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YIELD AND YIELD COMPONENTS OF WHEAT (*TRITICUM AESTIVUM* L.) AFFECTED BY APHID FEEDING AND SOWING TIME AT MULTAN, PAKISTAN

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Abstract

We assessed feeding effect of *Schizaphis graminum* Rond. and *Rhopalosiphum padi* L. (Homoptera: Aphididae) on yield losses to wheat (*Triticum aestivum* L.) (Cv. Sahar) sown on November 05th (early November), November 20th (late November) and December 05th (early December) during 2011, at Multan, Punjab (Pakistan). Aphids were controlled by applying imidacloprid 200 SL with Knapsack sprayer, as one spray (5th March), two sprays (5th and 26th March 2012) and no spray (control). Aphid densities were recorded on weekly basis starting from 12th March. At harvest shoot biomass, number of grains per spike, thousand grain weight and yield were recorded. Polynomial orthogonal contrasts were employed for evaluation of sowing dates, insecticides and their interactions for spray treatments on yield and yield components. Aphid (*S. graminum*) was dominant over *R. padi* and its highest number was observed on March 26th, 2012 in all sowing dates of both species. Delayed sowing of wheat increased aphid abundance, however, application of imidacloprid significantly reduced it. Sowing dates and insecticide(s) significantly affected shoot biomass and number of grains/spike. Highly significant differences for thousand grain weight and yield were observed in all sowing dates. Early sowing and application of insecticide(s) significantly increased the yield of wheat. One spray and two sprays of imidacloprid could significantly increase 1000 grain weight and yield in late November and December sown wheat. From this investigation, it is evident that early sowing of wheat is the best for reducing the risk of aphid attack on wheat crop.

Introduction

Wheat (*Triticum aestivum* L.) is an important cereal crop as being consumed for staple food in the world (Khan *et al*., 2000). There is a continuous need of obtaining higher yield to feed growing population of the world as it is a staple food for more than 35% of the world population (Khakwani *et al*., 2012). Proteins 'gluten' in wheat seeds of this cereal make it unique (Kausar & Shahbaz, 2013). Numerous factors are responsible for the low yield of wheat like abiotic factors and low yielding varieties (Khan *et al*., 2012), improper inputs such as irrigation and fertilizers (Kibe *et al*., 2006), sowing time (Aheer *et al*., 1993), weeds (Memon *et al.,* 2013) and insect pests (Khattak *et al*., 2007).

Among insect pests, 29 aphid species infest wheat crop (Geza, 2000). Dominant species are the greenbug, *Schizaphis graminum* (Rondani), bird cherry oat aphid, *Rhopalosiphum padi* (L.), English grain aphid, *Sitobion avenae* (Fabricius), Russian wheat aphid, *Diuraphis noxia* (Mordvilko) and rose-grass aphid, *Metopolophium dirhodum* (Walker) (Bospucperez & Schotzko, 2000). Aphid species *S. avenae*, *R. padi*, and *S. graminum* are the insect pests of wheat in Pakistan (Shah *et al*., 2006). Aphids suck sap from leaves and shoots that results in curling, chlorosis, distortion of leaves and hence stunted growth (Kindler *et al*., 1995; Akhter & Khaliq, 2003). Aphids can cause 35- 40% loss directly by sucking sap and 20- 80% indirectly by transmission of fungal and viral diseases (Kiechefer & Gellner, 1992; Rossing *et al*., 1994). *R. padi* alone caused yield losses up to 600 kg/ha in wheat (Hallqvist, 1991).

The origin of Integrated Pest Management (IPM) in agriculture began with the advent of synthetic organic pesticides and their immense impact on agriculture occurred during the late 1940s and 1950s (Castle & Naranjo, 2009). Negative effects and over-reliance on pesticides also began sooner on the agro-ecosystems (Smith & Allen, 1954). There were no other strategies available to lessen excessive use of pesticide until Stern *et al*., (1959) gave the integrated control concept. They recognized population sampling for Economic Threshold (ET) and Economic Injury level (EIL), augmentation of natural enemies and the use of selective insecticides as suitable strategies to control a particular pest. Determination of ET and EILs are difficult due to calculation of relationship between insect density/damage and crop yield loss (Hammond, 1996; Nault & Kennedy, 1998). ET is the number of pest population at which control should be applied to prevent from economic damage and if practically applied in the field, the outcome will be the less insecticide use (Pedigo *et al*., 1986).

