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Effect of dates of sowing, moisture regimes, varieties and weather factors on incidences of aphid, *Lipaphis erysimi* (Kalt.) in rape and mustard

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A B S T R A C T

Mustard aphid which is influenced by predisposing abiotic factors, has been widely reported as the most noxious insect pest limiting production of rape and mustard. Field experiment was carried out with 3 varieties of rape and mustard, 6 dates of sowing and 2 moisture regimes to understand aphid population dynamics during different phases of growth of rainfed vis-à-vis irrigated rape and mustard crops, and work out relationships between aphid population and weather parameters for its forewarning. Results revealed that initial incidence times of aphid varied from 19 November to 3 December, depending upon dates of sowing done during 1 October to 5 November, which fall under recommended dates of sowing. In crops sown during 22 October to 5 November, critical periods of aphid infestation (having greater than 30 aphids plant^{-1}) prevailed between 19 December and 21 January. Number of aphids plant^{-1} was consistently greater in crops grown under irrigated condition than those under rainfed condition. Aphid population was highest during siliqua formation phase due to prevalent conducive weather conditions, followed by reproductive and vegetative phases over all varieties. Weather conditions associated with critical period of infestation remained in the range of 21.7-28.9 °C, 7.3-17.8 °C, 14.5-23.3 °C, 78-98 %, 29-73 % and 53-85 % for Tmax, Tmin, Tmean, morning RH, after noon RH and RHmean, respectively. Tmax, Tmin, Tmean and degree-days showed consistently significant negative correlation, whereas Trange, which is the difference between Tmax and Tmin, registered always positive correlation with aphid population. On aphid observation date, morning RH showed significant positive correlation, whereas after noon RH registered significant negative association with aphid population. After noon RH prevailing 3 to 5 days prior to aphid counting dates exhibited positive correlation, thus exerting favourable influence to increase aphid population. Weather based regression models, which had coefficients of determination (R^2) being significant at 1 % level of significance, were able to account for 59 to 69 % of total variation in aphid population. It is concluded that weather thresholds as identified and regression models developed, along with medium range weather forecasts of 5 days available from India Meteorological Department (IMD), could be useful to forewarn aphid 2 days in advance for farmers. To escape critical aphid incidence, rape and mustard crops need to be sown by 15 October, because crops sown beyond this period are likely to be adversely affected by aphid.

Key words : Aphid, sowing date, moisture regime, weather parameters, correlation, regression

Introduction

Rape (*Brassica rapa* L. var. Sarson) and mustard (*Brassica juncea* (L.) Czern & Coss) group is the most important oilseed crop, occupying the largest area among all the winter crops grown in West Bengal. The state produces 0.383 million tonnes of rape and mustard seed from an area of 0.4215 million hectares, with an average productivity of 909 kg ha^{-1}, which is lower than the average productivity of India (1038 kg ha^{-1}) and far lower than the average productivity in Gujarat and Haryana of 1390 kg ha^{-1} and 1177 kg ha^{-1}, respectively (Anonymous 2007). Amongst several limiting factors responsible for lower yield of rape and mustard in West Bengal, non-availability of good quality seeds of superior varieties, severe infestation of aphid, weather variability and delayed sowing are worth mentioning (Nath 1982; Ghosh and Chatterjee, 1988). Although potato, summer rice (*boro*) and wheat are fully irrigated, a bulk of net area sown under rape and mustard is still rainfed, giving rise to much lesser yield. Mustard aphid, *Lipaphis erysimi* (Kalt.) (Aphididae: Homoptera), incurring an avoidable loss in yield, ranging from 35.4 % (Brar *et al*. 1987) to 91.3 % (Singh & Sachan 1994), is affected by weather conditions and other abiotic factors prevailing during the growing season of host crop (Ghosh 1993). Considering the dependence of aphid on weather, several studies involving aphid-weather relationships in irrigated rape and mustard have been reported (Kar & Chakravarty 2000; Roy & Baral 2002; Prasad 2003), but such studies as carried out under rainfed condition have not hither to been reported. Therefore, the present study was aimed at to understand aphid population dynamics during different phases of growth of rainfed vis-à-vis irrigated rape and mustard crops, sown on different dates, which fall under recommended dates of sowing, and work out relationships between aphid population and weather parameters associated with its growth.

