Imidacloprid as a Seed Treatment for the control of Russian Wheat aphid (*Diuraphis noxia)* (Homopetra: Aphididae) on Barley

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Abstract

Different rates of Imidacloprid as seed treatment for the control of Russian Wheat aphid (RWA) on barley were tested at Kotu and Chacha in northern Shewa during the 1995 and 1996 'belg' seasons. Combined analysis of variance over years and locations showed significant ($P < 0.5$) effects of insecticide treatments and some of their interactions. At all rates tested, Imidacloprid protected the growing plants from RWA damage throughout the two seasons and increased yields. Hence, as a seed treatment Imidacloprid provided an environmentally safer approach to the control of RWA than is possible with sprays of broad-spectrum insecticides.

Introduction

Barley is one of the important cereal crops grown in Ethiopia. But the yield is very low, the national average it is about 1 ton/ha (CSA, 1997). A number of factors contribute to the reduction of yield. However, Russian Wheat Aphid (*D. noxia*) is the most important pest which damages barley mainly in the "belg" (short rain) seasons.

Since its first record in 1973 (Hadera Gebre Medhin, personal Com.) RWA has become a major pest of barley widely distributed in all barley growing regions of the country, but it is more serious in North Shewa, particularly during the "Belg" season (Adugna and Kemal, 1985,; Bayeh and Tadesse, 1994; Adisu, 1996; Adisu, 1998). Varying amounts of losses have been reported fromdifferent countries (Hewet, 1988; Calhoum et al 1991; Archer and Bynum 1992). In Ethiopia, Miller and Adugna (1988) reported yield losses of 41-79 percent in barley and up to 68% in wheat based on station experiments. Amare and Adisu (1996) reported 86-100% yield losses from o-farm yield assessment trials on barley in the "belg" seasons of 1996 and 1997.To reduce RWA damage, farmers practice delayed 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 RWA damage on barley. Seed treatments, ideally, must be of low risk to non-target organisms, have desirable physiochemical characteristics of formulation for application to and retention on seeds, provide protection against target pests under variable conditions and cause no phytotoxicity or residue problems in crops (Hewett and Griffiths, 1978). Imidacloprid was developed having more or less these preconditions. It is a relatively new systemic insecticide for seed treatment and has a wider activity against several economically important insect pests such as aphids, thrips, leafhoppers, leaf miners and some beetles (Dewar and Read, 1990). So far, no work has been done on imidacloprid for the control of RWA in Ethiopia.

Therefore, the objectives of this study were to evaluate the performance of Imidacloprid on the control of RWA and to observe its effect on seed germination, plant growth and yield.

Materials and Methods

Laboratory Evaluation

Procedures developed by the Association of Official Seed Analysts (Copeland, 1978) for small grains were used to evaluate the effect of the insecticides on seed germination and seedling emergence. Germination and emergence tests were initiated 14 and 180 days after the seeds were treated with different rates of Imidacloprid and one rate of Carbofuran (standard check) details of which are described under field evaluation. The treated and untreated seeds were stored in the laboratory for the above number of days at room temperature.

Field Evaluation

The experiment was conducted during the 1995 and 1996 "belg" season (February to May) in two locations (Chacha and Kotu). In both locations, tillage was done with oxen-drawn "maresha' and harrowed with the same implement. Fertilizer was applied at the rate of 57/57 kg/ha of N/P_2O_5 and incorporated before planting. Hand weeding was done twice and other cultural practices were applied as recommended for the above areas. Sheno local, a susceptible barley cultivator was used for this experiment.

Five rates of Imidacloprid 70 ws at 0.5, 1.0, 1.5, 2.0 and 2.5 g a.i/kg of seed were used. Carbofuran 50% SD at 3g a.i/kg of seed was used as a standard check; in addition, untreated barley seeds of Sheno local were included as a check.

The experiment was laid out in a randomized complete block design with four replications. Plot size was 2.8m x 3m (14 rows, 20 cm apart) and the seed rate was 100 kg/ha.

Data were collected on the number of RWA on five randomly selected plants (21 to 90 days after emergence at two weeks interval) and percentage of damaged plants (45 days after emergence) with each plot. Aphid count and damage assessment were made on seven rows per plot.

Plants in the other seven rows of each plot were used for measuring yield. Plant height in cm was measured at full maturity of the barley plants. Plants left for yield measurement were harvested in each plot and then were dried and threshed. Grain yield was determined by adjusting the moisture content of the seed to 12 percent. Dry weight of straw was also measured from one meter section of a row, as a sample in each plot, and was determined for each treatment.

