International Journal of AgriScience Vol. 2(5): 393-402, May 2012 www.inacj.com
ISSN: 2228-6322© International Academic Journals

Management of thrips (*Thrips tabaci*) in bulb onion by use of vegetable intercrops

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Received February 2012; accepted in revised form April 2012

ABSTRACT
Field experiments were conducted between July 2008 and May 2009 to evaluate the effectiveness of intercropping carrot (*Daucus carota*), spider plant (*Cleome gynandra*) and French bean (*Phaseolus vulgaris*) with onion in the management of thrips *(Thrips tabaci)* in onion. Each of the three onion varieties, Bombay Red, Red Creole and Orient F1 were intercropped with each of the vegetables and insecticide imidacloprid was used as a standard check. Thrips damage incidence and severity were determined every 7 days with damage severity being estimated on a scale of 1-5. Total and marketable bulb yield were determined at physiological maturity. Intercropping onion with spider plant and carrot significantly ($p \leq 0.05$) reduced thrips population by up to 45.2% and 21.6%, respectively but French bean had no significant effect. The three vegetable intercrops significantly ($p \leq 0.05$) reduced thrips damage severity, with spider plant having the greatest reduction of up to 15.7%. Intercropping onion with carrot and spider plant significantly ($p \leq 0.05$) reduced onion bulb yield while the effect of French bean and imidacloprid on yield was not significant ($p \leq 0.05$). This study showed that spider plant and carrot can be utilized in the management of onion thrips. However, further investigations should be undertaken on their optimal spatial arrangement in an intercropping system to avoid reduction in bulb yield and, therefore, achieve optimum onion productivity.

Keywords: *Allium cepa, Daucus carota, Cleome gynandra*, intercropping, *Phaseolus vulgaris, Thrips tabaci*

INTRODUCTION
Onion (*Allium cepa* L.) is an important vegetable (Brewster 1994) produced across a wide range of latitudes in Africa, Asia, Europe and North America (Rabinowitch and Currah 2002). In Kenya, onions are grown in all provinces by both large- and small-scale farmers, where they have a ready domestic market (HCDA 2008, MOA 2006). Consumption of onions has been increasing significantly in the world partly because of the health benefits they possess (Havey et al. 2004, Wang et al. 2006). Onions are also rich in flavonoids and alkenyl cysteine sulphoxides which play a part in preventing heart disease and other ailments in humans (Gareth et al. 2002, Havey et al. 2004, Javadzedah et al. 2009).
Major factors limiting onion production are diseases such as downy mildew (*Peronospora destructor*), purple blotch (*Alternaria porri*), leaf spots and onion smudge (*Colletotrichum circinans*) and pests such as thrips (*Thrips tabaci*) and cut worms (*Agrotis* sp.) (Rabinowitch and Currah 2002, Muendo and Tschirley 2004).

Onion thrips (*Thrips tabaci*) which is considered to be the most economically important pest of onion worldwide (Trdan et al. 2005) is responsible for causing considerable reduction in yield (Brewster 1994, Nawrocka 2003, Trdan et al. 2005). In Kenya, thrips are present in all onion growing areas and can cause up to 59% loss in yield (Waiganjo et al. 2008).

Currently, growers manage thrips by applying insecticides several times in a growing season. However, most insecticides are ineffective because a large number of thrips are always protected between the inner leaves of the onion plant and the pupal stage is spent in the soil. In addition, *Thrips tabaci* is a very prolific species with many overlapping generations (Nault and Shelton 2010, Alimousavi et al. 2007, Shelton et al. 2006). Managing thrips is further complicated by lack of natural parasites and the presence of numerous other host plants on which the pest thrives (Brewster 1994). Development of resistance by onion thrips to most commonly used insecticides has been reported (Martin et al. 2003). Besides increasing the cost of production, the use of pesticides has negative effects on the environment and human health which is attributed to high chemical residues (Burkett-Cadena et al. 2008). Therefore, there is need to integrate the use of chemicals with other methods of control such as cultural practices and use of resistant varieties in the management of thrips and other pests of onion. One sustainable method of managing pests is intercropping (Trdan et al. 2006, Finckh and Karpenstein-Machan 2002), a system in which a plant species (the intercrop) is grown specifically to reduce pest damage on a main crop.

