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Effects of age and height of onion (*Allium cepa* L.) plants on infestation thrips, *Thrips tabaci* Linderman ((Thysanoptera: Thripidae) in Sokoto, Nigeria

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Three sets of onion *(Allium cepa* L.) crops transplanted at 4 week intervals were exposed to thrips, *Thrips tabaci* Lindeman (Thysanoptera, Thripidae) infestation at different times from February to May in 2001 - 2002 and 2002 - 2003. Results indicated that at 4, 8 and 12 weeks after transplanting (WAT), the oldest (12 weeks) and tallest (60 cm) plants had the highest thrips population of 240 thrips/plant and rose to 416 thrips/plant one week later. In the second and third generations, the middle aged plants (second oldest) had the highest thrips population of 608 thrips/plant and this was significantly different ($P < 0.05$) from the oldest and youngest, even though in some cases they were the second tallest. This was maintained at 5, 9 and 13; 6, 10 and 14 and 7, 11 and 15 WAT (first generation only). Plants exposed to thrips in March consistently had the highest thrips population. It was also observed that 40% of onion leaves constitute inner leaves, 50% intermediate and 10 % outer leaves. The percentages of thrips in those regions were 64, 33 and 3%, respectively. Therefore, it was obvious that the oldest crop had the highest population of thrips early in the season and later in the season. The second oldest crops continued to support the highest number of thrips irrespective of the period of the year.

Key words: Plant-age, height, infestation, onion, *Thrips tabaci.*

INTRODUCTION

Onion (*Allium cepa* Linn.) is an important vegetable crop grown in the northern states of Nigeria mostly by peasant farmers. The bulb onion is normally harvested at the start of the dormant period (Brice et al., 1997), but in the tropics it is mainly grown as an annual and the bulb is harvested as a vegetable crop. Onions are not highly nutritious but have health-giving properties partly associated with its high sulphur content (Straub and Emmett, 1992). Onion thrips, *Thrips tabac*i is a key insect pest in most onion production regions of the world. Thrips populations increase rapidly under hot, arid conditions and can lead to economic crop loss. The early bulb enlargement stage of onion growth is the most sensitive to thrips feeding (Alson and Drost, 2008).

Soni and Ellis (1990) reported that the production of onions and allied crops is threatened by a wide range of pests and between 10 and 25% of the world's production is lost as a result of pest attack each year. Kranz et al. (1977) stated that several thrips are important pests in tropical regions, one of the main ones being *Thrips tabaci* Lindeman on onion and cotton. Onion thrips (*T. tabaci* Lind) is a polyphagous insect, which has spread to all continents and is recognized as an economically harmful pest of cultivated plants (Liu and Sparks, 2003). Penzes et al. (1996) claim that *T. tabaci* causes the most damage to the leaves from the second to the fifth exterior leaf of the head.

Schmutterer et al. (1969) described onion thrips as a polyphagous pest attacking a great number of wild plants and crops like radish, pigeon pea, pumpkin, tomato, onion and cabbage. They reported that adults and nymphs of *T. tabaci* feed mainly near the base of the inner and intermediate leaves of onion bulbs; feeding on the outer leaves is slight. The feeding results in sunken silvery patches on which the excrement of the pests can be observed as dark and shiny droplets (Schmutterer et al.,

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1969). Young onion plants are more susceptible (Lewis, 1973) and may be killed by heavy thrips attack (Lewis, 1973; Schmutterer et al., 1969), whereas in older plants the yield and crop value is greatly reduced (Schmutterer et al., 1969). Trdan et al. (2005) reported that thrips damage on cabbage head was found as deep as the fifteenth leaf. However, the economically significant damage occurs between the third and sixth exterior leaf of the head.

Alson and Drost (2008) observed that thrips prefer to feed on the newly emerged leaves in the center of onion necks; the majority of thrips will be at the base of the youngest leaves in the lower center of the neck. Raheja (1973) observed that damage by thrips in early stages of crop growth would seem to be more important and is likely to result in substantial reduction in yield and this is certainly true in the dry season when most of the commercial onion crop is grown in northern Nigeria. Anon (2000) reported that thrips are the main pest issue in onion growing. They added that they feed by sucking on plant sap, thereby reducing crop yield significantly when infestation is during mid season and bulb formation has begun, and sometimes lead to complete crop failure. This study was designed to assess the effects of age and height of onion plants on infestation of onion crop.

