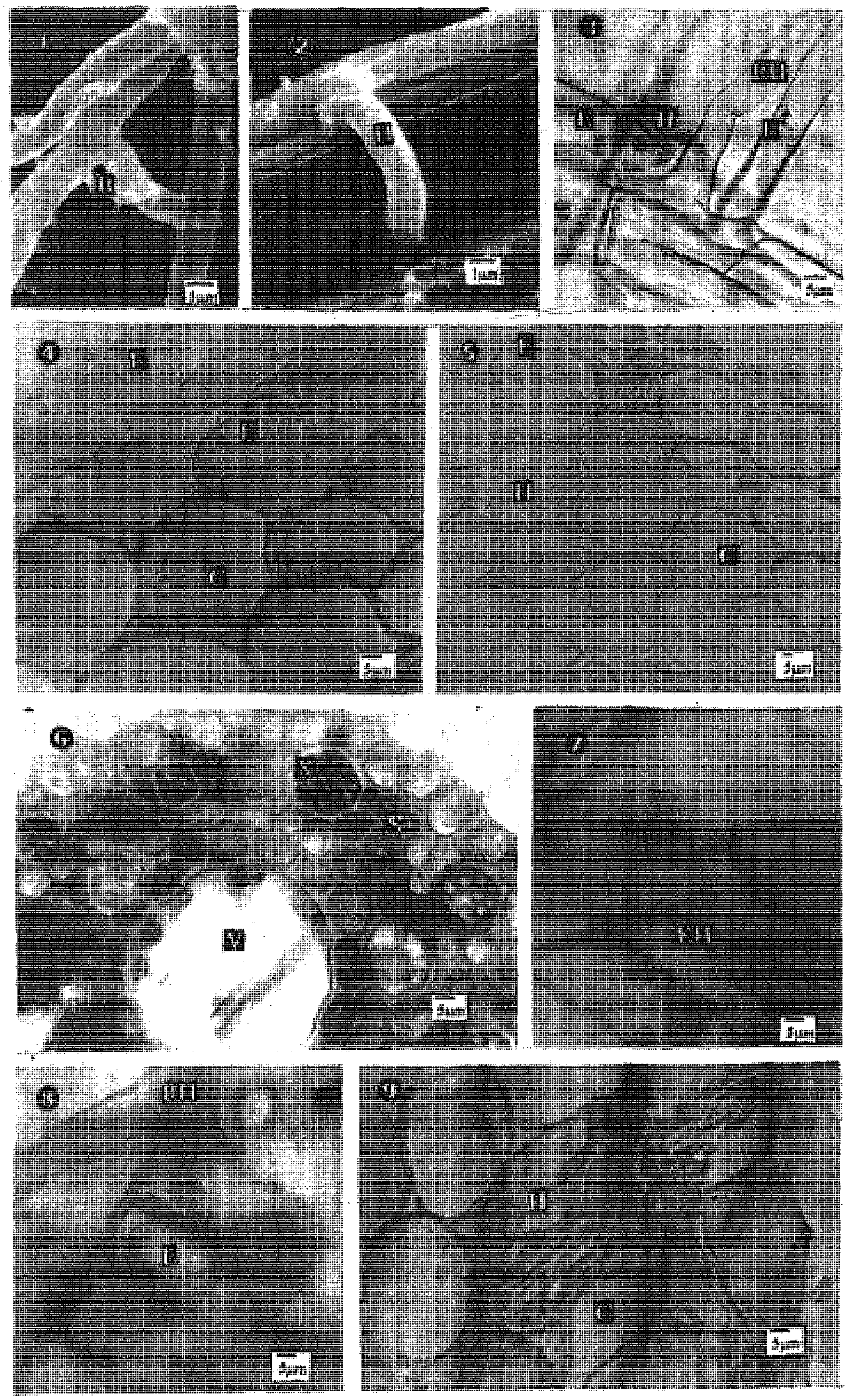

Fig 1 1, Runner hyphae spread on root surface of wheat and the sister hyphae matted together form a bridge structure (B). Observation made with scan electron microscopy; 2, infection hyphae (H) invades into the epidermis in the intercellular spaces (Scan electron microscopy); 3, lignitubers (L) produced in the epidermal cells (E) and root hair (RH) of wheat (Hand section, no strain); 4, infection hyphae spread vetically from the infection site cell to the endodermis in the cortex (C) and before entering in the other cells a lot of lignutubers (L) produced on the opposite wall (Hand section, Safranine O stain); 5, different kinds and sizes of lignitubers (L) formed in the cell wall opposite to the hyphal penetration on wheat roots (Hand section, trypan blue stain); 6, infection hyphae filled up the stele of wheat and the xylem (X), sieve (S) and the central vesessel (V) cells become dark by the substance secreted by the infected hyphae (Hand section, no stain); 7, kidney-shaped hyphopodia (KH) formed on the root surface of oat (no stain); 8, infection hypha is invading into the epidermis (E) on the intercellular space and the infection hypha was hindered and coiled on the oat roots (Trypan blue stain); 9, hyphae as cluster spread radially in the cortical cell (C) of oat roots (Hand section, no stain)

Table 1 The up and down ectotrophic growth of *Gaeumannomyces graminis* var. *tritici* on wheat and oat roots (mm)*

Contents	Growth on wheat '76120'				
	Post inoculation (days)				
	3	4	5	7	9
No. of roots observed	14	25	20	17	15
Up	3.36	7.18	14.42	21.30	29.14
Down	4.36	7.28	11.18	13.30	16.40
Total	7.72	14.46	25.60	34.60	45.54
Oat 'Canada 73-7'					
	15	31	26	25	19
	0.48	1.54	1.54	2.50	8.58
	0.72	1.78	1.84	3.40	6.78
	1.20	3.32	3.38	5.90	15.36

* Soil free inoculation method, cultured at 251 ± 1°C in the dark

growing colonies of *G. graminis* var *tritici*. Five seeds and discs were placed in 15 cm diameter pots filled with sterilized river sand and maintained in growth chamber held at 25±1°C with 12 hr intervals of light (250 µ E/s/m^2) and dark.

To make comparison between wheat and oat in *G. graminis* var *tritici* infection, sections (5 mm in length) of 5 roots (2 mm below the inoculum discs) were sampled from the seminal roots at 12 hr intervals after inoculation and viewed by light microscopy for the presence of hyphae with / without staining with aqueous 'trypan blue' or other stain such as safranine O.

Sand-free culture method was employed to measure the ectotrophic growth of *G. graminis* var *tritici* on the seminal roots of wheat and oat. For thus, germinated seeds were placed along the edge of plate (10 cm × 20 cm) coyesed with water soaked filter paper. The inoculum was placed directly on the seminal roots (4 cm in length) of wheat and oat and the ectotrophic growth was measured 3, 4, 5, 7 and 9 days after inoculation with the stereomicroscopy. All the procedures were carried out aseptically in dark in an incubator at 25±1°C .

RESULTS AND DISCUSSION

Infection process of G. graminis *var* tritici *on wheat roots*

The microscopic observations showed that the infection process of *G. graminis* var *tritici* on the seminal roots of wheat, cultured at 25±1°C under 12 hr intervals of light and dark could be divided into 4 stages, viz pre-infection, invasion of epidermis, invasion of cortex and invasion of stele stages within intervals of 0–48, 48–60, 60–120 and more than 120 hr after inoculation respectively.

Pre-penetration

Light and scanning microscopic observations showed that after inoculation, the fungus *G. graminis* var *tritici* spreads mainly as runner hyphae on the root and root hair surface. The sister hyphae growing together matted sometimes and formed a bridge structure (Fig 1). The infection hyphae produced simple hyphopodia on the root surface of wheat. After 5 days the ectotrophic growth in up roots was 1.5 times as fast as in down roots of wheat (Table 1).

Invasion of epidermis

After 48 hr of inoculation, the runner hyphae produced hyaline, thin-walled infection hyphae which penetrated into the epidermal cells of wheat roots from intercellular spaces and the base cells of root hairs (Fig 1). Three hyphae invaded epidermis at the same site. When the hyphae entered in the epidermal layer of wheat root and root hair, it invaginated the inner cell walls against the hyphae infection to form lignitubers (Fig 3). The hyphae in the epidermal cells spread in a cyclic and radial manner and entered into the cortex 12 hr later.

Invasion of cortex

After 60 hr of inoculation the take-all fungus penetrated into the cortical cells from the epidermal layer. The fungus generally penetrated the cell wall directly through infection hyphae. However, sometimes before penetration of the cortex, the hyphae formed a swollen or cushion like structure followed by an infection peg.

G. graminis var *tritici* grew and spread mainly in the intercellular and intracellular spaces of cortical cells singly or as a cluster of hyphae (Fig 4). The inner walls produced separate or connective lignitubers of different size against the infection hyphae (Fig 5). Yellow substance observed between the intercellular spaces (Fig 4) might have resulted from the intercellular pectin degradation.

Invasion of stele

After 120 hr of inoculation, *G. graminis* var *tritici* reached the pericycle, xylem and phloem resulting in the blockage of the vascular cells and making the transport system of wheat roots abnormal (Fig 6). Lignitubers were observed in the stele as well, however, their number was much less than those in cortical cells.

Infection process of G. graminis *var* tritici *on oat roots*

Based on the infection process on wheat roots, the infection process of *G. graminis* var *tritici* on oat seminal roots could also be divided into 4 similar stages, which were reached in different time intervals of 0–120, 120–132, 132–240 and 240 hr respectively in the same culture conditions.

Invasion of epidermis

After inoculation, runner hyphae of the fungus *G graminis* var *tritici* grew and spread slowly on the surface of the seminal roots of oat. Brown kidney- or fork-shaped hyphopodia were formed occasionally (Fig 7). The ectotrophic growth was not significantly different ($p<0.05$) on the down and up roots of oat (Table 1). However, 3, 5 and 9 days after inoculation respectively, the extent of ectotrophic growth on oat roots was 84.46, 86.80 and 66.27% (Table 1) less than that on the wheat roots.

Invasion of epidermis

After 120 hr of inoculation, the brown-runner hyphae generally produced hyaline infection hyphae on the root surface of oat which penetrated into the epidermal cells and root hairs through the intercellular spaces. However, the infection hyphae were hindered and become coiled or swollen and the interseptal space ultimately shortened (Fig 8). Lignitubers in different sizes were found in the infected epidermal cells and root hairs.

Invasion of cortex

After 132 hr of inoculation, the *G. graminis* var *tritici* moved from the epidermis to the cortical cells and spread radially in the cortex (Fig 9). Some infection hyphae in the cortex were dissolved (cell wall and cytoplasm degrade) and sometimes formed fork-shaped hyphopodia which also were degraded afterward. Less lignitubers were observed in the cortical cells of the oat roots in comparison to those in wheat roots as a result of *G. graminis* var *tritici* invasion.

Invasion of stele

After 240 hr of inoculation, the fungus could penetrate the endodermis and enter into the stele. However, only a few cells of stele were colonized by the infection hyphae of *G. graminis* var *tritici* in comparison to those of wheat roots. Meanwhile only a few hyphae existed in the cortical cells.

Light microscopy revealed that in the pre-infection stage, the fungus grows and spreads mainly as runner hyphae on the root surface and root hairs of wheat and oat. According to Brown and Hornby (1971), before penetration into the epidermis, *G. graminis* var *tritici* needs a ephemeral feeding stage (formation of clump of hyphae) on the root surface of wheat. However, it was observed here that there were more runner hyphae at the inoculation sites on wheat roots resulting from the fungal branching, which might be good for increasing the infection sites of *G. graminis* var *tritici*.

Kidney- and fork-shaped hyphopodia formed on oat roots but were absent in wheat, which indicated that the root surface of oat was not suitable for *G. graminis* var *tritici* survival. This may be associated with the fungitoxic avenacin produced by the oat root in the rhizosphere, which directly or indirectly inhibited the growth of *G. graminis* var *tritici* on its surface. Apart from the effects of avenacin on the resistance of oat to *G. graminis* var *tritici*, the hindered infection hyphae, when the fungus invaded the epidermal cells indicated that oat might have another structure mechanism to resist *G. graminis* var *tritici* infection.

The cortical cells of the oat roots also might have some ability to restrict the fungus spread into the stele. It turns 108 hr from the first layer to the endodermis of the cortex in the oat roots in comparison to only 60 hr in case of wheat roots. The formation of fork-shaped hyphopodia in the cortex of oat roots and their subsequent degradation in the cortical cells indicated that the cortex of oat is not suitable for the fungus growth and spread. Also less cells were colonized by the fungus in oat roots compared to those in wheat roots which agreed with Skou (1981).