Literature reports that populations of aphids on wheat started increasing from 1990s and got status as a pest in Pakistan (Aheer *et al*., 1994). Some farmers have started applying insecticides (personal communications local farmers). No attempt has been made to develop IPM of aphids. Even no recent research reports the losses due to aphid feeding. In this study we report incidence and abundance of aphids on wheat sown on different planting time. As there are no guide lines or ET to manage aphids on wheat, therefore, we evaluated selective insecticide (Imidacolprid) for optimum the number(s) of application needed to reduce the damage due to aphids on yield and yield components.

Materials and Methods

Cultivar Sahar of wheat was sown on November 05th (nominated as early November), November 20th (late November) and December 05th (early December) in 2011 at the Experimental Farm of Faculty of Agricultural Sciences and Technology, Bahauddin Zakariya University Multan, Pakistan. The experiment was arranged in a split plot design. Sowing date and number of insecticidal sprays were the main and sub-plot factors, respectively. The wheat seeds were sown by the broadcast method on recommended rate. Individual subplot measured by 4 m^2 making 12 m^2 of one main plot. Each sowing date was replicated three times and the distance between the replications was 1m. Main plots were subjected to three different aphid incidence conditions i.e. untreated control, one spray (applied on March 05th 2012) and two number of sprays (5th and 26th March 2012) to completely control aphids. The insecticide was Imidacloprid (Confidor 20%, SL, Warble Private Limited) and applied by Knapsack sprayer. Standard agronomic practices were applied uniformly on each plot.

Number of aphids was recorded weekly starting from March 12th 2012. Thirty (30) wheat ears were randomly examined visually for aphids from each plot. When the wheat crop reached to maturity stage then 1 m^2 area of each treated and untreated plot was harvested, tied into bundles containing tags and brought to laboratory for yield data. The shoot biomass, number of grains/spike, thousand grain weight and yield were recorded.

Data on aphids, yield and yield components for 3 sowing dates in Imidacloprid treated (one and two sprays) and control were analyzed by polynomial orthogonal contrasts to isolate treatment effects and their interactive effects (Steel & Torrie, 1980).

Results and Discussion

Impact of sowing dates and insecticide treatments on aphid abundance: Two aphid species, *S. graminum* and *R. padi* were observed but *S. graminum* was dominant over *R. padi* and their highest numbers were observed on March 26th, 2012 in all sowing dates of both species (Fig. 1C and Fig. 2B). Delayed sowing of wheat increased aphid number. There were significant differences in numbers of aphids (*S. graminum* and *R. padi*) in late November and early December sown wheat in all the sampling dates (Tables 1 and 2). Significantly lower numbers of aphids (*S. graminum*) were observed in early November sown wheat in all the sampling dates except for those of 19th March (Table 1). However, significantly lower numbers of aphids (*R. padi*) were noted in early November sown wheat on 26th March (Table 2). Application of imidacloprid (applied on 5th March) significantly reduced numbers of aphids up to 21days (*S. graminum* till 26th March) and 14 days (*R. padi* till 19th March) (Fig. 1C and Fig. 2A). Imidacloprid was applied again on 26th of March as treatment i.e., plots with two sprays.

