PREVENTIVE CONTROL ALTERNATIVES TO ROUTINE FOLIAR SPRAY AGAINST *THRIPS TABACI* IN ONION

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ABSTRACT

Two field trials were conducted on-station at the Kenya Agricultural Research Institute (KARI), Mwea Tebere, Kenya, to evaluate the potential of preventive control options for onion thrips, *Thrips tabaci* Lindeman on onion, *Allium cepa* L. The eight treatments tested included onion seed coating with Thiamethoxam, 350FS (Cruiser®) during planting, seedling drenching with neem oil, Azadirachtin, 0.15%w/w (Achook®), seedling drenching with neem powder, Azadirachtin, 0.03% w/w (Neemros®), seedling drenching with Imidacloprid, 200SL (Confidor®), overnight seedling dipping in Confidor®, soil placement with Carbofuran, 5G (Furadan®) during transplanting, foliar spray with Profenofos plus Cypermethrin mixture 440 EC (Polytrin®) as the standard and unprotected control. A randomised complete blocks design with four replications was adopted. All the preventive treatments significantly ($p = 0.05$) reduced thrips infestation during the early phenological growth stage and resulted in higher marginal returns than routine Polytrin® spray. However, only Confidor® nursery drench and Furadan® soil placement significantly ($p = 0.05$) increased onion bulb yield and quality over the unprotected control. The two preventive single application treatments recorded comparable yields to the standard spray. Bulb yield across treatments was significantly negatively correlated with thrips infestation. The results suggest that these two treatments are promising as preventive options for control of onion thrips.

Key words: *Allium cepa*, preventive thrips control, seedling drenching, single application

1.0 INTRODUCTION

The onion thrips, *Thrips tabaci* Lindeman is the most important pest of onions worldwide (Sinha *et al.*, 1984). Damage due to thrips has been reported to affect both the quality and the quantity of onion bulbs (Zaman, 1989). Protection of onions against thrips infestation is therefore essential for economic production of the crop. Presently, control of onion thrips in the sub-Saharan Africa is mostly by routine pesticide sprays. The application commences as soon as thrips infestation is first noticed and is continued throughout the growing season. This practice is both expensive and environmentally hazardous and tends to destroy the natural enemies, thus exacerbating the thrips problem. Since onions are largely grown at subsistence level by small scale farmers in the sub-Saharan Africa, there is need to develop low-cost technologies that are less hazardous to the user and the ecosystem and in addition save on the cost of controlling thrips.

Safer methods of pesticide application have been identified in recent years, such as coating onion seed with insecticides (El-Hamady and Sholoa, 1999; Ester *et al.*, 2001), seedling drenching and soil placement with granular systemic insecticides (Chang, 1973; Getzin, 1973; Sinha, *et al.*, 1984; Zaman, 1989). Botanicals like neem tree, *Azadirachta indica* Juss. extracts have also been shown to effectively control thrips (Altaf *et al.*, 1999; Tanzubil, 2000). However, contrasting results on neem (Azadirachtin 0.03EC at 0.1%) were reported in India (Gupta and Sharma, 1998), where it was found to be ineffective against onion thrips.

The objective of this study was to determine the relative effectiveness of preventive treatments in controlling the onion thrips and their effect on bulb yield, for the purpose of identifying promising options for incorporation in an integrated pest management (IPM) for the onion crop.

2.0 MATERIALS AND METHODS

Two field trials were conducted in 2001, at the Kenya Agricultural Research Institute (KARI) Mwea Tebere farm in Kirinyaga District, situated at an altitude of 1,158 m above sea level, latitude 0° 37' S and longitude 37° 20'E (Jaetzold and Schmidt, 1983). Onion seeds of cultivar Red Creole were sown in nursery beds using the standard onion production practices described in Anon (1989). After 45 days, the seedlings were transplanted in the field at a spacing of 10 cm within the rows and 30 cm between the rows. Diamonium phosphate (DAP) fertilizer was applied at the rate of 200 $kgha^{-1}$ at transplanting. The onions were top dressed with calcium ammonium nitrate (CAN) at the rate of 300 $kgha^{-1}$ after transplanting. The crop was kept weed-free through hand weeding and furrow irrigated when necessary, to avoid drought stress.

