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POPULATION DYNAMICS AND MANAGEMENT OF THRIPS IN BULB ONION USING VEGETABLE INTERCROPS

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ABSTRACT

Hossain MM, Khalequzzaman KM, Mamun MAA, Alam MJ, Ahmed RN (2015) Population dynamics and management of thrips in bulb onion using vegetable intercrops. *Int. J. Sustain. Crop Prod.* 10(3), 8-15.

The field experiment was conducted at Spices Research Centre, Shibganj, Bogra during Rabi season of 2014-15 to study the population dynamics and to evaluate the effectiveness of intercropping Carrot, Tomato and French bean with onion for the management of thrips attacking onion. Variety BARI Piaz-1 was intercropped with each of the vegetables and insecticide Imidacloprid was used as a standard check. The treatments were five including control. Infestation of onion thrips was started from the first week of February and it become gradually increases upto first week of April then it was declined. Thrips populations were positively correlated with temperature and negatively with relative humidity and rainfall. Thrips incidence and damage severity were determined at 7 days interval with damage severity being estimated on a scale of 1-5. Total and marketable bulb yield were determined at physiological maturity. Intercropping onion with carrot, tomato and insecticide Imidacloprid significantly reduced thrips population over control up to 52.42, 48.84 and 58.97%, respectively, but French bean had no significant effect. The three vegetable intercrops significantly reduced damage severity, with insecticide Imidacloprid showed the greatest damage reduction up to 23.81% followed by carrot (21.04%) and tomato (11.90%). Intercropping onion with tomato and carrot showed significantly lower onion bulb yield (6.6 t/ha and 7.54 t/ha, respectively) but statistically comparable to that of French bean (8.62 t/ha). The effect of Imidacloprid on yield (11.24 t/ha) was statistically higher. The reduction in bulb yield was compensated by the yield from the vegetable intercrops and, therefore, no loss was incurred in carrot and tomato showing higher MBCR (12.55 and 17.90, respectively) compared to Imidacloprid (5.52). This study showed that Carrot or Tomato intercrop may be utilized as intercrop for the management of onion thrips.

Key words: *population dynamics, management, thrips, intercrops, bulb onion*

INTRODUCTION

Onion (*Allium cepa* L.) is one of the most important commercial spice crop grown in Bangladesh. Total production of onion in Bangladesh is about 13.40 lakh t. of bulbs from 1.80 lakh ha of land (AIS 2014). Consumption of onions has been increasing significantly in the world partly because of the health benefits it possesses (Havey *et al.* 2004; Wang *et al.* 2006). Onions are 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; Javadzadeh *et al.* 2009). Major limiting factors of 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 which is considered to be the most economically serious pest of onion worldwide (Trdan *et al.* 2005) and is responsible for causing considerable reduction in yield (Brewster 1994; Nawrocka 2003; Trdan *et al*. 2005). Its feeding can reduce onion bulb weight (Kendall and Capinera, 1987; Rueda *et al.* 2007) resulting in yield losses of nearly 50% (Fournier *et al.* 1995) and 60% (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 parasitoids 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 (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). The intercropping and mixed cropping in various crops has been reported to reduce the pest incidence in different crops. Mixed cropping of carrots and onion reduced the thrips incidence (Uvah and Coaker, 1984) and intercropping of onion and garlic with tomato found to decrease the level of thrips incidence by 79 to 85% (Afifi

and Haydar, 1990). However, there are no reports of studies done in Bangladesh on population dynamics and management of thrips in bulb onion using vegetable intercrops. The present study was therefore undertaken to study the population dynamics and to evaluate the effectiveness of vegetable intercrops in the management of thrips in bulb onions.

