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BALANCED USE OF FERTILIZERS CAN REDUCE APHID INFESTATION AND IMPROVE YIELD IN WHEAT CROP

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ABSTRACT

Wheat aphids have attained the status of regular insect pests and cause economic losses at national level. Nutrient management can be an effective strategy in controlling cereal aphids. Little is known about how aphids respond to different doses of fertilizers under diverse agro-ecological conditions of Punjab, Pakistan. The present study was conducted to evaluate the impact of different doses of nitrogen, phosphorus and potash (N-P-K; 46-0-0, 69-0-0, 69-46-0, 69-0-25 and 69-46-25 kg/acre) fertilizers on aphid populations and yield parameters of wheat. A trial was conducted at four Adaptive Research Farms of Agriculture Extension Department located in four different agro-ecological zones of Punjab during wheat growing season of 2010-11. *Schizaphis graminum* was the most abundant aphid species followed by *Sitobion avenae* and *Rhopalosiphum padi* at all the four locations. Aphid populations behaved similarly at all the study sites; it was the minimum in the treatment that included nitrogen, phosphorus and potassium i.e. 69-46-25 kg/acre. Yield improved significantly in treatments with phosphorus while potash had no impact on it. Positive correlation was found between populations of aphids and their natural enemies. It suggests that balanced use of fertilizers (69-46-25 kg/acre) can significantly lower aphid infestations on wheat crop and increase its yield.

Keywords: Balanced fertilizers, cereal aphids, wheat, yield

INTRODUCTION

Wheat (*Triticum aestivum*) is the main staple food of Pakistan and contributes about 75% of the total food as well as protein intake of the people (CIMMYT, 1989). Pakistan is the 8th largest producer of wheat in the world and accounts for 3% of the world's wheat production from 3.75% of the total wheat growing area, which is about 37% of the total cropped area of Pakistan. Due to ever-increasing population of Pakistan, its demand is increasing day by day. The challenge of increasing wheat supplies is much greater in the developing countries than it is in the developed countries.

Several reasons have been documented for the low yield of wheat in Pakistan (Bashir et al., 2006). Aphids are one of the most important reasons of wheat decline in Pakistan during the last decade (Khan et al., 2012). These cause direct damage to the wheat plant by sucking phloem sap and blocking photosynthesis which ultimately results in leaf distortion, discoloration, stunting, leaf curling and wilting (Kindler et al., 1995; Gash, 2012). Several abiotic factors i.e., temperature, relative humidity, rainfall, wind etc. (Wains et al., 2008) and biotic factors i.e. host plant resistance, parasitism etc (Hufbauer, 2002; Akhtar et al., 2009), regulate the infestation of aphids. Both the host plant resistance (Riedell, 1990) and parasitism (Mohsin et al., 2009) are governed by macro or micro nutrients in wheat crop. Based on interaction between soils and pests, we can provide instructions for optimizing total agro-ecosystem (Chau and Heong, 2005).

It is an established fact that aphid populations are favoured by high levels of nitrogen applications whereas nitrogen in combination with phosphorus and potassium suppresses the aphid attack (Ram and Gupta, 1988; Khattak et al., 1996; Kumar, 2010). It is well documented that nitrogen fertilizer enhances the plant growth however, potassium and phosphorus increase its hardiness, making them less subjected to lodging (Mohsin et al., 2009).

The way in which plant nitrogen fertilization affects aphids in general, and cereal aphids in particular, is unclear (Gash, 2012). Much of such work has been done under controlled environmental conditions and has highlighted the complexity of relationships between aphids and plant nitrogen, which is now considered more complex than simple correlation with

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nitrogen contents of the insect's diet (Febvay et al., 1988). Only a few studies deal with aphid populations under natural conditions in this regard (Gash, 2012), reflecting that aphid response towards nitrogen works in a variable way depending upon aphid species (Honek, 1991; Gash et al., 1996; Duffield et al., 1997). In case of wheat aphid (*Metopolophium dirhodum*) the intrinsic rate of increase and fecundity is strongly predicted by the levels of nitrogen fertilizers but longevity may remain unaffected (Gash, 2012). Growth and longevity of *M. dirhodum* were not affected by the increasing levels of phosphorus and calcium fertilizers (Mohsin et al., 2009).