MATERIALS AND METHODS

Field experiments were conducted at the Teaching and Research Farm of Usmanu Danfodio University, Sokoto at Kwalkwalawa (13°01' N and 05°15' E), during the dry seasons of 2001 - 2002 and 2002 - 2003. In each season, the experimental site was ploughed, harrowed and labeled to ensure easy flow of irrigation water into the basins. Seedlings of onion variety, Ex-Gidan Kwano were raised at the nursery for eight weeks before transplanting. The transplanting were done at monthly intervals, from 11th December, 2001 to 2nd April, 2002 in 2001 - 2002 season and from 12th November, 2002, to 4th March, 2003 in the 2002 - 2003 season. Poultry manure at the rate of 10 t/ha was applied along with 90 kg of Nitrogen, at second (N.P.K.) and six weeks (Urea), after transplanting which is the recommended rate. Weeds were controlled when necessary. The transplanting were spaced 30 cm between and 15 cm within rows, in plots whose sizes were 2.5 x1.5 m accommodating five rows of 17plants/row.

Experiment one: Effect of age (height) of onion plants on thrips in the field

The treatments consisted of five transplanting in the two years at monthly intervals. The crops from the five transplanting were in the field at different times and of different ages. The five transplanting numbered 1, 2, 3, 4 and 5 were grouped into first, second and third generations that is, 1, 2 and 3 as first generation; 2, 3 and 4 as second generation and 3, 4 and 5 as third generation. These were also referred to as oldest (12, 13, and 14), second oldest (8, 9 and 10) and youngest crops (4, 5 and 6) weeks after transplanting. An age between crops in a generation is either 4 or 8 weeks. This ensured that three sets of onion crops existed in the field at anytime sampling was done. The treatments were laid out in a randomized complete block design replicated three times.

Experiment two: Effects of height of potted onion plants on the number of thrips landing in the field

In this experiment, onions were seeded in plastic pots, 10.3 cm upper diameter and 8.5 cm lower diameter. The volume of the container was 524.67 cm^3 or 0.524 l. Plants were thinned to the required densities of five onion plants per pot during the second week after germination. The plants were kept in a two-layer screen house, the inner layer made up of mosquito net (1.8 x 2.5 x 1.7 m) impenetrable to thrips because of their tiny nature. The plants were sown at different times at fortnightly intervals and they were allowed to attain different ages of 7, 9, 11 and 13 weeks after sowing until no further increase in height was recorded at 11 WAS, due to the inability of the plant roots to penetrate the pots.

Experiment three: Effects of size (height) of 'artificial' plants and onion plants on the number of thrips landing in the field

Onion and 'artificial' plants (plywood painted green to simulate onion plant) were cut to different heights of 5, 10 and 20 cm, corresponding approximately to the heights of onion plants between 1 and 2 true leaf stages (5 and 10 cm) and 2 - 3 true leaf stages (20 cm). Artificial plants were prepared by cutting plywood into 5, 10 and 20 cm and these were painted green to simulate green onion plant. Vaseline® was generously applied to the surfaces of the 'artificial' plants. Part of the onion plants in experiment two was used in this experiment. Onion plants at 13 weeks after sowing (WAS) were trimmed to give the above height. There were 5 onion plants in each pot. The leaves were cut about 16 h before their exposure to thrips in the field so that exudates from the wounded tissues did not interfere with the experiment. The procedure was used on oats by Adesiyun (1977). There were 3 artificial plants in each pot.

Sampling and exposure to thrips in the field

Both onion and 'artificial' plants in the experiments 2 - 3 above were taken to the onion field and arranged in a randomized complete block design in between plots. They were allowed to stay on the field for 48 h, during which thrips might have landed on them before putting them in the appropriate labeled polythene bag for examination under a binocular microscope in the laboratory and a count was made of thrips found on either onion or artificial plants.

Parameters taken in the experiments with onion plants included plant height, number of leaves and thrips number beginning from four weeks after transplanting in experiment one. Also thrips population per onion leaf was counted starting from the oldest to the newest leaf. Data in experiment 1 were generated by sampling two onion plants from each plot and these were subjected to statistical analysis of variance. Results from experiments 4 and 5 were not significant and therefore not presented.

