EFFECTS OF WEATHER ON THRIPS POPULATION DYNAMICS AND ITS IMPLICATIONS ON THE THRIPS PEST MANAGEMENT

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ABSTRACT

Onion thrips, *Thrips tabaci* Lindeman, is the most destructive insect pest of the onion crop, *Allium cepa* L. worldwide. Both larvae and adults attack the onion crop at all stages of its growth, resulting in reduction of yield and quality. Despite the heavy losses incurred as a result of damage by the onion thrips, very little efforts have been made to develop an integrated pest management strategy for the control of the pest in many African countries. Field trials were conducted in four seasons at the Kenya Agricultural Research Institute (KARI) Mwea-Tebere farm in Kirinyaga District. Onion plants were planted periodically and thrips populations monitored weekly from onion plant samples and blue sticky traps for a full year under natural field conditions. The purpose of the trials was to assess the effect of weather on thrips population in onions with the aim of predicting thrips control requirements for a given climatic trend. Weather variables monitored included: rainfall, temperature, relative humidity and wind. Thrips occurred in the onion field and infested onions in all the crop seasons. However, there was significant (P=0.05) variation in thrips numbers between the crop seasons. Dry weather (30.3 mm rainfall) with moderately high temperatures (15.6-28.2^{o}C) increased seasonal thrips numbers, while wet season (391mm rainfall) with moderately high relative humidity was negatively correlated with thrips numbers. Regression analysis (step-wise selection model) showed that minimum relative humidity was the only significant weather factor for predicting thrips infestation in the onion crop (R^2=0.15; y = 60.342-0.1022x). The results suggest that climatic trends can be used to determine the potential thrips control needs in onion production.

Key words: *Allium cepa*, Rainfall, Relative humidity, *Thrips tabaci*, Temperature, Wind.

INTRODUCTION

The total variability in thrips populations in crops is determined by the natural growth of population and the influence of weather on activity and rate of multiplication of the insects (Kirk, 1997). An understanding of the factors that influence these population changes is essential in predicting thrips population. Weather variables including rainfall, temperature, relative humidity and wind have been reported as important factors that significantly affect thrips numbers (Ananthakrishnan, 1993; Kirk, 1997; Legutowska, 1997). Relatively high temperatures and lack of rainfall have been associated with increase in onion thrips population, while high relative humidity and rainfall reduce thrips population (Hamdy and Salem, 1994). In addition to their effect on thrips activity, temperature and relative humidity further influence the intrinsic rate of natural increase of the thrips (Murai, 2000). A basic understanding of the relationship of these factors with thrips population is important in developing an integrated control strategy for thrips in onion and in determining the potential pest control needs for a given climatic trend. The objectives of the present study were to determine the seasonal population abundance pattern of thrips in onion and to characterise the associated weather pattern and thrips population dynamics with the aim of predicting climatic trends that would cause thrips outbreaks in onions.

MATERIALS AND METHODS

Field experiments were conducted at KARI-Mwea-Tebere farm in Kirinyaga District, Kenya. Onion seedlings were transplanted between 42 and 47 days after planting. Each field trial consisted of 12 plots measuring 6 m x 3 m each. The experimental design consisted of randomized complete blocks with two treatments (insecticide-treated and untreated plots) replicated six times. Thrips control was done using fortnightly foliar application of Polytrin® (400 g/l Profenofos and 40 g/l Cypermethrin) at the recommended rate (1 litre/ha) using a knapsack sprayer. The plots were separated by a 3 m buffer zone of bare ground. Onion crops were planted sequentially for four crop seasons ensuring continuous data collection for a full year.

Data collection on thrips numbers commenced from 14 days after transplanting (DAT) and was continued weekly until the crop matured. Thrips sampling from the onion plant was carried out through absolute thrips density estimation from whole plant cutting and bagging (Freuler and Fischer, 1984). Fifteen plants per plot were randomly selected for destructive sampling avoiding the border rows (Dent, 1991). Thrips extraction from the onion plants was carried out in the laboratory using alcohol extraction method (Bullock, 1963). In addition, aerial population of the adult thrips in the onion field was estimated using blue rectangular (17 cm x 25 cm) sticky traps. Environmental data included daily rainfall record readings from a rain gauge in millimeters, minimum and maximum atmospheric temperature in degrees Celsius using a thermometer, relative humidity using a hygrometer and wind speed in kilometers per hour using an anemometer. Data analysis was carried out using the SAS software (SAS, 2000). Analysis of variance (ANOVA) was performed and means separated using Student-Newman-Keuls (SNK) test to compare thrips numbers among seasons and between treatments. Correlation and regression analysis was performed to compare the relationships between thrips counts and weather variables.

