J. Biol. Control, 23(4): 375–379, 2009

Influence of weather factors and spray patterns on wheat aphids and their coccinellid predator

SANEHDEEP KAUR[1], VIJAY KUMAR[2], PARAMJIT SINGH[2] and K. S. BRAR[2]
[1]Department of Zoology, Guru Nanak Dev University, Amritsar 143005, Punjab, India.
[2]Department of Entomology, Punjab Agricultural University, Ludhiana 141004, Punjab, India.
E-mail: sanehsaini@gmail.com

ABSTRACT: Wheat is a premier winter cereal crop in India. Among the various insect pests, aphids appear as a complex of species including *Sitobion avenae* (F.), *S. miscanthi* (Takahashi), *Rhopalosiphum maidis* (Fitch) and *R. padi* (L.). *Coccinella septempunctata* L. is a dominant predator of aphids. Various spray patterns were tested to check their effectiveness against aphids. All the treatments more effectively controlled the aphids compared to control. However, the insecticides adversely affected the predator population. The predator populations was reduced by 87.5, 85.4 and 78.9%, respectively, one day after spray in completely sprayed, sprayed strip and unsprayed strip plots, whereas the reduction was only 22.8% in peripherally sprayed plot. The predator recovery started after 3 days in all the treated plots but it was very slow in the completely sprayed plot. Among all the treatments, the peripherally treated plot conserved maximum predator population and controlled the multiplication of the pest.

KEY WORDS: Wheat aphids, coccinellid, *Coccinella septempunctata,* spray pattern, recovery, weather factors

INTRODUCTION

Wheat (*Triticum aestivum* L.) is a winter cereal crop in India. Punjab is one of the major wheat producing states (Dhaliwal and Arora, 1996) where termites, armyworm, aphids, American bollworm and brown wheat mite are reported to be the key pests of wheat (Deol, 1990). Among these, aphids appear as a complex of species, consisting predominantly of *Sitobion avenae* (F.), *S. miscanthi* (Takahashi), *Rhopalosiphum maidis* (Fitch) and *R. padi* (L.) (Deol *et a1*., 1987). Aphids have become regular pests and cause great losses in yield by sucking sap, especially in the milky grain stage and also due to the development of sooty mould. Deol (1990) reported that 5, 15, 30 and 50 aphids per ear head can cause 13.3, 21.8, 38.1 and 47.7 % reduction in grain yield, respectively. A number of insecticides have been recommended for aphid control. However, their excessive use has resulted in a number of side effects. The need of the hour is to minimize the insecticide usage so as to conserve natural enemies. Among the natural enemies, coccinellids are often numerically dominant aphid predators on wheat. Among these, *Coccinella septempunctata* L. and *C. transversalis* F. play an important role in suppressing the aphid population. There are many reports which indicate that insecticides also adversely affect the predator population (Shukla *et al*., 1994; Rathod and Baporda, 2002). Leaving some unsprayed area in the field is a potentially useful technique for the conservation of biological control agents of cereal aphids. In the light of this, field trials were conducted by adopting need based spray using different methods including complete spraying, strip spraying and peripheral spraying of the plots. The present studies were conducted to investigate the method of spray that could keep the insect population below ETL level and conserve the predator population and to determine the level and duration of pest and predator depletion and their recovery / reinvasion pattern after insecticide treatment.

MATERIALS AND METHODS

The experiment was conducted during *rabi* 2004-2005 in an area of 0.8 ha (2 acres) in Jalandhar district of Punjab (India). The wheat variety PBW 343 was sown in the first week of November following all recommended practices of Punjab Agricultural University, Ludhiana (Punjab). The field was surrounded by wheat on all the sides and was divided equally into four plots for the following treatments:

T_1 = Strip spraying: Six metre wide strip was sprayed and 6m wide strip was left unsprayed alternately.

T_2 = Peripheral spraying: Three meter wide area on the periphery only was sprayed.
T_3 = Complete spraying: Whole of the plot was sprayed.
T_4 = Untreated control: No insecticide was sprayed.

Each treatment plot was further divided into five subplots. When the crop reached the earhead stage, observations were recorded on aphid and predator populations. The aphid and predator populations were counted on 30 randomly selected ears in each subplot at weekly interval. The grubs, pupae and adults of the predators were counted separately. When the pest population reached economic threshold level (ETL) (5 aphids/ear) in the second week of March, the recommended insecticide monocrotophos 36 SL (Nuvacron) @ 150 ml/acin 100 liters of water was sprayed with a knapsack sprayer.

