Vol. 18, No. 2, pp. 224-231 (2018)
Journal of Agricultural Physics
ISSN 0973-032X
http://www.agrophysics.in

Research Article

Effect of High Temperature on Aphid (*Lipaphis erysimi* Kalt.) Infestation in Indian Mustard Crop (*Brassica juncea* L.)

D.K. DAS*, R. NISHAD, JOYDEEP MUKHERJEE, P. KRISHNAN, V.K. SEHGAL, A. VASHISTH AND S.P. DATTA[1]

Division of Agricultural Physics, ICAR-Indian Agricultural Research Institute, New Delhi-110012
[1]Division of Soil Science and Agricultural Chemistry, ICAR-Indian Agricultural Research Institute, New Delhi -110012

ABSTRACT

India is a net importer of edible oil, though it is producing sufficient food grains to feed it's over a billion population. Productions of oilseed crops are very low particularly due to abiotic and biotic stresses. Mustard is second most important oil seed crop and grown in north western part of Indo-Gangetic plains mainly. Among the biotic stresses, insect pest aphid is the most important one. Delayed sowing (beyond October) is very common and it exposes the crop to high temperature and aphid infestation during reproductive stage. A study was conducted at ICAR-Indian Agricultural Research Institute, New Delhi, during *rabi* season 2016-17 to study the effect of high temperature on aphid infestation and to find the relationship among these parameters. A field experiment was conducted with three cultivars of Indian mustard (Pusa Vijay, Pusa Mustard-21 and Pusa bold) with three different dates of sowings (25th October, 7th November and 18th November). The crops sown beyond October month were considered late and supposed to experience high temperature at reproductive stage of the crop due to the seasonal effect. Daily weather data were collected from nearby agromet observatory and weekly mean values were computed. Aphid population was counted at weekly interval. The crop sown on 25th October, 7th November and 18th November took 139-144 days, 134-137 days and 124-127 days, respectively to attain physiological maturity. The vegetative stages elongated and reproductive stage shortened due to delay in sowing. The third sown crop was infested maximum by aphid population (227 aphids/top 10cm of main stem) minimum number of aphid (69 aphids/top 10cm of main stem) was observed in first sown crop. Among maximum, minimum and mean temperature, the minimum temperature during reproductive stage was found to be most dangerous as far as aphid infestation is concerned. Per degree rise in mean minimum temperature during reproductive stage of the crop, peak aphid population increased by 63 aphids/top 10 cm of main stem. Among the cultivars, Pusa Vijay was infested least by aphid.

Key words: High temperature, Aphid, *Lipaphis erysimi*, Mustard, *Brassica juncea*

Introduction

Indian mustard (*Brassica juncea* L.) is an important edible oil yielding crop in the group of oilseed *Brassica* accounting for about 80% of the cultivated area in North-Western (N-W) parts of India (Singh *et al*, 2014). Area wise India ranks second after China and in production wise ranks third after Canada. Globally India accounts for 19.29% and 11.13% of the total acreage and production (USDA, 2014). It is second most important oilseed crop (next to groundnut) in

*Corresponding author,
Email: dkdas.iari@gmail.com

India. Indian mustard is grown in *rabi* season (October to April) in northern plains of India and in summer season in hills. The crop is subjected to various types of stresses (abiotic and biotic) and productivity is very low. The crop is cultivated in an area of 56 lakh ha with a production of 67 lakh tonnes and an average yield of 1145 kg ha^{-1} (DRMR, 2013). Biotic stresses are due to insect pests and diseases. Major insect pests are aphid, saw fly and painted bugs and major diseases are white rust and *Alternaria* blight. Mustard aphid (*Lipaphis erysimi* Kalt.) is considered as a pest of national importance. Aphid, *Lipahis eyrsimi* Kalt., causes 10-60% losses in yield in India to these crops depending upon severity of damage and crop stage (Rana, 2005). Yield losses caused by aphid can exceed 50% in Poland, India, China, Australia and New Zealand (Bakhetia, 1989 and Kelm and Godomski, 1995).

