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Seasonal and temporal variation in population of mustard aphid, *Lipaphis erysimi* (Kalt.) on different species of rapeseed-mustard in relation to weather parameters

Shweta Patel and Chandra Pal Singh

Abstract
Field experiments were conducted in order to study the seasonal and temporal variation in population of mustard Aphid, *Lipaphis erysimi* at Norman E. Borlaug Centre of G. B. Pant University of Agriculture and Technology, Pantnagar (India) during *Rabi* season of 2016-17. *Brassica* spp. including *B. rapa* (BSH-1), *B. rapa* (YST-151), *B. carinata* (CCN-06-1), *B. nigra* (PBR-I), *B. juncea* (Varuna), *B. napus* (GSC-6) and *E. sativa* (T-27) were sown on five dates starting from October 3 to December 3, 2016, at fifteen days interval. Early sown crops had significantly lowest numbers of aphids as compared to late sown crops (after 2nd week of October) which had high numbers of aphids. Early sown crops had significantly lowest numbers of aphids as compared to late sown crops (after 2nd week of october) which had high numbers of aphids. it was found that increase in the relative humidity favours aphid multiplication while increase in temperature and rainfall had negative impact on the multiplication of the aphid.

Keywords: mustard aphid, sowing date, weather parameters, *Brassica* species

Introduction
Rapeseed-mustard is a major oilseed crop grown in India next to soybean in terms of production and ranked first in terms of oil yield among all oilseed crops sown during the *Rabi* season in India. It is grown on an area of about 6.4 m ha with a production of 8.02 mt and productivity is 1262 kg/ha. In India, *Brassica juncea*, among *Brassica* species shares about 90% in area. Even after availability of good production technology mustard crop is unable to give potential yield in the country. This is because *Brassica* crops suffer heavy loss in yield due to various biotic and abiotic factors. Among the biotic constraints, insect-pests are one of the most important biotic factors in reducing the crop yield. About 50 insect species have been found infesting rapeseed-mustard in India. Out of many insect pests, *Lipaphis erysimi* is considered important which causes considerable yield losses. The ecological approach to the pest management suggests using pesticides only when and where necessary. Therefore, for ensuring an effective and economical management of this serious pest, the present studies were undertaken for studying its population dynamics of mustard aphid, *L. erysimi* (Kalt.) on *Brassica* spp. with respect to sowing dates. These studies will provide an opportunity to face the pest challenge by manipulating sowing time, varietals selection, correct timing of pesticidal application besides other management practices.

Materials and Methods
Field trials were conducted in randomized block design to record the incidence of *L. erysimi* on *Brassica* spp. including *B. rapa* (BSH-1), *B. rapa* (YST-151), *B. carinata* (CCN-06-1), *B. nigra* (PBR-I), *B. juncea* (Varuna), *B. napus* (GSC-6) and *E. sativa* (T-27) at Norman E. Borlaug Crop Research Centre (NEBCRC) of G.B. Pant University of Agriculture and Technology, Pantnagar (India) during *Rabi* season of 2016-17. Five sowing dates viz., October 3 (First sowing), October 18 (Second sowing), November 3 (Third sowing), November 18 (Fourth sowing) and December 3 (Fifth sowing) were selected for raising the crop. The recommended practices for raising a good crop were followed except spray of insecticides. The plot size was 4.2m x 3m, the row to row and plant to plant distances as 30 cm and 10 cm, respectively. Each treatment was replicated thrice. Data on the aphid population were recorded from 10 randomly selected plants in each replicated plots on 10cm twig at 7 days intervals. The aphid population of different dates of sowing were subjected to the analysis of variance using simple randomized block design.

Result

First Sown: 3rd October, 2016-17

The first appearance of mustard aphid was recorded in 49th standard week only on *B. rapa* cv. YST-151(52.2 aphids per 10cm CSL) followed by *B. rapa* cv. BSH-1 (75.98 aphid per 10cm CSL) and *B. juncea* (42.72 aphids per 10cm CSL). In 3rd standard week, the initial population of the aphid was observed on *B. nigra*, *B. alba*, *E. sativa* and *B. carinata* with 101.09, 132.87, 34.55 and 44.80 aphids per 10cm CSL respectively. Peak population of aphid was observed in 2nd standard week on *B. rapa* cv. YST-151 (770.0 aphids per 10cm CSL) and minimum on *B. alba* (62.70 aphids per 10cm CSL) while no aphid population was recorded on *B. carinata* and *E. sativa*. From 50th standard week onwards, population of aphid keeps increasing which reaches on its peak level in 5th standard week. Successively, the aphid population start decreasing and almost disappeared from all *Brassica* species after 3rd week of February except on *B. carinata* (Table 1).

the population of *L. erysimi* showed negative correlation with minimum and maximum temperature in *B. rapa* cv. BSH-1, *B. rapa* cv. YST-151, *B. juncea* and *B. nigra* except *B. carinata*. evening relative humidity showed significant positive correlation in *B. napus* while negative correlation in *B. carinata.* Correlation between sunshine and population of *L. erysimi* exhibited significant negative in *B. rapa* cv. YST-151 while positive correlation in *B. carinata*. The regression between weather parameter and population of *L. erysimi* revealed that the population of mustard aphid highly influenced by weather parameters which ranged from 54 to 88 % among all *Brassica* species (Table 6).

