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Impact of Micro and Macro-nutrient Foliar Fertilizer Use on the Population of Wheat Aphid, *Diuraphis noxia* (Hemiptera: Aphididae) and Wheat Yield

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Abstract: Wheat aphid *Diuraphis noxia* (Hemiptera: Aphididae) is one of the most serious pests of wheat and other grain crops. The resistance of the wheat crop to *D. noxia* can be improved by foliar application of micro- and macro-nutrients, including via seed treatment. The effects of applications of foliar fertilizers containing micro- and macro-nutrients on aphid populations and wheat yields were studied during 2013-14. There were five treatments: T_0, control treatment; T_1('Spring Up' [*i.e.* P_2O_5, 11%; K_2O, 9%] as seed treatment and 'Blossom Plast' [*i.e.* Zn, 7%; Fe, 1%; Cu, 1%; Mn, 1%] and 'Super Flor' [*i.e.* N, 8%; P_2O_5, 8% ; K_2O, 6%] as foliar treatment); T_2 ('Spring Up' as seed treatment and 'Blossom Plast' and 'Super Flor' as foliar treatment); T_3 ('Spring Up' as seed treatment; and 'Blossom Plast' as foliar treatment); and T_4('Spring Up' as seed treatment). The wheat variety was Sehar-2006. Aphids appeared in the field on 4February 2014 and increased in number gradually until 14 March 2014. Data for aphid populations and yield were collected from 50 tillers. The lowest aphid population was observed under treatment T_1, with an average of 1.25 per tiller. The next lowest population was recorded under treatment T_2(3.12 per tiller). The control treatment (T_0) resulted in the highest aphid population (11.26 per tiller). Yield values (1000-grain weight) were 50 g under treatment T_1, 40 g under $T_2$and 20 g (the lowest value) under the control regime, T_0. Overall, the ranking was T1>T2>T3>T4>T0. The study reveals that by using micro- and macro-nutrients it is possible to develop resistance to wheat aphid in the wheat crop and that this can also assist in enhancing yield.

Key words: Spring up · Resistance · Foliar spray · Super flor · Nutrition

INTRODUCTION

Wheat (*Triticum aestivum* L.) is an important field crop that plays a crucial role in the economic stability of Pakistan [1]. Bread wheat is the most widely grown crop in the world. Pakistan lies in the top ten wheat producing countries of the world and ranks at ninth in terms of area, fifth in terms of yield per hectare and eighth in terms of production [2]. The average yield of wheat, however, is lower than in developed countries. In most wheat growing areas, inadequate supplies of essential elements at the appropriate developmental stages limit potential yields [3]. Furthermore a range of insect pests attack the wheat crop notably aphids (Aphididae: Homoptera), commonly called 'plant lice', which are significant sucking pests of various field crops, fruits and vegetables. Over the past few years, their population has increased in Pakistan and they now commonly attain pest proportions [4]. Aphids can cause direct yield losses of 35% to 40% by sucking the sap of the plants they infest and indirect losses of 20% to 80% by transmitting viral and fungal diseases [5]. Aphid feeding can cause difficulty in normal phloem transport that lead to delays the release of nitrogen components to cells and disrupt the photosynthetic flow [6]. It sucks the sap and injects the toxin into the plant and interferes with the grain formation [7].

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In order to approach optimal growth and development, plants require various nutrients in specific forms and in specific amounts delivered at the proper times [8]. Inadequate control and monitoring can lead to serious wastage; for example, nitrogen losses in the case of corn grown as a summer crop accounted for 50% of the recommended dose of nitrogen fertilizer, on account of denitrification and leaching. An established procedure to improve and increase the quality and quantity of crop products is the foliar feeding of nutrients [9]. This procedure can recover nutrient consumption and lower environmental pollution through reducing the amounts of fertilizers added to the soil [10]. It may promote absorption of the same nutrient from the roots [11] or other nutrients by enhancing nutrients uptake [12]. Farmers must have to adopt some production practices to reduce insect damage to plants. This is done by make sure that plants have favorable growing conditions such as adequate irrigation and fertilizer. High dose of nitrogenous fertilizer support the pest to attack while potash fertilizer improve plant ability to resist.

