Agric Res J **58** (5) : 801-807, *October* 2021
DOI No. 10.5958/2395-146X.2021.00114.9

INFLUENCE OF SOWING DATE AND WEATHER PARAMETERS ON THE RELATIVE ABUNDANCE AND DAMAGE OF MAJOR INSECT-PESTS OF WHEAT IN NORTH-WESTERN PLAINS OF INDIA

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ABSTRACT

Field studies were conducted during 2017-18 and 2018-19 to investigate the relative abundance and damage of major insect pests of wheat sown under four different sowing times (early, timely, late and very late). *Rhopalosiphum maidis* and *R. padi* species of aphids were more abundant during vegetative stages while *Sitobion miscanthi, S. avenae* and *Schizaphis graminum* species were recorded at earhead stage. The peak populations of 21.4, 22.8, 20.2 and 19.2 aphids per tiller were recorded in 8th, 9th, 10th and 11th in early, timely, late and very late sown crop, respectively during 2017-18. However, the peak of aphid population was recorded in 10th & 11 SMW in early and timely/late/very late sown crop, respectively during 2018-19. The aphid incidence got delayed with the delay in sowing time. The most vulnerable milky grain stage in the early sown crop (7-8 SMW) escaped the peak of aphid population while this stage coincided with peak of aphid attack in timely (9- 10 SMW) and late sown (9- 10 SMW) crop. The regression analysis of weather parameters showed that aphid incidence was not affected by any weather parameter in early sown while maximum and minimum temperature had significant positive effect on population build-up of aphids in timely sown wheat crop. With every one degree rise in maximum and minimum temperature, 2.05 and 3.88 fold increases in aphid incidence was observed in timely sown crop. Minimum temperature and morning relative humidity exerted their effects on late and very late sown wheat crop. With every one degree rise in minimum temperature, 3.51-3.85 fold increase in aphid incidence was recorded in late and very late sown crop. At the same time, with every one per cent rise in morning relative humidity, 1.97-1.98 fold increase in aphid population was recorded. The termite and pink stem borer damage was significantly higher in early sown crop as compared to timely and late sown crop during 2017-18. Relatively lower damage of termites and PSB was recorded in 2018-19 which could be attributed to lower minimum temperature (>2^{o}C) in December in 2018-19.

Keywords: Damage, Insect-pest, Relative abundance, Sowing time, Wheat

India is the second largest producer of wheat (*Triticum aestivum* L.) in world after China with a record production of 101.20 million tonnes during 2018-19 (Anonymous, 2019). Earlier, the wheat was considered as insect-pest free crop but after the adoption of rice-wheat cropping system in Indo-gangetic plains of India following green revolution, minor insects such as aphids, pink stem borer (PSB) and termites inflicted serious damage to the crop in certain pockets of the country (Deol, 1987). The insect pests inflict annual monetary losses to wheat crop in India to the tune of Rs. 413.68 billion (Dhaliwal *et al*., 2010). The wheat crop is attacked by more than 11 aphid species, out of which 5 are considered most important in north-western plains of India (Singh, 2009). Aphids damage the wheat crop by sucking sap from leaves, stem and earhead due to which infested leaves turn pale, wilt and wear a stunted appearance. Depending upon the environmental conditions and varieties, the pest can cause substantial (3-21%) yield losses (Singh and Deol, 2003). Termite is another important pest which damages wheat crop 3-5 weeks after sowing (WAS) while PSB damage is observed in late December to mid-January (4-10 WAS) (Singh, 2012). Generally, termite cuts the roots and underground stem portion of plants (Sharma *et al.,* 2004) while PSB bores into the stem and kills central shoots forming 'dead hearts' (Deol, 2002).

Climate change in terms of elevated temperature, changes in rainfall pattern and extreme climatic events has influenced crop productivity directly or indirectly by altering the crop-pest interactions (Chander *et al*., 2003, Prasannakumar *et al*., 2012). Climate change influences insect pest population and some insect viz. aphids multiply better at low temperature while others might be adversely influenced by reduced temperature (Aheer *et al*., 2008). Brabec *et al*., (2014) reported early arrival of aphids on wheat crop under warmer temperature based on 24 year sampling data in Czech Republic whereas Bell *et al*. (2014) reported no change

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Date of receipt: 22.06.2020, Date of acceptance: 04.07.2021

in aphid abundance with rise in temperature on the basis of 50-year suction trap data. Similarly the changes in the rainfall pattern and other weather parameters may also influence the insect pest scenario in wheat. Thus, adaption measures need to be taken to sustain wheat production of country in changed climate. Changes in the agronomic practices might play significant role in mitigating the effect of climate change. Alteration in the planting date is known to affect the prevalence of several insect pests in many crops.

