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Original Research Article

Role of Pot Marigold as a Companion Plant and Vermicompost in Protecting and Production of Tomato crop from Infestation with Tomatoes Moth in Egypt.

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A field experiments were carried out during the two successive seasons of 2012/2013 and 2013/2014, in Qualubia Governorate, Egypt, to study the effect of different rates of vermicompost (0, 2, 4, 8 ton/feddan) on different growth parameters, yield on pot marigold, tomato and protecting and production of tomato crop from infestation with Tomatoes moth in Egypt. Results showed that, application of vermicompost gave a significant increase in growth parameters and yield in pot marigold and tomato plants at the first and second seasons when compared with the control treatment. On the other hand, the addition of vermicompost of pot Marigold significantly increased natural enemies densities of *Trichogramma sp* and *Diadegma sp* or repellent and improved for tomatoes moth control. In addition, data showed that planted marigold with tomato in the same plot increased growth and yield as compared to planted Tomato alone without marigold as resulting to decrease the pest populations.

Keywords vermicompost; Pot marigolds; tomato crop; growth parameters; yield Tomatoes moth

INTRODUCTION

The chemical fertilizers might increase plant yields, but they do nothing for plant health. This natural support for the plants is not available with chemical fertilizers. The distribution of the compost through the soil also helps to encourage healthy root growth. Vermicomposting produces a product that is naturally designed to benefit plants in several different ways. The most important aspect of compost produced by earthworms is that it is 100% organic. There are no harm vermicomposting, it is produced by biodegradation of organic material through interactions between earthworms and microorganisms (Jesikha, 2013).

Hence, vermicompost is an important source of plant available nutrients and its addition to soil improves physical, chemical and biological properties of soil. Growth, quality and flower production of medicinal plants were shown to be strongly affected by soil conditions and amendments of earthworm-worked compost and other ornamental plant species (Azarmi *et al.*2008; Tharmaraj *et al.* 2011).Federico *et al.,* (2007)found that addition of sheep-manure increased tomato yields and soluble and insoluble solids, in tomato fruits. Tahmineh and Parviz (2013) found that the results revealed that addition of vermicompost with a rate of 15 t ha^{-1}significantly increased growth and yield compared to control. Increase in growth and yield of tomatoes due to the presence of rich organic matter present in the vermicompost to enhance the soil fertility. Earlier, vermicompost treated tomato plants to enhance the growth and yield. Joshi and Vig , (2010)found an increase in growth and yield of tomatoes due to the presence of rich organic matter present in the vermicompost to enhance the soil fertility.

There is growing public concern about pesticides' non-target effects on humans and other organisms, and many pests have evolved resistance to some of the most commonly used pesticides. Together, these factors have led to increasing interest in non-chemical, ecologically sound ways to manage pests (Denholm and Williamson, 2002 ;Abd El-Salam *et al*., 2013). One pest-management alternative is the diversification of agricultural fields by establishing "polycultures" that include one or more different crop varieties or species within the same field, to more-closely match, the highest species richness typical of natural systems (Altieri,1999). After all, destructive, explosive herbivore outbreaks typical of agricultural monocultures are rarely seen in highly diverse unmanaged communities.

There are several reasons that diverse plantings might experience fewer pest problems. First, it can be more difficult for specialized herbivores to "find" their host plant against a background of one or more non-host species (Root, 1973).

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Second, diverse plantings may provide a broader base of resources for natural enemies to exploit, both in terms of non-pest prey species and resources such as pollen and nectar provided by the plant themselves, building natural enemy communities and strengthening their impacts on pests (Root,1973). Both host-hiding and encouragement of natural enemies have the potential to depress pest populations, reducing the need for pesticide applications and increasing crop yields (Emden and Williams,1974).

On the other hand, crop diversification can present management and economic challenges for farmers, making these schemes difficult to implement. For example, each of two or more crops in a field could require quite different management practices (e.g., planting, tillage and harvest all might need to occur at different times for the different crops), and growers must have access to profitable markets for all of the different crops grown together. "Companion planting" is one specific type of polyculture under which two plant species are grown together that are known, or believed, to synergistically improve one another's growth.

That is, plants are brought together because they directly mask the specific chemical cues that one another's pests use to find their hosts, or because they hold and retain particularly effective natural enemies of one another's pests. Companion plants as interplantings of one crop (the companion) within another (the protection target), where the companion directly benefits the target through a specific known (or suspected) mechanism (Finch and Collier,2000). Companion plants can control insect pests either directly, by discouraging pest establishment, and indirectly, by attracting natural enemies that then kill the pest. The ideal companion plant can be harvested, providing a direct economic return to the farmer in addition to the indirect value in protecting the target crop.

