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Research Article

Impact of Conservation Agriculture on Aphid infestation in Mustard under Rice-Mustard Cropping System

PRAGYA[1], D.K. DAS[1]*, V.K. SEHGAL[1], T.K. DAS[2] AND J. MUKHERJEE[1]

[1]*Division of Agricultural Physics, Indian Agricultural Research Institute, New Delhi-110012*
[2]*Division of Agronomy, Indian Agricultural Research Institute, New Delhi-110012*

ABSTRACT

One of the reasons for lower mustard (*Brassica juncea* L.) production in India is aphid (*Lipaphis erysimi* Kalt) infestation which considerably reduces both quality and quantity of produce. These losses can be minimized by suppression of aphid population through modification of crop microenvironment. Field experiments were conducted to know the aphid [*Lipaphis erysimi* (Kaltenbach)] population under different treatments of conservation agriculture (CA) in mustard (*Brassica juncea* var. Pusa Mustard - 25) of rice-mustard cropping system so as to determine best treatment to suppress their population. Number of mustard aphids per top 10 cm of the main shoot was counted on randomly selected plants at weekly intervals in all the treatments. Aphid appeared during 51st standard meteorological week (SMW) might be due to cloudiness and rainfall occurred in 50th SMW. Among the 8 treatments, treatment T6 consisting of mungbean residue + zero till direct seeded rice followed by rice residue + zero till mustard recorded the least number of aphids (50 aphids/10 cm of main shoot) during the peak infestation time(5th SMW) whereas the conventional treatment T8 consisting of transplanted rice followed by conventional till mustard) had second highest number of aphid population (104 aphid /10 cm main shoot). Except treatment T2 (zero till direct seeded rice + brown manuring followed by zero till mustard) all other conservation treatments showed lower aphid population. Maximum aphid population (205 aphids/10 cm main shoot) was observed in T2 which is difficult to explain and further research is needed on this aspect. This study suggests that the modification of microenvironment of mustard crop under different CA treatments may decrease aphid infestation in mustard to some extent which in turn may reduce the need for application of harmful chemicals vis-a-vis the cost of plant protection. This may be useful to protect the environment from degradation. Therefore, it could be included as one of the important components in the integrated pest management module.

Key words: Aphid, Conservation agriculture, Crop residues, Crop rotation, Cropping systems, Mustard, No tillage

Introduction

Indian mustard (*Brassica juncea* L.) is a major winter (*rabi*) season oilseed crop grown mainly in northern parts of India. Though India ranks first in both acreage and production of mustard and rapeseed in Asia, the average yield (per hectare) is low in comparison to other mustard growing countries. One of the reasons of low yield is infestation of this crop by a number of pests. Mustard aphid, *Lipaphis erysimi* (Kaltenbach) (Homoptera: Aphididae) is the most destructive one (Das, 2002) and it can reduce the yield by 20 to 50 per cent and in extreme conditions the loss can go as high as 78 percent (Prasad and Phadke, 1983). Insect population

*Corresponding author,
Email: dkdas@gmail.com

dynamics is affected by numerous factors among which abiotic parameters play crucial role. Temperature and relative humidity play an important role on aphid appearance, multiplication and disappearance (Vekaria and Patel, 2000).

At present, the pest management strategy mainly relies on broad-spectrum insecticides. To control increasing pest infestation, higher doses of chemical pesticides are used. Development of pesticide resistance in pests has resulted in requirement of higher doses of pesticides. In about 150 plant pathogens, 100 weeds, and more than 500 insect and mite pests, resistance has been observed (WRI, 1994). Excess usage of harmful chemicals has led to deterioration of natural resources and environment, thus, posing threat to water, land and atmosphere. With a view of sustainable development in agriculture, adjustment in management techniques such as crop rotation, sowing dates, plant density, row spacing and stubble retention are getting importance to minimize insect pest populations (Bardner, 1983; Berlandier and Bwye, 1998; Jones, 2001; McEwen and Yeoman, 1989). Arthropod management is still heavily reliant on broad-spectrum insecticides for many pests, particularly aphids. But field assessment, tillage, sowing date, plant density and weed control can minimize pest incursions also (Stoddard *et al*., 2010).