Wheat is generally planted in November and harvested in early summer. However, available studies on effect of sowing time on insect pests of wheat yielded conflicting results; some researchers documented the higher incidence of some insect pests in early sown wheat viz. aphids (Pike and Schaffner, 1985, Brooks *et al*., 2003) while others demonstrated that late sown wheat harboured higher aphid population (Bhambhro, 2002). Therefore, concrete information on the incidence/damage of insect pests in wheat under different sowing times is still lacking. Thus, it becomes important to evaluate the effect of sowing time to devise sustainable crop production technologies under climate change scenario.

MATERIALS AND METHODS

The field experiments were conducted during 2017-18 and 2018-19 seasons at Punjab Agricultural University, Ludhiana (30° 55' N, 75° 54' E and 247 m above mean sea level). The wheat variety HD 2967 was sown in 8 x 2.5 m^2 = 20 m^2 plots with row to row spacing of 22.5 cm during two years of experimentation. The crop was sown using 100 kg/ha of seed in Randomized Block Design at four different dates of sowing i.e. early (first fortnight of November), timely (second fortnight of November) and late (first fortnight of December) and very late (second fortnight of December) during both the years of experimentation. Each treatment was replicated five times. The crop was raised by following agronomic practices as per recommendations of standard package of practices except for the application of insecticides (Anonymous, 2017). The data on major insect pests viz. foliage feeding aphids, termites and PSB, etc. were recorded at peak period of their activity. The first incidence and population build-up of aphids was recorded by counting the number of aphids per tiller from five randomly selected tillers from each plot starting from 50th standard meteorological week (SMW) to 14th SMW during 2017-18 and 2018-19. The observation on termite damage was recorded by counting damaged and total tillers from one-meter row length. These observations were recorded from five different spots at weekly intervals from each plot at 3, 4, 5 and 6 weeks after sowing (WAS).

The relative abundance and damage of PSB in wheat was examined in a separate experiment where no insecticide had been applied in the preceding crop for the control stem borers and the crop was manually harvested leaving 3-6 inch long rice stubble. The seeds of wheat variety HD 2967 were sown in field using Happy Seeder in Randomized Complete Block experiment design. There were five replicates for each treatment and size of the sub-plot was 8 × 2.5 = 20 m^2. Paddy straw @ 5 tonnes/ha, as is usually found in combine-harvested crops, was left in the experimental field. The observations on PSB damage were recorded by counting damaged and total tillers from one-meter row length. These observations were recorded from five different spots at weekly intervals from each plot 3, 4, 5 and 6 WAS. These observations were recorded until the first week of January every year. The PSB and termite damaged tillers were counted and removed from the plot to avoid repeated counting of the same tillers during the crop season.

The data on aphid incidence recorded during 2017-18 and 2018-19 was correlated with different weather parameters viz. maximum temperature (^oC), morning relative humidity (%), evening relative humidity (%) and rainfall (mm) and a regression model was developed using Minitab software. Termite and PSB damage data was insufficient for any correlation studies and it was subjected to one-way ANOVA. Similarly, average aphid incidence of the crop year 2017-18 and 2018-19 was also subjected to one-way ANOVA. The means were separated using least significant difference (LSD) at 5% probability level (Gomez and Gomez, 1984). Termites and PSB damage data were transformed to arcsine values prior to one way analysis of variance.

RESULTS AND DISCUSSION

The data on the weekly weather parameters and incidence of aphids recorded during *Rabi* 2017-18 and 2018-19 are shown in Fig. 1. During 2017-18, the maximum temperature ranged from 15.5- 34.8^oC whereas minimum temperature ranged from 5.3-20.6^oC. The temperature was almost similar during 2018-19 with maximum temperature ranging from 17.2-34.3^oC and minimum temperature ranged between 2.8-18.3^oC. Morning relative humidity ranged from 69-96 and 83-95% during 2017-18 and 2018-19, respectively. The evening relative humidity ranged between 29-76 and 33-62 % during 2017-18 and 2018-19, respectively. The highest rainfall of 21.4 mm and 68.4 mm was recorded during 7th and 6th SMW of 2017-18 and 2018-19, respectively.

