SPECIES COMPOSITION AND OCCURRENCE OF THRIPS ON TOMATO AND PEPPER AS INFLUENCED BY FARMERS' MANAGEMENT PRACTICES IN UGANDA

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Received: November 14, 2012
Accepted: April 4, 2013

Abstract: A biological monitoring survey was carried out in central Uganda for two consecutive seasons to provide information on species composition and occurrence of thrips on tomato and pepper as influenced by farmers' management practices. A total of 50 farms for each crop participated in the study. Data was collected on cropping system, crop variety, type of pesticide used, pesticide spray regime, and on thrips populations. Results indicated that a total of six thrips species: *Frankliniella occidentalis, Thrips tabaci, F. schultzei, Scirtothrips dorsalis, Ceratothrips ericae* and *Megalurothrips sjostedti* infest tomato in the region. Pepper had the same thrips profile with the exception of *F. schultzei*. There was a distinct seasonal effect on thrips occurrence in the case of tomato. Higher thrips populations (61%) were recorded in the first season of the study as compared to the second. The majority of the thrips were recorded in the flowering stage of crop development for both crops, and 100% in the case of pepper. Generally, for both crops, plants in intercropped arrangements had higher thrips counts than the monocropped ones. Different tomato/pepper varieties sustained variable thrips populations. All the farmers applied pesticides to manage the complex of pests on the crops, albeit to variable extents. In this region, thrips populations were reduced when an increase in the number of pesticide applications in a given week was used.

Key words: cropping system, pesticide application regime, plant genotype, type of pesticides

INTRODUCTION

In Uganda, tomato (*Lycopersicum esculentum*) and pepper (*Capsicum* spp.) are among the important crops for small scale farmers and the most promising areas for horticultural development (Andrews 1984; FAO 1990; Swinkels *et al*. 1994; Bosland and Votava 2000; FAO 2003; Sejjemba 2008; Buyinza and Mugagga 2010). Tomatoes are the most locally marketable vegetable in Uganda (Kasenge *et al*. 2002; Ssonko *et al*. 2005). Sweet peppers also have a thriving local market. Hot peppers are an important fresh export crop of Uganda with the country being an important player in the supply of high quality hot peppers to the European Union (EU) market (UIA, 2009). Tomato and pepper yields at the farm level in Uganda are generally much lower than the potential for the two crops (Kagezi *et al*. 2001). Though a range of factors contribute to the low yields, insect pests and diseases have been found to be among the most damaging (Kagezi *et al.* 2001; Ssekyewa 2006; Karungi *et al.* 2009). The most important insect pests afflicting the two crops are aphids, whiteflies, thrips, African bollworm, and mites (Defrancq 1989; Mwaule 1995; Kagezi *et al.* 2001; Ssekyewa 2006). Thrips merit attention because they cause direct and indirect damage. Thrips feed on plant tissue by rasping and sucking sap, resulting in tissue scarification and depletion of the plant's resources (Welter *et al*. 1990; Shipp *et al*. 1998). The scarification reduces the photosynthetic capacity of leaves and causes blemishes on fruits. Indirectly, thrips transmit the tomato spotted wilt virus (TSWV) on tomato. The direct injury and the virus disease result in discoloration of fruits, thus lowering the quality of the fruits. Kagezi *et al*. (2001) found that thrips cause a tomato yield loss of 23.7%. Despite the importance of the pest, the factors affecting thrips occurrence in farmers' fields and the thrips species composition on the crops in Uganda, are not well understood. This study was, therefore, carried out on farmers' fields to determine the occurrence of thrips under different production and management approaches. Tomato and pepper were used as case studies.

MATERIALS AND METHODS

A biological monitoring survey was conducted for two consecutive growing seasons: the second rains of 2008

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(2008B) and the first rains of 2009 (2009A) in central Uganda in the districts of Mpigi (0°49′22S; 11°37′25E) and Wakiso (0°24′16N; 32°27′34E) where production of the horticultural crops is high. The districts lie within an altitude of 1,200–1,325 m above sea level, and have a humid tropical climate with mean monthly temperatures between 25–27°C. These districts receive a bimodal type of rainfall with growing seasons in March-June and September-December; with a long term annual average of 1,590 mm.

