Original Article **Asian J Agri Biol, 2016, 4(4): 126-133.**

FIELD EVALUATION OF DIFFERENT INSECTICIDES AGAINST WHEAT APHIDS AND THEIR NATURAL ENEMIES IN PAKISTAN

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ABSTRACT

Nine insecticides were evaluated against three wheat aphid species (*Rhopalosiphum padi* L., *Schizaphis graminum* Rond. and *Sitobion avenae* F.) and their Coccinellid predators at recommended field doses under field conditions during wheat growing season 2012-13. The insecticides were malathion (Malathion®), carbosulfan (Advantage®), imidacloprid (Confidor®), thiamethoxam (Actara®), pymetrozine (Plenum®), aliphatic hydrocarbons+mineral oil (Diver®), azadirachtin+salannin (Neemosal®), mineral oil (Foliol®), bifenthrin (Talstar®) at recommended field doses, i.e.,1235 ml, 1235 ml, 198 ml, 60gm, 988, 494 ml, 2470 ml, 4940 ml and 618 ml, respectively. Malathion, bifenthrin and thiamethoxam effectively reduced the population of *S. graminum* while bifenthrin and imidacloprid were more effective against *S. avenae*. All the insecticides were more effective against *R. padi* than for *S. graminum* and *S. avenae*. However, bifenthrin, malathion, imidacloprid, thiamethoxam, pymetrozine and carbosulfan significantly lowered the population of *R. padi*. Aliphatic hydrocarbons+mineral oil, azadirachtin+salannin and mineral oil could not significantly lower the population of *S. graminum* and *S. avenae*. Imidacloprid proved to be effective against all aphid species yet it was the safest against coccinellids. Thiamethoxam showed the maximum decrease in coccinellid populations followed by malathion, pymetrozine and carbosulfan.

Keywords: Wheat aphids, field efficacy, Insecticides, coccinellids

INTRODUCTION

Wheat being the second most important food crop after rice, contributes 20% of the daily protein to 4.5 billion people i.e. almost half of the total population of the world (Bos et al., 2005). It contributes 14.4 percent to the value addition in agriculture and 3.1 percent to GDP of Pakistan (GoP, 2010).Up to nineties there was a good natural equilibrium between aphid population and its natural enemies (Zia et al., 1999). However, during recent past, this natural balance seems is disturbed due to extensive and indiscriminate use of non-selective pesticides on various cereal crops (Irshad, 2008). The shift in sowing time of wheat, availability of relatively photo insensitive varieties, temperature tolerant genotypes and higher fertilizer input have led changes in pest complex of wheat and elevated the status of aphids from occasional to regular pests on wheat crop since 2002 (Patil et al., 2009). Seven aphid species on wheat crop have been recorded from various districts of Punjab, Pakistan, i.e., *Metopolophum dirhodum*, *Sitobion avenae* (F.), *S. miscanthi*, *Schizaphis graminum* (Rond.), *Rhopalosiphum rufiabdominalis* (Sasaki), *R. padi* and *R. maidis* (Fitch) (Hashmi et al., 1983).

Aphids cause direct damage by sucking plant sap while indirect damage by transmitting virus and by favoring mold growth on their honeydews (Rossing et al., 1994). Kuroli and Nemeth (1987) reported that aphids may reduce 50 and 70 percent grains weight per year in winter and spring wheat, respectively. The highest affinity and yield loss occurs when *S. avenae* fed on milky grain stage of wheat (Rios-de-Saluso and Conde, 1986). Overall, the direct wheat yield reduction caused by aphids ranged from 35-40% when 15 aphids were maintained per seedling for 30 days (Kiechkhefer and Gellner, 1992). Riedell et al. (1999) demonstrated that, at the seedling stage in four winter wheat cultivars, grain yield was reduced 21% by feeding ≈ 25 to 30 individuals of *R. padi* per plant.

The efficacy of insecticides against any test insect is the function of tempo-spatialvariation in insecticide resistance (Foster et al., 2002) besides the variation in temperature (Amarasekare and Edelson, 2004) and relative humidity (Barson, 2006). Therefore, different studies have shown different patterns for

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laboratory and field efficacy of insecticides in controlling wheat aphid species (Carter et al., 1989; Wilde et al., 2001; Patil et al., 2009; Cui et al., 2010).

