International Journal of Entomology Research
www.entomologyjournals.com
ISSN: 2455-4758
Received: 11-04-2022, Accepted: 26-04-2022, Published: 12-05-2022
Volume 7, Issue 5, 2022, Page No. 46-51

Management of Russian wheat aphid, *Diuraphis noxia* (Homoptera: Aphididae) using Seed treatment insecticides and its effect on yield and yield components of wheat

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Abstract
Russian wheat aphids (*Diuraphis noxia*) is a major constraint of insect pests of wheat crops in Ethiopia. In an attempt to understand the effect of seed dressing of chemical insecticides against Russian wheat aphids (*D. noxia*). The experiment was carried out at Ambo from June to November 2018, and 2019. The experiments were laid out in randomized complete block design within three replications. The result indicated that the seed dressing insecticide (Seed star 24% FS) and Titan 25 WDG resulted interesting during the study year. Significant ($P < 0.05$) differences were observed from untreated control. The treatments showed persistent effects and gave significant control over untreated check-ups to harvesting. At flowering and maturity stages, the treated treatments were infested 0-3.78 in 2018 and 0.4.13 in 2019 while the infestation of untreated control increased to 34.55 aphids/ plant in 2018 and 42.25 in 2019. At the maturity stage, the population of aphids in treated treatments increased from 2.25-23.35 aphids/plant and 8.13-33.12 aphids/plant, in 2018 and 2019, respectively. But at the maturity stage, the population of aphids per plant was observed 39.35 in 2018 and 43.25 aphids per plant were observed. These results showed that when the crops attain near ripeness, the infestation level of aphids increases. The use of seed dressing chemical insecticides was the safest, cheapest, and mainly successful means of controlling Russian wheat aphids at early stages.

Keywords: *Diuraphis noxia*, Infestation, Seed star 24% FS, Titan 25 WDG, Yield, Yield loss

Introduction

Wheat is an important cereal crops grown in Ethiopia. But in all parts of the country's varied agro-ecological zones. However, the yield of wheat is very low due to several constraints as an average it is about 2.736 ton/ha in "Meher" season (CSA, 2018) [10]. In Ethiopia, wheat ranks fourth after tef, maize, and sorghum in area coverage and third in total production (CSA, 2018) [10]. Ethiopia is the second-largest wheat production area in sub-Saharan Africa, with about 500,000 ha (Tesema *et al*., 2016) [23]. However, the yield of wheat is very low due to several constraints. Although many insect pests are known to cause losses to wheat in Ethiopia, the Russian wheat aphids (*Diuraphis noxia*)is the most important key insect pest.

Wheat production in sub-Saharan Africa is increasing by about 650, 000,000 tons per year (Mason *et al*., 2012) [12]. Its yields have reduced significantly in the last century, mainly due to different constraints *viz.* as insect pests and diseases management (Semenove *et al*., 2014) [21]. The Russian wheat aphid, *D. noxia* still emerges at irregular intervals throughout western Shoa of Ethiopia. When thorough for the Russian wheat aphid in wheat, it is often significant to see for symptoms first then for the aphids (Michaud and Phillip, 2005) [15].

To manage Russian wheat aphids and to find alternative management options, the newly introduced seed dressing treatment. To reduce *D. noxia* damage, farmers practice delaying planting, but it is not the best way of reducing damage satisfactorily. On the other hand, use of safer, seed dressing insecticides can be an effective alternative for reducing *D. noxia* damage on wheat. Seed treatment, ideally, must be of low risk to non target organisms having desirable physiochemical characteristics of formulation for application to an retention on seeds, provide protection against target pests under varuiable conditions and cause no phytotoxicity or residue problems in crops (Hewett and Griffiths, 1978; Addisu and Tadesse, 1999)[12,3]. The combination of three active ingredients Thiamethoxam+Fludioxonil+ Difenconazole (Seed star 24% FS) and Thiamethoxam (Titan 25 WDG) alone were developed having more or less these preconditions. So far, no workhas been done on Thiamethoxam + Fludioxonil + Difenconazole and Thiamethoxam for the control of *D. noxia* in Ethiopia. Seed dressing treatment Seed dressings is relatively new systematic insecticide and has a wider activity against several insect pests (Butts *et al*., 1982; Dewar, 2007; Babar *et al*., 2018) [8, 11, 5]. Hence, this experiment was designed to evaluate the performance of Thiamethoxam+Fludioxonil+ Difenconazole and Thiamethoxam on the control of *D. noxia* and to observe the effect on seed germination, plant growth and yield.

