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Degree-day based forewarning system for mustard aphid

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ABSTRACT

Studies carried out at Delhi revealed that temperature accumulation (Degee-days) values during *rabi* seasons to be more reliable than mean temperatures for forewarning the infestations of *Lipaphis erysimi* K. on rapeseed-mustard. Degree-day accumulations from 1st January to 25th January were observed to be indicative of trends of high/low aphid population. The proposed thumb rule, "lower the degree-day accumulation rates in January, higher the probable peak aphid population" was tested on four years data. The degree-day accumulations of mean air temperature computed from 1 January to 25 January for four years showed less deviations form each other. As the season progresses, the differences become wider. Form the variations seen by 25 January itself, one can forewarn the aphid infestation level during that year, about four to five weeks in advance. To support the thumb rule a few points also enumerated.

Key words: Mustard aphid, *Lipaphis erysimi*, degree-days, forewarning, *Brassica* spp., and mustard

Rapeseed-mustard (*Brassica* spp.,) are grown as monoculture, intercrop and short duration crop to fit into intensive cropping pattern under both assured irrigation as well as rainfed conditions. The maximum production is from Rajasthan followed by Uttar Pradesh, Haryana, Madhya Pradesh, Gujarat, Assam and Punjab. According to the latest estimates in India, the rapeseed-mustard are grown in an area of 4.83 million hectares of land with a total production of 5.34 million tonnes maintaining an average yield of 1106 kilogram per hectare (Chakravarty and Gautam, 2002). These crops need special attention because there is considerable gap between yield potential and harvest. The avoidable yield losses due to mustard aphid, *Lipaphis erysimi* (K) (Homoptera: Aphididae) alone are reported to be between 20-50% and in extreme conditions, it might exceed further. Weather appears to play an important role in deciding the crop yield in presence of insect pests and diseases.

Probably due to inadequate information on the quantitative relationship between weather parameters and the dynamics of aphid, appropriate or satisfactory models could not be developed so far to forewarn the mustard aphid. Whalon and Smilowitz (1979), Rohitha and Penman (1983), Janson and Smilowitz (1985) studied the relationship of day-degree with different kinds of aphids and their predators. In India the degree-day concept has been widely adopted and used for cereal, legume crops (Chakravarty and Shastry, 1983; Chakravarty *et al.*, 1984) and mustard crop (Kar, 1996) relating it with crop growth, phenological development and yield. Studies have been carried out for cabbage aphid (Kotwal and Bhall, 1983; Kotwal *et al.*, 1985) and *Myzus persicae* (Sulzer) on seed potato (Kashyap and Bishnoi, 1988) and a preliminary study on mustard aphid by Prasad and Phadke (1980). However, Sastry (1996) mentioned that cumulative degree-days during January seem to be indicative of the probable aphid infestation (qualitative) in any *rabi* season in the Delhi region. In view of the gap in knowledge and importance of forewarning the mustard aphid for preparedness and reduction in pesticide use, an attempt was made in the present study, to develop a simple thumb rule to forewarn atleast a month in advance using the degree-day concept.

MATERIALS AND METHODS

Data on aphid infestation were recorded from the field experiments carried out at IARI, New Delhi, with three varieties of *Brassica* viz., Pusa Bold, B.O -54 and Toria T-9 sown on 23 Oct, 3 Nov, and 16 November and on 15 Oct, 29 Oct and 12 November during 1993-94 and 1994-95. Aphids colonized on the main shoot (top 10cm length) were counted at two to three dates intervals starting from the first appearance of the aphid till their complete disappearance. Data on the peak aphid population were used for the present study. Data on the aphid population during 2000-01 and 2001-02 were collected from the experiments carried out in he same location with three varieties (Agrani, Pusa Jaikisan and Varuna) sown on three dates at fifteen days intervals from 1 Oct onwards. All these field experiments were carried out with three replicates in RBD. The crops were raised following the standard recommended agronomic practices applications of chemicals sprays. The data on temperature were taken from the meteorological observatory near the experimental plot. Degree-day summations were computed following Nuttunson (1955). For mustard crop, a base temperature of 5 °C was used as suggested by Morrison *et al.* (1990).