Aphid incidence

Wheat crop was found to be infested by a complex of five species viz. *Rhopalosiphum maidis* (Fitch.)*, R.*

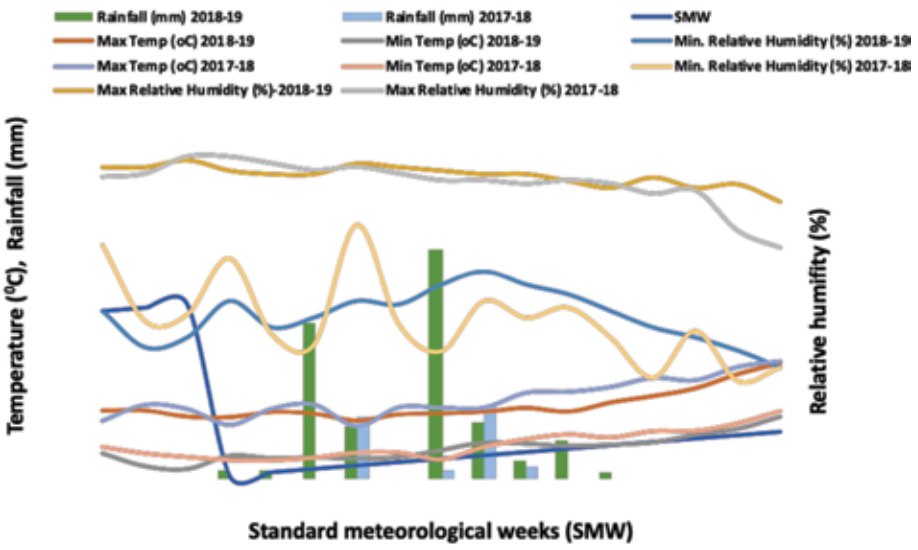

Fig. 1. Weather conditions during 2017-18 and 2018-19

padi (L.)*, Sitobion miscanthi* (Takahashi)*, S. avenae* (F.) and *Schizaphis graminum* (Rondani). The crop was mainly infested by *Rhopalosiphum* species during vegetative stages while *Sitobion miscanthi, S. avenae* and *Schizaphis graminum* damage was recorded at earhead stage. During 2018-19, the aphid incidence on crop was higher than that of previous year (Table 1). The results are based on mixed counts of different aphid species and the detailed results of each year are discussed below separately.

During 2017-18, the aphids first appeared during 51st SMW (2017) in early and timely sown crop while it appeared in 52nd SMW (2017) and 4th SMW (2018) in late and very late sown wheat crops, respectively (Table 2). A peak population of 21.4, 22.8, 20.2 and 19.2 aphids per tiller was recorded in 8th, 9th, 10th and 11th of 2018 in early, timely, late and very late sown crop, respectively. Thereafter aphid population started declining and got totally disappeared after 13th SMW in early, timely and late sown crop while it disappeared totally after 14th SMW in very late sown wheat crops.

During 2018-19, the aphids started appearing late than 2017-18 crop season in all sowing times (Table 1). The first incidence of aphids was observed in first and 3rd week January (2019) in early and timely sown crop. However, it first appeared in the last week of January (2019) in late and very late sown crops. The highest peak population of 10.9 aphids per tiller was recorded in 10th SMW (2019) on early sown crop. However, a peak of 10.4, 11.2 and 12 aphids per tiller was recorded in 11th SMW (2019) in timely, late and very late sown crop, respectively. Thereafter aphid population started declining and got totally disappeared after 13th SMW in early and timely sown crop and 14th SMW in late and very late sown crops. The recorded data indicated that the aphid incidence got delayed with the delay in sowing time. Overall, the sum of aphid population throughout the crop season was highest in early sown crop (82.6 aphids/tiller) and lowest in very late sown (72.0 aphids/tiller) during 2017-18. The same trend was observed in 2018-19 but fewer aphids/tiller (32.8-38) were recorded during 2018-19 as compared to previous years. It has been observed that substantial population of aphid was brought down by frequent rainfalls at regular intervals during 2018-19. At the same time, winters got delayed during 2018-19 which extended the period of aphid attack.

The incidence of aphids on earhead caused far more damage as compared to leaves (Singh *et al*., 2019). Because of this reason, the economic threshold level (5 aphids per earhead) was established on the basis of earhead damage (Singh *et al*., 2003). The results of present study revealed that the most vulnerable milky grain stage of early sown crop (7-8 SMW) escaped the peak of aphid infestation. However, the milky grain stage of timely (9-10 SMW) and late sown (9-10 SMW) crop coincided with the peak of aphid attack. The late sown crop was at vegetative stage at the time of peak period of aphid attack and hence evaded aphid attack. It has been reported earlier that the potential of aphid attack could be avoided by October sowing of wheat crop (Aheer *et al*., 1993; Barabas and Benovsky, 1985). Besides, earliness is also considered a key to adaption under terminal heat stress (Mondal *et al*., 2013). However, only a small percentage of farmers sow wheat crop in the month of October. Likewise, only few farmers sow wheat crop in the last week of December (very late sown) because of poor yields. Moreover, late sown wheat crop might be badly damaged by aphid attack,