Second Sown: 18th October, 2016-17

Mustard aphid first appeared in 51th standard week with higher aphid population on *B. rapa* cv. YST-151(300.9 aphids per 10cm CSL) followed by *B. alba*, *B. juncea*, *B. rapa* cv. BSH-1 and *B. napus* with 111.2, 79.3, 58.2 and 49.3 aphids per 10cm CSL, respectively while no aphid population was reported on *B. carinata*, *B. nigra* and *E. sativa*. With subsequently, the highest population of 639.21 aphids per 10cm CSL was observed on *B. rapa* cv. YST-151 followed by *B. rapa* cv. BSH-1 (362.6 aphids per10cm CSL) in 4th standard week while on *B. juncea* (322.08 aphids per 10cm CSL) in 5th standard week. On *B. nigra* and *B. alba* on the other hand peak population (233.24 and 319.60 aphids per 10cm CSL) was attained in 6th standard week and on *B. napus* (183.5 aphids per 10cm CSL) in 7th standard week. In the 10th standard week it was observed that all the of *Brassica* species free from aphid except *B. carinata* due to late flowering. In all the *Brassica* species the population declined considerably after attaining peak population of aphid (Table 2).

the population of *L. erysimi* showed significant negative correlation with minimum temperature while significant positive correlation with morning and evening relative humidity in *B. rapa* cv. BSH-1and *B. rapa* cv. YST-151 except *B. carinata*. sunshine hours exhibited significant negative correlation with population *L. erysimi* in *B. rapa* cv. BSH-1, *B. rapa* cv.YST-151 and *B. juncea*, except *B. carinata*. The regression revealed that the weather parameters were found to dominate of *L. erysimi* on *B. rapa* cv. BSH-1, *B. rapa* cv. YST-151, *B. juncea*, *B. napus*, *B. carinata*, *B. nigra*, *E. sativa* and *B. alba* with 76, 87, 84, 53, 75, 45, 64 and 63 %, respectively (Table 6).

Third sown: 3rd November, 2016-17

the first appearance of the aphid population was recorded in 51st standard week with maximum population on *B. rapa* cv. YST-151 (135.0 aphids per 10cm CSL) followed by *B. rapa* cv. BSH-1 and *B. juncea* (123.7 and 78.3 aphids per 10cm CSL) while no aphid population was found on *B. alba*, *B. nigra*, *B. napus*, *B. cariata* and *E. sativa*. In 1st standard week, it was found that there was an abrupt rise in population of *L. erysimi* on *B. rapa* cv. YST-151, *B. rapa* cv. BSH-1, *B. juncea* and *B. napus* of *Brassica* species which harboured (517.7, 254.3, 179.2 and 67.1 aphids per 10 cm CSL, respectively). Subsequently, the peak population of mustard aphid was noted in 7th standard week on *B. rapa* cv. YST-151, *B. juncea*, *B. rapa* cv. BSH-1, *B. alba*, *B. napus*, *B. nigra* and *E. sativa* with 624.8, 313.0, 311.3, 305.2, 169.0, 119.6 and 3.0 aphids per 10cm CSL, respectively. The sudden decrease was observed in pest population which was reached its lowest level on *E. sativa* followed by *B. napus*, *B. juncea*, *B. rapa* cv. YST-151, *B. nigra* and *B. alba* (1.2, 204.1, 190.5, 183.3, 89.3 and 79.43 aphids per 10cm CSL, respectively) in the 8th standard week. In 10th standard week, among all *Brassica* species only on *B. carinata* with 5.28 aphids per 10cm CSL (Table 3).

The population of mustard aphid displayed significant positive correlation with minimum and maximum temperature in *B. rapa* cv. BSH-1 except *B. alba.* Wind speed also showed significant negative correlation in *B. rapa* cv. BSH-1, *B. rapa* cv. YST-151, *B. juncea* and *B. napus*. correlation between rainfall and the population of *L. erysimi* showed significant negative in *B. nigra* and *B. alba*. The regression between weather parameter and population of *L. erysimi* exhibited R^2 value ranged from 23 to 88 percent among all *Brassica* species (Table 6).

Fourth sown: 18th November, 2016-17

The initial appearance of aphid was observed in 1st standard week on *B. rapa* cv. YST-151 (30.8 aphids per 10cm CSL) followed by *B. rapa* cv. BSH-1 (29.3 aphids per 10cm CSL) and *B. alba* (17.8 aphids per 10cm CSL) while *B. juncea*, *B. napus*, *B. carinata*, *B. nigra* and *E. sativa* was free from aphid attack. In 3rd standard week, it was found that there was an abrupt rise in population of mustard aphid on *E. sativa*, *B. napus*, *B. alba*, *B. juncea*, *B. rapa* cv. Y5T-151 and *B. rapa* cv. BSH-1 with 5.1, 26.9, 119.2, 137.0. 303.2 and 387.2 aphids per 10cm CSL, respectively. The peak population of mustard aphid was noted in the last week of February on *B. rapa* cv. YST-151 (718.8 aphids per 10cm CSL) followed by *B. juncea* (326.9 aphids per 10cm CSL), *B. rapa* cv. BSH-1 (302.4 aphids per 10cm CSL) *B. alba* (201.3 aphids per 10cm CSL) and *B. napus* (164.6 aphids per 10cm CSL). The sudden decrease in the population was observed which reached its lowest level on *B. alba* (27.6 aphids per 10cm CSL) while highest on *B. juncea* (315.7 aphids per 10cm CSL) followed by *B. napus* (189.6 aphids per 10cm CSL), *B. nigra* (168.8 aphids per 10cm CSL) and *B. rapa* cv. YST-151 (110.8 aphids per 10cm CSL) in 9th standard week (table 4). Morning and evening relative humidity showed significant positive correlation with the population of *L. erysimi* in *B. rapa* cv. BSH-1 while negative correlation in *B. carinata*. Correlation between sunshine hours and mustard aphid exhibited significant negative in *B. rapa* cv. BSH-1 whereas rainfall also showed significant positive correlation in *B. carinata.* maximum temperature exhibited significant positive correlation with the population of *L. erysimi* in *B. napus* and *B. nigra*. the regression between weather parameter and population of *L. erysimi* was revealed that population of mustard aphid highly influenced by weather parameter with r^2