Intercropping is an important cultural practice that has been utilized in the management of weeds, insect pests and diseases in many crops worldwide (Trdan et al. 2006, Finckh and Karpenstein-Machan 2002). It is traditionally practiced by subsistence farmers in developing countries as a crop production system (Sodiya et al. 2010). The system is characterized by minimal use of pesticides and increased land productivity (Ullah et al. 2007). However, there are no reports of studies done in Kenya on management of thrips in bulb onions using intercrops. This study was therefore undertaken to evaluate effectiveness of vegetable intercrops in the management of thrips in bulb onions.

MATERIAL AND METHODS

Experimental design and layout

Field experiments were carried out at the Faculty of Agriculture Kabete field station, University of Nairobi for two growing seasons between July 2008 and May 2009. Weather data for Kabete field station during the experimental period is shown in Table 1. Treatments consisted of three onion varieties - Bombay Red, Red Creole and Orient F1 - and three vegetable intercrops - carrot *(Daucus carota*), French beans *(Phaseolus vulgaris*) and spider plant (*Cleome gynandra*). Controls consisted of pure stands of each onion variety. Thrips in positive control plots were controlled using the insecticide imidacloprid applied at the rate of 0.3 mL/m^2 at 7 days interval. Negative controls were not sprayed with any insecticides.

The experiment was laid out in a randomized complete block design with split plot arrangement and replicated four times. The main plots were 4.5 x 6m while the subplots measured 4.5 x 2m, with 1 m and 1.5m paths separating the blocks and plots, respectively. The vegetable intercrops were assigned to main plots while onion varieties were assigned to subplots. On each plot where intercropping was done, one row of intercrop was alternated with four rows of onion. A spacing of 30 x 10cm for onion, 45 x 10cm for carrot, 45 x 20cm for French bean and 45 x 15cm for spider plant was maintained in both seasons. Two guard rows of onion were planted around the experimental area two weeks before transplanting onion seedlings in the plots.

Assessment of thrips population and damage

Assessment of thrips population entailed random destructive sampling of 5 plants per plot from the inner rows of each plot. This involved cutting the stem at the crown and putting the whole shoot in 70% ethanol. Coarse vegetation was separated by sieving and the suspension allowed to settle. The suspension was put in a Petri dish and the number of thrips counted under a dissecting microscope at x12 magnification. Sampling was done at two weeks interval from the fourth week after transplanting until physiological maturity.

Silvery patches characteristically caused by thrips on onion leaves were used to assess thrips damage on a weekly basis from the fourth week after transplanting to physiological maturity of the crop. Incidence of thrips damage was determined by counting the number of damaged plants over the total number of plants per plot. Thrips damage severity was determined by randomly sampling ten plants from the inner rows of each plot. The percentage of leaf surface showing thrips damage was assessed based on a scale of 1 - 5 (Smith et al. 1994) where 1 = no damage, 2 = up to 25%, 3 = 26-50%, 4 = 51-75% and 5 = >75% damage.

Assessment of bulb yield

Harvesting was done by hand at physiological when 50-80% of the foliage had fallen over and the tops and roots were cut off. The bulbs from each plot were weighed and the marketable bulbs that were greater than 3 cm diameter separated and graded into non-split or non-double bulbs according to HCDA (1991). The bulb yield for each onion-vegetable intercrop treatment was extrapolated into kilograms per hectare.

Data analysis

All data were subjected to analysis of variance (ANOVA) using the PROC ANOVA procedure of Genstat (Lawes Agricultural Trust Rothamsted Experimental Station 2006, version 9). Differences among treatment means were separated using the Fisher's protected LSD test at 5% probability level.