The collected data were subjected to combined analysis of variance (ANOVA) available from MSTAT-C version by R.D. Freed for personal computers. Whenever the computed ANOVA showed significant F values, means separation was done using Duncan's multiple range test and the data were transformed to their logarithm and arc sins for the number of aphids per plant and the percentage of damaged plants respectively (Gomez & Gomez, 1984).

Results and Discussion

Laboratory Evaluation

Treated and untreated barley seeds stored in laboratory for 14 and 180 days showed somewhat reduced levels of germination but were not significantly different from the check except that of Carbofuran (Table 1) . Seeds treated with Carbofuran, however, showed increased level of reduction in germination ($P < 0.05$) as compared to the untreated check and Imidacloprid treated seed both after 14 and 180 days.

Hence, only Carbofuran had deleterious effect on plant growth (Table 1); it had caused significant ($P < 0.05$) reduction in seedling stand as compared to Imidacloprid treatment and the untreated check. Pike *et al.* (1993) and Elbert *et al.* (1991) tested Imidacloprid against RWA on barley and wheat and corn leaf aphid on maize and arrived at similar conclusion. In this evaluation also it is found that Carbofuran 50% SD suppresses seed germination. Bayeh and Tadesse (1994) also reported that Carbofuran was the best insecticide as a seed treated against

RWA but its inherent toxicity to mammals is very high (WHO, 1989) and it is phytotoxic if used at higher rate.

Field Evaluation

The RWA infestation in the field was noticed two weeks after planting. In both years, there was a very high infestation of the aphid which enabled us to differentiate among the treatments.

Analysis of variance showed significant effects of insecticide treatment (I) on all the variables measured ($P < 0.05$). Highly significant effects of year (Y), location (L) and Y x L interaction were obtained for grain yield, straw weight and plant height. The Y x I, L x Y and Y x L x I interactions were also significant for all the variables measured ($P < 0.05$) (Table 2). These results indicate that insecticide treatments gave increased grain yield, straw weight and plant height in which the two latter parameters also indirectly contributed to increased grain yield. The number of aphids per plant and percentage of damaged plants were significantly higher ($p < 0.05$) in the untreated plots compared with the treated ones (Table 3 and 4). There was also significant difference both on the number of aphids per plant and the percentage of damaged plants among the treated plots.

Hence, Imidacloprid treatment has resulted in the reduction of aphids per plant and the percentage of damaged plants compared to the untreated and standard checks both at Kotu and Chacha. Low infestation and damage were recorded from the highest rate of Imidacloprid (2.5 g ai/kg of seed) and high infestation and damage from the lowest rate of Imidacloprid (0.5g ai/kg of seed).

Highly significant differences ($P < 0.01$) was observed between the two years on infestation and damage; the highest number of aphids per plant and damaged plants were recorded in 1995 (35.2 ± 8.6 and 21.6 ± 2.9, respectively). In both years, infestation and plant damage was significantly higher at Kotu (34.1 ± 6.8 and 21.5 ± 3.4 respectively) than at Chacha (27.8 ± 7.1 and 17.6 ± 3.0 respectively) regardless of insecticide treatment.

After evaluating Imidacloprid at the rate of 0.6, 1.3, and 2.5g a.i/kg of seed, Pike et. al. (1993), similarly, reported that the insecticide controlled RWA for 27-85 days and there was only less than 2 percent damage on plants grown from the treated seed. Archer (1994) also reported that out of the five rates (0.23, 0.35, 0.47, 1.25 and 1.87 g a.i/kg of seed) tested, Imidacloprid at the rate of 1.25 and 1.87 g a.i/kg of seed provided more than 90% control of RWA on winter wheat.

There was a highly significant difference ($P < 0.01$) in grain yield between the treated and the untreated plots and the highest grain yield was obtained from all the treated plots. Year and location difference, too, were highly significant ($P < 0.01$) with 1263 ± 55.6 kg/ha and 1014 ± 62.3 kg/ha for 1995 and 1996 respectively and 1263.4 ± 61.0 kg/ha at Kotu and 1014.4 ± 56.6 kg/ha at Chacha. Straw weight was greater in the treated plots. In both years, straw yield was significantly higher at Kotu (2949.2 ± 115.9 kg/ha) than at Chacha (2584.6 ± 97.6 kg/ha). But there was not significant year effect. Girma *et. al.* (1993) also reported similar results.

