VARIETAL RESISTANCE IN MAIZE AGAINST CHEMICAL CONTROL OF STEM-BORER, SHOOT-FLY AND TERMITES IN SAHIWAL, PUNJAB, PAKISTAN

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The chemical control integrated with varietal resistance against insect pests of maize (maize stem borer (C*hilo partellus* Swinhoe), shoot fly (*Atherigona soccata* Rond.) and termites was conducted to sort out the need for additional and separate control measure for termites in spring and autumn maize at "Maize and Millet Research Institute" Sahiwal. From a total of ten varieties (AG-2002, NX-8441, EV-1098, 7982, SWL-2002, 666, EV-5098, Engro-2512, 34-N-43, 32-W-86) sown under Randomized Complete Block Design (RCBD), AG-2002 was considered resistant because termites' count (8.55), shoot fly (1.94%) and borer infestation (2.53%) was lowest and thus this variety was used in experiments of chemical control. The chemical control aimed against the termites with seed treatment (imidaclopird) and soil application of Lorsban 40EC could bring difference of infestation, between, before and after treatment, being 0.76 and 0 in case of shoot fly and borer, respectively. However, the termites' population increased with a difference of 6.86 times from pre- to post-treatment. Seed treatment alone was ineffective in reducing the termites' population. Application of fenpropathrin10 EC @ 300ml, triazophos 40 EC @ 600 ml, furadan 3G @ 8 Kg and Lorsban 40EC @ 2 litre acre^{-1} could not bring a reduction in termites' population. It is concluded from the data that chemical control of borers' and shoot fly would have no effect on termites and vice versa. Therefore, termites should be controlled in maize apart from treatment for shoot fly and borer.
Key words: Maize, varieties, chemical control, *Chilo partellus, Atherigona soccata*, termites

INTRODUCTION

Maize (*Zea mays*), one of the most important cereal crops, was grown on an area of 941 thousand hectares with annual production of 1771 thousand tons in Pakistan (Anonymous, 2005). Being third leading cereal crop in the world after wheat and rice in respect of area and production, it is a multipurpose crop providing fuel and food to human being, feed to animals and poultry, and fodder to livestock. Although it can be grown successfully throughout Pakistan, yet its cultivation has been concentrated in the N.W.F.P and Punjab. These provinces contribute 98 % to the total production of the country.

In Pakistan, per hectare yield of maize has not increased despite the introduction of high yielding varieties, the major obstacle in achieving this goal is the attack/infestation by insect pests. The notable insect pests are maize and jawar stem borer (*Chilo partellus*) and shoot fly (*Atherigona soccata)* the infestation of which ultimately result in total failure of autumn and spring crops, respectively (Rao and Panwar, 1996; Ahmed *et al*., 2002; Ahmed *et al*., 2003; Naz *et al.,* 2003).

In order to prevent infestation of maize crop by maize stem borer and shoofly, insecticides particularly granular formulations are recommended as soil and/or whorl application at 25 and 45 days after sowing (Halimie *et al*., 1989; Javed *et al.,* 1998; Karimullah *et al*., 1992; Wahla *et al*., 1995; Khan *et al*., 1999; Khan *et al*., 2004).

Fungus-growing termite, *Microtermes*, *Ancistrotermes*, *Allodontermes*, and *Odontotermes* species are the predominant pests of maize in southern Africa (Hillocks et al., 1996). Lodging is regarded as the most severe symptom of damage by termites in maize. In South Africa, up to 100% of the maize plants may be attacked, resulting in crop losses of between 3 and 30 % (Riekert and Van den Berg, 2003). In parts of Kenya, Tanzania, Zambia, Malawi, Zimbabwe and South Africa, 20–30% of preharvest loss in maize was due to termites (Munthali *et al*., 1999). However, subterranean termites caused 43% and 8-12% yield reduction in the maize and wheat crops, respectively. Termites' activity exceeds economic threshold level in cotton field of country, while in N.W.F.P termite caused100 % infestation in fruit orchids (Sattar and Salihah 2001). According to a recent survey in maize growing areas of the Punjab, termites are posing a threat to maize but it is not known when and how control should be adopted?

The Maize and Millet Research Institute, Yusufwala, District Sahiwal, has a long history of maize production. Termites, maize stem borer and shoot fly have become a permanent nuisance at seedling and near harvesting time, rendering either early loss of plants and fuel sources at later stages. The present project was initiated to study a comprehensive set of control measures, which would affect insect pest of maize including termites. Efficacy of different chemicals including imidacloprid 70 WS as a seed treatment and Lorsban 40EC as soil application and use of plant chemicals as soil treatment coupled with varietal resistance was determined for this purpose. Objective of this study was to investigate the need for the separate chemical control for the termites in maize which otherwise can be effectively managed with application of insecticides usually meant for shoot fly and maize stem borer.