RESULTS AND DISCUSSION

Basis of development of the model

It was observed that the aphid population varied from 80 to 500 in the 1993-94 and from 100-700 in the following season (Table 1). Interestingly, in the other set of two consecutive *rabi* seasons 2000-01 and 2001-02 study (Chakravarty and Gautam, 2002), the peak aphid population varied from 614 to 2612 in the former while in the latter seasons it remained as low as 0 to 351 (Table 2). In the variety Pusa Jaikisan, the aphid infestation was nil in the second and third sown crops in the second season which requires further investigations. Since the aphids start building up rapidly from January 1st, reach peak by about 3rd week of

Table 1: Peak aphid infestation in *Brassica* varieties during two *rabi* seasons in Delhi

Variety	1993-94	1994-95
Date of Sowing:	23.10.93	15.10.94
Pusa Bold	80	100
BO 54	250	260
Toria T-9	150	440
Date of Sowing:	3.11.93	29.10.94
Pusa Bold	180	200
BO 54	300	240
Toria T-9	400	470
Date of Sowing:	16.11.93	12.11.94
Pusa Bold	120	260
BO 54	250	260
Toria T-9	500	700

Table 2: Peak aphid population in three varieties in 2000-01(I) and 2001-02 (II) seasons

Variety	Peak population of aphid in crops sown on					
	1st October		15th October		30th October	
	I	II	I	II	I	II
Agrani	614	77	2612	72	1867	351
Pusa Jaikisan	1569	10	1110	0	2546	0
Varuna	784	63	1466	0	440	82

February and disappear from the crop by mid-March in Delhi region, the mean daily temperatures from 1st January to 18th March were closely examined for these four years (Fig. 1). During these years, variations of 12° C was observed in the mean daily temperatures on individual days indicating the temperature might not be a stable index for developing the forewarning system. Hence, the degree-days were accumulated from January 1st to March 18th for these corresponding years (Fig. 2). It is clear that variation of degree-day accumulation (as the season progresses) among the four years is relatively less as compared to that in mean daily temperatures. Based on the earlier work applying the degree-day concept to wheat (Chakravarty and Sastry, 1983), barley (Chakravarty *et al.*, 1984), mustard (Kar, 1996) crops, it was felt that the degee-day concept could be of some use in developing

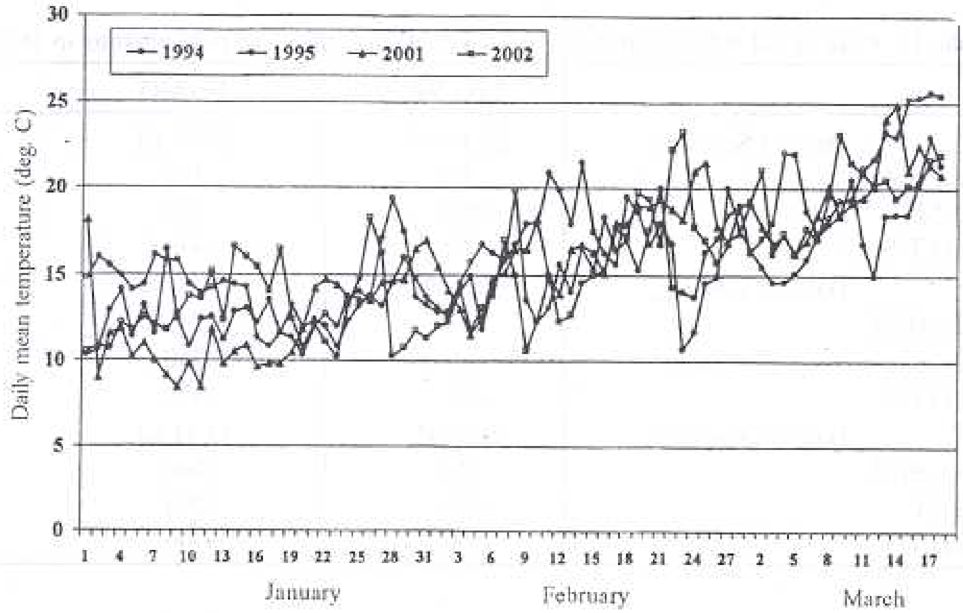

Fig. 1: Daily mean temperatures during 1 January to 18 March.