RESULTS AND DISCUSSION

Effect of vegetable intercrops on thrips population

The mean number of thrips per plant was low during the initial weeks of sampling but the population progressively increased towards physiological maturity (Table 2). Spider plant, carrot and the insecticide Imidacloprid significantly ($p \leq 0.05$) reduced thrips population on the three onion varieties with the spider plant resulting in the highest reduction of up to 45.2%. However, the effect of French bean on thrips population was not significant ($p \leq 0.05$) compared to non treated controls (Table 2). Overall, there were no significant ($P \leq 0.05$) differences in thrips population among the three onion varieties (Table 3).

The high thrips population in the three onion varieties could be attributed to high temperatures during the experimental period which may have increased the rate of multiplication (Waiganjo et al. 2008; Rhainds et al. 2007). *Thrips tabaci* is a very prolific species and can have overlapping generations under conducive environmental conditions especially at high temperatures (Alimousavi et al. 2007, Bergant et al. 2005). This study showed that intercropping onion with spider plant and carrot significantly decreased thrips population. This could have been due to visual and physical interference of thrips by the intercrops. Physical interference could entail attracting the thrips to the two intercrops instead of onions thereby resulting in reduction of their population on the latter (Alston and Drost 2008, Trdan et al. 2006). Thrips injury to intercrops is not as economically damaging as injury to onions (Alston and Drost 2008). The reduction could also be attributed to reduced food concentration in a mixed ecosystem with non-host plants thereby reducing the rate of multiplication of thrips. Rämert and Lennartson (2002) observed that insects are attracted to and concentrated on their food plant resources which are more apparent in a simple monoculture system. Lack of any significant effect on thrips population by French bean could be attributed to the crop also being a host to thrips, mainly *Frankliniella occidentalis* and *Megalurothrips sjostedti* (Nderitu et al. 2007).

The significant reduction of thrips population on onions in spider plant-onion intercrop in the current study concurs with previous findings by Waiganjo et al. (2007) and Fletcher (1999). Spider plant which had the greatest effect on thrips population has been reported to possess insecticidal, antifidant and repellent properties (Fletcher 1999). Waiganjo et al. (2007) observed that intercropping snap bean with spider plant significantly reduced the population of spider mites on the former. Besides the direct effect on thrips population associated with the spider plant, it was also observed to be a host for *Orius* spp. which is a natural enemy to thrips. These natural enemies could have played a role in reducing the thrips population (Silveira et al. 2004). Rämert and Lennartson (2002) observed that natural enemies are more effective and numerous in diverse cropping systems. Similar to the current study, reduction of pest population has also been reported in other intercropping systems. For example, Theunissen et al. (1995) observed a significant reduction of various cabbage pests including moths, aphids, and root fly in a cabbage-white clover intercropping system. This was attributed to suppression of oviposition and larval populations of these pests. Other intercropping systems which have significantly reduced thrips population and plant infestation include leek with clover (Belder et al. 2000); leek with carrot, and clover with French bean (Kucharczyk and Legutowska 2002).

Table1. Weather data for the Faculty of Agriculture Kabete field station during the experimental period

Month/Year	Mean max. temp. (^oC)	Mean min. temp. (^oC)	Total rainfall (mm)	No. of Rainy days	Mean relative Humidity (%)
July, 2008	20.2	11.7	64.7	9	88.0
August	21.8	12.8	9.1	3	84.0
September	24.5	12.1	46.6	3	79.0
October	24.3	14.4	165.1	16	87.0
November	23.4	14.4	209.6	8	82.0
December	24.3	14.0	5.3	2	76.0
January, 2009	24.8	13.8	42.8	3	71.6
February	25.2	14.0	18.1	3	78.4
March	26.7	14.7	76.6	6	75.6
April	24.7	15.2	75.7	10	83.0
May	23.2	14.7	186.7	16	87.0