MATERIALS AND METHODS

The study was conducted at Spices Research Centre, Shibganj, Bogra during Rabi season of 2014-15 to study the population dynamics of onion thrips and to evaluate the effectiveness of intercropping carrot, Tomato and French bean with onion for the management of thrips attacking in onion. The experimental plot was prepared with five ploughings and cross ploughings followed by laddering. The weeds and stubbles of previous crops were removed from the soil. The unit plot size was 4 m × 1.80 m and the spacing was 15 cm × 10 cm for onion, 45cm × 50 cm for tomato, 45cm × 10cm for carrot and 45 cm × 15cm for French bean. The treatments were Onion intercropped with carrot; Onion intercropped with tomato; Onion intercropped with French bean; Spraying Imidacloprid (Admire 200SL) @ 0.5ml/L (as standard check) and an untreated control. Treatments were arranged in a randomized complete block design with three replications. Variety BARI Piaz-1 was used as main crop whereas unknown cultivar of carrot, BARI Tomato-9 and BARI Zhar Sheem-2 were used as intercrop for this trial. The seedlings of onion were transplanted on 28 December 2014. On each plot where intercropping was used, one row of intercrop was alternated with three rows of onion. Cowdung at 5 t/ha, fertilization with $N_{120}P_{40}K_{75}S_{30}$ kg/ha were applied. The entire amount of cow dung, TSP and ½ of N and K were applied during final land. The rest N and K was applied in two equal splits as top dress at 25 and 50 days after transplanting (DAP) following Anonymous (2010). Three weeding were done at 25, 50 and 75 DAP. To control purple blotch disease, the crop was sprayed three times with Rovral 50 WP @ 2g/l of water at 35, 45 and 55 DAP. Three irrigations were done at 10-20 days interval during vegetative growth stage. On the maturity, the crop was harvested on 12 April 2015. Thrips population was counted at 7 days interval starting from the first appearance of infestation. Number of thrips (both nymphs and adults) was recorded from 20 randomly selected plants in each plot by keeping a white sticky paper below the plant and then shaking the plants with finger. Silvery patches characteristically caused by thrips on onion leaves were considered 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. The Minolta SPAD 502 chlorophyll meter was used for the measurement of onion leaf color. Harvesting was done by hand at physiological maturity when 50-80% of the foliage had fallen over and then 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 ton per hectare. Another data were recorded on plant height at 85 DAT, SPAD (CCI) value at 85 DAT, bulb diameter, bulb weight and yield at harvest. The recorded data were analyzed and mean values were adjusted and means were separated by Duncan's Multiple RangeTest (DMRT) (Gomez and Gomez, 1984). Percent thrips population reduction over untreated control was calculated using following formula of Dutta *et al.* (2014):

$$\text{Percent thrips population reduction over untreated control} = \frac{\text{Mean of control} - \text{Mean of treatments}}{\text{Mean of control}} \times 100$$

RESULTS AND DISCUSSION

Population dynamics of onion thrips

Mean number of thrips population per plant observed at different dates in onion are presented in Fig. 1. Meteorological data during the growing period with mean thrips population are presented in Table 1. It was evident that the thrips population increased gradually from first week of February to first week of April and then declined. The population density increased from 4.71 to 5.26 thrips/plant during 5th February to 26th February. During the month of March, its population increased from 6.10 to 12.82 thrips/plant (5th March to 26th March). The peak population was recorded on 2nd April (19.21

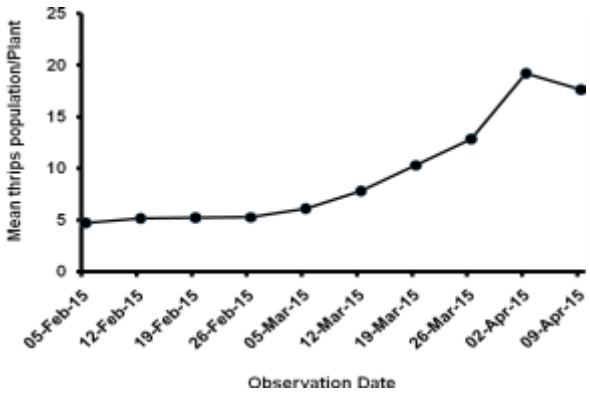

Fig. 1. Mean number of thrips population /plant observed at different dates in onion

thrips/plant). Afterward, the pest population declined from 19.21 to 17.63 thrips/plant during second week of April. The sudden drop in population was due to maturation of crop, leaf hardening and migration of thrips to other crops. Hussain *et al*. (1997), and Hyder and Shariff (1987) also found almost similar results. Hussain *et al.* (1997) reported that population of the *Thrips tabaci* began to build up in early February and reached maximum during April.