Laboratory experiments

Laboratory experiments were conducted to further evaluate the effects of size of substrate on the response of onion thrips when landing. Here 'artificial' plants were prepared as in experiment three above. The 'artificial' plants thus prepared were placed in pots at 3/plot. Pots containing 'artificial' plants of different heights were then placed in a cage (50 cm^3) and the adult thrips introduced into the cage. Thrips were allowed to land on the sticky 'artificial' plants for 48 h after which they were counted.

Experiment four: Effects of 'artificial' plants of the same width but different heights (different area) on landing of onion thrips

In this experiment the 'artificial' plants were of the same width (1 cm) but different heights (5, 10 and 20 cm). Three pots each containing 'artificial' plants of heights 5, 10 and 20cm making a total of 9 pots were placed in a cage into which adult thrips were introduced and allowed to land for 48 h.

Experiment five: Effects of 'artificial' plants of different widths and heights, but same area on landing of onion thrips

In this experiment 'artificial' plants were cut to different widths and heights to have the same area. The three sizes 5 × 1 cm wide, 10 × 0.5 cm wide and 20 × 0.25 cm wide each with an area of 5 cm^2.

RESULTS

The effect of age of onion plants on thrips infestation is presented in Table 1. This showed that crops present in the field in February (2002 - 2003) and March (2001 - 2002) had different population of thrips. It revealed that the oldest crop, 12 weeks after transplanting had the highest population of thrips (240.7 and 32.2) irrespective of the period of the year, but the February crop in 2002 - 2003 had about eight times the number of thrips found on the middle aged crop. The middle aged and youngest crop (8 and 4 WAT) did not differ significantly in thrips population in the 2001 - 2002 season. No data were taken on plant height and number of leaves in the first year, but in the second year, the oldest crop was the tallest (60.2 cm) and had the highest number of leaves (17.3), which differed significantly from the middle-aged in number of leaves. At 5, 9 and 13 WAT, a similar trend was maintained; the only difference was that the oldest crop now became second tallest. Also at 6, 10 and 14 WAT the insects concentrated on the middle-aged crop. When the crops were 7, 11 and 15 WAT (only in the first generation) the trend showed that the thrips population increased in nearly all crops, with the middle-aged supporting the highest number of thrips (265.5) though not significantly different from the others.

Table 2 shows treatment means of thrips, plant height and number of leaves at 4, 8 and 12 WAT in the second generation in March (2002 - 2003) and April (2001 - 2002). Unlike in February and March crops (Table 1), the highest number of thrips was on the middle-aged 8 WAT in the two years, even though this did not differ statistically from the oldest crop. In contrast to the first generation of crops, there was significant difference between 4 and 8 WAT in thrips population, plant height and number of leaves. It was observed that while the number of thrips was decreasing on the oldest crop (13 WAT) in the two years, it was increasing on the middle-aged, reaching the highest population in the 2002 - 2003 season and on the youngest crop in both years. In the same Table, it was evident that thrips population had reduced on the oldest and middle-aged crops in both years and slightly increased in the youngest crop in the 2002 - 2003 season. Thrips population were generally higher in the oldest crops in first generation in 2001 - 2002 and higher in 2002 - 2003 in the second generation crops, because thrips populations are higher in March than in April, probably due to fairly high temperature and older crops are senescing.

The third generation's crops are presented in Table 3 where the crops were present in late March (2002 - 2003) and late April (2001 - 2002). The Table showed that at 4, 8 and 12 WAT there were no significant differences among treatments in the number of thrips per plant in the two years. The middle-aged (8 WAT) had the highest population of thrips in the 2002 - 2003 season and the March crop had a higher population than the April crop, similar to what was observed in the second generation. At 5, 9 and 13 WAT, there were highly significant differences among treatment means in the number of thrips in the 2001 - 2002 season and in the number of leaves in 2001 - 2002 and 2002 - 2003 seasons. As in previous ages, the middle-aged had the highest population and was significantly different from the oldest (Tables 1and 2).

The treatments were found to be significantly different according to age, indicating that an interval of two weeks made a significant difference ($P < 0.05$) (Table 4). However, with respect to plant height and number of leaves, plants at 11 and 13 WAS were not significantly different from each other, but were significantly different from either 7 or 9 WAS. With respect to thrips population, it was also found that plants at 13 WAS were not significantly different from 7 WAS, but after transformation they were found to differ statistically. This is in spite of the fairly higher number of leaves and marginal difference in height between 7 and 13 WAS crops.

