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GRAIN AND BIOMASS YIELD REDUCTION DUE TO RUSSIAN WHEAT APHID ON BREAD WHEAT IN NORTHERN ETHIOPIA

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ABSTRACT

Russian wheat aphid (*Diuraphis noxia* Mordvilko) is an important insect pest of wheat and barley in Northern Ethiopia. The objective of this study was to find out the impact of *Diuraphis noxia* on yield and performance of wheat. An experiment was conducted at Mekelle Agricultural Research Center in Ethiopia during 2013- 2014, in the off-season with irrigation. Insecticide treated and untreated plots were compared for biomass and grain yield, damage, days to heading and maturity. *Diuraphis noxia* reduced wheat grain yield by 67.7% and biomass by 51.6%. Weight per 1000 seeds declined by 20%. Heading and maturity were generally delayed. Fenitrothion 50 EC, a contact insecticide, controlled *D. noxia* and prevented biomass and grain yield loss.

Key Words: Dimethoate*,* *Diuraphis noxia*, Fenitrothion

RÉSUMÉ

Le puceron russe du blé (*Diuraphis noxia* Mordvilko) est une des plus redoutables insectes-peste du blé et de l'orge au nord de l'Ethiopie. L'objectif de cette étude était d'évaluer l'impact de *Diuraphis noxia* sur le rendement et la performance du blé. A cet effet, une expérimentation agricole a été conduite au centre de recherche agricole Mekelle en Ethiopie de 2013 à 2014, en saison sèche avec irrigation. Une comparaison du rendement en biomasse et en grains, des dommages créés par le puceron, de la date d'épiaison et de maturité a été réalisée entre une parcelle traitée à l'insecticide et une autre non traitée. Il a été observé que *Diuraphis noxia* réduit le rendement en grains du blé de 67.7% et 51.6% du rendement en biomasse. Le poids par 1000 grains diminue de 20%. L'épiaison et la maturité étaient globalement retardées. Fenitrothion 50 EC, un insecticide de contact permet de prévenir les pertes en grains et en biomasse dues à *D. noxia*.

Mots Clés: Dimethoate*,* *Diuraphis noxia*, Fenitrothion

INTRODUCTION

Bread wheat (*Triticum aestivum* L. (Poales: Poaceae)), is one of the most widely cultivated cereal crops in the highlands of eastern Africa. In the main season in Ethiopia, wheat is the third common cereal crop after sorghum and teff in area coverage and total production (CSA, 2013). Bread wheat is grown in the spring season, though the yield is lower than the main season (Bekelle *et al.,* 2000). The crop grows in diverse agroecological conditions, with an altitude range of 1500 to 3000 metres above sea level (Demeke and DI-Marcantonio, 2013). Yield of wheat under farmers' management is far lower than under on-station and on-farm researcher managed plots (Kindie, 2014). Kindie (2014) ascribed low productivity to stress from low moisture, shortage of seeds for improved varieties and insect pests and diseases.

Russian wheat aphid (*Diuraphis noxia* Mordvilko) is one of the major insect pests of barley and wheat in many areas of the world. It is indigenous to Southern Russia, Iran, Afghanistan and countries neighbouring the Mediterranean Sea (Hewitt *et al*., 1984). It was first recorded on barley in Atsbi and Adigrat areas of Northern Ethiopia in 1972 (Adugna and Megenassa, 1987).

Diuraphis noxia feeds on leaves of infested plants and causes breakdown of chloroplasts, leading to white and yellow longitudinal streaks (Fouche *et al.,* 1984). Other symptoms, include leaf folding and rolling (Khan *et al.,* 2009). Preferential feeding of *D. noxia* on thin-walled sieve tubes and probing of xylem for water is the cause for leaf streaking, rolling and chlorosis (Saheed *et al.,* 2010). South African *D. noxia* biotypes have differential feeding and water uptake-related damage on phloem and xylem tissues on barley (Jimoh *et al.,* 2011). High CO_2 conditions increased *D. noxia* population and led to biomass loss on barley, with the possibility of an early and severe crop loss (Jimoh *et al.,* 2013). *Diuraphis noxia biotypes* were reported from the USA (Burd *et al*., 2006) and South Africa (Jankielsohn, 2011); while *D. noxia* resistant wheat cultivars containing Dn_4 gene became susceptible to Northern Ethiopian populations (Smith *et al*., 2004). In 2012, however, *D. noxia* resistant barley cultivars (Burton and RWA-1758) from USA were resistant to populations in Northern Ethiopia (Alemu *et al.,* 2014).

