



Yield Reductions of Wheat Cultivar Obora (UTIQUE96/FLAG-1) due to Russian Wheat Aphid (*Diuraphis noxia*) Infestation under Field Conditions at Selected Districts of West Showa Zone, Ethiopia

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ABSTRACT

Background: Wheat (*Triticum aestivum* L.) is an important cereal crop as being consumed as staple food in the world as well as in Ethiopia. The production of wheat in Ethiopia decreased due to the incidence of insect pests. Out of insects' pests the Russian wheat aphid (*Diuraphis noxia*) is the recent one that causes yield loss either directly or indirectly.

Methods: The experiment was carried out at selected districts of West Showa zone, Ethiopia during off cropping season 2019 to evaluate the yield reduction in wheat crop due to the invasion of Russian wheat aphids. Malamar, Dimethoate, neem seeds, leaves, *Beaveria bassiana* and *Metarhizium anisopliae* were used in form of spray.

Result: However, Malamar and Dimethoate highly significantly lowered the population of *Diuraphis noxia*. The combination of *Beaveria bassiana* and *Metarhizium anisopliae* significantly lowered the population of Russian wheat aphid. The combination of Neem leaf and Neem seeds, as well as *Beaveria bassiana*, proved to be effective against Russian wheat aphid yet they were protected and sound against the environments. Malamar showed the maximum decrease in *Diuraphis noxia* populations followed by Dimethoate, the combination of *Beaveria bassiana* and *Metarhizium anisopliae*.

Key words: *Beaveria bassiana*, *Diuraphis noxia*, *Metarhizium anisopliae*, Yield loss.

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 a growing population of the world (Khakwani *et al.* 2012). It is positioned next amongst the majority key cereal crops in the world, rice and traded globally (FAO, 2009; Najafi, 2014; Falola *et al.* 2017). The magnitude of wheat fabrication in the globe financial system is confirmed by cultivation of 15% from 1500 million hectares arable land in the world (Kiss, 2011). Wheat improvement and consumption are grown rapidly as a result of income growth and rapid urbanization in Sub-Saharan Africa (produce 30% of their domestic requirements) (Sultan, 2016). Ethiopia is the second-largest wheat producers in Sub-Saharan Africa next to South Africa, with a potential expansion to 1.3 million hectares (Nigussie *et al.* 2015; Haregewoin *et al.* 2018).

In Ethiopia, wheat is one of the majorities of cereal crops in terms of the area of land allocated (1.6 million hectares), with a production of 3.9 million tons and many farmers occupied in its production (4.7 million farmers) utilizing productivity of 2.4 tone per hectare (CSA, 2014; ATA, 2014). The highlands of the central, south-eastern and northwest parts of the country are the key wheat-growing areas of; and regionally, wheat production comes from Oromia (57.4%), Amhara (27%), SNNP (8.7%) and Tigray (6.2%) of the nationwide production (CSA, 2014). But nearly all wheat, except few governments, owned large-scale (state) farms and commercial farms produced wheat in the country, is

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produced under rain-fed conditions mostly by small level farmers (Demeke and Di Marcantonio, 2013). The production of wheat in Ethiopia decreased due to few abiotic and biotic stress like the incidence of insect pests and diseases. Out of those, insects' pests the Russian wheat aphid (RWA) *Diuraphis noxia* Mord is the recent one that causes yield losses either directly or indirectly (Alsam *et al.* 2005).