However, "sacrificial" companion plants which themselves provide no economic return can be useful when their economic benefit in increased yield of the target exceeds the cost of growing the companion (Altieri,1999). Companion planting has received less attention from researchers than other diversification schemes (such as insectary plants and cover crops), but this strategy is widely utilized by organic growers (Hokkanen, 1991 &Finch and Collier,2000). Generally, recommendations on effective companion-target pairings come from popular press articles and gardening books, which make claims of the benefits of bringing together as companions aromatic herbs, certain flowers (Held et al.,2003), or onions (*Allium* L. spp.); nearly always, vegetables are the protection target. However, these recommendations most-commonly reflect the gut-feeling experiences of particular farmers that these pairings are effective, rather than empirical data from replicated trials demonstrating that this hunch is correct.

Indeed, more-rigorous examinations of companion-planting's effectiveness have yielded decidedly mixed evidence (e.g. Finch and Collier,2000; Thiery and Visser,1987). The tomato moth, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) is an important tomato pest in Egypt and several countries with several morphological and chemical factors of plants influencing their populations (Picanço et al., 1998). Females of *T. absoluta* deposit their eggs on leaves, stems and petioles. The four larval instars usually feed and develop in leaf mines on the inside of the leaf between the upper and lower epidermis but may also be found in fruit and stems. The pupae are principally found in the ground or on the fabric of the greenhouse, but may also occur on the tomato plant. The damage produced by this pest is focused on the larval galleries made on the leaves, the terminal buds, the flowers and the fruits of the tomato crops (Guedes et al., 1994). It has been reported that this pest can cause reductions in crop yield of up to 90%. Its control is based on intensive insecticide applications (Picanco et al., 2000). Also, insecticide resistance development in populations of *T. absoluta* to several insecticides like organophosphorous, pyrethroids, abamectin, cartap, methamidophos and permethrin (Moore 1983, Larraín 1986; Salazar & Araya 1997, 2001). On the other hand, many studies were carried out using different methods except chemical insecticides (Salem et al 2015).

The current investigation was carried out to study the effect of different rates vermicompost on growth parameters and yield of herbs and flowers of Calendula Officinalis and tomatoes. In addition, in this work we evaluated the efficacy of the pot marigold plant as an attractive plant to natural enemies and to determine whether Calendula Officinalis significantly increased natural enemies densities or repellent and improved for tomatoes moth control.

MATERIALS AND METHODS

Two field experiments were carried out during two successive seasons of 2012/2013 and 2013/2014, in Qualubia Governorate, Egypt, to study the effect of different rates of vermicompost on different growth parameters, yield on pot marigold, tomato and protecting and production of tomato crop from infestation with the Tomatoes moth in Egypt.. Prior to any practices, a composite soil sample was taken from the soil surface(0-30 cm) of the experimental site, air-dried, sieved by 2 mm sieve and analyzed the physical and chemical(Table 1).
The treatments consisted of cattle manure vermicompost different concentrations of rates (0, 2, 4and 8 ton/feddan). The analysis of cattle manure vermicompost indicated: PH 7.58, N 1.67%, P 0.39%, K=0.88%, Cu=44 ppm, Zn=132 ppm, Fe=1850 ppm, Mn=358 ppm and EC=13.18 dS/m. The required quantities of vermicompost were applied and incorporated to the top 5 cm layer of soil in the experimental beds before the plantation.

Experimental Design

An area 1000 m^2 divided into three blocks , the front and the hind blocks(250 m^2 each) were planting with *Calendula officinalis* L. plants and the middle block (750 m^2 each) was planting with tomato plants. The seeds of *Calendula officinalis* L. plants were kindly provided by the Department of Medicinal and Aromatic Plants, Ministry of Agriculture, Egypt. Seeds were sown on October 1st during both seasons. The experimental design was complete randomized blocks with five replicates. Each block was divided into 5 plots. The front area (block) was 175 m^2 and also, the hind area was specialized for Pot marigold. The block was contained rows; and the distance between the hills was 25cm and 50 cm apart. .The irrigation was carried out whenever plants needed.

Hybrid tomato (*Lycopersicum esculentum*) cv KTM-141(Provided by Takii & Co., LTD; Kyoto-Japan) was sown in the nursery on October 10, 2013 and October 17, 2014, respectively. KTM-141 is a cultivar recommended for open field cultivation with saline water. During the seedbed preparation, super phosphate (15.5% P_2O_5) with a rate of 31 kg P_2O_5/fed. Seedlings were transplanted to the experimental plots at November 25, 2013 and November 30, 2014, respectively at 0.3 m within rows and 0.8 m between rows. The experimental area (the middle area) was plowed, leveled and divided into 5 plots (to represent the replications).