Little is known about the insecticidal control of different wheat aphid species in Pakistan. Khaliq et al. (1995) confirmed pirimicarb as effective insecticide against *S. avenae* followed by chlorpyrifos and dimethoate. Shafique et al. (2016) found Imidacloprid, lambda-cyhalothrin and pymetrozine as the most effective against *S. graminum* at recommended field doses while Iqbal et al. (2005) suggested carbosulfan, furathiocarb and mineral oil as equally potent. A rare wheat aphid species, *Macrosiphum miscanthi*, has also been tested for its insecticidal control (Khan and Maqbool, 2002) resulting in methamidophos as the most effective followed by endosulfan and cypermethrin.

The objective of the current study was to test the susceptibility of wheat aphids and their coccinellid predators against insecticides of different groups keeping in view the future prospective of insecticidal application to wheat crop as the last resort.

MATERIALS AND METHODS

Field evaluation of nine different insecticides was carried out in order to test their efficacy against three cereal aphid species, i.e., *Rhopalosiphum padi*, *Schizaphis graminum* and *Sitobion avenae* on wheat crop and their three coccinellid predators i.e. *Coccinella undecimpunctata*, *C. septempunctata* and *Cheilomenes sexmaculata*.

Insecticides tested

Insecticides used in these experiments were selected from different modes of action. Commercial formulations of insecticides used in the experiment were: malathion 57% EC (Malathion®; HELB), carbosulfan 20% EC (Advantage®; FMC), imidacloprid 20% SL (Confidor®; Bayer Crop Science), thiamethoxam 20 WG (Actara®; Syngenta), pymetrozine 50 WG (Plenum®; Syngenta), aliphatic hydrocarbons 97%+mineral oil 100% (Diver®; HELB), azadirachtin + salannin 0.5% (Neemosal®; STEDEC), mineral oil 84% W/W (Foliol®; Grace Chemicals), bifenthrin 10% EC (Talstar®; FMC). Doses recommended (per hectare) at the labels were 1235 ml for malathion, 1235 ml for carbosulfan, 198 ml for imidacloprid, 60gm for thiamethoxam, 988 gm for pymetrozine, 494 ml for aliphatic hydrocarbons 97%+mineral oil 110%, 2470 ml for azadirachtin+salannin, 4940 ml for mineral oil and 618 ml for bifenthrin.

Field evaluation

Wheat variety ‘Sehar 06’ was planted on 25th of October, 2012 at the experimental area of Oilseed Research Institute, Ayub Agricultural Research Institute at Faisalabad during the growing year 2012-13. The experiment was conducted under Randomized Complete Block (RCB) design with 3 replications. There were 10 treatments including control. Each treatment had a plot size of 6x12m and received homogenous agronomic practices. Each plot was separated from neighboring plot by a 7m buffer crop. Recommended doses of insecticides were applied using a knapsack sprayer on March 15, 2013.

Nine plants per plot were randomly selected and species wise data of aphids and coccinellids was recorded on all the nine plants in the field before and after application of treatment insecticides. The post-treatment data regarding populations of aphids and their coccinellid predators was recorded after 48, 72 and 168 h exposure to insecticides.

Data Analysis

To see the effectiveness of field evaluation experiment, mean population of aphid species and coccinellids in insecticide plots were compared with that of control plot. Percent population change (increase or decrease) was calculated by using modified Abbot’s formula (Flemings and Ratnakaran, 1985). All the three aphid species were analyzed separately while populations of cocinellid species were pooled as they were very low in population. Data regarding populations of aphid species and coccinellids were subjected to statistical analysis using Analysis of Variance (ANOVA). The means were compared by LSD test at P=0.05.

RESULTS

***Schizaphis graminum*:** One 48 hours after spray, the maximum decrease in population was observed with malathion (69%) followed by bifenthrin (57%). Simultaneously, increase in population was also observed with azadi-rachtin+salannin, pymetrozine and thiamethoxam (Table 1). On 72 hours after spray, malathion resulted maximum population reduction (80%) followed by thiamethoxam (77%), aliphatic hydro-carbons+mineral oil (74%) and bifenthrin (57%). Carbosulfan could not effectively reduce the population (9.2%). A 22% increase of population was observed in mineral oil treated plots.On 168 hours after spray, the population decrease was observed only in thiamethoxam (56.4%) and bifenthrin (51.8%). Maximum population increase was recorded in plots treated with mineral oil followed by pymetrozine, carbosulfan, malathion, aliphatic hydrocarbons+mineral oil and azadirachtin+salannin.