Conservation agriculture (CA) practices which incorporate minimal disturbance of the soil, along with good agronomic practices such as crop rotation and residue management can be useful to control the aphid infestation. It is a concept which considers all the factors for sustainable crop production *i.e.,* economy, ecology and performance. Among the abiotic factors, temperature and relative humidity are important parameters. They are perhaps the most important overall causes of insect pest outbreaks in agroecosystems through their impacts on insect physiological migration, development and dispersal (Risch, 1987). The microenvironment including temperature and humidity prevailing within crop profile is different from outside environment and has great influence on pests and diseases, Thus, reduction in pests and diseases incidences by modifying microclimate instead of completely relying on harmful pesticides can prove beneficial for environment in the long run along with saving cost of plant protection.

The studies on crop microenvironment under conservation agriculture and conventional practices in relation to pest and disease infestation are very limited. Review has been done for habitat management focussing attention on practices favouring natural predators and parasitoids and implementation of conservation biological control (Landis *et al*., 2000). System and management affecting microclimate of the crop should be understood properly for effective management (Olanya *et al*., 2006). Thus, present study was undertaken in a conservation agriculture (CA) system where rice (rainy season)-mustard (winter season) being practised for three years (2012-2015).

The study was conducted with a objective to find the effect of microclimate modification through conservation agriculture on aphid abundance and yield of mustard in rice-mustard cropping system.

Materials and Methods

Field experiments were conducted on mustard in rice-mustard cropping system during winter (November-April) seasons of 2014-15 on a fairly leveled topography at the experimental farm of ICAR-Indian Agricultural Research Institute (IARI), New Delhi (28°37′ N, 77°12′ E and 228.16 m above the mean sea level). The climate of the site was characterized by a typical semi-arid type with dry hot summer and cold winter and with an average annual rainfall of 710 mm (80% of which is received during southwest monsoon during June–September). The surface soil (0–30 cm) is sandy loam in texture with 52.1% sand, 22.6% silt and 25.3% clay. The average bulk density was 1.48 Mg m^{-3}; pH (1:2.5 soil : water suspension) was 8.0; organic C content was 0.57%; available N, P and K were found to be 170.6, 18.6 and 275 kg ha^{-1}, respectively.

Table 1. Treatments adopted in the experiment

S. no.	Treatment description	Treatment short form	Treatment code
1	Zero Tillage Direct Seeded Rice–Zero Tillage Mustard	ZT DSR - ZTM	T1
2	Zero Tillage Direct Seeded Rice + Brown Manuring – Zero Tillage Mustard	ZT DSR + BM -ZTM	T2
3	Zero Tillage Direct Seeded Rice +Mustard Residue–Rice Residue + Zero Tillage Mustard	ZT DSR + MR – RR + ZTM	T3
4	Zero Tillage Direct Seeded Rice + Mustard Residue + Brown Manuring – Rice Residue + Zero Tillage Mustard	ZT DSR + MR + BM –RR + ZTM	T4
5	Zero Tillage Direct Seeded Rice+ Mungbean Residue-Zero Tillage Mustard	ZT DSR + MBR – ZTM	T5
6	Zero Tillage Direct Seeded Rice+ Mungbean Residue- Rice Residue + Zero Tillage Mustard	ZT DSR + MBR – RR + ZTM	T6
7	Transplanted Rice - Zero Tillage Mustard	TPR – ZTM	T7
8	Transplanted Rice - Conventional Till Mustard	TPR – CTM	T8

Treatments T1 to T7 were considered conservation agriculture (CA) treatments and treatments T8 was considered conventional treatment.

The experiment was laid out in a randomized block design (RBD) with 8 treatments (Table 1) The treatments were replicated thrice. The mustard crop (cultivar-Pusa Mustard-25) was sown on 11th November 2014 after harvest of the rice crop (cultivar-PRH 10) and standard agronomic practices were followed to ensure optimum plant growth during the experimental period.

Aphid population was recorded on top 10 cm on main stem on 10 plants in each replication at weekly intervals. Daily meteorological data on maximum temperature (T_{max}) and minimum temperature (T_{min}); mean relative humidity (RHmean); mean wind speed (MWS); hours of bright sunshine (SUNSHINE); rainfall and open pan evaporation (EP) for all locations were collected from adjacent standard agro-meteorological observatory.

Crop profile temperature and relative humidity were measured at different heights from the ground (0 cm, 30 cm, 60 cm, 90 cm, 120 cm and top of canopy) for mustard with the help of a pocket weather tracker (Model: Kestrel 4000) around 14:00 hours and average profile temperature and relative humidity of each treatment were worked out.

For crop yield, an area of 1m x 1m was harvested manually from each plot after physiological maturity of mustard. After sufficient air drying, these samples were weighed to get final above ground biomass (g m^{-2}). Then plant samples were thrashed in the laboratory and the seeds were separated.