Table 1. Meteorological data during the growing period and the mean thrips population

Date of observation	Average temperature (°C)	Relative humidity (%)	Average rainfall (mm)	Mean thrips population/plant
05 February 2015	16.10	80.0	00	4.71
12 February 2015	18.95	76.6	19	5.14
19 February 2015	20.05	74.6	29	5.21
26 February 2015	22.00	74.0	25	5.26
05 March 2015	23.35	73.2	22	6.10
12 March 2015	23.95	71.0	10	7.81
19 March 2015	24.90	66.6	00	10.29
26 March 2015	25.15	66.0	00	12.82
02 April 2015	27.15	62.8	00	19.21
09 April 2015	26.57	60.6	10	17.63

Source: Meteorological station, Bogra

Relationship between thrips population and weather parameter in onion

The relationship between temperature and thrips population in onion are presented in Fig. 2. There was strongly positive correlation between temperature and thrips population in onion. The regression equation was y = 1.266x-19.48 and correlation coefficient was r = 0.8258**. The figure indicated that thrips population was increased with the increase of temperature.

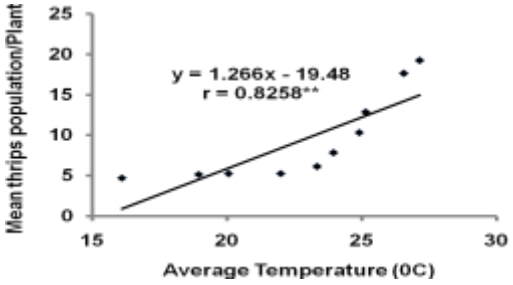

Fig. 2. Relationship between average temperature (°C) and thrips population in onion

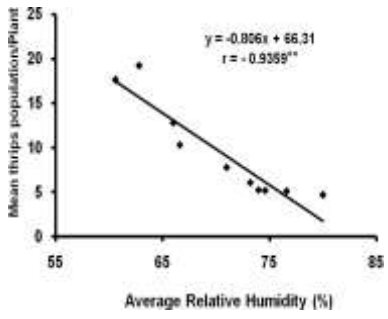

Fig. 3. Relationship between average relative humidity (%) and thrips population in onion

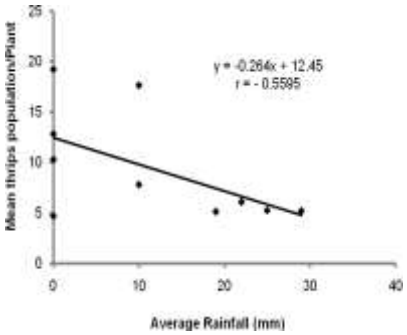

Fig. 4. Relationship between average rainfall (mm) and thrips population in onion

The correlation and regression relationship between relative humidity and thrips population in onion are presented in Fig. 3. Thrips population was negatively correlated with relative humidity in onion. The regression equation was y = -0.806x+66.31 and correlation coefficient was r = -0.9359**. The figure indicated that thrips population decreased with the increase of relative humidity. Similarly, the correlation and regression relationship between average rainfall and thrips population in onion are presented in Fig. 4. Thrips population was negatively correlated with average rainfall in onion. The regression equation was y = -0.264x+12.45 and correlation coefficient was r = -0.5595. The figure indicated that thrips population decreased with the increase of average rainfall.

Observation are comparable to those of Domiciano *et al.* (1993) who observed that the typical condition with temperature of 20.29°C in absence of rainfall favored rapid increase in the thrips population. Lorini and Junior (1990) reported that high temperature and lack of rainfall increased population density of *Thrips tabaci* on garlic in Brazil. Hamdy and Salem (1994) also reported that the rate of development of *T. tabaci* is positively affected by increased temperature and decreased by increased relative humidity.