The trial was laid out in a randomised complete block design, with eight treatments replicated four times. Each of the two trials consisted of 32 plots measuring 3 x 3 m each, separated by buffer strips of bare ground of 3 m wide between the blocks and 1 m within the blocks. The eight treatments tested included seed coating with Thiamethoxam 350g/l a.i (Cruiser®350FS) during planting, seedling drenching with Imidacloprid, 200g/l a.i. (Confidor®200SL), overnight seedling dipping in Confidor® solution, seedling drenching with neem extracts consisting of Azadirachtin, 0.15%w/w (Achook®EC) and Azadirachtin, 0.03% w/w (Neemros®), soil treatment with Carbofuran 5% a.i (Furadan®5G) during transplanting and an unprotected control. The treatments were compared with Profenofos 400g/l a.i plus Cypermethrin 40g/l a.i mixture (Polytrin®440 EC) fortnightly spray as the standard. Treatment rates recommended in the manufacturers label were used and applications carried out as shown in Table 1.

Seedling emergence and vigour was monitored in each nursery and time (days) recorded for >50% of the seedlings to emerge. Seedlings were examined for any signs of phytotoxicity shown by onion leaf scotching. Seedling vigour was assessed using a score of 1-5 (1 = <10% healthy seedlings; 2 =10-20%; 3 = >20-50%; 4 = >50-75%; 5 = >75%). Monitoring of thrips population commenced 14 days after transplanting (DAT) and was continued weekly until 42 DAT, when the onion crop matured. Estimation of the absolute thrips density was carried out by the whole plant cutting and bagging method (Freuler and Fischer, 1984). From each plot, ten plants were randomly selected while avoiding the border rows (Dent, 1991). Extraction of thrips from the cut onion plants was done in the laboratory, using 70% alcohol (Bullock, 1963). A vacuum suction pump was used to filter thrips, which were then counted under a dissecting microscope. To assess the final bulb yield and quality, the onion crop was harvested when more than 50 percent of the leaf bundles had lodged. The tops and roots were cut off and bulbs air-dried (cured) for seven days before grading and weighing for yield assessment. The bulbs were sorted in three grades based on the bulb diameter (grade 1 = >5 cm, grade 2 = d" 5 >3cm and grade 3 = d"3 cm). From each plot, the weight of bulbs from the four (3m long) middle rows comprised the net plot and yield was calculated into tons per hectare.

2.1 Data Analysis

Data was subjected to analysis of variance (ANOVA) and means separated using Student-Newman-Keuls (SNK) multiple range test. Regression analysis was performed for onion bulb yield and thrips pressure. Thrips pressure was computed as the cumulative thrips-days per plant (CTDP) (Fournier *et al.*, 1995) as described below.

$$CTDP = cumj + [([cj+ck]/2).\ (datej - datek)]$$

Where; *Cumj* = Cumulated number of thrips days per plant at the *j*th sampling occasion, *j* and *k* are two consecutive sampling occasions, *c* = number of thrips per plant and the date is expressed in Julian day. Economic analysis was performed using the method described by Zawedde *et al.* (2001), in which a partial budget for onion production in Kirinyaga District was developed by including the varying costs of each treatment, namely, costs of insecticides, labour for insecticide application, spraying equipment and the yield value of onion from each treatment. Yield gains due to the application of the protection regimes (yield value) were calculated as the difference between the yield from each protection regime and that yield from the unprotected control calculated separately (Zawedde *et al.*, 2001) for the large and medium (Grade 1 and 2) and for small grade (Grade 3). Marginal returns were estimated as the income of yield gain divided by the cost for the control option.

3.0 RESULTS

3.1 Effects of the Treatments on Onion Seedlings

Seedlings in the nursery beds emerged from 7 -7.5 days after sowing, except seedlings from the seed coated treatment (Cruiser®), which were visible after about 9.5 days (Table 2). However, there was no significant difference ($p = 0.05$) between the treatments in the seedling emergence duration ($F = 2.59$; d.f = 7,8; $P = 0.1028$) and seedling vigour ($F = 0.51$; d.f = 7, 32; $P = 0.8221$) respectively. No phytotoxicity was observed in all the treatments.

3.2 Effect of Treatments on Thrips Infestation Levels in Different Growth Stages of the Onion Crop

Thrips infestation levels differed among the treatments during the pre-bulbing stage (0-28 DAT) in the first ($F = 51.54$; d.f = 7, 950; $P<0.0001$) and second trial ($F = 6.46$; d. f = 7, 952; $P<0.0001$) respectively (Table 3). During this stage, significantly higher thrips numbers ($p = 0.05$) were recorded in the unprotected plots in both the first and second trials, respectively (9.1 and 2.1 thrips plant^{-1}). Thrips infestation also differed among the treatments during the bulbing stage, in the first ($F = 98.80$; d.f = 7, 1269; $P<0.0001$) and second trial ($F = 18.51$; d.f = 7, 1310; $P<0.0001$), respectively. During this growth stage, all the treatments recorded significantly fewer thrips numbers than the unprotected (control) in both trials. However, Neemros® did not show effective control of thrips in the second trial.