Materials and Methods

Field experiment was conducted during the winter season of 2004-05 in the 'C' Block Farm of Bidhan Chandra Krishi Viswavidyalaya, Kalyani (2257´N; 8820´E; 9.75 m a.m.s.l.), with 2 moisture regimes viz., rainfed and irrigated as main plots, 6 dates of sowing viz., 1 October, 8 October, 15 October, 22 October, 29 October and 5 November as subplots and 3 varieties viz., 'Binoy', 'Seeta' and 'Varuna' as sub-subplots, designed in split plot with four replications. The variety Binoy belongs to *Brassica rapa* (yellow sarson), whereas Seeta and Varuna belong to *Brassica juncea* (Indian mustard, or Rai). Crops were sown at 30 cm apart rows, and at 15 days after emergence, crop was thinned out to maintain population at 10 cm apart in a line. The crop, which was grown without any application of pesticide, received 80 kg nitrogen ha^{-1} and 40 kg P_2O_5 ha^{-1}, and 40 kg K_2O ha^{-1}. Irrigated crops received three uniform irrigations at flower bud initiation, siliqua initiation and end of siliqua formation stages, while all rainfed crops were grown with residual soil moisture as carried over from previous wet season and whatever meagre rainfall received during growing season. For counting of aphid population, 10 plants were randomly selected and tagged in each plot. Number of aphids was counted from 10 cm top terminal main shoot of each plant (Singh & Lal 1999) at weekly interval starting from first date of incidence in each plot and average population per plant was calculated for each observation date from aphid population recorded from 10 plants. Dates of phenological events (Patel & Mehta 1987) like emergence, first flower, 50 % flowering, 100% flowering, end of flowering and maturity were recorded from each treatments. Seed yields from each treatment were recorded at harvest and expressed in kg ha. Daily weather data like maximum (Tmax) and minimum (Tmin) temperatures, and morning (RHI) and after noon (RHII) relative humidity were collected from nearby agrometeorological observatory of the university. From these weather parameters daily mean temperature (Tmean), daily mean relative humidity (RHmean), temperature range (Trange), and degree-day (DD) were calculated. The Trange is the difference between daily maximum and minimum temperatures. The DD is the mean daily temperature minus base temperature (Ring *et al.* 1983); a base temperature of 5 °C (Patel & Mehta 1987) was used in the present study. Since rape and mustard is indeterminate crop, its flowering and siliqua formation phases take a long time and hence, long exposure to aphid infestation.

According to various phenological events from emergence to maturity, whole life cycle of the crop was divided into: vegetative, flowering and siliqua formation phases, and entire growth period, and aphid population during corresponding phases were summed up. The data on daily weather variables, consisting of Tmax, Tmin, Tmean, Trange, DD, RHI, and RHII, coinciding with each aphid counting dates (X), and those which coincided with 1 to 5 days before aphid counting dates, such as X-1, X-2, X-3, X-4 and X-5 were utilized in the correlation analysis for assessing the impact of these variables on aphid population dynamics. Further, aphid population as dependent variable and selected weather variables showing strong and significant correlation with aphid population as independent variables were used for developing multiple regression models for prediction of aphid population. There were 42 independent variables, which included 7 weather parameters with each using 6 days' (X, X-1, X-2, X-3, X-4, X-5) daily weather data. Further, there were 7 dates of aphid counting and 6 dates of sowing and hence, the sample size of each dependent and independent variables were 42. Economic threshold level (ETL) date was considered when number of aphids exceeded 30 in 30 % of plants (Nayban and Chowdhury 2002). Correlation and regression analysis involving weather parameters and aphid population were performed following the procedures described by Gomez & Gomez (1984).