Diuraphis noxia is the major insect pest of wheat in the spring season and under irrigation in Ethiopia. Systemic insecticides (Dimethate 40 EC, Gaucho WS 70, Cruiser 70 WP, Furathicarb 400 CS) as well as Pirimiphos-methyl 50 EC are recommended for control of *D. noxia* in Ethiopia (Bayeh *et al.,* 2011). Rolled leaves, resulting from its feeding habit that causes the leaves to roll around the aphid colony, protectes *D. noxia* from contact insecticides (Givovich and Niemeyer, 1996; Tolmay *et al.,* 2000; Khan *et al*., 2009; Dahleen *et al*., 2012). But rolled leaves may not protect aphids from contact insecticides and provided there are contact insecticides safe for the environment, rolled leaves are not beyond the reach of such treatments.

Information about the importance of *D. noxia* on wheat in Ethiopia is limited. The only yield loss data available is for barley (41-79%) in Central Ethiopia (Miller and Adugna, 1988). While crop protection is meant to prevent and control crop losses (Oerke, 2006), crop loss information is required to decide if *D. noxia* is important and needs attention. The objective of this study was to assess the effect of *D. noxia* on yield and yield components of wheat.

MATERIALS AND METHODS

A field experiment was carried out at the Mekelle Agricultural Research Centre in Ethiopia (13°5’0” N, 39°6’0” E, at 1970 metres above sea level). The centre is situated in a semi-arid agroecological zone, with annual rainfall ranging from 344 to 710 mm; and temperatures ranging from 11.3 to 26.8 °C. The area has an average relative humidity of 51%.The soil type is mainly clay loam, with a pH of 7.47.

The field experiment was conducted during the spring seasons of 2013 and 2014. Insecticide treated and control plots were replicated three times in randomised complete block design. Plots were 2 m x 1 m and had five rows at 20 cm row spacing. Plots and blocks were 1 and 2 metres apart.

Fenitrothion 50 EC and Dimethoate 40 EC (Adami Tulu Pesticide Processing SC Ziway, Ethiopia) were used at rates of 1.0 and 1.5 L ha^{-1}, respectively. Two sprays at 10-day intervals were applied. Dimethoate 40 EC is recommended for control of RWA on barley (DBARC, 2003); while Fenitrothion 50 EC is a contact insecticide registered in Ethiopia for the control of armyworm and locusts on cereals and pastures (MOA, 2013).

The first spray was applied two weeks after planting and at this time, *D. noxia* incidence was nearly 100%. The second spray followed ten days later. Plants were checked for *D. noxia* damage symptoms and for the presence of the aphid itself (Wysocki, 1990). Plots were fenced with canvas to avoid drift to other plots.

The bread wheat variety used was Mekelle 1 and is susceptible to *D. noxia* (Tesfay, B.

Unpublished data). Mekelle 1 is an early bread wheat variety developed by Mekelle Agricultural Research Center of the Tigray Agricultural Research Institute. Seed rate used was 150 kg ha^{-1}.

Leaf chlorosis (1-9 score scale) and rolling (1-3 score scale) were recorded following the procedures of Burd *et al*. (1993). Other data included days to heading and maturity, grain and biomass yield and weight of 1000 seeds. Treated and untreated plots were photographed to show differences in *D. noxia* damage.

Levene's test was conducted. Independent-sample t-test procedure of the IBM SPSS Statistics 20 software (IBM-SPSS, 2011) was employed to compare differences in days to heading and maturity, chlorosis and leaf rolling damages, biomass and grain yield.

RESULTS

The Levene's test for equality of variances was not significant (P>0.01) for most parameters, indicating that the variances of the treatments were homogenous. There were significant differences between insecticide treated and the control (P<0.05) for biomass, grain yield and thousand seed weight (Table 1). *Diuraphis noxia* inflicted damage and caused a decrease of 3891.7 kg ha^{-1} biomass yield (51.6%) and 2296.1 kg ha^{-1} grain yield (67.7%) on the bread wheat variety (Table 1). The decrease in weight per 1000 seeds caused by RWA damage was 6.9 g (20%). Severe leaf chlorosis and rolling was noted in the control (Fig. 1).

Results from the independent-samples t-test for days to heading and maturity, leaf chlorosis,

TABLE 1. The effect of spraying insectcides on yield parameters of wheat (Mekelle 1) in Ethiopia in 2013 and 2014

Treatment	Chlorosis	Leaf rolling	Days to heading	Days to maturity	Biomass yield (kg ha^{-1})	Grain yield (kg ha^{-1})	1000 seed weight (g)
Untreated (no spray)	8.1	2.8	65	105	3650	1096.6	27.07
Insectcide sprayed	1.2	1.1	56	99	7541.7	3392.7	33.93
Levene's Test							
F	0.000	0.000	3.2	16.00	10.1	9.5	0.082
probability	1.000	1.000	0.148	0.016	0.01	0.012	0.789
Independent-samples t-test							
t	55.3	20.8	6	9.5	-2.9	-4.7	-5.073
df	4	4	4	4	10	10	4
probability	0.000	0.000	0.004	0.001	0.020	0.002	0.007