Reduced yield of wheat per hectare in Ethiopia is due to conventional techniques of farming, varieties, lack of

irrigation services, soil productivity and occurrence of insect pests and diseases. Even though a lot of insect pests infests wheat (*Triticum aestivum* L.) in Ethiopia, aphids are the major concerned. Aphids cause yield reductions by sucking the sap of the plants also indirectly (20-80%) by transmitting viral and fungal diseases (Alsam *et al.* 2005). The aphid population depends on the abiotic factors (Aheer *et al.* 2007/2008; Wains *et al.* 2008). During spring (February-March) aphid population increases, at the same time biocontrol agents like coccinellids exert a natural check on this pest (Khan *et al.* 2011). Wheat yield loss due to RWA damage in Ethiopia was estimated to be 70% (Miller and Haile, 1988); consider years of rainfall shortage, which favors the development of the pest population (Kinelskaya, 2010). It is the major reason for the low yield of wheat is the damage by RWA (Alemu *et al.* 2012). Russian Wheat Aphids (RWA) is a significant pest problem in many areas in the world (Anna-Maria *et al.* 2003). This pest has a global distribution the Middle East, USA, South Africa and Ethiopia (Burnett *et al.* 1991). The invasion causes severe deformation of vegetations and inflorescence and be able to considerably reduce the yield due to feeding. The reduction in the yield in the wheat crop is more than out of few a biotic factors like, conventional techniques of farming, reduce yielding varieties, somewhat low stage of soil productiveness and a higher occurrence of insect pests and diseases. The work was carried out to estimate the yield reduction in wheat crop due to the invasion of Russian wheat aphids. Their management to increase the wheat production.

MATERIALS AND METHODS

The experiment was carried out at selected districts of West Showa zone, Ethiopia during off cropping season 2019 to observe yield reduction in wheat crop infested by Russian wheat aphid. The information of Russian wheat aphids and its yield reduction were recorded throughout the entire trial time (from the third week of January 2019 to the second week of April 2019). The bread wheat Obora (UTIQUE96/FLAG-1) obtained from Holleta Research Center was used as a cultivar. The crop was sown in rows on the 15th of January, 2019. The treatments were distributed in 27 plots; measuring 4.5 m². The trial was replicated thrice in RCBD. Nine wheat plants from each plot were randomly selected and the number of aphids per tiller of every plant was counted. Yield was recorded from both sprayed and unsprayed plots to evaluate yield reduction. 1000 grains of each plot were calculated and their weights were compared. The abiotic factors (RH% and °C) were recorded from an observatory of the field. ANOVA was used to compare the yield reduction and thousand-grain weight reduced, after counting proportion yield reduction (LSD $P \leq 0.05$) using Statistically Analysis Software (SAS, 2000) or Minitab 16.1 software as well as IBM, SPSS 20 package was used for statistical analyses. The means were compared through DMRT at 5% level. Yield loss percentage was calculated by comparing the Weight of treated grain yield with untreated treatments.

The yield reduction percentages were calculated by using the following formulas:

$$\text{Yield loss (\%)} = \frac{\text{Protected treatment} - \text{Unprotected treatment}}{\text{Protected treatment}} \times 100$$

RESULTS AND DISCUSSION

The primary detection of aphids on the crop was recorded on 12th of February 2019 (Table 1); (1.82 aphid/plant), afterward a slowly boost in the population were observed that attaining peak in the 3rd week of March 2019 (14.35 aphid/plant). After the 4th week of March, the population started dwindling down 11.25 aphid/plant afterwards, during the 2nd week of April onwards no aphids were seen in the fields. The aphid invasion was concentrated on leaves, spikes and during the mid of March also seen on the stem too.

Effects of temperature and moisture on population dynamics of aphids

Aphid invasion happening during in 2nd week of February on the foliage. At this time, the moisture was 34.2% and temperature fluctuated between 27.4°C to 11.1°C. At the end of February, the population were slowly declining at the same time as a slight variation in the moisture and temperature were recorded. The declining aphid population maintained the 3rd week of March till the 1st week of April (Table 1). At this time, 45% moisture; 27.1°C temperature and 11.9°C temperature were recorded. Subsequently, the aphid population started declining in the 1st week of April 2019, (2.96 aphids/plant) was recorded (Table 1). Throughout April, the RH ranged from 41% to 49% and temperature from 27.1°C

Table 1: Population dynamics of wheat aphids.