MATERIALS AND METHODS

Location for Experiments: Experiments were carried out at the experimental areas of "Maize and Millet Research Institute" Sahiwal. A field of maximum termite activity was selected which has been remained under maize cultivation for last many years.

Experiment 1.

Seasonal infestation of insect pests on different maize varieties

A total of ten varieties including hybrid and synthetic types of maize i.e., AG-2002, NX-8441, EV-1098, 7982, SWL-2002, 666, EV-5098, Engro-2512, 34-N-43, 32-W-86 were sown to determine the infestation level of borer, shoot fly and population of the termites. All the varieties were sown under Randomized Complete Block Design (RCBD) with three replications in a net plot size of 15 m^2 and R x R distance of 0.75 cm. Data for termites, borers and shoot fly were recorded at 15 days intervals.

Experiments 2.

Effect of insecticides application for termites on infestation of borer and shoot fly

Two varieties (V1= AG-2002; V2= NX-8441) of maize were sown using Split plot Randomized Complete Block Design (RCBD) with three replications having varieties in main plots. All standard agronomic practices were followed while keeping row-to-row distance 75cm in a net plot size of 18.75m^2. Following four treatments including a control comprised of this experiment ($\mathbf{T_1}$ Seed treatment with imidacloprid 70WS and no soil application; $\mathbf{T_2}$ No seed treatment and soil spray of Lorsban 40 EC @ 2L $acre^{-1}$ after sowing, 2^{nd} and 3^{rd} application of Lorsban was done at 40and 80 days after sowing; $\mathbf{T_3}$ Seed treatment and soil spray of Lorsban 40 EC @ 2L $acre^{-1}$, 2^{nd} & 3^{rd} application of Lorsban 40EC after 40 and 80 days of sowing the crop; $\mathbf{T_4}$ Control (no seed and soil treatment).

Experiment 3.

Effect of insecticide application for borer and shoot fly on population density of the termites

Maize variety (AG-2002), known to be resistant against borer and shoot fly, was sown in Randomized Complete Block Design (R x R 0.75 m; net plot size 18.75m^2). Five treatments including a control in this experiment were as follows: $\mathbf{T_1}$ fenpropathrin10 EC @ 300ml; $\mathbf{T_2}$ triazophos 40 EC @ 600 ml; $\mathbf{T_3}$ furadan 3G @8 Kg; $\mathbf{T_4}$ Lorsban 40E@ 2 litre $acre^{-1}$; $\mathbf{T_5}$ Control. These treatments were applied at economic threshold level of either borer and/or shoot fly. The data were recorded before and after spraying the maize crop. In this experiment extent of termites suppression was recorded along with the borers and shoot fly. Seeds were treated with imidacloprid 70WS @ 5g/Kg seed.

Data Collection

The percentage infestation of maize stem borer and shoot fly damage were recorded using different visible symptoms of whole damage or dead hearts by selecting 25 plants randomly from each plot. The population density of termite was taken randomly from five places in each plot with a soil sampler that would take 30 x 30 x 30 cm soil core. The soil was examined thoroughly by spreading on a black cloth and termite individuals were counted. Termite damage at seedling and later stages were counted as well.

Statistical Analysis

Data were analyzed statistically by using MiniTab (Version 11). Means of infestation of borer, shoot fly in the experiment of varietal resistance and chemical control were separated through Duncan's Multiple Range Test at $p<0.05$. Data on termites' population were analyzed by Kruskal Wallis Test and means were separated by Mann Whitney test at $p<0.05$.

RESULTS

Experiment 1

Table 1. Seasonal termites' population, shoot fly and borer infestation on different varieties of maize