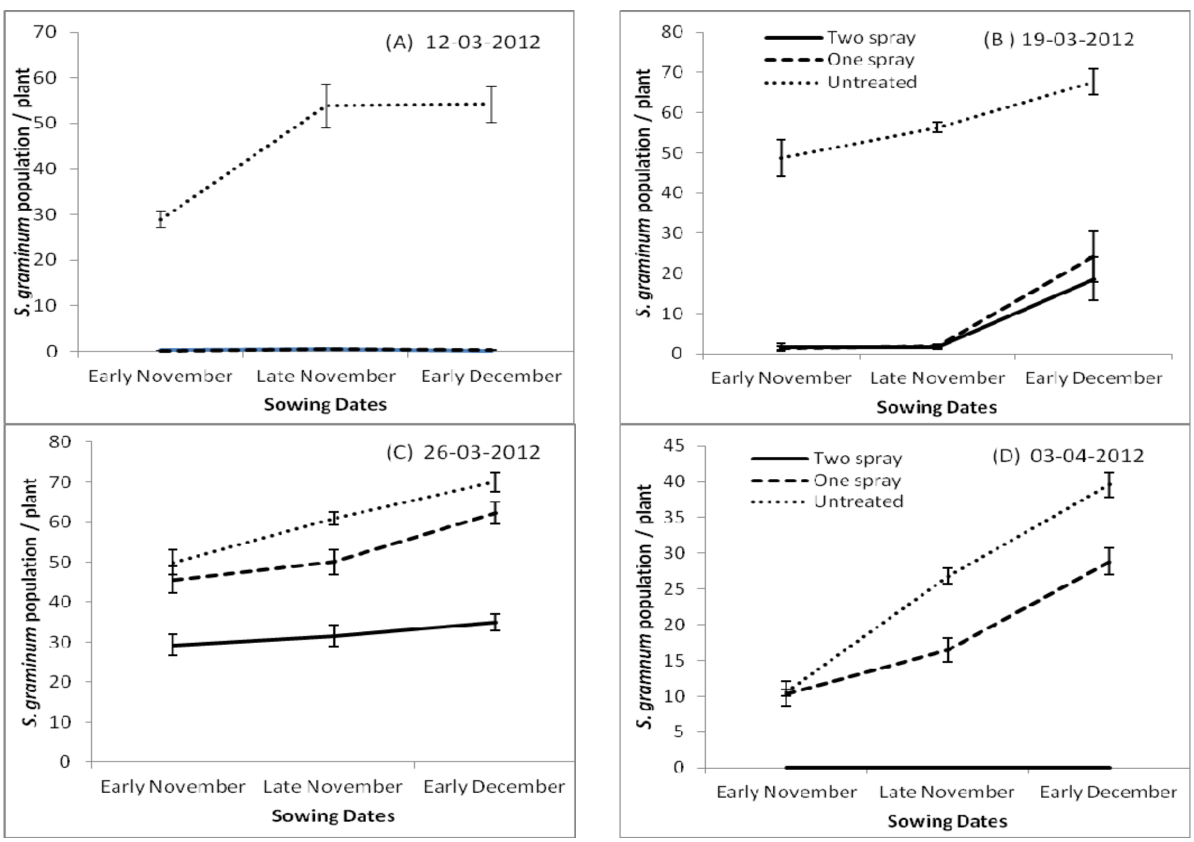

Fig. 1. Mean numbers of *Schzaphis graminum* per plant recorded on different sampling dates in early November, late November and early December sown wheat in insecticide untreated plots and where one and two sprays of Imidocloprid were applied, respectively.

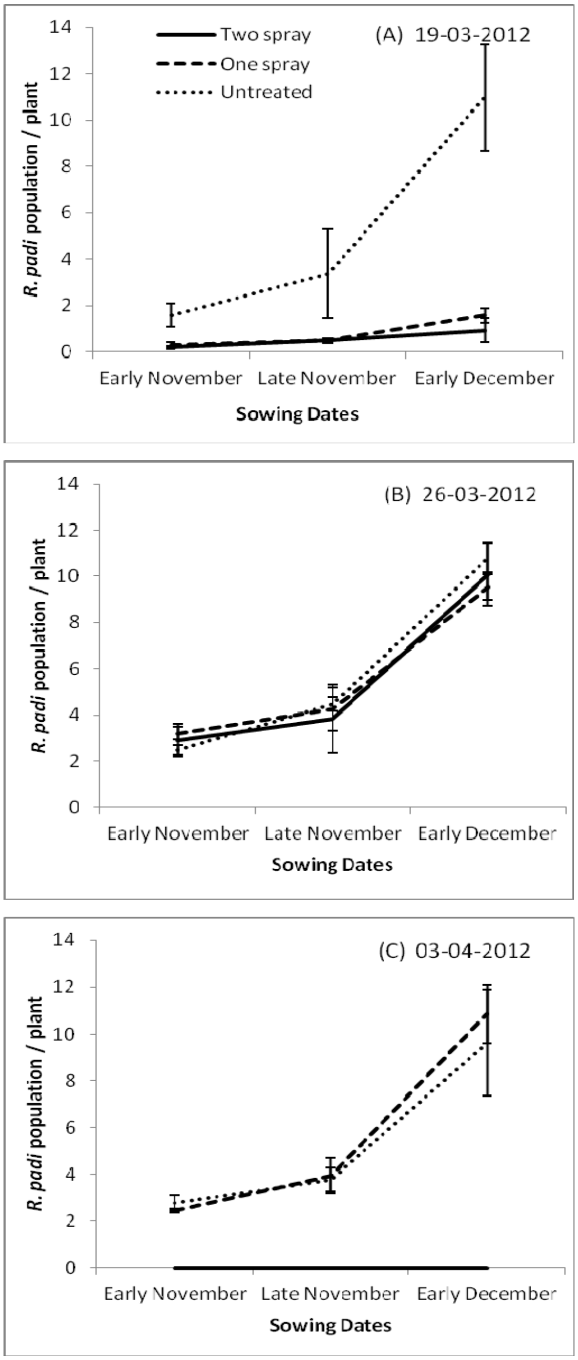

Fig. 2. Mean numbers of *Rhopalosiphum padi* per plant recorded on different sampling dates in early November, late November and early December sown wheat in insecticide untreated plots and where one and two sprays of Imidocloprid were applied, respectively.