The field was sprayed only once as the pest population did not reach ETH level subsequently. Before spraying, the data on aphid and predator population were recorded separately in each subplot of each treatment. The observations were recorded on 1, 3, 7 and 15 days after insecticidal treatment. Both pest and predator populations were recorded separately in sprayed and unsprayed strip and periphery and the unsprayed centre of that plot. The data were transformed by n+1 square root transformation and then analyzed using ANOVA on each date separately. Besides this, the data on maximum and minimum temperature and relative humidity were also recorded.

RESULTS AND DISCUSSION

Effect of weather factors on aphid and predator population

The aphids appeared in the second week of February (0.01 aphids/ear) and the population remained very low (0.01-1.50 aphids/ear) till the 4th week of February. During February, the minimum temperature ranged between 5.68 and 11.07°C while the maximum temperature was 18.44-26.68 °C with relative humidity (RH) of 70.87-75.14%. The peak aphid population was recorded in the second week of March (7.48 aphids/ear), when the temperature was 14.56-28.78 °C and RH was 67.43%. By that time the activity of the predators also started with an average population of 0.17 beetles per ear. Thereafter the predator population increased whereas the aphid population started declining. By the second week of April, the aphids almost disappeared from the ears but the predator population was quite high (0.34/ear) (Table 1). Temperature range of 10-28°C and RH of 67-70% favored the multiplication of the aphids. However, temperature more than 30°C and RH below 67% were found to be suitable for the predator multiplication, but unsuitable for the aphid. Among the predators, *C. septempunctata* was the predominant one whereas *C. transversalis* was observed in low numbers. Singh and Deol (1994) reported the aphid appearance in the 1st week of February when the temperature was 11.2-15.3°C and RH was 67-76% under Punjab conditions. In the present investigation, aphids appeared when the minimum temperature ranged between 8.31 and 10.51°C and RH was 72.28%. However, the predators appeared late when the minimum temperature was 11.07°C and maximum temperature reached 26.68°C. Soni (2000) has also reported the appearance of the predator in the 3rd week of February (0.05 adults/ear head) when the temperature varied between 13.8 and 20.4°C and RH was 65%. Acreman and Dixon (1989) showed that the aphid mortality increased drastically on ears and flag leaves at 30°C. So these studies indicate that temperature above 30°C is not suitable for aphid multiplication. Besides temperature, increase in natural enemy population also helped in reducing the aphid population.

Table 1. Effect of weather factors on aphid and predator populations

Month	Week	No. of aphids / ear	No. of predator / ear	Maximum temperature (°C)	Minimum temperature (°C)	Relative humidity
February	Ist	0.00	0.00	18.44	5.68	75.14
	2nd	0.01	0.00	21.73	8.31	72.28
	3rd	0.08	0.02	25.18	10.51	71.71
	4th	1.50	0.03	26.68	11.07	70.87
March	Ist	3.50	0.09	27.50	9.81	67.28
	2nd	7.48	0.17	28.78	14.56	67.43
	3rd	6.66	0.19	32.21	15.32	66.57
	4th	2.11	0.29	34.44	14.88	51.90
April	Ist	1.50	0.33	37.21	17.83	47.71
	2nd	0.05	0.34	41.12	20.77	32.62

Effect of different spray patterns on wheat aphids

Before the spray, the aphid population in all the plots did not differ significantly except the central portion, which harboured the lowest population. Significant differences were recorded between sprayed and unsprayed plots after treatments (Table 2).

One day after the insecticidal spray, significant reduction (69.66-84.24%) in aphids was detected in all the treated plots relative to the untreated ones. The lowest aphid population (1.33/ear) was recorded in the treated plot which was on par with the treated strip and treated periphery. However, no significant differences were observed between the untreated strip and the central portion of the peripherally treated plot. Except for the central portion and the untreated control, the aphid population further decreased 3 days after the treatment with the lowest population in the completely sprayed plot (1.29 aphids/ear). Increase in the aphid population (8.82 aphids/ear) was recorded in untreated control.

The aphid population decreased in all the treatments with the lowest number in completely treated plot (0.42 aphids / ear) after 7 days of spray. Though a reduction was recorded in aphid population in the untreated control, even then it had significantly higher population (6.66 aphids / ear) than the other treatments. Although a decline in aphid number was recorded after 15 days, no statistical differences were observed between the central portion (2.09 aphids/ ear) and the untreated control (2.71 aphids / ear). These treatments still had significantly higher aphid numbers than all the other treatments. As indicated in the results (Table 2), the central portion of the field harboured less aphids than the periphery.