Weather plays an important role on initiation and population development of mustard aphid (Jitendrakumar *et al*., 1999; Vekaria and Patel, 2000). Temperature is the major factor that directly effects insect development, reproduction and survival (Dhaliwal, 2002). Intensive studies aimed at quantifying the relationship between thermal time (growing degree days) and mustard aphid incidence, its multiplication were worked out (Kar and Chakravarty 2000). A temperature based thumb rule relating aphid population and degree-days accumulation was developed at IARI and the rule stated an inverse relationship between degree day accumulation in January and aphid population development rate (Chakravarty and Gautam, 2002). Relationships of temperature and relative humidity with the incidence and multiplication of aphid in the mustard crop was also developed (Prasad and Phadke, 1980; Rana *et al*., 1993).

Time of sowing has a significant effect on the infestation of mustard crop by aphid. Sowing the crop early in the season is reported to be affected less by aphid attack because of phenological asynchrony between the most susceptible crop growth stage and pest population (Patel *et al*., 2004). 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, particularly the temperature. Keeping the above mentioned points in view, a study was conducted at ICAR-IARI farm, New Delhi to quantify the effect of high temperature on aphid infestation in mustard cultivars during the reproductive stage of the crop.

Materials and Methods

A field experiment was conducted in split plot design with three different dates of sowings (25th October, 7th November and 18th November) as main plot treatment and three cultivars of Indian mustard (Pusa Vijay, Pusa Mustard-21 and Pusa bold) as sub plot treatments with three replications. The main plot treatments (dates of sowing) were referred as D_1, D_2, D_3 while sub plot treatments (cultivars) were referred as V_1, V_2 and V_3, respectively. Each plot size was 5m x 4m in dimension. The recommended agronomic practices were followed to have a good growth of the crop. The normal sowing time of mustard crop at N-W plains is the last fortnight of October (D_1 here). The crops sown beyond October month were considered to be late (D_2) and very late (D_3) and supposed to experience progressively higher ambient temperature at reproductive stage due to the seasonal effect as well climate change effect.

Data of daily weather parameters i.e., maximum temperature minimum temperature and rainfall during the crop season (sowing to harvesting) were collected from the agro-meteorological observatory of Division of Agricultural Physics, ICAR-IARI, New Delhi situated near by the experimental field and weekly mean values were computed. Average values of maximum, minimum and mean temperature of each treatment was computed for vegetative and reproductive stages of the crop.

Observations on crop phenology were recorded twice in a week and days taken by vegetative (50% emergence to 50% flowering) and reproductive (50% flowering to physiological maturity) stages by each cultivars for each sowing dates were computed.

Mustard aphid (*Lipaphis erysimi* Kalt.) infestation was measured by counting the number of aphids (aphid population) at the top 10 cm of main stem of ten randomly selected plants at weekly interval from each plot.

The data sets were processed ultimately for analysis of variance as applicable to split plot design, to test the difference among the treatments within replications and their interactions using Statistical Analysis System (SAS) with the help of Indian National Agricultural Research System (NARS) statistical computing portal of ICAR-IASRI, New Delhi.

Results and Discussion

Results obtained from the field experiments conducted during *rabi* season of 2016-17 on three cultivars of Indian mustard sown on different dates of sowings are presented below.

Weather condition during rabi *season 2016-17*

The temperature and rainfall condition that prevailed during the *rabi* season of 2016-17 as recorded at ICAR-IARI Agromet Observatory are presented in Fig.1. From the daily data collected, weekly (standard meteorological weeks) means during the season were computed. During *rabi* season of 2016-17, the weekly mean maximum temperature gradually decreased from 34.3°C at starting of the crop season (42nd standard meteorological week–SMW in October) to 17.6°C (2nd SMW in January). After that there it gradually increased upto 32.4°C (12th SMW in March) at the end of the crop season. In the case of mean minimum temperature during this season it started from a high value of 13.6°C (42nd SMW) during germination to the lowest value of 4.2°C (2nd SMW) during the start of seed filling and again reached the highest value of 14.8°C at 12th SMW during maturity.