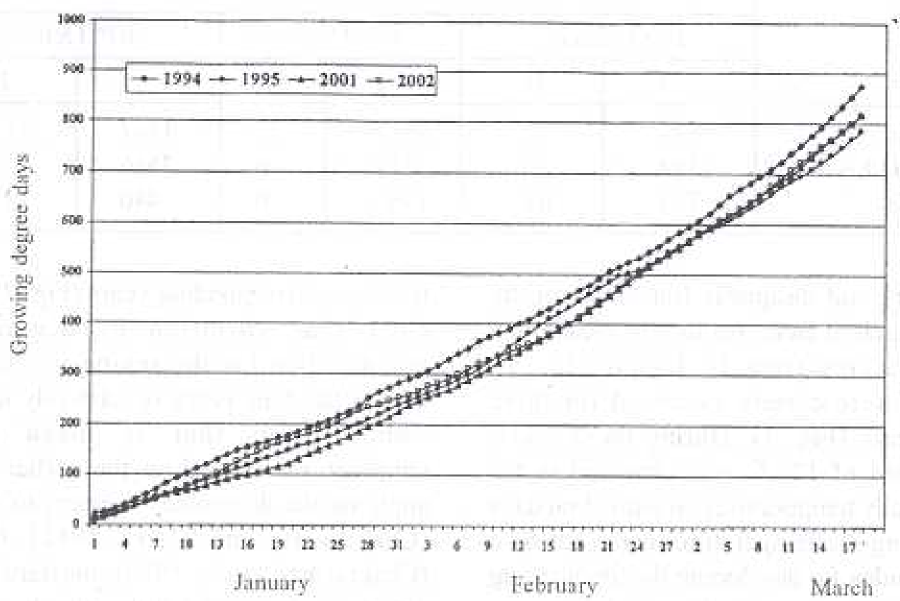

Fig. 2: Cumulative degree days during 1 January to 18 March

Table 3 : Degree-days corresponding to selected dates in different years

Date	1994	1995	2001	2002
10th January	102	74	59	69
15th January	148	111	85	117
20th January	179	148	111	161
25th January	208	184	157	198

Table 4 : Degree-days accumulated from 1st January, on selected dates with relative ranking low (L) or high (H)

Date	Degree-days	
15th January	90 (H)	140 (L)
20th January	115 (H)	190 (L)
25th January	150 (H)	245 (L)

the aphid-forewarning model as initially indicated by Sastry (1996).

Basic theory of forewarning

Usually, in Delhi, since the first appearance of the aphid on the mustard crop is around December/ January, it is possible that the weather during January is significant for the aphid growth and development leading to a peak population in the second/ third week of February. Hence, it is expected that the degree-day accumulations from January 1st might give us some meaningful indications about the peak populations likely to be reached during the succeeding month. Keeping this in view, degree-day accumulations were computed form 1st January to 25th January for four years (1993-94,1994-95,2000-01 and 2001-02) and the curves are drawn in Fig 3. It can be inferred that initially the degree-days showed less deviations from each other (from 1st January every year) and as season progresses, the differences became wider. This wider variation can be clearly seen by 25th January itself.

The hypothesis proposed is that "peak aphid population may be more in a year when the degree-day accumulation in the January is slower and vice versa". When the aphid infestation was corroborated with the degree-day accumulations (Table 3), the interpretation became much simpler. The degree-days accumulated from 1st January till 15th, 20th and 25th January (as read from the lowest and highest rates accumulation curves in Fig. 1) were observed to vary considerably. Following the above hypothesis, the lower the degree accumulation rates, higher the probable peak aphid population; markings were made as "H" indicating high and "L" indicating lower population (Table 4). As an illustration, suppose in any year, accumulation degree-days from 1st January to 15th January is around 90°D, then, it is possible that infestation could be high. On the other hand if the degree-days are around 140, then it could be a low infestation year. This can be further verified on 20th January or on any date later. In any case, by 25th January, one