Table 2. Mean number of thrips per plant over time on three onion varieties under different treatments

Onion variety	Intercrop / Insecticide	Weeks after transplanting					
		4	6	8	10	12	14
Bombay Red	No spray	3.7	26.7	36.1	42.7	122.5	171.7
	Imidacloprid	2.3	21.5	24.3	36.1	114.1	119.4
	Carrot	4.8	23.6	30.0	42.9	109.2	105.6
	French bean	3.8	30.0	46.0	51.7	155.6	179.6
	Spider plant	2.0	20.1	26.4	25.9	50.1	96.7
Red Creole	No spray	2.3	21.4	17.1	37.7	118.4	157.8
	Imidacloprid	1.9	28.8	38.5	45.1	127.0	136.8
	Carrot	2.4	18.6	32.7	48.7	129.3	181.9
	French bean	2.7	21.6	24.3	37.5	145.4	137.4
	Spider plant	2.2	20.4	19.9	27.2	59.1	182.3
Orient F1	No spray	3.2	41.1	36.7	45.4	121.3	170.0
	Imidacloprid	3.8	24.7	30.6	41.6	108.7	149.8
	Carrot	3.0	22.4	41.9	50.6	93.8	121.7
	French bean	3.3	34.1	36.4	37.8	129.4	139.2
	Spider plant	3.5	18.2	38.5	37.0	61.4	135.8
	$LSD_{(P \leq 0.05)}$						
	Treatment	Ns	5.9	7.4	Ns	41.7	Ns
	$LSD_{(P \leq 0.05)}$ Variety	0.9	4.9	5.5	Ns	Ns	Ns

LSD: least significant difference; Ns: Not significantly different ($p \leq 0.05$).

Table 3. Mean number of thrips per plant on three onion varieties under different treatments

Intercrop / Insecticide[1]	Onion Variety[2]		
	Bombay Red	Red Creole	Orient F1
No spray	67.2 a-d	65.1 b-e	69.6 ab
Imidacloprid	53.0 e-g	57.1 c-g	59.7 b-g
Carrot	52.7 e-g	68.9 a-c	55.6 d-g
French bean	77.8 a	61.5 b-f	63.4 b-f
Spider plant	6.9 h	51.9 fg	49.1 gh

Values are mean number of thrips per plant during the sampling period.
[1] Means with same letter(s) are not significantly different (independent multivariate, Fisher's protected LSD test at $p \leq 0.05$).
[2] No significant difference ($p \leq 0.05$) among varieties.

Effect of vegetable intercrops on thrips damage incidence and severity

Thrips damage was evident on all experimental plants as silvery patches caused by the pest. Thrips damage incidence was high from the first week of sampling and remained high until physiological maturity (Table 4). Intercropping onion with carrot, French bean and spider plant as well as application of imidacloprid did not significantly ($p \leq 0.05$) reduce thrips damage incidence (Table 4). Thrips damage severity was low in the first week of sampling but increased gradually over time in all onion varieties (Table 5). However, there was no significant ($p \leq 0.05$) difference on thrips damage incidence among the three onion varieties (Table 6). Intercropping onion with carrot, French bean, spider plant and application of imidacloprid significantly ($p \leq 0.05$) reduced thrips damage severity. Imidacloprid had the greatest overall effect in reducing thrips damage severity by up to 15.6% (mean = 2.82) closely followed by spider plant by up to 15.7% (mean = 2.76). There were significant ($p \leq 0.05$) differences in thrips damage severity on the three onion varieties (Table 6) and ranked in the decreasing order as follows: Red Creole (mean = 2.99), Orient F1 (mean = 2.96) and Bombay Red (mean = 2.89), respectively. The significant differences in thrips damage severity among the onion varieties indicates that the onion varieties evaluated possess vaying levels of susceptibility to thrips. Our findings concur with reports by Malik et al. (2003) and Alimousavi et al. (2007) on susceptibility of onion to thrips infestation and damage.

