ASSESSMENT OF YIELD LOSSES IN MUSTARD (*Brassica juncea* L.) DUE TO MUSTARD APHID (*Lipaphis erysimi* Kalt.) UNDER DIFFERENT THERMAL ENVIRONMENTS IN EASTERN CENTRAL INDIA

S.R. PATEL[1]* – A.K. AWASTHI[2] – R.K.S. TOMAR[3]
**e-mail: srpatelsr@yahoo.com*

[1]*Principle Scientist (Agronomy) Department of Agricultural Meteorology, Indira Gandhi Agricultural University, Raipur 492 006 (C.G.) India (Phone/fax: +91-771-2442557)*
[2]*Senior Scientist (Entomology) College of Agriculture & Research Station, Bilaspur 495 001 (C.G.) India (Phone: +91-7752-255024; Fax: +91-7752-254380)*
[3]*Scientist (Entomology) Regional Agricultural Research Station, Raigarh 496 001(C.G.) India (Phone: +91-7762-222402; Fax: +91-7762-244049)*

(Received 4th Dec 2003; accepted 9th April 2004)

Abstract. Mustard aphid (*Lipaphis erysimi.* Kalt.) has been reported as one of the devastating pests in realizing the potential productivity of Indian mustard (*Brassica juncea* L.). The experiment was carried out to assess the yield losses in mustard due to mustard aphids grown in different thermal environments under protected and unprotected conditions. To provide different thermal environments the crop was sown on 5 dates i.e. 08, 18 and 28 November and 08 and 18 December during winter seasons of 1995-96, 1996-97 and 1997-98. It was observed that yield attributes and yield of mustard was significantly decreased in delayed sowing even under protected conditions. On an average maximum seed yield of 1409 kg/ha was harvested when the crop was sown on 08 November under protected condition, while only 279 kg/ha seed yield was recorded under unprotected condition. Similarly the yield attributes and yields drastically reduced under unprotected condition as compared to protected one in all the thermal environments. On the mean basis 80.6, 81.4, 95.2 and 97.6 per cent yield loss was observed under unprotected condition as compared to protected condition in 08, 18, 28 November and 08 and 18 December sowing, respectively. It was also observed that the critical period of mustard exposure to aphids was found to be the 3rd week after aphid appearance when the crop was in flowering stage and hence the control measures have to be initiated before flowering. There was not much difference in natural aphid population/plant in the crop sown up to end of November while the aphid population increased suddenly in December sown crop.
Keywords: *mustard, Lipaphis erysimi, avoidable losses, yield.*

Introduction

In the eastern part of Central India insect-pests is one of the major limiting factors influencing oilseed production especially mustard yield. About three-dozen insect-pests have been found infesting mustard crop in India [12]. On the basis of economic importance mustard aphids are considered to be the key pests, out of three species of aphids namely *Lipaphis erysimi* Kalt., Myzus persicae Sulzer and *Brevicoryne brassicae* Linn., the first one is the most serious, cosmopolitan and has attained the importance of national pest and causes yield loss from 35.4 to 91.3% [4, 21]. The peak activity of pest is observed between January and March in different locations. This variation in the incidence is largely governed by weather parameters. Under the hypothesis of integrated pest management, alteration in sowing time provides wider opportunity to minimize the