Termites population		Shoot fly infestation (%)		Borers' infestation (%)	
V_8 (Engro-2512)	70.87± 1.52a	V_6 (666)	7.00±1.32a	V_8 (Engro-2512)	6.33±0.3a
V_{10} (32W86)	51.37± 0.57b	V_8 (Engro-2512	6.58±1.89a	V_{10} (32W86)	5.6± 0.34ab
V_6 (666)	40.55±1c	V_9 (34N43)	5.41±1.42ab	V_9 (34N43	5.06±0.11bc
V_9 (34N43)	39.44±1c	V_5 (SWL-2002)	5.31±1.18ab	V_3 (EV-1098)	4.0±0.91cd
V_7 (EV-5098)	26.67± 1d	V_4 (7982)	4.00±0.74bc	V_4.(7982	3.93± 0.98cd
V_4 (7982)	25.99±1d	V_3 (EV-1098	3.16±0.38cd	V_5 (SWL-2002)	3.8 ±0.8 de
V_3 (EV-1098)	23.57±0d	V_7 (EV-5098)	2.66±0.72cd	V_7 (EV-5098)	3.73±0.64def
V_5 (SWL-2002)	17.00± 0.57e	V_{10} (32W86)	2.31± 052cd	V_6.(666	3.67±0.75def
V_2 (NX-8441)	14.23±0.57e	V_2 (NX-8441)	2.00±1d	V_2 (NX-8441)	2.6±0.52 ef
V_1 (AG-2002)	8.55±0.57f	V_1 (AG-2002)	1.94±0.53d	V_1 (AG-2002	2.53 ±0.64f

Comparative infestation of borer and shoot fly and population density of termites in the fields of different varieties is given in Table 1. Plots of V_1 and V_2 (AG-2002 and NX-8441, respectively) had significantly different lowest density of termites (8.55 and 14.23). V_2 was statistically at par with V_5 (SWL-2002) in termites' density (17.00). V_8 (Engo-2002) harbored highest density of termites (70.87). V_1 had lowest (1.94%) infestation of shoot fly and was statistically at with V_2 (2.00%), V_5 (2.31%), V_7 (2.66%) and V_4 (3.16%). Highest shoot fly infestation was in V_6 (666) with 7% and it was statistically similar to V_8 (6.58%). The latter had highest infestation of borer (6.33%) and was statistically at par with V_{10} (32W86).

Experiment 2

Effect of insecticides application (for termites) on infestation of borer, shoot fly and population of termites is given in Table 2a and 2b. In case of shoot fly' infestation there was non-significant difference among the insecticide treatments after 35 days of first application. T_1 received no application of the insecticide and hence exhibited highest infestation (6.67 and 2.5%), respectably, at 15 and 30 days after second application. However, T_3 showed statistically lowest infestation of shoot fly significant difference at 15 and

30 days with 1.17 and 0.5% infestation, respectively (Table 2a). In case of borer infestation, T_3 had lowest mean infestation (1.50%) and was statistically different from other testaments at 30 days after second and 15 days after third application. Population of termites registered an increasing trend in different treatments at different intervals after application except in case of T_3 where population was lowest amongst the treatments.

Table 2(a). Infestation of Shoot fly and borer at different intervals after insecticides application

Treatments	Shoot fly infestation				Borers infestation				
	35 days AFA	BSA	ASA		BSA	ASA		BTHA	
			15 days	30 days		15 days	30 days		15days
T_1	2.83 b	5b	6.67 b	2.5 b	3.00 b	3.0b	3.83b	3.5b	3.17b
T_2	3.00 b	3.67c	3.67c	1.33c	2.67b	2.0bc	2.66c	1.67c	1.67c
T_3	2.50 b	1.5 d	1.17d	0 .5c	2.33b	1.5c	1.50d	0.83c	0.67d
T_4	6.50a	6.33a	8.17a	4.83a	5.0a	7.0a	7.16a	7.5a	4.0a

AFA; after first application; BSA, before second application; ASA, after second application; BTHA, before third application; ATHA, after third application

Table 2(b). Population of termites at different intervals after insecticides application

Treatments	ASA	BTHA	ATHA		Mean Lodged	Yield (tons acre^{-1})
	30 days		15	30		
T_1	12.5b	19.67b	36.00b	50.33b	4.00b	2.31c
T_2	8.0c	12.67c	8.17c	14.00c	0.83c	2.73b
T_3	2.83d	8.00d	4.17d	6.50d	0.17c	2.98a
T_4	18.83a	27.67a	64.83a	78.83a	6.83a	1.24d

ASA, after second application; BTHA, Before third application; ATHA, after third application

Experiment 3

All the treatments except T_4 reduced the shoot fly infestation significantly as compared to the control treatment (Table 3a). Lowest infestation of shoot fly was observed in T_2 (1.67%) and T_1 (0.33%) after 7 and 22 days after application. In case of borer' infestation the lowest infestation was observed in T_3 after 7 days (1%) and 52 days (0.0%) after application. Population of termites increased as compared to pre spray termites' counts. However, lowest number of termites' count was recorded in T_4 (Table 3b).