Material and Methods

The study was conducted on farmers' fields from 2018 to 2019 at Ambo University of Ethiopia. Ambo is at a geographical coordinate of 8 °59'N latitude and 37.85°E longitude with an altitude of 2100 meters above sea level (Bigger, 2012) [6]. The average annual rainfall is 1028.7 mm and the maximum and minimum temperatures of the area were 29.6°C and 11.8°C, respectively during the study period.

Experimental design and data collections

The seed of 'Danda'a' cultivar was cultivated on mid of June at both locations. The experiment was laid in a randomized completely block design (RCBD) with three replications. The seed of wheat was treated with two chemical insecticides namely: Thiamethoxam+Fludioxonil+ Difenconazole (Seed star 24% FS) and Thiamethoxam (Titan 25 WDG) at three different rates before sowing. After the germination of the plants, the Russian wheat aphids were monitored at different stages of the plants and recorded the infestation number of aphids per plant till harvesting. After harvesting yield data were calculated and recorded. There are two treatments in three different rates, standard check and untreated control were used in the study *viz.* T1= Seed star 24% FS (1250 ml), T2= Seed star 24% FS (1500 ml), T3= Seed star 24% FS (1750 ml), T4= Titan 25 WDG (200 gm), T5= Titan 25 WDG (250 gm), T6= Titan 25 WDG (300 gm), T7= Pro-seed plus 63 WS (200 gm), and T8= Untreated check.

The studies evaluated the value of yield and yield components and their contribution to the differences in grain yield per hectare. The yield losses were calculated according to the following formula (Pradhan, 1964; Tadele and Emana, 2017) [18,22].

$$\text{Yield loss (\%)} = \frac{\text{Potential yield} - \text{actual yield}}{\text{Potential yield}} \text{ X } 100$$

Potential yield is the best treatment as considered the standard for comparison with the other one's untreated check.

Data Analysis

Infestation of aphids population number and grain weight losses were subjected to analysis, using SAS version 9.1 (SAS, 2009) [20]. Mean were separated using Student-Newman-Keuls (SNK) Range Test.

Results and Discussion

Results

Figure 1 depicts the rate of all treatments showed that significantly ($P < 0.05$) higher than that of the untreated check. Lowe infestation of T_3, T_6, and T_7 were observed while the remaining treatments accept the untreated check. In both years, there were significant differences between treated and untreated treatments. Wheat with seed dressing treatment was low infestation of aphids at the vegetative stage, while the untreated treatment was infested with Russian wheat aphids and infestation level was high 22.13 and 26.13 aphids/plant were observed at vegetative stage.

The results indicated in the Figure 1 at flowering stage, the treated treatments were infested at low level ranged from 0-3.78 in 2018 and 0.4.13 in 2019 while the infestation of untreated control increased to 34.55 aphids/ plant in 2018 and 42.25 in 2019. At maturity stage, the population of aphids increased from 2.25- 23.35 aphids/plant and 8.13-33.12 aphids/plant, in 2018 and 2019, respectively. These results showed that at the early stage the seed dressing insecticides were controlling the population of aphids infestation and at the maturity stage slightly increased the aphids population. But the other treatments had non-infested at the vegetative stage and slightly increased from flowering to maturity stages. When the crops attain near ripeness number of aphids increases.

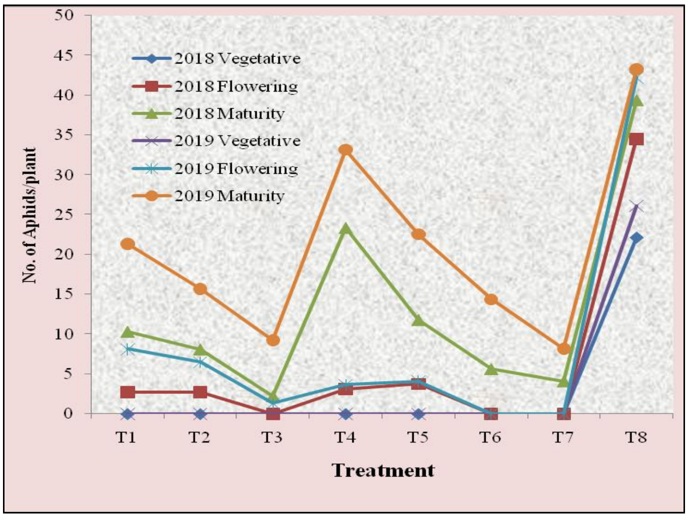

Fig 1: Effect of seed dressing on different stages of wheat in infestation number of wheat aphids, *Diuraphis noxia* and yield under open field conditions during 2018 and 2019.