Results and Discussion

Seasonal incidence of aphid

Differential moisture regimes could not influence initial, ETL and peak incidence times of aphid over different treatments. Initial incidence times of aphid over all the varieties and moisture regimes under study varied from 19 November to 3 December, depending upon dates of sowing which continued from 1 October to 5 November and fell under recommended dates of sowing. In case of crops sown during 1 to 15 October, the periods of aphid activity occurred during 19 November to 31 December, while in crops sown from 22 October to 5 November, aphid activity prevailed during the period from 19 November to 21 January. Aphid population did not reach ETL in crops sown during 1 to 15 October, whereas in crops sown beyond 15 October, aphid population was greater than ETL. Dates of first ETL incidences in crops sown during 22 October to 5 November varied from 19 December in Binoy variety of yellow sarson to 24 December in mustard varieties, irrespective of moisture regimes. Peak aphid activity time varied from 14 to 21 January in crops sown from 22 October to 5 November. Thus, the critical periods (having greater than 30 aphids plant^{-1}) of exposure of crops to aphid infestation prevailed from 19 December to 14 January in Binoy variety, and from 24 December to 21 January in mustard varieties and hence, these periods could be earmarked for scheduling pesticide application for control of aphid. When all varieties were considered together, the critical period aphid infestation prevailed from 19 December to 21 January. These findings are in agreement with the observations of Prasad & Pradhan (1971) who reported that peak activity of mustard aphid occurred in January. Biswas & Das (2000) working in Bangladesh concluded that aphid population build-up occurred during January-February, with peak reaching on 8th February.

Influence of dates of sowing on aphid population

Due to variation in dates of sowing (Tables 1, 2, 3), there were large differences in aphid population. With advancement of sowing dates number of aphids plant^{-1} increased in all the varieties grown under both rainfed and irrigated conditions. When seasonal total aphid population plant^{-1} over different treatments were compared, it appeared that aphid population was least in crop sown on 1 October, whereas it was highest in crop sown on 5 November. Thus delay in sowing caused gradual increase in aphid population. In case of crops sown during 1 to 15 October, aphid population did not attain ETL level (30 aphids plant^{-1}), whereas in crops sown during 22 October to 5 November, there were severe infestations of aphid. Aphid population was found to increase sharply in crops sown on 22 October and onwards. Seasonal total aphid population over entire growth period of crops sown during 22 October to 5 November in Binoy, Seeta and Varuna varieties grown under irrigated condition varied from 565 to 1044, 193 to 849 and 329 to 862, whereas under rainfed condition they extended from 297 to 940, 148 to 701 and 201 to 689, respectively. Upadhyay (1996) also indicated that delayed sowing (30 October and 15 November) was conducive to severe build-up of *Lipaphis erysimi* on Indian mustard and resulted in greater damage by lowering yield, as compared with earlier sowings (1 and 15 October).

Influence of varieties on aphid

The highest incidence of aphid was observed in Binoy variety under *Brassica rapa*, followed by Varuna and Seeta varieties under *Brassica juncea* (Tables 1, 2 3) in both irrigated and rainfed crops. This corroborated the findings of Prasad and Phadke (1980) and Kalra *et al*. (1987). On seasonal basis, total aphid population under irrigated condition varied from 245 plant^{-1} in Seeta variety to 429 plant^{-1} in Binoy variety and also similar trend was observed in rainfed crops but much less population than the former. Varieties which received irrigations thrice at flower bud initiation, siliqua initiation and end of siliqua formation stages harboured greater number of aphids than those grown without irrigation.

Influence of moisture regimes on aphid population

Differential moisture regimes (Tables 1, 2, 3) as induced by irrigation and no irrigation resulted in considerable variation in aphid population. Number of aphids plant^{-1} was consistently greater in crops grown under irrigated condition than those under rainfed condition. On an average, aphid population plant^{-1} on seasonal basis was more in irrigated crop (300) than in rainfed crop (222). As influenced by irrigation, aphid population was also more during different phases of crop growth than those phases of crops raised without irrigation. Seasonal total aphid population in crops sown later from 22 October to 5 November varied from 201 in 22 October sown crop to 688 in 5 November sown crop under rainfed condition, as against 329 in 22 October sown crop to 862 in 5 November sown crop under irrigated condition. Lower aphid population in rainfed crops than those in irrigated crops may be due to more succulence or lesser hardiness of plant parts especially upper parts including inflorescence in irrigated crops than those in rainfed crops as was observed by Singh *et al*. (1989).

Table 1.