During *rabi* season of 2016-17, a cumulative rainfall of 12.0 mm was received in four rainy days. On 4th SMW, the highest rainfall (8.5 mm) was received. Some more rainfall was received during 10th SMW (2 mm), 1st SMW (0.7 mm) and 11th SMW (0.7 mm). North western (N-W) part of India generally received one to few spell of rainfall during winter season due to western disturbances. This rainfall is good for *rabi* season crops (Das *et al.*, 2015). These rainy spells met some amount of water requirement of the crop and saved 1-2 irrigations.

Phenology of the Crop

Across the cultivars, the vegetative stage (50% emergence to 50% flowering) of D_1, D_2 and D_3 took 49-59 days, 60-67 days and 67-79 days, respectively (Table 1). As the sowing got delayed, the crop took more number days to complete this

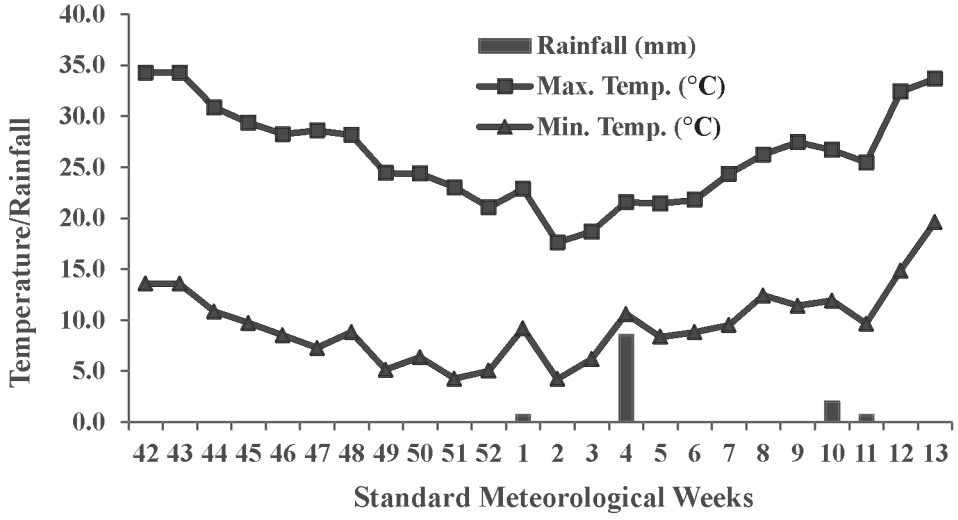

Fig. 1. Variation of temperature and rainfall at ICAR-IARI farm New Delhi during *rabi* season of 2016-17

Table 1. Time taken (days) to complete phenological events/stages by mustard cultivars under different dates of sowings

Phenological events/stage	Treatments								
	D_1V_1	D_1V_2	D_1V_3	D_2V_1	D_2V_2	D_2V_3	D_3V_1	D_3V_2	D_3V_3
50% Emergence (E50)	5	5	4	7	7	6	7	8	6
50% Flowering (F50)	51	59	49	61	67	60	68	75	67
Physiological Maturity (PHM)	139	144	142	134	137	134	124	127	126
Vegetative stage (E50 to F50)	46	54	45	54	60	54	61	67	61
Reproductive Stage (F50 to PHM)	88	85	93	73	70	74	56	52	59

D_1= 25th Oct 2016, D_2= 7th Nov 2016, D_3= 18th Nov 2016,V_1= Pusa Vijay, V_2= Pusa Mustard-21, V_3= Pusa Bold

stage. On the other hand, the reproductive stage (50% flowering to physiological maturity) got shortened as the sowing was delayed. D_1, D_2 anD_3 sown crops took 85-93 days, 70-74 days and 49-56 days, respectively to complete this stage. The crop sown on 25th October, 7th November and 18th November took 139-144 days, 134-137 days and 124-127 days, respectively to attain physiological maturity.