http://www.ecology.kee.hu • ISSN 1589 1623

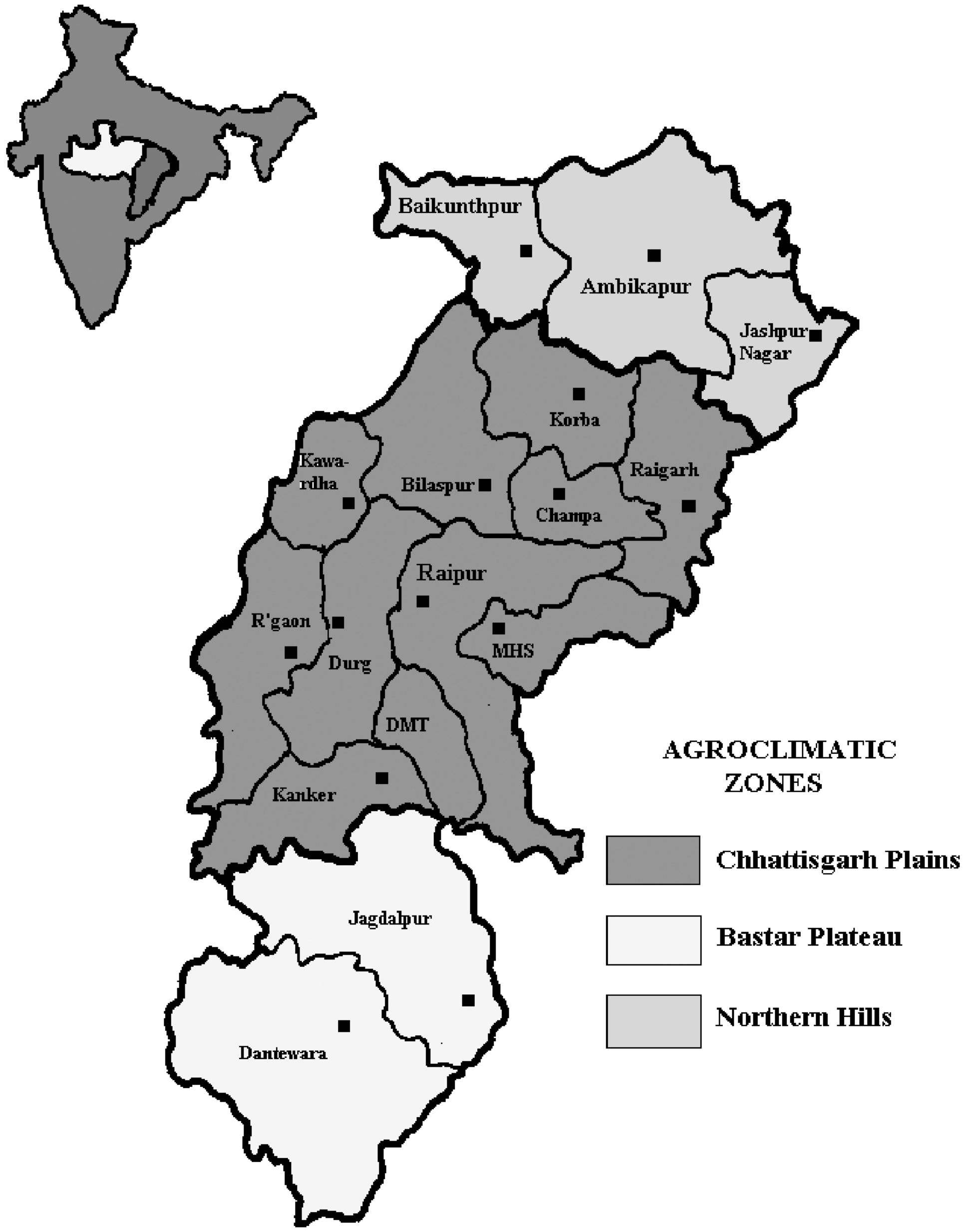


Figure 1. Location and agroclimatic zones of Chhattisgarh in India

damage due to insect pest because the susceptible crop stage is not coinciding and escapes the peak pest population. In agro-ecological conditions of northern India the crop sown before 20th October suffered less damage from aphid than sown later [2, 20, 22]. In eastern part of Central India i.e. Chhattisgarh State (*Figure 1*) mustard is widely grown under irrigated conditions in rice based cropping system. The productivity of mustard in this state is far below as compared to National average, as the sowing is often delayed due to late harvesting of rice crop and thereby field preparation for sowing. Apart from the delayed sowing the winter span in Chhattisgarh State is also shorter as compared to traditional mustard growing Northern India. The information pertaining to the extent of losses due to key pest of mustard is very meagre in this region. In view of this the present investigation was undertaken to assess the yield losses due to mustard aphid under different thermal environments.

Materials and Methods

A field experiment was conducted for 3 years during the winter seasons of 1995-96, 1996-97 and 1997-98 at Regional Agriculture Research Station, Indira Gandhi Agricultural University, Raigarh. The investigation was aimed to assess the losses in yield due to aphids under different thermal environments. Two separate experiments were laid out in randomised block design with four replications. The crop was sown at five dates representing five thermal environments i.e. November 08, 18, 28 and December 08 and 18 in each year under protected and unprotected conditions. The soil of the experimental site was sandy loam in texture representing the 40 per cent area in the state. The average initial nutrient status of the soil was low in available N (230.1 kg/ha) and P (10.7 kg/ha) and medium in K (342.0 kg/ha) with pH 6.9. A fertilizer dose of 80 kg N, 21.8 kg P and 24.9 kg K/ha was given to all the treatments uniformly. Half of N and entire quantity of P and K were applied at the time of sowing, remaining N was given after 35 days of sowing at flower bud initiation stage. Three irrigations were given to the crop at rosette, 50% flowering and pod filling stage. Under protected condition plant protection measures were adopted to protect the crop from aphid damage by spraying endosulfan at 1.5 ml/litre. Ten plants were randomly selected to record observations on yield attributes, whereas the yield was recorded from net plot and finally computed in kg per hectare. A total of 8.6, 5.0 and 265.5 mm rainfall were received during the cropping season of 1995-96, 1996-97 and 1997-98, respectively. The relationship between seed yield and aphid population with delay in sowing in days was examined through regression analysis in linear model. All the data were tabulated and analysed statistically as per the procedure suggested by Chandel [6] and Panse and Sukhatme [11]. The ‘F’ (Fisher's) test was used for judging the significance of the treatment mean at 5 per cent probability level. Whenever ‘F’ test showed significant difference, the differences between treatment means were further tested using critical difference (CD) values.

http://www.ecology.kee.hu • ISSN 1589 1623

To compare different mean value of treatments, critical difference (CD) values were calculated as follow:

(i) SEm ± = $\sqrt{Ems/n}$

Where
SEm ± = Standard Error of mean
Ems = Error mean square
n = number of observations on which the mean value is based
(ii) CD (P=0.05) = SEm x 't' (at 5%) for Error degree of freedom

Aphid count

Observations on insect pests along with natural enemies were recorded on randomly selected 5 plants/plot at weekly interval. At the vegetative stage of the crop, aphid (*Lipaphis erysimi* Kalt.) population was recorded on three leaves (upper, middle and lower) and at flowering, pod filling and maturity stages of the crop, it was observed on 4 twigs of 10 cm/plant including central shoot on 5 plants/plot. All 20 twigs/plot were observed to record the aphid population at these crop stages. The extent of leaf damage by flea beetle (*Phyllotreta cruciferae* Goeze) and the sawfly (*Athalia lugensproxima* Klug) larvae were assessed in terms of percentage leaf area damaged by foliage feeders. Coccinellid predators (*Menochilus sexmaculatus* Fabr. and *Coccinella septempunctata* Linn.) were also observed on whole plant basis.