During the bulb-enlargement stage (63-84DAT), differences were observed in thrips numbers among the treatments in the first ($F = 124.97$; d.f = 7, 1269; $P = <0.0001$) and second trials ($F = 201.16$; d.f = 7, 1101; $P < 0.0001$). In the second trial, Furadan® soil treatment controlled thrips significantly until the bulb-enlargement stage. Thrips infestation differed among the treatments ($F = 66.38$; d.f = 7, 950; $P < 0.0001$ and $F = 5\ 7.63$; d.f = 7, 713; $P < 0.0001$) in both the first and second trials, respectively.

Thrips pressure in cumulative thrips-days plant^{-1} (CTDP) for the unprotected plots (Figure 1) showed that the first trial experienced higher thrips infestation levels in all the onion growth stages than the second trial. The highest increase in CTDP occurred between the bulbing and bulb-enlargement stage (602.2 to 1963.9 CTDP in the first trial and between the bulb-enlargement and maturation stage from 800.8 to 1629.7 CTDP in the second trial.

3.3 The Effects of Treatments on Onion Bulb Yield and Quality

In the first trial, the total bulb yield was different among the treatments ($F = 4.88$; d.f = 7, 21; $P = 0.0011$) (Table 4) and ranged between 10.4 and 25.9 tons ha^{-1}. Polytrin® spray treatment resulted in the highest bulb yield (25.87±1.87), followed by Furadan® soil treatment (23.27±2.38) and Confidor® seedling drench (22.05±2.73) in that order, but not significantly different from one another. There was a similar trend in the yield of premium bulb quality. All the other preventive treatments did not show significant increase in bulb yield. The yield of premium onion bulb quality (Grade 1) also differed among the treatments ($F = 3.49$; d.f = 7, 21; $P = 0.0076$), but the yield of the lower quality (Grades 2 and 3) were not significantly different among the treatments ($F = 1.81$; d.f=7, 21; $P = 0.12$ and $F = 1.43$; d.f 7, 21; $P = 0.24$).

In the second trial, there was no significant difference in the total bulb yield among the treatments ($F = 2.04$; d.f = 7, 21; $P = 0.0812$). However, the yield of premium onion bulbs (Grade 1) differed significantly among the treatments ($F = 2.51$; d.f = 7, 21; $P = 0.0361$). The total yield and quality of onions was higher in the second than in the first trial.

3.4 The Relationship Between Onion Bulb Yield and Thrips Infestation

The relationship between onion bulb yield and thrips density, plant damage and thrips pressure (stepwise regression analysis), showed that thrips pressure in cumulative thrips-days $plant^{-1}$ had a significant negative relationship with onion bulb yield, yield = 27.818-0.0054 ctdp, ($R^2 = 0.6013$ $P>0.0002$) and Yield = 66.193-0.0065 ctdp ($R^2 = 0.915$; $P>0.0238$) in the first and second trial respectively. However, the relationship was best described by a third order polynomial regression model, which gave a higher coefficient of determination ($R^2 = 0.77$, $R^2 = 0.98$) (Figure 2), for both the first and second trial respectively, when compared with the linear model.

3.5 Comparison of Cost-Benefit among Treatments

Economic analysis for pooled yield means for the two trials (Table 5) showed that all the single dose preventive treatments gave higher marginal returns than the routine pesticide spray with Polytrin®. The highest marginal returns were recorded from Confidor® seedling drench (164.98), followed by Cruiser® seed coating treatment (151.43), while Polytrin® spray treatment resulted in the lowest marginal returns (10.68).

4.0 DISCUSSION

The preventive treatment involving seed coating was found to be safe for seedling emergence. The seedling vigour was also not adversely affected by this treatment, or by nursery soil drenching products. As such, lack of any phytotoxicity at this stage was found to be favourable to further evaluate the treatments for thrips infestation and crop yield. The results also showed that the preventive treatments effectively controlled thrips infestation during the pre-bulbing and bulbing stages in the first and second trials, except Neemros® (an oil-free powder formulation), which was effective only during the pre-bulbing stage (28DAT). However, the other neem product tested (Achook®), an emulsifiable concentrate (oil formulation), had a longer (56 DAT) residual effect against thrips. Neem extracts have been reported to control many arthropod pests (Altaf *et al.*, 1999; Tanzubil, 2000). The addition of oil and detergents could probably increase the effectiveness of Neemros®, which is prepared from neem seed kernels from which oil has been removed.