In each study district, two sub-counties were purposely selected based on production levels. In the Mpigi district, the Mpenja and Buwama sub-counties were selected whereas in the Wakiso District, the Busukuma and Gombe sub-counties were selected. Twenty-five (25) farmers were selected in each district for each crop, giving a total of fifty (50) tomato fields and 50 pepper fields studied across the growing seasons. On each selected farm, ten plants were randomly selected from each pepper and tomato field. Data were collected on thrips occurrence, from each selected plant, by counting and collecting thrips found on the underside of the three top-most, fully-expanded tomato leaflets. Thrips samples were collected in the late morning hours by gently tapping on the leaves, which dislodged the thrips from the leaves to white plastic trays placed under each plant. Using camel hair brushes, the thrips were then transferred to vials containing 60% ethanol, glycerin, and acetyl glyceric acid (AGA) fluid in the ratio 10:1:1, respectively for preservation of features (Palmer *et al*. 1989; Palmer 1990). The vials of thrips were then taken to the laboratory for counting and identification. In addition, one flower per tomato plant, and five flowers per pepper plant were randomly picked and preserved in the AGA (Riley and Pappu 2004). Thrips were mounted and identified under a compound light microscope (manufactured by Leica), using the procedure described by Palmer (1990), at a magnification of 40. The Lucid key developed by Moritz *et al*. (2001) and the dichotomous keys adapted from Palmer *et al*. (1989), Palmer (1990), and Mound *et al.* (1976) were used for identification of thrips species, using the morphological features.

On each farm, the pest management practices employed by the farmers during production of tomato and pepper; the cropping system, the crop stage, pesticide type and spray regime, and the variety grown were all recorded. These pest management practices were considered as the different factors that may be affecting the occurrence of thrips on the crops in farmers' fields.

Data were analysed using the GenStat computer package, Release 32 (Lawes Agricultural Trust, Rothamsted Experimental Station, 1993) and a statistical package for social scientists (SPSS) version 16.0, for Microsoft windows to generate analysis of variance (ANOVA) and means. Means were separated by the least significant difference (LSD) at 5%. For pepper, data was only collected during the flowering stage because sampling at the vegetative stage did not yield any thrips. All the thrips collected on peppers were from the flowers.

RESULTS

Species composition of thrips on tomato and pepper in farmers' fields

In the laboratory, all the sampled thrips were identified to species level as shown in table 1. In all, six thrips species *Frankliniella occidentalis, Thrips tabaci, F. schultzei, Scirtothrips dorsalis, Ceratothrips ericae* and *Megalurothrips sjostedti* were identified. *T. tabaci* had the highest occurrence (27 samples) whereas *F. schultzei* (5 samples) had the lowest occurrence (Table 1). Occurrence of *T. tabaci* was more on tomato (20 samples) than on pepper (7 samples). *F. schultzei* was found to occur only on tomatoes and not on pepper. The most common thrips species on pepper was *F. occidentalis* (12 samples).

Thrips occurrence as influenced by the different growing season and growth stages of tomato plants

On tomato there were distinct trends in thrips populations with regard to season and growth stages (Table 2). The overall thrips population was higher during the 2008B growing season at an average of 2.2 thrips per plant, compared to the 1.4 thrips per plant recorded in 2009A growing season. In all the growing seasons, significant differences ($p < 0.001$) were observed across the growth stages (Table 2). In both growing seasons the

Table 1. Species composition of thrips on tomato and pepper in farmers' fields

Species	Number of thrips samples		The total
	tomato	pepper	
Frankliniella occidentalis	8	12	20
Thrips tabaci	20	7	27
F. schultzei	5	0	5
Scirtothrips dorsalis	1	11	12
Ceratothrips ericae	13	6	19
Megalurothrips sjostedti	7	5	12
The total	54	41	95