RESULTS

Seasonal Thrips Abundance in the Sticky Traps and Onion Plants

The seasonal mean thrips numbers caught in sticky traps and from plant samples in the insecticide-treated and insecticide-untreated plots are shown below (Table 1). Thrips caught in the sticky traps from the insecticide-treated and untreated plots were not significantly different at P=0.05. In contrast, significantly higher thrips numbers were observed in onion samples from untreated plots in all the crop seasons.

There were significant differences in thrips numbers between the four crop seasons on both sticky traps and onion plant counts. The highest thrips numbers were recorded during the first and third onion crop seasons from both sticky traps and onion plants, while the lowest thrips numbers were recorded during the second and fourth onion crop seasons.

The lowest seasonal rainfall (30.3 mm) among the crop seasons was recorded during the first crop season. Temperatures ranged from 15.6^{o}C to 28.2^{o}C, while the relative humidity varied between 35.0% and 66.4%. Wind speed varied from 4.2 to 6.3 km/hr in the first season. During the second crop season, total rainfall recorded was 277.6 mm. The relative humidity during this season, ranged from 42.0% to 88.1%, while the minimum and maximum temperatures varied from 15.7^{o}C to 29.8^{o}C and wind speed varied from 5.1 to 7.4 km/hr. During the third crop season, the total seasonal rainfall was 298.8 mm, minimum and maximum relative humidity varied from 38.7% to 81.3%, while the mean minimum and maximum ambient temperatures varied from 13.9^{o}C to 31.6^{o}C. The wind speed varied from 4.1 to 7.1 km/hr during this season. The highest amount of rainfall (391.0 mm) was recorded during the fourth crop season. Relative humidity was high during this crop season, varying from 57.7% to 84.4%, while the air temperatures varied from 15.6 to 28.7^{o}C. The wind speed varied between 2.9 and 4.6 km/hr, during the fourth crop season which was the lowest among the four onion crop seasons.

Table 1. Thrips caught in sticky traps and plant samples in insecticide-untreated and insecticide-treated onion plots in four crop seasons at Mwea-Tebere, Kenya

Sample source	Season	Insecticide-untreated	Insecticide-treated	F-value	df	*P*-value
Sticky traps	1	519.14±59.57Aa	576.04±70.14Aa	0.02	1, 166	0.890
	2	202.43±23.30Ba	268.77±29.28Ba	3.44	1, 166	0.065
	3	152.60±15.29Ba	176.15±18.31Ca	1.95	1, 166	0.165
	4	123.92±23.93Ca	164.77±29.53Ca	2.65	1, 166	0.107
	F	24.17	16.29			
	d.f	3, 332	3, 332			
	P-value	<0.0001	<0.0001			
	Season	Insecticide-untreated	Insecticide-treated	F-value	df	*P*-value
Plants	1	63.15±1.61Aa	0.94±0.05Ab	5144.57	1, 2265	<0.0001
	2	21.68±1.04D	0.34±0.04Bb	986.31	1, 2458	<0.0001
	3	26.26±0.84Ba	0.35±0.05Bb	2932.25	1, 2268	<0.0001
	4	22.10±0.63Ca	0.27±0.05Bb	3013	1, 2458	<0.0001
	F	385.99	78.16			
	d.f	3, 4685	3, 4734			
	P-value	<0.0001	<0.0001			

Means within a column of each sample source compare number of thrips between crop seasons and are not significantly different at *P*=0.05, according to SNK test when marked by the same uppercase letter. Means within a group (sticky traps or plant samples) across the row compare number of thrips between insecticide-untreated and treated onion plots and are not significantly different at *P*=0.05, according to SNK test when marked by the same lower case letter.