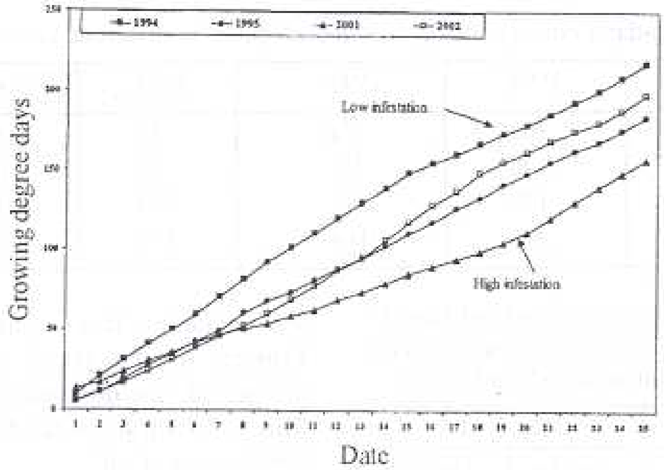

Fig. 3 : Cumulative degree days during January 1 to January 25

should be able to firmly say about the infestation level.

Again, it can be seen from the Table 1, that the infestation was relatively less in the year 1993-94 as compared to 1994-95. When the degree-day accumulations are compared, it can be seen that the accumulations were low in 1995 as compared to 1994 indicating aphid population might be more in the former year.

The differences in the growing degree-days for 2000-01 and 2001-02 clearly indicate the aphid population in the year 2000-01 could be much higher than population in the subsequent year (Table 2). The wide differences in the two curves as the days progressed, also confirm that the differences in the infestation level could be much higher. From the peak aphid population data of 2000-01 (Chakravarty and Gautam, 2002), it can be seen that in all three sowings, in the three varieties, Agrnai, Pusa Jaikisan and Varuna, the peak populations were far higher than those discussed above for the years 1993-94 and 1994-95. Following the hypothesis, the degree-day accumulation of 2001 also clearly gives an indication that peak aphid population might be relatively higher as compared to other years which confirms the actual population observed in the field. Hence, the hypothesis is found to be valid for four years data considered for the study.

It may be concluded that the present hypothesis relating the degree-days with the peak aphid population may be used as a thumb rule and might serve as an indicator to predict the levels of aphid populations well in time so that control measures could be suggested which if implemented, would go a long way in increasing the mustard crop production as well as productivity, leading to sustainability in this crop.

To support the above hypothesis, the

following points are enumerated.

1. Under low temperatures prevailing for over relatively longer periods, the aphids keep on feeding on different parts of the crop according to their choice, lay nymphs to their potentials (about 15 per day for 5-7 days) leading to higher population. The multiplication of predators also remains low due to lower degree-day accumulation (in other words lower temperatures). Besides, the low degree-day accumulations prolong the phenological stage, which is congenial for the aphid

2. If the accumulations grow faster, there is a possibility that nymphs might develop into winged adults having the tendency of dispersal. Very likely, such a population may end up with the natural mortality. Even the adults surviving on the crop become less productive and survival of their young nymphs also become difficult due to biotic factors, parasitoids and predators besides abiotic factors.

3. Higher rate of degree-days accumulations also make the crop develop early into pod stage. The pods rich in oil content are likely to increase the metabolism of aphids and in general may lead to their dispersal.

4. With relatively higher rate of accumulations of degree-days, it is possible to have clear sunny days along with light to moderate winds, which may not favour aphid colonization. At the same time these environmental conditions favour its natural enemies especially voracious feeders like *Coccinella septempunctata* L, *C. transversalis* F, *Cheilomenes* (*Menochilus*) *sexmaculata* (F), Syrphid flies and *Chrysoperla carnea* Stepnens (Gautam, 1994) besides parasitiods like *Aphidius* spp.

From the above enumeration, it can be concluded that the proposed thumb rule is simple to use and stable because the degree-days are less variable than other direct measured weather parameters. Further it may be added that if efforts are made to develop a dynamic simulation model incorporating this hypothesis along with biology of aphids and their natural enemies under the field conditions, probably, a better forewarning system could be developed. Further studies are in progress to achieve the goal.

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