Table 1. Incidence and population build of aphids under different dates of sowing during 2017-18 and 2018-19

Date of sowing of wheat crop	Aphid incidence (number of aphids\tiller) during different standard meteorological weeks (SMW)																	Sum of aphid population recorded throughout the season	Average of aphid population recorded throughout the season
2017-18																			
	50	51	52	1	2	3	4	5	6	7	8	9	10	11	12	13	14		
I Fortnight of November	0	0.4	0	0	0.2	0.6	1.8	6.2	11.2	18.6	21.4	10.8	9	2.2	0.2	0	0	82.6	4.86
II Fortnight of November	0	0.2	0.2	0	0	0.2	0.8	2.8	4.6	6.8	10.6	22.8	15.4	6.8	2	0	0	73.2	4.31
I Fortnight of December	0	0	0	0	0	0	0.6	0.2	2.4	2	10.4	12.8	18.4	19.2	8.2	3.8	0	78	4.59
II Fortnight of December	0	0	0	0	0	0	0.4	1.8	2	5.4	7.8	13.4	20.2	14.8	6.2	0	0	72	4.24
LSD (p =0.05)																			NS
2018-19																			
I Fortnight of November	0	0	0	0	0	0.2	0.6	0	0.6	1.2	2.6	4.2	7.4	10.4	3.2	2.4	0	32.8	1.93
II Fortnight of November	0	0	0	0.2	0	0.4	1.2	0	0.4	1.6	3.4	5.8	10.9	8.2	1.2	0.8	0	34.1	2.01
I Fortnight of December	0	0	0	0	0	0	0.2	0	0	0	0.8	2.4	5.2	11.2	4.6	8.4	1.4	34.2	2.01
II Fortnight of December	0	0	0	0	0	0	0.2	0	0	0	0.8	1.8	6.4	12	5.8	9.8	1.2	38	2.24
LSD (p =0.05)																			NS

Table 2. Regression equation of aphid incidence with different weather factors

Aphid incidence in early sown wheat	(R^2=0.22) = - 80 + 0.68 Max Temp + 0.16 Min. Temp + 0.79 Max Relative Humidity - 0.06 Min. Relative Humidity + 0.41 Rainfall
Aphid incidence in timely sown wheat	(R^2=0.47) = -97 + 2.05* Max Temp + 3.88* Min. Temp + 1.53 Max Relative Humidity + 0.46 Min. Relative Humidity - 0.16 Rainfall
Aphid incidence in late sown wheat	(R^2=0.72) = -146.5 + 1.35* Max Temp + 3.85* Min. Temp + 1.97* Max Relative Humidity + 0.62 Min. Relative Humidity + 0.13 Rainfall
Aphid incidence in very late sown wheat	(R^2=0.76) = -158.9 + 0.81 Max Temp + 3.51* Min. Temp + 1.98* Max Relative Humidity + 0.56 Min. Relative Humidity + 0.10 Rainfall

* Weather factors having significant effect

if the cool and cloudy weather continues in the month of March (Bhambhro, 2002). Amongst the timely and late planting, late sown crop harboured more aphids at most susceptible stage of wheat crop. In view of threat of terminal heat in late planting, timely sowing deemed to be an important agronomical adaption under climate change (Khan *et al*., 2007; Roy *et al.*, 2013).

The regression analysis of aphid incidence with different weather parameters indicated that none of the weather parameter exerted significant influence on aphid incidence in early sown wheat crop. The temperature has significant effect on population build-up of aphids in timely sown wheat crop. With every one degree rise in maximum and minimum temperature, 2.05 and 3.88 fold increase in aphid incidence was observed in timely sown crop, respectively (Table 2). On the other hand, minimum temperature and morning relative humidity exerted its effect on late and very late sown wheat crop. With every one degree rise in minimum temperature, 3.51 to 3.85 times increase in aphid incidence were recorded in late and very late sown crop. At the same time, with every one per cent increase in morning relative humidity, 1.97 to 1.98 fold multiplication in aphid population was observed in late and very late sown crop.