Weather

The daily weather parameters viz maximum and minimum temperature, morning and evening relative humidity and rainfall that have distinct influence in the multiplication of aphid population were collected and the weekly pattern of these parameters were illustrated through *Figure 2.* The steps down regression equations between aphid populations with different weather parameters were also worked out to predict the influence of rainfall, temperature and humidity on aphid multiplication using Statistical Software SPAR 1.

Results and discussion

Crop phenology

The days taken for different physiological events as influenced by different thermal environments are presented in *Table 1.* It was obvious from the data that the duration for emergence and 50% flowering was delayed due to delay in sowing from 08 November to 18 December. The days taken for emergence delayed by 2 days while the days taken for 50% flowering was extended by 5 days. The prolonged duration for emergence and 50% flowering under delayed sowing was mainly attributed due to lower temperature during the germination and vegetative phase of the crop. After the 50% flowering it was observed that the duration for start and end of seed filling was shortened by 3 and 13 days respectively in 18 December sowing as compared to 08 November sowing. Finally the duration for physiological maturity was shortened by 17 days and causes forced maturity due to higher temperature at the time of grain filling. The increase in duration of vegetative phase and decrease in reproductive and maturity phase as observed in the

http://www.ecology.kee.hu • ISSN 1589 1623

present study were also reported by Singh et al. [23] under the agro-climatic conditions of Hisar, situated in Northern India.

Phenological stages (Days after sowing)	Dates of sowing				
	08 Nov.	18 Nov.	28 Nov.	08 Dec.	18 Dec.
P_1 – Emergence	4	4	4	5	6
P_2 - 50% flowering	45	45	46	48	50
P_3 - Start of seed filling	55	54	55	56	57
P_4 - End of seed filling	95	94	92	89	84
P_5 - Physiological maturity	108	106	102	98	91

Table 1. *Phenology of mustard as influenced by different thermal environments under protected conditions.*

Yield attributes and yield

The data presented in *Table 2* revealed that the yield attributes were significantly influenced due to different thermal environments. Significantly higher values of yield attributes i.e. plant height, branches/plant, siliquae/plant, seeds/siliqua and test weight were recorded with earlier sowing on 08 November as compared to sowing on 18 and 28 November and 08 and 18 December. All these parameters were drastically reduced as the sowing was delayed from 08 November to 18 November onwards. Sharma et al. [17] also reported decline in yield attributing characters when sowing was done after 25 October under the agroclimatic conditions of Gwalior in Central India. Whereas, Chandrakar and Urkurkar [7] reported significant decrease in yield attributes when the crop was sown after 23 November under Raipur conditions. Reddy and Kumar [13], Singh et al. [23] and Singh and Singh [24] also reported the similar results.

Table 2. *Yield attributes and yield of mustard as influenced by different thermal environments under protected condition (mean of 3 years)*

Sowing dates	Plant height (cm)	Branches/ plant	Siliquae/ plant	Seeds/ siliqua	1000 seed weight (g)	Oil content (%)	Seed yield (kg/ha)	
							Pro	Unpro
D_1-08 Nov.	151.8	10.8	211.8	17.5	5.93	38.9	1409	279
D_2-18 Nov.	136.3	8.0	169.8	15.6	4.93	37.9	842	152
D_3-28 Nov.	116.9	5.6	80.8	13.3	4.43	37.5	515	77
D_4-08 Dec.	99.3	4.5	43.4	11.4	3.83	37.2	330	15
D_5-18 Dec.	89.7	3.4	28.2	8.0	3.10	36.9	198	05
S Em$\pm$	4.3	0.4	6.5	0.5	0.20	0.5	43	30
CD (p= 0.05)	13.2	1.3	19.7	1.7	0.60	1.1	128	89

Pro = Protected, Unpro = Unprotected, S Em + = Standard Error of mean and CD = Critical difference

Significant decrease in seed yield was observed with successive delay in sowing from 08 November to 18 December at 10 days interval during all the years of study. On the mean basis sowing on 08 November produced seed yield of 1409 kg/ha that was 40.2, 63.4, 76.6 and 85.9 per cent higher then the seed yield of sowing on 18 and 28 November and 08 and

http://www.ecology.kee.hu • ISSN 1589 1623

18 December, respectively (*Table 2*). Significant decrease in seed yield in delayed sowing may be due to shortening of growing period of the crop due to rise in temperature during grain filling and maturity. Sharma et al. [17], Butter and Aulakh [5], Sarmah [16], Sonani et al. [25], Tomar and Mishra [27] and Upadhyay [28] also reported similar results. The predicted pattern of decrease in grain yield was well fitted with the observed values. The rate of decrease in grain yield was higher in 1995-96 with coefficient of determination of 0.97 (*Figure 3*). The rate of decrease in grain yield was 37.1 kg/ha for every one-day delay in sowing in 1995-96. On the other hand the rate of decrease in grain yield was found to be 28.66 and 22.20 kg/ha/day in 1996-97 and 1997-98 with R^2 values of 0.83 and 0.77 respectively. Oil content in seed did not influence much during first year of study. But, significantly higher oil content was recorded with 08 November sowing as compared to 28 November and 08 or 18 December sowing. However, it was on par with sowing of crop on 18 November. Higher oil content in early sown crop may be due to favourable prolonged environmental conditions for better growth and development of the crop, which enhanced the oil content. These results are in agreement with the findings of Kurmi and Kalita [9], Sarmah (16), Sharma et al. [17] and Singh and Singh [24].