In the present study, Confidor® seedling drench effectively controlled thrips up to 56 DAT, and significantly increased the onion bulb yield. The treatment also gave the highest marginal returns among the treatments. However, overnight seedling dipping in the same product (Confidor®) was not equally effective. The ineffectiveness of the same product (Confidor®) when used as an overnight seedling dip may be due to the mode of application, in which the short overnight period may not have allowed adequate amounts of the active ingredient to be assimilated in the plant system. Similar differences in effectiveness due to the mode of application were reported by Allan (1964), who observed that dipped onion transplants in insecticide emulsions at Perkerra, Kenya, did not lead to increased bulb yield, while seedling drenching with the same insecticides (DDT, Aldrin and Methyl-demeton) was more effective. Other trials done using Imidacloprid products as seed dressing and seedling drenching have shown the product to be a highly effective insecticide with low mammalian toxicity and an effective early season control for thrips and other sucking insects (Attique and Ghaffer, 1996; El-Hamady and Sholoa, 1999; Ester *et al.*, 2001).

In the present study, Furadan® soil treatment showed the longest preventive residual effect against thrips infestation in the first trial and significantly increased the bulb yield. Sinha *et al.* (1984) reported that Carbofuran applied at 1.0 kg a.i./ha was the most effective among five granular insecticides and controlled thrips for 23 days without any residues being detected in the mature bulbs. Using similar and lower dosages (0.5 kg a.i./ha) Carbofuran alone was reported to reduce thrips populations but did not increase yield (Bhardwaj *et al.*, 1993). However, the use of a single application of Carbofuran as a side dressing near rows of onion three months after transplanting and Carbofuran at 1 kg a.i/ha. plus 2 sprays of Monocrotophos caused significant yield increases (Zaman, 1989). The product was also reported to suppress thrips for 28 days (Sato and Nakano, 1990) to 56days (Getzin, 1973) in onions. Gupta *et al.* (1988) observed that one application of Carbofuran granules at sowing and the other a month later was the most economical treatments with regard to cost benefit ratio.

In all the preventive treatments, higher levels of thrips infestation occurred late in the onion crop growth. Such delay in thrips population build-up may have contributed to the increased yield and high quality bulbs among the preventive treatments and in all the treatments during the second trial. The results of the present study are in agreement with the findings by Sato and Nakano (1990), that early stages of the onion crop are more affected by thrips infestation than the later stages. In the present study, significant negative relationship between onion bulb yield and thrips infestation was observed in both trials. This is in conformity with earlier reports that onion bulb yield and bulb quality correlated negatively with increased thrips numbers (Edelson *et al*., 1986; Zaman, 1989; Bhardwaj *et al.,* 1992).

The economic analysis showed that the marginal returns were much higher for all the preventive treatments than Polytrin (standard). Among the preventive options evaluated, Confidor® seedling drench and Furadan® soil treatment were most promising for incorporation into an integrated pest management of the thrips in onion. It is also possible for the farmers to adopt options easily, since they are available in the market and are less cumbersome than foliar spraying. These should be further evaluated to optimise their effect in integration with other environmentally friendly control options, with the aim of maximising their potential benefits.

5.0 CONCLUSION

Seedling protection using Confidor® seedling drenching and Furadan® soil placement had the longest residual effect against onion thrips and resulted in comparable increase in onion bulb yield and quality to foliar spray with Polytrin®. The preventive options also resulted in the highest marginal returns due to the yield increase and low protection cost associated with single application. Since the preventive pesticides are available in the market and less cumbersome to use than routine foliar spraying, the single dose application would benefit resource-poor farmers, especially women who are more vulnerable to pesticide contamination.

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REFERENCES

Allan R. G. (1964). Onions, Ann. Rep. Dept. Agric. Vol. II, Record of Investigations, pp 32, Nairobi, Kenya.

Altaf H. H., Muhammad S., Juma K., Muhammad I. and Saifullah K. (1999). Effects of Non-Chemical Methods and Botanical Insecticides on Onion Thrips, *Thrips tabaci,* Lind. (Thysanoptera: Thripidae) in Onion Crop in Balochistan. *Sarhad J. Agric.*, **15**, pp 619 - 624.

Attique M. R. and Ghaffer A. (1996). Control of Early Season Sucking Pests of Cotton with Seed Protectant Insecticides and their Impact on Natural Enemies and Yield of Seed Cotton. *Pakistan J. Zool.*, **28**, pp 253 - 255.

Anonymous (1989). Horticultural Production Guidelines. Farm Management Handbook Vol. 5. Nairobi, pp 220.