***Sitobion avenae*:** One 48 hours after spray, the maximum decrease (88.6%) in population was observed in plots where mineral oil was sprayed followed by aliphatic hydrocarbons + mineral oil (86%), bifentrin (69%), impida-cloprid (67%) and pymetrozine (64%), respectively (Table 2). On 72 hours after spray, the maximum decrease (78%) in population was observed with bifenthrin and imidacloprid (67%). The population increased in Azadirachtin+salannin treatment. On 168 hours after treatment, imidacloprid and carbosulfan showed maximum population decrease of 66% and 59%, respectively. Two insecticides showed the population increase, i.e., bifenthrin and azadirachtin+salannin. The later completely failed in reducing the population of *S. avenae* at all the three post spray observations.

***Rhopalosiphum padi*:** *R. padi* proved to be more susceptible to all insecticides than *S. graminum* and *S. avenae*. On 48 hours after spray, all insecticides proved to be effective. The maximum decrease (>90%) in population was observed in plots treated with bifenthrin, malathion and imidacloprid. On 72 hours after spray, more than 90% population decrease was observed in malathion, thiamethoxam, imidacloprid, pymetrozine and carbosulfan (Table 3). On 168 hours after treatment, all the insecticides had reduced effectiveness and the maximum population decrease was recorded in imidacloprid (66%) and thiamethoxam (64%) treated plots.

***Coccinellids*:** Coccinellid fauna on wheat consisted of three beetle species i.e. *Coccinella undecimpunctata*, *C. septempunctata* and *Cheilomenes sexmaculata*. Imidacloprid and azadirachtin+salannin proved to be least toxic to coccinellids, however; their populations increased at 168 hours after treatment in case of imidacloprid while decreased in case of azadirachtin+salannin. Thiamethoxam showed the maximum decrease in coccinellid populations followed by malathion, pymetrozine and carbosulfan (Table 4).

Table 1: Percent population increase or decrease (in parenthesis) and mean population per plant of *Schizaphis graminum* on different times before and after spray under field conditions

Insecticides	Before Spray	48 HAT*	72 HAT	168 HAT
Malathion	9.72±3.14	1.15c (68.80)	2.28c (80.24)	3.50a (-16.30)
Carbosulfan	7.96±2.06	1.59c (9.75)	4.00bc (9.20)	2.72a (-22.29)
Imidacloprid	3.74±3.93	1.44c (28.93)	3.02c (40.64)	2.13a (6.42)
Thiamethoxam	6.00±2.94	7.22a (-21.99)	3.11bc (77.06)	2.70a (56.42)
Pymetrozine	6.52±3.10	3.18bc (-54.69)	2.72c (32.98)	4.20a (-150.65)
A.H.+mineral oil	6.59±3.15	4.74abc (32.24)	3.18bc (74.47)	5.46 a (-7.54)
Azadirachtin+salannin	4.52±7.26	6.00ab (-60.00)	7.13b (22.79)	4.89a (-3.00)
Mineral oil	8.70±2.11	2.37bc (3.50)	4.06bc (-21.86)	5.02a (-253.40)
Bifenthrin	4.00±2.74	1.26c (56.95)	2.65c (56.85)	1.17a (51.84)
Control	4.41±0.98	5.74ab (0.00)	11.26a (0.00)	5.57a (0.00)
ANOVA				
F		2.95	4.01	0.84
d.f		9	9	9
P		0.021	0.005	0.589

*HAT: Hours after treatment, Means±S.E.

Table 2: Percent population increase or decrease (in parenthesis) and mean population per plant of *Sitobionavenae*on different times before and after spray under field conditions

Insecticides	Before Spray	48 HAT*	72 HAT	168 HAT
Malathion	0.88±0.59	0.15 (33.33)	0.92b (20.61)	1.94ab (12.50)
Carbosulfan	0.29±0.19	0.11b (55.24)	0.81b (27.88)	1.20ab (59.26)
Imidacloprid	1.37±0.69	0.29b (66.67)	0.37b (66.67)	0.39b (65.56)
Thiamethoxam	0.78±0.77	0.78ab (30.07)	0.48b (27.10)	1.02ab (25.93)
Pymetrozine	0.56±0.29	0.44ab (64.13)	1.11b (56.97)	1.24ab (39.51)
A.H.+mineral oil	1.23±0.50	0.78ab (86.29)	1.00b (43.39)	1.20ab (35.56)
Azadirachtin+salannin	0.11± 0.03	0.41ab (-128.57)	0.55b (-83.27)	1.53ab (-11.11)
Mineral oil	0.66±0.22	1.33ab (88.57)	0.98ab (27.27)	1.78ab (7.41)
Bifenthrin	0.33± 0.07	0.211b (69.14)	0.56b (78.18)	0.85ab (-22.22)
Control	0.89±0.88	1.81a (0.00)	2.35a (0.00)	2.48a (0.00)
ANOVA				
F		1.23	1.14	0.90
d.f		9	9	9
P		0.329	0.380	0.539