Table 1: some characteristics of the experimental site in two seasons

seasons	Physical properties				Chemical properties						
	Sand	Silt	Clay	Texture	pH	EC dSm^{-1}	$CaCO_3$ %	OM %	N	P	K
	%								(ppm)		
7/8/2012	14.1	26.9	59.0	Clay	8.20	0.66	2.80	1.40	115	2.11	26.3
8/ 9/2013	13.2	27.8	59.0	Clay	7.97	0.59	3.11	1.60	120	2.20	25.4

Table (2): Effect of vermicompost fertilizer on growth parameter and yield in herbs and flowers of *Calendula Officinalis*. planted with tomatoes in the same plot (In both seasons). Means within columns followed by the same letter are not significantly different.

Treatments (Ton/feddan)	Flowers								Herbs			
	Mean Fresh weight (g / plant)		Mean Dry weight (g / plant)		Mean Flowers number		Mean Flowers diameter (cm)		Mean Fresh weight (g / plant)		Mean Dry weight (g / plant)	
Organic fertilizer	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
2.0	42.8b	46.8c	10.0bc	10.6bc	3.2a	3.8b	3.2a	3.4a	81.0b	84.6a	22.6b	25.2b
4.0	68.6a	79.6a	19.4a	20.4a	4.4a	5.4ab	3.6a	4.0a	101.4a	107.8a	34.6a	38.6a
8.0	58.2a	66.0b	15.6ab	16.2ab	4.0a	6.0a	3.6a	3.8a	88.0b	90.0a	27.4b	32.8ab
Control	23.4c	28.2d	5.4c	6.0c	1.4a	1.6c	2.0a	2.0a	58.6c	61.4a	15.2c	17.0c
F	26.5*	37.5*	6.9un	8.4un	1.2un	7.5un	1.9un	1.04un	16.12un	108un	13.16un	12.76un
$L.S.D_{05}$	11.45	10.98*	7.1	6.5	3.3	2.15	1.6	2.6	13.34	29.08	6.7	7.86

Table (3): Effect of vermicompost fertilizer on growth parameter and yield in tomatoes planted with *Calendula Officinalis* in the same plot(In both seasons)

Treatments (Ton/feddan)	Mean plant height (cm))		Mean stem diameter (mm)		Mean leaf numbers		Mean fruit weight (g)		Mean No. of fruit/ plant		Mean tomato yield plant (kg)	
Organic fertilizer	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
2.0	78.8b	76.6b	16.2a	16.6a	35.0ab	35.0b	89.0b	91.0b	31.0a	33.4ab	1.6a	1.8a
4.0	88.2b	90.8a	17.4a	18.0a	42.0a	44.0a	108.0a	110.0a	36.6a	39.8ab	2.0a	2.8a
8.0	90.6a	93.6a	17.0a	17.6a	45.0a	48.0a	101.0ab	103.0ab	34.2a	34.4ab	1.8a	2.8a
Control	63.4c	66.4c	15.4a	15.8a	29.0b	31.0b	76.0c	68.0c	28.2a	28.4b	1.2a	1.4a
F	20.28un	28.3*	0.16un	0.11un	3.5un	12.7un	11.7un	9.3un	1.05un	1.7un	1.15un	0.5un
$L.S.D_{05}$	7.8	7.2	6.5	8.8	11.46	6.5	12.6	18.09	10.7	10.6	2.2	1.01

Means within columns followed by the same letter are not significantly different.

Table (4): Effect of vermicompost fertilizer on growth parameter and yield in tomatoes alone (Inboth seasons)

Treatments (Ton/feddan)	Mean plant height (cm))		Mean stem diameter (mm)		Mean leaf numbers		Mean fruit weight (g)		Mean No. of fruit/ plant		Mean tomato yield plant (kg)	
Organic fertilizer	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
2.0	66.6ab	68.8bc	15.0a	15.8a	30.0a	33.0ab	75.0b	77.0b	28.2a	28.0a	1.2ab	1.4ab
4.0	73.2a	76.2ab	16.4a	17.0a	33.0a	36.0a	90.0a	92.0a	31.2a	32.0a	1.6a	1.8a
8.0	76.8a	80.2a	16.6a	16.8a	32.0a	36.0a	89.0a	90.0a	30.4a	30.8a	1.6a	1.8a
Control	58.4b	60.0c	14.6a	14.8a	25.0a	27.0a	66.0a	68.0c	25.0a	25.6a	0.6a	0.6a
F	4.18un	5.7un	0.2un	0.3un	1.2un	3.4un	13.8un	14.8*	1.06un	0.9un	4.06un	2.1un
$L.S.D_{05}$	11.8	11.1	5.7	5.4	9.4	6.8	9.3	8.6	8.05	8.7	0.7	1.16

Means within columns followed by the same letter are not significantly different.