Present study was performed to observe the impact of different N-P-K doses on wheat aphid species under natural field conditions aiming to give farmers a suitable cultural control strategy of wheat aphids with optimum use of fertilizers in Punjab, Pakistan.

MATERIALS AND METHODS

The study was conducted at four experimental farms of Adaptive Research Stations of Agriculture Extension Department, Government of Punjab, located in four different agro-ecological zones of Punjab, Pakistan (Table 1) i.e. arid zone (Chakwal), rice zone (Sheikhupura), mixed zone (Sargodha) and cotton zone (Vehari) (PARC, 1980).

The study was conducted during wheat growing season of 2010-2011. There were five combinations of Nitrogen, Phosphorus and Potassium (N-P-K) viz. 46-0-0, 69-0-0, 69-46-0, 69-0-25 and 69-46-25 kg/acre. A control treatment was also maintained with no fertilizers. Those plots were selected for the trials where previously exhausted crops were sown like cotton, maize, sugarcane and sunflower followed by a soil lab analysis.

Wheat variety 'Seher' was sown during 2nd week of November in all the five adaptive research farms. All the doses of N-P-K were applied at the time of land preparation with the help of hand drill. The trials were laid out under Randomized Complete Block Design (RCBD) in three replications.

Irrigation and manual weeding were made as per requirement of the crop. Weekly data of aphid and their natural enemies was recorded from 1st week of February to 4th week of March. Aphids were recorded by randomly selecting 10 tillers in each treatment and counting all aphid individuals irrespective of their species, size and stage. Likewise, natural enemies were recorded by randomly observing 10 plants in each treatment and counting all the existing natural enemies and aphid mummies irrespective of their stage. Harvesting was undertaken manually and grains were separated from the ears using a static threshing machine. Total grain weight was calculated for each treatment separately.

Data on aphid population was subjected to ANOVA separately for each location while the data on yield was first pooled for all the four locations and then subjected to ANOVA. The means were compared with LSD test at alpha 0.5. To see the relationships between aphids, their natural enemies, wheat yield and yield attributing characteristics, Pearson's correlation coefficients were determined. Statistical analysis was performed on XLSTAT software (XLSTAT, 2010).

RESULTS AND DISCUSSION

At Sargodha, the maximum aphid population was recorded in N-P-K ratio of 69-0-0 followed by 69-0-25, 46-0-0 and 69-46-0, respectively (Table 2). The lowest aphid population was recorded in N-P-K dose 69-46-25 and 0-0-0. Likewise, at Vehari, the maximum aphid population was recorded in 46-0-0 followed by 69-0-0, 69-0-25 and 0-0-0. N-P-K dose 69-46-0 showed relatively low aphid population while the minimum population was observed in 69-46-25 (Table 2). Similarly in Sheikhupura, all the treatments were statistically diverse i.e. the maximum aphid population in N-P-K dose 69-0-0 followed by 46-0-0, 69-46-0, 69-0-25, 69-46-25 and 0-0-0, respectively. In Chakwal, the maximum aphid population was recorded in dose 69-0-0 and 69-0-25 (statistically similar) followed by 46-0-0, 69-46-0 and 69-46-25. The minimum aphid population was recorded in ratio 0-0-0 (Table 2).

In all the four study locations, the maximum aphid population were recorded in plots where only nitrogen was applied i.e. N-P-K dose of 46-0-0 and 69-0-0. The impact of increasing nitrogen doses on cereal aphid infestation is not fully known. Some studies suggest no impact of increasing nitrogen levels (Honek, 1991; Fluegel and Johnson, 2001) whereas others favour the positive correlation between cereal aphids and nitrogen doses (Duffield et al., 1997; Aqueel and Leather, 2010; Gash, 2012).

Different cereal aphid species may respond differently towards increasing nitrogen doses (Honek, 1991; Duffield et al., 1997; Aqueel and Leather, 2011).