value of 84, 73, 83, 81, 84, 60 and 63% on *B. rapa* cv. BSH-1, *B. rapa* cv. YST-151, *B. juncea*, *B. napus*, *B. nigra*, *E. sativa* and *B. alba*, respectively (table 6).

Fifth sown: 3rd December, 2016-17

Aphid population was first reported in 5th standard week on five *Brassica* with maximum population on *B. rapa* cv.YST-151 (328.8 aphids per 10cm CSL) followed by *B. rapa* cv. BSH-1 (287.9 aphids per 10cm CSL) while minimum on *B. napus* (66.3 aphids per 10cm CSL) except *B. carinata*. In 7th standard week, maximum population of aphid was recorded on *B. rapa* cv. YST-151(659.1 aphids per 10cm CSL) followed by *B. rapa* cv. BSH-1 (421.4 aphids per 10cm CSL), *B. juncea* (337.9 aphids per 10cm CSL), *B. napu s*(236.0 aphids per 10cm CSL) *B. alba* (228.0 aphids per 10cm CSL), *B. nigra* (85.7 aphids per 10cm CSL) and *E. sativa*(13.8). There was abrupt fall in the population of mustard aphid of the species of *B. napus*, *B. alba*, *B. nigra*, *B. rapa* cv. YST-151, *B. carinata* and *E. sativa* which harboured 193.5, 149.1, 132.2, 85.1, 72.7 and 4.8 aphids per 10cm CSL, respectively (table 5).

Morning relative humidity showed significant positive correlation with the population of *L. erysimi* in *B. rapa* cv. BSH-1 and *B. juncea* while negative correlation in *B. carinata.* Rainfall and sunshine exhibited significant negative correlation with mustard aphid in *B. rapa* cv. BSH-1 and *B. rapa* cv. YST-151, respectively. Only in *B. nigra* aphid showed significant positive correlation with maximum temperature. the regression revealed that the population of *L. erysimi* was found to dominate on aphid population on *B. rapa* cv. BSH-1, *B. rapa* cv. YST-151, *B. juncea*, *B. napus*, *B. carinata*, *B. nigra*, *E. sativa* and *B. alba* with R^2 value 75, 78, 80, 74, 65, 70, 64 and 56%, respectively (table 6).

Discussion

Abiotic factors seem to influence the aphid population due to the large variation in sowing dates. The cloudiness and wind velocity also played an important role in arrival as well as build-up of aphid population. Increase in cloudiness initially leading to multiplication of aphid on *Brassica* species. On the other hand, there was a sharp increase in temperature, resulting into reduction of *L. erysimi* on rapeseed -mustard. So, frequent fluctuation in temperature, cloudiness and relative humidity influenced supported the multiplication of aphid. The findings of Gami *et al*. (2002) [5] and Chattopadhyaya *et al*. (2005) are in complete agreement with present findings.

It was observed that in early sown crop the prevailing weather conditions are not favourable for aphid multiplication but become favourable under delayed sowing. Earlier workers have variously reported the period of peak population of *L. erysimi* from last week of November to first week of January (Veda and Shaw, 1998 and Singh and Sachan, 1999) [20]. On the basis of two years study Jandial and Kumar (2007) on the other hand reported that the incidence of mustard aphid occurred in last week of December and attained peak in second week of February during 2002-03 and 2003-04. Hugar *et al*. (2008) [6] reported that the incidence of the mustard aphid started from December 1st week and subsequently reached it's peaked in 3rd week of January. Sinha *et al.,* 1989 [21] also reported that the mustard aphid appeared in the third week of December, attained its peak population in 6th and 7th standard week during 1980 and 1981. Phadke (1982) and Rana *et al*. (1993) [17] also recorded the aphid population appeared during January. These findings are in agreement to those reported by others (Bishnoi *et al*, 1992; Naqvi, 2003 and Ansari *et al*, 2007) [11, 3, 1].

The aphid population was disappeared from the infested field in 8th and 9th standard week. Samdur *et al.* (1997) [19] also noticed significant positive correlation between the age of crop and aphid population. Correlation showed that maximum and minimum temperature and slight rainfall have positive with aphid population. Findings of Sinha *et al*. (1989) [21] also agreed with present results that relative humidity had little impact on aphid population.

However, among the eight *Brassica* species studied for aphid population, the least population of aphid was found on *E. sativa* followed by *B .carinata* in the present study. These findings are in close agreement with Manzar *et al.,* 1998 who reported that higher population of mustard aphid on *B. rapa* as compared to *B. juncea*. These observations are in conformity with those of Kalra (1988) [9] who observed that aphid population was higher on yellow sarson as compared to Indian mustard. Rana *et al*. (1995) [17] reported that the lowest population of mustard aphid was found on *B. carinata* which agreement with the present finding. Lower population of mustard aphid was observed on *B. napus* and *B. carinata* due to the late flowering of these *Brassica* species.