Dates of observation	Aphid population 1 plant
02/02/2019	0.00
12/02/2019	1.82
22/02/2019	3.00
04/03/2019	8.77
14/03/2019	14.35
22/03/2019	11.25
03/04/2019	2.96

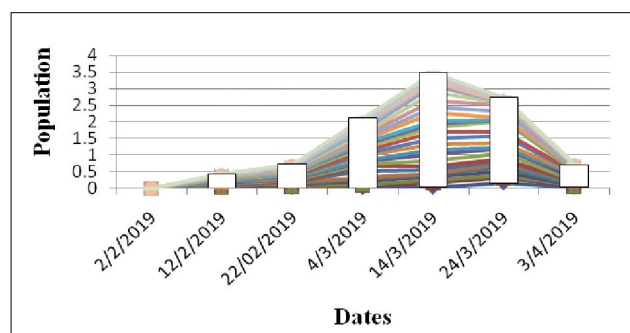


Fig 1: The effect of weather parameters on the population dynamics of wheat aphids.

to 11.9°C being highest and lowest respectively. RH attained 50% and aphid population lowered down to 2.96 aphids/plant while at the end no counts were seen in the field (Fig 1).

Yield loss estimation

The results showed that the yield per plot ranged between 189.40 gm to 1015.00 gm with an average of 695.00 gm in treated plots as compared to 10.00 gm to 15.6 gm with an average of 12.67 gm in untreated plots (Table 2). 21.37% further yield was recorded in plots treated with Malamar 50% EC (W/V). On the other hand, the statistical analysis shows that the means varied significantly between treatments.

The 1000-grain weight per plot ranged from 24.50 to 40.40 with an average of 29.89 gm (Table 3) in treated plots as compared to 10.00 to 15.60 with an average of 13.50 gm in untreated plots, 10.60% boost happened in 1000-grain weight in the plot where insecticide was sprayed (Table 2).

An infestation of Russian wheat aphids occurred in the 2nd week of February on the foliage and slowly augmented throughout the vegetative growth of the wheat crop. Khan *et al.* (2011), reported that wheat crop yield victims caused by the Aphids Invasion at Dry Zone Research Institute (AZRI), Bhakkar, Pakistan through 2004-05. The population reached its peak in the 3rd week of March throughout the heading stage of the wheat and gradually declined till the crop reached maturity with 2.96 aphids/plant in April. Similar results were shown by Karimullah and Ahmad (1989); who observed that aphids' infestation started in the 2nd week of February and peaked in the latter 2nd week of March with fluctuations in population size thereafter up to the beginning of April. Our results are in conformity to Azhar *et al.* (2011) who observed that effect of wheat cultivars on aphids and their predator populations and Nawaz, (2000); the population

of aphids in the field increased with the development of the wheat and peaked at the heading stage. Graphical presentation (Fig 1) shows that the aphid infestation started in the 2nd week of February up to the end of March, the increase in the population remained very slow, where temperature range was 10.2°C-19.5°C and the RH ranged 30%-49%. At the beginning of the 2nd week of March, the slow boost in temperature occurred and a pointed increase in population was recorded up to the mid of March. The temperature in which the population increased was in the range of 11.6°C-27.5°C and RH 64-75% was recorded. After the mid of March, the temperature and RH again increased but a pointed reduction in the aphid population was recorded. After the 1st week of April, no aphids were observed in the field.

Our finding are in parity with Yang, (1990); who reported that at low temperature, the developmental stage was late, while high temperatures reduce the reproductive ability and he besides done that a temperature of 25°C is favorable for population growth. In the present experiment, the maximum population was recorded on 14th March that was 14.35 aphids/plant at 19.5°C. likewise, Kostyukovskii and Kushneuk (1990); see that the number of aphids increased at 15-18°C during the earing and flowering of wheat. The maximum population concentration was recorded for the period of heading and grain development. The turn down in the aphid population could moreover be the result of the crop maturity as stated by Riedell, (1990); that invasion of aphids on the wheat crop is abundant for the duration of the heading and flowering phases and is declined for the period of the maturity point of the crop. In finding, a decrease of 15.60% in the yield and 10.00% in the thousand-grain weight

Table 2: Yield losses assessment due to aphid infestation in wheat.