Effect of seed dressing insecticides on germination percentage of seeds

The study presented in Figure 2 showed that the seed dressing insecticides in both years no significant (P > 0.05) difference among the treatments and between the years. Therefore, the seed dressing chemical insecticides at all rates gave no impact on seed germination as compared with the standard check and untreated control.

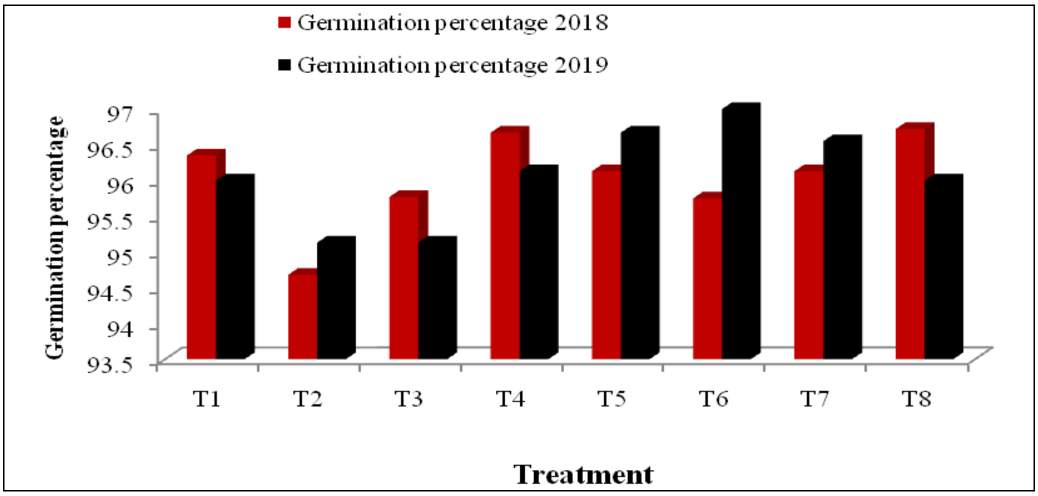

Fig 2: Effect of seed dressing insecticides on seed germination during 2018 and 2019

Effect of treatments on yield

In 2018, the highest yield was recorded by seed star 24% FS (3917.53) kg/ha at maximum rate followed by Pro-seed plus 63 WS (3882.75) kg/ha. The study showed that the rate increased yield also increased and the infestation level of aphids decreased. Similarly, trends of yield results observed in 2019, the highest yield was recorded by seed star 24% FS (3854.62) kg/ha followed by Pro-seed plus 63 WS (3768.94) presented in Table 2.

The infestations of aphids more sever in 2018 than in 2019. In general, the lowest aphid's population infestation was observed on untreated check compared to the other treatments across the two years results. In 2018, the yield differences between treated and untreated treatments were statistically significant. But the highest yield loss (20.22%) was recorded on untreated check and the lowest (0.90%) on pro-seed plus 63 WS.

In 2019, Table 2 depicts highly significant (P< 0.01) differences observed between seed dressing treatments and an untreated check. Based on these results, the relative grain yield loss ranged from 2.22 to 22.25%. The highest wheat yield loss occurred on untreated check followed by Titan 25 WDG at a rate of 250g/100kg, while the lowest was on seed star at a maximum rate.

Table 1: Mean yield and yield loss estimation of seed dressing chemical insecticides at different rates

Treatments	Rate/100 kg seed	2018		2019	
		Mean yield in kg/ha	Yield loss Estimation (%)	Mean yield in kg/ha	Yield loss Estimation (%)
T1	1250 ml	3363.12	14.15	3359.16	12.85
T2	1500 ml	3715.75	5.15	3528.19	8.47
T3	1750 ml	3917.53[a]	0.00	3854.62	0.00
T4	200 g	3330.13	15.01	3089.46	19.85
T5	250 g	3685.67	5.92	3254.69	15.56
T6	300 g	3815.55	2.61	3729.52	3.25
T7	200 g	3882.75	0.90	3768.94	2.22
T8		3122.14	20.30	2996.85	22.25

Effect of seed dressing insecticides on yield components

Significant (P<0.05) differences were observed in the different rates on yield and yield losses of wheat with respect to the high percentage of yield loss recorded in untreated check. It is obvious from the resulted treatment that more tillers recorded in both years 2018 and 2019 (6.69 and 6.55) tillers/ mother, respectively, whereas low number of tillers/mother plant (1.33, 1.78) were recorded when Titan 25 WDG at a rate of 200 gm/100 kg was used. The tillering was much high at maximum rate of seed dressing insecticides when compared to untreated check.