There was highly significant difference ($P < 0.01$) in plant height between the insecticide treated and untreated plots (Table 3 & 4), but there was no significant difference among insecticide treated plots; the aphids were effectively controlled by the insecticide that the plants reached their normal height. On the other hand, plants in the untreated plots were heavily infested by the RWA and remained stunted. There was significant difference on plant height between the two years. However, between the two locations, the highest plant height was recorded at Kotu (67.4 ± 1.4) than at Chacha (64.9 ± 1.0). Burd *et al.* (1994) also found that RWA damage resulted in plant stunting. Similarly, Girmal *et al.* (1993) indicated the deleterious effect of RWA on the height of barley plants.

The results of the correlation analysis between grain yield, straw weight and plant height with then umber of aphids per plant and the percentage of damaged plants were found to be negatively and significantly correlated (Table 5). On the other hand, there was a strong, positive correlation between grain yield, straw weight and plant height and also between the number of aphids per plant and the percentage of damaged plants. In general, the study shows that RWA infestation and damage on barley resulted in significant reduction of yield and yield components in the absence of any control measure. The results of the two-year study demonstrated that the use of Imidacloprid as a seed treatement can effectively reduce populations of RWA and minimize yield loss.

As a result of this study, it is recommended that during the "meher" season Imidacloprid should be applied at the rate of 1.0 g a.i/kg of seed and during the "belg" season at the rate of 1.5g a.i/kg of seed. Lower rate is needed during the "meher' season because after June the pest population will decrease due to high rainfall.

The use of environmentally safe, systemic insecticide such as imidacloprid applied to seed where RWA is a major menace to barley production is one recommendable part of integrated pest management; by and large it affects the target pest unlike bread-spectrum spray insecticides which also kill the natural enemies of the pest and thus, create ecological imbalance.

Table 1. Effect of Imidacloprid (70 WS) seed treatment on seed germination and seedling emergency of barley.

Treatment	Geminated seeds %		Emerged seedlings %	
	14 DAT*	180 DAT	14 DAT	14 DAT
Control (untreated)	98.0a	99.0a	97.0a	96.0a
Carbofuran 3 ml/kg seed	86.0b	86.0b	85.0b	85.0b
Imidacloprid 0.5g ai/kg seed	97.0a	95.0a	96.0a	93.0a
Imidacloprid 1.0.g ai/kg seed	98.0a	97.0a	96.0a	94.0a
Imidacloprid 1.5g ai/kg seed	95.0a	96.0a	95.0a	94.0a
Imidacloprid 2.0g ai/kg seed	97.0a	97.0a	94.0a	98.0a
Imidacloprid 2.5g ai/kg seed	96.0a	96.0a	95.0a	95.0a
CV (%)	3.3	3.5	5.4	5.1

*Means within a column followed by the same letter are not significantly different (P < 0.05); Duncan's [1955] multiple range test); * DAT = Days After Treatment.*

Table 2. Partial ANOVA for number of aphids per plant (NAPP), percentage of damaged plants (PDP), plant height (PH), grain yield (GY), straw weight (SW), kernel number per head (KNPH), kernel weight per hear (KWPH), and two hundred kernel weight (TKW) in barley treated with different rates of imidacloprid and sown at two locations (Kotu and Chahca) during the 1995 and 1996 cropping seasons.

		Mean Squares							
Source	DF	NAPP	PDP	PH	GY	SW	KNPH	KWPH	TKW
Year(Y)	1	0.07*	295.0*	104.7*	174909.3*	30972.4	3.3	0.01	1279.8**
Location(L)	1	0.67*	89.2*	174.8**	1725231.3**	3722237.7**	3095.4**	3.33**	28.8*
UL	1	1.00*	47.3*	430.2**	1345975.7**	332.9	0.1	0.08*	86.6*
R(LY)	12	0.06*	21.0	124.5**	109963.4**	324424.2*	62.4*	0.09*	28.6*
Insecticide (I)	6	3.92**	3679.6**	891.5**	2401450.9**	8308315.6**	191.7**	0.48**	76.7**
UI	6	0.11*	16.7	27.3*	46750.7*	351831.4*	20.5*	0.01	9.3*
LY	6	0.09*	8.4	28.7*	92682.2*	165695.2*	9.0	0.01	14.0*
YLI	6	0.06	32.5*	97.7**	57996.1*	530134.9*	27.9*	0.09**	8.9*
Error	72	0.06	21.9	15.5	18019.5	147360.9	20.3	0.04	8.7
CV (%)		21.8	20.4	6.0	11.8	13.9	15.9	16.6	8.0