Avoidable losses in yield

The seed yield production was drastically reduced under unprotected condition as compared to protected condition in all the thermal environments (*Table 3*). Highest seed yield was obtained from earliest sowing on 8 November under protected condition. Seed yield of 1591, 1475 and 1161 kg/ha was recorded with 08 November sowing during 1995-96, 1996-97 and 1997-98, respectively (*Table 3*). The seed yield decreased considerably in 18 and 28 November and 08 and 18 December sown crop. Higher seed yield in early sowing was due to higher number of siliquae/plant, seed/siliqua and 1000 seed weight. It was significantly higher over all other treatments. During all the three years of study the seed yield was lowest in unprotected condition. The yield loss varied from 76.0 to 92.7 % in 1995-96, 81.5 to 100.0 % in 1996-97 and 84.4 to 100.0 % in 1997-98. Thus, it was observed that there was 100 per cent yield loss of mustard without proper and timely plant protection under delayed sowing on 18 December as the crop could not sustain the infestation and failed to survive. On an average there was 80.0 to 97.6 percent yield loss without plant protection. Singh and Sachan [21] also reported the avoidable losses due to mustard aphid up to 69.6 per cent. Similarly Bakhetia [1] observed 57.8 to 80.6 per cent yield loss due to mustard aphid and Suri et al. [26] observed 42.1 per cent yield loss under different agroclimatic conditions. Jadhav and Singh [8] also reported the similar results. The additional yield from protected plot as compared to unprotected plot ranges from 1209 to 192, 1202 to 215 and 980 to 175 kg/ha in 1995-96, 1996-97 and 1997-98 respectively under different thermal environments.

Population dynamics of aphids and predators

The data on population dynamics of mustard aphid (*Lipaphis erysimi*) as given in *Table 4* revealed that there was significant variation in aphid population under different thermal environments. The minimum number of aphids was recorded when the crop was sown on 08 November and gradually increased as the sowing was delayed. There was not much difference in aphid population with the crop sown in the month of November,

http://www.ecology.kee.hu • ISSN 1589 1623

Table 3. Avoidable yield losses under different thermal environments due to mustard aphid.

Sowing dates	**Seed yield (kg/ha)**		**Additional yield over unprotected (kg/ha)**	**Avoidable losses in seed yield (%)**
	Protected	**Unprotected**		
1995-96				
D_1 - Nov. 08, 1995	1591	382	1209	76.0
D_2 - Nov. 18, 1995	1280	206	1074	83.9
D_3 - Nov. 28, 1995	795	167	628	79.0
D_4 - Dec. 08, 1995	338	37	301	89.1
D_5 - Dec. 18, 1995	207	15	192	92.7
S Em$\pm$	27	23	-	-
CD (P = 0.05)	83	65	-	-
1996-97				
D_1 - Nov. 08, 1996	1475	273	1202	81.5
D_2 - Nov. 18, 1996	747	149	598	80.5
D_3 - Nov. 28, 1996	439	45	394	89.7
D_4 - Dec 08, 1996	401	00	401	100.0
D_5 - Dec. 18, 1996	215	00	215	100.0
S Em$\pm$	55	38	-	-
CD (P = 0.05)	165	110	-	-
1997-98				
D_1 - Nov. 08, 1997	1161	181	980	84.4
D_2 - Nov. 18, 1997	500	101	399	79.8
D_3 - Nov. 28, 1997	311	20	291	93.6
D_4 - Dec 08, 1997	252	09	243	96.4
D_5 - Dec. 18, 1997	175	00	175	100.0
S Em$\pm$	47	31	-	-
CD (P = 0.05)	136	90	-	-

S Em + = Standard Error of mean and CD = Critical difference

http://www.ecology.kee.hu • ISSN 1589 1623

Table 4. Population dynamics of Lipaphis erysimi as influenced by different thermal environments under unprotected condition.