Bhardwaj B. S., Gupta R. P. and Singh J. B. (1992). Effect of Thrips Population on the Yield of Onion Bulb Crop. Nat. Hort. Res. Dev. Found. Newslet., **12**, pp 9 - 11.

Bhardwaj B. S., Gupta R. P. and Srivastava P. K. (1993). Studies on the Different Doses of Carbofuran Granules for the Economic Control of Thrips in Kharif Onion set Nursery. *Newsl. Ass. Agric. Dev. Found.*, **13**, pp 5 - 7.

Bullock J. A. (1963). Extraction of Thysanoptera from Samples of Foliage. *J. Econ. Entomol.*, **56**, pp 612 - 614.

Chang L. C. (1973). Soil Treatment with Granular Insecticides against Onion Thrips *Thrips tabaci* Lindeman. *J. Taiwan Agric. Res.*, **22**, pp 285 - 289.

Dent D. (1991). *Insect Pest Management* pp 15 - 81. CAB Int. Wallingford Oxon OX10 8DE, UK.

Edelson J. V., Cartwright B. and Royer T. A. (1986). Distribution and Impact of *Thrips tabaci* (Thysanoptera: Thripidae) on Onions. *J. Econ. Entomol.*, **79**, pp 502 - 505.

El-Hamady S. E. E. and Sholoa M. K. A. A. (1999). Field Evaluation of Imidacloprid Applied as Seed Treatment to Control *Thrips tabaci* Lind. on Cotton with regard to Soil Pollution. *Arab. Univ. J. Agric. Sci.*, **7**, pp 561 - 574.

Ester A., Huiting H. F. and Biddle A. L. (2001). Filmcoating the Seed of Leek with Fipronil to Control Onion Thrips, Onion Fly and Leekmoth. Seed Treatment Challenges and Opportunities. Proc. Int. Symp. Wishow, N. Warwickshire, UK. pp 159 -166.

Fournier F., Boivin G. and Stewart R. K. (1995). Effect of *Thrips tabaci* (Thysanoptera: Thripidae) on Yellow Onion Yields and Economic Thresholds for its Management. *J. Econ. Entomol.*, **88**, pp140 -147.

Freuler J. and Fischer S. (1984). Methods of Monitoring Populations of the Onion Tthrips *Thrips tabaci* Lind. *Mitl. Schweiz. Entomol. Gessellschaft.*, **57**, pp 163-171.

Getzin L. W. (1973). Suppression of Onion Thrips with Systemic Insecticide Treatments. *J. Econ. Entomol.,* **66**, pp 975 - 977.

Gupta R. P, Bhardwaj B. S. and Singh J. B. (1988). Effect of Different Insecticides on the Control of Thrips in the Nursery of Kharif Onion Sets. *Veg. Sci.*, **15**, pp 200 - 201.

Gupta R. P. and Sharma R. C. (1998). Effect of New Insecticides/Biopesticides on Control of Onion Thrips. *Newsl. Nat. Hort. Res. Dev. Found.*, Karnal (Haryana), India, **18**, pp 5-7.

Jaetzold R. and Schmidt H. (1983). *Farm Management Handbook of Kenya* Vol. 2. Nairobi.

SAS (2000). *SAS User's Guide*: Statistical Analysis Systems, Version 8. SAS Institute, Inc. Cary, NC.

Sato M. E and Nakano O. (1990). Influence of Period of Infestation of *Thrips tabaci* Lindeman, 1888 on the Development and Yield of Onion Plants (*Allium cepa* L.) *Ecossistema,* **15**, pp 79 - 88.

Sinha N.; Chakrabarti A. K., Agnihortri N. P., Jain H. K. and Gajbhiye V. T. (1984). Efficacy and residual toxicity of some systemic granular insecticides Against *Thrips tabaci* on onion. *Trop. Pest. Manage.*, **30**, pp 32 - 35.

Tanzubil P. B. (2000). Field evaluation of Neem, *Azadirachta indica* Extracts for Control of Insect Pests of Cowpeas in Northern Ghana. *J. Tropic. For. Prod.*, **6**, pp 165-172.

Zaman M. (1989). Evaluation of Granular Systemic Insecticides Against the Golden Wing Moth and Thrips on Onion in Swat. *Pesticides*, Bombay, **23**, pp 30 - 33.