Total phasic and seasonal aphid population per plant over different observation dates in irrigated rape and mustard varieties

Growth phases	Dates of sowing						Mean
	1 Oct	8 Oct	15 Oct	22 Oct	29 Oct	5 Nov	
Binoy							
GS1	0	0	0.3	6	1.2	25.6	5.5
GS2	3.2	4.4	9	169.4	281.8	305.8	128.9
GS3	5	8.5	20.8	390	630.2	713	294.6
Seasonal total	8.2	12.9	30.1	565.4	913.2	1044.4	429.0

GS1=Vegetative phase; GS2=Flowering phase; GS3=Siliqua formation phase; Seasonal total= Emergence to maturity

Contd...

Growth phases	Dates of sowing						Mean
	1 Oct	8 Oct	15 Oct	22 Oct	29 Oct	5 Nov	
Seeta							
GS1	0	0	0	0.5	3.5	7.4	1.9
GS2	1.6	2.5	6.1	81.1	187.9	256.9	89.4
GS3	2.7	7.1	6.8	111.7	208.3	585	153.6
Seasonal total	4.3	9.6	12.9	193.3	399.7	849.3	244.9
Varuna							
GS1	0	0	0	0.7	0.9	3.6	0.9
GS2	1.4	2.6	3.8	105.2	141.4	240	82.4
GS3	1.2	3.2	4.9	123.3	282.1	450	144.1
Seasonal total	2.6	5.8	8.7	229.2	424.4	693.6	227.4
Mean (over seasonal total)	5.0	9.4	17.2	329.3	579.1	862.4	300.4

GS1=Vegetative phase; GS2=Flowering phase; GS3=Siliqua formation phase; Seasonal total= Emergence to maturity

Table 2.

Total phasic and seasonal aphid population per plant over different observation dates in rainfed rape and mustard varieties

Growth phases	Dates of sowing						Mean
	1 Oct	8 Oct	15 Oct	22 Oct	29 Oct	5 Nov	
Binoy							
GS1	0	0	0.1	0.8	0.2	12.4	2.3
GS2	1.3	3.6	5.7	116.2	224.4	286.7	106.3
GS3	4.5	6.3	13.2	180	355	641	200.0
Seasonal total	5.8	9.9	19	297	579.6	940.1	308.6
Seeta							
GS1	0	0	0	0	0.8	1.3	0.4
GS2	0.9	1.5	4.7	67.5	181.3	150	67.7
GS3	2.2	5.6	4	80	178.3	550	136.7
Seasonal total	3.1	7.1	8.7	147.5	360.4	701.3	204.7
Varuna							
GS1	0	0	0	0.3	0.3	0.7	0.2
GS2	0.7	1.1	1.7	67.5	125.9	233.3	71.7
GS3	0.5	1.9	2.8	91.1	195	190	80.2
Total	1.2	3	4.5	158.9	321.2	424	152.1
Mean (over seasonal total)	3.4	6.7	10.7	201.1	420.4	688.5	221.8

GS1=Vegetative phase; GS2=Flowering phase; GS3=Siliqua formation phase; Seasonal total= Emergence to maturity

Aphid incidences during different phases of growth of crops

Highest aphid population was counted from siliqua formation phase, followed by flowering and vegetative phases of all the varieties under study irrespective of moisture regimes (Tables 1, 2, 3). Trends in crop phase-wise aphid population were similar in both rainfed and irrigated crops. The cause of infestation of more number of aphids in siliqua formation phase is due to prevailing conducive physical environmental factors which helped colonize a greater number of aphids.

Influence of aphid population on seed yield

Seed yield was highest in crop sown on 15 October and in crops sown beyond this, there was a gradual and significant reduction in seed yield in all varieties grown under both rainfed and irrigated conditions (Table 3). Trends in yield reduction as influenced by different sowing dates and moisture regimes were also similar to those observed in aphid population build-up. Correlation coefficients between seed yield and seasonal total aphid population showed significant negative correlation with seed yield. Values of correlation coefficients ranged from -0.85 in Varuna to -0.94 in Binoy under rainfed condition, as against those being extended from -0.88 to -0.98 under irrigated condition. Thus, the differences in values of correlation coefficients tended to imply stronger negative association in irrigated crops than in rainfed crops. Dubey & Yadu (1998) demonstrated that seed yield decreased with increase in aphid infestation level and thereby they obtained a linear relationship between the two.