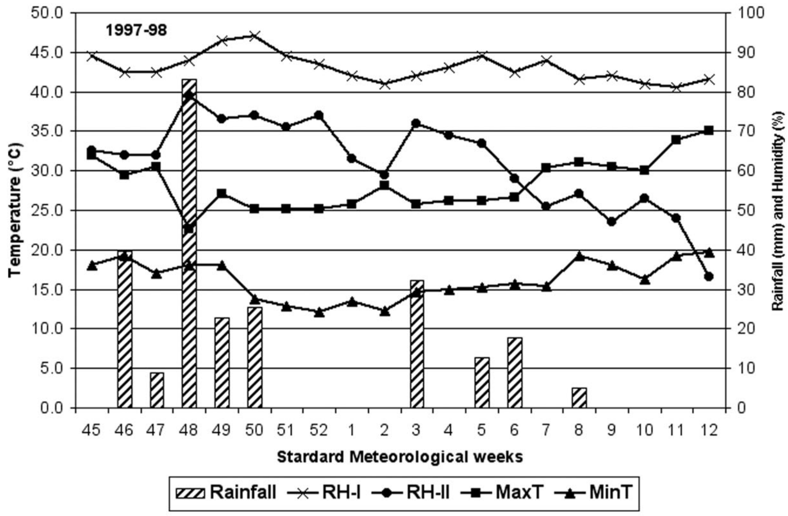
Sowing dates	Aphid population/ plant	Flea beetle population/ plant	Leaf damage (%)	Predator population/ plant
1995-96				
D_1 - Nov. 08, 1995	60.8 (7.8)	0.50	29.5	0.14
D_2 - Nov. 18, 1995	65.9 (8.1)	0.47	22.0	0.16
D_3 - Nov. 28, 1995	76.9 (8.8)	0.46	25.5	0.26
D_4 - Dec. 08, 1995	328.7 (18.1)	1.17	27.1	0.22
D_5 - Dec. 18, 1995	702.8 (26.5)	0.06	45.0	0.33
S Em±	1.41	-	-	-
CD (P=0.05)	4.34	-	-	-
1996-97				
D_1 - Nov. 08, 1996	98.8 (10.0)	1.36	11.0	0.10
D_2 - Nov. 18, 1996	128.2 (11.4)	1.08	18.8	0.12
D_3 - Nov. 28, 1996	147.7 (12.2)	1.89	21.3	0.17
D_4 - Dec. 08, 1996	498.8 (22.3)	0.63	20.2	0.23
D_5 - Dec. 18, 1996	915.4 (30.2)	0.21	17.6	0.29
S Em±	1.12	-	-	-
CD (P=0.05)	3.45	-	-	-
1997-98				
D_1 - Nov. 08, 1997	117.5 (10.9)	2.34	14.3	0.19
D_2 - Nov. 18, 1997	140.3 (11.9)	2.11	19.4	0.16
D_3 - Nov. 28, 1997	156.8 (12.5)	1.95	18.6	0.26
D_4 - Dec. 08, 1997	481.9 (22.0)	1.01	24.2	0.32
D_5 - Dec. 18, 1997	902.4 (30.0)	0.82	23.3	0.35
S Em±	1.44	-	-	-
CD (P=0.05)	4.43	-	-	-

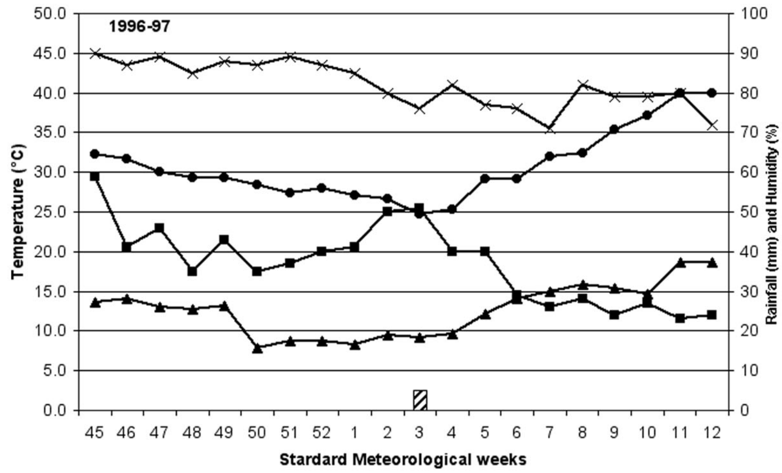
Figures in parenthesis are square root transformed values
S Em + = Standard Error of mean and CD = Critical difference

Table 5. *Stepwise regression equations for estimating the influence of weather parameters on aphid population during 1997-98.*

Sowing date	Regression equations	R^2
Nov. 08,1997	$Y = 875.77-1.613x_1-21.746x_2+14.875x_3-2.421x_4-3.693x_5$	0.463
	$Y = 740.03-1.391x_1-20.964x_2+12.824x_3-4.700x_5$	0.443
	$Y = 589.16-0.358x_1-10.595x_2-3.947x_5$	0.326
	$Y = 605.91-10.015x_2-4.494x_5$	0.297
	$Y = 173.04-2.077x_5$	0.092
Nov. 18,1997	$Y = 855.54-0.862x_1-20.107x_2+11.959x_3+0.052x_4-6.671x_5$	0.499
	$Y = 858.91-0.865x_1-20.114x_2+12.000x_3-6.658x_5$	0.499
	$Y = 778.46-13.962x_2+5.199x_3-6.579x_5$	0.456
	$Y = 742.64-11.459x_2-5.881x_5$	0.417
	$Y = 278.91-3.499x_5$	0.318
Nov. 28,1997	$Y = 707.67-0.228x_1-11.659x_2+8.116x_3+0.051x_4-7.004x_5$	0.739
	$Y = 709.85-0.289x_1-11.630x_2+8.130x_3-6.984x_5$	0.739
	$Y = 658.27-8.946x_2+6.027x_3-6.870x_5$	0.735
	$Y = 315.69+4.380x_3-4.914x_5$	0.707
	$Y = 389.02-5.025x_5$	0.673
Dec. 08, 1997	$Y = -1159.10-0.610x_1+28.445x_2+49.696x_3+0.815x_4-3.428x_5$	0.966
	$Y = -1132.57-0.588x_1+28.339x_2+49.785x_3-3.286x_5$	0.966
	$Y = -1132.46+29.926x_2+47.679x_3-3.548x_5$	0.965
	$Y = -1724.69+43.758x_2+47.157x_3$	0.961
Dec. 18, 1997	$Y = -1911.69-5.177x_1+51.892x_2+111.757x_3-15.573x_4+6.933x_5$	0.962
	$Y = -937.10-4.840x_1+28.054x_2+111.095x_3-14.206x_4$	0.955
	$Y = -2406.30-3.853x_1+40.034x_2+105.943x_3$	0.945
	$Y = -2626.60+54.445x_2+92.737x_3$	0.934