Table 2. Effect of different growth stages on thrips occurrence per tomato plant

Tomato	Thrips populations per plant		Overall mean
Growth stage	2008 b	2009 a	
Vegetative	2.3 a	1.6 a	1.94
Flowering	2.5 a	1.6 a	2.05
Fruit Ripening	1.8 b	1.0 b	1.42
Overall mean	2.2	1.4	1.8
LSD ($p < 0.05$)	0.34	0.24	

Means in the same column followed by the same letter are not significantly different at $p \leq 0.05$

highest mean number of thrips of 2.1 thrips per plant was recorded at the flowering stage and the lowest at the fruit ripening stage of 1.4 thrips per plant (Table 2).

Effect of the cropping system on thrips occurrence on tomato and pepper

Generally, the majority of the sampled farmers' tomato fields (55%) grew tomato in a mixed cropping system. The different companion crops included: hot pepper, maize, coffee, banana, passion fruit, and cassava. The rest of the farmers (45%) grew tomato as a sole crop (monocropping system). For pepper, the reverse was true with most farmers (65%) growing it as a monocrop whereas the rest of the farmers (35%) had intercropped their pepper with different crops like tomato, maize, coffee, banana, and cassava. The different cropping systems had no significant effect on the occurrence of thrips per plant on tomato in 2008B ($p < 0.05$). In 2009A, however, cropping system had a significant ($p < 0.05$) effect on the occurrence of thrips, with higher incidences recorded in the intercropped fields (mean of 1.70 thrips per plant) than in the monocrop (mean of 1.30 thrips per plant) (Table 3). For pepper, the reverse was true, with cropping system having a significant effect ($p > 0.05$) on thrips occurrence in the 2008B growing season but not in 2009A. In 2008B, thrips population on pepper was higher in the intercrop (2.10 thrips per plant) compared to the monocrop (1.62 thrips per plant).

Effect of variety on thrips occurrence on tomato and pepper

The selected farmers were growing Heinz 1370, Romania, and MT56 as their tomato varieties of choice. Short-thai (*C. annum*), Super-hot (*C. annum*), scotch bonnet (*C. chinense*) and green pepper (*C. annum*) were the Capscicum species being grown by the selected farmers. There was a significant difference ($p < 0.05$) in thrips occurrence among the tomato varieties during the growing seasons of 2008b and 2009a. In both growing seasons, thrips occurrence was highest in Heinz 1370 (mean of 1.94 thrips per plant) and lowest on MT56 (mean of 1.61 thrips per plant) (Table 4). For pepper, in 2008B, the type of pepper/variety had a significant effect ($p < 0.001$) on thrips occurrence. The type of pepper/variety did not have a significant effect on thrips occurrence in 2009A (Table 4). The variety *Green pepper* registered the highest occurrence of thrips per plant (2.00) whereas Super- hot had the least (1.50).

Effect of types of pesticides used and farmers' spray regimes on thrips occurrence on tomato and pepper

All the farmers sampled used pesticides or fungicides on a regular basis to control insect pests and diseases on tomato. The most commonly used fungicide was Mancozeb (Dithane M45) while the most commonly used insecticide was Cypermethrin (under different trade names). Some farmers used combinations of pesticides (fungicide + insecticide, or two different insecticides together). Gen-

Table 3. Effect of cropping system on the mean number of thrips per plant on tomato and pepper

	Thrips occurrence per plant					
	tomato			pepper		
Cropping system	2008 b	2009 a	overall mean ±SE	2008 b	2009 a	overall mean ±SE
Monocropping	2.30 a	1.30 b	1.80±0.10	1.62 b	1.70 a	1.66±0.11
Intercropping	2.23 a	1.70 a	1.97±0.13	2.10 a	1.80 a	1.95±0.12
Overall mean/season	2.27	1.50	1.88	1.86	1.75	1.81
LSD ($p < 0.05$)	0.21	0.29		0.40	0.34	

Means in the same column followed by the same letter are not significantly different at $p \leq 0.05$; ±SE – Standard error