DISCUSSION

All varieties were found significantly different in response to the maize borer (*Chilo partellus*), Shoot fly (*Atherigona soccata*) and termites. The infestation of maize stem borer, shoot fly and population of termite ranged from, 2.56 to 6.33%; 2 to 7% and 8.55 to 70.87, respectively. The lowest and highest percentile of the latter range was not found in a single variety; Engro 2512 was regarded as susceptible variety despite the variable response for borer infestation.

Table 3a. Infestation of Shoot fly and borer at different intervals after insecticides application

Treatments	Shoot fly' infestation (%)			Borers' infestation (%)		
	Pre-spray	After spray		Pre-spray	After spray	
		7 days	22 days		7 days	52
T1	4±1b	2 ±1 c	0.33±0.57e	4±1a	1.33±0.57c	1.33±1.54b
T2	4.33±0.57b	1.67±0.57c	1.67±0.57d	4.33±0.5a	1.67± .57c	1.67±0.57b
T3	3.67±0.57b	2.33±0.57c	3.33±1.52c	4±1a	1±1c	0.0±0.57c
T4	3.67±0.57b	4 ±1b	5.67±0.57b	4.67±0.57a	3.33±0.57b	2.33±0.57b
T5	5.67±0.57a	8 ±1a	9±1a	5.33±0.57a	7.67±0.57a	6.33±1.54d

Table 3b. Population of termites at different intervals after insecticides application

Treatments	Before	After	Before	After	
		22 days		52 days	Mean lodged plants by termites
T1	5.33±0.57b	9.67±0.57bc	25.33±2.51b	63.0±8.14b	4.0±0.57b
T2	3.33±0.57bc	10.33±0.57b	19.67±3.05c	53.33±2.30c	3.0±0.57bc
T3	2.0±0cd	7.33±1.15cd	12.67±1.15d	16.0±2.64d	2.0±1.53cd
T4	1.0±0.57d	5.00±1d	8.33±0.57e	9.67±0.57e	0.67±2.88d
T5	13.33±0.57a	20.67±2.08a	40.67±2.08a	97.0±7.63a	6.67±0a

Lodging is regarded as the most severe symptom of damage by termites in maize crop, resulting in crop losses between 3-30 % (Van den Berg & Riekert, 2003) and 20–30% (Munthali *et al*., 1999). Two hybrid varieties AG-2002 and NX-8441 had minimum lodging i.e., 1.67 and1/25 plants, respectively, while the yield of these were 2.73 and 2.83 tons acre^{-1} (data not shown), which suggested that these varieties are highly resistant against termites. No lodging was recorded in variety 7982 and termites' population showed, as well, that this variety was resistant against termite but it had low yield potential (2.31 tons acre^{-1}) as compared to AG-2002 and NX-8441. Variety AG-2002 (synthetic) was comparatively resistant against termites, maize stem borer (*C. partellus*) and maize shoot fly (*A. soccata*) infestation, followed by NX8441. These varieties would give high yield, if were sown in spring season. All other varieties are resistant to one insect but susceptible to other insects. No comparable data was available on these varieties in the scientific literature. Commercially available varieties, therefore, cannot be compared with these varieties for which infestation level has been reported earlier (Khaliq and Mahmood, 1991; Ahmed *et al*. 2002).

In order to determine the effect of chemical control meant for termites on borer and shoot fly infestation (experiment 2), results revealed that the termites' population was significantly different in all treatments. Infestation of the shoot fly and borer was not significantly different at pre-spray and after spray at different intervals, but the treatments had difference among them as well. This shows that the insecticides application for the termites cannot manage the infestation of the other pests. These results agree with earlier in the sense that chemicals used in the present trial were effective in their experiments too (Rao and Panwar, 1996; Balikai, 2000; Karibasavraja *et al.* 2005). A small reduction (>30%) of borer and shoot fly infestation after the soil application of chlorpyrifos has been substantiated with the fact that maize borer lay eggs in the debris or on soil near the base of plants.

The effect of borer and shoot fly control on the termites revealed that despite reducing the infestation later, the treatments were not able to control the termites' population (experiment 3). The suppression of infestation by the chemicals used in the present experiments has also been reported by many earlier studies (Balikai, 1999, Singh and Marwaha, 1999; Khan *at el.* 2004). However, same insecticides have been found effective against termites as soil application for their control (Anonymous, 2001a, b).