In different dates of sowing, our results were in accordance to that of Joshi *et al*. (1989) [8] and Bhadauria *et al*. (1992) [2] who reported that lowest aphid population was found at early sown crops in India. Similarly, we recorded the lowest number of aphids on early sown crops. Raj *et al.* (2002) [16] reported that late sowing (1st week of November) of mustard had no significant effect of aphid population. Likewise, Saljoqi *et al*. (2009) [18] had reported that late sown crops had the highest number of aphid population.

In our findings, there was a difference in insect pest occurrence while a significant difference in terms of abundance on *Brassica* species in different dates of sowing. there was a no difference in occurrence as well as their abundance of different insect pests in different dates of sowing. Early sown crops had significantly lowest numbers of aphids as compared to late sown crops (after 2nd week of october) which had high numbers of aphids. In the present investigation it was found that increase in the relative humidity favours aphid multiplication while increase in temperature and rainfall had negative impact on the multiplication of the aphid.

Table 1: Population build -up of *L. erysimi* on *Brassica* species in first date of sowing during *Rabi* 2016-17

SW/*Brassica* species	Aphid population per 10 cm CSL during standard week														
	49	50	51	52	1	2	3	4	5	6	7	8	9	10	11
B. rapa cv. BSH- 1	76.0(8.6)	308.3(17.5)	222.3(14.9)	160.8(12.7)	332.3(18.2)	347.0(18.5)	178.6(13.3)	353.7(18.8)	361.6(19.0)	86.1(9.3)	40.7(6.2)	0.0(0.)	0.0(0.0)	0.0(0.0)	0.0(0.0)
B. rapa cv. YST- 151	52.3(22.7)	728.7(27.0)	543.9(23.2)	661.2(25.7)	631.6(25.0)	770.0(27.6)	529.1(22.9)	661.7(25.6)	480.4(21.9)	354.8(18.8)	46.6(6.5)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)
B. juncea	42.7(6.5)	87.0(9.2)	208.8(14.4)	133.6(11.5)	293.7(17.1)	242.4(15.5)	167.0(12.9)	223.5(14.8)	293.3(17.1)	266.2(16.3)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)
B. napus	44.0(6.6)	0.0(0.0)	224.9(14.9)	273.9(16.5)	148.5(12.2)	148.4(12.1)	67.65(8.2)	110.4(10.5)	151.4(12.2)	79.3(8.9)	9.4(3.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)
B. carinata	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	44.8(6.7)	36.6(6.0)	46.6(6.8)	45.1(6.7)	43.5(6.6)
B. nigra	0.0(0.0)	0.0(0.0)	101.6(10.0)	18.6(4.3)	74.9(8.6)	204.8(14.3)	101.0(10.0)	110.9(10.5)	146.0(12.1)	149.5 (12.2)	161.9(12.7)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)
E. sativa	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	34.5(5.5)	7.1(2.6)	9.4(3.1)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)
B. alba	0.0(0.0)	0.0(0.0)	0.00(0.0)	132.9(11.2)	29.3(5.0)	62.7(7.4)	116.2(10.8)	117.7(10.8)	258.6(16.1)	193.0(12.8	285.4(16.9)	57.1(7.5)	40.7(6.3)	0.0(0.0)	0.0(0.0)
Sem	31.8(0.8)	17.9(0.6)	23.6(0.7)	20.1(0.7)	31.8(0.8)	46.0(1.1)	19.9(0 .7)	24.8(0.5)	18.9(0 .6)	35.7(1.4)	11.5(0 .7)	0.9(0.06)	2.0(0.2)	2.8(0.2)	1.9(0.1)
F-test	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s
C.D. at 5%	96.4(2.46)	54.3(1.8)	71.5(2.0)	60.9(2.2)	96.3(2.5)	139.6(3.4)	60.6(2.1)	75.3(1.7)	57.4(1.7)	108.3(4.4)	35.0(2.2)	2.7(0.2)	6.1(0.5)	8.4(0.6)	5.7(0.4)
CV	64.2(25.3)	22.1(15.3)	25.0(12.0)	20.2(12.4)	29.1(13.1)	35.9(16.1)	23.2(11.5)	21.7(8.1)	15.4(7.7)	43.8(25.6)	27.2(19.6)	13.3(6.0)	31.8(16.9)	8.4(44.9)	60.1(29.5)

*Figures in the parentheses are (n+0.5)1/2 transformed values

** SW=Standard week, DOS=Date of sowing, D1=3rd October, D2=18th October, D3=3rd November, D4=18th November, D5=3rd December

Table 2: Population build -up of *L. erysimi* on *Brassica* species in second date of sowing during *Rabi* 2016-17