Micronutrient deficiency can greatly reduce plant yield and quality and in consequence impairs the health of domestic animals and humans. The foliar application of fertilizers is a particularly useful technique designed to meet the specific needs of plants for one or more micro or macro-nutrients, especially trace minerals. It enables deficiencies to be corrected, weak or damaged crops to be strengthened, growth rates to be increased and overall better and healthier plants to be grown. Microelements such as Fe, Zn, Mn and Cu are added to foliar fertilizers in order to compensate for deficiencies, especially in arid and semiarid regions [13].

For example, foliar spraying with Zn (100 ppm) in blue sage (*Salvia farinacea* L.) has been found to enhance the length of the peduncle, the length of the main inflorescence, the number of inflorescence and florets and the fresh and dry weight of inflorescences per plant and in chamomile (*Matricaria chamomilla*), it has been reported that flower yield, essential oil percentage and essential oil yield are all increased compared to control plants, by foliar applications of Fe and Zn [14].

Zn is an important micronutrient that is closely involved in the metabolism of RNA and that also affects the ribosomal content of plant cell sit can therefore promote carbohydrate, protein and DNA formation. It is also required for the synthesis of tryptophan, a precursor of IAA which acts as a growth promoting substance [15]. Zinc (Zn) deficiency is a wide spread all over the world and adversely affects human health, due to low intake of Zn in our diet. This can be overcome by using food having high content of Zn [16]. The application of Zn increased yields of rice and wheat grown on calcareous soils and on Zn-deficient soils Zn uptake was increased [17]. Iron (Fe) is another micro-nutrient that is a cofactor for approximately 140 that catalyze unique biochemical reactions. Hence, iron has many essential roles in plant growth and development including chlorophyll synthesis, thylakoid synthesis and chloroplast development [15].

The aim of study is to investigate the influence of foliar fertilizer on aphid population and crop yield consequences after foliar fertilizer application with the aphid population and crop yield.

MATERIALS AND METHODS

Experimental Details and Treatments: The experiment was conducted in the field at young wala square no. 7, Department of Agricultural Entomology, University of Agriculture Faisalabad during the year 2013-14.

Sowing Method: Time of sowing was November 16, 2013 and the crop was sown by drill method with row to row distance of 9 cm with plot size of each experimental unit was 87.6x35.33 sq meter. All the recommended agronomic practices were carried out. Fertilizer ratio was applied as per recommendations i.e 2 bags of DAP and one bag of Urea in split doses. Crop was irrigated five to six times during the season.

Treatments: The experiment was laid out in a randomized complete block design (RCBD) of five treatments with three replications. Seed was treated with Spring up fertilizer base seed treatment as per recommendation by the technique seed priming. Seed were spreads on a ploythene sheet and pour the Spring up (P_2O_5=11%, K_2O = 9%) on seed mix it up as the seed is well wetted and absorbed the fertilizer. After treated with spring up seed was placed in shadow to dry. As the seed became dry after two hours seed was ready to sow with drill method. There were three foliar fertilizer mixture sprays of Nature Time (P_2O_5=11%, K_2O = 9%) Blossom Plast (Zn =7 %, Fe=1%, Cu=1%, Mn=1%) and Super Flour (N = 8%, P_2O_5= 8%, K_2O = 6%).foliar application were performed at different time interval with total 6 sprays especially 1st spray was being at tillering stage 2nd at the ear formation and 3rd at booting stage with. First data pre-treatment aphid population was recorded 4-02-14 and the last data was taken dated 14-03-14. Each data was noted after five days interval from first date to last date.

Aphid population/ Insects: The data on wheat aphid was collected from different plots according to diagonal method and putting the quadrate in the experimental unit. Select the 50 tillers from that place and aphids were collected by a camel hair brush from the spikes and calculate the numbers of aphids for population dynamics. The data regarding wheat aphid will be taken throughout the experiment according to Diagonal method on 50 tillers and data about the yield were taken as the 1000 seed weight.

Treatment Combinations: All the four foliar sprays were combined to form a mixture of micro and macronutrients for the T1 and were sprayed with knapsack machine. As same for other treatments procedure was adopted. The material will be comprised of Russian wheat aphid, macro and micronutrients (Spring Up, Bollosom Plast, Super Flor, Nature Time, as foliar form, camel hair brush, wheat seed, knapsack sprayer, Petri dishes and electrical balance.