Effect of vegetable intercrops on thrips population of onion

Effects of vegetable intercrops on thrips population are presented in Table 2. The mean number of thrips per plant was low during the initial weeks (4 weeks after transplanting) of sampling but the population progressively increased towards physiological maturity. Carrot, Tomato and the insecticide Imidacloprid significantly reduced thrips population in onion with the Imidacloprid resulting the highest reduction of up to 58.97% followed by carrot intercrop up to 52.42% and tomato intercrop up to 48.84%. However, the effect of French bean intercrop on thrips population was not significant compared to that of untreated controls (Table 2). The high thrips population in onion 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 tabac*i is a very prolific species and can have overlapping generations under conductive environmental conditions especially at high temperatures (Alimousavi *et al.* 2007; Bergant *et al.* 2005).

Table 2. Effect of vegetable intercrops on thrips population infesting onion

Intercrop/ Insecticide	Weeks after transplanting					% reduction over control				
	4	6	8	10	12	4	6	8	10	12
Carrot	5.14b	6.10c	9.52c	9.44b	10.00b	46.57	52.42	37.45	44.96	48.05
Tomato	5.21b	7.81bc	10.20bc	10.50b	12.20b	48.84	39.08	32.98	38.78	36.62
French bean	8.54a	10.29ab	13.92ab	14.76a	17.64a	11.23	19.73	8.54	13.94	8.36
Imidacloprid	4.77b	5.26c	8.57c	8.85b	9.98b	50.42	58.97	43.69	48.40	48.16
No spray	9.62a	12.82a	15.22a	17.15a	19.25a	-	-	-	-	-
Level of sigf.	**	**	**	**	**	-	-	-	-	-
CV (%)	13.85	12.95	11.85	9.02	6.86	-	-	-	-	-

Mean followed by the same letter (s) in the same column did not differ significantly from each other at 1% level by DMRT

This study showed that intercropping onion with carrot and tomato significantly decreased thrips population. This could have been due to visual and physical interference of thrips by the intercrops. Physical interference could induce attracting the thrips to the (carrot & tomato) intercrops instead of onions thereby resulting reduction of Thrips population on the latter. This phenomena was also indicated by the other authors (Alston and Drost, 2008; Trdan *et al.* 2006). Thrips damage to intercrops is not as economically profound as in onions (Alston and Drost, 2008). The reduction could also be attributed to reduce food choice in a mixed ecosystem with non-host plants may reduce the rate of multiplication of thrips. Ramert and Lennartsson (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 being a host to thrips, mainly *Frankliniella occidentalis* and *Megalurothrips sjostedti* (Nderitu *et al.* 2007). A mixed cropping habitat is likely to encourage thrips predators, as has been shown for the minute pirate bugs (*Orius* sp.) (Parella and Lewis, 1997). These natural enemies could have played a role in reducing the thrips population (Silveira *et al.* 2004). Ramert and Lennartsson (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. 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. Afifi and Haydar (1990) reported that intercropping of onion and garlic with tomato decrease the level of thrips incidence by 79 to 85%. 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).

Effect of vegetable intercrops on thrips damage incidence over time in onion

Effects of vegetable intercrops on thrips damage incidence over time in onion are presented in Table 3. Thrips damage was evident on all experimental plants as silvery patches caused by the pest. Thrips damage incidence was high from the first week (4^{th} weeks after transplanting) of sampling and remained high until physiological maturity (12 weeks after transplanting). Intercropping onion with carrot, tomato and French bean as well as application of Imidacloprid did not significantly reduce thrips damage incidence.