Relationship between Thrips Population and Weather Factors
Both maximum and minimum relative humidity and rainfall were negatively correlated with thrips numbers, while temperature and wind speed had a positive correlation with thrips from sticky traps and plant samples (Table 2). Maximum relative humidity and wind speed had a significant correlation with thrips numbers caught in the sticky traps.

Thrips numbers in the plant samples, established significant negative correlation with both maximum and minimum relative humidity. However, linear regression analysis (stepwise selection model) showed the minimum relative humidity as the only significant weather variable that could predict thrips population in the onion plants (R^2=0.15, P=0.0046, N=53). The negative linear relationship trend of the thrips numbers from plant samples with the minimum relative humidity is shown in Figure 1.

Table 2. Correlation coefficients (r) for weather factors affecting thrips populations sampled from the sticky traps and onion plants in the insecticide-untreated onion plots (N=53)

Weather variable	Thrips from sticky traps		Thrips from onion plants	
	Pearson's r	*P* value	Pearson's r	*P* value
Rainfall	-0.187	0.1805	-0.152	0.28
Maximum air temperature	0.115	0.4127	0.143	0.31
Minimum air temperature	0.155	0.2687	0.152	0.28
Maximum relative humidity	-0.281	0.0415	-0.375	0.01
Minimum relative humidity	-0.261	0.0597	-0.414	0.00
Wind speed	0.275	0.0466	0.266	0.05
Maximum soil temperature	0.264	0.057	0.208	0.13
Minimum soil temperature	0.171	0.2221	0.163	0.24

DISCUSSION
In the present study, thrips numbers in the sticky traps were about eight fold higher compared with the infestation levels in the plant samples, giving an exaggerated indication of the infestation in the plants. The thrips were probably attracted by the onion plant but only a few colonized the onion plant. The finding confirms the observations by Kirk (1997) that sticky traps are better indicators of thrips activity more than population density. Thrips occurred in the onion fields and infested the plants in all the crop seasons and crop development stages.

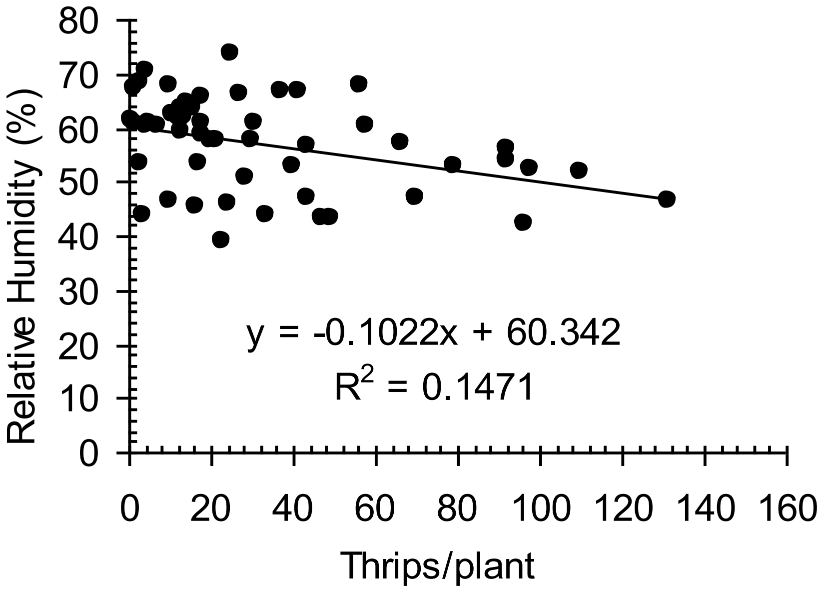

Figure 1. Relationship of thrips from onion plant samples with minimum relative humidity. Data analyzed using linear regression, stepwise selection model.