It was contained rows with a spacing of 0.8 m and distance of 5 m. Each plot was bounded by 1 m dikes to avoid the interference effect. The experimental site was irrigated using surface irrigation system, whenever plants needed. Another area (1000m^2) was planted tomato plants (the same cultivar) but it was distant 2km from the first area as a control. The area divided into five plots and the same treatment in the first area.

Plant Samples And Analysis

Growth parameters (plant height (cm),stem diameter(mm.), leaf numbers ,number of fruit/ plant and yield in tomato were recorded and fresh and dry weights (g/plant) of herbs and flowers of *Calendula Officinalis* and tomatoes that dried at 70 ^{O}C were recorded. Physical and chemical properties of the soil were determined according to Chapman and Pratt (1961).

Part Insects

Samples for evaluation of population of the tomato moth (Eggs & larvae): The first area: leaf samples were taken randomize each 10 days from tomato plants that surrounded with pot marigold. Also, the second area that planting with tomatoes alone and distance 2 km. 100 leaves were taken from each plot (500 leaf for the first area and also, the second area. Each leaf samples put in paper bags and transport to the laboratory and checked to observe the egg hatching to *Tuta* larvae or emerging of *Trichogramma* adults and developmental larvae to *Tuta* pupae or emerging of *Diadegma* adults every 48 h until no adult parasites were seen for 10 days. Number of *Tuta absoluta* eggs, larvae nonparasites and parasites was counted in each area. Identification of parasitoids was performed according to the methods of Noda (1989) and Paik *et al.* (2007).

In case of the pot marigold is attracted to *Trichogramma sp* and *Diadegma sp.* Also, the percentage parasitism was calculated by the following equation, by Kalule and Wright (2002), Percentage parasitism = (m/[a + m]) x 100) Where: m is the total number of Eggs parasitism and a is the number of Eggs nonparasitism. Statistical analysis: The data were statistically analyzed using one- way analysis of variance (ANOVA) and comparisons were made based on Duncan' s new multiple range test (computer program Microstat version 2.5, 1991).

RESULTS AND DISCUSSION

The Effect of Vermicompost fertilizer on vegetative growth and yield of pot Marigold planted with or without tomato in the same plot. It is quite clear from the data presented in table (2) that application vermicompost fertilizer of different rates (0, 2, 4 &8 ton/feddan), affected herbs and flowers of *Calendula Officinalis.* Fresh and dry weights were significantly increased in first and second seasons when compared with the control.. These results are in a good harmony with (Edwards ,1995; Aziziet al. ,2008; Lazcano et al., 2009; Jesikha ,2013)reported that in a study with 25 types of vegetables, fruits or ornamentals, earthworm casts performed better than compost and commercial potting mixture amendments.

Results mentioned above indicate that superiority of fresh and dry weight of herbs and flowers under the beneficial effect of earthworms on plant growth may be due to several reasons apart from the presence of macronutrients and micronutrients in vermicompost and in their secretions in considerable quantities. Cantanazaro*et al.*,1998 & Mitra*et al.,* (2013) demonstrated the importance of the synchronization between nutrient release and plant uptake and showed that slow release fertilizers can increase plant yield and reduce nutrient leaching. The maximum fresh and dry weight of flower were (64.6, 71.6 ,19.4 and 20.4g / plant) in first and second season and herbs (101.4, 107.8 , 38.6 and 44.6g / plant) were obtained by using 4.0 ton vermicompost per feddan as compared with 2.0 and 8.0 ton / feddan and control. In addition also, flower number and Flowers diameter (cm) was maximum when compared applied at 2.0 ton vermicompost per feddan to other treatments.

From our results in table (3). it can be concluded that cattle manure vermicompost application to soil at rates (0, 2, 4 and 8 ton/feddan) increased growth parameters (plant height (cm), stem diameter (mm.), numbers of leaves, fruits / plant and yield in tomato plants at the first and second seasons when compared with the control .Sundararasu and Neelanarayanan (2012)found that vermicompost treated soil showed increased plant growth, number of leafs, flower and fruits compared to control soil. Significant yield was recorded in vermicompost soil. It is more favorable for the vigorous production of tomatoes.

The use of cattle manure vermicompost could be a better option and farmers need to be educated about the importance of vermicomposting .It is assured that other factors, such as the presence of beneficial microorganisms or biologically active plant growth influencing substances such as phytohormone are released by beneficial microorganisms present in the vermicompost rich soil (Atiyeh *et al.,* 2000; Arancon*et al.*2008 and Pascal *et al.*(2010). Root initiation, increased root biomass, enhanced plant growth and development and sometimes, alterations in plant morphology are among the most frequently claimed effects of vermicompost treatment Azarmi *et al,* (2008).