Figure 1 shows the distribution of thrips on onion leaves. It showed that the number of thrips on the first leaf of the 11 and 14-leaf stages was 0%, while it was up to 3% each on the 10 and 12-leaf stages. The number remained 0% on the second leaf of 11 and 14-leaf stages and 2% each on the 10 and 12-leaf stages. This implies that the more leaves on an onion plant, the fewer thrips on the outer leaves. The results also indicated that the number of thrips on one side (leaves 1, 3, 5 and 7) was higher than on the alternate side (leaves 2, 4 and 6). The 8-leaf was found to have the highest population of thrips in the 10-leaf stage (23%) or second highest in the 11-leaf stage (20%), 14 % in the 12- leaf stage and 17% in the 14-leaf stage (a factor of 3). The ninth leaf supported the highest population of thrips in the 11-leaf stage (23%). The number of thrips in the 10-leaf stage was lower than in the 9-leaf stage in all onion plants, though in the 12-leaf plant the difference was marginal (1%).

One may therefore conclude that the peak population of thrips occurred in the eight and ninth leaves (23%) of 10 and 11-leaf plants, or the third youngest leaf. The 12 and 14-leaf stages had the highest population in the eleventh

Table 1. Effect of plant height and number of leaves of onion plants on thrips population in first generation (1, 2 and 3)

			2002/2003		2001/ 2002	2002/ 2003	2002/ 2003		2002/2003		
Transplanting date		**WAT**	**Mean Pt. Ht**	**Mean No.Lvs/pt**	**Mean No. thrips/plant**		**DOT**	**WAT**	**Mean Pt.Ht.**	**Mean No.Lvs/pl.**	**Mean No. thrips/plant**
11/12/01	12/11/02	12	60.2	17.3	240.7	32.2	12/11/02	15	53.5	17.7	176.0
8/1/02	10/12/02	8	55.5	10.7	64.3	3.7	10/12/02	11	59.4	13.2	265.5
5/2/02	7/1/03	4	18.1	4.7	16.0	0.00	7/1/03	7	46.7	9.3	87.8
		P	0.006	0.002	0.03	ns		P	ns	0.05	Ns
		LSD	21.90	4.86	168.47	-		LSD	-	6.65	-
		SE	6.33	1.41	48.72	8.75		SE	4.07	1.92	59.0
		CV%	24.58	22.3.8	78.8	127.0		CV	13.3	24.9	58.0
11/12/01	12/11/02	13	57.9	13.3	416.2	73.3					
8/1/02	10/12/02	9	62.8	12.3	209.8	32.5					
5/2/02	7/1/03	5	23.3	6.3	99.2	0.3					
		P	0.0001	0.01	0.01	ns					
		LSD	9.20	4.04	168.44	-					
		SE	2.66	1.16	48.7	16.96					
		CV%	9.6	18.9	34.9	83.0					
11/12/01	12/11/02	14	63.3	14.33	222.6	71.8					
8/1/02	10/12/02	10	66.6	12.83	283.0	92.7					
5/2/02	7/1/03	6	37.4	7.33	148.17	1.3					
		P	0.004	0.0006	ns	0.04					
		LSD	14.07	2.23		71.64					
		SE	4.06	0.646	67.66	20.71					
		CV%	12.6	9.72	53.77	64.9					

WAT= weeks after transplanting, Pt. Ht=plant height (cm), No.Lvs= number of leaves, SE= standard error.

leaf (20 and 21 %). In other words the highest concentration of onion thrips on onion plant was either on the third youngest (10 and 11-leaf stages); second youngest (12-leaf stage) or fourth youngest (14-leaf stage).

Table 5 indicates that no thrips were observed on the artificial plants of 5 cm. However, one thrips/pot was recorded on the corresponding height on the onion plant. At 10 cm height, more thrips had landed on the artificial plant than on the onion plant; possibly because they were stuck on the plant. At the height of 20 cm, more thrips were found on the onion plants (3.0) than on the artificial plants (1.3). Generally, it was observed that there was no difference in the number of thrips between 10 and 20 cm on the artificial plants, but the 20 cm onion plant attracted more thrips, although the difference was not significant.

In the laboratory experiments where only 'artificial' plants were offered to adult thrips in cages, no single thrips landed on any of the 'artificial' plants. This seems to suggest that onion thrips will only land in response to stimuli from the host plants.