**1 and ** denote significance at P < 0.05 and 0.01, respectively. Aphid count and percentage date were transformed to logarithm (log x+1) and Arc Sine, respectively.*

Seed treatment for the control of RWA

Table 3. Effect of Imidacloprid on the RWA, plant height grain and straw yields of barley at Kotu and Chacha in 1995

Insecticide	Rate a.i.g/kg seed	aphids per plant a	Damaged plants b (%)	Plant height (cm)	yield kg/ha Grain	yield kg/ha Straw
			Kotu			
Control	(untreated)	186.2a	70.5a	54.2c	225.0e	1475.0c
Carbofuran	3ml	16.8a	16.1b	75.5a	1453.0abc	2887.3b
Imidacloprid	0.5g	16.4c	11.5bc	73.7ab	1356.3cd	3269.3a
Imidacloprid	1.0	13.8cd	8.6c	72.0b	1472.2ab	3393.8a
Imidacloprid	1.5	8.0de	10.0c	71.5b	1303.0d	3317.4a
Imidacloprid	2.0	4.2e	16.2c	71.6b	1403.0bc	3297.3a
Imidacloprid	2.5	4.4e	3.1d	74.0ab	1525.6a	3132.9ab
			Chacha			
Control		188.3a	62.4a	48.7e	115.1e	1004.9d
Carbofuran	ml	15.0b	19.6b	61.8d	805.0cd	2616.2c
Imidacloprid	0.5g	14.9b	11.5bc	63.7cd	745.0d	2715.0c
Imidacloprid	1.0	6.2c	6.6c	67.7ab	839.4cd	3060.6a
Imidacloprid	1.5	7.0c	4.1cd	66.5bc	871.6c	2738.4bc
Imidacloprid	2.0	7.6c	5.5cd	70.5a	975.5b	3060.0a
Imidacloprid	2.5	4.7c	3.9d	68.7ab	1109.2a	3001.3ab
LSD 5%		0.17	3.29	2.77	94.61	270.60
CV (%)		21.8	20.4	6.0	11.8	13.9
SE		0.06	1.17	0.98	33.56	95.97

Means within a column followed by the same letter are not significantly different (P < 0.05; DMRT); a Logarithmic transformation; b Arcsine transformation

Table 4: Effect of Imidacloprid on the RWA, plant height grain and straw yields of barley at Kotu and Chacha in 1996.

Insecticide	Rate a.i.g/kg seed	aphids per plant a	Damaged plants b (%)	Plant height (CM)	Grain	Yield (kg/ha) Straw
			Kotu			
Control	(untreated)	107.8a	88.8a	44.7e	320.3e	1140.5a
Carbofuran	3ml	51.0b	20.3b	59.9d	1245.3d	3092.5c
Imidacloprid	0.5g	18.8c	19.1c	60.6d	1224.8d	2312.8d
Imidacloprid	1.0	17.3c	12.2de	65.2c	1277.5d	2722.5bc
Imidacloprid	1.5	19.1c	10.2de	70.5b	1279.0c	3093.8c
Imidacloprid	2.0	8.2d	9.1cd	74.4a	1694.8b	3432.3b
Imidacloprid	2.5	6.1d	6.3e	76.4a	1807.8a	4217.6a
				Chacha		
Control		105.8a	76.3a	51.4b	556.9c	1179.8d
Carbofuran	3 ml	10.6c	14.3b	67.0a	1148.0b	2472.0c
Imidacloprid	0.5g	12.5b	10.3b	67.8a	1237.9b	2722.1bc
Imidacloprid	1.0	7.2cd	9.3c	68.5a	1424.6a	2855.4ab
Imidacloprid	1.5	5.0d	11.4b	69.4a	1426.5a	3086.0a
Imidacloprid	2.0	2.8e	7.6c	69.5a	1436.6a	2743.4bc
Imidacloprid	2.5	0.17	8.1c	67.0a	1510.9a	2929.1ab
LSD 5%		21.8	3.29	2.77	94.61	270.60
CV (%)		21.8	20.4	6.0	11.8	13.9
SE		0.06	1.17	0.98	33.56	95.97

Means within a column followed by the same letter are not significantly different ($P < 0.05$; Duncan's [1955] multiple range test).
a Logarithmic transformation; 2b Arcsine transformation

Table 5: Coefficients of correlation, r, between infestation and agronomic variables.