The treatment detail will be as follow

Treatments	Seed Treatment	Sprays		
T_1	Spring up	Blossom plast	Super flor	Nature time
T_2	Spring up	Blossom plast	Super flor	-
T_3	Spring up	Blossom plast	-	-
T_4	Spring up	-	-	-
Control	-	-	-	-

The sprays were consisting of following nutrients:

Spray	Ingredients
Spring up	P_2O_5=11% , K_2O = 9%
Blossom plast	Zn =7 %, Fe=1%, Cu=1%, Mn=1%
Super Floor	N = 8%, P_2O5= 8%, K_2O = 6%
Nature time	P_2O_5=11% , K_2O = 9%

Statistical Analysis: Data of all the treatment was analyzed statistically by using software Statistix version 8.1 (Analytical software, 2005) and means werecompared using Tukey's Honestly Significant Difference (HSD) test at 5% level of significance.

RESULTS

Pre Treatment Data of Aphid Population: The data regarding pre-treatment were statistically show highly significant results. T_1 treatment maximum number of aphid population (603.67±3.84) was recorded from near to crop maturity level at last date 14-03-14 followed by 582±11.14, 568.34±07.84 and 558.33±11.76 from T_2, T_3 and T_4 respectively (Table.1). While minimum aphid population was observed from the first date 04-02-14, at initial stage showed different population viz, 14.33±1.76, 9.0±0.58, 10.33±0.88, 8.0±1.53 and 10.67±1.20 from T_1, T_2, T_3, T_4 and T_5 respectively (Table 1). The results showed that aphid population was less at initial stage but it become increase as the crop reach its maturity.

Post Treatment Data of Aphid Population: Three application of foliar spray was applied after 60, 90 and 120 days. The aphid population data was noted after 5 days interval from first application date 19-03-14 to onward continuously.

Highest aphid population was observed in treatment T_1 (626.67±14.53) and minimum population was recorded in T_4 (603.66±12.53)where as in control treatment (661.67±12.13) as shown in (Table 1).2nd application of spray was done dated 29-03-14. Minimum

Aphid popultion Before and After Application of foliar Spray

Before Treatment		After Treatment			
4-02-2014	14-03-2014	19-03-2014	03-04-2014	13-04-2014	18-04-2014
14.33 ± 1.76^{A}	558.33 ± 11.67^{B}	626.67 ± 14.53^{A}	448.33 ± 07.26^{C}	173.33 ± 12.02^{D}	62.67 ± 06.74^{D}
9.00 ± 0.58^{B}	568.33 ± 07.84^{B}	568.33 ± 18.66^{BC}	496.67 ± 29.06^{BC}	243.33 ± 23.33^{C}	156.67 ± 28.48^{C}
10.33 ± 0.88^{B}	582.00 ± 11.14^{AB}	582.00 ± 16.65^{BC}	506.00 ± 07.02^{B}	373.33 ± 08.82^{B}	295.33 ± 02.91^{B}
8.00 ± 1.53^{B}	603.67 ± 03.84^{A}	603.67 ± 03.84^{AB}	531.67 ± 14.81^{B}	398.33 ± 04.41^{B}	330.00 ± 15.28^{B}
10.67 ± 1.20^{AB}	561.67 ± 06.36^{B}	561.67 ± 12.13^{C}	695.33 ± 07.97^{A}	581.00 ± 35.09^{A}	563.00 ± 32.13^{A}

Aphid Population at 5 days intervals.