Effect of vegetable intercrops on onion bulb yield

Intercropping onion with carrot and spider plant significantly ($p \leq 0.05$) reduced onion bulb yield but the yield reduction by French bean was not significant ($p \leq 0.05$) (Table 7). The mean bulb yield among the three varieties in decreasing order was: Bombay Red (13949 and 10583kg/ha), Orient F1 (12709 and 10200kg/ha) and Red Creole (12047 and 8334kg/ha), for total and marketable yield, respectively. The observed reduction in bulb yields in onion-spider plant and onion-carrot intercrops concurs with findings reported by other researchers (Kabura et al. 2008, Trdan et al. 2006). Working on an onion-pepper intercrop, Kabura et al. (2008) indicated that onion planted as a monocrop had higher total and marketable yield than the intercrop. Intercropping onion with *Lacy phacelia* also resulted in reduced onion yield (Trdan et al. 2006). The reduction in onion bulb yield could be attributed to competition for growth resources such as light, nutrients and water (Trdan et al. 2006). However, among the vegetables investigated in this study, French bean did not significantly reduce bulb yield and therefore it can be a suitable onion intercrop on the basis of yield parameter.

Table 4. Thrips damage incidence (%) over time on two varieties of onion under different treatments

Onion variety[1]	Intercrop / Insecticide[2]	Weeks after transplanting							
		4	5	6	7	8	9	10	11
Bombay Red	No spray	95.2	98.3	100.0	100.0	100.0	100.0	100.0	100.0
	Imidacloprid	94.4	98.0	100.0	100.0	100.0	100.0	100.0	100.0
	Carrot	97.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	French bean	96.7	99.6	100.0	100.0	100.0	100.0	100.0	100.0
	Spider plant	97.1	99.1	100.0	100.0	100.0	100.0	100.0	100.0
Red Creole	No spray	95.9	99.3	100.0	100.0	100.0	100.0	100.0	100.0
	Imidacloprid	96.0	98.9	100.0	100.0	100.0	100.0	100.0	100.0
	Carrot	94.9	98.5	100.0	100.0	100.0	100.0	100.0	100.0
	French bean	94.0	99.5	100.0	100.0	100.0	100.0	100.0	100.0
	Spider plant	99.1	99.6	100.0	100.0	100.0	100.0	100.0	100.0
Orient F1	No spray	91.1	96.6	100.0	100.0	100.0	100.0	100.0	100.0
	Imidacloprid	96.3	98.8	100.0	100.0	100.0	100.0	100.0	100.0
	Carrot	96.3	99.8	100.0	100.0	100.0	100.0	100.0	100.0
	French bean	96.5	99.3	100.0	100.0	100.0	100.0	100.0	100.0
	Spider plant	97.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[1,2] No significant difference ($p \leq 0.05$) among varieties and treatments (intercrops and Insecticide), respectively; LSD: least significant difference.

Table 5. Thrips damage severity per plant over time on three onion varieties under different treatments