SW/*Brassica* species	Aphid population per 10 cm CSL during standard week											
	51	52	1	2	3	4	5	6	7	8	9	10
B. rapa cv. BSH- 1	58.2(7.5)	121.1(11.0)	317.9(17.8)	194.4(13.86)	179.8 (13.4)	362.6(19.0)	346.0(18.4)	228.9(15.0)	156.9(12.5)	0.00(0.0)	0.0(0.0)	0.0(0.0)
B. rapa cv. YST- 151	300.9(17.3)	175.5(13.2)	520.7(22.8)	578.3(24.0)	730.2(27.0)	639.2(25.2)	568.5(23.8)	489.4(22.1)	411.5(20.3)	0.0(0.0)	0.0(0.0)	0.0(0.0)
B. juncea	79.3(8.3)	0.0(0.0)	118.9(10.9)	150.6(12.3)	224.8(15.0)	219.6(14.8)	322.1(17.8)	294.6(17.1)	138.4(11.7)	57.0(7.5)	0.0(0.0)	0.0(0.0)
B. napus	49.4(6.9)	73.5(8.6)	244.8(15.6)	75.3(8.6)	150.5(12.3)	67.8(8.2)	77.1(8.8)	59.8(7.7)	183.5(13.5)	24.4(4.9)	0.0(0.0)	0.0(0.0)
B. carinata	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	12.2(3.4)	60.5(7.8)	30.9(5.5)
B. nigra	0.0(0.0)	0.0(0.0)	0.0(0.0)	58.4(7.6)	69.3(8.3)	112.8(10.6)	81.2(9.0)	233.2(15.2)	124.6(11.1)	112.2(10.6)	0.0(0.0)	0.0(0.0)
E. sativa	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	8.1(2.8)	32.3(5.6)	28.0(5.3)	17.8(4.2)	3.5(1.8)	0.0(0.0)	0.0(0.0)	0.0(0.0)
B. alba	111.2(10.5)	0.0(0.0)	0.0(0.0)	0.0(0.0)	91.6(9.6)	252.9(15.9)	220.0(14.8)	319.6(17.8)	175.9(13.1)	22.7(4.7)	0.0(0.0)	0.0(0.0)
Sem	14.75(0.82)	5.3(0.2)	12.3(0.3)	15.5(0.4)	7.0(0.3)	25.5(0.6)	35.2(0.9)	24.9(0 .8)	19.5(0.7)	6.0(0.4)	0.9(0.6)	0 .7(0.6)
F-test	s	s	s	s	S	s	S	S	s	S	s	S
C.D. at 5%	44.73(2.50)	16.2(0.6)	37.3(0.8)	46.9(1.3)	21.4(1.0)	77.5(2.0)	106.9(2.8)	75.6(2.3)	59.0(2.2)	18.1(1.2)	2.8(0.2)	2.1(0.2)
CV	34.12(22.63)	20.0(8.9)	14.2(5.7)	20.3(8.7)	6.7(5.1)	20.9(9.0)	29.7(13.1)	21.0(10.8)	22.6(11.8)	36.2(17.8)	21.2(10.5)	30.4(15.4)

*Figures in the parentheses are (n+0.5)1/2 transformed values

** SW=Standard week

Table 3: Population build- up of *L. erysimi* on *Brassica* species in third date of sowing during *Rabi* 2016-17

SW/*Brassica* species	Aphid population per 10 cm CSL during standard week											
	51	52	1	2	3	4	5	6	7	8	9	10
B. rapa cv. BSH- 1	123.7(11.1)	112.5(10.6)	254.3(15.9)	109.3(10.4)	158.8(12.6)	305.4(17.5)	323.1(17.9)	260.9(16.1)	311.3(17.6)	0.0(0.0)	0.0(0.0)	0.0(0.0)
B. rapa cv. YST- 151	135.0(11.6)	220.1(14.8)	517.7(22.7)	412.7(20.3)	385.2(19.6)	565.1(23.7)	515.6(22.7)	747.2(27.3)	624.8(24.9)	183.3(13.5)	0.0(0.0)	0.0(0.0)
B. juncea	78.3(8.8)	0.0(0.0)	179.2(13.4)	106.5(10.2)	114.8(10.7)	235.9(15.3)	188.9(13.7)	272.6(16.5)	313.0(17.7)	190.5(13.8)	21.0(4.6)	0.0(0.0)
B. napus	0.0(0.0)	0.0(0.0)	67.1(8.2)	99.7(10.0)	133.1(11.5)	232.5(15.1)	74.3(8.6)	80.8(9.0)	168.9(13.0)	204.1(14.2)	98.7(9.9)	0.0(0.0)
B. carinata	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	29.7(5.4)	52.8(7.3)
B. nigra	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	69.8(8.1)	36.4(6.0)	10.9(3.30)	119.6(10.9)	89.3(9.4)	138.7(11.8)	0.0(0.0)

E. sativa	0.0(0.0)	0.0(0.0)	0.0(0.0)	7.7(2.8)	2.8(1.7)	20.6(4.5)	17.2(4.1)	15.8(4.0)	3.0(1.7)	1.2(1.1)	0.0(0.0)	0.0(0.0)
B. alba	0.0(0.0)	79.8(8.9)	41.6(6.4)	114.5(10.7)	136.9(11.7)	180.5(13.4)	157.9(12.5)	258.2(16.0)	305.2(17.4)	79.4(8.9)	0.0(0.0)	0.0(0.0)
Sem	4.3(0.2)	4.1(0.1)	8.0(0.2)	8.8(0.4)	11.2(0.3)	20.8(0.7)	11.2(0.3)	24.2(0.5)	33.5(0.7)	10.2(0.4)	4.4(0.2)	1.0(0.07)
F-test	s	S	s	s	s	s	S	s	s	s	s	s
C.D. at 5%	12.9(0.7)	12.4(0.4)	24.3(0.7)	26.6(1.2)	40.0(0.9)	63.1(2.2)	33.9(1.0)	73.5(1.6)	101.7(2.3)	31.0(1.2)	13.3(0.7)	3.2(0.2)
CV	17.5(9.9)	13.8(5.7)	10.5(4.9)	14.3(8.3)	16.7(6.4)	17.9(10.2)	11.8(5.2)	20.4(8.1)	25.2(10.1)	19.0(9.0)	21.1(10.5)	27.4(13.9)