X1= Rainfall (mm/week), x2 = Temperature oC (Maxi.), x3 = Temperature oC (Mini.), X4 = Relative Humidity % (morning) and x5 = Relative Humidity % (evening)





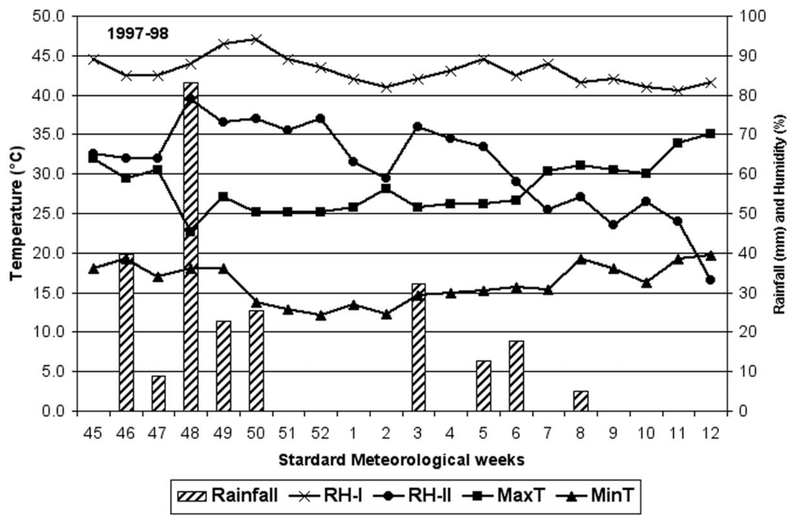


Figure 2. *Weekly pattern of temperature (°C), relative humidity (%) and rainfall (mm) during the winter seasons of 1995-96, 1996-97 and 1997-98.*

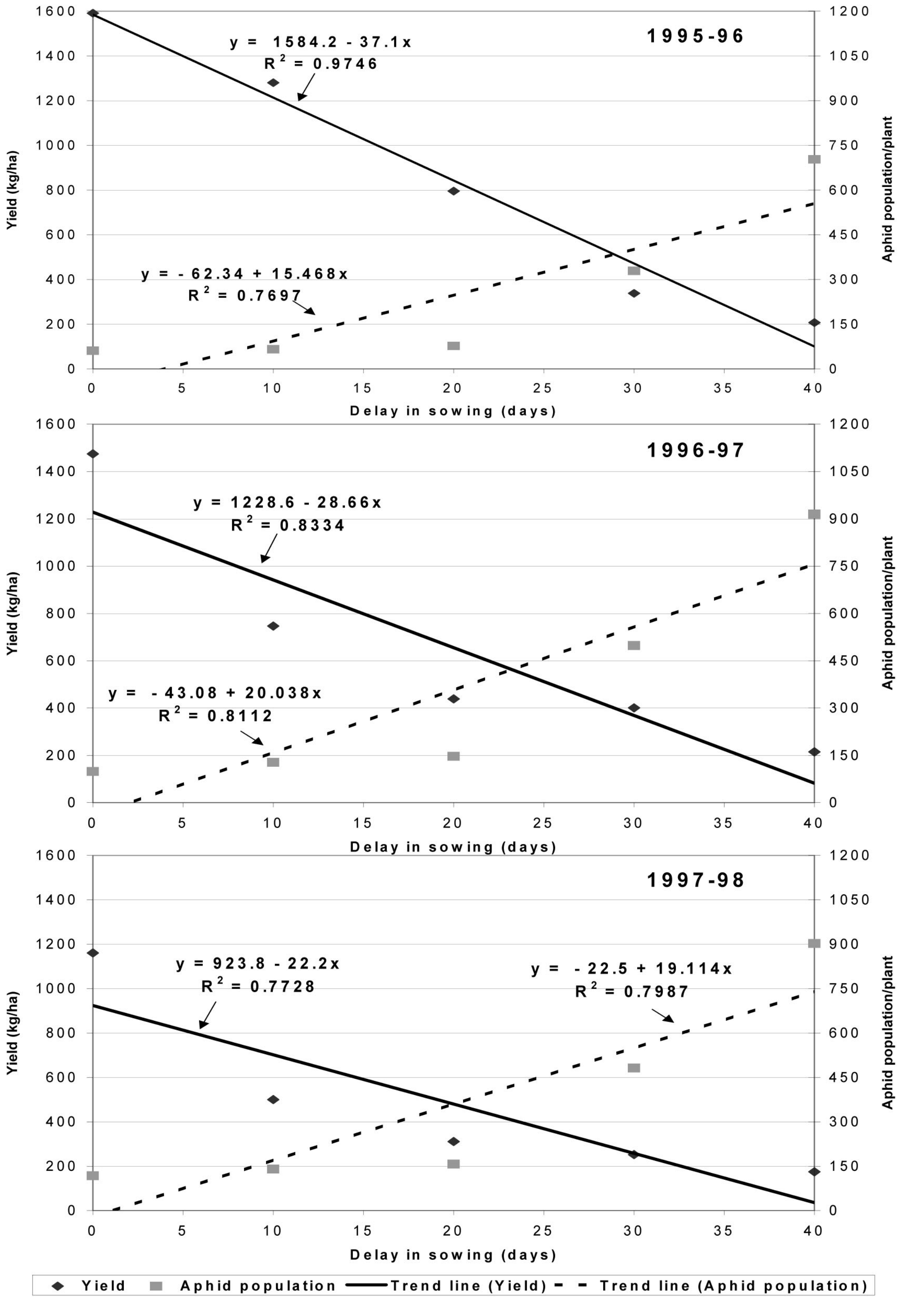


Figure 3. Relationship between delay in sowing with seed yield (protected) and aphid population (unprotected). Trend lines indicates predicted pattern of changes using regression analysis.