When the hyphae of *G. graminis* var *tritici* entered in the stele, they colonized and blocked the vascular tissues, rendering transport system of wheat roots abnormal resulting in seedling death or 'white head' symptoms (Penrose 1985, 1991).

By comparing the characteristics of infection process of *G. graminis* var *tritici* on wheat and oat, the study shows that the resistance of oat was due to the inhibition of the penetration and spread of *G. graminis* var *tritici*. This resistance may be associated with the avenacin production and additional structural resistance mechanism.

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Economic viability and energetics of teosinte (*Euchlaena maxicana*) : ricebean (*Vigna umbellata*) associations under different fertility levels

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Intercropping of forage cereal and legume improves the quality of forage on one hand and maintain the soil fertility on the other besides it enhances total biomass production/unit space and time (Choubey and Bhagat 1998). Teosinte (*Euchlaena maxicana* L. Schrad) being a multicut forage species provides higher herbage yield for a longer period (Choubey 1994) while association of ricebean [*Vigna umbellata* (Thunb) Ohwi and Ohashi] facilitated balance ration to dairy industries (Choubey *et al.* 1997). Since, the agronomy of these 2 forages is not very adequate under plateau conditions of Bihar. Hence, an experiment was carried out to assess the herbage productivity along with their economics and energetics under 2 environmental conditions.

A field experiment was conducted at Ranchi during monsoon season of 1994 and 1995 to assess the yield, economics and energetics of 'Sirsa' teosinte and 'RBL 1' ricebean intercropping. The soil was red sandy loam (Alfisol) with high permeability and low water-holding capacity (23.5% at 0.3 bar and 9.5% at 1.5 bar). It was low in available N (193.5 kg N/ha), available P (12.8 kg P/ha) and medium in available K (115.0 kg K/ha) with *p*H 5.8. The experiment was laid out with 3 nutrient levels (100, 75 and 50% of recommended doses of NPK to teosinte and ricebean) in main plot and 2 sole seeding of teosinte and ricebean alongwith their 4 associations (1:1, 1:2, 2:1, and 2:2) in sub-plot of 3.90 m × 3.0 m. at 30 cm row spacing. Thus, altogether 18 treatments were put in split-plot design and replicated thrice. The nutrients were supplied as per the row ratio of the 2 component species.

The rainfall during the cropping (June–October) in 1994 and 1995 was 1617.2 and 1598.3 mm respectively. The green herbage yield and economics of both the years were pooled and statistically analysed while energetics of the system were computed from the recorded data for each items of operations expressed (MJ/ha) taking standard values as suggested by Singh and Mittal (1992). To know the efficiency of different treatments, energy-use efficiency based on net output : input energy ratio was determined. Energy productivity (g MJ/ha) was calculated by dividing green forage yield by the corresponding energy inputs.

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Herbage productivity

The performances of different treatments for green herbage production were similar during 1994 and 1995 due to almost similar weather condition. Thus, pooled green herbage yield (Table 1) under the different levels of N, P and K nutrients revealed that 100% of the recommended dose of nutrients gave the highest green herbage yield (19.4 tonnes/ha) which was very close to yield (19.1 tonnes/ha) received at 75% of the nutrients level. Among the different associations, combination of these 2 components species significantly out yielded over their respective sole stand yield. Accordingly, association of teosinte and ricebean (2:1) gave the maximum green herbage (22.5 tonnes/ha) which was statistically superior to rest of the associations. It was further observed that teosinte : ricebean (2:1) at 75% of the recommended level of nutrients gave the maximum green herbage yield (24.6 tonnes/ha). As such, this combination even gave a slightly higher (2.9%) green herbage yield over the yield received at 100% nutrients at the same row ratio. The green herbage yield at 75 and 100% nutrient were statistically on par with each other. Thus, it appeared that the association of these 2 component species in 2:1 row ratio at 75% NPK can save up to 25% of the nutrients even by giving a little more yield over the yield received at 100% NPK. Manoharan and Subramanian (1993) and Jayanthi *et al.* (1994) also reported similar results for Maize (Zea mays L.) : Cowpea (*Vigna unguiculata* L. Walp) in 2:1 association.

Economic feasibility

Economic parameters of pooled yield (Table 1) reveal that the crop receiving 75% of the recommended dose of nutrient gave the highest net return (Rs 4 431 /ha), net return/rupee investment (1.58) which were significantly superior to the rest of the treatments. The crop grown at 100% NPK accounted for the highest per day return (Rs 158.82) and monetary advantage (Rs 4 113/ha), however, these parameters were statistically

Table 1 Green herbage yield and economics of teosinte : ricebean intercrop associations under different nutrient levels (pooled data of 2 years)

Treatment	Yield (tonnes/ha)	Net return (Rs/ha)	Net return (Rs/Re)	Per day return (Rs/ha/day)	Monetary advantage (Rs/ha)
100% NPK levels					
Teosinte (Sole)	17.8	464	1.06	115.79	
Ricebean (sole)	12.5	2 042	1.26	129.99	
Teosinte : ricebean					
1 : 1	20.3	4 662	1.57	166.47	3 326
1 : 2	19.8	4 659	1.58	166.05	3 258
2 : 1	23.8	6 705	1.81	194.59	5 481
2 : 2	22.1	5 662	1.69	180.06	4 385
75% NPK levels					
Teosinte (Sole)	16.3	478	1.03	106.17	
Ricebean (sole)	14.5	4 106	1.55	151.22	
Teosinte : ricebean					
1 : 1	19.5	4 775	1.62	162.54	2 556
1 : 2	18.8	4 460	1.58	157.62	2 111
2 : 1	24.6	7 685	1.99	201.43	5 689
2 : 2	20.3	5 322	1.69	169.61	3 165
50% NPK levels					
Teosinte (Sole)	13.6	- 492	0.92	88.59	
Ricebean (sole)	10.4	1 191	1.17	108.34	
Teosinte : ricebean					
1 : 1	16.0	2 987	1.41	133.40	2 630
1 : 2	15.5	2 586	1.36	127.51	2 171
2 : 1	19.1	4 542	1.62	154.02	4 334
2 : 2	16.5	3 174	1.44	135.87	2 751
CD (P=0.05)	0.15	840.15	0.2949	26.91	1 558.27

Table 2 Energetics of teosinte : ricebean associations as influenced by nutrient levels (pooled data of 2 years)

Treatment	Gross energy output (MJ/ha)	Net energy output (MJ/ha)	Energy-use efficiency	Energy Productivity (g MJ/ha)
100% NPK levels				
Teosinte (Sole)	53 505	42 651	3.93	273.67
Ricebean (sole)	43 854	37 530	5.94	385.17
Teosinte : ricebean				
1 : 1	62 634	54 159	6.39	410.67
1 : 2	63 093	55 297	6.96	449.84
2 : 1	72 273	63 119	6.90	438.83
2 : 2	73 170	65 127	8.10	505.33
75% NPK levels				
Teosinte (Sole)	51 327	42 170	4.61	311.50
Ricebean (sole)	47 736	41 965	7.27	459.34
Teosinte : ricebean	63 150	55 817	7.61	478.33
1 : 1	58 680	51 867	7.61	478.50
1 : 2	74 628	66 773	8.56	527.67
2 : 1	69 273	61 950	8.46	525.67
2 : 2				
50% NPK levels				
Teosinte (Sole)	41 886	34 424	4.63	311.67
Ricebean (sole)	37 176	32 067	6.28	404.34
Teosinte : ricebean				
1 : 1	50 580	44 387	7.17	453.67
1 : 2	47 013	41 181	7.06	448.00
2 : 1	60 633	54 245	8.50	527.33
2 : 2	52 221	46 026	7.43	468.34
CD (P=0.05)	390	450	0.64	33.47

similar to crop yield received at 75% NPK nutrients.

Among the planting pattern, teosinte intercropped with ricebean (2:1) recorded significantly the highest net return (Rs 6 310/ha), net return /rupee investment (1.81), per day return (Rs 183.35/ha) and monetary advantage (Rs 5 168 /ha). However, when planting pattern and nutrient management were taken into consideration, teosinte grown in association with ricebean (2:1) receiving 75% recommended dose of nutrients accounted for the maximim net return (Rs 7 685/ ha), net return/rupee investment (1.99), per day return (Rs 201.43/ha) and monetary advantage (Rs 5 689/ha). Similar results were also reported by Gadhia *et al.* (1993).

Energetic viability

Intercropping of teosinte : ricebean in 2:1 row ratio at 75% of the recommended dose of nutrients was found better in respect to gross (74 628 MJ/ha) and net (66 773 MJ/ha) energy output, energy-use efficiency (8.56) and energy productivity (527.67 g MJ/ha) due to better biomass productivity to per unit area. Such accountability of energy due to higher biomass yield has also been recorded by Thakur *et al.* (1995) at the same agro-ecological situations.

Thus, for receiving higher forage productivity in unit time and space with economic feasibility and better energy output, the intercropping of teosinte : ricebean (2:1) at 75% of the recommended dose of nutrients may be a sustainable association under agroclimatic conditions of plateau region of Bihar.

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Integrated nutrient management using fish meal and fertilizers for rice (*Oryza sativa*)*

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Integrated nutrient management system emphasizes the use of organic manures and bio-fertilizers along with inorganic fertilizers. The conjunctive use of organic manure like fish manure and fertilizers will improve the soil health and maximise sustainable production. The aquaculture in the country is on the threshold of a blue revolution as country's total annual fish production is reached to 4.95 million tonnes (Ayyappan 1997). Sea food canning industry is coming up along the coastal region of the country. It is reported that 50 % portion of any edible fish is thrown out as a waste in this industry. Besides, non-edible and less tasty variety of fishes, such as trash fish, squilla or puchee etc. are discarded during processing due to their low market value. The indiscriminate throwing away of these wastes/residues in the landing place near seashore causes offensive smell problem due to its rotting, resulting into environmental pollution. If recycled efficiently, the big quantum of this waste can be served as a valuable organic manure. Hence the present investigation is carried out to explore the possibility of using fish manure in integrated nutrient management for rice production.

A field experiment was conducted during rainy season (*kharif*) of 1997 in lateritic soil of Dapoli classified under Isohyperthemic family of Udic Paleustalf of Alfisol with 'Ratnagiri 1' rice (*Oryza sativa* L.). The lateritic soil had clay loam texture, pH 5.90, E.C. 0.08 d S/m (Jackson 1973), available N 334.5 kg/ha, available P_2O_5 8.6 kg/ha (Bray and Kurtz 1945), available K_2O 222.0 kg/ha (Jackson 1973), available Ca 2.6 m.e./100 g and available Mg 4.0 m.e./100 g (Chopra and Kanwar 1978). The treatments consisted of 3 levels of NPK fertilizers, viz 0, 50 and 100% recommended dose of fertilizers (100:50:50) and 4 levels of fish meal, viz 0, 1, 2 and 3 tonnes/ha. Thus, 12 treatment combinations were tested in a factorial randomised block design replicated thrice. The fish meal containing total N 5.8%, P_2O_5 4.5%, K_2O 1.1%, Ca 3.8%, Mg 1.0% and total micronutrients, viz Zn 17 ppm, Cu 98 ppm, Mn 18 ppm and Fe 2430 ppm was used as a manure. The fish meal was applied and mixed well in the soil during puddling of rice field. The P_2O_5 and K_2O were applied as basal dressing in the form of single superphosphate and muriate of potash. Nitrogen was applied in the form of urea in 3 splits, half as basal and remaining half in 2 equal splits at tillering and panicle initiation stages of the crop. Grain and straw yields were recorded after harvest of the crop. The grain and straw samples were analysed for total N, P, K, Ca and Mg uptake while the grain samples were analysed for protein content by standard chemical methods.

Yield of rice

The different levels of fertilizers and fish meal and their interactions significantly affected the grain as well as straw yield of rice (Table 1). Application of 50 and 100% recommended dose of fertilizers increased the grain yield by 30 and 57% respectively over no fertilizer application while 20, 52 and 80% increase in yield was observed due to application of 1, 2 and 3 tonnes/ha fish manure respectively in comparison to no fish manure application. The yield of rice straw increased by 24, 53 and 82% due to fish meal application @ 1, 2 and 3 tonnes/ha respectively. At all the levels of fertilizer application, fish meal application in gradation up to 3 tonnes/ha resulted into significant increase in grain as well as straw yield of rice. Maximum grain and straw yield of rice was recorded in the treatment receiving 3 tonnes of fish meal/ha with recommended dose of fertilizers which was superior over rest of the treatment combinations. This may be due to better extraction of nutrients from the soil treated with chemical and organic sources of nitrogen resulting into fixation of nutrients and better retention and release of macro as well as micro-nutrients required for mineral nutrition for rice. Similar findings are also reported by Smith (1985) and Kuo (1995).