Within the warm tropical regions, breeding of thrips is continuous unlike in cooler regions where there could be only one or two generations per year (Lewis, 1997). The occurrence of thrips throughout the year has serious implications in their management. The highest seasonal thrips means from sticky traps and onion plant samples occurred in the first cropping season, which coincided with a dry season with moderately high temperatures. Total rainfall and mean relative humidity during this season were low compared to the fourth crop season, which received over 390 mm rainfall in three months and high relative humidity. Similar findings have been reported by other workers (Lorini and Junior, 1990; Domiciano et al., 1993; Hamdy and Salem, 1994). Lorini and Junior (1990) reported that high temperatures and lack of rainfall increased thrips population density of *T. tabaci* on garlic in Brazil. The highest thrips numbers (174.6 thrips per plant) were reached when temperatures were between 18^{o}C and 21^{o}C and when rainfall was low (114 to 144 mm per month). In another study, Hamdy and Salem (1994) reported that *T. tabaci* females lay the most eggs and lived longest within temperatures of 21.1^{o}C to 23.6^{o}C and relative humidity of 52%.

Temperatures above 35^{o}C and drought have been reported to be unfavorable to the survival of thrips, resulting in population decline (Varadharajan and Veeraval, 1995). In the present study, temperatures ranged from 13.9^{o}C to 32.7^{o}C throughout the sampling period. High temperatures which would be unfavorable to the survival of thrips therefore did not occur.

In the present study, significantly low seasonal thrips numbers from the insecticide-untreated plots were observed during the second cropping season from the onion plant samples and the fourth crop seasons in the sticky traps samples, which coincided with the short and long rains seasons respectively. During the fourth cropping season, the highest total seasonal rainfall was recorded, while the lowest (30.3 mm) was recorded during the first cropping season, which had the highest seasonal thrips numbers (63.15 thrips per plant and 519.1 thrips per trap).

Minimum relative humidity established a significant negatively linear relationship with thrips population in the plant samples. The study showed both relative humidity and rainfall were negatively correlated with thrips population increase. Heavy rain has been reported to wash thrips off plants down to the soil surface, causing sharp declines in their population density (Harris et al., 1936; North and Shelton, 1986). The rate of development of *T. tabaci* is positively affected by increased temperature and decreased by increased relative humidity (Hamdy and Salem, 1994).

In the present study, only the minimum relative humidity significantly predicted thrips infestation in the onion plants, even though the relative humidity is known to be increased by rainfall. Similar relationship of thrips populations with relative humidity and rainfall have been reported previously (Hamdy and Salem, 1994; Varadharajan and Veeraval, 1995).

In the present study, wind was found to correlate positively with thrips increase in the sticky traps. Similar findings were reported by Panickar and Patel (2001), who observed significant correlation of *T. tabaci* population with wind. However, Lewis (1997) cautioned that mean wind speed measured over hours may only provide a general guide and recommended high powered infra-red remote sensing system to be used to detect flight activity of small airborne insects like thrips. The ability of thrips to naturally disperse widely by flight, or within the vegetation contributes greatly to their pest status and the flight take-off is associated with some air movement (Lewis, 1997).

Based on the numbers caught in the sticky traps, the study also revealed the potential of accurate prediction of adult infestation in the onion plants. The relationship of thrips trap catches with plant populations have been reported to be complex, requiring careful study for each combination of pest and host crop (Lewis, 1997).

While thrips numbers in the insecticide-treated plots remained low in the plant samples, thrips numbers captured in the sticky traps placed in the same plots were equally as high as in the sticky traps placed in insecticide-untreated plots. Since thrips select their host using colour, shape, size and volatiles associated with the host plant (Terry, 1997), the thrips which did not colonize the insecticide-treated plants were probably caught in the sticky traps during their host selection activities and on their way of escape from the apparently unsuitable host.

CONCLUSIONS AND RECOMMENDATIONS

Among the weather factors assessed in the present study, relative humidity (minimum and maximum) established significant negative correlation with thrips population increase. Rainfall emerged a poor predictor of thrips population even though it is directly related to the increase in relative humidity and has frequently been demonstrated as a decisive thrips mortality factor (Kirk, 1997). Studies on direct evaluation of this factor in simulation models could be useful in determining its influence on thrips populations and their interactions with the onion crop.

The continuous occurrence of thrips on onion confounds the pest management in an irrigated crop like onion which is grown all year round. Plant health adherence through removal of volunteer onion plants and weeds around the cultivated fields and crop rotation would be useful in minimizing thrips populations in an onion field.

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