Temperature condition during reproductive stage of the crop

The most vulnerable stage of the crop is flowering, followed by pod formation and seed filling for aphid infestation. All these stages come under reproductive stage. As the reproductive stage (50% flowering to physiological maturity) got shortened in progressively in late sown mustard cultivars, the mean maximum (Tmax), mean minimum (Tmin) and mean (Tmean) temperature during this stage were studied (Table.2). D_1, D_2 and D_3 sown crops were exposed to mean maximum temperature range, (22.7-22.9°C), (23.4-24.3°C) and (24.9-26.0°C), respectively. Similarly, D_1, D_2 and D_3 sown crops were exposed to mean minimum temperature range, (8.3-8.8°C), (9.5-10.0°C) and (10.7-11.0°C), respectively. D1, D2 and D3 sown crops were exposed to mean temperature range, (15.5-15.8°C), (16.4-17.2°C) and (17.8-18.5°C), respectively. As the sowing was delayed, the crop was getting exposed to higher Tmax, Tmin and Tmean at reproductive stage. Progressive increase in temperature during reproductive stage probably decreased the duration of this stage in late and further late sown crop.

Aphid infestation

The data aphid infestation was recorded, expressed as 'No. of aphids/top 10cm of main shoot' and presented in (Fig. 2). The aphid infestation started in mustard from flowering stage onward in each treatment then reached a peak value around seed filling stage to pod formation stages. As indicated by peak values, first sown crop (D_1) was least affected by aphid (69.4 aphids) followed by second sown (D_2) (161.8 aphids) and third sown (D_3) crop was infested maximum (226.7 aphids) (Table 3). Similar result was found by Das *et al.* (2009). Shekhawat *et. al*.(2012) also reported date of sowing influenced the incidence of insect pest and disease. Among the cultivars, Pusa Vijay (V_1) was infested lesss (149.2 aphids) than Pusa Mustard-21(V_2) (155.6

Table 2. Mean temperature condition during reproductive stage of mustard cultivars sown on different dates during *rabi* season 2016-17

Temperature	D_1V_1	D_1V_2	D_1V_3	D_2V_1	D_2V_2	D_2V_3	D_3V_1	D_3V_2	D_3V_3
Tmax (°C)	22.7	22.9	22.8	23.4	24.3	23.7	24.9	26.0	25.3
Tmin (°C)	8.4	8.8	8.3	9.5	10.0	9.6	10.7	11.0	10.8
Tmean (°C)	15.5	15.8	15.5	16.4	17.2	16.6	17.8	18.5	18.1

aphids) and Pusa Bold (V_3)(153.2 aphids). There was no significant difference in aphid population in the later two cultivars. But Pusa Vijay differed significantly from other two cultivars in this respect. So Pusa Vijay is a supirior cultivar as it was infested less by aphid. The highest aphid population (232 aphids) was observed in D_3V_3 treatment (Fig. 2). Aphid population declined with the maturity of the crop when flowering period was over and further increase of temperature after 7th SMW (15-02-17). Among all growth stages (vegetative to seed setting), the flowering is the most vulnerable stage of crop to aphid infestation (Singh, 2010).

Effect of temperature on aphid population

Increase of aphid population (no. of aphids/ top 10 cm main shoot) for delayed sowing due to temperature increase during reproductive stage