Table 3. Effect of vegetable intercrops on thrips damage incidence (%) over time in onion

Intercrop/ Insecticide	Thrips damage incidence (%) at weeks after transplanting				
	4	6	8	10	12
Carrot	95.2	99.4	100.0	100.0	100.0
Tomato	96.7	99.4	100.0	100.0	100.0
French bean	97.0	99.5	100.0	100.0	100.0
Imidacloprid	94.4	99.2	100.0	100.0	100.0
No spray	97.1	99.8	100.0	100.0	100.0
Level of sig.	NS	NS	NS	NS	NS

NS = Not Significant

Effects of vegetable intercrops on thrips damage severity over time in onion

Effects of vegetable intercrops on thrips damage severity over time in onion are presented in Table 4. Thrips damage severity was low in the first week (4 weeks after transplanting) of sampling but increased gradually over time in onion. Intercropping onion with carrot, tomato and French bean, and application of Imidacloprid significantly reduced thrips damage severity. Imidacloprid had the greatest overall effect in reducing thrips damage severity by up to 23.81% closely followed by carrot by up to 21.04% and tomato by up to 11.90%. The significant difference in thrips damage severity among the onion varieties indicated that the onion varieties evaluated possess varying 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.

Table 4. Effects of vegetable intercrops on thrips damage severity (%) over time in onion

Intercrop/ Insecticide	Weeks after transplanting					% reduction over control				
	4	6	8	10	12	4	6	8	10	12
Carrot	1.95b	1.98b	2.77bc	3.25b	3.34b	15.95	15.38	17.55	11.92	21.04
Tomato	2.06b	2.09b	2.96abc	3.26b	3.97a	11.21	10.68	11.90	11.65	6.15
French bean	2.08b	2.17ab	3.06ab	3.49ab	4.01a	10.34	7.26	8.93	5.42	5.20
Imidacloprid	1.94b	1.97b	2.56c	3.25b	3.28b	16.38	15.81	23.81	11.92	22.46
No spray	2.32a	2.34a	3.36a	3.69a	4.23a	-	-	-	-	-
Level of sigf.	*	*	**	*	**	-	-	-	-	-
CV (%)	5.70	6.02	5.39	5.03	5.14	-	-	-	-	-

Mean followed by the same letter (s) in the same column did not differ significantly from each other at 5% level (*) and 1% level (**) by DMRT

Effect of vegetable intercrops on yield and yield contributing characters of onion

Effect of vegetable intercrops on yield and yield contributing characters of onion are presented in Table 5. All of the treatments gave significant effect on plant height, SPAD value (CCI), bulb weight, bulb diameter and yield of onion over the untreated control plot. The tallest plant (63.20 cm) was recorded from insecticide Imidacloprid treated plot which was closely followed by carrot (62.81cm) and tomato (61.50 cm) intercropped plot and the shortest plant (52.33cm) was recorded from untreated control plot. The increases of plant height over control in carrot, tomato intercrops and insecticide Imidacloprid treated plot were 20.03, 17.52 and 20.77%, respectively. The highest Chlorophyll Concentration Index (CCI) of leaf (68.12) was also recorded from insecticide Imidacloprid treated plot followed by carrot (68.07) and tomato (66.90) intercropped plot and the lowest Chlorophyll Concentration Index of leaf was observed from untreated control plot. The maximum bulb weight (63.23g) and bulb diameter (3.98 cm) was recorded from Imidacloprid treated plot followed by carrot (60.83g and 3.87cm) and tomato (58.93g and 3.74 cm) intercropped plot and the minimum bulb weight (46.17g) and bulb diameter (2.40 cm) was recorded from the untreated control plot.

Intercropping onion with carrot, tomato and French bean gave statistically similar but reduced onion bulb yield (7.54, 6.60 & 8.62 t/ha) compared to that of Imidacloprid (11.24 t/ha) and untreated control plot (9.48 t/ha) (Table 5). The observed reductions in bulb yields in onion-carrot intercrops were comparable to the findings of Kabura *et al.* (2008) and Trdan *et al.* (2006). Working on an onion-pepper intercrop, Kabura *et al.* (2008) indicated that onion planted as a mono crop had higher total and marketable yield than the intercrop. The reduction in onion bulb yield could be attributed to competition for growth resources such as light, nutrients and water (Trdan *et al.* 2006). The reduction in bulb yield was compensated by the yield from the vegetable intercrops and, therefore, no net loss faced by the farmer. In addition, the intercrop may act as buffer against total crop loss and diversifies the production. Therefore, the onion-vegetable intercrop would be suitable to small-scale farmers who do not have adequate resources for purchasing chemical insecticide. This system would also be very ideal for organic vegetable production, in which chemical application is not required. 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 bulb yield parameter.