Table 4. Effect of variety grown on occurrence of thrips per plant on different tomato and pepper varieties

	Thrips occurrence per tomato plant		
Variety	2008 b	2009 a	overall mean ±SE
MT56	2.21 b	1.00 b	1.61±0.48
Romania	2.23 ab	1.55 a	1.90±0.11
Heinz 1370	2.38 a	1.50 a	1.94±0.14
Overall mean/season	2.27	1.35	1.81
LSD (p < 0.05)	0.30	0.30	
	Thrips occurrence per pepper plant		
Variety	2008 b	2009 a	overall mean ±SE
Short thai	1.60 a	1.60 a	1.60±0.22
Super-hot	1.30 b	1.70 a	1.50±0.36
Scotch bonnet	2.14 a	1.70 a	1.92±0.34
Green pepper	2.20 a	1.80 a	2.00±0.27
Overall mean/season	1.81	1.70	1.76
LSD (p < 0.05)	0.45	0.40	

Means in the same column followed by the same letter are not significantly different at p < 0.05; ±SE – Standard error

erally, the mean thrips population decreased with increasing number of sprays in a week ($F_{1, 148} = 5.473^{**}$) regardless of the dosage. In fact, the Pearson 2-tailed correlation between thrips populations and number of sprays in a week was significant and negative (r = –0.189**, N = 150). The highest thrips occurrence was recorded with farmers applying one pesticide spray per week (4 sprays per month) as compared to those using 2 sprays a week (Fig. 1). Most farmers were found to be applying 4 sprays per month.

All the farmers involved in the study used pesticides for growing pepper. In pepper production, fungicide usage was not encountered but insecticides were used regularly. The most encountered insecticides were cypermethrin, dimethoate, abamectin, and profenofos. Though there was no significant effect of pesticide regimes or types on thrips occurrence on pepper (p < 0.05), choice of pesticide was significantly correlated to production region (location) (Pearsons 2-tailed, r = 0.447**, N = 50).

DISCUSSION

The identification results recorded six thrips species which occur on tomato and pepper. *Thrips tabaci* was the more abundant species, especially on tomato. A predominance of *T. tabaci* on tomato was also indicated in earlier reports by Nyiira (1973), NARO (1990), and Kagezi *et al.* (2001). The thrips profile on pepper found in our study, was in agreement with the results from a study in East Africa by ICIPE (2009) who found that *F. schultzei* was prevalent throughout Kenya and Uganda. Of concern is the fact that invasive *F. occidentals and S. dorsalis* were very predominant on pepper in the region. *S. dorsalis* may be a major threat to peppers in the country.

Studies by Dobson *et al.* (2002) and Akemo *et al*. (1999), indicated that the drier the weather, the quicker the onset of thrips damage and the more severe the symptoms. This was also true in our study, as a high thrips populations were observed in 2008B a season that was dry and characterized with low and infrequent rains (average of 74.8

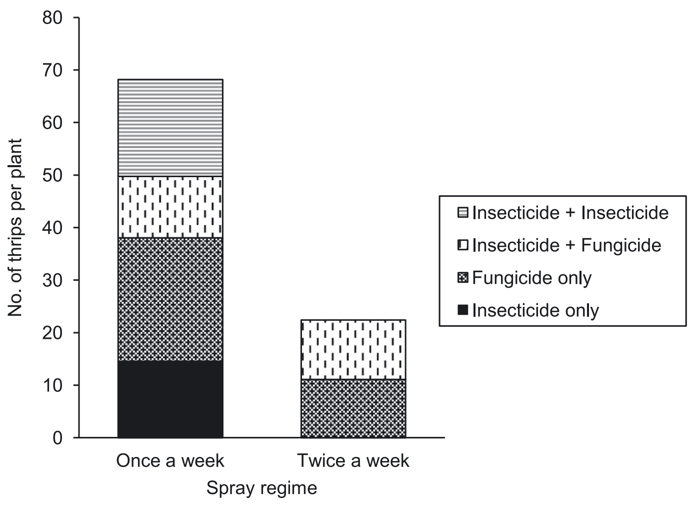

Fig. 1. Effect of spray regime and type of pesticide on thrips occurrence on tomato

mm/month). These weather conditions probably favored a thrips build-up on tomato and pepper as compared to 2009A which had relatively long and heavy rains (an average of 140.7 mm/month). This was also in agreement with earlier findings by Lewis (1997) that the distribution of a thrips population is strongly influenced by climatic conditions.