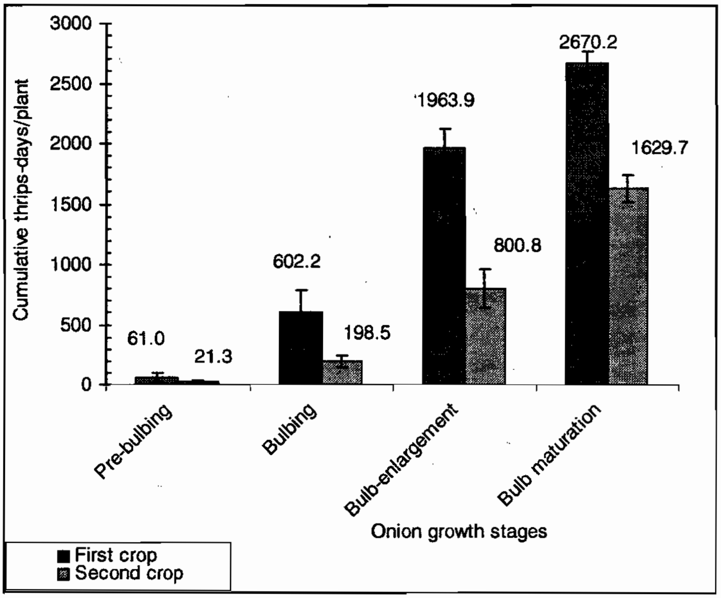

Figure 1: *Thrips infestation in cumulative thrips days per plant within the onion growth stages in the unprotected crop during the first and second onion crop*

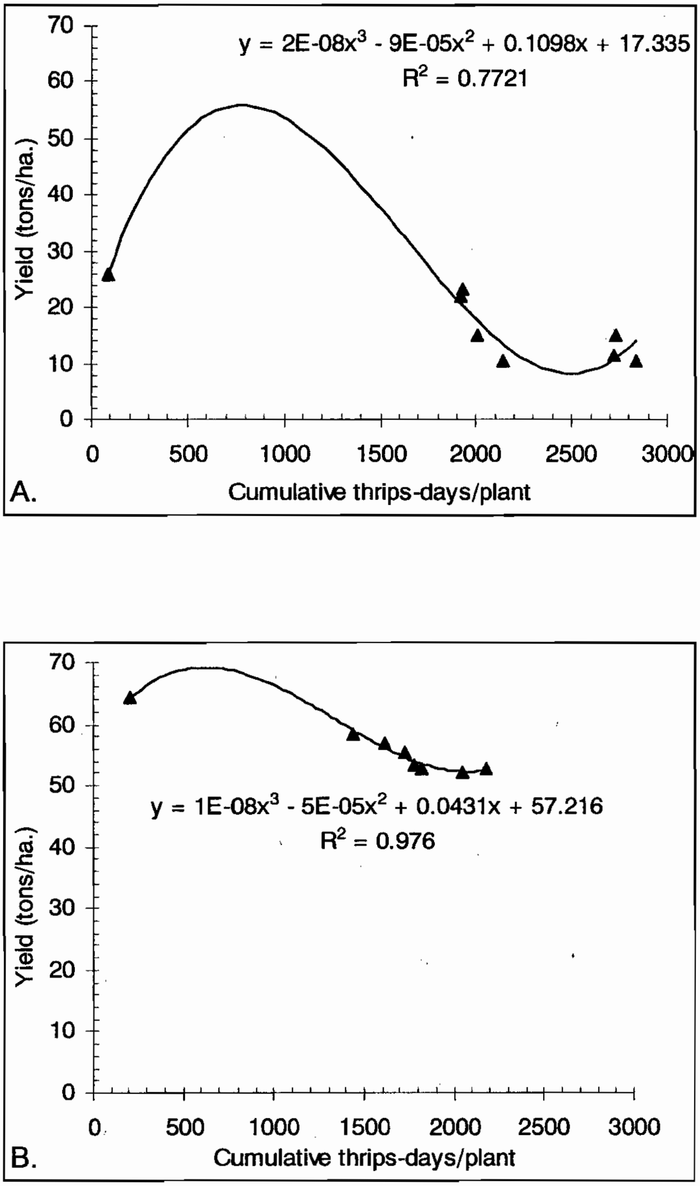

Figure 2: The relationship between thrips infestation pressure in cumulative thrips–days per plant and onion bulb yield (tons.ha.) during the first (A) and second (B) field trials at Mwea-Tebere, Kenya