The obtained results suggest that the impact of cattle manure vermicompost application on growth and yield of tomato plants depended on the vermicompost application dose Stem diameter (mm.), fruit weight (g), yield (kg fruit/plant) and number of fruit/ plant increased was obtained by the addition4 ton / feddan cattle manure vermicompost as compared with 2 and 8 ton/feddan of cattle manure vermicompost. It is more appropriate for plant height (cm) and leaf numbers for plants when a bigger dose of 8 ton/feddan vermicompost were added. From the aspect of yield, no clear difference increasing of yield between application 4 and 8 ton/feddan of cattle manure vermicompost. Under this study data showed that planted marigold with tomato in the same plot increased growth and yield as compared to planted Tomato alone without marigold as resulting to decrease the pest population.

In conclusion, it is clearly indicated that small proportion of vermicompost can effectively enhanced growth and yield of tomatoes and pot marigold by improving various physico-chemical properties of the soil Population of immature stage of the tomato moth , eggs and larval parasitoids: In tomatoes with pot marigold field, the numbers of *Tuta absoluta* eggs, no parasitism, range from 7.2 to 11.0/ leaf while the larvae no parasitism were between 4.4 &13.2 /leaf. *Tuta absoluta* eggs collected from field revealed one parasitoids, which were identified as *Trichogramma sp*. The mean number of emerging *Trichogramma sp* was ranged from 4.4 to 8.4 / leaf. The mean percentage parasitism was 41.6% on eggs of *Tuta absoluta* during November 2013 (Table 5&6).

In tomatoes without pot marigold field, the eggs of *Tuta absoluta* ranged between 13.0 to 19.2 nonparasite eggs / leaf while, the parasite eggs recorded 2.0 eggs parasitoid / leaf in the final of the season and the mean percentage of parasitism was 7.82%. Metspalu et al.,(2003) studied that the planting of cabbage plots was surrounded as a border around garden beds, by the following plant species: *Salvia harminum* L., *Chrysanthemum carinatum*, *Tagetes patula* L., *Allium cepa* L., or *Calendula officinalis* L. Companion plants were replanted on experimental plots in two rows. On control plots, only cabbage was growing. The authors found that French marigold, *Tagetes patula* and Chrysanthemum *carinatum* were oviposition repellent to *Pieris brassicae* compare the control variant; butterflies laid fewer eggs on cabbage of these variants. At the same time, flowers of *Tagetes patula* were attractive to adults of *Pieris brassicae* as the butterfly fed intensively on the flowers.

There were no butterflies on flowers of Chrysanthemum *carinatum* allowing us to conclude that this plant was repellent to adults of butterfly. Certain repellent effects of painted sage appeared towards the end of the summer, when the plants were in full flower. Butterflies lay eagerly eggs on cabbage plants surrounded by calendula and onion.The mean percentage of egg parasitism with an attractive crop (pot marigold) was the highest to recording (41.6%) followed by the field without crop (7.8%).

At the same trend, Gontijo et al.,(2013) stated that the floral resources that sweet Alyssum plants provided attracted natural enemies and indirectly suppressed densities of woolly apple aphids, suggesting an effective means for apple growers to enhance biological control. The mean number of *Tuta absoluta* larvae recorded 4.4/leaf after 40 days from seedling stage increasing to 13.2 /leaf with the fruiting stage. The mean percentage of larval parasitism was 36.1% in the tomatoes with the pot marigold field. While, in the tomato field without an attractive crop, the mean number of larvae of Tuta was 6.4/ leaf with planting start and reached the 19.6 / leaf with the final season. However, the larval endoparasitoid of *Diadegma sp* was found to be the highest in the field with attractive crop (36.1% as mean), whereas it was lower in the field without attractive crop (5.9% as mean)(Table 5&6). Flowering plants have both enhanced natural enemy populations and improved pest suppression (Heimpel and Jervis, 2005).

In the 2014 season, in the tomatoes with pot marigold ,the observation that the infestation with *Tuta absoluta* nonparasite eggs and larvae decreased to recorded 5.4 &3.6 /leaf in starting season compared with the 2013 season. However, in the previous season recorded 7.2 &4.4/ leaf eggs and larvae, respectively. Also, the percentage of parasitism by *Trichogramma sp* or *Diadegma sp* were highly from the previous season, recording as average 64.42 % egg parasitoid and 69.32% larval parasitoid (Table 6&7) comparing with the previous season recorded as average 41.66% egg parasitoid and 36.15% larval parasitoid (Table 4&5). In the tomatoes without attractive crop , the infestation of *Tuta absoluta* eggs &larvae was nearly from the 2013 season, whereas, it was recorded 29.8 eggs /leaf & 26.4 larvae /leaf, respectively at the end of the season (Table 7&8). Also, the percentage of parasitism recorded as an average 7.93% for eggs & 14.75% for larvae of *Tuta absoluta*.