Weather conditions associated with incidences of aphid

Weather conditions (Table 4) associated with aphid incidences in crops sown over different dates and moisture regimes have been identified. Tmax of 25.6 to 28.6 ^{0}C, Tmin of 14.7 to 18.3 ^{0}C and Tmean of 20.1 to 23.4 ^{0}C were associated with initial incidence of aphid. On the other hand, onset of ETL (30 aphids plant^{-1}) incidence was governed by Tmax of 25.5 to 26 ^{0}C, Tmin of 9.2 to 10.4 ^{0}C and Tmean of 17.3 to 18.2 ^{0}C. However, these physical environmental conditions associated with critical period of aphid infestation (period having consistently ≥ 30 aphids plant^{-1}) tended to remain in the range of 21.7-28.9 ^{o}C, 7.3-17.8 ^{o}C, 14.5-23.3 ^{o}C, 78-98 %, 29-73 % and 53-85 % for Tmax, Tmin, Tmean, morning RH, after noon RH and mean RH, respectively. These results corroborate the findings of Biswas and Das (2000) who observed that Tmax of 23.7 to 25.4 ^{0}C and RH ranging from 62.0 to 74.3 % during January-February appeared to be the conducive factor for aphid multiplication in Bangladesh.

Aphid-weather relationship

In order to assess the impact of weather factors on aphid population build up, simple linear correlation analysis was performed with data on aphid population and physical environmental factors, such as Tmax, Tmin, Tmean, Trange, DD, morning RH and after noon RH. Since aphid population of a given date is governed by

Table 3.
Variation in total seasonal aphid population per plant, seed yield (kg ha^{-1}) and correlation coefficients (r) between seed yield and seasonal total aphid population

Moisture regime	Variety	Dates of sowing						Mean	r
		1 Oct	8 Oct	15 Oct	22 Oct	29 Oct	5 Nov		
Rainfed	B9	6 (1026)	10 (958)	19 (842)	297 (676)	580 (553)	940 (399)	309 (743)	-0.94**
	B85	3 (1002)	7 (873)	9 (749)	148 (709)	360 (626)	701 (539)	205 (750)	-0.86*
	Varuna	1 (1022)	3 (962)	5 (726)	159 (663)	321 (606)	424 (360)	152 (723)	-0.85*
	Mean	3 (1018)	7 (931)	11 (772)	201 (683)	420 (595)	688 (433)	222 (739)	-
Irrigated	B9	8 (1635)	13 (1733)	30 (1465)	565 (1263)	913 (1022)	1044 (853)	429 (1329)	-0.98**
	B85	4 (1507)	10 (1690)	13 (1400)	193 (1365)	400 (1224)	849 (982)	245 (1361)	-0.90*
	Varuna	3 (1562)	6 (1718)	9 (1632)	229 (1401)	424 (1268)	694 (832)	227 (1402)	-0.88*
	Mean	5 (1568)	10 (1714)	17 (1499)	329 (1343)	579 (1171)	862 (889)	300 (1364)	-

Figures in parentheses indicate seed yield; ** significant at 1 % level; * significant at 5 % level.

Table 4.
Weather conditions (pooled over different varieties and dates of sowing) associated with first, ETL and peak incidences of aphid

Weather conditions at	Weather parameters(^{0}C)					
	Tmax ^{0}c	Tmin ^{0}c	Tmean ^{0}c	Morning RH (%)	Afternoon RH (%)	RH mean(%)
Initial incidence	25.6-28.6	14.7-18.3	20.1-23.4	78.9-84.2	46.6-62.4	64.0-71.1
ETL onset	25.5-26.0	9.2-10.4	17.3-18.2	87.9-89.7	41.5-42.1	64.7-65.9
Peak incidence	23.6-28.2	9.1-15.0	16.4-21.6	78.3-92.8	31.5-57.9	59.3-75.4
Critical period	21.7-28.9	7.3-17.8	14.5-23.3	78-98	29-73	53-85