Table 1: Treatments application rates and procedures

Treatment	**Treatment application rates*	*Application procedure*
Cruiser® 350 FS	Seed treatment flowable concentrate insecticide at 350g/l a.i (Thiamethoxam)	Seed coating at 20ml slurry/ 100g seed during sowing
Achook® E.C	Seedling treatment using neem kernel based emulsifiable concentrate (E.C) containing Azadirachtin 0.15% w/w (1500 ppm) Min. at 6l/ha.	Seedling drenching at 10ml/5l water/ $5m^2$ at two weekds after sowing
Neemros®	Seedling treatment using neem kernel cake powder (NKCP) containing Azadirachtin 0. 5% w/w at 2kg/ha	Seedling drenching at 125g/5l water applied to $5m^2$ nursery, two weeks after sowing
Confidor ® 200SL	Imidacloprid soluble concentrate (SL) containing 200g a.i. at 400ml/ha	Seedling drenching at 7.5ml/5l water applied $5m^2$ nursery, two weeks after sowing
Confidor ® 200SL	Systemic soluble concentrate Imidacloprid containing 200g a.i. at 400ml/ha	Overnight seedling dipping in 7.5ml/5l mixture in 5l bucket before transplanting
Furadan ®5G	Systemic granular insecticide Carbofuran at 10kg/ha	Soil placement in the furrows with 5g/m Carbofuran granules during transplanting
Polytrin®	400g/l Profenofos + 40g/l Cypermethrin (E.C) at 1.5l/ha.	Foliar insecticide spray at 100ml/20l water applied fortnightly throughout the crop season
Control	Unprotected	No pesticide treatment

®Trade name *Treatment rates and methods of application obtained from pesticide labels.

Table 2: The seedling emergence duration and seedling vigour in different treatments in two onion trials in Kenya

Treatments	*Days to seedling emergence*	*Seedling vigour (1-5 score)*
Cruiser® seed coating	9.5±0.5	4.40±0.4
Achook® drench	7.0±0.0	4.40±0.4
Neemros®drench	7.5±0.5	4.40±0.4
Confidor® drench	7.50±0.5	4.40±0.4
Confidor® dip	7.5±0.5	4.00±0.32
Furadan® soil treatment	7.50±0.5	3.80±0.2
Polytrin® spray	7.5±0.5	4.0±0.32
Control	7.50±0.5	4.0±0.32
F	2.59 n.s	0.51 n.s
d. f	7,8	7,32
P	0.1028	0.8221

®Trade mark
n.s. not significant
Treatments means were not significant at p=0.05

Table 3: Comparison of thrips infestation levels for eight treatments during the onion phenological growth stages in two onion trials in Kenya

Treatments	First trial (12/04/01-19/07/01)				Second trial(26/07/01-26/10/01)			
	Pre-bulbing (0-28 DAT)	Bulbing (35 -56 DAT)	Bulb-enlargement (63-84 DAT)	Bulb-maturation (91-105DAT)	Pre-bulbing (0-28 DAT)	Bulbing (35-56 DAT)	Bulb-enlargement (63-84 DAT)	Bulb-maturation (91-105 DAT)
Cruiser® seed coating	4.96±0.75Bd	15.36±1.04BCc	36.48±2.48Ba	25.46±1.87Ab	0.99±0.21Bd	7.81±0.62BCc	32.75±1.19Ba	29.07±1.70Ab
Achook® drench	2.13±0.34CDd	13.84±0.94BCc	43.84±3.40Ba	25.94±2.46Ab	1.00±0.16Bd	8.60±0.63BCc	32.77±1.43Ba	27.93±2.31Ab
Neemros®drench	3.20±0.41Cd	14.44±1.06BCc	64.57±4.34Aa	24.39±2.16Ab	0.94±0.14Bd	9.81±0.77ABc	38.22±1.40ABa	29.40±2.60Ab
Confidor® drench	1.37±0.28Dd	9.78±0.73Dc	42.88±3.15Ba	23.90±1.41Ab	1.08±0.23Bd	7.14±0.57Cc	32.12±1.39Ca	26.68±1.79Ab
Confidor® dip	2.27±0.37CDc	21.28±2.08Bb	65.53±5.39Aa	23.36±1.40Ab	0.42±0.10Bd	7.16±0.67Cc	40.38±2.48Aa	26.26±1.50Ab
Furadan® soil treatment	3.60±0.50BCd	12.34±0.80Cc	37.26±2.34Ba	25.43±1.75Ab	0.37±0.12Bd	7.00±0.54Cc	27.13±1.05Da	23.71±1.54Ab
Polytrin® spray	1.18±0.24Da	0.68±0.15Ea	0.69±0.17Ca	1.15±0.23Ba	0.44±0.08Bc	2.81±0.45Db	1.79±0.19Eb	4.36±0.81Ba
Control	9.13±0.89Ac	41.54±3.42Aa	36.55±2.49Ba	24.79±1.60Ab	2.10±0.44Ad	10.42±0.69Ac	34.36±1.64BCa	27.50±1.89Ab
F	51.54	98.80	124.97	66.38	6.46	18.51	201.16	57.63
P	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
d. f	7, 950	7, 1269	7, 1269	7, 950	7, 952	7, 1310	7, 1101	7, 713

®Treatment trade name. DAT= Days after transplanting.
Data for thrips numbers was log transformed ($x'=\log_{10}(x+1)$) during analysis. Within a column, means compare thrips populations among the treatments within the same growth stage and means with the same upper case letter are not significantly different (P=0.05, SNK test). Within a row means compare thrips population among the growth stages in one treatment and means marked with the same lower case letter are not significantly different (P=0.05, SNK test).