The sprayed periphery or sprayed strips were quite effective in checking the rapid multiplication of aphid in unsprayed portion where the aphid numbers were significantly lower than the untreated plots. The aphid population in the centre of the peripherally treated plot remained low. In strip spraying, the aphid population failed to multiply further in unsprayed strip. However, Carter (1987) reported rapid population build up in the unsprayed strip as the peak density was almost twice than that in the other strip and also recolonized the sprayed strip more quickly than the sprayed block to cause resurgence. But in the present studies no such colonization / resurgence was observed.

The aphid population remained significantly higher in the unsprayed plots than the sprayed ones till 7 days after treatment. However, after 15 days all the treatments except the central portion and the untreated control were on par. The temperature at that time was quite high ranging 14.88-34.44^{o}C and RH 51.90%, which could be one of the major reasons for reduction in pest population.

Effect of different spray patterns on predator population

The pre-treatment data of predator population (Table 3) indicated no statistical differences among the plots. A decline of 22.80-87.50 per cent was recorded in different treatments one day after treatment. The sprayed strips and completely sprayed plots respectively showed a reduction of 85.43 and 87.50 per cent in comparison to 22.80 per cent in peripherally treated plot. The predator population was reduced in all the treatments except for the centre of peripherally sprayed plot and the untreated control which were statistically on par. The lowest population (0.02 beetles / ear) was recorded in the completely sprayed plot and the highest (0.21 beetles/ear) in the centre of peripherally treated plot. It started recovering in the treated plot 3 days after insecticidal spray. Among the treated plots,

Table 2. Effect of different spray patterns on aphid population

Spray pattern	Number of aphids* / ear					
	Before spray	1 day after	3 day after	7 day after	15 day after	
Strip spraying	S	6.03 (2.65)	1.83 (1.65)	1.58 (1.59)	1.02 (1.41)	0.69 (1.29)
	US	5.77 (2.59)	4.66 (2.35)	3.02 (1.99)	2.55 (1.87)	1.19 (1.48)
Peripheral spraying	P	6.12 (2.66)	1.81 (1.65)	1.36 (1.52)	0.99 (1.41)	1.09 (1.44)
	C	3.66 (2.16)	3.20 (2.05)	3.55 (2.12)	2.85 (1.95)	2.09 (1.72)
Complete spraying		7.49 (2.90)	1.33 (1.52)	1.29 (1.48)	0.42 (1.18)	0.85 (1.36)
Untreated control		6.14 (2.67)	6.77 (2.78)	8.82 (3.12)	6.66 (2.79)	2.11 (1.76)
CD (P = 0.05)		(0.27)	(0.37)	(0.37)	(0.28)	(0.26)

* Mean of three replications (30 ears/replication); figures in parentheses are n+1 square root transformation; US - unsprayed strip; S - Sprayed strip; P - Periphery; C - Center

Table 2. Effect of different spray patterns on aphid population

Spray pattern		Number of aphids* / ear				
		Before spray	1 day after	3 day after	7 day after	15 day after
Strip spraying	S	0.21 (1.09)	0.03 (1.01)	0.06 (1.03)	0.15 (1.07)	0.19 (1.09)
	US	0.19 (1.09)	0.04 (1.02)	0.11 (1.05)	0.15 (1.07)	0.25 (1.12)
Peripheral spraying	P	0.11 (0.05)	0.09 (1.04)	0.09 (1.05)	0.22 (1.10)	0.25 (1.12)
	C	0.19 (1.09)	0.21 (1.09)	0.21 (1.10)	0.37 (1.17)	0.33 (1.15)
Complete spraying		0.14 (1.07)	0.02 (1.01)	0.05 (1.03)	0.01 (1.00)	0.19 (1.01)
Untreated control		0.17 (1.08)	0.18 (1.0 9)	0.19 (1.09)	0.29 (1.13)	0.29 (1.14)
CD (P = 0.05)		NS	(0.04)	(0.03)	0.34	NS

* Mean of three replications (30 ears / replication); US - unsprayed strip; S - sprayed strip; P - periphery; C - center

after 7 days of spraying the maximum colonization of the predator took place in peripherally sprayed plot. But there was a very high recovery in the coccinellid population in all the sprayed treatments 15 days after the spray and no significant differences were recorded between them.