This study showed that the attractive crop (pot marigold) could increase the parasitoid density of *Tuta absoluta* . The parasitism of the *Tuta absoluta* was found to be higher in the field with attractive crops than in the conventional fields. Two egg and larval parasitoids of *Tuta absoluta* dominated in the tomatoes with attractive crop fields; as was reported in previous studies, the dominant species were *Trichogramma sp* and *Diadegma sp*(Huh and Park, 2005; Paik et al., 2007). Previous studies showed that the addition of companion plants providing nectar and pollen near crops enhanced biological control (Landis et al., 2000; Seagraves and Yeargan, 2006).Also, Folukemi & Park(2010) found that *Harmonia axyridis* (Natural enemy) significantly preferred yellow to any other colors. The result of this study suggested that odor and color of some companion plants (olfactory and visual cues) could assist in the use of biological control by attracting *H. axyridis* adults to the cropping area.

The difference in the parasitoid densities of the tomatoes with or without pot marigold fields was clearly significantly different. On the basis of the above findings, both species of parasitoids seem to be important for biological control of moth of *Tuta absoluta* management; perhaps *Trichogramma sp* is more efficient than *Tuta absoluta* because it is a gregarious parasitoid and has been found to hyper parasitize the eggs of *Trichogramma sp*. However, the abilities of parasitoids may differ according to their locations and environmental conditions, as well as the in field host conditions.

Thus, the competition and dominance hypothesis would need further study in relation to conservation biological control and attractive cropping. Balmer et al.,(2014) found that adding cornflowers (*Centaurea cyanus*) into cabbage (*Brassica oleracea*) fields significantly increased larval and egg parasitation (*Trichogramma* spp. egg parasite) and egg predation (*Telenomus sp.*) of the herbivore (the cabbage moth *Mamestra brassicae*), reduced herbivory rates, and increased crop biomass in at least 1 year. These findings show that the addition of a single, well-chosen flowering plant species can significantly increase natural top-down pest control in monocultures but success is variable.

This is relevant on two applied levels. First, well chosen companion plants may partially substitute pesticides in agriculture if the approach is optimized, reducing negative effects such as the unspecific killing of non-target organisms, residues in food, contamination of soils and water-bodies and increasing pesticide resistances. Our results suggest that, from an agro-economical point of view, egg parasitoids or predators may be the best targets for habitat management because strong natural selection acts on larval parasitoids to keep their hosts alive for their own development. Second, the addition of non-crop vegetation to monocultures benefits biodiversity conservation directly through resource diversification and indirectly through the reduction of pesticide application that increased natural control makes possible.

In the case of the attractive crop with cash crop (tomatoes) fields, the total parasitism rate was higher than that of the cash crop field. In addition, Lim et al. (2007) ,also reported that, even within a close distance, but a different environment, the dominant parasitoids of the same pest could be strikingly different. Thus, it would be important to have a better understanding of the ecological aspects of each natural enemy in order to have a successful implementation of the biological control. The egg survival and parasitism rate were found to be inversely related. In tomatoes with marigold crop fields, the egg survival rate was low, whereas the parasitism rate was higher as compared to other fields.

In the control fields, the egg survival rate was low and the parasitism rate was higher. Thus, the *Trichogramma sp* and *Diadegma sp* population would likely be higher in the tomatoes with marigold field than in the tomato crop field. Trap cropping is defined as plant stands grown to attract insects in order to protect target crops from pest attack, preventing pests from reaching the crop, and concentrating them on a certain part of a field where they can be economically controlled (Hokkanen, 1991). Trap cropping has been suggested as a tactic for the management of stink bugs (Rust, 1977; McPherson and Newsom, 1984; Rea et al., 2002). Trap crop is usually focused on the interaction of a host plant and a pest rather than the natural enemies of the pest. However, trap cropping in conjunction with habitat manipulation can enhance biological control methods by providing refuge or alternative food sources for the natural enemies (Landis et al., 2000; Gurr et al., 2005).