Wheat planting in early season or in November markedly has low infestation of aphids (Acreman & Dixon, 1985; Wains *et al*., 2008). Other studies on wheat also revealed that abundance of aphids increased on late plantings as compared to timely planting of wheat in Faisalabad and Sargodha Districts of the Punjab, Pakistan (Aheer *et al*., 1993; Tabasum *et al*., 2012). Higher populations of *Myzus persicae* Sulzer, *Brevicoryne brassicae* L. and *Lipahis eyrsimi* Kalt. have been recorded in late sown cauliflower and different oilseed brassica species (Siddiqui *et al*., 2009; Razaq *et al*., 2011). Imidacloprid has been found effective for reducing aphids in wheat (Ali *et al*., 2011).

Sowing dates and insecticide(s) significantly affected shoot biomass and number of grains/spike but both these parameters were not affected by insecticides among different sowing dates (Table 3, Fig. 3A). Feeding by *S. graminum* significantly reduced plant growth but its honeydew presented a major loss in dry weight loss of the infested plants (Behle & Michels, 1993). Reduced plant biomass is due to decreased photosynthetic rate induced by greenbugs as they degrade chlorophyll contents (Holmes *et al*., 1991). Ahmed *et al*., (2001) reported significant differences between different treatments in the number of grains/spike relative to the untreated control. Another study on wheat proved spray of Supracide (Methidathion 40 EC) on wheat significantly increased number of grains/spike (Khan *et al*., 2007). It has been reported that plenty of aphids affect number of grains/spike due to injection of toxic saliva into the plants that ultimately interrupts grain formation (Ciepiela, 1993; Kannan, 1999).

Orthogonal contrasts revealed highly significant difference for thousand grain weight in all sowing dates. Insecticide treatments could significantly increase 1000 grain weight in late November and December sown wheat sown where one spray and two sprays of imidacloprid were applied (Table 3, Fig. 3C). Ali *et al*., (2011) reported that grain weight of sprayed plots was 8% higher than that in untreated plots by the use of Imidacloprid in wheat cv. Sahar. Non- significant differences between treated and untreated aphid infested wheat lines have been recorded for grain weight (Riazuddin *et al*., 2004; Khattak *et al*., 2007). Aphids are responsible to adversely influence the protein contents, nitrogen concentration and weight of thousand grains (Ciepiela, 1993).

Early sowing and application of insecticide(s) significantly increased the yield of wheat. One spray or two sprays of imidacloprid in early November and late November sown wheat did not increase the yield. December sown crop suffered the highest losses as there were significant differences in yield where one and two sprays of Imidacloprid were applied when compared to late November (Table 3, Fig. 3D). Valenciano *et al*., (2006) reported that application of insecticide progressed yield and was lower in unsprayed plots than that in sprayed plots in bean crop. Aheer *et al*., (1993) revealed that aphid was higher on late sown crop which resulted in reduced yield in comparison with normal wheat planting. Higher yield was recorded in treated plots as compared to that in untreated plots but were non-significantly different in wheat crop (Riazuddin *et al*., 2004; Khattak *et al*., 2007; Khan *et al*., 2012). In the present study, the contrast, sowing date × insecticide: late November-early December: Control × Spray, is significant which indicates that insecticide application is very important in late sown wheat to remove aphids in order to obtain higher yield (Table 3). Wangai *et al*., (2000) reported that, in Imidacloprid treated plots yield increased 36-43% (highly significant, $p<0.001$) more than that of the untreated control in the late sown barley crop. Wains *et al*., (2010) reported that higher aphid populations are the reasons of yield losses in wheat. Early sown crops might have the better environmental conditions with fewer aphids which resulted into higher yield.

Table 1. Polynomial orthogonal contrast analysis for numbers of *Schizaphis graminum* per plant influenced by sowing dates and insecticide treatment.