Uptake of nutrients

The uptake of major nutrients such as N, P, K, Ca and Mg by rice was increased significantly with increase in levels of fertilizers as well as fish meal (Table 2). Incorporation of fish meal from 1 to 2 tonnes/ha with no, half and full doses of fertilizers resulted in successive and significant increase in

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Table 1 Effect of fish meal alone and in different combinations with mineral fertilizers on yield (tonnes/ha) of rice

Fish meal level (M) (tonnes/ha)	Levels of recommended dose of fertilizer (F) 0%	50%	100%	Mean
	Grain yield			
0	2.97	3.36	4.61	3.65
1	3.42	4.19	5.59	4.40
2	3.88	5.66	6.97	5.50
3	5.30	7.05	7.36	6.57
Mean	3.90	5.07	8.18	
CD (P = 0.05)	M = 0.21	F = 0.18	F × M = 0.11	
	Straw yield			
0	2.94	3.42	4.67	3.68
1	3.53	4.41	5.70	4.55
2	4.13	5.74	7.09	5.65
3	5.32	7.22	7.47	6.69
Mean	4.00	5.20	6.23	
CD (P = 0.05)	M = 0.15	F = 0.14	F × M = 0.08	

the uptake of all macronutrients. Total uptake of nitrogen by rice increased by 39 and 86% in the treatments receiving 50 and 100% recommended dose of fertilizers, respectively over no fertilizers. Total uptake of nitrogen increased by 23, 58 and 92% when fish meal was added @ 1, 2 and 3 tonnes/ha respectively over no fish meal. There was increase in phosphorus uptake by 45 and 94% over no application of inorganic fertilizers when fertilizers were added @ half and full recommended dose, respectively. Total phosphorus uptake increased by 29, 67 and 100% when fish manure was added @ 1, 2 and 3 tonnes/ha respectively over no fish manure. Total potassium uptake increased by 40 and 84% over no fertilizer application when the dose of fertilizers was added @ half and full recommended dose respectively. Total potassium uptake increased by 26, 57 and 91% when fish meal was added @ 1, 2 and 3 tonnes/ha respectively over no fish manure application.

The results on interaction effects presented in Table 2 revealed that incorporation of fish meal in gradation with and without two levels of fertilizers also exhibited significant increase in uptake of N, P, K and Ca by rice. Maximum uptake of said nutrients was recorded in the treatment receiving 3 tonnes of fish manure in conjunction with recommended dose of fertilizers. The reasons attributed to this are complexing properties present in fish manure must have prevented precipitation and fixation of nutrients and kept them in available form. Similar observations were reported by Kuo (1995).

Protein content of rice

The effect of two different doses of fertilizers had sufficient influence in respect of protein content of rice grain (Table 3). Maximum protein content of 8.84% was recorded in the treatment F_{100} followed by F_{50} (8.20%), which were superior over F_0. Similarly, application of increasing levels of fish meal exhibited a corresponding increase in levels of fish

Table 2 Effect of fish meal alone and in different combinations with mineral fertilizers on total nutrient uptake (kg/ha)

Fish meal level (M) (tonnes/ha)	Levels of recommended dose of fertilizer (F) 0%	50%	100%	Mean
	Total nitrogen uptake			
0	48.9	58.2	88.7	63.3
1	56.2	74.0	111.7	80.6
2	66.7	102.7	141.1	103.5
3	92.8	133.5	150.6	125.6
Mean	66.1	92.1	123.0	
CD (P = 0.05)	M = 3.0	F = 2.6	F × M = 5.2	
	Phosphorus uptake			
0	9.3	11.7	17.7	12.9
1	11.4	15.4	23.3	16.7
2	13.4	22.2	29.1	21.5
3	18.6	27.0	31.8	25.8
Mean	13.6	19.0	25.5	
CD (P = 0.05)	M = 1.8	F = 1.6	F × M = 3.2	
	Potassium uptake			
0	58.6	71.0	108.3	79.3
1	70.9	93.8	136.4	100.4
2	82.1	124.5	167.5	124.70
3	110.7	162.5	181.7	151.6
Mean	80.5	112.9	148.5	
CD (P = 0.05)	M = 3.7	F = 3.2	F × M = 6.4	
	Calcium uptake			
0	11.7	14.6	22.3	16.2
1	13.9	19.6	27.5	20.3
2	16.7	26.7	34.7	26.0
3	22.9	34.3	38.6	31.9
Mean	16.3	23.8	30.8	
CD (P = 0.05)	M = 1.6	F = 1.4	F × M = 0.8	
	Magnesium uptake			
0	8.6	11.5	17.8	12.6
1	11.3	15.3	22.3	16.3
2	12.6	17.1	27.8	19.2
3	17.8	26.0	30.4	24.8
Mean	12.6	17.5	24.6	
CD (P = 0.05)	M = 2.6	F = 2.2	F × M = N.S.	

Table 3 Effect of fish meal alone and in different combinations with mineral fertilizers on protein content (%) of rice grain

Fish meal level (M) (tonnes/ha)	Levels of recommended dose of fertilizer (F) 0%	50%	100%	Mean
0	7.64	7.93	8.62	8.08
1	7.58	7.99	8.89	8.15
2	7.87	8.28	8.83	8.33
3	7.97	8.54	9.01	8.51
Mean	7.76	8.20	8.84	8.27
CD (P = 0.05)	M = 0.13	F = 0.11	F × M = 0.30	

manure at all the three doses of fertilizers resulted into corresponding increase in protein content, which may be due to corresponding increase in nitrogen uptake by rice grain. Shukla and Sharma (1994) also reported significant increase in protein content of rice with conjunctive use of fish manure and chemical fertilizers together.

It is, therefore, inferred that integrated use of mineral fertilizers and fish meal can improve the mineral nutrition and yield of rice which will help to utilize the locally available organic resources more efficiently.

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Response of soybean(*Glycine max*) to nitrogen, its application time and sulphur

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Key words : soybean, nitrogen, N-application time, sulphur, leaf area index, chlorophyll content, branching and nodulation

Soybean (*Glycine max* (L.) Merr.) crop has been well recognized to augment protein and oil supply in the recent past considering higher yield potentials (2–3 times over traditional pulses), rich in protein (42 %) and oil content (20 %). Soybean is also used in preparation of soymilk for the poor, production of antibiotics, cattle and poultry feed, soil fertility improvement, etc. Soybean being a leguminous crop is capable to fix atmospheric nitrogen through symbiosis. However, several studies have shown that the symbiotic N–fixation is not able to meet high N-requirement of this crop particularly under N-deficient conditions. About half of the nitrogen in mature soybean grains is translocated from different parts of the plant and remaining is derived from the soil and nodules (Hanway and Weber 1971). Higher levels of nitrogen fertilizer decreases the number and dry weight of root nodules(Papastylianou 1986). The excessive basal N promotes vegetative growth which can lead to lodging or a reduction in the development of nitrogen fixing nodules. Soybean has a relatively high N requirement especially at later growth stages (Watanabe *et al.* 1983). Sulphur is considered as fourth major nutrient. It is best known for its role in the formation of sulphur containing amino acids, synthesis of proteins, vitamins, chlorophyll and oil in oilseeds. Sulphur promotes nodulation in legumes, gives bold seeds in oilseeds consequently, sulphur, deficiency affects the quality of food for human beings.

An experiment was conducted during rainy season (*kharif*) of 1995 and 1996. The soils were clay loam in texture with bulk density of 1.38 Mg/m^3. Soils were alkaline calcareous in reaction with *p*H 8.2, with normal EC of 1.20 and 0.89 dS/m , high in organic carbon, medium in total N and available P and well supplied with available K. The SO_4^{-2} sulphur content of soil was 9.4 and 9.7 ppm in 2 respective years. The treatment for the experiment comprised combinations of 3 factors each at three levels, ie 3 nitrogen levels (30, 60 and 90 kg N/ha) thrice nitrogen applications (all basal , ½ basal + ½ top dressing at pre-flowering and ½ basal +1/4 top dressing at pre-flowering +1/4 foliar spray at pod development) and 3 sulphur levels (0, 30 and 60 kg S/ha).These 27 treatment combinations were replicated thrice in randomised block design. 'PK 472' soybean was sown on 4,1 July and harvested on 21 and 20 October during 1995 and 1996 respectively. A spacing of 30 cm × 10 cm was adopted. A uniform dose of 50 kg P_2O_5 /ha was drilled through diammonium phosphate. Leaf area was determined using laser leaf area meter, leaf area/plant at 30 days after sowing and 60 days after sowing was computed to work out leaf area index.

Leaf area index (LAI) = Leaf area/plant (cm^2)/ground area occupied by each plant (cm^2)

The chlorophyll content of fresh soybean leaves at 60 days after sowing was estimated as per standard procedure given by Arnon (1949) :

$$\text{Total chlorophyll (mg / g)} = \frac{20.2\,(A645) + 8.02\,(A663) \times v}{a \times 100 \times w}$$

where a , length of light path cell (1 cm); v, volume of extract (25 ml);w , weight of leaf sample (0.1 g); A, absorbency in (nm).

Nodules and branches/plant were also counted using standard methods.

Nitrogen

Increasing rate of N application significantly improved leaf area index at successive growth stages and branches/ plant at harvest during both the years . Chlorophyll content of fresh leaves at 60 days after sowing was found increased significantly with increase in N levels up to 90 kg / ha. The mean increase in chlorophyll content with 90 kg N/ha was 15.9 % over 30 kg N /ha (Table 1). Number of nodules / plant were significantly decreased by each increase in N level from 30–60 and 60–90 kg / ha . The maximum number of nodules / plant 16.42 and 17.37 were recorded with 30 kg N/ha during first and second year respectively. Nitrogen is one of the essential constituents required in the synthesis of proteins, chlorophyll and other organic compounds having physiologically

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Table 1 Effect of nitrogen, its application time and sulphur on leaf area index (LAI), chlorophyll content, branching and nodulation of soybean

Treatments	Leaf area index						Chlorophyll content (mg/g)			Branches / plant			Nodules / plant		
	30 DAS			60 DAS			60 DAS			at harvest			60 DAS		
	1995	1996	Mean	1995	1996	Mean	1995	1996	Mean	1995	1996	Mean	1995	1996	Mean
N(kg/ha)															
30	0.570	0.577	0.573	3.33	3.69	3.51	1.419	1.433	1.426	1.44	1.38	1.41	16.42	17.37	16.89
60	0.593	0.600	0.596	3.68	4.05	3.86	1.602	1.611	1.606	1.87	1.78	1.82	14.47	14.98	14.72
90	0.609	0.616	0.612	3.85	4.20	4.02	1.650	1.656	1.653	2.03	1.96	1.99	12.66	12.89	12.77
SEm ±	0.010	0.010		0.087	0.112		0.005	0.005		0.043	0.053		0.516	0.519	
CD (P=0.05)	0.030	0.030		0.25	0.32		0.015	0.015		0.12	0.15		1.46	1.47	
N application time															
AB0.614	0.621	0.617	3.57	3.94	3.75	1.535	1.545	1.540	1.95	1.90	1.92	13.38	13.87	13.62	
1/2B+1/2T	0.579	0.586	0.582	3.72	4.11	3.91	1.557	1.565	1.561	1.71	1.62	1.66	14.50	15.42	14.96
1/2B+1/4T	0.579	0.586	0.582	3.57	3.89	3.73	1.79	1.591	1.585	1.68	1.61	1.64	1.64	15.97	15.82
+1/4F															
SEm +	0.010	0.010		0.087	0.112		0.005	0.005		0.043	0.053		0.516	0.519	
CD (P=0.05)	0.030	0.030		NS	NS		0.015	0.015		0.12	0.15		1.46	1.47	
S(kg/ha)															
0	0.573	0.580	0.576	3.41	3.67	3.54	1.512	1.522	1.517	1.62	1.53	1.571	12.18	13.06	12.62
30	0.594	0.601	0.597	3.70	4.02	3.86	1.567	1.576	1.571	1.85	1.79	1.82	15.33	15.86	15.59
60	0.604	0.611	0.608	3.75	4.24	3.99	1.592	1.602	1.597	1.87	1.81	1.84	16.05	16.33	16.19
SEm ±	0.010	0.010		0.087	0.112		0.005	0.005		0.043	0.053		0.516	0.519	
CD (P=0.05)	NS	NS		0.25	0.32		0.015	0.015		0.12	0.15		1.46	1.47	

importance . It is even essential for nodules information and development in legume seedlings before N fixation begins. Tanaka (1983) has reported high N requirement of soybean crop.He further suggested that N fixation and applied N compensate for one other to meet high N requirement of soybean might be reason of decrease in N fixing ability . The observed results are in close conformity with the finding of Kumawat (1996).