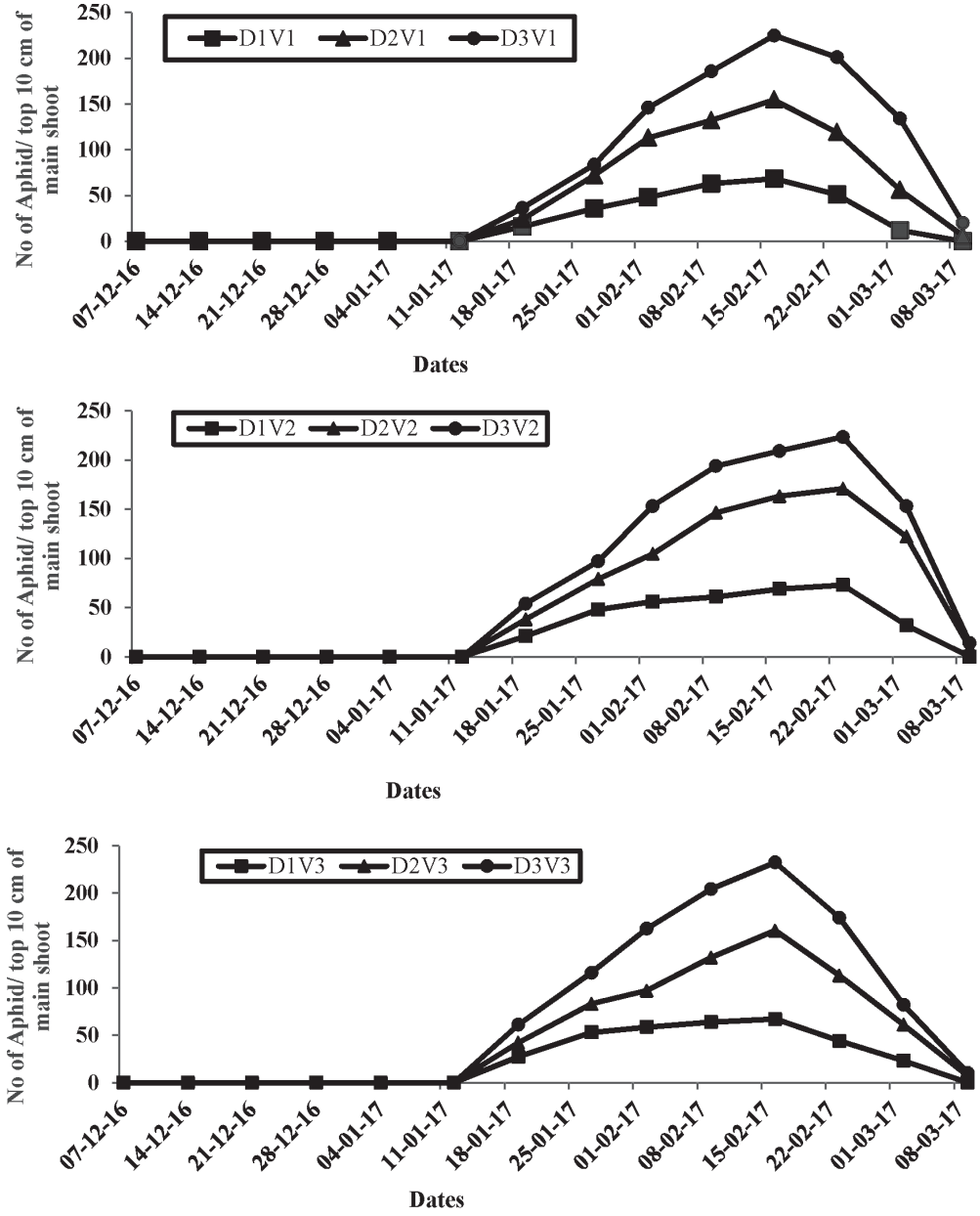

Fig. 2. Aphid infestation on mustard cultivars (V1: Pusa Vijay, V2: Pusa Mustard -21, V3: Pusa Bold) sown on different dates during *rabi* season of 2016-17

Table 3. Peak aphid population recorded among different mustard cultivars in different dates of sowings during *rabi* season of 2016-17

Treatments	Peak aphid population/ top 10 cm main shoot
Effect of different dates of sowing	
D_1	69.4^C
D_2	161.8^B
D_3	226.7^A
$LSD_{5\%}$	4.9
Effect of Cultivars	
V_1	149.2^B
V_2	155.6^A
V_3	153.2^A
$LSD_{5\%}$	3.7

was studied. It was found that mean maximum, minimum and mean temperature of reproductive stage had positive impact on aphid population (Fig. 3). Maximum increase in aphid population took place due to increase of minimum temperature. Per degree rise in minimum temperature increased the aphid population by 63 aphids/ top 10 cm main shoot and the increase of aphid population for per degree rise in maximum and mean temperature during reproductive stage was 51 and 56 aphids/top 10 cm of main shoot. Field and laboratory studies indicated that insect pest attack increases with rise in temperature (Cannon, 1998; Bale *et al*., 2002) and the global warming projected an increase in pressure of herbivore on plants (Coley, 1998; Bale *et al*.,