	Damaged Plants (%)	Plant height (cm)	Yield (kg/ha)	
			Grain	Straw
Aphids per plant	-0.999	-0.983	-0.983	
Damaged plants (%)		-0.981	-0.976	-0.985
Plant height (CM)			0.993	0.992
Grain yield (kg/ha)				0.992

** *All values are significant at the 0.05 level of probability (n-2 = 5 degrees of freedom).*

References

Adisu Berhan. 1998a. Russian wheat aphid on barley: A growing problem for Ethiopian farmers. A paper presented in the Seventh Annual conference of the Biological Society of Ethiopia, which was held from 6-7 February 1998, Addis Ababa, Ethiopia (In press).

Adisu Berhan.1998b. Research on the management of small cereal aphids in Ethiopia. A paper presented in the Aphid/Virus Workshop, which was held from 20-23 April 1998, ICARDA, Aleppo, Syria.

Adisu Berhan. 1996. Management o the Russian wheat aphid, *Diuraphis noxia* (Homopetera: Aphididae), on barley. M.Sc. Thesis. Alemaya University of Agriculture, Ethiopia.

Amare Andargie and Adisu Berhan. 1996. On farm Yield Loss Assessment o Barley due to RWA. A paper presented in the annual barley coordination meeting, 20-23 May 1996, Addis Ababa, Ethiopia.

Archer TL. 1994. Economic Injury Levels and Chemicals Control of Russian Wheat aphid. pp. 97-106. In: Peairs FB, Kroening MK and Simmons CL (eds). Proceedings of the 6th Russian wheat aphid conference, 23-25 January, Colorado, Fort Collins, USA.

Archer TL. and Bynum ED. 1992. Economic injury level for the chemical control of Russian wheat aphid (Homopetera: Aphididae) on dry land winter wheat. *Journal of Economic Entomology*. 85: 987-992.

Bayeh Mulatu and Tadesse G/Medhin. 1994. Russian Wheat Aphid: A major pest of barley in Ethiopia. pp. 169-174. In: Frank BP, Kroening MK and Simmons CL (eds.), proceedings of the sixth RWA Workshop, January 23-25, 1994, Colorado State University, Colorado.

Burd JD, Webster AJ and Porter DR. 1994. Russian wheat aphid injury and plant damage. pp. 21-36. In: Peairs FB, Kroening MK, and Simmons CL (eds.). Proceedings of the 6th annual Russian wheat aphid conference, 23-25 January 1994, Fort Collins, Colorado, USA.

Calhoun DS, Burnett PA, Robinson J and Vivar HE. 1991. Field resistance to Russian wheat aphid in barley: I. Symptom expression *Crop Science*. 31: 1464-1467.

Central Statistical Authority. 1997. Ethiopia: Statistical Abstract. Addis Ababa, p.93.

Copeland LO (ed). 1978. Rules for testing seed of the Association of Official Seed Analysts. *Journal of Seed Technology* 3(3): 1-126.

Dewar AM. and Read LA. 1990. Evaluation of an insecticide seed treatment, Imidacloprid, for controlling aphids on sugar beets, pp. 721-726. In: Proceedings, Brington Crop Protection conference, pests and diseases, Bringhton, England.

Girma M, Wilde GE and Harvey TL. 1993. Russian wheat aphid (Homopetera: Aphididae) affects yield and quality of wheat. *Journal of Economic Entomology*. 86: 594-601.

Gomez KA. and Gomez AA. 1984. *Statistical procedures for agricultural research*. 2nd ed., John Wiley and Sons Inc., New York.

Hewett PH. 1988. The South African experience with the Russian wheat aphid. In: Peairs FB and SD Pilcher (eds.). Proceedings of the Second Russian wheat aphid workshop, pp. 1-3. October 11-12, 1988, Denver, Colorado.

Hewett PD. and DC Griffiths. 1978. The biology of seed treatment. pp.4-9. In: Jeffs KA (ed.) Seed treatment monograph 2. Collaborative International Pesticides Analytical Council, Hefers, Cambridge, England.

Miller RH and Adugna Haile. 1988. Russian wheat aphid on barley in Ethiopia. Rachis. 7: 51-52.

Pike KS, Reed GL, Graf GT and Allison D. 1993. Compatibility of Imidacloprid with fungicides as a seed treatment control of RWA and effect on seed germination, growth, and yield of wheat and barley. Journal of Economic Entomology. 86: 586-93.

WHO. 1989. The WHO Recommended Classification of Pesticides by Hazard and Guidelines to Classification. Division of Vector Biology and Control, WHO, Geneva. p. 39.