*Figures in the parentheses are (n+0.5)1/2 transformed values
** SW=Standard week

Table 4: Population build -up of *L. erysimi* on *Brassica* species in fourth date of sowing during *Rabi* 2016-17

SW/*Brassica* species	**Aphid population per 10 cm CSL during standard week**									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
B. rapa cv. BSH- 1	29.3(5.4)	173.2(13.1)	387.2(19.5)	341.6(18.4)	286.9(16.9)	232.6(15.2)	302.4(17.2)	86.6(9.2)	0.0(0.0)	0.0(0.0)
B. rapa cv. YST- 151	30.8(5.5)	48.6(7.0)	303.2(17.4)	686.2(26.2)	638.6(25.0)	593.4(24.3)	718.8(26.7)	378.9(19.4)	110.8(10.5)	0.0(0.0)
B. juncea	0.0(0.0)	0.0(0.0)	137.1(11.6)	197.4(14.0)	238.9(15.4)	263.3(16.2)	326.9(18.1)	341.2(18.4)	315.7(17.6)	0.0(0.0)
B. napus	0.0(0.0)	0.0(0.0)	26.9(5.1)	32.4(5.7)	90.9(9.5)	51.1(7.1)	164.6(12.8)	223.6(14.9)	189.6(13.7)	0.0(0.0)
B. carinata	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	13.3(3.6)
B. nigra	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	99.4(10.0)	159.5(12.6)	210.0(14.5)	168.8(13.0)	0.0(0.0)
E. sativa	0.0(0.0)	0.0(0.0)	5.1(2.2)	0.0(0.0)	16.2(4.0)	16.6(4.1)	6.8(2.6)	2.5(1.5)	0.0(0.0)	0.0(0.0)
B. alba	17.8(4.2)	26.9(5.2)	119.2(10.9)	61.1(7.8)	109.3(10.4)	341.5(18.5)	201.3(14.2)	93.1(9.4)	27.6(5.2)	0.0(0.0)
Sem	1.4(0.1)	2.6(0.1)	24.5(0.7)	14.1(0.4)	50.4(1.0)	14.7(0.4)	44.0(1.0)	13.2(0.6)	25.8(0.8)	0.2(0.03)
F-test	s	S	s	s	s	s	s	s	s	s
C.D. at 5%	4.2(0.4)	7.9(0.4)	74.2(2.2)	42.8(1.1)	152.9(3.1)	44.5(1.2)	133.4(3.3)	40.1(1.8)	78.3(2.4)	0.7(0.1)
CV	24.9(11.7)	14.6(7.6)	34.6(15.2)	14.8(7.2)	50.6(17.6)	12.7(5.6)	32.4(13.3)	13.7(9.3)	44.0(18.2)	24.1(11.9)

*Figures in the parentheses are (n+0.5)1/2 transformed values
** SW=Standard week

Table 5: Population build-up of *L. erysimi* on *Brassica* species in fifth date of sowing during *Rabi* 2016-17

SW/*Brassica* species	**Aphid population per 10 cm CSL during standard week**						
	5	**6**	**7**	**8**	**9**	**10**	**11**
B. rapa cv. BSH- 1	287.9(16.9)	400.3(19.9)	421.4(20.5)	328.8(18.1)	352.9(18.8)	0.0(0.0)	2.4(1.5)
B. rapa cv. YST- 151	328.8(18.1)	711.2(26.6)	659.1(25.6)	434.8(20.8)	85.1(9.2)	0.0(0.0)	0.8(0.7)
B. juncea	79.4(8.9)	711.2(14.5)	337.9(18.3)	261.8(16.1)	467.5(19.2)	0.0(0.0)	1.6(1.2)
B. napus	66.3(8.1)	153.8(12.4)	235.9(15.3)	239.7(15.5)	193.5(13.9)	14.2(3.7)	2.0(1.4)
B. carinata	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	72.7(8.5)	26.0(5.1)	2.4(1.5)
B. nigra	0.0(0.0)	0.0(0.0)	85.7(9.2)	92.5(9.6)	132.2(11.5)	22.7(4.8)	0.7(0.7)
E. sativa	0.0(0.0)	18.4(4.3)	13.7(3.7)	5.10(2.25)	4.8(2.2)	0.0(0.0)	0.5(0.5)
B. alba	70.6(8.4)	177.7(13.3)	228.1(15.1)	231.9(15.2)	149.1(12.2)	0.0(0.0)	2.4(1.5)
Sem	8.6(0.3)	23.7(0.6)	22.5(0.5)	14.5(0.4)	112.6(2.5)	2.2(0.3)	0.5(0.3)
F-test	s	s	s	s	s	s	s
C. D. at 5%	26.1(0.9)	71.9(1.7)	68.4(1.6)	44.1(1.2)	341.6(7.5)	6.8(0.8)	1.5(0.8)
CV	14.3(6.5)	19.7(8.8)	15.8(6.85)	12.6(5.8)	107.0(36.1)	49.6(27.1)	54.4(40.8)