http://www.ecology.kee.hu • ISSN 1589 1623

but the aphid population increased suddenly in 08 and 18 December sowing. Mishra et al. [10], Saha and Kanchan [15], Shrivastava [18] and Vekaria and Patel [29] also observed higher aphid population in delayed sowing. The linear relationship between aphid populations with delay in sowing showed significant relationship among them. The predicted pattern of aphid population was found to be more or less similar to the observed population with R^2 values of 0.82, 0.86 and 0.84 in 1995-96, 1996-97 and 1997-98, respectively (*Figure 3*). The population of flea beetle (*Phyllotreta cruciferae*) was observed to be lowest in delayed sowing on 18 December in all the years of experimentation. However, the activity of flea beetles was fluctuating in different thermal environments in the first two years. During 1995-96 the highest flea beetle population was observed in 08 December sown crop while in 1996-97 it was highest in 28 November sowing. In 1997-98 the highest flea beetle population was recorded in early sowing on 08 November and gradually decreased as the sowing was delayed. The percent leaf damage due to this foliage feeder ranged from 22.0 to 45%, 11.0 to 21.3% and 14.3 to 24.2% in 1995-96, 1996-97 and 1997-98, respectively.

The natural enemies observed during the cropping seasons were *Menochilus sexmaculatus* and *Coccinella septempunctata* as predominant aphid predators. The population of these predators was recorded to be low in crop sown on 08 and 18 November, and increased gradually in delayed sowing. Maximum predator population was observed in 18 December sowing. This shows that the predator population increased proportionately with the aphid population.

Regression analysis

The influence of rainfall, temperature and relative humidity on aphid population during 1997-98 was worked out through step down regression analysis.

From the step down regression analysis it was observed that the combined effect of these weather parameters had the least influence on aphid population in early sown crop on 08 November as the R^2 value was only 0.463. But, when the sowing was delayed the combined influence of this these parameters increased with R^2 value of 0.499, 0.739, 0.966 and 0.962 in 18, 28 November, 08 and 18 December sowing respectively (*Table 5*). It was observed that in early sown crop the prevailing weather conditions are not favourable for aphid multiplication, but weather conditions become favourable under delayed sowing. In 08 November the combined effect of these parameters increased with R^2 value of 0.739 and when rainfall, maximum temperature and morning relative humidity were deleted the R^2 value comes down to 0.707. This shows that these parameters have only 0.032 per cent influence on aphid multiplication. Whereas in case of 08 and 18 December sowing the value of coefficient of determination with all these parameters were 0.966 and 0.962 respectively. When the rainfall, morning and evening relative humidity were deleted the R^2 value comes down to 0.961 and 0.934 respectively. This indicates that in 08 and 18 December sowing the maximum and minimum temperature has greater influence on aphid multiplication and that the temperature alone (maximum and minimum) has more than 93% influences on aphid multiplication under late sown condition. Thus, low night temperatures are not favourable for aphid growth. The value of coefficient of determination was 0.934 when maximum and minimum temperature was considered in 18 December sowing. The next important factor besides temperature was the evening relative humidity in influencing the growth of aphids. The present findings are in complete agreement with that of Bishnoi [3], Roy and Kanchan [14] and Shrivastava et al. [19].

From the above findings it was concluded that to avoid the peak aphid population sowing of mustard should be completed before 08 November i.e. first week of November for higher yield under rice based cropping system in Chhattisgarh state in eastern central India.