Youn & Jung (2008) investigate the integration of several pest management techniques which can minimize the use of chemical pesticides. The authors determine the effect of trap cropping on the egg parasitism of *Riptortus clavatus* (Thunberg) (Heteroptera: Alydidae) in the field level. Each soybean field was separately treated with trap cropping, trap cropping with nectar (buckwheat), and control; Daewon was the main soybean variety in each of these soybean fields. Egg parasitism of *R. clavatus* was compared among treatments. *Ooencyrtus nezarae* (Ishii) (Hymenoptera: Encyrtidae) and *Gryon japonicum* (Ashead) Hymenoptera: Scelionidae) (Ishii) are parasitoids that were found in the experimental fields in Andong, south-eastern part of the Republic of Korea and the sex ratios of *O. nezarae* and *G. japonicum* were 0.78 and 0.67, respectively.

The eggs of *R. clavatus* were parasitized by more than one *O. nezarae*. One to six *O. nezarae* emerged from a single host egg, averaging 3.0 per egg. Total egg parasitism was higher in trap crop fields than in the trap crop with nectar (buckwheat) or control fields, with parasitism levels of 83%, 75%, and 70%, respectively. Parasitism of *O. nezarae* was highest in trap crop fields (52%), whereas it was lower in the trap crop with nectar fields (20%). However, no significant differences were found among the parasitism rates of *G. japonicum* in the three treatments. Furthermore, a negative relationship was found between the parasitism levels of *O. nezarae* and *G. japonicum*. The hatchability of *R. clavatus* eggs were higher in control fields (22%) and lower in trap crop fields (11%). This study suggests the use of trap cropping for the enhancement of biological control agents.

Tavares et al., (2015) evaluated eleven plants for their potential to serve as insectary plants and attract beneficial arthropods. Buckwheat (*Fagopyrum esculentum*), cilantro (*Coriandrum sativum*) and dill (*Anethum graveolens*) attracted more numerous and diverse beneficial arthropods among the plants. *Trichogramma* wasps were natural enemy that might have played a role in suppressing caterpillar pests on pak choi in the insectary plant system treatment, as they parasitized 54% of Lycaenidae eggs from the sunn hemp border. Trichogramma are egg parasitoids of a wide range of lepidopteran pests (Pinto and Stouthamer, 1994).

Manandhar (2013) interplanted sunn hemp as companion plants in corn fields in Hawaii and found increased parasitism of cornear worm by *Trichogramma* wasps (Manandhar, 2013).Caterpillar damage on pak choi was clearly reduced in the insectary plant system treatment. Despite up to 60–70% of the leaves showing caterpillar damage, adult and immature lepidopteran pests were rarely detected during sampling, suggesting nocturnal behavior. It is not clear which natural enemies suppressed caterpillars in the insectary plant system. A few diamond back moths were parasitized by *Cotesia plutellae*, but their numbers were low and no significant differences were observed among treatments.

From this experiment, it is cautiously concluded that the combination of attractive cropping and conservation of natural enemies, i.e. egg& larval parasitoids may provide a good option to manage *Tuta absoluta*, but a better understanding of chemical pressures and ecological interactions such as competition or compensation requires further exploration in diverse environmental conditions. Also, in this work, the additives of vermicompost might be to lead to suppress the infestation of the tomato moth and increasing the parasites, this ideal need to another study in the future.

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Table (5): Effect pot marigold with Tomatoes on parasitism success by *Trichogramma sp*. against *Tuta absoluta* eggs (2013 season).

crop	After40day from seedling stage Mean No.		% parasitism	After50day from seedling stage Mean No.		% parasitism	After60day from seedling stage Mean No.		% parasitism	After70day from seedling stage Mean No.		% parasitism	% Mean parasitism
	Fresh Eggs/leaf ±SE	parasitized Eggs/leaf ±SE		Fresh Eggs/leaf ±SE	parasitized Eggs/leaf ±SE		Fresh Eggs/leaf ±SE	parasitized Eggs/leaf ±SE		Fresh Eggs /leaf ±SE	parasitized Eggs/leaf ±SE		
Tomatoes with marigold	7.2±1.98a	4.4±0.58a	37.93	8.4±2.01b	7.0±2.0a	45.45	11.0±1.6b	8.4±1.02a	43.29	9.0±1.04b	6.0±0.9a	40.0	41.66
Tomatoes without marigold	13.0±1.7a	1.2±0.33b	8.45	17.0±1.43a	1.2±0.2b	6.59	19.2±1.7a	1.2±0.58b	5.88	16.4±1.2a	2.0±0.54	10.86	7.82
F	2.1un	32.8*	----------	8.0*	21.2*	----	11.9*	37.0*	-----	21.3*	16.6*	---	---
LSD_{05}	6.0	1.49	----------	5.7	2.5	-----	5.47	2.7	--------	3.6	2.48	---	----

Means within columns followed by the same letter are not significantly different.