Contrasts	d.f.	Sampling dates							
		12th March		19th March		26th March		03rd April	
		F value	P value	F value	P value	F value	P value	F value	P value
Block	2	3.45	0.13	1.18	0.39	5.05	0.08	3.01	0.15
Sowing date	2	28.77	0.00	15.52	0.01	40.27	0.00	718.35	0.00
Sowing date: Early November × Late November	1	43.67	0.00	0.47	0.52	12.54	0.02	319.80	0.00
Sowing date: Late November × Early December	1	13.87	0.02	30.62	0.00	67.99	0.00	1116.90	0.00
Residuals	4								
Insecticide	2	445.74	0.00	427.74	0.00	92.37	0.00	262.22	0.00
Insecticide: Untreated (control) × Spray	1	891.48	0.00	854.55	0.00	93.35	0.00	266.55	0.00
Insecticide: 1 Spray × 2 Spray	1	0.00	0.98	0.93	0.35	91.38	0.00	257.89	0.00

d.f.= Indicates error degree of freedom

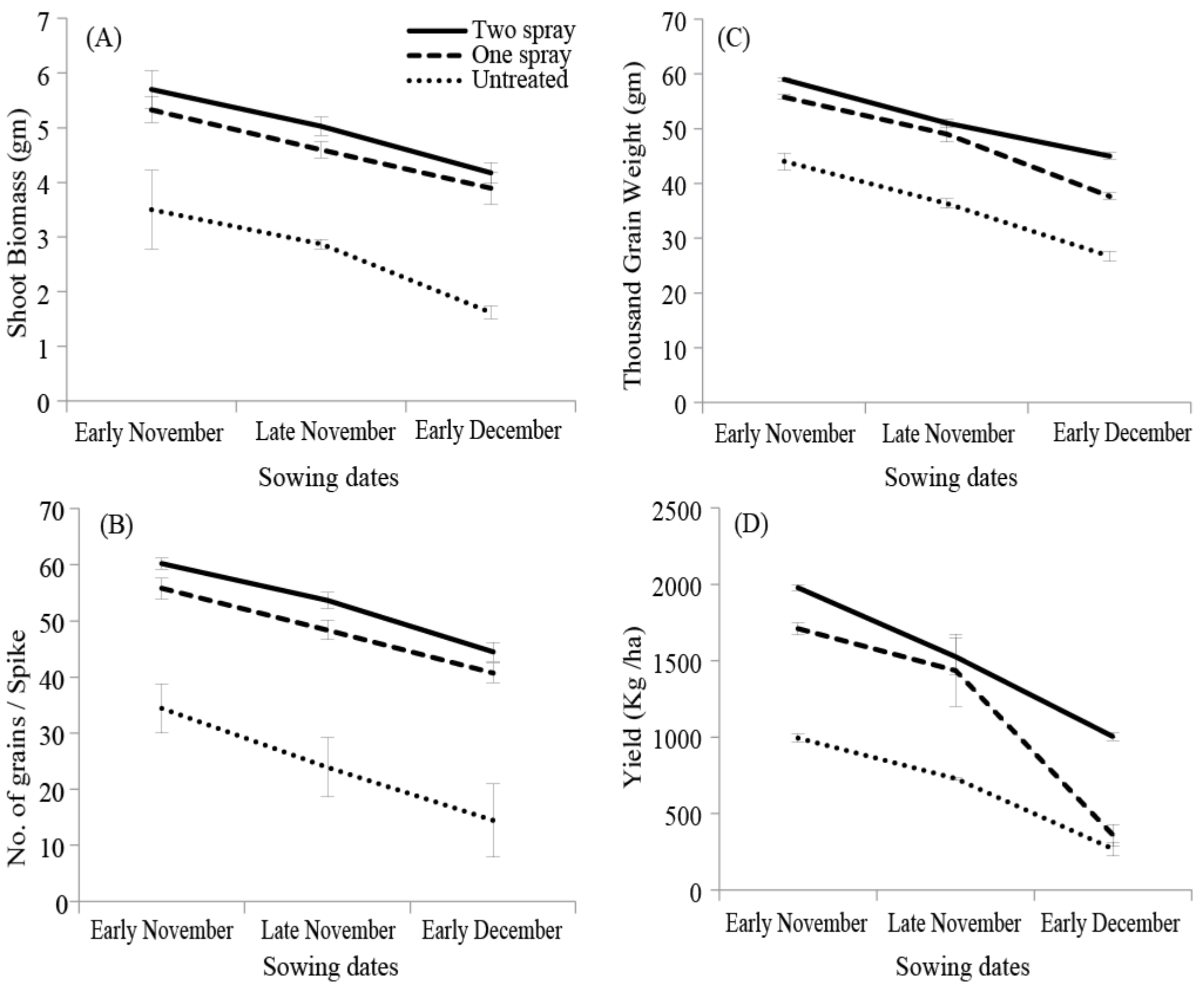

Fig. 3. Shoot biomass (gm), numbers of grains/spike, thousands grain weight (gm) and yield (kg/ha.) recorded in early November, late November and early December sown wheat in insecticide treated plots (Imidacloprid two spray, one spray) and untreated plots at Multan during 2012.