Statistical analysis

The data sets were processed at last for analysis of variance as applicable to randomized block design, to test differences among the various treatments and their interactions using Statistical Analysis System (SAS).

Results and Discussion

In this study, the effect of weather parameters (recorded in nearby observatory) on aphid appearance and population growth across the treatments were found out first. Later, the variation of aphid population in conservation agriculture and conventional treatments was presented and the causes of variation were tried

Table 2. Temporal variation of aphid infestation in mustard (no. of aphids/top 10 cm main shoot) as influenced by different treatments under conservation and conventional agriculture during winter (*rabi*) season (2014-15)

Treatments	SMW			
	51st	2nd	5th	7th
T1	28	46	99	71
T2	46	96	205	115
T3	36	61	92	52
T4	15	35	55	38
T5	18	64	88	51
T6	12	26	50	28
T7	25	66	90	56
T8	34	78	104	55
LSD ($p<0.01$)	12	26	14	43

SMW- Standard Meteorological Week

to be found out with the help of micrometeorological parameters recorded with in the canopies.

Over all aphid population dynamics with respect to temperature

Time taken for the first appearance of aphids and its subsequent attainment of peak population in presented in Table 2. The infestation of aphid across the treatments started in 51st standard meteorological week (SMW) which might be associated with cloudiness rainfall occurred in 50th SMW. However, during the next 4 weeks the aphid population growth was low which may be attributed to low (<8°C) minimum temperature (Fig. 1 and Fig. 2). During 4th SMW, minimum temperature increased beyond 8°C and probably resulted in increased population growth. This time coincided with the flowering stage of mustard crop that made the situation favourable for population increase. Aphid infestation in mustard depends on crop phenology and also on prevailing weather parameters. The bright yellow flowers of the mustard crop attracted the aphid and 100% flowering stage with weekly mean minimum temperatures above 8°C along with cloudiness with light rain were found to be most congenial for aphid growth (Das *et al*., 2009).

The effect of daily maximum and minimum temperatures on aphid population growth was studied during 3rd to 6th SMW separately. The study revealed that during 3rd SMW, daily maximum temperature remained high (around 20°C) and minimum temperature remained low (<8°C) (Fig. 3) and aphid population was also found to be low mainly (Fig. 2). It started peaking up during 4th SMW. During this week, daily

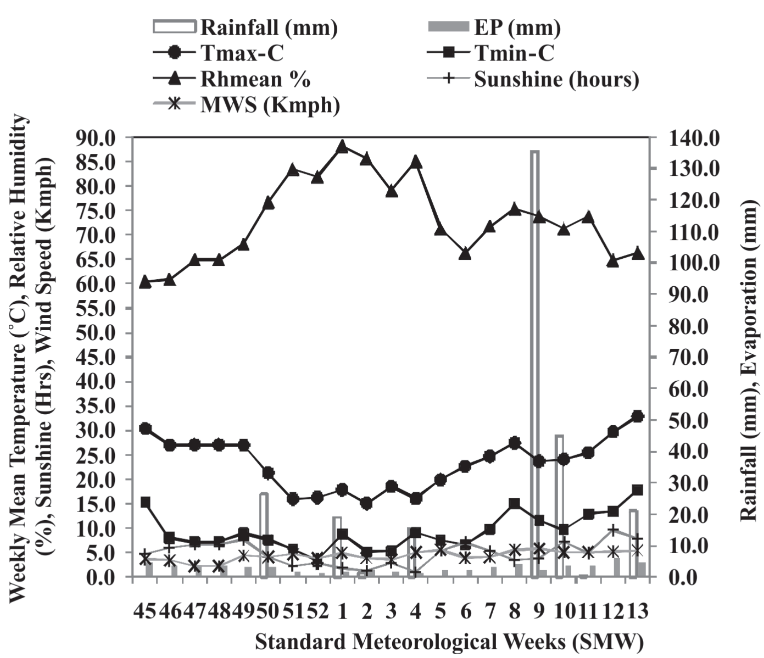

Fig. 1. Weather parameters for winter (*rabi)* season (2014-15)