N-application time

Splitting of nitrogen application caused significant reduction in leaf area index (LAI) at 30 days after sowing and branches/plant at harvest in comparison to all basal application. However, at 60 days after sowing leaf area index did not vary significantly due to time of N application. Chlorophyll content of fresh leaves estimated at 60 days after sowing improved significantly with the split application treatments compared to all basal application . Mean maximum chlorophyll content of 1.585 mg/g of fresh leaves was estimated with ½ basal + ¼ top dressing + ¼ foliar spray treatment (Table 1).Significant increase in nodules/plant was recorded under split application compared to all basal. During 1995 , ½ basal + ½ top dressing was statistically at par with all basal while during 1996, ½ basal + ½ top dressing was found significantly superior over all basal application . On two years mean basis, when plots were fertilized with nitrogen as ½ basal + ¼ top dressing + ¼ foliar spray produced 5.7 and 16.1 % more nodules over ½ basal + ½ top dressing and all basal application, respectively . Tanaka (1983) reported that with increasing nitrogen concentration in growth media, soybean fixing ability decreases mostly because of decrease in specific activity of nodules. This tendency suggests that N fixed and applied N absorption compensate for one another. Nodulation in soybean plants starts to 10 days after sowing at this time there was abundant basal available nitrogen.

Sulphur

Leaf area index at 30 days after sowing did not vary significantly due to sulphur application (Table 1). Leaf area index at 60 days after sowing , branches/plant and nodules/ plant were increased significantly with increase in S level up to 30 kg /ha . Further increase in S level up to 60 kg /ha did not bring increase in aforesaid parameters. Significant increase in chlorophyll content was estimated with the successive increase in S level up to 60 kg/ha during both years. On mean basis, the highest chlorophyll content (1.597 mg/g) was recorded when the crop was fertilized with 60 kg S /ha with the increment of 1.65 and 5.27 % over 30 kg S/ha and the control respectively. The importance of S in chlorophyll formation is as constituent of succenyl Co-A which is precursor in biosynthesis of chlorophyll. Thus in sulphur deficient plants chlorophyll content declines. The influence of S fertilization on leaf area index and branching could be attributed to increase metabolic process in plants which seems to have promoted meristametic activities causing apical

Table 2 Combined effect of level of nitrogen and sulphur on chlorophyll content (mg/g) of fresh leaves of soybean at 60 days after sowing

Treatment (N kg/ha)	S (kg/ha)					
	1995			1996		
	0	30	60	0	30	60
30	1.409	1.423	1.427	1.422	1.433	1.444
60	1.538	1.619	1.649	1.547	1.29	1.658
90	1.591	1.660	1.700	1.599	1.668	1.703
SEm±	0.009			0.008		
CD (P=0.05)	0.026			0.023		

growth. Sulphur is associated (As 4 Fe - 4S cluster)with the smaller component of nitrogenase enzyme involved in N fixation by nodule bacteria and pre-living bacteria. Further S forms a part of feredoxin which acts as electron courier connected with supply of energy for the N fixing process. This is in close agreement with the finding of Ismunadji (1986).

Interaction (N × S)

During both the years under each level of sulphur, increase in N level from 30 to 90 kg N/ha tended to record significantly higher chlorophyll content. While at 60 to 90 kg N/ha level, S application enhanced chlorophyll significantly up to 60 kg S/ha. The highest chlorophyll content (1.700 and 1.702 mg/g) was recorded with combine application of 60 kg S/ha and 90 kg N/ha during 1995 and 1996 respectively.

It has been empirically established that for every 15 parts of N in proteins, there is one part of S which implies that N : S ratio is fixed within a narrow range of 15:1. Therefore, deficiency of S would reduce the amount of protein synthesised even if there is plenty of N available to plants (Dev and Sharma 1988). Sulphur is known to increase the metabolic utilization of N by keeping N : S ratio within optimum range.

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Seed ageing on hybrid seed production in maize (*Zea mays*)*

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Key words : maize, seed ageing, hybrid seed production

Seeds are basic in crop production. High quality seed should be high in germination, vigour and purity. Among these components, seed vigour is an important factor of seed quality which must be taken into account to maximise the productivity. However, association of seed vigour with crop performance varies from crop to crop and between hybrids and varieties of crop. Moreover, implications of using aged parental seeds for hybrid seed production require elucidation. Hence, an attempt was made to study the influence of ageing of parental seed on hybrid seed production in maize (*Zea mays* L.).

The parental seeds of maize hybrid 'COH 2' ('UMI 810' × 'UMI 90') were size graded with 19/64" round perforated metal sieve and subjected to accelerated ageing at 40° C and 100% relative humidity for 6–18 days. Two separate field experiments were conducted during summer 1994–95 at Coimbatore.

In 1 experiment, the male line seeds ('UMI 90') were non-aged and the female line seeds were acceleratedly aged for 0 (T_0), 6 (T_1), 12 (T_2) and 18 (T_3) days. Female and male parental seeds were sown in the field with 4:2 (female : male) ratio in randomized block design with 5 replications. Detasseling of female plants was done as soon as the tassels emerged out from the leaf sheath. In another experiment, the acceleratedly aged seeds (0, 6, 12 and 18 days) of male parent were sown in the field adopting randomized block design with 5 replications. In both the experiments the plot size was 20 m² in each replication.

Germination decreased during ageing upto 43 % in the female parent seed and 50 % in the male parent seed (after 18 days of acceleratedly ageing). However, seed rate was so adjusted that equal population (120 plants/20 m²) was maintained in all the ageing treatments after carrying out thinning in the field 10 days after sowing.

Various observations on yield components were recorded on 5 randomly selected plants /plot in each replication of female and male parents of first and second experiment respectively. In addition, observations on pollen productivity (weight of pollen grains/tassel) and pollen fertility (based on potassium iodide staining) were also recorded in the second experiment. Besides, plants showing abnormalities were counted.

The performance of the seedling after emergence in the field was essentially dependent on the initial seed vigour, as clearly observed in the plant height, stem girth and leaf number/ plant (Table 1). Ageing treatments had severe impact on these parameters and they were altered based on the level of deterioration of source seeds caused by ageing phenomenon. Similar result was reported in maize (Ravichandran 1991).

The ageing severity was also expressed in yield components of both the parental lines of maize hybrid, through a delayed flowering and reduction in style length (Table 1). Delayed flowering in maize caused by ageing finds support from Hussaini et al. (1988). Burris (1975) evidenced the same result in maize as the tassel length and silking date were somewhat delayed and barrenness increased due to reduction in seed vigour.

Similarly, ageing caused 11 and 28 % reduction in cob weight / plant in the 18 – day aged population of female and male lines of maize hybrid respectively. This might be the reason for the considerable reduction of seed yield / plant (Table 1). The seed yield of both the parental lines were severely affected by the ageing treatments. Hybrid seed yield and male seed yield were 15 and 30 % more in non-aged seeds as compared to 18–day aged seeds. Similar results of reduced yield due to ageing treatments were reported in wheat (*Triticum aestivum* L. emend. Fiori and Paol), maize and Hussaini *et al.* 1988) and maize, groundnut (*Arachis hypogaea*) and soybean (*Glycine max* (L.) Merr.) (Ravichandran 1991).

Results of pollen study revealed that ageing had profound influence on the pollen production as well as pollen fertility, which accounts for a reduction of 17 and 11 % respectively in the 18–day aged population as compared to control of male parent (Table 2). Similar observations were reported in wheat and barley (*Hordeum vulgare* L.) (Purkar and Banerjee 1980). They concluded that the loss in pollen viability might be correlated with increase in the frequency of chromosomal aberration and genic changes in pollen mother cell.

According to Purkar (1980) ageing of seeds under storage results in increased frequency of chromosomal aberrations and point mututions. Abnormalities were noticed in the aged populations of both female and male parents of 'COH 2' maize

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Table 1 Effect of seed ageing on yield and its components in the parental lines of maize hybrid 'COH 2'

Parameters/ Parents	Treatments				Mean	CD (P=0.05)
	T_0	T_1	T_2	T_3		
Plant height (cm)						
'UMI 810'	145.29	141.96	140.66	137.04	141.24	3.30
'UMI 90'	195.58	195.73	191.24	186.67	192.31	4.79
Mean	170.44	168.85	165.95	161.86		
Stem girth (cm)						
'UMI 810'	3.21	3.11	2.99	2.69	3.00	0.04
'UMI 90'	2.87	2.79	2.80	2.60	2.77	0.07
Mean	3.04	2.95	2.90	2.65		
Leaf number						
'UMI 810'	16.68	16.24	16.04	15.76	16.18	0.24
'UMI 90'	15.76	15.58	15.24	15.18	15.44	0.28
Mean	16.22	15.91	16.64	15.47		
Days to 50% tasseling						
'UMI 810'	60.00	62.20	63.00	63.20	62.10	1.75
'UMI 90'	59.60	60.40	61.00	61.60	60.65	0.60
Mean	59.80	61.30	62.00	62.40		
Days to 50% cobing						
'UMI 810'	61.40	62.80	63.40	64.80	63.10	1.00
'UMI 90'	61.60	62.60	63.40	63.40	62.75	0.85
Mean	61.50	62.70	63.40	64.10		
Style length (cm)						
'UMI 810'	42.80	41.78	40.04	39.52	41.04	1.08
'UMI 90'	42.53	41.93	39.18	38.47	40.53	0.86
Mean	42.67	41.86	39.61	39.00		
Cob weight/plant (g)						
'UMI 810'	87.40	81.68	76.31	74.63	80.01	1.66
'UMI 90'	100.46	91.29	76.23	72.34	85.08	4.76
Mean	93.93	86.49	76.27	73.49		
Seed yield/plant (g)						
'UMI 810'	64.27	60.38	56.52	55.03	59.05	1.22
'UMI 90'	81.51	71.20	60.91	57.18	67.70	4.28
Mean	72.89	65.79	58.72	56.11		

Table 2 Effect of seed ageing on pollen productivity and pollen fertility in the male line of 'COH 2' maize hybrid

Treatment	Pollen productivity (g/plant)	Pollen fertility (%)
T_0	4.46	96.55
T_1	4.16	90.44
T_2	3.82	88.10
T_3	3.69	85.86
SEd	0.09	0.97
CD (P=0.05)	0.19	2.10

hybrid to an extent of 5%, whereas control population had no such abnormalities. Abnormalities in the female parent were in the form of silking in the basal areas of cob and in the male parent it was in the form of appearance of cob from the tassel. Further studies on the cytology of the abnormal plants will throw more light on the mutations occurring in the aged seed population of parental lines.

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Stability for green pod yield in garden pea (*Pisum sativum*)*

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Key words : *Pisum sativum*, green pod yield, stability, correlation

'Hortense' garden pea (*Pisum sativum* L.) is an important cash crop of the dry-temperate zone of Himachal Pradesh grown during summer season. Being an off-season crop, it fetches very high premium from the market of plains. However, not much attention has so far been paid to identify and develop the garden pea genotypes suitable for this zone. In any breeding programme, the ultimate objective is to pick up genotypes from a large number of collections which can give superior yield and stable performance in different environments. Hence, an attempt was made to study the adaptability parameters of some elite pea lines selected out of large number of collections over years for green pod yield.

The study included 7 genotypes of peas, viz 'VL 3', 'VL 6', 'Bonneville', 'Lincoln', 'Palampriya', 'DPP 62' and 'Azad P 1' evaluated during the 4 summer season of 1994, 1995, 1996 and 1997 at the Research Sub-Station, Leo (Kinnaur) situated in the trans-Himalayan region where monsoons fail to reach. It was planted in randomized complete block design using 3 replications. Row-to-row and plant-to-plant spacings of 45 cm and 15 cm, respectively were kept in plot size of 2.5 m × 1.80 m. Recommended cultural practices were followed to raise the crop. Observations were recorded on green pod yield on the plot basis at 7-day interval. At last harvest the green pod yield was summed up and converted into tonnes/ha for computation of stability parameters.

Analysis of variance was done individually for 4 seasons and the data were combined for different seasons following standard statistical analysis. The pooled data were subjected to statistical analysis to calculate 3 parameters of stability, viz mean (X_i), regression coefficient (b_i) and deviation from regression coefficient (S^2d_i) following the model of Eberhart and Russell (1966). Correlation coefficients were also calculated between means and stability parameters to establish the type of association among them.