Yield losses estimation (gm/plot)	Treatments	Range		Mean	CV%	LSD
Thousand Grain Weight	Unsprayed	15.6	205	161.67 ^a	20.25	158.2
	Neem seed	33.8	330	285.00 ^{de}		
	<i>M. anisopliae</i>	30.9	335	296.67 ^{de}		
	<i>B. bassiana</i>	30.8	455	366.67 ^{cd}		
	Neem leaf	32.8	455	381.67 ^{cd}		
	<i>B. bassiana</i> + <i>M. anisopliae</i>	32	545	461.67 ^c		
	Neem Leaf + Neem seed	28	525	491.67 ^c		
	Dimeto 40% EC	33.4	890	703.33 ^b		
	Malamar 50% EC (W/V)	40	1055	913.33 ^a		
	Untreated	10	15.6	12.667 ^d	10.80	5.59
	Neem seed	20.3	33.8	28.467 ^c		
	<i>M. anisopliae</i>	24.5	32.8	28.833 ^{bc}		
	<i>B. bassiana</i>	27.8	30.8	28.967 ^c		
	Neem leaf	28	31.1	29.433 ^c		
	<i>B. bassiana</i> + <i>M. anisopliae</i>	30.1	31	31.667 ^{ab}		
	Neem Leaf + Neem seed	32	34.3	35.100 ^c		
	Dimeto 40% EC	33.4	38.6	36.300 ^{ab}		
	Malamar 50% EC (W/V)	32.2	40.4	37.533 ^a		

P≤0.05; T1-T8 = Sprayed; T9 = Unsprayed.

Table 3: ANOVA for yield (1000-grain weight).

Source of variation	Yield loss assessment (gm/plot)					1000-grain weight comparison				
	DF	SS	MS	F-Value	PR>F	DF	SS	MS	F-Value	PR>F
Replication	3	1330120.37	133012.04	15.92	<.0001	16	1356.319	135.63	13.02	<.0001
Treatments	9		8353.704					10.42		
Error	27	133659.26				27	166.655			
Corrected total	26	1463779.63				26	1522.974			
R-Square	CV(%)		RMSE	LSD	Mean	R-Square	CV (%)		RMSE	LSD
0.908689	20.25		91.39	158.2	451.29	0.89	10.799		3.23	5.59

was recorded due to aphid infestation (Table 3). Here, our results are in parity with (Miller and Haile, 1988) who observed a reduction in yield as 70% in wheat in Ethiopia and Khan, (2000); while Gair *et al.* (1987) and Oakley *et al.* (1993); observed a decrease in yield and thousand-grain weight as 39% and 12% respectively which are more as in our schoolwork.

CONCLUSION

In accordance to our findings, it is accomplished that before maturity, wheat cultivar Obora (UTIQUE96/FLAG-1) were the most susceptible to aphid infestation under the field conditions. Optimum temperature and relative humidity, as well as plant growth conditions for the development of *Diuraphis noxia* (RWA), survived in wheat. Total susceptible fruitful plants infested with RWA were observed in wheatscultivar Obora (UTIQUE96/FLAG-1). However, the variety of Obora (UTIQUE96/FLAG-1) was most preferred during the vegetative and flowering stages. Moreover, the 2nd week of March was verified as the most critical period for the maximum aphid infestation on the wheat crop, starting from February and continued till the 1st week of April under field conditions. The yield losses of yield and 1000-grain weight were estimated in Obora (UTIQUE96/FLAG-1) infested with RWA was, 15.60% and 10.00%, respectively.

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