*HAT: Hours after treatment, Means±S.E.

Table 3: Percent population increase or decrease (in parenthesis) and mean population per plant of *Rhopalosiphum padi* on different times before and after spray under field conditions

Insecticides	Before Spray	48 HAT[a]	72 HAT	168 HAT
Malathion	10.22±3.46	0.70a (94.44)	0.74b (98.81)	0.46a (58.85)
Carbosulfan	6.04±2.51	2.81a (70.96)	2.06a (94.49)	2.72a (47.01)
Imidacloprid	1.48±0.48	0.37a (90.58)	0.39b (95.88)	0.22a (66.03)
Thiamethoxam	3.89±2.09	2.37a (78.39)	0.98b (98.20)	0.83a (63.87)
Pymetrozine	4.07±1.18	2.37a (81.41)	0.72b (95.70)	1.52a (32.97)
A.H.+mineral oil	5.96±4.00	2.48a (75.76)	0.93b (77.02)	1.04a (45.20)
Azadirachtin + salannin	6.37±4.84	2.11a (62.49)	2.89ab (64.98)	1.46a (32.14)
Mineral oil	1.78±1.92	1.37a (49.97)	1.24b (50.22)	2.46a (28.12)
Bifenthrin	4.59±1.34	0.33a (96.20)	0.56b (87.27)	0.79a (35.30)
Control	4.70±4.13	2.67a (0.00)	6.24a (0.00)	1.63a (0.00)
ANOVA				
F		0.57	1.49	0.67
d.f		9	9	9
P		0.799	0.216	0.727

*HAT: Hours after treatment, Means±S.E.

Table 4: Percent population increase or decrease (in parenthesis) and mean population per plant of coccinellids on different times before and after spray under field conditions

Insecticides	Before Spray	48 HAT*	72 HAT	168 HAT
Malathion	0.034±0.03	0.083a (32.02)	0.003a (33.33)	0.035a (32.35)
Carbosulfan	0.003±0.00	0.018a (32.85)	0.002a (33.33)	0.018ab (22.53)
Imidacloprid	0.003±0.00	0.007a (0.00)	0.017a (-20.63)	0.022ab (15.50)
Thiamethoxam	0.009±0.00	0.015a (29.73)	0.011a (52.63)	0.017ab (50.46)
Pymetrozine	0.022±0.02	0.006a (32.65)	0.031a (25.52)	0.019ab (29.73)
A.H.+mineral oil	0.009±0.00	0.003a (0.00)	0.023a (33.33)	0.019ab (26.13)
Azadirachtin + salannin	0.025±0.02	0.006a (29.83)	0.034a (-10.77)	0.020ab -21.79)
Mineral oil	0.006±0.00	0.000a (0.00)	0.000a (33.33)	0.019ab (31.98)
Bifenthrin	0.003±0.00	0.000a (33.33)	0.006a (40.45)	0.009b (11.73)
Control	0.028±0.02	0.046a (0.000)	0.028a (0.000)	0.015ab (0.000)
ANOVA				
F		1.06	1.09	0.65
d.f		9	9	9
P		0.427	0.410	0.735

*HAT: Hours after treatment, Means±S.E.

DISCUSSION

Insecticides are not generally used against aphids on wheat crop in Pakistan, However, cereal aphid species have also been reported on corn crop on which they are subjected to targeted or untargeted chemical control (Alvi et al., 2003). Testing and comparing a large number of insecticides with different modes of action is useful tool in order to understand the latest trends in insecticide resistance. The efficacy of insecticides is a variable phenomenon and changes with the resistance level of corresponding population (Zuo et al. 2016).