*Period having consistently ≥30 aphids per plant

predisposing environmental conditions, the weather data, occurring on aphid counting date (X) as well as 1 to 5 days preceding aphid observation dates, designated as (X-1), (X-2), (X-3), (X-4) and (X-5) days, respectively, were considered in the correlation analysis. Five days' predisposing abiotic conditions taken into account in accordance with past work (Singh et al. 1989) and availability of medium range forecasts of weather elements concerned for a span of 5 days from India Meteorological Department could be useful for forewarning aphid incidences through weather based systems in the present study. Values of correlation coefficients so determined by taking into account aphid population counted on different dates at weekly interval under different dates of sowing, and weather parameters on the corresponding dates as well as 1 to 5 days prior to the dates of aphid counting have been presented in Table 5. Tmax, Tmin, Tmean and DD prevailing on different dates showed consistently significant negative correlation with aphid population in all the varieties. Further, aphid population tended to show greater values of correlation coefficients with Tmax, Tmin, Tmean and DD of 3 to 5 days before aphid infestation dates. Among these variables, DD which is an important variable for modeling of insect pest, registered better association with aphid population than those registered by Tmax, Tmin, and Tmean. In case of Binoy variety of yellow sarson, values of correlation coefficients varied from -0.36 to -0.59, -0.39 to -0.66, -0.46 to -0.71 and -0.49 to -0.73 involving Tmax, Tmin, Tmean and DD, respectively. Thus, higher aphid population was associated with lower temperatures and DD. Almost similar variation was also noted in the remaining varieties. Gami *et al.* (2002) also reported that aphid population showed significant negative association with maximum and minimum temperatures. However, the results of present investigation contradicted the findings of Laskar *et al.* (2004) who observed that aphid population was positively correlated with minimum temperature. Temperature range (Trange) which is the difference between Tmax and Tmin had always showed positive correlation with aphid population in all the varieties (Table 5). Usually Trange value becomes less in warm season, whereas the reverse becomes true in cool season. Since mustard aphid is a cold loving insect, it favourably responds to higher Trange and thus generates positive correlation. Morning and after noon RH occurring on different dates caused both favourable and depressive influences on aphid population. As compared to morning RH, response of aphid to after noon RH differed. On aphid observation date, morning RH showed positive correlation, whereas after noon RH exhibited negative correlation with aphid population. On 5^{th} day before aphid observation date, morning and after noon RH registered positive association with aphid population in all the varieties under test. Further, after noon RH prevailing 3 to 5 days prior to aphid counting date exhibited positive correlation, thus exerting favourable influence on aphid growth. These results are in agreement with the findings of Singh *et al.* (1989) who observed that over preceding 3 days of aphid observation date morning and after noon and RH played important role to increase aphid population. At Delhi also the after noon RH (RHII) had positive correlation with aphid population (Kar & Chakravarty (2000). Thus, it is obvious that meteorological factors appear to be important determinants for population build up of mustard aphid.

Weather based multiple regression equations for prediction of aphid population

Weather variables showing strong significant association with aphid population were selected as independent variables for regression equation. Using number of aphids plant^{-1} recorded on different dates over dates of sowing as dependent variable and Tmax existing 3, 4 and 5 days before, Tmin occurring 5 days before, Tmean prevailing 3, 4 and 5 days before, and DD existing 3, 4 and 5 days before aphid counting dates as independent variables, multiple linear regression equations for prediction of aphid population was developed for all the varieties and moisture regimes separately. Intercept, regression coefficients and coefficient of determination (R^2) of multiple regression equations are given in Table 6. Values of coefficients of determination of models, which were significant at 1 % level of significance, varied from 0.59 in rainfed Seeta variety to 0.69 in irrigated Varuna variety. Thus, the models were able to predict aphid population 2 days in advance by accounting for 59 to 69 % of total variation in aphid population. There is scope for further improvement of the models by incorporating data on multiple years, natural enemies and micro-meteorological parameters.

It is concluded that weather thresholds as identified and regression models developed, along with medium range weather forecasts of 5 days from India Meteorological Department (IMD), could be useful to forewarn aphid for farmers in the New Alluvial Zone of west Bengal. To escape critical period of aphid incidence, rape and mustard crops need to be sown by 15 October, because crops sown beyond this date are likely to be adversely affected by aphid.

Table 5.