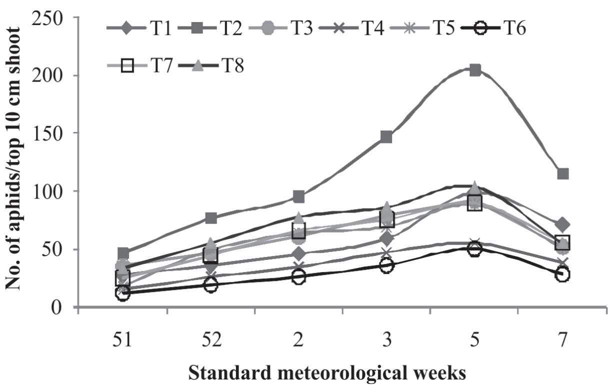

Fig. 2. Effects of different treatments under conservation and conventional agriculture on aphid infestation in mustard during winter (*rabi)* season of (2014-15)

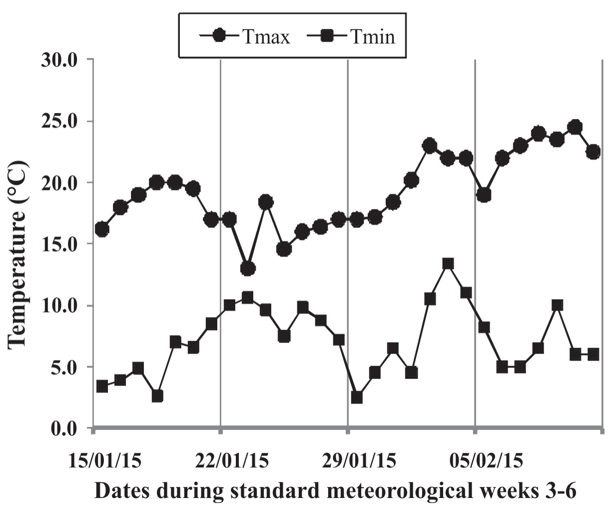

Fig. 3. Daily maximum and minimum temperature during 3rd to 6th standard meteorological weeks (SMW)

maximum temperature reduced and remained within 13°C and 17°C, whereas, daily minimum temperature increased and remained mostly above 8°C. Low maximum and high minimum temperature might be congenial for aphid population growth. As a result, the highest population was observed during 4th-5th SMW. From 5th SMW, both daily maximum and minimum temperature started increasing and a decline of the aphid population was observed across the treatments. During 4th SMW, the daily range of temperature (i.e., maximum minus minimum) was less. That might be another reason for population peak up and it reached maximum at 5th SMW (with one week lag period).

Variation of aphid population in conservation and conventional treatments in relation to mean profile temperature and relative humidity within the Canopy

Among all the treatments, T2 (ZT DSR+ BM-ZTM) reported maximum aphid population followed by conventional treatment T8 (205 and 104 aphids/top 10 cm main shoot, respectively). Also, other conservation treatments showed aphid population lower than the conventional treatment T8.

The mean profile temperature and relative humidity of the mustard crop in three different days after sowing for mustard crop was shown in Table 3. On 70 days after sowing (DAS), the mean profile temperature of T6 (MBR+ZT DSR-RR+ZTM) was found to be the highest (16.3°C) among the treatments and was significantly different from the conventional treatment T8 (15.6°C). Similar trend was observed in other two dates of observations (80 and 90 DAS). The lowest aphid population was observed in T6 treatment (peak value 50 aphids/top 10 cm main shoot on 5th SMW). Earlier study reported higher accumulation of GDD, a temperature based index led to lower infestation of mustard aphid (Chakravarty and Gautam, 2002). Aphids tend to select plants surrounded by bare soil (Jallad *et al.,* 2007). T6 treatment included mung bean residue retention in rice crop and rice residue retention in mustard crop. This might have affected the aphid population negatively. Population of leaf hopper (*Amrasca bigutulla)* certainly reduced in zero tillage and the rice stubble mulch. This pattern was observed due to strong predisposition of insects to land on bare soil, which is assumed to be related to long-wavelength radiation obstruction by the mulch and stubble on the zero-tillage treatments (Stinner and House, 1990). The highest infestation of aphid in T2 treatment could be explained to some extent as it did not contain rice residue. As T2 treatment did not have rice residue to check soil evaporation and unchecked soil evaporation probably created profile humidity at par with conventional treatments which in turn attracted the aphids. Aphid colonization of lupins and

Table 3. Temporal variation in mean profile temperature within the canopy in mustard in different treatments under conservation and conventional agriculture during winter *(rabi)* season (2014-15)