Thrips occurrence was generally highest in tomato's flowering stage. On pepper, thrips were only recorded in the flowering stage. This is in agreement with earlier findings by Terry (1997), who indicated that the primary characteristic in thrips locating a host plant is color. Thrips are able to locate hosts via visual clues such as the colors blue, white, and yellow. Childers and Brecht (1996) and de Kogel and Koschier (2003) found that all hosts of *F. occidentalis* contained twice as many thrips when flowers were present than those plants of the same age with the flowers removed. They also found that the least preferred pre-flowering host supported 60 times more thrips when flowering. The varieties grown by tomato and pepper farmers had a significant effect on the recorded thrips population. This can be explained by the differences in morphological as well as biochemical characteristics of the different varieties (Kendall 1989; Kendall and Capinera 1987).

Farmers of tomato and pepper routinely applied a variety of pesticides at varying rates and frequencies of application to manage insect pests and diseases on the crops. This is in agreement with findings by Karungi *et al.* (2011) and Akemo *et al.* (2000). Pesticide usage was variable depending on production region as well as the crop grown. While the frequent use of pesticides proved effective against thrips in this study and in earlier findings (Steele *et al.* 1985; Bal 1991; Alghali 1992a, b; Sabiiti *et al.* 1994; Kyamanywa 1996; Nampala *et al.* 1999; Karungi *et al.* 2000, b), there is a need to check the increasing reliance on chemical pesticides to avoid the associated hazards to humans and the environment. A case in point being the probable development of resistance to the pesticides as reported by Bommarco and Ekbom (1995), and ICIPE (2009). Use of pesticides may also reduce the population of natural enemies for the thrips which may result in the increased abundance of thrips populations (Funderburk *et al*. 2000). The effect of the pesticide spray schedule (number of sprays a week) had a significant effect on thrips populations on tomato but this trend did not hold for pepper. This may be due to the fact that on pepper, thrips were only found in the flowers, the cryptic nature of which could have influenced the outcome.

With regard to cropping system, the study showed a trend towards higher thrips population in intercrops as compared to monocrops for both of the studied crops (tomato and pepper). This is in agreement with the findings of Karungi *et al*. (2010) who recorded higher infestation levels of thrips and whiteflies in a hot pepper and cowpea system compared with the hot pepper monocrop. These results, however, are contrary to the popularly held view that diversified cropping systems sustain fewer insect herbivores (Root 1973; Risch *et al*. 1983; van Lenteren 1998; Smith and McSorley 2000; Hooks and Johnson 2003). The variations in herbivore load in mixtures, compared with monocultures, have been attributed to differences in efficacy and/or abundance of natural enemies, difference in food or resource concentration among cropping systems, and modification of crop microclimate (Root 1973; Risch *et al*. 1983; Kyamanywa and Ampofo 1988; Ogenga-Latigo *et al*. 1992; Kyamanywa *et al*. 1993). Results of this study showed that there was no significant interaction of cropping system and pesticide usage regime on thrips population, with a tendency by farmers to spray regularly despite the cropping system. This could have an impact on the abundance of natural enemies in both systems, negating a factor of great importance with regard to herbivore abundance in diversified cropping systems.

From these results concerning the management of thrips in tomato and pepper cropping systems, it would be prudent that calendar sprays of pesticides be stopped. Safer options such as using only targeted sprays during the critical flowering stage, in combination with ecological management tactics are needed.

ACKNOWLEDGEMENT

We are grateful to the Integrated Pest Management Collaborative Research Support Program under the United State Agency for International Development, for financing this research through the Regional site in East Africa. Special appreciation goes to the farmers that participated in this study.

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