Correlation coefficients between number of aphids plant^{-1} (Y) at weekly interval and weather parameters on aphid countingdate (X), and 1(X-1), 2 (X-2), 3 (X-3), 4 (X-4) and 5 (X-5) days before aphid counting date in irrigated condition

Variety	Date	Weather parameters						
		Tmax	Tmin	Tmean	Trange	DD	RHI	RHII
	X	-0.38	-0.53	-0.51	0.51	-0.49	0.30	-0.38
	X-1	-0.38	-0.56	-0.56	0.53	-0.58	0-.17	-0.28
	X-2	-0.36	-0.39	-0.46	0.22	-0.51	0-.07	-0.34
	X-3	-0.55	-0.45	-0.53	0.06	-0.56	0.15	0.30
Binoy	X-4	-0.55	-0.45	-0.53	0.06	-0.73	0.15	0.30
	X-5	-0.59	-0.66	-0.71	0.13	-0.64	0-.10	0.12
	X	-0.39	-0.49	-0.48	0.45	-0.42	0.30	-0.31
	X-1	-0.38	-0.55	-0.56	0.52	-0.53	0-.17	-0.28
	X-2	-0.37	-0.40	-0.48	0.20	-0.47	0-.10	-0.31
	X-3	-0.55	-0.44	-0.53	0.02	-0.52	0.19	0.30
	X-4	-0.57	-0.64	-0.69	0.12	-0.69	0-.11	0.13
Seeta	X-5	-0.70	-0.52	-0.62	0.13	-0.62	0.43	0.08
	X	-0.33	-0.45	-0.43	0.43	-0.45	0.28	-0.37
	X-1	-0.29	-0.40	-0.45	0.24	-0.53	0-.11	-0.37
	X-2	-0.29	-0.40	-0.45	0.24	-0.45	0-.11	-0.37
	X-3	-0.53	-0.43	-0.52	0.03	-0.55	0.16	0.32
Varuna	X-4	-0.56	-0.62	-0.68	0.10	-0.71	0-.10	0.18
	X-5	-0.65	-0.48	-0.57	0.11	-0.57	0.44	0.08

Significance of r≥0.39 at 1 % & r≥0.30 at 5 %; Tmax=Maximum temperature; Tmin=Minimum Temperature; Tmean=Mean temperature; Trange=Temperaturerange; DD=Degree-day; RHI=Morning relative humidity; RHII=After noon relative humidity

Table 6.

Intercept (a), regression coefficients and coefficient of determination (R^2) of multiple regression equations involving number of aphids plant^{-1}(Y) in each observation dates and predisposing weather factors (X_i) prevailing on 3rd, 4th and 5th day before aphid counting dates

Variety & moisture regime	a	Regression coefficients										R^2
		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	
Rainfed Binoy	12.48	-0.94	0.52	-0.78	-1.22	0.60	-1.16	3.91	0.90	-1.45	-1.45	0.61**
Irrigated Binoy	4.88	-0.40	0.21	-0.62	-0.67	0.26	-0.83	4.89	1.24	-1.96	-3.20	0.67**
Rainfed Seeta	7.43	-0.73	0.45	-0.79	-1.00	0.46	-1.00	4.41	1.06	-1.66	-2.18	0.59**
Irrigated Seeta	0.80	-0.83	0.66	-1.02	-1.40	0.33	-1.19	6.18	1.40	-2.02	-3.11	0.63**
Rainfed Varuna	-3.58	-1.10	0.76	-1.03	-1.71	0.07	-1.43	7.83	2.00	-2.26	-4.16	0.63**
Irrigated Varuna	-5.53	-1.21	0.82	-1.22	-1.92	-0.04	-1.66	9.50	2.46	-2.69	-5.21	0.69**

X_i, where i is the number of weather variable from X_1 to X_{10}; X_1=Maximum temperature on 3 rd day before aphid counting date; X_2= Maximum temperature on 4th day before aphid counting date; X_3= Maximum temperature on 5th day before aphid counting date; X_4= Minimum temperature on 5th day before aphid counting date; X_5= Mean temperature on 3rd day before aphid counting date; X_6= Mean temperature on 4th day before aphid counting date; X_7= Mean temperature on 5th day before aphid counting date; X_8=Degree-day(DD) on 3rd day before aphid counting date; X_9= DD on 4th day before aphid counting date; X_{10}= DD on 5th day before aphid counting date; R^2=Coefficient of determination

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