There is a need to regularly monitor the resistance level in aphids in order to make future strategy of its insecticidal control. Moreover, field efficacies should also be monitored since insecticides that are effective in laboratory bioassay may be less effective in the field where insects may not experience the direct exposure as in laboratory bioassay, and may also be able to avoid residues on the plant (Fitzger et al., 2003).

In this study, the maximum decrease in population of *S. graminum* was observed in plots treated with malathion, bifenthrin and thiamethoxam. On the other hand mineral oil, pymetrozine, carbosulfan, aliphatic hydrocarbons+mineral oil and azadirachtin+salannin failed to reduce population of *S. graminum* effectively. Shafique et al. (2016) evaluated Pymetrozine, Imidacloprid and Lambda-cyhalothrin against *S. graminum* at recommended field doses and found Imidacloprid as the most effective with the maximum percentage mortality of 97% followed by lambda-cyhalothrin (93%) and pymetrozine (87%) assessed fourteen days after application. However, in our study pymetrozine did not proved to be an effective insecticide against *S. graminum* while imidacloprid showed only 41% reduction in *S. graminum* population three days after spray.

Royer et al. (2011) observed a significant temporal variation in field efficacy of imidacloprid towards reducing the population of *S. graminum* over the period of four years, i.e., post spray (after 14 hours) population of *S. graminum* decreased by 90% in 2002 while it increased by 14% in 2003. The spatial variation in insecticide resistance among aphid populations is a major cause of insect pest control failure (Chang et al. 2010).

In this study, the maximum decrease in population of *S. avenae* was observed with, bifentrin and impidacloprid. Carbosulfan proved to be effective only on seventh day after treatment wile bifenthrin lost its efficacy. Insecticide efficacy against *S. avenae* is poorly reported from Pakistan. Only few studies have been reported on efficacy of different neem products (Aziz et al. 2013) and efficacy of some insecticides as seed treatment (Baloch, 1993; Suhail et al. 2013).

In this study, *R. padi* proved to be more susceptible to all insecticides than *S. graminum* and *S. avenae*. Besides changes in genetic makeup of a population, insecticide resistance may also be due to phenotypically plastic characteristic of different aphid species (Godfrey and Fuson, 2001). Moreover, answering the high susceptibility of *R. Padi* as compared to *S. graminum* needs a detailed bionomics of both species including host plant range, distribution patterns, population dynamics and insecticidal exposures. Such kind of information is poorly documented from Pakistan.

Maximum decrease (>90%) in population was observed with bifenthrin, malathion, imidacloprid, thiamethoxam, pymetrozine and carbosulfan. Khan et al. (2016) reported highest mortality (80%) of *R. padi* at 8, 4 and 2 ppm of imidacloprid while only 41% mortality in case of chlorpyrifos even at highest concentrations. Similarly Zuo et al. (2016) reported susceptibility of *R. padi* to chlorpyrifos, malathion, thiamethoxam, beta-cypermethrin, acetamiprid and pymetrozine but moderate resistance to bifenthrin, decamethrin, and abamectin. Keeping in view the widespread and variable nature of resistance in *R. padi*, Zuo et al. (2016) urged to rotate insecticides of different classes to delay the onset of high level of resistance.

Neonicotinoid insecticides are considered as the safest against natural enemies yet these may also be harmful if ingested (Cloyd and Bethke, 2011), e.g. when fed on hosts (prey) that have consumed leaves contaminated with the active ingredient. In our study imidacloprid was safer than thiamethoxam for the coccinellids. This finding should be confirmed through laboratory bioassay of different coccinellid species since we combined all the three conccinellid species into one data set. There is a chance that a certain coccinellid species may show more susceptibility to thiamethoxam. Therefore, this area needs more elaborative work.

CONCLUSION

Malathion, bifenthrin and thiamethoxam effectively reduced the population of *S. graminum* while bifenthrin and imidacloprid proved to be more effective against *S. avenae*. All the insecticides proved to be more effective against *R. padi* than that of *S. graminum* and *S. avenae*. However, bifenthrin, malathion, imidacloprid, thiamethoxam, pymetrozine and carbosulfan significantly lowered the population of *R. padi*. Aliphatic hydrocarbons+mineral oil, azadirachtin+salannin and mineral oil could not significantly lower the populations of *S. graminum* and *S. avenae*. Imidacloprid proved to be effective against all aphid species yet it was the safest against coccinellids. Thiamethoxam showed the maximum decrease in coccinellid populations followed by malathion, pymetrozine and carbosulfan.

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