Analysis of variance indicated the presence of sufficient genetic variability for green pod yield in the material (Table 1). However, variance due to environments and genotype × environment was observed to be non-significant. Further partitioning of g × e interaction into linear and non-linear components expressed the predominance of the former

Table 1 Analysis of variance over different environments for green pod yield in pea

Source	df	Mean sum of squares
Genotype	6	6056.70**!!
Environment	3	262.44
Genotype × Environment	18	98.24
Environment + (Genotype × Environment)	21	121.70**!!
Environment (linear)	1	787.39**!!
Genotype × Environment (linear)	6	234.67**!!
Pooled deviation	14	25.74
Pooled error	48	83.92

**Significant against pooled deviation at P= 0.01; !! significant against pooled error at P=0.01

Table 2 Estimates of stability parameters in different environments for green pod yield in peas

Genotype coefficient	Mean yield) (tonnes/ha) (X_i)	Rank	Regression coefficient (b_i)	Deviation from regression (S^2d_i)
'VL 3'	11.43	6	0.77	—24.46
'VL 6'	11.52	5	0.22	31.14
'Boneville'	12.57	4	2.20*	—3.12
'Lincoln'	10.09	7	—0.04	16.24
'Palampriya'	20.27	1	1.41	—13.66
'DPP 62'	18.07	2	3.35**	2.44
'Azad P 1'	16.37	3	—0.91	—24.21
Grand mean	14.33			
SEm ± 2.92				
SE b_i ± 0.47				

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

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component making it easier to predict the performance of the genotypes. Similar results were reported by Rathore *et al.*(1993). Further the stability analysis was carried out for green pod yield (Table 2). 'Palampriya' recently released for cultivation in the dry-temperate region was observed as the high yielding followed by 'DPP 62' and 'Azad P 1'. The genotypes 'Palampriya' and 'Azad P 1' with high mean values showed average regression coefficient (b_i=1) and least deviation from regression coefficient (S^2d_i=0), hence identified as stable in performance. The line 'DPP 62' was observed to be unstable though with high *per se* performance.

Association among different adaptability parameters is an ideal indicative of developing cultivars with wider degree of adaptation. Correlation between X_i and b_i (r=0.73) suggested that the yield stability of a variety needs due attention while breeding for high yield. However, there was absence of association between X_i vs S^2d_i and bi vs S^2d_i indicating that the green pod yield in peas can be increased without influencing the environmental response.

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Wheat (*Triticum aestivum*) diseases in trans-Himalayan region*

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Key words : wheat, powdery mildew , yellow rust, trans-Himalayan region, germplasm

Cold desert regions of Great-Himalayas characterized by high altitude (above 10000 feet), sub-zero temperatures(–25 to –35°C minimum temperature) for many months of the year and low rainfall (20 cm average rainfall) are the least studied ones from agriculture point of view. There is only one crop growing season during the summer, and barley (*Hordeum vulgare* L.), wheat (*Triticum aestivum* L. emend. Fiori & Paol) and peas (*Pisum sativum* L.) are the important crops of the region. Among these crops, production of wheat is insufficient to meet the local demands and government has to pay huge on transportation of wheat grain flour to these remote areas.

Major reasons for low yield of wheat in this region appears to be the prevalence of deseases such as yellow rust and powdery mildew which reduce the yield. Yield losses due to powdery mildew in wheat were estimated to vary from 20–55% depending upon the severity of the disease (Linhares1988). No efforts have, however been made to study the severity of wheat diseases, their epidemiology and evaluation of resistance among local whet lines in this region.

Puccinia striiformis causing yellow rust and *Erysiphe graminis tritici* causing powdery mildew of wheat have been reported to survive on cultivated wheat in the Himalayan region during offesason and provide primary inoculum for infection of wheat in foot-hills and plains of India (Nagarajan *et al.* 1992, Sharma *et al.* 1992). Severe epidemics of yellow rust were observed not only in several middle eastern countries including Iran and Pakistan (Johanson 1997). A study was undertaken to estimate the (i) severity of wheat deseases, (ii) progress of important diseases on a local line of wheat and (iii) to evaluate local germplasm lines for resistance to important diseases in the region.

Estimates of severity of wheat diseases were made from farmers' fields selected randomly at 8 locations, viz Lari, Tabo, Poh, Sichling, Lalung, Kaza, Lidang and Sumra situated between 3000 – 3800 m above mean sea level in the cold desert region of Himachal Pradesh. Selected fields at each location were traversed in an inverted V with analysis of randomly selected plants in a 1 m^2 area from 3 sites situated on the inverted V path. Incidence of loose smut and foot/root rot was recorded at firm dough stage of the crop. Intensity of rust was recorded as per the scale given by Saari and Prescott (1975) and that of powdery mildew as per Couture (1980). Assessment of mildew and rust diseases was made at medium silk to dough stages of crop growth, ie between stages 75 and 85 described by Zadocks *et al.* (1974). Percentage of hill bunt infected grains was estimated from 3 wheat samples (250 g each) collected randomly from the threshing floor from each of 8 locations.

Development of powdery mildew and yellow rust with respect to time was studied on a local germplasm line 'LW 10' collected from Spiti valley of Himachal Pradesh. Severity of diseases was recorded at 6 weekly intervals from 5 random sites at Lari where plants of 'LW 10' were raised during 1996 and 1997. The crop was sown in the third week of April during both the years. The data obtained from different sits were pooled to calculate the final disease severity. Rate of development of disease (r) was recorded based on initial and final disease data as per the procedures described by Van der Plank (1963).

Germplasm lines collected from ten locations of cold desert region of Himachal Pradesh were evaluated for grain yield and resistance to yellow rust and powdery mildew under natural epiphytotic conditions. The sowing of crop for this experiment was done during second week of May in both the years. The experiment was conducted in randomized block design with 3 replications. Yield data were recorded from the same plots from where disease severity data were recorded.

Disease survey

Loose smut caused by *Ustilago segetum var tritici*, yellow rust caused by *Puccinia striiformis*, powdery mil.dew caused by *Erysiphe graminis tritici*, hill bunt caused by *Tilletia caries* and *T. foetida* and foot and root rot caused by *Helminthosporium sativum* were recorded on wheat. Average incidence of hill bunt and loose smut was 0.9 and 0.2% respectively during 1995 and 0.9 and 0.3% respectively during

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Table 1 Evaluation of wheat germplasm lines for yield and diseases

Accession	Grain yield (kg/ha)			Terminal disease severity (%)			
				Powdery mildew		Yellow rust	
	1996	1997	Mean	1996	1997	1996	1997
LW 1	548	685	617	1.0	5.3	91.7	2.0
LW 2	822	592	707	20.0	33.3	52.8	1.0
LW 3	914	1 096	1 005	1.0	15.0	91.7	4.0
LW 4	822	640	731	6.7	20.0	70.8	2.0
LW 5	457	457	457	3.3	58.3	21.7	0.7
LW 6	1 188	1 188	1 188	11.1	41.7	50.0	5.3
LW 7	640	685	663		41.7		6.7
LW 8	640	640	640	8.9	33.3	75.0	8.3
LW 9	457	777	617	6.1	33.3	86.1	3.7
LW 10	914	868	891	4.1	50.0	75.0	5.0
Sonalika	1 115	1 090	1 103	6.7	38.3	50.0	6.7

1996. Intensity of rust and mildew was high with 25.4 and 30.7% severity respectively during 1995 and 30.6 and 21.7% during 1996. Rust and mildew however did not appear at Kaza and Lalung which are situated at high altitude and experiance low temperature.

Ascospore bearing cleistothesia of *E. graminis tritici* were observed at all the locations surveyed. These cleistothesia may serve as the source of primary inoculum for the infection of wheat in foot hills of the country (Sharma *et al.* 1992).

Common root rot was recorded from Kaza and Lalung only where rust and mildew were absent. Overall incidence of common root rot in the region was 9.7% during 1995, whereas at Lalung and Kaza it was 43.81 and 14.34% respectively. During 1996, there was slight increase in the incidence of common root rot (average incidence 11.2%). Common root rot incidence was 46.8% at Lalung and 20.4% at Kaza.

This is the first report of hill bunt caused by *Tilletia caries* and *T. foetida* and common root rot caused by *Helminthosporium sativum* in this region.

Development of powdery mildew and yellow rust of wheat in Spiti valley

Powdery mildew appeared during first week of July in 1996 and third week of July in 1997. Ater its appearance, the disease developed at a faster rate during 1997 compared to 1996. Rate of progress of desease was 0.04 units/day in 1996 and 0.09 units/day in 1997. Terminal disease severity was 16.4% during 1996 but not in 1997.

Rust appeared late on the crop than mildew, i e second week of July during 1996 and first week of August during 1997. Terminal rust severity recorded on 14 August was 0.34% during 1997 and 39% during 1996. Rate of progress of disease on leaves was 0.05 and 0.06 units/day during 1996 and 1997 respectively. The disease was observed on the ears of infected plants during 1996 but not during 1997.

The data indicate year to year variation in rust and mildew severity probably due to strong effects of environment and inoculum. Late appearance of rust and mildew might be due to late arrival of the inoculum.

Evaluation of wheat germplasm lines for yield and diseases

Among the 10 germplansm lines evaluated for yield and disease resistance, accession no. LW 6 gave highest yield (1.18 tonnes) followed by LW 3 (1.05 tonnes) and LW 10 (0.89 tonne). The yield of check variety 'Sonalika' was 1.10 tonnes/ha and was statistically at par with highest yielder LW 6 (Table 1). Among all the lines tested for disease severity, only LW 1 showed some degree of resistance to mildew with 1% mildew during 1996 and 5.3% during 1997 (Table 1). Rest of lines were susceptible to highly susceptible to rust and mildew. Accession no. LW 6, LW 3 and LW 10 appear to tolerance to rust and mildew which is evident from high yields of these lines despite high susceptibility to both the diseases.

The results of present investigation indicate that wheat crop grown in the cold desert region of the great-Himalayas is infected by a number of pathogens especially *E. graminis tritici* and *P. striiformis* which may be potential source of inoculum during winter in the foot-hills and plains of India. Crop should be sown earlier in this region to minimize losses caused by powdery mildew and yellow rust as these diseases appear late in the season. Local lines 'LW 6', 'LW 3' and 'LW 10' sown presently in the region are susceptible but tolearant to powdery mildew and yellow rust whereas LW 1 is resistant to mildew.

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Effect of blight (*Colletotrichum dematium*) on seed yield of chickpea (*Cicer arietinum*)

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Key words : *Colletotrichum* blight, chickpea, yield loss, weather factors, toxin, seed dressing, foliar spray

Chickpea blight caused by *Colletotrichum dematium* (Pers ex Fr Grove) was first reported by Mishra *et al.* (1975) from Jabalpur and seen again in 1997–98 season.

The studies on losses due to the disease were made by comparing influence on chickpea yield parameters in protected and unprotected plots (4 m × 2.5 m). The plants in protected plot were sprayed thrice with carbendazim (0.05%) at 15 days interval from the disease appearance. Observations on disease development were recorded at weekly interval on 10 randomly tagged plants 'JG–74' from December 97 to February 98. disease intensity was recorded following 0–5 scale. The per cent disease intensity was calculated by dividing stem lesions (number × size) by plant height/plant and multiplied with hundred. Influence of environmental factors on disease initiation and development was studied by correlating data on disease intensity and weather each week.

To study toxin production the fungus was incubated on Richards medium and inoculated for 10,15 and 20 days at 25±1°C. Later mycelial mat was separated and the filtrate was passed through seitz filter unit using pad filter of grade 5 (pore size 0.65– 0.84). Bioassay was done by seed soaking in pure and 8 dilutions of filtrate for 4 hr and placed in petri–dishes and pots (10 cm × 15 cm) containing sterilized soil.

For detecting seed infection, 400 seeds were taken randomly from the infected field. Diseased and healthy looking seeds were counted and sown in pots to see influence on emergence and mortality. Seed health testing was done by blotter (Doyer 1938), deep freezing (Limonard 1966,1968),component platting (Maden *et al.* 1975) and agar tube methods (Khare *et al.* 1977).

Nine fungicides were evaluated *in-vitro* by poisoned food technique with 2 doses. Seeds 'JG 74' from infected field were pre–treated with 8 fungicides alone or in combination and were planted in pots (10 cm × 15 cm) in 3 replications along with 2 checks comprising sterilized and field soil. Five systemic and nonsystemic fungicides were tried as foliar spray at 65.80 and 95 days after sowing in plots (4 m × 2.5 m) having susceptible 'JG 74' chickpea in 4 replications using randomised block design.