04-02-2014	09-02-2014	14-02-2014	19-02-2014	24-02-2014	29-02-2014	06-03-2014	09-03-2014	14-03-2014
14.33 ± 1.76^{A}	$12.67 \pm 1.20b^{c}$	$225.00 \pm 7.64^{AB(B)}$	310.67 ± 15.56^{A}	223.33 ± 13.35^{A}	343.33 ± 18.56^{C}	439.33 ± 08.69^{AB}	473.33 ± 16.67^{C}	558.33 ± 11.67^{B}
9.00 ± 0.58^{B}	10.00 ± 0.58^{C}	$203.33 \pm 9.28^{A}(^{C})$	313.33 ± 14.81^{A}	221.00 ± 14.53^{A}	360.00 ± 18.03^{BC}	435.00 ± 10.00^{AB}	497.00 ± 07.00^{ABC}	568.33 ± 07.84^{B}
10.33 ± 0.88^{B}	12.33 ± 0.88^{BC}	$251.00 \pm 4.58^{B(A)}$	306.33 ± 23.88^{A}	230.00 ± 11.55^{A}	412.33 ± 11.33^{A}	453.67 ± 06.84^{A}	530.33 ± 16.50^{A}	582.00 ± 11.14^{AB}
8.00 ± 1.53^{B}	16.00 ± 1.00^{A}	$222.00 \pm 7.02^{AB(B)}$	322.67 ± 20.83^{A}	218.67 ± 09.40^{A}	395.67 ± 12.45^{AB}	464.67 ± 10.04^{A}	517.00 ± 07.51^{AB}	603.67 ± 03.84^{A}
10.67 ± 1.20^{AB}	14.33 ± 0.88^{AB}	$229.33 \pm 8.84^{B(B)}$	303.67 ± 20.25^{A}	231.00 ± 08.62^{A}	359.00 ± 21.55^{BC}	412.33 ± 06.96^{B}	486.00 ± 05.51^{BC}	561.67 ± 06.36^{B}

Aphid population after the treatment application.

19-03-2014	24-03-2014	29-03-2014	03-04-2014	08-04-2014	13-04-2014	18-04-2014
626.67 ± 14.53^{A}	615.00 ± 10.41^{B}	555.00 ± 17.56^{D}	448.33 ± 07.26^{C}	296.00 ± 03.06^{D}	173.33 ± 12.02^{D}	62.67 ± 06.74^{D}
568.33 ± 18.66^{BC}	638.33 ± 15.90^{B}	560.33 ± 30.77^{CD}	496.67 ± 29.06^{BC}	396.67 ± 26.03^{C}	243.33 ± 23.33^{C}	156.67 ± 28.48^{C}
582.00 ± 16.65^{BC}	617.67 ± 08.82^{B}	607.00 ± 12.34^{BC}	506.00 ± 07.02^{B}	436.67 ± 07.26^{BC}	373.33 ± 08.82^{B}	295.33 ± 02.91^{B}
603.67 ± 03.84^{AB}	629.33 ± 15.34^{B}	629.33 ± 15.34^{B}	531.67 ± 14.81^{B}	485.00 ± 18.03^{B}	398.33 ± 04.41^{B}	330.00 ± 15.28^{B}
561.67 ± 12.13^{C}	683.33 ± 7.13^{A}	692.00 ± 05.69^{A}	695.33 ± 07.97^{A}	721.00 ± 14.73^{A}	581.00 ± 35.09^{A}	563.00 ± 32.13^{A}

1000 grain wieght Table

Yield 1000 grain weight
50.00 ± 1.15^{A}
40.00 ± 2.08^{B}
28.67 ± 1.76^{C}
25.00 ± 0.58^{CD}
20.00 ± 1.00^{D}