Table 4: The effect of different control options on onion bulb yield and quality in two trials at Mwea Tebere, Kenya

Treatment	First Crop (12/04/01-19/07/01)				Second crop ((26/07/01-26/10/01)			
	Grade 1	Grade 2	Grade 3	Total yield	Grade 1	Grade 2	Grade 3	Toatal Yield
Cruiser® seed coating	4.17±1.13b	6.94±0.57a	4.00±1.15a	15.11±0.91bc	24.54±3.50b	30.56±2.45ab	0.38±0.38b	55.47±3.71a
Achook® drenching	0.87±0.52b	5.90±1.04a	3.82±0.35a	10.59±1.04c	22.69±1.91b	28.24±3.81ab	2.41±0.80ab	53.33±4.90a
Neemros® drenching	3.96±2.56b	5.90±1.64a	1.74±0.35a	11.60±4.01c	21.30±3.16b	28.70±2.45ab	2.78±0.93ab	52.78±2.88a
Confidor® drench	9.90±3.31ab	8.33±0.98a	3.82±0.67a	22.05±2.73ab	20.37±3.78b	35.19±3.12a	1.48±0.84ab	57.04±2.75a
Confidor® dip	3.47±1.44b	5.56±1.50a	6.25±1.65a	15.28±1.79bc	23.61±1.75b	27.78±0.76ab	0.74±0.37ab	52.13±2.32a
Furadan® soil treatment	10.07±2.5ab	9.37±1.43a	3.82±1.28a	23.27±2.38ab	24.08±2.39b	34.26±3.42a	0.14±0.09a	58.47±4.76a
Polytrin® spray	13.20±1.84a	9.03±1.20a	3.65±0.52a	25.87±1.87a	40.28±3.88a	22.23±2.14b	1.35±0.36a	64.35±5.68a
Control	0.66±0.29b	4.17±0.00a	5.56±0.57a	10.38±0.66c	21.76±5.15b	27.32±3.15a	3.80±1.27a	52.87±2.79a
F	3.49	1.81	1.43	4.88	2.51	2.78	2.71	2.04
P	0.0076	0.12	0.24	0.0011	0.0361	0.02	0.026	0.0812
d.f.	7, 21	7, 21	7, 21	7, 21	7, 21	7, 21	7, 21	7, 21

®Treatment trade name. DAT= Days after transplanting. Grade1=>5 cm, Grade 2=d" 5 >3cm and Grade 3=d"3 cm, bulb diameter.
Means within a column marked by the same letter are not significantly different (P=0.05, SNK test)

Table 5: Economic analysis of thrips protection treatments in onion grown in two field trials during year 2001 at Mwea-Tebere, Kenya

Protection regime	*Protection cost/Ha.	Bulb Yield (tons/Ha.)		**Yield value (US$).)		Total yield gain	Marginal returns (US$.)
		Grade1&2	Grade3	Grade1&2	Grade3		
Control	-	26.95	4.68	5649.39	549.46	-	
Cruiser®	6.58	33.10	2.19	6938.20	257.03	996.28	151.43
Achook®	7.57	28.85	3.11	6046.85	365.87	213.77	28.25
Neemros®	7.57	29.93	2.26	6273.49	265.11	339.65	44.89
Confidor® drench	11.18	36.89	2.65	7732.60	311.52	1845.18	164.98
Confidor® dip	11.18	30.21	3.50	6332.18	410.81	544.04	48.64
Furadan®	63.16	38.89	1.98	8151.29	232.50	2184.85	34.59
Polytrin®	281.26	42.36	2.75	8879.40	322.98	3003.44	10.68

®Treatment trade name
[1](1US$=76KSh.). *Insecticide price was provided at the retail agrochemical shops, Knapsack sprayer cost @US$ 111.84 and Protective clothing @ US$ 41.17 payable in three years. **Farm gate price of onions estimated at US$ 0.21 and 0.12/Kg for grade1&2 and grade 3, respectively.