Assessment of yield loss studies in chickpea due to colletotrichum blight showed significant reduction in pods (35.44%) plant yield (41.17%), plot yield (60.37%), 100–seed

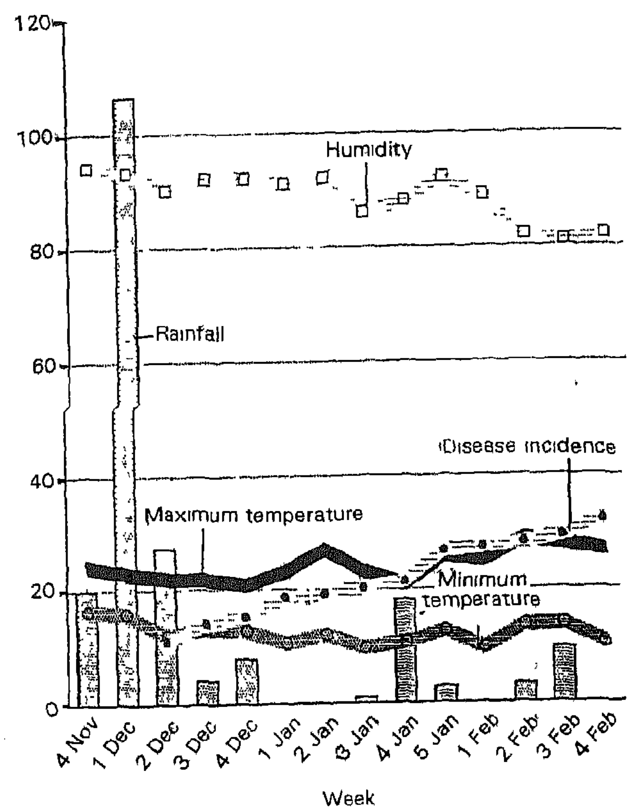

Fig 1 Influence of weather factors on *Colleotolrichum* blight of chickpea

* Short note

Base on complete information of M Sc (Ag) thesis of the first author submitted to the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur in 1998 (unpublished)

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Table 1 Efficacy of seed dressing fungicides for the contral of *Colletotrichum* blight of chickpea in pots

Fungicide	Dose (%)	Germination (%)	Mortality	
			Pre-emergence (%)	Post emergence (%)
Tetra methyl thiuram disulphide (TMTD)	0.25	100.00	0.00	0.00
TMTD + Captan	0.25 (1:1)	93.30	6.60	7.14
Carbendazim	0.25	100.00	0.00	6.60
Benomyl	0.25	66.60	23.30	26.00
Tria-dimefon	0.25	76.60	23.30	26.00
Carboxin	0.25	90.00	10.00	7.40
Mancozeb	0.25	86.60	13.30	0.00
Propineb	0.25	70.00	30.00	42.80
Chlorothalonil	0.25	93.30	6.60	7.14
TMTD+Carbendazim	0.25 (4:1)	83.30	16.60	0.00
Mancozeb+ Carbendazim	0.25 (4:1)	86.60	13.30	15.38
Check (Sterilized soil)		56.60	44.33	76.40
Check (Unsterilized soil)		50.00	50.00	86.60
CD (P = 0.05)		15.52	12.46	13.35

* Mean data of 3 replications

weight (20.65%) and sound seeds (16.19%). Thus the disease resulted in discoloured shrivelled seeds of reduced size and weight. Similar yield loss (22.4 – 61.7%) was found in anthracrose (*C. dematium* var *truncatum*) of 'Clark 63' soybean (*Glycine max* (L.) Merr.) (Verma and Upadhyay 1973).

The disease (11%) appeared in field in second week of December (Fig 1). The mean values of weather factors in the previous 2 weeks were 23.5°C maximum temperature 16.1°C minimum temperature, 93.5% relative humidity, 63.1mm rainfall and 2.35 hrs sunshine. The disease intensity showed a gradual increase with maximum (32%) in the last week of February. However, statistical significance increase was recorded in January first (3.4%) and last week (5.4%). The weather factors which favoured were rise in maximum temperature (20.8–23.1 and 20.7–25.7°C), minimum temperature around 12°C, relative humidity (92%), rainfall (7.9 and 9 mm) and sunshine (4–5 hr). Statistical correlation of weather factors with disease intensity was positively sighificant with maximum temperature and sunshine hours, whereas it was negatively significant with minimum temperature, relative humidity, rainfall and rainy days. This is because of gradual rise in disease under the influence of weather factors which fluctuated in favourable limits. Mishra *et al.* (1975) reported moderate temperature and high relative humidity as favourable weather factors for the disease.

Samples from infected field showed 30% seed infection, 50% germination and 30% mortality due to reddish–brown lesions appeared at basal part of the seedling. Detection of seed infection of the pathogen revealed 66% association of *C. dematium by deep freezing, whereas 14% by blotter method.* Component platting of different parts of diseased seed revealed pathogen association with seed coat (50%) and cotyledones (100%) indicating *C. dematium* in chickpea to be internally seed borne. Seedling symptom test by agar tube method showed reduction in germination (50%) and redish-brown sunken lesions at collar region of the seedilings which collapsed after 10 days. Ungerminated seeds were covered with *C. dematium* mycelial growth causing pre-emergence rot (50%).

In-vitro evaluation of all the fungicides showed inhibition (63.3–100%) in growth of *C. dematium* with 100% by carbendazim (0.050–0.1%), mancozeb (0.2, 0.25%), tetra methyl thiuram disulphide (0.25%) and benomyl (0.15%).

Results of chickpea seed dressing (Table 1) showed that all the fungicides except propineb (antracol 75 wp) significantly improved germination over the control. But seed dressings by tetra methyl thiuram disulphide (Thiram), carbendazim (Bavistin) and tetra methyl thiuram disulphide + captan were the best. However, minimum germination (50, 50.6%) were recorded in the 2 checks but the difference between them was non-significant, Agrawal *et al.* (1972) and Jharia *et al.* (1977)

Table 2 Influence of fungiciedal spray fungiciedal spray on Colletotrichum blight of chickpea in field

Fungicike	Dose (%)	Disease incidence (%)		Yield/ plant (g)	Yield (g)	100 seed k weight	Sound seed (%)
Mancozeb	0.20	18.35	(25.36)	12.95	1162.50	17.62	78.78
Profrineb	0.20	25.60	(30.37)	12.65	738.75	17.40	75.56
Carbendazim	0.05	16.92	(24.28)	16.03	1350.00	19.41	85.75
Triadmefon	0.10	25.30	(30.15)	13.08	895.00	17.07	77.43
Chlorothalonil	0.30	22.92	(28.59)	13.68	920.00	17.57	80.85
Copper oxychloride	0.30	26.20	(30.74)	12.48	612.50	16.97	75.37
Benomyl	0.10	25.30	(30.18)	12.57	835.00	17.48	77.15
Check		32.00	(34.40)	09.47	535.00	15.40	69.56
CD (P = 0.05)		2.77		2.20	256.74	1.12	2.67

* Mean data of 4 replications
+ Figures in parenthesis transformed values

have reported similar findings in blackgram (*Phaseolus mungo*) and chillies (*Capsicum annuum* L.)

As foliar spray carbendazim (Bavistin 0.05%) was most effective followed by mancozeb (Dithane M 45, 2.0%) and chlorothalonil (Kavach 0.3%). All the other fungicide sprays were significantly superior in reduction disease intensity as well as increasing yield and sound seed over the check (Table 2). Similar results were reported by Chauhan and Duhan (1977) in dieback of chillies and Issa (1985) in bean anthracnose.

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Compatibility of *Bacillus thuringiensis* with chemical insecticides used for insect control in soybean (*Glycine max*)*

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Key words : *Bacillus thuringiensis*, insecticide compatibility, soybean

Bacillus thuringiensis (Bt), bacculovirus and nuclear polyhedrosis virus have been used by many workers earlier (Jaques 1988, Sharma and Odak 1996, Biswas *et al.* 1996, Dutta and Sharma 1997, Sharma 1998) to control insect pests of various crops. For soybean [*Glycine max* (L.) Merr.] recommended chemical insecticides, eg endosulfan – 0.07%, quinalphos – 0.05, monocrotophos – 0.036 and triazophos – 0.05 gave satisfactory insect control (Sharma 1999) but their indiscriminate use and related problems thereafter necessitated alternate management practices. Hence, a study was undertaken to test the compatibility of commercial *Bacillus thuringiensis* formulation and recommended chemical so that tank-mixing can be adopted and number of sprays can be kept to minimum.

Four insecticides (eg monocrotophos, endosulfan, triazophos and quinalphos) recommended for control of insect pests in soybean were tested further for their compatibility with commercial *Bacillus thuringiensis* formulation - Dipel (Table 1). These were mixed in 200 ml pre-sterilized, molten nutrient agar medium to obtain the final concentration of 0.036, 0.07, 0.05 and 0.05 % respectively. Eight replications were maintained for each treatment. The media were poured aseptically in sterile petri plates. Six successive dilutions were made from and from 6th dilution, 50 µl inoculum was aseptically drawn by micro pipette and released in each petri-plate for uniform spread over the medium. The medium without insecticide served as control. The plates were incubated at 25 ± 1°C for 48 hr. The bacterial colonies were counted and the colony forming unit/ml (CFU/ml) was calculated. The *Bacillus thuringiensis* colonies grown on plain nutrient agar plates were considered as the total count of bacteria present in the original solution and compared with the bacterial colonies grown on insecticide amended medium. Plates which did not bear *Bacillus thuringiensis* colonies 48 hr after incubation were incubated further for a week.

*Short note

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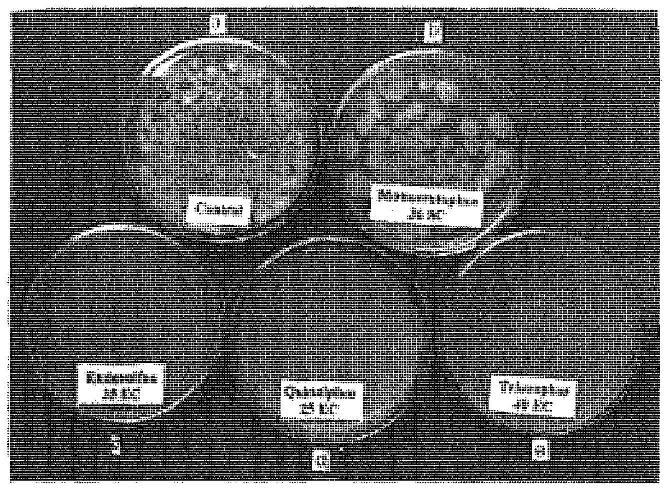

Fig. 1 *Bacillus thuringiensis* colonies growing on nutrient agar medium with or without insecticides (a, conrol; b, monocrotophos; c, endosulfan; d, quinalphos; e, triazophos)

The bacteria did not grow on the medium having endosulfan, triazophos and quinalphos (Table 1) but it grew on plain nutrient agar (control) and on medium containing monocrotophos (Fig 1). Average bacterial population recorded for monocrotophos was 5.92×10^9 CFU/ml whereas for control plates average was 6.36×10^9 CFU/ml. Though a marginal reduction in the bacterial colonies was obtained with monocrotophos, this insecticide had little inhibitory effect while the other 3 insecticides completely inhibited the growth of bacteria, and no colony developed even after 7 days of incubation (Fig 1). Pramanik *et al.* (1997) had maintained those recommended doses of quinalphos (0.05%) and endosulfan (0.07%) were toxic and inhibited the growth of the bacterium while monocrotophos did not.

In soybean, farmers traditionally spray the crop first with endosulfan during 20–25 days after sowing and then with monocrotophos at 50–55 days after sowing. The incidence of lepidopterous defoliators (eg *Spodoptera litura* (Fab.), *Chrysodeixis acuta* (Wlk.), *Diachrysia orichalcea* (Fab.), *and Spilosoma obliqua* (Wlk.) usually reach to

Table 1 Bacterial colony (CFU/ml) in the medium with or without insecticide

Treatment	No. of CFU/ml*
Control (*Bacillus thuringiensis* var *kurstaki* alone)	6.36×10^9
Bt + Monocrotophos 36 SC (0.036 %)	5.92×10^9
Bt + Endosulfan 35 EC (0.07 %)	
Bt + Triazophos 40 EC (0.05 %)	
Bt + Quinalphos 25 EC (0.05 %)	

*Average of 8 replications. Plates that did not have initial bacterial colonies, were further incubated for 7 days

Bt, *Bacillus thuringiensis*

maximum during 40–45 days after sowing. The damage caused by stem boring girdle beetle, *Oberiopsis brevis* Swed. is also seen simultaneously (Singh and Singh 1999). Since monocrotophos seems to be compatible with *Bacillus thuringiensis* formulation, it is recommended the infestation of these insects may be reduced by spraying the crop with tank mixed monocrotophos (0.036 %) and *Bacillus thuringiensis* formulation (eg Dipel @ 1 litre/ha) during 40–45 days after sowing (Jaques 1988).