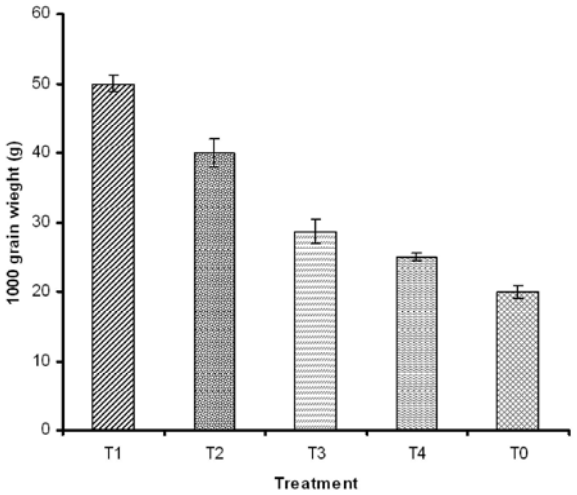

Fig. 1: Grain yield data at different treatment

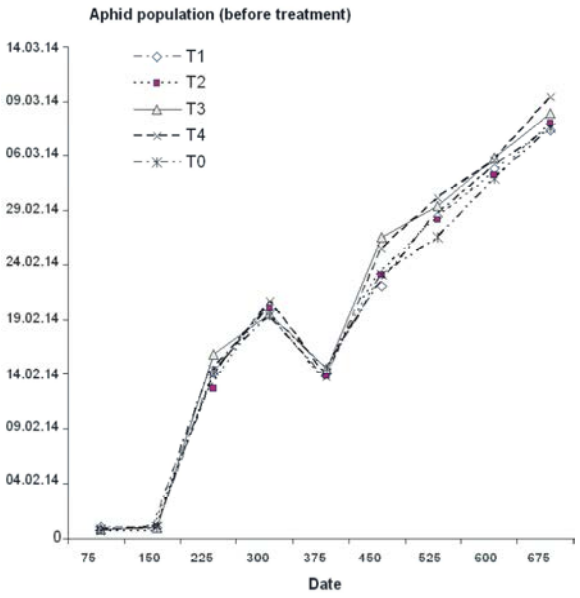

Fig. 2: Aphid population before treatment

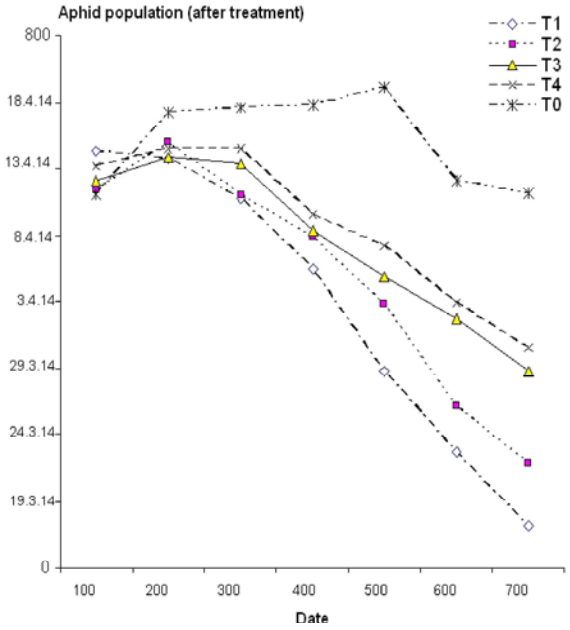

Fig. 3: Aphid population after treatment

Aphid population (448.33± 07.26) was recorded in T_1 followed by T_2, T_3 and T_4 i.e. 496.67±29.06, 506.00± 07.02 and 531.67± 14.81 respectively whereas in control treatment aphid population was 695.33±07.97, data recorded after 2nd treatment dated 03-04-14 (Table 1). 3rd treatment application was done dated 13-4-14. The data noted after 3rd treatment dated 18-04-14, Minimum aphid population (62.67± 06.74) was recorded in treatment T_1 while maximum population (330.0±15.28) was recorded in treatment T_4. But to compare with control treatment aphid population was recorded maximum (563.0±32.13) as given in the (Table 1).

Grain Yield Data: The data regarding grain yield was statistically show highly significant results as given in the (Table.1).The data regarding yield, 1000 grain weight of wheat was recorded from different treatment. Maximum grain weight was noted treatment T1 (50.0±1.15) followed by 40.0±2.08, 28.67±1.76 and 25.0±0.58 in treatment T_2, T_3 and T_4 respectively whereas in control treatment T_0 (20.0±1.0).

DISCUSSION

The present research study was conducted to find out the effect of micro and macro nutrients on the aphid population and wheat yield the results are discussed as under.

All the five treatments give better results and perform well with different combination of micro and macro nutrients. It is also recognized that supplementary foliar fertilization during crop growth improves the mineral status of plants and increase the crop yield [18,19].