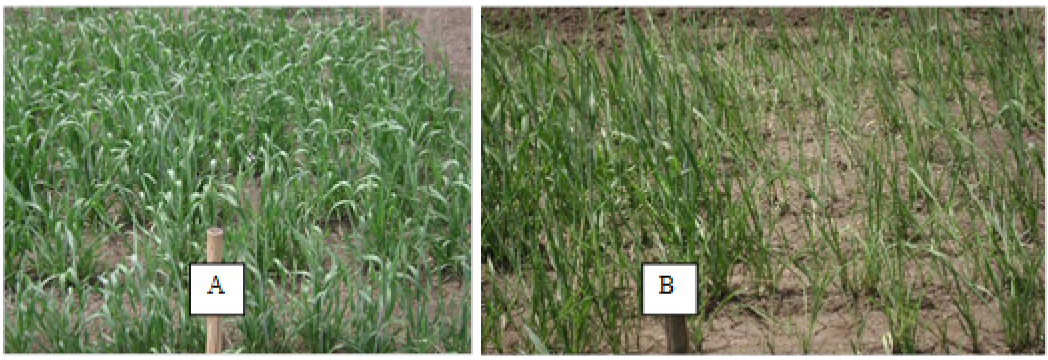

Figure 1. Fenitrothion 50 EC sprayed (A) and untreated plots (B), 2013 (Note leaf rolling and colour on B).

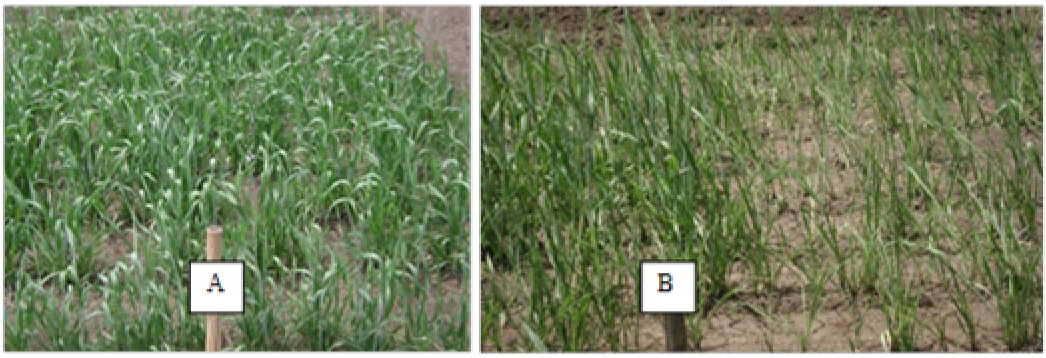

Figure 2. Deformed heads on untreated (A) compared to none on Dimethoate 40 EC treated plots (B), 2014.

and leaf rolling are shown in Table 1. There were highly significant differences (P<0.001) in chlorosis and leaf rolling between the insecticide treated and the unsprayed (Table 1). Chlorosis (8.1 on a scale of 1-9) was severe and plants in the untreated plots had leaf tip necrosis. Leaf rolling (2.8 on a scale of 1-3) was also significantly higher on untreated plots, and plants had prostrate growth, thus preventing emergence of the head (Fig. 2). Dimethoate 40 EC treated plots recovered from *D. noxia* damage and appeared healthy, with no significant leaf chlorosis (1.2 on a scale of 1-9) or leaf rolling (1.1 on a scale of 1-3) (Fig. 2). There were significant differences (P<0. 01) in days to heading and maturity between insecticide treated and the unsprayed treatments. Treated headed 9 days and matured 6 days earlier than the untreated.

DISCUSSION

The results from this study suggest that *D. noxia* cause significant damage to bread wheat in Northern Ethiopia. The delay in heading and maturity of wheat due to *D. noxia* is also significant for the dry lands of Northern Ethiopia and similar agroecologies where late-season stress from low moisture limits crop production. The grain yield loss obtained from this study was in the range reported by Miller and Adugna (1988) for barley in Ethiopia, wheat in South Africa (Du-Toit and Walters, 1984), Kenya (Macharia *et al.,* 1999) and the US (Mirik *et al*., 2009). The biomass yield loss recorded in this study was however slightly lower than that reported by Mirik *et al.* (2009) in the USA.

It might also be possible to control *D. noxia* with contact insecticides contrary to the reports of Givovich and Niemeyer (1996), Tolmay *et al*. (2000) and Dahleen *et al.* (2012). The rolled leaves in which the aphids live may not be as air tight to prevent contact insecticides with residual or fumigant action from acting on the aphids. Contact insecticides can gain entry into rolled leaves if applied at early stages of the infestation before the damaged plants assume prostrate growth. These are several possible reasons for the control of *D. noxia* infestation by Fenitrothion 50 EC with contact action. Provided there are contact insecticides that are safe for the environment, these results suggest including them in efficacy trials for *D.noxia* management. The results from this study, therefore, highlight the need for comprehensive research program into the management of *D. noxia* in Ethiopia including host-plant resistance, biological control, cultural control and identification of suitable insecticides.

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