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Management of pea powdery mildew in trans-Himalayan region

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Key words : pea powdery mildew, trans-Himalayan region, disease development

Pea (*Pisum sativum* L.) is one of the major cash crops and mean of income of majority of farmers of cold desert areas of Himachal Pradesh comprising of Spiti valley of Lahaul and Spiti and Pooh subdivision of Kinnaur districts. These areas lie between 10000–15000 feet above mean sea level and experience heavy snowfall, low rainfall (20 cm/year) and low temperature (min of –30 –35°C) during winter season.

Perusal of literature showed that the region had never been surveyed systematically for diseases of peas and only pea powdery mildew (*Erysiphe pisi* DC.) had been reported form this region. Lack of studies on management of powdery mildew in this region has led to the excessive use of chemicals by the farmers which may be hazardous to the fragile ecology of the region. The studies, therefore, were undertaken to conduct disease survey and optimize number of sprays for effective management of pea powdery mildew.

The localities for disease survey conducted during 1995 and 1996, were selected at random at a distance of 20 km (approx) from each other. Pea fields at each location were traversed in a W- path and 5 random sites approximately 100 m apart were slected on this path. At each site 1 m^2 area was selected for recording disease incidence and severity. A total of 17 locations, viz Lari, Tabo, Dankar, Kibber, Ki, Kaza Rangrik, Pangmo, Kaito, Hanse, Lossar, Gulling, Kungri, Chango, Nako and Gyabung were surveyed in the present study.

Root rot and wilt incidence was recorded from 10 plants selected randomly at each site. Roots of selected plants were washed with tap water, observed visually for root rot and vascular discolouration and preserved in blotting sheets for isolation of pathgens on potato dextrose agar (potato extract 200 g, dextrose 20 g and agar 16 g/ litre) medium. Pathogenicity of isolated *Fusaria* was determined using hydroponics method, ie by culturing 15–20 day-old plants grown in sterilized sand and inoculated with conidial suspension (10^4 spores/ ml) of fungi in tubes containing Hoagland solution (Hoagland and Aron 1950) and incubating them at 25±1°C at 16 hr light and 8 hr dark cycle for 15 days.

Severity of mildew was recorded from 10 plants selected randomly using 0–2 scale originally described by Srivastava *et al.* (1971) and modified in this study where 0, no disease; 0.1, 1–10% leaf area covered with mildew, 0.5, > 10–25% leaf area covered with mildew, 1.0, >25 –50 % leaf area covered with mildew, 1.5, >50–75% leaf area covered with mildew and 2.0, > 75% leaf area covered with mildew. Disease severity index (%) was calculated as per Singh (1988).

To optimize number of sprays for magagement of mildew on a highly susceptible 'Lincoln' and moderately resistant 'Palam Priya', 4 spray treatments with karathane (0.1%), viz single spray on 14 July, two sprays on 7, 14 July, 3 sparays on 7, 14 and 21 July and 4 sparays on 30 June, 7, 14 and 2, July were evaluated. The experiment was conducted in the farmer's field at village Lari in spiti valley during 1996 and 1997 with three replications in each experiment. Development of mildew on sprayed as well as unsprayed plots was studied by recording mildew severity at 5 weekly intervals starting from 7 July. Rate of progress of disease was recorded as per Van der Plank (1963).

Powdery mildew, wilt and root rot diseases were detected on pea crop in cold desert regions of Himachal Pradesh. Overall powdery mildew severity in the region was 53.4% during 1995 and 46.4% during 1996. At Poh and Lari 100% leaf area was covered with mildew. The severity of disease however was low in villages situated in the interior of Spiti valley and disease was not observed at all at Lossar, the interior-most village of the valley and at Kibber, the highest village in Asia connected with road. The reason for low intensity of mildew in the interior of Spiti might be the low temperature.

Overall root rot and wilt incidence was 27.8% during 1995 and 51.9% during 1996. Disease incidence was highest at Kaza (84.8%) and lowest at Dankar (7.6%) during 1995. The disease was also detected at Kibber (35.2% incidence) and Lossar (14.2% incidence) indicating the necessity of deployment of disease management practices throughout the region. *Fusarium oxysporum* f. sp. *pisi* and *Fusarium solani* f. sp. *pisi* were the major pathogens associated with root rot and wilt complex. *Fusarium solani* f. sp. *pisi* was isolated from 75.3% infected plants whereas *F. oxysporum* f. sp. *pisi* was isolated from 53.1% infected plants. Co-infection by these pathogens was observed on 28.9% diseased plants. Apart

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Table 1 Effect of karathane (0.1%) sprays on development of powdery mildew on 'Lincoln' pea

No. of spray	Date of Spray	Mildew Severity (%)									
		1996					1997				
		7 July	14 July	21 July	28 July	5 Aug	7 July	14 July	21 July	28 July	5 Aug
0		0.6	5.0	25.0	75.0	100.0	2.3	20.0	50.0	83.3	100.0
1	14 July	2.0	15.0	20.0	41.7	83.3	3.7	20.0	20.0	50.0	75.0
2	7, 14 July	1.0	2.0	3.7	10.0	25.0	3.3	3.7	5.0	15.0	33.3
3	14, 21 July	0.6	1.0	2.3	2.3	10.0	3.7	3.7	3.7	3.7	8.3
4	7, 14,21 July	0	0	0.3	0.3	0.2	0	0	0.7	1.0	2.3

Table 2 Effect of karathane (0.1%) sprays on development of powdery mildew on 'Palam Priya'

No. of spray	Date of Spray	Mildew severity (%)									
		1996					1997				
		7 July	14 July	21 July	28 July	5 Aug	7 July	14 July	21 July	28 July	5 Aug
0		0	0.3	4.0	25.0	50.0	0	1.0	5.0	33.3	50.0
1	14 July	0	0.7	0.7	3.7	15.0	0	1.0	0	5.0	25.0
2	7, 14 July	0	0	0	0.7	3.7	0	0	0	[illegible]	5.0
3	7,14, 21 July	0	0	0	0	0.8	0	0	0	[illegible]	0.3
4	30 June and 7,14, 21 July	0	0	0	0	0.3	0	0	0	0	0.4

from these 2 fungi, *Sclerotinia sclerotiorum* was also isolated from 0.4% diseased plants at a single location, ie Ki in Spiti Valley.

This is the first report of wilt and root rot caused by *F. Solani* f sp *pisi*, *F. oxysporum* f sp *pisi* and *Sclerotinia sclerotiorum* from this region.

Management of pea powdery mildew

The mildew on 'Lincoln' was first detected on 5 July during 1996 and 7 July during 1997. The progress of the disease was rapid thereafter (0.07–0.08 units/day), and unsprayed plants were covered completely with mildew within a month (Table 1). Single spray after disease appearance was not effective in its management and terminal disease severity of 75% was recorded. Two and/or 3 sprays were lso inadequate for effective management of the disease. Three sprays at weekly interval were found to manage the disease below 4% severity during the first 2 pickings and below 10% during the third pod picking. Four sprays at weekly intervals however was found effective in the management of the disease below 5% during the entire green pod-harvesting season. Terminal disease severity after four sprays was only 2.3% compared with 100% in control.

Initial appearance of disease on Palam Priya was delayed by about 1 week compared to 'Lincoln'. Terminal disease severity recorded on unsprayed plots was 50% during both the years as compared to 100% on 'Lincoln' (Table 2). Single spray of karathane @ 0.1% restricted the disease below 4% for first 2 pickings, whereas 2 sprays managed it below 5% during the entire green pod picking season. The disease severity was less than 1% when crop was sprayed thrice and less than 0.5% when crop was sprayed 4 times.

Karathane has been used frequently for the management of powdery mildew of peas (Singh 1985). Systemic fungicides have also been used for management of the disease (Gupta and Shyam 1998). Kapoor and Thakur (1997) suggested that during pod picking it was safer to use only protectant fungicides. Karathane (0.1%) has been found to be highly effective in the management of powdery mildew in the present study.

It was concluded that powdery mildew, wilt and root rot have become important deseases of peas in the cold desert regions of trans-Himalayas which were considered free of diseases. Maximum number of spray of karathane (0.1%) for effective management of pea powdery mildew in trans-Himalayan region should be restricted to 4 on 'Lincoln' and to 2 on 'Palam Priya.'

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Assessment of yield loss due to host pest interactions in linseed (*Linum usitatissimum*)*

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Key words : linseed, bud fly, *Alternaria* blight, losses

Five popular cultivars of linseed (*Linum usitatissimum* L.), namely 'Neelum', 'Laxmi 27', 'Garima', 'Sweta' and 'Shubhra' were grown for 5 consecutive season (1992–93 to 1996–97) in randomized block design each year with 4 replications to observe various factors including insects, diseases and physiological disorders which are responsible for direct losses in seed yield. These factors were found to cause unfertilized/ infertile buds resulting in reduction of the produce as follows : (i) Infestation of bud fly (*Dasyneura lini* Barnes) maggots, which feed upon the androcium, one of the reproductive parts of the buds interrupting fertilization process, (ii) infection of *Alternaria* blight (bud blight) disease (*Alternaria lini*) at the early age of floral bud forming a ring on peduncle just below the bud base, which checks the nutrient supply to upper part of the bud resulting in the bud starved/ unfertilized, and (iii) the buds, which appear in later stage of crop growth (secondary/ tertiary flowering) and do not receive proper environment for their development and fertilization, remain immature/ unfertilized.

The infestation of bud fly (*D. lini*) was 27.88–43.97% to floral buds followed by 15.12– 25.47% mortality due to *Alternaria* blight (bud blight) while 3.10–4.11% floral buds were immature/ unfertilized in different varieties of linseed (Table 1). Significantly higher infestation of bud fly and *Alternaria* blight was 43.97 and 25.47 % on 'Neelum', while on 'Garima' these losses were confined to 27.88 and 15.12%. Immature buds could show only numerical difference among these varieties. Total losses due to all these factors in seed production were significantly maximum 74% on 'Neelum' followed by 58.74, 54.84, 54.00 and 46.75% on 'Laxmi 27', 'Shubhra', 'Sweta' and 'Garima' varieties respectively. Critical review of previous work revealed that a lot of research has been done on the screening of varieties/ germplasm for bud fly (Singh *et al.* 1990) as well as *Alternaria* blight disease (Chauhan and Srivastava 1975) individually but regarding the quantified degree of damage due to these individual factors collectively are lacking.

*Short note

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Table 1 Yield losses due to various factors in linseed

Varieties	Bud fly infestation (%)	Alternaria infection (%)	Immature buds (%)	Total bud infestation (%)
'Neelum'	43.97	25.47	4.11	74.00
	(41.54)	(30.31)	(11.70)	(59.34)
'Laxmi 27'	34.56	20.43	3.58	58.74
	(36.01)	(26.87)	(10.91)	(50.03)
'Garima'	27.88	15.12	3.50	46.75
	(31.87)	(22.88)	(10.78)	(43.14)
'Sweta'	31.71	18.76	3.43	54.00
	(34.27)	(25.67)	(10.67)	(47.30)
'Shubhra'	30.21	21.35	3.10	54.84
	(33.34)	(27.52)	(10.15)	(47.78)
SEm ±	1.06	1.42	0.49	1.64
CD (P= 0.05)	3.27	4.38	N.S.	5.06

Figures in parenthesis are transformed angular values

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Combining ability and heterosis for field resistance to late blight in potato (*Solanum tuberosum*)*

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Key words : Late blight, Phytophthora infestans, resistance, combining ability, heterosis, potato

Late blight caused by fungus *Phytophthora infestans* (Mont.) de Bary is the most destructive disease of potato and appears regularly in an epidemic form in the hill regions of the country. Little is known about the inheritance of field resistance to late blight. This was investigated in the present study by line × tester combining ability analysis.

Twelve potato genotypes (Table 1) known to be resistant to late blight were crossed in 9 × 3 (line × tester) mating design (Kempthorne 1957) during 1993 at the Research Station, Kufri (32°N, 77°E, 2500 meters above sea-level) and true seeds produced were used to raise seedlings during 1994 at Shimla. During 1995, the seedlings' produced (first clonal generation seed material) were used to lay a trial in a randomized complete block design at Kufri. Each cross was represented by a single row of 15 genotypes (1 hill/genotype) replicated thrice and planted at intra- and inter-row spacings of 20 cm and 50 cm respectively. Late blight susceptible cultivar 'Kufri Chandramukhi' was planted after every 10 rows to act as spreader. Recommended manurial and cultural schedules were followed.

Data on late blight incidence (per cent leaf area with late blight lesions) were recorded at weekly intervals starting from the date of appearance of late blight (29 July 1995) to haulms cutting (19 August 1995) and used to compute the area under disease progress curve (AUDPC) (Shanner and Finney 1977). The normalised AUDPC values were subtracted from unit before subjecting them to the combining ability analysis using computer software SPARI (IASRI, New Delhi). Fixed effect model was used considering the set of parents as complete population and the application of results would be restricted to the parents and the crosses evaluated.