The present investigations on correlation of weather

Table 3. Incidence and population build of termites and pink stem borer under different dates of sowing during 2017-18 and 2018-19

Sowing time	Termites damage (% damage)					Pink stem borer damage (% damage)				
	Weeks after sowing (WAS)					Weeks after sowing (WAS)				
	3	4	5	6	Total	3	4	5	6	Total
2017-18										
Early (I fortnight Nov.)	3.46	3.69	3.88	2.10	13.13 (21.23)	2.31	2.66	1.58	0.80	7.35 (15.71)
Timely (II fortnight Nov.)	3.10	3.59	3.57	2.01	12.27 (20.49)	1.76	2.29	1.21	0.71	5.97 (14.13)
Late (I fortnight Dec.)	-	2.76	2.83	2.72	8.31 (16.74)	-	0.92	1.12	0.97	3.01 (9.97)
Very late(II fortnight Dec.)	-	-	2.09	2.10	4.19 (11.80)	-	-	1.09	1.10	2.19 (8.49)
LSD (p =0.05)					(0.31)					(0.35)
2018-19										
Early (I fortnight Nov.)	2.95	3.80	3.13	1.80	11.68 (19.97)	1.87	2.22	1.30	0.60	5.99 (14.18)
Timely (II fortnight Nov.)	2.80	3.09	2.83	1.10	9.82 (18.25)	1.52	2.05	1.03	0.45	5.05 (12.97)
Late (I fortnight Dec.)	-	2.08	2.79	2.52	7.39 (15.76)	-	1.10	1.73	0.64	3.47 (10.72)
Very late(II fortnight Dec.)	-	-	2.08	1.82	3.90 (11.37)	-	-	-	-	-
LSD (p =0.05)					(0.44)					(0.47)

* Figures in parentheses are arcsine transformed means

factors with aphid incidence showed that a maximum and minimum temperature of 20-27.2°C and 9.6-12.2°C was highly conducive for the growth and multiplication of aphids. Aphids did not appear below 5.3-5.9°C and it started declining after 26.9-27.2°C in present studies. Appearance of winged forms of aphids at higher temperature helps in their migration and ultimately results in the decline of aphid population (De Barro, 1992). Chander (1996) also reported that a temperature of 7-25°C was highly favourable for multiplication of wheat aphids. The total rainfall was comparatively high in 2018-19 (165 mm) as compared to 2017-18 (45.4 mm) and it happened at regular intervals which did not allow the aphid population to exceed beyond 10.9 aphids/tiller in 2018-19. The regression analysis in present study revealed negative relationship between aphid incidence and rainfall. Previously Chander (1998) also reported similar results.

Termite damage

During 2017-18, the cumulative termite damage recorded at seedling stage in different dates of sowing indicated that early sown crop (13.13 %) suffered significantly more termite damage as compared to timely (12.27 %), late (8,31 %) and very late sown (4.19%) crop (Table 3). Similarly, the termite damage was significantly higher in early sown crop (11.68%) as compared to timely (9.82%), late (7.39%) and very late sown (3.90%) crops during 2017-18. However, the termite damage was comparatively less during 2018-19 as compared to 2017-18. Most of the weather parameters did not differed significantly among the two years of investigation except the minimum temperature. The average minimum temperature of 2018-19 was 5.13°C as compared to 7.10°C during 2017-18. Earlier, Singh *et al.* (2014) also reported that early onset of winter lower the termite damage in wheat crop.

Pink stem borer damage

As with the termite damage, the pink stem borer damage was significantly higher in early sown (7.35 %) crop as compared to timely (5.97 %) and late (3.01 %) sown crop on all dates of observations during 2017-18 (Table 3). Similar trend was observed in 2018-19 but this year overall population of pink stem borer was comparatively less as compared to previous year. Relatively lower minimum temperature (2.8-7.4°C) recorded during December 2018-19 as compared to 2017-18 (6.3-9.3°C) could be a possible reason for less PSB damage (Fig. 1). The results of present study are corroborated by findings of Hatchett *et al*. (1987) and Singh (2012) also who reported that early-planted wheat is more likely to be inhabited and damaged by lepidopetous insect pest.

Overall, the present studies concluded that aphid incidence was not influenced by weather parameter in early sown crop while temperature and relative humidity increased their population at most vulnerable milky grain stage of timely and late sown crop. The termite and pink stem borer damage was higher in early sown crop as compared to timely and late sown crop. Thus, farmers should regularly monitor timely/late sown crop for aphid incidence and early sown crop for termite and pink stem borer damage.

Authors' contribution

Conceptualization of research work and designing of experiments (BS); Execution of field/lab experiments and data collection (BS); Analysis of data and interpretation (PS); Preparation of manuscript (BS, PS).

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