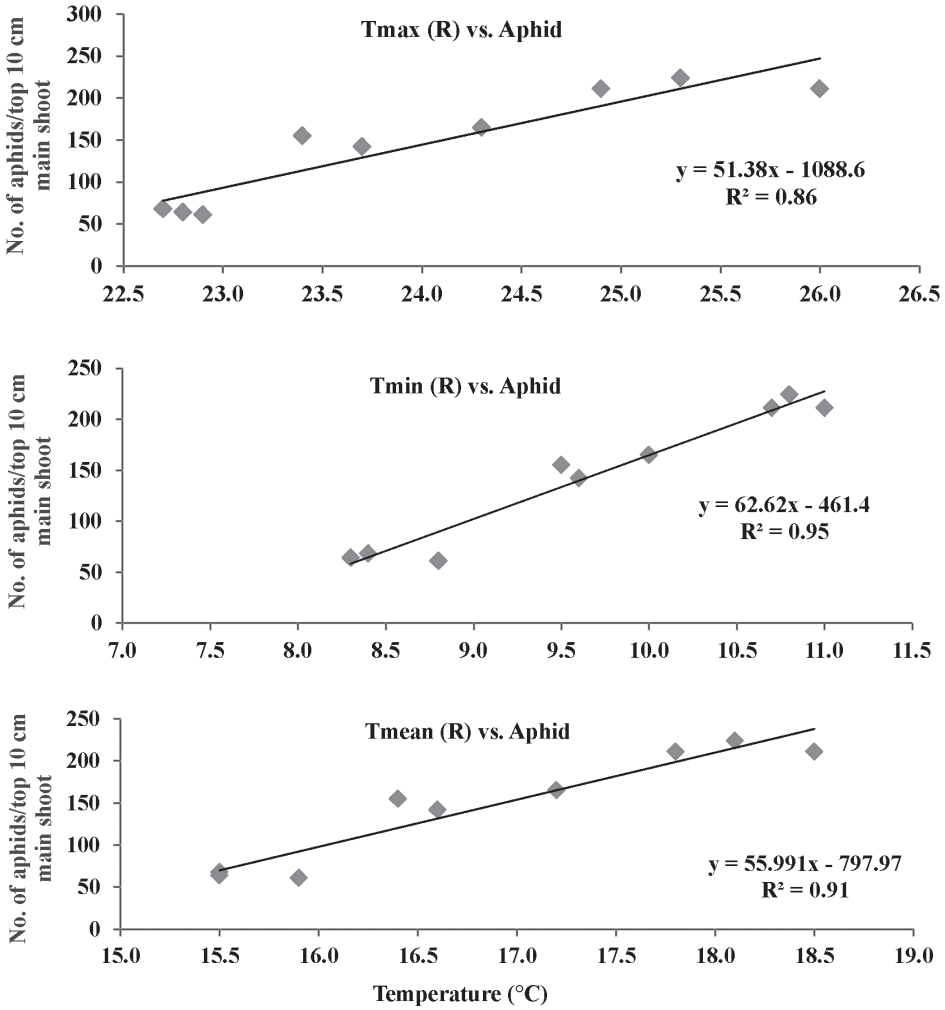

Fig. 3. Aphid population on mustard crop as influenced by maximum (Tmax), minimum (Tmin) and mean temperature (Tmean) at reproductive stage during *rabi* season of 2016-17

2002, Das *et al.,* 2011). Studies also indicated that mustard aphid incidence was higher when maximum and minimum temperature ranged between 9.3 to 25.9°C and 8.2 to 25.2°C (Narjary *et al*. 2013). However, the present study indicated that the role of minimum temperature on increase of aphid population was more important than that of maximum and mean temperature.

Conclusion

It can be concluded from this study that delayed sown (beyond October) mustard crop is infested more by aphid due to increase in temperature (which may be favourable for aphid multiplication) during the reproductive stage of the crop. Favourable range of mean maximum temperature was found to be in the range of 24.9°C to 26.0°C and that of mean minimum temperature was found to be 10.7°C to 11.0°C for aphid multiplication. Impact of minimum temperature is more than maximum or mean temperature. Among the cultivars, Pusa Vijay was infested least by aphid. Therefore, Pusa Vijay cultivar can be recommended to be grown with normal sowing time (second fortnight of October) to minimize the loss by mustard aphid in north western part of India.

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Received: September 18, 2018; Accepted: November 20, 2018