Table 3. Polynomial orthogonal contrast analysis for shoot biomass, number of grains / spike, thousand grain weight and yield influenced by sowing dates and insecticide treatment.

Contrasts	d.f.	Shoot biomass		No. of grains/ spike		Thousands grain weight		Yield	
		F value	P value	F value	P value	F value	P value	F value	P value
Block	2	1.48	0.33	0.38	0.71	2.68	0.18	1.61	0.30
Sowing date	2	12.42	0.01	14.79	0.01	268.20	0.00	94.75	0.00
Sowing date: Early November × Late November	1	4.32	0.10	6.84	0.06	109.88	0.00	19.17	0.01
Sowing date: Late November × Early December	1	20.51	0.01	22.74	0.01	426.52	0.00	170.33	0.00
Residuals	4								
Insecticide	2	79.24	0.00	60.29	0.00	296.29	0.00	63.79	0.00
Insecticide: Untreated (control) × Spray	1	155.16	0.00	117.99	0.00	555.04	0.00	107.59	0.00
Insecticide: 1 Spray × 2 Spray	1	3.31	0.09	2.59	0.13	37.53	0.00	20.00	0.00
Sowing date × Insecticide (Interactions)	4	0.38	0.81	0.17	0.95	3.04	0.06	4.48	0.01
Sowing date: Insecticide: Early November-Late November: Control × Spray	1	0.02	0.87	0.34	0.57	0.04	0.84	0.37	0.55
Sowing date: Insecticide: Late November-Early December: Control × Spray	1	1.40	0.26	0.30	0.59	0.85	0.38	8.00	0.01
Sowing date: Insecticide: Early November-Late November: 1 Spray × 2 Spray	1	0.01	0.89	0.02	0.90	0.51	0.49	0.96	0.34
Sowing date: Insecticide: Late November- Early December: 1 Spray × 2 Spray	1	0.08	0.77	0.03	0.86	10.76	0.01	8.60	0.01
Residuals	12								

d.f. = Indicates error degree of freedom

Table 2. Polynomial orthogonal contrast analysis for numbers of *Rhopalosiphum padi* per plant influenced by sowing dates and insecticide treatment.

Contrasts	df	Sampling dates					
		19th March		26th March		03rd April	
		F value	P value	F value	P value	F value	P value
Block	2	0.25	0.79	3.86	0.11	0.92	0.46
Sowing date	2	7.58	0.04	144.81	0.00	64.73	0.00
Sowing date: Early November × Late November	1	0.54	0.50	8.35	0.04	2.97	0.16
Sowing date: Late November × Early December	1	14.61	0.01	281.27	0.00	126.49	0.00
Residuals	4						
Insecticide	2	21.69	0.00	0.10	0.89	28.39	0.00
Insecticide: Untreated (control) × Spray	1	43.29	0.00	0.20	0.65	11.59	0.00
Insecticide: 1 Spray × 2 Spray	1	0.09	0.76	0.00	0.93	45.18	0.00

df indicates error degree of freedom

The present study reveals that early sown wheat crop escaped aphid populations ultimately avoiding losses in the yield as application of insecticide did not increase the yield in early November and late November sown wheat despite the presence of 50 aphids per tiller of wheat. The December sown crop suffered the highest losses as there were significant differences in yield where one and 2 sprays of Imidacloprid were applied when compared to late November. Therefore, the best option would be the avoidance of late sown wheat in the areas of Multan. It will be more appropriate to avoid application of insecticides on wheat because besides problems of insecticide resistance, appearance of secondary insect pests, resurgence of aphids in higher numbers due to depletion of predators and parasitoids and environmental pollution as witnessed in different crops from 1950s, there might be the problem of toxic residues in wheat which is staple food of the country. In late November and early December sown wheat, two applications significantly improved the yield of wheat, therefore determination of time of application or number (s) of insecticide applications needs detailed assessment for biopesticides.