http://www.ecology.kee.hu • ISSN 1589 1623

REFERENCES

[1] Bakhetia, D.R.C. (1984): Chemical control of Lipaphis erysimi (Kaltenbach) on rapeseed and mustard crop in Punjab. – Journal of Research Punjab Agricultural University. 21: 63-75.
[2] Bakhetia, D.R.C. and Sekhon, B.S. (1989): Insect pest and their management in rapeseed and mustard. – Journal of Oilseeds Research 6(2): 269-299.
[3] Bishnoi, O.P., Singh Harvir and Singh, R. (1992): Incidence and multiplication of mustard aphid, Lipaphis erysimi (Kalt.) in relation to meteorological variables. – Indian Journal of Agricultural Sciences, 62(10): 710-712.
[4] Brar, N.S., Bakhetia, D.R.C. and Sekhon, B.S. (1987): Estimation of losses in yield of rapeseed and mustard due to mustard aphid, Lipaphis erysimi (Kalt.). – Journal of Oilseeds Research, 4(2): 261-264.
[5] Butter, G.S. and Aulakh, C.S. (1999): Effect of sowing date, nitrogen and row spacing on growth, yield attributes and yield of Indian mustard (Brassica juncea). – Indian Journal of Agronomy, 44(4): 813-815.
[6] Chandel, S.R.S. (1984): A handbook of Agricultural Statistics. – Achal Prakashan Mandir, Kanpur (U.P.) India. pp 149-318.
[7] Chandrakar, B.L. and Urkurkar, J.S. (1993): Performance of mustard (Brassica juncea) varieties to dates of sowing in rice fallow. – Indian Journal of Agronomy, 38(1): 143-144.
[8] Jadhav, S.N. and Singh, N.P. (1992): Water use and soil moisture extraction pattern of mustard (Brassica juncea) under varying sowing dates, insect pest control measures and irrigation. – Indian Journal of Agronomy, 37(1): 198-200.
[9] Kurmi, K. and Kalita, M.M. (1992): Effect of sowing date, seed rate and method of sowing on growth, yield and oil content of rapeseed (Brassica napus). – Indian Journal of Agronomy, 37(3): 595-597.
[10] Mishra, S.K., Kanwat, P.M. and Sharma, J.K. (2001): Effect of dates of sowing and intercropping on the seed yield and incidence of mustard aphid, Lipaphis erysimi (Kalt.). – Annals of Agricultural Research, 22(3): 445-446.
[11] Panse, V.G. and Sukhatme, P.V. (1967): Statistical Methods for Agricultural Workers. Second Edition. – Indian Council of Agricultural Research New Delhi, India.
[12] Rai, B.K. (1976): Pest of Oilseed crops in India and their control. – Indian Council of Agricultural Research, New Delhi, India.
[13] Reddy, M.D. and Kumar, K.A. (1997): Effect of dates of sowing on performance of mustard (Brassica junica L.) varieties in non-traditional area of Andhra Pradesh. – Journal of Oilseeds Research, 14(2): 207-209.
[14] Roy, Santosh Kumar and Baral, Kanchan. (2002): Role of weather parameters on population build up of mustard aphid, Lipaphis erysimi (Kaltenbach). – Journal of Oilseeds Research, 19 (1): 86-89.
[15] Saha, C.S. and Kanchan, B. (1999): Effect of dates of sowing and potash levels on incidence of mustard aphid (Liphaphis erysimi Kalt.). – Environment Ecology, 17(1): 211-215.
[16] Sarmah, P.C. (1996): Effect of sowing date and row spacing on rainfed mustard. – Journal of Oilseeds Research, 13(1): 10-12.

[17] Sharma, M.L., Bharadwaj, G.S. and Chauhan, Y.S. (1992): Response of mustard (Brassica juncea) cultivars to sowing dates under irrigated conditions. – Indian Journal of Agronomy, 37(4): 837-839.
[18] Shrivastava Ajay (1999): Effect of date of sowing and varieties on the incidence of mustard aphid, Lipaphis erysimi (Kalt.) on rapeseed-mustard. – Journal of Oilseeds Research, 16(2): 380-381.
[19] Shrivastava Ajay, Singh Harvir and Thakur Hira Lal (1995): Impact of abiotic factors on the population dynamics of mustard aphid, Lipaphis erysimi (Kalt). – Journal of Oilseeds Research, 12 (2): 197-202.
[20] Singh, B. and Bakhetia, D.R.C. (1987): Screening and Breeding techniques for aphid resistance in oleiferous Brassicae. – A review. – The oil crops network, International Development Research Centre, Canada, p. 50.
[21] Singh, C.P. and Sachan, G.C. (1994): Assessment of yield losses in yellow sarson due to mustard aphid, Lipaphis erysimi (Kalt). – Journal of Oilseeds Research 11 (2): 179-184.
[22] Singh, H., Rohilla, H.R., Kalra, V.K. and Yadav, T.P. (1984): Response of Brassica varieties sown on different dates to the attack of mustard aphid, Lipaphis erysimi (Kalt.). – Journal of Oilseeds Research, 1(1): 49-56.
[23] Singh Raj, Rao, V.U.M., Singh Diwan and Kant Surya. (2002): Effect of sowing date and plant density on phenological behaviour, yield and its attributes in Oilseed Brassicae. – Journal of Oilseeds Research 19(1): 119-121.
[24] Singh, Y. and Singh, M. (1991): Effect of sowing time, spacing and nitrogen levels on yield of mustard. – Indian Journal of Agronomy, 36(3): 429-430.
[25] Sonani, V.V., Patel, P.T. and Patel, G.G. (2002): Performance of mustard under different dates of sowing in Bhal and coastal agro-climatic zone of Gujrat. – Journal Oilseeds Research 19(1): 122.
[26] Suri, S.M., Darshan Singh and Brar, K.S. (1988): Estimation of losses in yield of brown sarson due to aphids in Kangra Valley. I. Effect of crop growth stages and aphid feeding exposure. – Journal Inst. Science 1: 162-167.
[27] Tomar, R.K.S. and Mishra, G.L. (1991): Influence of sowing dates and nitrogen on the yield of mustard (Brassica juncea L.). – Journal of Oilseeds Research, 8(2): 210-214.
[28] Upadhyay, S. (1995): Influence of sowing dates and fertilizer levels on the incidence of aphid (Lipaphis erysimi Kalt.) on Indian mustard. – Indian Journal of Entomology, 57(3): 294-297.
[29] Vekaria, M.V. and Patel. G.M. (2000): Effect of sowing dates on the incidence of mustard aphid and its natural enemies in north Gujrat. – Journal of Oilseeds Research, 17(2): 335-340.

http://www.ecology.kee.hu • ISSN 1589 1623