The species-wise pooled population for all the four adaptive research farms showed that *S. graminum* was the most dominant species followed by *S. avenae* and *R. padi*, respectively (Fig 1).Insect pests may vary temporally and spatially in their relative abundance (Harrison et al., 2005). Understanding the temporal and spatial fluctuations with reference to biotic and a-biotic factors is very important in devising any pest management strategy (Harrison et al., 2005). The most dominant species in this study was *S. graminum* (47% of the total aphid population). Previously the response of *S. graminum* against different nitrogen levels in wheat crop is poorly known. However, Duffield et al. (1997) and Honek (1991) reported that *S. Avenae* population was least affected by increasing nitrogen levels in wheat crop.

The comparison of yield among five fertilizer ratios was done on pooled data of all the four locations. The highest yields (1778 and 1613 kg/acre) were recorded in the plots where fertilizer doses of 69-46-25 and 69-46-0 were applied followed by 69-0-25, 69-0-0 and 46-0-0, respectively. The minimum yield (843 kg/acre) was recorded in plots where no fertilizers were applied at all (Fig 2). Our results suggested that with the increase of phosphorus doses, the aphid infestation decreased significantly whereas, with the increase of potash, aphid infestation further reduced. This shows the importance of balanced fertilization towards restricting the aphid infestation.

Phosphorus is the second most limiting element in the soils (Yoshida, 1981) and an important component of living matter. In many plant species of family Brassiceae, phosphorus and potash application has resulted in reduced aphid populations (Ram and Gupta, 1988; Kumar, 2010; Sarwar et al., 2011). However, this phenomenon is not understood in cereal crops (Mohsin et al., 2009).

The Pearson correlation matrix between yield, yield attributing components and insect populations showed that there was a strong positive relationship between populations of aphids and their natural enemies (Table 3). Yield decreased significantly with the increasing aphid infestations. Yield significantly increased with the increase in number of tillers per meter square, plant height, number of grains per spike and 1000 grain weight. The weight of 1000 grains also increased with the increase in number of grains per spike.

It is well established that aphids decrease the wheat yield (Rabbinge et al., 1981; Rossing, 1991; Hammon et al., 2003) however; balanced use of fertilizers not only improved the yield but also decreased aphid populations in this study. Phosphorus seems more useful for enhancing yield than that of potassium since N-P- K doses of 69-46-25 and 69-46-0 were statistically similar. The addition of potassium and phosphorus increase the hardiness of crops (Mohsin et al., 2009) and make it less vulnerable to aphid infestation (Sarwar et al., 2011). There was a positive relationship between aphids and their natural enemies. This is a commonly observed relationship between predator and prey of any ecosystem.

In conclusion, balanced use of fertilizers i.e. nitrogen, phosphorus and potassium (69-46-25 kg/acre) which is generally recommended for better wheat yield can also significantly lower the aphid infestations on wheat crop in all the four agro ecological zones.

Table – 1: Details of study sites at Adaptive Research Farms in Punjab, Pakistan.

	Study location	**Agro-ecological zones**
1	Adaptive Research Farm Chakwal	Arid zone
2	Adaptive Research Farm Sheikhupura	Rice zone
3	Adaptive Research Farm Sargodha	Mixed zone
4	Adaptive Research Farm Vehari	Cotton zone

Table – 2: Comparison of aphid populations (per tiller) among six fertilizer treatments at four adaptive research farms during 2011. (Mean +S.E).

Treatments	Sargodha	Vehari	Sheikhpura	Chakwal
69.00.00	13.44 + 0.99 a	3.54 + 0.30 ab	73.67 + 1.84 a	3.26 + 0.34 a
46.00.00	9.46 + 0.82 b	3.58 + 0.24 a	66.61 + 1.64 b	2.82 + 0.27 ab
69.46.00	9.89 + 0.24 b	2.77 + 0.14 b	61.22 + 1.98 c	2.25 + 0.19 bc
69.00.25	11.46 + 0.18 ab	3.04 + 0.28 ab	54.56 + 1.62 d	3.28 + 0.14 a
69.46.25	7.29 + 0.83 c	1.79 + 0.12 c	48.17 + 1.17 e	2.57 + 0.24 abc
00.00.00	5.36 + 0.19 c	3.02 + 0.33 ab	41.94 + 1.26 f	1.87 + 0.22 c

Means sharing similar letters are statistically non-significant at alpha 0.05.

Table – 3: Matrix of Pearson's correlation coefficients between aphids, natural enemies, yield and yield attributing characters at four adaptive research farms of Punjab during 2011.