*Figures in the parentheses are (n+0.5)1/2 transformed values
** SW=Standard week

Table 6: Correlation and regression between the population of *L. erysimi* and weather parameters on *Brassica* species in different dates of sowing during *Rabi* 2016-17

***Brassica* species**	**DOS**	**Multiple regression equation**	**R^2**	**T_{max}**	**T_{min}**	**RH1**	**RH2**	**RF**	**SS**	**WS**
B. rapa cv. BSH-1	D1	$Y=2122.1-69.65\ X_1+30.03X_2-7.01X_3-15.1.72X_4-4.11X_5+48.47X_6-41.06X_7$	0.54	-0.65	-0.27	0.25	0.53	-0.02	-0.45	-0.39
	D2	$Y=5535.39-70.47X_1+79.30X_2-28.73X_3-15.14X_4-7.27X_5-123.76X_6-52.02X_7$	0.76	-0.60	-0.15	0.46	0.67	-0.11	-0.69	-0.12
	D3	$Y=5258.40-45.82X_1+67.81X_2-27.64X_3-15.47X_4-8.65X_5-148.53X_6-81.85X_7$	0.72	-0.40	-0.03	0.43	0.53	-0.14	-0.58	-0.34
	D4	$Y=-2753.8+143.04X_1-145.85X_2+38.08X_3-3.54X_4+953.41X_5-295.66X_6-133.9X_7$	0.84	-0.56	-0.35	0.73	0.63	-0.44	-0.80	-0.16
	D5	$Y=241.32+165.37\ X_1-138.16X_2-2.08X_3-144.75X_5-324.55X_6-74.87X_7$	0.75	-0.16	0.18	0.63	0.21	-0.63	-0.53	-0.56
B. rapa cv. YST-151	D1	$Y=5343.93-89.56X_1-4.84X_2-19.07X_3-10.19X_4+24.68X_5-58.69X_6-58.02X_7$	0.77	-0.80	-0.31	0.38	0.68	0.23	-0.69	-0.45
	D2	$Y=7651.78-87.63X_1+55.51X_2-34.10X_3-17.99X_4-24.72X_5-221.74X_6-62.01X_7$	0.87	-0.82	-0.51	0.66	0.68	-0.24	-0.83	-0.11
	D3	$Y=7589.94-149.83X_1+172.98X_2-16.35X_3-45.70X_4-16.03X_5-171.63X_6-71.51X_7$	0.54	-0.43	-0.12	0.43	0.38	-0.19	-0.54	-0.03
	D4	$Y=-4214.46+271.63X_1-198.33X_2+61.74X_3-16.96X_4+1427.75X_5-574.84X_6-278.54X_7$	0.73	0.0	0.19	0.37	0.22	-0.42	-0.40	-0.22
	D5	$Y=-15823.42+315.29\ X_1-472.38X_2+175.03X_3+2049.90X_5-352.29X_6-152.21X_7$	0.78	-0.38	0.01	0.78	0.34	-0.47	-0.65	-0.41
B. juncea	D1	$Y=407.35-71.37X_1+50.15X_2+13.28X_3-9.10X_4-3.93X_5+46.89X_6-21.01X_7$	0.88	-0.63	-0.43	0.52	0.39	-0.004	-0.004	-0.19
	D2	$Y=3909.89-46.01X_1+54.98X_2-16.41X_3-15.23X_4-14.31X_5-124.92X_6-22.21X_7$	0.84	-0.55	-0.20	0.49	0.50	-0.38	-0.71	0.06
	D3	$Y=-357.93-28.21X_1+56.98X_2+15.75X_3-10.71X_4-16.91X_5-23.34X_6-15.52X_7$	0.50	-0.04	0.12	0.24	0.07	-0.44	-0.25	-0.01
	D4	$Y=-394.37+126.06X_1-4.47X_2+14.42X_3-21.47X_4+404.52X_5-337.8X_6-104.33X_7$	0.83	0.51	0.45	-0.02	-0.43	-0.45	0.14	0.36
	D5	$Y=5386.25X_1+390.43X_2-441.68X_3-52.35X_5+371.92X_6-831.54X_7$	0.80	-0.002	-0.12	0.33	-0.15	-0.44	-0.30	-0.09
B. napus	D1	$Y=-268.08-14.90X_1-3.06X_2+8.79X_3-1.51X_4+14.75X_5+18.25X_6-29.76X_7$	0.78	-0.50	-0.48	0.63	0.35	0.58	-0.19	-0.39
	D2	$Y=-323.04-47.88X_1+55.52X_2+13.29X_3-5.94X_4-5.07X_5+414.09X_6-29.95X_7$	0.53	-0.38	-0.08	0.40	0.42	-0.05	-0.37	-0.36
	D3	$Y=1938.95+17.46X_1-2.87X_2+14.86X_3+3.44X_4-10.77X_5-1.11.X_6+32.42X_7$	0.39	0.07	0.12	0.07	-0.05	-0.40	-0.11	0.34
	D4	$Y=-2887.90+46.72X_1-26.15X_2+15.29X_3+8.71X_4-396.45X_5+41.58.X_6+4.16X_7$	0.81	0.67	0.50	-0.23	-0.61	-0.32	0.47	-0.09
	D5	$Y=-2763.84+103.88X_1-67.15X_2+22.08X_3+84.35X_5-122.92X_6-43.52X_7$	0.74	0.30	0.40	0.38	-0.06	-0.50	-0.13	-0.39

Table 6: Contd….