Table 5. Effect of vegetable intercrops on yield and yield contributing characters of onion

Intercrop/ Insecticide	Plant height at 85 DAT (cm)	% increase over control	SPAD value at 85 DAT (CCI)	Mean bulb weight (g)	Bulb diameter (cm)	Bulb yield (t/ha)
Carrot	62.81a	20.03	68.07a	60.83a	3.87a	7.54b
Tomato	61.50a	17.52	66.90a	58.93a	3.74a	6.60b
French bean	56.75ab	8.46	59.75ab	54.42ab	3.32ab	8.62ab
Imidacloprid	63.20a	20.77	68.12a	63.23a	3.98a	11.24a
No spray	52.33b	-	54.20b	46.17b	2.40b	9.48ab
CV (%)	6.06	-	7.37	9.46	16.09	11.77
Level of sigf.	*	-	*	*	*	**

Mean followed by the same letter (s) in the same column did not differ significantly from each other at 5% level (*) and 1% level (**) by DMRT. CCI = Chlorophyll Concentration Index of leaf

Economic analysis of different treatments applied against thrips infesting onion

The marginal benefit-cost ratio (MBCR) as worked out based on the expenses incurred and value of crops obtained from the treated plot for the control of thrips infesting onion is presented in Table 6. It was noted that expenses incurred referred to those only on pest control. It was revealed that the highest marginal benefit-cost ratio (17.90) was obtained from the onion plots intercropped with tomato followed by carrot (12.55) and French bean (6.46). Blaser *et al.* (2007) reported that benefits of intercrop system include erosion control, reduce leaching of nutrients, balanced distribution of labour and higher economic returns than sole cropping.

Table 6. Economic analysis of different treatments applied against thrips infesting onion

Intercrop/ Insecticide	Yield (t/ha) from		Gross return (TK/ha) from		Gross return (TK/ha)	Cost of treatment (TK/ha)	Net return (TK/ha)	Adjusted net return (TK/ha)	MBCR
	Onion	Intercrop	Onion	Intercrop					
Carrot	7.54	12.01	226200	180150	406350	9000	397350	112950	12.55
Tomato	6.60	22.85	198000	182800	380800	5100	375700	91300	17.90
French bean	8.62	12.62	258600	201920	460520	23600	436920	152520	6.46
Imidacloprid	11.24	-	337200	-	337200	8100	329100	44700	5.52
No spray	9.48	-	284400	-	284400	-	284400	-	-

MBCR = Marginal Benefit-Cost Ratio

[Price of onion bulb @Tk. 30.00 per kg, Carrot: Price of fresh carrot @Tk. 15.00 per kg, Seed cost @Tk. 6000 per ha, Labor cost (sowing + harvesting) 10 labor @Tk. 300 per labor, Tomato: Price of fresh tomato @Tk. 8.00 per kg, Seed cost @Tk. 600 per ha, Labor cost (sowing + harvesting) 15 labor @Tk. 300 per labor, French bean: Price of fresh bean @Tk. 16.00 per kg, Seed cost @Tk. 20000 per ha, Labor cost (sowing + harvesting) 12 labor @Tk. 300 per labor, Cost of Imidacloprid @Tk. 180/25ml and Cost of spray: Two labours/spray/ha @300Tk./labour/day; Spray volume required: 500L/ha]

CONCLUSION

From the study, it may be concluded that carrot or tomato intercrop may be utilized for the management of thrips infesting onion with higher economic return.

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