Mean squares due to combining ability were significant for all sources namely females, males and females × males. However, mean squares due to replications were non-significant indicating that late blight incidence was uniform across the replications. Error mean square was of low magnitude reflecting thereby the accuracy with which data could be recorded for this character.

* Short note

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Table 1 Estimated general combinig ability and specific combining ability effect for resistance to late blight

Parents (Male and females)	Specific combining ability			General combining ability
	'QB/A 9-120'	'Kufri Badshah'	'HB/83-39'	
'Dr McIntosh'	—0.11**	0.07**	0.05*	0.14**
'CIP 676082'	—0.04*	0.04*	0.00	0.01
'Atzimba'	0.12**	—0.14**	0.02	—0.20**
'G 6246'	—0.06**	0.01	0.04*	0.09**
'CFK 69.1'	0.21**	0.10**	—0.31**	—0.16**
'Muziranzara'	0.03	—0.12**	0.09**	0.02
'CFJ 69.1'	0.00	—0.07**	0.07**	0.01
'AL 624'	—0.16**	0.04*	0.12**	0.03**
'POOS 16'	0.00	0.07**	—0.07**	0.06**
General combining ability	0.14**	—0.09**	—0.04**	

$^*P \leq 0.05$; $P \leq 0.01$

Estimates of variance components due to combining ability effects indicated the preponderance of non-additive gene action(sca), additive variance (gca) being only one third of the total variance. These findings agree with those of Killick and Malcolmson (1973). Though sca was more important than gca, significance of gca effect showed that estimates of general combining ability would be useful in identifying parents with high breeding value. The gca effects (Table 1) showed that 'Dr McIntosh,' 'G 6246, ' 'POOS 16' and 'AL 624' among females and QB/A 9-120 among males were good general combiners, whereas 'Atzimba' and 'CFK 69.1' among females and 'Kufri Badshah' and 'HB/83-39' among males were poor general combiners. Specific combining ability effects of crosses (Table 1) showed that performance of many crosses deviated significantly from that expected on the basis of the gca effects of the parents involved. Crosses with sca effect in the desired direction involved parents with low × high, medium × medium, low × medium as well as low × low general combining ability effect. Thus, there was no clear relationship between the combining ability of the parents and the crosses indicating that selection of parents on the basis of combining ability will not limit the exploitation of sca effects for the improvement of resistance to late blight. Top 5 crosses with significantly positive (desired) sca effect were 'CFK 69.1' × 'QB/A 9-120,' 'Atzimaba ' × 'QB/A 9-120' 'AL 624' × 'HB/83-39,' 'CFK 69.1' × 'Kufri Badshah' and 'Muziranzara ' × 'HB/83-39.' These progenies may be exploited for isolating genotypes with high field resistance to late blight.

Significance of parents vs hybrids mean squares showed the presence of heterosis for resistance to late blight. However, none of the cross combinations gave significant positive heterosis over better parent and only 2 cross combinations, viz 'Dr McIntosh' × 'Kufri Badshah' and 'CFK 69.1' × 'QB/A 9-120' gave significant positive heterosis over mid-parent.

In conclusion, both general and specific combining ability effects should be taken into consideration while planning the crossing programme for improving resistance to late blight.

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Efficacy of some insecticides against eggs and grubs of soybean girdler (*Oberea brevis*) in the field

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Key words : soybean girdler, *Oberea brevis*, egg mortality

The girdle beetle (*Oberea brevis* Swed.) (Coleoptera : Lamiidae) is a predominant and serious pest of soybean in India (Singh *et al.* 1998). The pest attacks soybean plant by making girdle on stem, petiole and petiolet. The girdled plant part wither within 24 hr. Dimethoate, quinalphos, FMC, cypermethrin and fenthion were tested and found effective (Singh *et al.* 1978, Singh 1986). In the persent study emulsions of some insecticides having different mode of action were tested to elucidate their effectivity in killing the eggs and grubs of the pest.

Seven insecticides viz chlorpyriphos 0.05% (Ruban 20 EC), endosulfan 0.07% (Thiodan 35 EC), methomyl 0.05% (Dunet 12.5 L), monocrotophos 0.04% (Nuvacron 36 WSC), phosphomidan 0.03% (Dimecron 85 SL), mixtuer of profenofos and cypermethrin 0.05% (Polytrin C-44 EC), triazophos 0.05% (Hostathion 40 EC) with a control were tested in randomized block design with 3 replication at research farm of Mandsaur on 'JS 335' soybean. Insecticidal spray was done at 44-days-old crop. All the girdled parts were removed before 3 days of spraying to record accurately the effect of insecticides on fresh eggs and grubs. Fifteen infested plant parts/plot were tagged immediately after spraying by collecting all infested plant parts. Eggs showing no sign of development and were shrivelled were considered as dead. Grubs that bored into the stem and then died were recorded as dead. Mortality (%) was worked out and percentage data were transformed to angular scale and then subjected to statistical analysis.

Triazophos 0.05% a new insecticide recorded superior mortality of eggs, however, it was not effective for controlling grubs. Chlorpyriphos, endosulfan, monocrotophos, methomyl and mixture of profenofos and cypermethrin also recorded better egg mortality but methomyl, mixture of profenophos and cypermethrin and chlorpyriphos could not control gurbs effectively. Non-significant data were observed in case of grub mortality, however, monocrotophos recorded better grub mortality. Considering the egg and grub mortality athe best insecticide was triazophos followed by endosulfan, monocrotophos and chlorpyriphos.

Thus among new insecticides triazophos and among conventional insecticides monocrotophos, endosulfan and chlorpyriphos effectively controlled eggs and grubs of soybean girdler.

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Table 1 Comparison of the xortality (%) of eggs and grubs of girdle beetle treated with different insecticides

Insecticide	Concentration (%)	Mortality (%) Egg	Grub
Monocrotophos	0.04	36.66 (36.93)^{b}	26.66 (30.29)*
Methomyl	0.05	26.66 (30.00)^{bc}	03.33 (06.14)
Chlorpyriphos	0.05	46.66 (43.07)^{b}	13.33 (17.21)
Endosulfan	0.07	46.66 (42.99)^{b}	16.66 (23.85)
Triazophos	0.05	80.00 (64.63)^{a}	06.66 (12.29)
Profenofos+Cypermethrin	0.05	23.33 (28.77)^{bc}	06.66 (08.85)
Phosphomidan	0.03	13.33 (17.70)^{cd}	13.33 (17.21)
Control (Water spray)		00.00 (00.00)	00.00 (00.00)
SEm ±		(05.99)	(07.10)
CD (P= 0.05)		(18.17)	(NS)

* Figures in parentheses are angular transformed values

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(a) Photographs; colour/black and white	Appopriate/should be...% more/less
(b) Line:graphs, histograms	Appopriate/should be...% more/less
3. Articles to be accepted if submitted within — years after conducting experiment	Soon/2 or 5 years/no time limit
4. Quality of articles	E/VG/G/A/P

(i) Title
(ii) Abstracts
(iii) Introduction
(iv) Materials and Methods
(v) Results and Discussion
(vi) References
(vii) Tables
(viii) Figures (colour, black and white, line graphs or histogram)
(ix) Language
(x) Miscellaneous

4. Quality of research review articles (specify)
5. Quality of book reviews (specify)
6. Representation of disciplines/crops

(i) More articles are needed in disciplines/crops	Yes/No
(ii) Articles should be less in disciplines/crops	Yes/No
(iii) Complete information of Ph.D. thesis in 1 article only/in many parts	Yes/No
(iv) Complete information of a study should be in 1article and a part of study or preliminary findings in short note	Yes/No
(v) Articles in series	Yes/No
(a) Each article should be independent	Yes/No
(b) Articles may be published in series (not in parts; only if all parts of a series are published in the same journal by the same authors	Yes/No

8. Prompt, critical comments from referees (Payment of honararium to referees was not accepted and was not considered desirable by several Editorial Boards and ICAR administration. For research journals run by institutions, refereeing is done for the cause of science)
9. Ways to obtain good articles
10. Other useful suggestions

Agrobios (India)

Behind Nasarani Cinema, Chopasani Road, JODHPUR 342 003, Phone (0291) 642 319

NAME OF THE BOOK	AUTHOR	YEAR	PRICE
1. Advances in Plant Hormones Research- Indian Scenario	Malik, C. P.	1999	990.00
2. Agricultural Biotechnology	Purohit, S. S.	1999	850.00
3. Agricultural Extension: Impact and Assessment	Singh, A. P.	1999	395.00
4. Agricultural Statistics: Techniques and Procedure	Mandal, R. C.	1999	350.00
5. Agro's Annual Review of Crop Ecology – Vol. I	Dahama, A. K.	1998	800.00
6. Agro's Annual Review of Plant Physiology (B & A) – Vol. I-IV	Purohit, S. S.	1995-99	3000.00
7. Agro's Dictionary of Biotechnology	Krishnan, A.	1999	695.00
8. Agro's Dictionary of Horticulture (IInd Ed.)	Prasad, S.	1999	350.0
9. Agroforestry: Principles, Importance and Utility **(Hindi)**	Solanki, K. R.	1999	495.00
10. Analysis of Soil Physical Properties	Majumdar,S.	1999	395.00
11. Animal Biotechnology	Ranga, M. M.	1999	595.00
12. Biotechnology: Fundamentals and Applications III Ed	Purohit, S. S.	1999	850.00
13. Biotechnology **(Hindi)**	Purohit, S. S.	1999	350.00
14. Community Forestry	Vyas, G.P.D.	1999	395.00
15. Encyclopedia of Commercial Food Products	Blumenthal, S.	1999	1800.00
16. Fruit Growing in Pots	Day, S. C.	1999	250.00
17. Farm Manure	Thorne	1999	450.00
18. Food Technology: Processing and Laboratory Control	Ayuard, F.	1999	695.00
19. Green House Management for Horticultural Crop Production	Prasad, S.	1999	695.00
20. Hand Book of Foods and Nutrition	Black, C.	1999	750.00
21. Hand Book of Soil, Fertilizer and Manure	Gupta, P. K.	1999	550.00
22. Impact of Plant Biotechnology on Horticulture (IInd Ed.)	Prasad, S.	1999	695.00
23. Laboratory Manual of Plant Biotechnology	Purohit, S. S.	1999	395.00
24. Methods in Environmental Analysis: Water, Soil and Air	Gupta, P. K.	1999	395.00
25. Methods in Plant Tissue Culture	Kumar, U.	1999	550.00
26. Microbiology: Fundamentals & Applications (VIth Ed.)	Purohit, S. S.	1999	700.00
27. Milk and Milk Products	Winton, A. L.	1999	450.00
28. Milk Testing: The Laboratory Control of Milk	Davis, J. G.	1999	300.00
29. Modern Weed Management	Gupta, O. P.	1998	990.00
30. Multipurpose Tree Species for Agroforestry	Solanki, K. R.	2000	595.00
31. Mushroom Growing	Dey, S. C.	1999	250.00
32. Mushroom: Production and Processing Technology	Pathak, V. N.	1999	250.00
33. Organic Farming of Sustainable Agriculture (IInd Ed.)	Dahama, A. K.	1999	450.00
34. Ponds and Fish Culture	Hall, C. B.	1999	400.00
35. Pot Culture of Roses	Dey, S.C.	1999	250.00
36. Principles of Horticulture	Prasad, S.	1999	1200.00
37. Principles of Pesticide Chemistry	Handa, S. K.	1999	395.00
38. Rural Housing: Agro-socio-Economic Impact	Ambadker, S.	2000	495.00
39. Soil, Plant, Water and Fertilizer Analysis	Gupta, P. K.	1999	495.00
40. Soilless Culture of Horticultural Plants	Ellis, C.	1999	595.00
41. Techniques of Food Analysis	Winton, A. L.	1999	1800.00
42. Trace Elements and Crop Production	Wallace, T.	1999	495.00
43. Transgenic Plants	Ranjan, R.	1999	200.00
44. Trends in Plant Tissue Culture and Plant Biotechnology	Pareek, L. K.	1999	850.00
45. Tropical Roots and Tuber Crops	Mandal, R. C.	1993	500.00
46. Vegetable Growing	S. C. Day	1999	250.00
47. Water Environment and Pollution	Kumar, U,	1999	350.00
48. Water Treatment and Purification Technology	Ryan, W. J.	1999	495.00
49. Weed Management of Horticultural Crops	Shanmugavelu, K.	1999	250.00
50. Weed Management: Principles & Practice	Gupta, O. P.	1998	400.00
51. Weed, Weedcide and Weed Control Principles & Practice	Mandal, R. C.	1997	600.00