DISCUSSION AND CONCLUSION

The effect of age on thrips, plant height and number of leaves showed that in the first two weeks of February and March when sampling of thrips started, the oldest crop (12 WAT) had the highest population of thrips because the population was already high when the later crops were introduced (Table 1). The population of thrips on the oldest (12 WAT) plant was 15 times more than on the youngest plant (4 WAT) in 2001-2002 season. It is therefore expected that the first crop would have a higher number of thrips as it was approaching maturity. The ratio of thrips between the oldest and middle-aged crops was about 4:1 in the same year. The oldest crop was the tallest, and having the highest number of leaves, similar to the findings of Adesiyun (1977) that more frit flies (*Oscinella frit* L.) (Diptera, Chloropidae) landed on taller plants than on the shorter ones. Adedokun and Adesiyun (1992) found significant differences in the number of insects collected on sunflower, where the early-planted crops gave the highest number of insect population as well as excellent yield, while the last date gave the least number of insects. Later in the season, it was observed that the middle -aged, that is depending on the ages of crops, were sheltering the highest thrips population. The possible reason might be that the oldest crop had many feeding sites and approaching maturity, thereby losing water and making it unattractive to sap feeders. The other possible reason was that 13 leaves were adequate enough

Table 2. Effect of plant height and number of leaves of onion plants on thrips population in second generation (2, 3 and 4).

DOT		WAT	Mean Pt. Ht (cm)		Mean No. lvs./plant		Mean No. thrips/plant	
2001/ 2002	2002/ 2003		2001/ 2002	2002/ 2003	2001/ 2002	2002/ 2003	2001/ 2002	2002/ 2003
8/1/02	10/12/02	12	39.0	58.2	13.3	10.5	198.0	239.3
5/2/02	7/1/03	8	31.3	50.32	10.0	10.5	224.7	352.8
5/3/02	4/2/03	4	23.0	23.0	6.3	5.7	54.0	32.7
		P	0.008	<0.0001	0.002	0.007	0.05	0.01
		LSD	8.18	7.16	2.75	1.76	141.69	179.29
		SE	2.36	2.07	0.79	0.50	40.97	51.84
		CV%	13.2	8.2	13.9	9.9	44.6	43.1
8/1/02	10/12/02	13	35.0	62.2	15.0a	13.2	125.0	208.3
5/2/02	7/1/03	9	32.3	46.1	9.7b	10.3	78.0	608.3
5/3/02	4/2/03	5	26.0	25.3	8.7b	6.3	86.3	97.3
		P	ns	0.0007	0.02	ns	ns	0.003
		LSD	-	11.43	4.26	-	-	224.95
		SE	4.05	3.30	1.23	1.16	45.33	65.05
		CV%	22.6	12.9	19.2	36.0	81.41	37.0
8/1/02	10/12/02	14	34.3	39.3	14.3	11.7	10.3	48.3
5/2/02	7/1/03	10	36.3	46.4	10.0	12.3	12.7	338.3
5/3/02	4/2/03	6	31.7	28.3	8.3	9.0	9.0	170.0
		P	ns	0.01	0.001	ns	ns	0.0001
		LSD	-	9.64	2.21	-	-	63.22
		SE	4.33	2.78	0.63	0.98	3.83	18.28
		CV%	22.0	12.7	10.2	62.3	62.3	17.1

WAT= weeks after transplanting, Pt. Ht.=plant height (cm), No. Lvs= number of leaves, pl.=plant, SE= standard error.

to provide shelter against natural enemies, when compared with 7 leaves. At maturity, even though the number of thrips on the middle-aged was three times the youngest and 1.5 times the oldest, there was no significant difference in the number of thrips, plant height and number of leaves.

The height of onion plants is important in influencing the number of thrips that land and rest on the plants up to a critical height, which probably lies between 22 and 26 cm and this depends on the number of leaves, with only 1 thrips/pot in the 3-leaf stage. This is because young plants do not provide enough shelter for the thrips and protection from natural enemies. This confirmed earlier results where the middle-aged (second oldest) had more thrips than the oldest or the youngest (Table 3). By considering ages 9, 11 and 13 WAS, even though they were significantly different in age, middle-aged 11 WAS had the highest thrips population and this was significantly different from those at 13 WAS.