Table (6): Effect pot marigold with Tomatoes on parasitism success by *Diadegma sp*. against *Tuta absoluta* larvae (2013 season).

Crop	After40day from seedling stage Mean No.		% parasitism	After50day from seedling stage Mean No.		% parasitism	After60day from seedling stage Mean No.		% parasitism	After70day from seedling stage Mean No.		% parasitism	% Mean parasitism
	Larvae /leaf ±SE	parasitized Larvae/leaf ±SE		Larvae /leaf ±SE	parasitized Larvae/leaf ±SE		Larvae /leaf ±SE	parasitized Larvae/leaf ±SE		Larvae /leaf ±SE	parasitized Larvae/leaf ±SE		
Tomatoes with marigold	4.4±1.02a	0.6±0.2	12.0	7.0±0.7a	2.4±0.4a	25.53	13.2±2.6a	7.0±0.89a	68.62	6.4±1.96b	4.0±0.5a	38.46	36.15
Tomatoes without marigold	6.4±1.56a	0.0±0.0	0.0	8.4±1.9a	0.4±0.24b	4.54	19.0±1.18a	1.2±0.48b	5.94	19.6±3.5a	3.0±0.24b	13.27	5.93
F	1.13un	6.0*	----	0.47*	18.18*	----	3.9un	32.3*	---	10.8*	45.1*	----	-----
LSD_{05}	4.32	0.56	----	4.7	1.08	----	6.7	2.3	----	9.2	1.3	-----	-----

Means within columns followed by the same letter are not significantly different.

Table (7): Effect pot marigold with Tomatoes on parasitism success by *Trichogramma sp*. against *Tuta absoluta* eggs(2014 season).

crop	After40day from seedling stage Mean No.		% parasitism	After50day from seedling stage Mean No.		% parasitism	After60day from seedling stage Mean No.		% parasitism	After70day from seedling stage Mean No.		% parasitism	% Mean parasitism
	Fresh Eggs/leaf ±SE	parasitized Eggs/leaf ±SE		Fresh Eggs/leaf ±SE	parasitized Eggs/leaf ±SE		Fresh Eggs/leaf ±SE	parasitized Eggs/leaf ±SE		Fresh Eggs/leaf ±SE	parasitized Eggs/leaf ±SE		
Tomatoes with marigold	5.4±0.7 a	6.2±1.7a	53.44	7.2±0.86 b	13.4±1.07 a	65.4	8.6±1.3 b	15.8±2.4 a	64.75	6.6±0.9 b	18.8±7.6 a	74.1	64.42
Tomatoes without marigold	10.2±2.1a	1.2±0.4	10.52	16.0±2.0 a	1.6±0.6b	9.09	22.4±2.59a	2.2±1.2b	9.01	29.8±6.8a	2.4±1.1b	3.1	7.93
F	4.5un	6.4*	---	15.6*	91.6*	----	9.2*	25.4*	----	11.2*	4.5*	-----	---
LSD_{05}	5.2	4.1	---	5.1	2.8	----	5.6	6.2	----	15.99	17.7	-----	---

Means within columns followed by the same letter are not significantly different.

Table (8):Effect pot marigold with Tomatoes on parasitism success by *Diadegma sp*. against *Tuta absoluta* larvae(2014 season).

crop	After40day from seedling stage Mean No.		% parasitism	After50day from seedling stage Mean No.		% parasitism	After60day from seedling stage Mean No.		% parasitism	After70day from seedling stage Mean No.		% parasitism	% Mean parasitism
	Larvae /leaf ±SE	parasitized Larvae/leaf ±SE		Larvae /leaf ±SE	parasitized Larvae/leaf ±SE		Larvae /leaf ±SE	parasitized Larvae/leaf ±SE		Larvae /leaf ±SE	parasitized Larvae /leaf ±SE		
Tomatoes with marigold	3.6±0.8a	3.4±0.5a	48.57	2.8±0.8b	6.8±1.15a	89.47	3.0±0.3 b	13.6±0.9a	69.38	4.4±0.7 b	10.2±0.86a	69.86	69.32
Tomatoes without marigold	8.4±1.2a	1.6±0.2b	16.0	13.0±1.8a	3.2±0.58b	19.75	23.6±2.5a	3.0±0.7b	11.27	26.4±2.2b	3.6±0.9	12.0	14.75
F	10.8*	10.12*	----	6.6*	25.7*	----	66.7*	82.6*	---	89.2*	27.2*	---	---
LSD_{05}	3.3	1.3	----	5.35	4.6	----	5.8	2.6	----	5.3	2.9	---	----

Means within columns followed by the same letter are not significantly different.