Treatments	Mean profile temperature (°C)			Mean relative humidity (%)		
	70 DAS (3rd SMW)	80 DAS (5th SMW)	95 DAS (7th SMW)	70 DAS (3rd SMW)	80 DAS (5th SMW)	95 DAS (7th SMW)
T1	15.7^DE	16.5^BC	20.8^C	70.5^AB	49.7^BCD	50.5^AB
T2	15.6^E	16.1^D	21.3^ABC	71.4^A	53.2^A	51.7^A
T3	16.0^BC	16.6^AB	21.3^ABC	68.4^C	49.9^D	45.2^DE
T4	16.2^AB	16.6^AB	21.6^AB	68.3^C	49.5^BCD	45.8^DE
T5	16.1^BC	16.6^AB	21.8^AB	68.1^C	50.9^ABC	46.8^CDE
T6	16.3^A	16.7^A	22.0^A	68.7^BC	51.5^ABC	49.6^ABC
T7	16.1^BC	16.5^BC	21.2^BC	71.1^A	49.1^CD	44.2^E
T8	15.6^E	16.3^C	21.0^BC	71.4^A	53.5^AB	47.8^BCD
LSD (p<5%)	0.2	0.1	0.7	1.9	2.9	3.4

Values followed by same letter do not differ significantly by DMRT; DAS- Days after sowing; SMW- Standard Meteorological Week

wireworm infestation of sunflowers were reduced when planted directly into cereal stubble (Robertson and Kettle, 1993; Berlandier and Bwye, 1998; Bwye *et al*., 1999). The aphid population was also higher in conventional treatment, T8. Significantly higher mean profile relative humidity (above 71%) was recorded with in the canopies of T2 and T8 than that of other CA treatments on 70 DAS. Higher relative humidity within the canopy probably played an important role in determining the level of infestation in the subsequent period. Effect of high humidity (72-85%) along with temperature (10-13.5°C) and cloudiness were optimal for population increase (Bishnoi *et al*., 1992).

Conservation treatments modified the microclimate which resulted in higher mean profile temperature in winters and lower relative humidity in this winter season except T2. Since conventional treatment had lower mean profile temperature *i.e.* (5th SMW) 16.3°C and higher mean relative humidity (53.5%), therefore, it showed high aphid abundance than other conservation treatments (except T2).

Pest abundance and distribution is also determined by tillage than compared to other cultural or agronomic practices such as cropping patterns and pesticide usage. Moreover, interaction of tillage with other agronomic practices affects the changes in invertebrate pest communities. Twenty eight percent of the species and their damage increased with decreasing tillage, 29% showed no significant influence of tillage, and 43% decreased with decreasing tillage (Fava *et al*., 1996).

Table 4. Final biomass and yield of mustard in different treatments under conservation and conventional practices during winter (*rabi*) season (2014-15)

Treatments	Final biomass ($t\ ha^{-1}$)	Yield ($t\ ha^{-1}$)
T1	5.50	1.54
T2	6.50	1.64
T3	6.40	2.04
T4	7.55	2.18
T5	6.83	1.89
T6	7.80	2.57
T7	6.03	1.63
T8	5.63	1.67
LSD (p < 0.05)	1.20	0.32

Above ground dry final biomass and seed yield

Above ground biomass and yields of mustard crop in all treatments (conservation and conventional) was given in Table 4. In mustard, final above ground biomass and yield was observed maximum in T6 (MBR+ ZT DSR- RR+ ZTM) (7.80 $t\ ha^{-1}$ and 2.57 $t\ ha^{-1}$ respectively) due to low damage done by aphid population. T8

(TPR- CTM) recorded the lowest final biomass (5.63 t ha^{-1}) and yield (1.67 t ha^{-1}) followed by T1 (ZT DSR- ZTM) and T2 (ZT DSR + BM – ZTM). Thus, despite being the highest aphid population in T2 yield reduction was less compared to conventional treatment T8 (TPR – CTM).

Conclusions

Aphid infestation causes significant decline in mustard yield. So it is necessary to find out alternative ways to check their population instead of completely relying on harmful pesticides. In this regard micrometeorology plays crucial role by checking the population of these pests and diseases without causing environmental degradation. In this study, all the conservation plots showed lower aphid population in mustard (except T2). Treatment T6 (Zero till direct seeded rice+ Mungbean residue followed by Rice residue + Zero till mustard) showed the least aphid abundance whereas T2 (Zero till direct seeded rice + brown manuring followed by Zero till mustard) showed maximum aphid population. Conventional treatment T8 (Transplanted Rice followed by Conventional Till Mustard) showed higher aphid population than rest other conservation treatments (except T2). High incidence of aphid population in conservation plot T2 is still difficult to explain and could be an area of further research. Microclimate modifying conservation agriculture practices can be used to reduce aphid population thereby decreasing the yield losses. Hence, it can be included in integrated pest management approach in future.

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