In the second generation, the middle-aged crop had the highest population of thrips, higher than the oldest, even though they did not differ significantly in the first week. This indicated that although the oldest crop was the tallest, it had a lower number of thrips when compared with the middle-aged, implying that the oldest crop supported the greatest number only for the first two weeks, after which the middle-aged overtook. This agreed with Lowry et al. 1992; Lewis, 1997 and Kirk, 1997 that with increasing temperature there is increased thrips activity, development and population growth up to the point when hosts begin to senesce and thrips flight decline. Variation in the population of insects in crops may be due to differences in the initial numbers of arrivals (Southwood and Way, 1970), or to differences of multiplication in the crop (Way and Heathcote, 1966) or different mortality rates (Smith, 1976). Adesiyun (1978) stated that insects often succeed in attacking crops because of synchronization between their arrival in the crop and the susceptible stage of the plant. Also in Table 3, the oldest crop was two weeks to harvest and had started drying and was therefore less attractive to thrips. Kranz et al. (1977) observed that large numbers of thrips attacking onion crop at the seedling stage could cause severe damage or even total loss. However, once established and growing vigorously, most plants could tolerate feeding damage. Also the population on the oldest and middle-aged crops was declining and rising on the youngest crop, possibly because the height was increasing. The maximum height seems to be between 9 and 10 WAT. Edelson et al. (1989) observed that onion bulbs are matured at 12 - 16 WAT. Umar et al. (2000) reported maximum height of onion to be at between 7 and 9 WAT, while Babatola and

Table 3. Effect of plant height and number of leaves of onion plants on thrips population in third generation (3, 4 and 5)

DOT	WAT	Mean plant height (cm)	Mean No. leaves/plant	Mean No. Thrips /plant	DOT	WAT	Mean plant height (cm)	Mean No. leaves/plant
2001/2002	2002/2003		2001/2002	2002/2003	2001/2002	2002/2003	2001/2002	2002/2003
5/2/02	7/1/03	12	30.0	44.2	12.0	9.3	24.8	44.0
5/3/02	4/2/03	8	33.7	34.7	8.0	12.0	24.7	144.3
2/4/02	4/3/03	4	22.7	18.1	5.0	6.7	11.3	24.7
		P	0.03	0.003	0.04	0.005	ns	ns
		LSD	7.78	10.82	5.29	2.49	-	-
		SE	2.24	3.12	1.52	0.72	13.28	37.77
		CV%	13.6	16.7	31.7	13.5	113.5	92.1
5/2/02	7/1/03	13	34.5	37.2	12.0	13.3	2.8	41.3
5/2/02	7/1/03	13	34.5	37.2	12.0	13.3	2.8	41.3
5/3/02	4/2/03	9	23.3	38.2	8.0	14.3	22.2	92.0
2/4/02	4/3/03	5	19.0	25.6	6.7	7.3	16.3	24.0
		P	ns	0.002	0.003	0.04	0.003	ns
		LSD	-	5.45	2.41	5.77	5.77	-
		SE	4.67	1.57	0.69	1.66	1.66	22.27
		CV%	31.6	8.1	13.5	24.7	30.8	73.6
5/2/02	7/1/03	14		32.7		12.7		20.7
5/3/02	4/2/03	10		46.8		12.3		88.0
2/4/02	4/3/03	6		27.8		7.3		47.7
		P		0.02		ns		ns
		LSD		13.08		5.02		-
5/2/02	7/1/03	13	34.5	37.2	12.0	13.3	2.8	41.3