B. carinata	D1	$Y=-157.24+6.89X_1-3.02X_2-0.84X_3+1.40X_4-1.17X_5+5.82X_6+2.276X_7$	0.77	0.81	0.28	-0.53	-0.70	-0.17	0.76	0.40
	D2	$Y=791.50+0.96X_1-1.60X_2-7.03X_3-1.55X_4+0.61X_5-10.30X_6-0.63X_7$	0.75	0.65	0.37	-0.81	-0.67	-0.13	0.73	0.28
	D3	$Y=479.19+5.25X_1-6.89X_2-6.83X_3+1.90X_4+0.18X_5-2.43X_6-2.23X_7$	0.85	0.51	0.35	-0.86	-0.36	-0.09	0.66	0.29
	D4	-	-	0.29	0.27	-0.66	-0.04	0.92	0.43	0.26
	D5	$Y=2527.92+5.29X_1+5.29X_2+14.36X_3-27.28X_5-210.63X_5-46.56X_6+2.85X_7$	0.65	0.54	0.20	-0.66	-0.36	0.19	0.47	-0.004
B. nigra	D1	$Y=50.75-26.81X_1+4.93X_2+5.80X_3-1.18X_4-8.18X_5+35.84X_6-19.55X_7$	0.62	-0.52	-0.62	0.48	0.18	-0.21	-0.08	-0.17
	D2	$Y=729.81-12.89X_1+24.53X_2+2.40X_3-10.35X_4-5.09X_5-51.94X_6+16.32X_7$	0.45	-0.04	0.05	0.18	-0.04	-0.29	-0.25	0.38
	D3	$Y=807.24+6.52X_1+5.70X_2-5.66X_3-4.47X_4-2.51X_5-26.89X_6-11.70X_7$	0.50	0.64	0.46	-0.45	-0.56	-0.24	0.49	0.01
	D4	$Y=-3300.37+43.20X_1-27.14X_2+34.86X_3-8.67X_4+162.64X_5-4.89X_6-28.55X_7$	0.84	0.73	0.44	-0.31	-0.80	-0.25	0.58	0.07
	D5	$Y=554.27+29.03X_1+13.81X_2-11.31X_3-202.69X_5-35.99X_6-17.11X_7$	0.70	0.72	0.52	-0.23	-0.33	-0.20	0.39	-0.28
E. sativa	D1	$Y=-94.24+0.38X_1-1.02X_2+0.47X_3+0.76X_4-0.54X_5-0.08X_6+3.97X_7$	0.66	-0.45	-0.24	0.39	0.36	-0.11	-0.31	0.16
	D2	$Y=563.97+1.52X_1+0.83X_2-4.62X_3-0.43X_4-0.72X_5-22.78X_6-2.0X_7$	0.64	-0.26	0.09	0.23	0.46	-0.20	-0.57	0.13
	D3	$Y=376.0-0.52X_1+0.86X_2-2.73X_3-0.64X_4-0.42X_5-12.41X_6-0.72X_7$	0.54	-0.34	-0.08	0.22	0.36	-0.24	-0.51	0.20
	D4	$Y=163.80-3.30X_1+4.87X_2+1.42X_3-2.94X_4+67.82X_5-12.01X_6-7.17X_7$	0.60	-0.17	0.10	0.35	0.22	-0.25	-0.39	-0.13
	D5	$Y=-231.15+11.44X_1-17.41X_2+2.70X_3+57.12X_5-16.29X_6-3.97X_7$	0.64	-0.12	-0.22	0.42	-0.03	-0.37	-0.34	-0.18
B. alba	D1	$Y=-1118.75-37.03X_1+51.08X_2+16.15X_3-2.62X_4-0.58X_5+56.50X_6-14.86X_7$	0.60	-0.12	-0.02	0.31	0.16	0.13	-0.01	-0.12
	D2	$Y=5393.41+14.31X_1+9.30X_2-36.52X_3-13.88X_4-8.34X_5-234.38X_6-39.13X_7$	0.63	-0.13	0.03	0.28	0.20	-0.28	-0.46	0.001
	D3	$Y=2334.68-25.47X_1+36.46X_2-8.82X_3-11.37X_4-3.45X_5-76.47X_6-15.90X_7$	0.23	-0.21	-0.01	0.25	0.22	-0.11	-0.35	0.02
	D4	$Y=-460.13+18.15X_1-0.53X_2+62.74X_3-60.11X_4+1844.15X_5-291.94X_6-172.32X_7$	0.63	-0.01	0.04	0.32	-0.07	-0.33	-0.27	0.06
	D5	$Y=-3835.68+106.98X_1-88.38X_2+34.87X_3+228.14X_5-120.22X_6-41.49X_7$	0.56	0.16	0.32	0.52	0.01	-0.55	-0.27	-0.37

*Tmax =Maximum temperature °C, Tmin =Minimum temperature °C, RH1 =Morning relative humidity %, RH2 =Evening relative humidity, %, RF =Rainfall, mm, SSH =sunshine hours, WS=wind speed, DOS=Date of sowing, D1=3rd October, D2=18th October, D3=3rd November, D4=18th November, D5=3rd December

** Bold values indicates the significant correlation

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