References

Acreman, T.M. and A.F. Dixon. 1985. Developmental patterns in the wheat and resistance to cereal aphids. *Crop Prot*., 4: 322-328.

Aheer, G.M., I. Haq, M. Ulfat, K.J. Ahmad and A. Ali. 1993. Effects of sowing dates on aphids and grain yield in wheat. *J. Agric. Res.*, 31: 75-79.

Aheer, G.M., K.J. Ahmad and A. Ali. 1994. Role of weather in fluctuating aphid density in wheat crop. *J. Agric. Res*., 32: 295-301.

Ahmed, N.E., H.O. Kanan, S. Inanaga, Y.Q. Ma and Y. Sugimoto. 2001. Impact of pesticide seed treatments on aphid control and yield of wheat in the Sudan. *Crop Prot*., 20: 929-934.

Akhter, I.H. and A. Khaliq. 2003. Impact of plant phenology and coccinellid predators on the population dynamic of rose aphid *Macrosiphum rosaeiformis* Das (Aphididae: Homoptera) on rose. *Plant Sci.*, 2: 119-122.

Ali, I., B.S. Khan, M. Sagher and A. Ali. 2011. Determination of varietal resistance for and losses by aphids in wheat cultivars. *Pak. Entomol*., 33: 157-160.

Behle, R.W. and G.J.Jr. Michels. 1993. Greenbug (Homoptera: Aphididae) feeding affects nonstructural carbohydrate levels in seedling sorghum. *J. Econ. Entomol.*, 86: 363-368.

Bospucperez, N.A. and J.D.J. Schotzko. 2000. Wheat genotypes, early plant growth stage and infestation density effects on Russain wheat aphid (Homoptera: Aphidae) population increase and plant damage. *J. Entomol. Sci*., 35: 22-38.

Castle, S. and S.E. Naranjo. 2009. Sampling plans, selective insecticides and sustainability: the case for IPM as 'informed pest management'. *Pest Manage. Sci*., 65: 1321-1328.

Ciepiela, A.P. 1993. The harmful effect of cereal aphid on winter wheat crop. *Ochrona–Roslin*, 37: 9-10.

Geza, K. 2000. Aphid flight and change in abundance of winter wheat pests. Archives phytopatholgy. *Plant Prot*., 33: 361-373.

Hallqvist, H. 1991. Bekampningstosklar for havrebladlus (*Rhopalosiphum padi*) I varsad-resultatfran Mellansvergie. p. 197-205. In: 32nd Swedish Crop Protection Conference. *Swedish university of Agricultural Sciences,* Uppsala.

Hammond, R.B. 1996. Limitations to EILs and thresholds, p. 58-73. *In*: *Economic thresholds for integrated pest management*. (Eds.): L. G. Higley and L. P. Pedigo, University of Nebraska Press, Lincoln, NE.

Holmes, R.S., R.L. Burton, J.D. Burd and J.D. Ownby. 1991. Effect of greenbug (Homoptera: Aphididae) feeding on carbohydrate levels in wheat. *J. Econ. Entomol.* 84: 897-901.

Kausar, F. and M. Shahbaz. 2013. Interactive effect of foliar application of nitric oxide (no) and salinity on wheat (*Triticum aestivum* L.). *Pak. J. Bot*., 45(SI): 67-73.

Khakwani, A.A., M.D. Dennett, M. Munir and M. Abid. 2012. Growth and yield response of wheat varieties to water stress at booting and anthesis stages of development. *Pak. J. Bot*., 44: 879-886.

Kannan, N.O. 1999. Population dynamics of wheat aphid *Schizaphis graminum* (Rondani) (Homoptera: Aphididae) and its natural enemies in the field. *Sudan J. Agric. Res*., 2: 65-68.

Khan, A.M., A.A. Khan, M. Afzal and M.S. Iqbal. 2012. Wheat crop yield losses caused by the aphids infestation. *J. Biofertil. Biopestici*., 3:122. doi:10.4172/2155-6202.1000122.

Khan, H., M. Ayaz, I. Hussain, Z. Khan and M.K. Khattak. 2000. Effect of sowing methods and seed rates on grain yield and yield components of wheat variety Pak-81. *Pak. J. Biol. Sci*., 3: 1177-1179.

Khan, S.A., N. Hussain, Farmanullah and Y. Hayat. 2007. Screening of wheat genotypes for resistance against cereal aphids. *Sarhad J. Agric*., 23: 427-434.