Onion variety	Intercrop / Insecticide	Weeks after transplanting							
		4	5	6	7	8	9	10	11
Bombay Red	No spray	2.07	2.19	3.36	3.23	3.19	3.39	3.66	4.43
	Imidacloprid	2.02	1.98	3.06	2.60	2.72	3.03	3.25	2.93
	Carrot	2.05	1.98	2.77	2.84	2.78	3.15	3.26	3.97
	French bean	2.32	2.17	2.96	2.85	3.05	3.26	3.49	4.01
	Spider plant	1.98	2.09	2.56	2.63	2.68	3.00	3.25	3.34
Red Creole	No spray	1.95	2.13	3.02	3.23	3.41	4.00	4.26	4.45
	Imidacloprid	1.98	1.95	2.95	2.62	2.77	3.12	3.36	3.93
	Carrot	2.08	2.00	2.72	2.93	3.03	3.39	3.67	4.27
	French bean	1.87	2.05	2.43	2.86	3.25	3.61	3.66	4.34
	Spider plant	1.99	1.99	2.57	2.90	2.96	3.16	3.33	3.56
Orient F1	No spray	2.04	2.23	3.28	3.24	3.31	3.61	4.15	4.39
	Imidacloprid	1.97	1.99	3.01	2.59	2.69	3.00	3.30	3.99
	Carrot	2.23	1.95	2.83	2.96	2.91	3.15	3.36	4.02
	French bean	2.17	2.17	2.85	2.94	3.06	3.19	3.38	4.10
	Spider plant	2.09	2.08	2.64	2.60	2.72	3.09	3.33	3.64
$LSD_{(P\leq 0.05)}$ Treatment		Ns	0.14	0.20	0.22	0.23	0.18	0.23	0.17
$LSD_{(P\leq 0.05)}$ Variety		0.09	Ns	0.12	Ns	0.09	0.14	0.14	0.13

LSD: least significant difference; Ns: Not significantly different ($p \leq 0.05$).

Table 6. Thrips damage incidence and severity on three varieties of onion under different treatments

Intercrop / Insecticide	Incidence (%)[1]			Severity[2]		
	Bombay Red	Red Creole	Orient F1	Bombay Red	Red Creole	Orient F1
No spray	99.18	99.37	98.47	3.19 b	3.31 a	3.28 a
Imidacloprid	99.06	99.42	99.39	2.70 gh	2.83 f	2.82 f
Carrot	99.63	99.18	99.50	2.85 ef	3.01 c	2.92 de
French bean	99.53	99.20	99.47	3.01 c	3.01 c	2.98 c
Spider plant	99.52	99.83	99.72	2.69 h	2.81 f	2.77 fg

[1] No significant difference ($p \leq 0.05$) in damage incidence either among treatments or varieties.

[2] Means followed by same letter(s) are not significantly different (independent multivariate, Fisher's protected LSD test at $p \leq 0.05$).

Table 7. Total and marketable bulb yield (kg/ha) of three onion varieties intercropped with three vegetables

Intercrop plant/ Insecticide	Bombay red		Red Creole		Orient F1	
	Total Yield	Marketable yield	Total Yield	Marketable yield	Total Yield	Marketable yield
No spray	14126 a	10959 a	11006 a	6996 b	12408 a	9839 a
Imidacloprid	14884 a	11765 a	14342 a	10603 a	13537 a	11402 a
Carrot	11785 b	8567 b	9875 b	7080 b	11535 a	9123 a
French bean	15022 a	10776 a	12822 a	8051 ab	12688 a	10230 a
Spider plant	13930 a	10850 a	12190 a	8942 ab	13379 a	10407 a

Means followed by the same letter(s) within columns are not significantly different ($p \leq 0.05$); Means are separated by LSD ($p \leq 0.05$).

This study showed that thrips population and damage on onion can be significantly reduced when the crop is intercropped with other vegetables. The significant reduction in thrips population and damage in the onion-spider plant and onion-carrot intercrops shows that spider plant and carrot can be utilized in managing this economically important pest of bulb onion. This would offer an alternative to the use of chemicals thereby reducing the development of resistance that has been reported in many of the currently registered insecticides (Diaz-Montano et al. 2011; Nault and Shelton 2010; Shelton et al. 2006). In addition to reducing population of pests, intercropping onion with other vegetables will preserve beneficial insects, redice labour costs incurred in application of pesticides, control weeds and stabilize yields (Alamu et al. 2002). However, the optimal spatial arrangements, plant population, nutrient and water requirements under intercropping conditions should be investigated for optimum productivity and returns.

ACKNOWLEDGEMENTS

This research was carried out with the financial support from the Deans Committee Research Grant of the University of Nairobi, Kenya.

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