	Aphids	Natural enemies	Yield	Germi-nation	No of tillers	Plant height	No of grains / spike
Natural enemies	0.830*						
Yield (kg/acre)	-0.313*	-0.319*					
Germination (%)	0.087	0.033	0.183				
No. of tillers	-0.429*	-0.492*	0.716*	-0.069			
Plant height (inc.)	-0.076	-0.157	0.666*	0.553*	0.328*		
No of grains/spike	-0.055	-0.070	0.637*	0.023	0.360*	0.654*	
1000 grain weight (gm)	0.144	0.062	0.457*	0.534*	0.059	0.822*	0.479*

*, significant at the level of significance alpha=0.050 (two-tailed test)

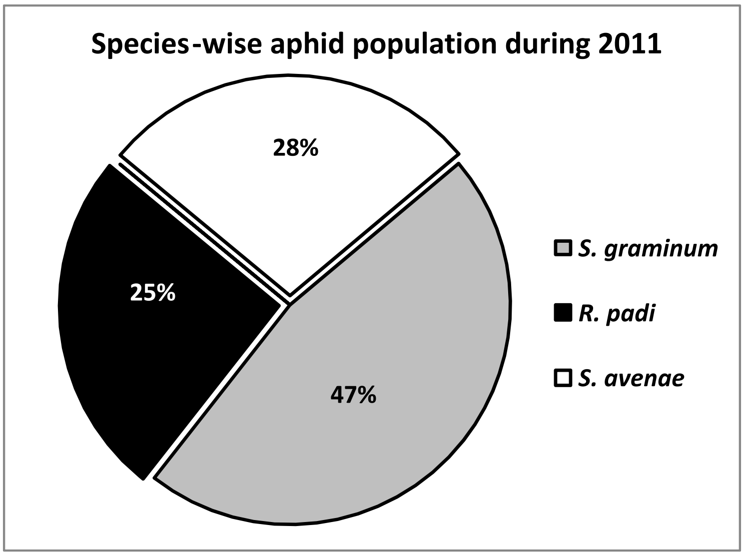

Fig – 1: Comparison of overall abundance of three aphid species at four adaptive research farms of Punjab during 2011

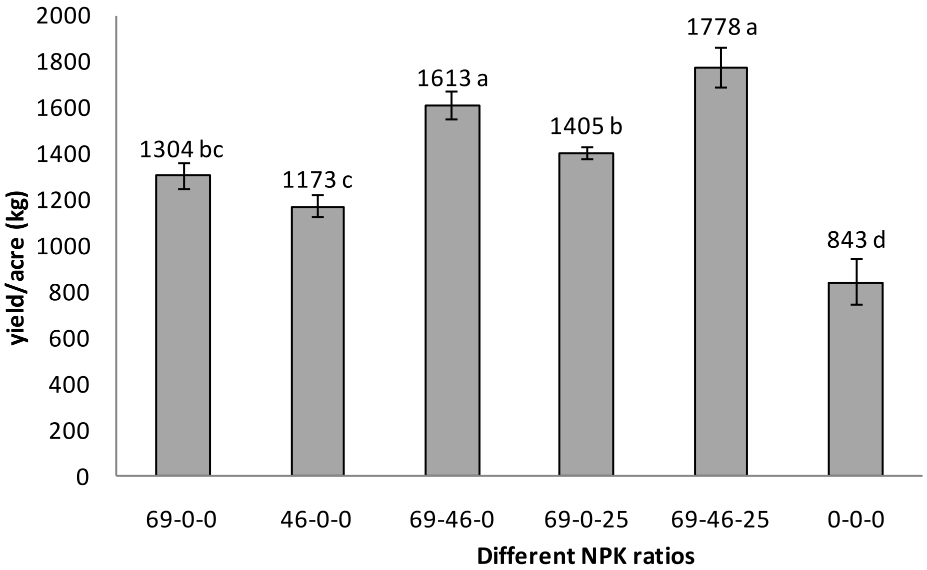

Fig – 2: Comparison of wheat yield among six different fertilizer ratios at four adaptive research farms of Punjab during 2011. Error bars indicate standard errors. Same letters are non-significant at alpha=0.05.

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