CONCLUSION

1. Termites' attack is not independent of varieties/host races. Hybrid types of maize were used in these experiments, which are being promoted in market for higher yields.
2. The chemical control for borers and other insects with potent insecticides can have an effect on the population of the termites but cannot prevent the damage.
3. Additional application of chemical or other practices to discourage the plant damage by the termites is, therefore, needed. The plant damage was obvious in the latter stage of crop maturity and it will be an arbitrary time to decide when to apply the chemicals if the termites were problem in certain fields. Potential of cheap plant oils/extracts as soil and stem treatments can explored to prevent damage by the termites.

REFERENCES

Ahmed, S., A. Shahzad, M. Naeem and M.Y. Ashraf. 2003. Determination of Efficacy of cypermethrin, regent and carbofuran against *Chilo partellus* Swin. and biochemical changes following application of these insecticides in maize plants. Intl. J. Agric. Biol., 5 (1): 30-35.

Ahmed, S., M.A. Saleem and I. Rauf. 2002. Field efficacy of some bioinsecticides against Maize and Jowar stem borer, *Chilo partellus* (Pyralidae: Lepidoptera). Intern. J. Agri. Biol., 4 (3): 332-334.

Anonymous. 2005. Pakistan Economic Survey. Min. Food, Agric. Lives. Fed. Bureau Stat., Islamabad. pp.21-23.

Balikai, R.A. 2000. Bio-efficacy of imidacloprid 70 WS against sorghum shoot fly in rabi season. Res. on Crops, 1(2): 192-195.

Naz, F., M. Hussain, Faridullah and M. Din. 2003. Insect Pests of Maize and their Losses. Asian J. Pl. Sci., 2(5): 412-414.

Halimie. M.A., M.S. Mughal, S.A. Mehdi and Z.A. Rana. 1989. Response of different timing of carbofuran (Furadan 3G) on the maize borer incidence and yield of the crop. J. Agric. Res., Lahore. 27(4):337-340.

Hillocks, R.J., J.W.M. Logan, C.R Riches, A. Russel-Smith and L.J. Shaxson. 1996. Soil pests in traditional farming systems in sub-Saharan Africa–A review. Part 1. Problems. *Intern. J. Pest Manage.*, 42: 241–251.

Javed, H.I., H. Rahman, M. Aslam and A. Raqib. 1998. Economic method of Furadan application against maize stem borer *Chilo partellus* (Swinhoe). Sarhad J. Agric., 14:2. p.153-156.

Karibasavraja, L.R., R.A. Balikai and V.P. Deshpande. 2005. Thiamethaxan 70WS a new promising seed dress with the suppression of sorghum shoot fly. Ann. Pl. Protect. Sci., 13(1): 85-87.

Karimullah, M.A. Mashwani and S. Ahmed. 1992. Insect pests of maize crop in different localities of Kalam. Sarhad J. Agri., 8: 513-518.

Khaliq, A. and K. Mahmood. 1991. Studies on relative resistance of six maize varieties to *Chilo partellus* at Rawalakot. Pak. Entomol., 13 (1-2): 91-94.

Khan, M.A., Y. Waqarullah, G.S. Shah, A. Ishtiaq and M. Liaqatullah. 2004. Effect of different insecticide formulations and doses against maize stem borer in corn field. Sarhad J. Agri., 20 (4): 609-612

Khan, M.A., A. Din, M.A. Khan and M. Anwar. 1999. Management of maize stem borer. Sarhad J. Agric., 15 (5): 476-471.

Munthali, D.C., J.W.M. Logan, T.G. Wood and G.K.C. Nyirenda. 1999. Termite distribution and damage to crops on small holder farms in Southern Malawi. Insect Sci. Applic., 19: 43–49.

Rao, K.R. and V.P.S. Panwar. 1996. Study on oviposition-damage relationship in respect of shoot fly species (*Atherigona soccata* and *A .naqvii*) in maize. Ann. Pl. Protect. Sci., 4 (2): 172-173.

Riekert, H.F. and J. van den Berg. 2003. Chemical control measures for termites in maize. South Afr. J. Pl. Soil, 20 (1): 1-5.

Sattar, A. and Z. Salihah. 2001. Detection and control of subterranean termite technologies for sustainable Agriculture. Proceed. Natl. Workshop, 24-26 Sept., NIAB, Faisalabad, Pakistan. p.195-198.

Wahla, M.A., M. Afzal and M. Yaseen. 1995. The comparative efficacy of some Furadan-impregnated schedules of insecticide treatment against the Pest–insect complex of Akbar maize. Pak. Entomol., 17 (1/20): 34-36.