Lawal (2000) obtained their maximum height at 12 WAT. Rey et al. (1974)indicated that the maximum height was when the bulb began to form and leaves 8 - 13 appeared and the time when the 2nd and 3rd leaves desiccated. In Table 2, the middle-aged plant continued to maintain the highest population of thrips even though it was not the tallest. In March and April there was a reduction in the population of thrips in virtually all ages irrespective of plant height; the only exception was in the youngest crop, which either remained constant or slightly increased, probably because of high temperature and younger plants had already suffered attacks in the early part of their growing season. This was in accordance with Morsello et al. who observed that the varying number of thrips captured on yellow sticky traps throughout the spring season, is no doubt influenced by many factors beyond weather, plant composition, thrips population size and proportion of the population that is dispersing, behaviour and agricultural practices. They added that regression analysis determined that temperature (measured as degree-days) accumulation from 1 January, was the single most influential factor positively affecting *F. fusca* and *T. tabaci.* Kisha (1977) reported that independent of transplanting date, thrips breed only between February and April and that high temperature from April onwards were responsible for a sudden population decline. It clearly showed that the oldest crop had the highest population of thrips only in the first two weeks, where also it was the tallest, probably due to good environmental conditions. The possible reason why the middle-aged plants had the highest population in all situations except in the first two weeks was that the oldest plants were approaching maturity and therefore drying and possibly topping, while the number of thrips was still rising on the youngest plants having more leaves, and possibly having few or none feeding sites. The oldest had the highest population in the first two weeks probably because it was four weeks older in the field before subsequent crops were introduced. In other words it served as a trap crop. and low humidity It was apparent that the onion plant was at its maximum height between 9 and 10 weeks after transplanting, three weeks after the commencement of bulbing and four weeks to maturity, at the time when no production of new leaves was observed. This indicated that the most critical stages in the life of an onion is the period before bulbing when it would need to attain maximum height (1 - 5 WAT) and period of bulbing (6 - 11 WAT) when the production of new leaves ceased. Therefore thrips coming after the period 12 - 15 WAT may not pose any serious threat or cause any significant damage because leaves were not fresh enough to attract many insects and those already present may not affect the photosynthetic ability as the bulb formation was already at an advanced stage. Figure 1 revealed how onion thrips