Figure 3 depicts there was a highly significant (P<0.01) difference in grain yield between the treated and the untreated plots and the highest grain yield was obtained from all the treated plots. The aphids were effectively controlled by highest rate in both seed dressings and high grain seed recorded in both years 2018 and 2019 (58.16 and 57.67) while a low number of seed grain were recorded by untreated check in 2018 and 2019 (36.68 and 37.13), respectively.

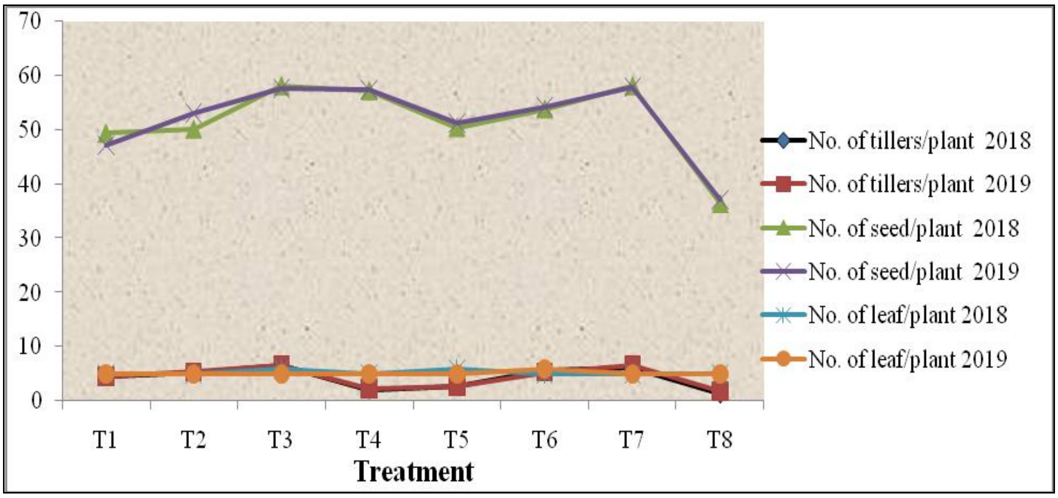

Fig 3: Effect of seed treatment on yield components of wheat

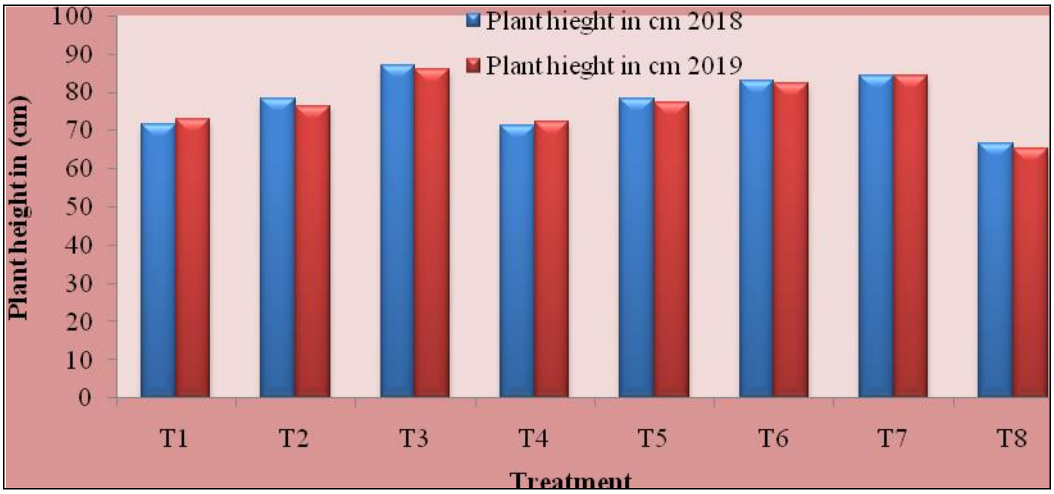

Fig 4: Effect of seed treatment on height of wheat in (cm)