Khattak, M.K., Riazuddin and M. Anayatullah. 2007. Population dynamics of aphids (aphididae: homoptera) on different wheat cultivars and response of cultivars to aphids in respect of yield and yield related parameters. *Pak. J. Zool.*, 39: 109-115.

Kibe, A.M., S. Singh and N. Kalrac. 2006. Water-nitrogen relationships for wheat growth and productivity in late sown conditions. *Agric. Water Manage*., 84: 221-228.

Kieckhefer, R.W. and J.L. Gellner. 1992. Yield losses in winter wheat caused by low density cereal aphid populations. *Agron. J*., 84: 180-183.

Kindler, S.D., T.L. Springer and K.B.L. Jensen. 1995. Detection and characterization of the mechanisms of resistance to Russian wheat aphid (Homoptera: Aphididae) in tall wheat grass. *J. Econ. Entomol*., 88: 1503-1509.

Memon, R.A., G.R. Bhatti, S. Khalid, A. Mallah and S.Ahmed. 2013. Illustrated weed flora of wheat crop of Khairpur District, Sindh. *Pak. J. Bot*., 45: 39-47.

Nault, B.A. and G.G. Kennedy. 1998. Limitations of using regression and mean separation analyses for describing the response of crop yield to defoliation: a case study of the Colorado potato beetle (Coleoptera: Chrysomelidae) on potato. *J. Econ. Entomol*., 91(1): 7-20.

Pedigo, L.P., S.H. Hutchins and L.G. Higley. 1986. Economic injury levels in theory and practice. *Annu. Rev. Entomol*., 31: 341-368.

Razaq, M**.,** A. Mehmood, M. Aslam, M. Ismail, M. Afzal and S.A. Shad. 2011. Losses in yield and yield components caused by aphids to late sown *Brassica napus* L., *brassica juncea* L., and *Brassica carrinata* A. Braun at Multan, Punjab (Pakistan). *Pak. J. Bot.*, 43: 319-324.

Riazuddin., M. Anayatullah and M.K. Khattak. 2004. Screening resistant wheat lines against aphids. *Pak. Entomol*., 26: 13-18.

Rossing, W.A.H., R.A. Daamen and M.J.W. Jansen. 1994. Uncertainty analysis applied to supervised control of aphids and brown rust in winter wheat. Part II. Relative importance of different components of uncertainty. *Agric. Systems*, 44: 449-460.

Shah, A.K., Farmanullah, N. Hussain. A.U.R. Saljoqi, Y. Hayat and S. Sattar. 2006. Distribution pattern of the cereals aphids in the wheat growing areas of the province Khyber Pukhtunkhwa of Pakistan. *Sarhad J. Agric*., 22: 655-959.

Siddiqui, S.S., M. Naeem and N.A. Abbasi. 2009. Effect of planting dates on aphids and their natural enemies in cauliflower varieties. *Pak. J. Bot*., 41: 3253-3259.

Smith, R.F. and W.W. Allen. 1954. Insect control and the balance of nature. *Sci. Am*., 190: 38-42.

Steel, R.G.D. and J.H. Torrie. 1980. *Principles and Procedures of Statistics: A Biometrical Approach.* p. 633. New York, McGraw-Hill.

Stern, V.M., R.F. Smith, R. van den. Bosch and K.S. Hagen. 1959. The integrated control concept. *Hilgardia,* 29: 81-101.

Tabasum, S., I.R. Noorka, M. Afzal and A. Ali. 2012. Screening best adopted wheat lines against aphid (*Schizaphis graminum* Rondani) population. *Pak. Entomol*., 34: 51-53.

Valenciano, P.A., Casquero, J.A. Boto and M. Guerra. 2006. Effect of sowing techniques and seed pesticide application on dry bean yield and harvest components. *Field Crops Res.*, 96: 2-12.

Wains, M.S., A.U. Rehman, M. Latif and M. Hussain. 2008. Aphid dynamics in wheat as affected by weather and crop planting time. *J. Agric. Res*., 46: 361-366.

Wains, M.S., M.A. Ali, M. Hussain, J. Anwar, M. Zulkiffal and W. Sabir. 2010. Aphid dynamics in relation to meteorological factors and various management practices in bread wheat. *J. Plant Protec. Res*., 50: 385-392.

Wangai, A.W., R.T. Plumb and H.F.V. Emden. 2000. Effects of sowing date and insecticides on cereal aphid populations and barley yellow dwarf virus on barley in Kenya. *J. Phytopathol.* 148: 33-37.

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