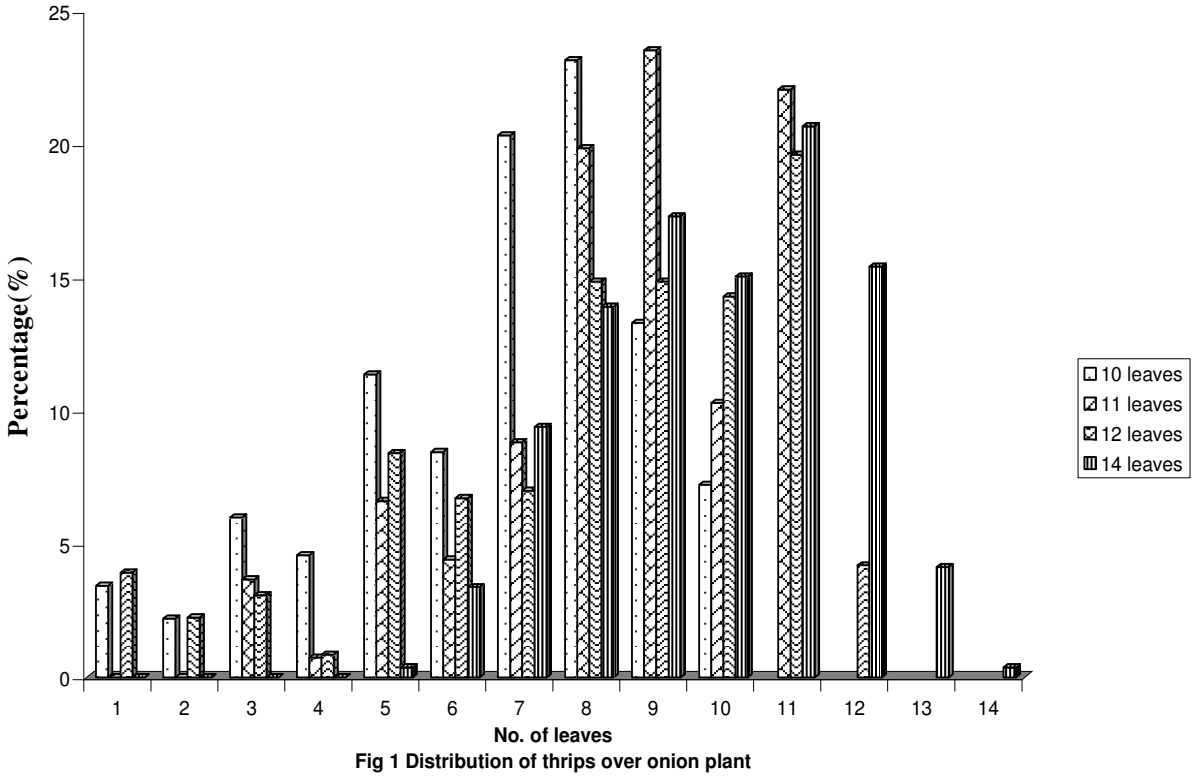

Figure 1. Distribution of thrips over onion plant

Table 4. Effect of age, plant height and number of leaves on thrips population

Treatment	Age in weeks	Plant ht. (cm)	Number of. leaves/plant	Mean no. of thrips/pot	
				Actual	Transformed*
OP1	13.0	26.0	5.0	7.0	2.7
OP2	11.0	26.2	4.5	17.0	3.8
OP3	9.0	21.5	3.5	9.25	3.4
OP4	7.0	19.9	3.3	1.0	1.2
P	0.0001	0.004	0.005	0.008	0.0004
LSD	1.0	3.52	0.969	9.58	1.41
SE	0.32	1.15	0.31	3.13	0.46
CV (%)	0.0	9.79	15.48	119.2	44.82

OP =Onion plant , SE= standard error,

Table 5. Mean number of thrips per onion and artificial plants

Treatment	Mean number of thrips/pot
APH, 5 cm	0.0
OPH, 5 cm	1.3
APH, 10 cm	1.3
OPH, 10 cm	1.0
APH, 20 cm	1.3
OPH, 20 cm	3.0
P (0.05%)	
CV (%)	
SE	0.86

APH=Artificial plant height, OPH= onion plant height, ns = not significant
SE= standard error

are distributed over an onion plant starting from the oldest to the newest leaf. The three thrips each per leaf on the 10 and 12-leaf stage onion plant recorded was high enough to require insecticide spray as stated by Reuda and Shelton (2000) that the economic threshold should be validated for each geographical region given the thrips incidence, the cultivar used, environmental conditions and the price of the control measures and onion in the market. They gave the threshold in New York (U.S.A.) to be 3-thrips/green leaf. However, in Honduras, they recommended an economic threshold of 20% of the plants infested. The number of thrips in the second leaf of the 10 and 12-leaf stages was lower, probably indicating that they are older than the first leaf. From this figure, one may observe that leaves 1, 3, 5 and 7 had higher number of thrips than those in the alternate (180°) position (leaves 2, 4 and 6). This may be because they are softer and more attractive and therefore succulent to the rasping- sucking insects.

What was apparent was that the highest population was within a narrow range of 20 - 23% in all the plants examined, occurring in the second youngest (12-leaf stage), third youngest (10 and 11-leaf stage) or fourth youngest (14-leaf stage). This agreed with Reuda and Shelton (2000) that thrips prefer to feed on young plant tissue in the newest emerged leaves and Soni and Ellis (1990) stated that the area between the newest leaves concealed majority of juvenile and adult thrips. Also this agreed with Alson and Drost (2008) that thrips prefer to feed on the newly emerged leaves in the center of the onion necks, the majority of thrips will be at the base of the youngest leaves in the lower center of the neck. Similarly Theunissen and Legutowska (1991) reported that *T.tabaci* were distributed normally along a leaf sequence in the horizontal plane, with intermediate leaves having most adults and larvae. Also Jianhua et al. (2008) found that leaves of intermediate ages carried a greater proportion of eggs than the outermost or inner-most leaves

Raheja (1973) also noted that build up after insecticide spray was attributed to the new leaf growth and Hale and Shorey (1965) noted that thrips have a tendency to collect where there is young growth. The insects may be in their greatest numbers between the leaf sheath and the stem (Metcalf *et al*., 1967). In March in the unsprayed plot, up to 140 thrips/leaf were found, while in the insecticide sprayed plot, the number was up to 100 thrips/plant (29% control). In April when the thrips population was declining, the population was 70 thrips/plant in the unsprayed plot and three in the sprayed plot. Pollard (1955) asserted that damage is greatest at the base of central leaf and intermediate leaves, the number of thrips occurring in these regions being 60 and 37% respectively, the remaining 3% occurring on the outer leaves. From the above, depending on the number of leaves in a particular plant, the number of leaves constituting the above varied.

In this study the results agree with Pollard (1955) when considering the 10-leaf plant where the first leaf supported 3%, leaves 2, 3, 4, 5 and 6 (33%) and leaves 7, 8, 9 and 10 (64%). In other words, inner leaves constitute 40%, intermediate 50% and outer leaves 10%. Similarly at the 12-leaf stage leaves 8, 9, 10, 11 and 12, which constituted 41.6%, had 68% thrips population.

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