In line of these results Roemheld and El-Fouly [9] also reported that the efficiency of foliar feeding is higher than of soil fertilization one reason is because of the supply of the required nutrient goes directly to the location of the high demand in the leaves and its relatively quick absorption. It has been also reported that the time of 50%absorption of nitrogen as urea is 1/2 -2 hours and 1-2 days for both Zn and Mn. It is well known that micronutrients are essential elements for life, even though they are present in small amount in plant. They activate some 100 enzymes in various plants [20] the positive marked effect of spraying micronutrient on the studied parameters may also be due to the stimulating effect of these nutrients on root growth and nutrient uptake by root as reported by Abdalla and Mobarak [21]. It is also noticed that foliar feeding of nutrient may actually promote root absorption of the same nutrient similar results were obtained by Oosterhuis and Soepardi [11]. In this study foliar application of urea at tillering at 20kg N ha^{-1} significantly ($P<0.05$) increased the number of tillers/m^{-2} from 210.8 to 230.2 and 184.8to 230.1, spikes/m□□ from 184.8 to 217.2 and 167.3to 215.4 in 2005 and 2006 respectively similar results have been reported by Parvez *et al.* [22].

The aphids population appears from the first week of February and goes on peak stage during the third week of march these finding are similar with the finding of [23] while these are contradicting with those with Singh, Sekhar and Sharma [24] which found peak population of aphid during 2nd week of January 1999 this may be happen due to change in the climatic condition.

Aphid population was low during the January and it remains with same situation in low population during the 3rd week of February. Present study show same line as with Ahmad and Nasir [25]. Reason supporting this may be because of wheat was in its initial stage. And producing tillers and aphids does not reproduce on early stage of wheat due to in adequate food availability for aphids. Quality of sap available in early stage is low and its changes with the life of plant and its growth stages that ultimately affect the longevity distribution reproduction speed of development and survival of insects [26].

After the application of micro and macro nutrients aphid's population tends to decrease in T_1 where three micro and macro nutrients both were applied, aphid population was decrease from the 19th of march and totally eliminates in the 2nd week of April these finding are similar with finding of Aslam *et al.* [5] that describes that the aphid population and infestation started in the third week of January and peak at the 16th of march and was eliminated in the 2nd week of April that may be due to when the nutrients are applied to wheat crop. They aid in the formation of amino acids, sugars, enzymes, phenols and alkaloids, which affect the resistance and tolerance to the insect pest.

The substances known to influence pest activity include amino acids, sugars, enzymes, phenols and alkaloids [27]. When nutrients are made available to crop plants in required quantities, they aid in the formation of these substances that impart resistance/tolerance to insect pests. The micro and macro nutrients are most important for the wheat crop and they improve the grain yield and their concentration and numbers have greatly show feedback to the population of aphid.

As wheat reaches to its milking stage then there is exponential increase in the aphid population aphid population and reaches to a peak on the 19th of March. Our results match with work of [28] they observe aphid population at milk stage it may be because of aphid reproduce rapidly and increase population at heading or earing stage and it may be due to the availability and surplus quantity of food in the ears. According to Trdan and Mileroj [29] it may be due to the temperature favorability. Favorable temperature ranging from 7.7 to 25.2°C [30] and optimum temperature for aphid growth is 23.44 °C.

The aphid population starts decreasing during the last week of March and almost diminish during the 3rd week of April. These finding are similar to [31, 28]. This may be because of increase in temperature, crop maturity and hardiness of grain and unavailability of sap due to senescence of crop.

All the five treatments give better results and perform well with different combination of micro and macro nutrients. The treatment T_1 where a spring up (P_2O_5= 11%, K_2O =9 %), blossom plast, super floor (N=8, P_2O_5=8%, K_2O=6%) and nature time (P_2O_5= 11%, K_2O =9 %) was applied show better result having the maximum value of

1000 grain weight such as 50 grams that have significant result with all other treatments. Present findings are almost similar to the finding of [32,33] who spray on wheat with 1 % urea that increase grain yield, grain micronutrients concentration, weight of grain this may be because of urea stimulate the plant physiological functioning and make plant to perform and helps the plants to show rapid response. As it is familiar to every person that foliar fertilization improves the mineral status of plant, making plant tolerant and resistant to the stress conditions such as disease insect pests and increase the yield [18,19]. Roemheld and El-Fouly [9] also supported my work by reporting that foliar fertilization show higher efficiency then the soil fertilizer. Soylu *e t al*. [34], Guenis *et al*. [35] and Hussain *et al*. [36] Reported significant increase in 1000-grains weight of wheat with foliar application of micronutrients.

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