Discussions

The *Diuraphis noxia* from the wheat crop adapted populations were expected to perform poorly on wheat infestation. This is because *Diuraphis noxia* population in this area are well established on wheat. The presented studies showed that at vegetative and flowering stages there was low number of aphids in the treatment plots recorded while on untreated chick high number of aphids recorded. This showed that at intimal stage seed dressing treatments effective against *D. noxia* where Seed star 24% FS and Titan 25 WDG were used as a seed dressing treatment. There was no consistent performance of all treatments throughout the season and the population of aphids increased significantly during the late maturity stage. This result consistent to the other researcher Ahmed *et al*. (2001) [4] who reported their seed dressing has useful over a regular spray. Present results are in concord with the work of Burd *et al*. (1996) [8]. Who reported effect to aphids damage on plants growth from seeds treated with imidacloprid, which protected plants for 45 days after sowing, while Ahmed *et al* (2001) [4] reported that imidacloprid in combination with tebuconazole can control aphids for eight weeks when applied as a seed treatment. Similarly, Royer *et al*., (2005) [19] found that seed treatment with imidacloprid and other insecticides decreased the population of sucking insect pests such as cereal aphids and leafhoppers. Liu *et al*. (2005) [13] and Abd-Ella *et al*. (2016) [1] found that imidacloprid and thiamethoxam seed treatments can efficiently control wheat aphids throughout the wheat growing season, and increased wheat production.

Control *D. noxia* saved a significant amount of grain yield, which are known as the principal constitute of farmers production. This was probably due to controlling insect pests, which would have to reduce the photosynthetic surface of the plant by sucking the leaf tissue or yellowing the leaves, or by affecting chloroplasts. Losses resulting from both years in untreated control are very high as compared to other treatments. Adisu *et al*. (2003) [2] reported that early, heavy damage on barley and wheat can cause total crop loss and significantly affect grain quality (Bregitzer and Jones, 2003) [7]. However, this study showed heavy infestation has appeared at flowering and vegetative stages in untreated check while at early maturity in treated plots. Although it was not statistically significant, the loss in yield and other components in both cropping seasons. In 2018, cropping season, the grain loss 20.3% while in 2019, it had resulted in a loss of 22.25% for grain yield. As there was no significant variation in leaf number and plant height.

In all cases, there was significant variation in number of seed per plant spike and weight between the treated and untreated check. This and highly significant association between seed weight and number of grain seeds suggest that the insect pests influence on the yield of wheat in mainly through their effect on the seed weight. This finding goes in line with the report of several researchers Adisu *et al*., 2003; Nematollahi, 2017) [2, 16] and/or significantly affect grain quality (Bregitzer and Jones, 2003; Nematollahi, 2017) [7, 16]. Who stated the reduction in grain weight is the most common cause of yield loss due to insect pests.

These results indicate that insecticide seed dressing gave increased grain yield, weight and plant height in which the two parameters also indirectly contributed to increased grain yield. The number of aphids per plant and damaged plants were significantly higher (P<0.05) in the untreated plots compared with the treated one. There was also significant difference both on the number of aphids per plant and the damaged plants among the plots. Similarly, Pike *et al* (1993) [17] and Nematollahi (2017)[16]. Who reported the seed dressing treatment can controlled aphids for 27-85 days and there was only less than 2 percent damage on the plants grow from the treated seed. This result was confirming the previous study of Addisu *et al.* (2003)[2] and Babar *et al*. (2018) [5]. Who reported that the aphids were effectively controlled by the insecticide that the plants reached their normal height. It is in contrast with this study, during the maximum stage the number of aphids increased in all plots.

Conclusion

In conclusion, *D. noxia* insect pest warrant control measures at West Shoa, particularly in the Ambo area. The results showed that at vegetative and flowering stages the population number of Russian wheat aphids was very low and almost none but when the crops attain near ripeness number of aphids increased. This indicated that at the early stages seed dressing treatments were promising, it is the safest, cheapest, and most effective means of controlling Russian wheat aphids' early stages. It is necessary to control this insect pest in addition to seed dressing treatment, research should focus on the development of integrated pest management strategies that will increase cultural practices, use of resistant varieties, and other control methods.

Acknowledgement

I am grateful to thanks Mr. Alemneh Abebe and Mr. Fikadu Balcha for their enthusiastic effort they made in collecting the data in field and laboratory activities.

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