From the results it is evident that the insecticide adversely affected the predator populations in all the treated plots. The predator population was also depleted initially in the untreated strip. This may be due to drifting of the insecticide or indirect mortality of the beetles. On the third day after the treatment a slight recovery was recorded in all the treated plots, which may be due to reinvasion from the other plots. Although coccinellids are often less susceptible to insecticides than their prey (Croft, 1990), predaceous coccinellids are highly susceptible to several insecticides applied on wheat (Poehling, 1988; Wiles & Jepson, 1993). In the present studies, the predator recovery started after 3 days and by the seventh day after treatment, the predator population was quite high in all the plots except the completely sprayed plot. However, Angood and Stewart (1980) reported reduction in coccinellid numbers for up to 7 days after deltamethrin and primicarb treatment, but after 14 days of treatment no significant difference was recorded in coccinellid numbers. Large untreated central area of peripherally treated plot helped in rapid predator recovery as compared to the strip sprayed plot. Zeobelein (1988) also reported that coccinellids rapidly colonize agricultural fields after insecticide application if sufficient prey is present. After peripheral treatment the central portion had significantly higher aphid and predator populations than the periphery.

The results suggest that instead of completely spraying the field, we can adopt strip spraying or peripheral spraying. Peripheral spraying should be preferred as the pest enters from the periphery to the centre where pest population generally remains low. So it will be helpful in checking the further increase in aphid population because the predator population was quite high in the center and on spraying the periphery, most of the beetles due to repellency shift towards the center where prey is available to them. So this practice would help in managing the pest population and conserve the natural enemies which are important components of integrated pest management.

ACKNOWLEDGEMENTS

The authors are thankful to the Head, Department of Entomology, PAU, Ludhiana, for providing necessary facilities for the present studies.

REFERENCES

Acreman, S. C. and Dixon, A. F. G. 1989. The effects of temperature and host quality on the rate of increase of grain aphid (*Sitobion avenae*) on wheat. *Annals of Applied Biology,* **115**: 3-9.

Angood Ba, S. A. and Stewart, R. K. 1980. Effect of granular and foliar insecticides on barley field and their natural enemies on field barley in Southwestern Quebec. *Canadian Entomologist*, **112**: 1309-1313.

Carter, N. 1987. Management of cereal aphids (Hemiptera: Aphididae) population and their natural enemies in winter wheat by alternate strip spraying with a selective insecticide. *Bulletin of Entomological Research*, **77**: 677-682.

Croft, B. A. 1990. *Arthropod Biological Control Agents and Pesticides*. Wiley and Sons, New York. 723 p.

Deol, G. S. 1990. Key pests of wheat and barley and their management. Paper presented at the summer institute, "Key insect pests of India-their bioecology with special reference to IPM" held at Punjab Agricultural University, Ludhiana, India from June 6-15, 1990.

Deol, G. S., Gill, K. S. and Brar, J. S. 1987. Aphid outbreak on wheat and barley in Punjab. *Newsletter Aphidological Society, India*, **6**: 7-9.

Dhaliwal, G. S. and Arora, R. 1996. An estimate of yield losses due to insect pests in Indian Agriculture. *Indian Journal of Ecology*, **23**: 70-73.

Poehling, H. M. 1988. Influence of cereal aphid control on aphid specific predators in winter wheat (Homoptera: Aphididae). *Entomon,* **13**: 163-174.

Rathod, R. R. and Baporda, J. G. 2002. Relative toxicity of various insecticides to coccinellid predators in cotton. *Indian Journal of Plant Protection*, **30**: 29-31.

Roitberg, B. D. and Myers, J. H. 1978. Effect of adult Coccinellidae on the spread of a plant virus by an aphid. *Journal of Applied Ecology,* **15**: 775-779.

Shukla, R. M., Kumar, A., Chandra, M. and Saini, M. L. 1994. Effects of some commonly used pesticides on *Coccinella septempunctata* Linn. (Coleoptera: Coccinellidae). *Plant Protection Bulletin,* **46**: 48-49.

Singh, S. and Deol, G. S. 1994. Studies on the biology of grain aphid *Sitobion avenae* (Fabricius) on wheat. *Journal of Research, Punjab Agricultural University,* **31**: 412-420.

Soni, 2000. *Studies on the role of predator* Coccinella septempunctata *Linn. in the management of aphid complex in wheat*. M.Sc. Thesis, Punjab Agricultural University, Ludhiana, Punjab, India.

Wiles, J. A. and Jepson, P. C. 1993. The susceptibility of a cereal aphid pest and its natural enemies to deltamethrin. *Pesticide Science,* **36**: 263-272.

Zoebelein, G. 1988. Long term field studies about pesticide effects on lady bird beetle (Coleoptera: Coccinellidae). *Entomologia Generalis,* **13**: 175-187.

(Received: 25.01.2009; Revised: 21.04.2009; Accepted: 22.08.2009)