

## Research Article

# Effect of additive intercropping kidney bean *Phaseolus vulgaris* with some aromatic plants on *Thrips tabaci* population

Vahab Rahimi and Hossein Madadi\*

Department of Plant Protection, Faculty of Agriculture, Bu-Ali Sina University, Hamedan, Iran.

**Abstract:** Intercropping is defined as the simultaneous cultivating of two or more crops together at the same time within a field. It has many advantages like pest population reduction, which increases crop yield. This study compared the impact of additive intercropping kidney bean *Phaseolus vulgaris* L. with some aromatic plants on *Thrips tabaci* Lindeman, 1889 population. The treatments included kidney bean sole crop, 100 + 50 kidney bean + coriander *Coriander sativum* L., 100 + 50 kidney bean + ajwain *Carum copticum* L., 100 + 50 kidney bean + basil *Ocimum basilicum* L., and 100 + 50 kidney bean + dill *Anethum graveolens* L. There were six sampling dates at weekly intervals after onion thrips emergence on the leaves. Kidney and bean leaves were collected on each sampling date, and the number of thrips larvae or adults was recorded. Results showed that the intercropping system significantly influences the onion thrips population. The minimum and maximum thrips per leaf were recorded in kidney bean + basil mixed and kidney bean sole crop treatments (0.208 and 0.540 Thrips/leaf). Moreover, there was a significant negative relationship between the number of thrips and kidney beans yield. The highest yield was recorded in kidney bean + basil treatments (2756 kg/ha). Besides, intercropping increased the Land Equivalent Ratio (LER) of bean monoculture. For instance, all intercropping treatments had higher LER than kidney bean monoculture. Among the intercropping treatments, the kidney bean + basil treatment had the highest LER (1.433). Finally, intercropping kidney beans with some aromatic plants could be an eco-friendly strategy in integrated pest management.

**Keywords:** Conservation, LER, Monoculture, Polyculture, Sustainable agriculture

## Introduction

Kidney bean *Phaseolus vulgaris* L. is a major grain legume consumed worldwide for its edible seeds and pods (Heuzé, 2013). Because of its high protein content (20–25%), complex carbohydrates (50–60%), and a good source of vitamins, minerals, and poly-unsaturated fatty acids, it is one

of the most globally essential legume crops for human nutrition (Rehman *et al.*, 2001).

*Thrips tabaci* L. (Thysanoptera: Thripidae) is a severe global pest of many economically important crops worldwide (Waiganjo *et al.*, 2008). During the high infestation, its population may reach upto 100 individuals/plant (Ullah *et al.*, 2007). Thrips direct feeding causes leaf whitening (blast), leaf curling, and twisting,

Handling Editor: Yaghoob Fathipour

\* Corresponding author: hmadadi@basu.ac.ir

Received: 12 October 2021, Accepted: 06 April 2022

Published online: 06 June 2022

leading to plant stunting. Besides direct injuries, it serves as a principal vector of different diseases (e.g., tospoviruses and *Alternaria porri*) and causes yield loss (Riley *et al.*, 2011; Gill *et al.*, 2015).

Several ecofriendly control tactics have been developed to reduce thrips damage in field vegetable crops (Riley and Pappu, 2004; Rueda *et al.*, 2007). However, more selective insecticides have been introduced into crop protection recently. This development helped overcome insecticide resistance problems (Rueda *et al.*, 2007). Besides increasing the cost of production, pesticides have some adverse effects on the environment and human health, attributed to high chemical residues (Burkett-Cadena *et al.*, 2008). The rapid resistance development by onion thrips to the most commonly used insecticides has been reported frequently (Martin *et al.*, 2003; MacIntyre Allen *et al.*, 2005). Therefore, it is necessary to integrate the use of chemicals with other control tactics such as cultural practices to keep the *T. tabaci* population below the economic damage.

Intercropping has been developed to minimize the reliance on pesticides and reduce pest densities (Midega *et al.*, 2018; Zakka *et al.*, 2018). It is defined as growing more than one crop in the same field simultaneously, where plants coexist throughout the whole period or at least during a prominent part of their cycle (Ferreira *et al.*, 2014). This intercropping system is a fundamental agronomic technique to prevent pest population outbreaks and keep it below the economic injury level (Malik *et al.*, 2003).

Intercropping is considered an essential component of crop production systems in developing countries (Sodiya *et al.*, 2010). It can provide numerous benefits to cropping systems through increasing total yield and land-use efficiency (Dhima *et al.*, 2007), improving biodiversity and yield stability of cropping systems (Lithourgidis *et al.*, 2006), enhancing light, water, and nutrient use (Lithourgidis *et al.*, 2007), controlling weeds, insects, or diseases (Vasilakoglou *et al.*, 2008), increasing

soil fertility and conservation of natural predatory fauna (Rao *et al.*, 2012).

Medicinal plants are considered a source of health products, essential oils, and other natural aroma chemicals in the national and international markets (Sujatha *et al.*, 2011). These plants have a particular position in traditional medicine. Aromatic plants (AP), produce high amounts of volatile secondary metabolites; thus, they are potential candidates for testing intercropping designs aimed at interfering with or masking host plant odors to disturb host selection by insect pests (Sujatha *et al.*, 2011). Several studies have emphasized the use of medicinal plants such as okra *Abelmoschus esculentus* L. (Muoneke and Mbah, 2007), chili pepper *Capsicum frutescens* L. (Uddin and Odebiyi, 2011), saffron *Crocus sativus* L. and three species of chamomile *Matricaria chamomilla*, *Tanacetum parthenium*, and *Anthemis nobilis* (Naderi Darbaghshahi *et al.*, 2012) in intercropping systems.

Several studies have demonstrated that intercropped repellent plants or trap plants can be effective alternative methods to reduce pest pressure on the primary crop (Tang *et al.*, 2013). Onion and clover intercropping causes a reduction in the onion thrips population and higher onion yield (Trdan *et al.*, 2006). Chilies intercropped with garlic and onion showed lower pest infestation levels and a higher yield (Aswathanarayanareddy *et al.*, 2006). Analysis of 207 case studies involving 287 pest species showed a pest population reduction of 52% in polyculture cases compared with monocultures (Andow, 1991).

The kidney bean is often a suitable companion crop in intercropping systems due to its non-aggressive and short growth cycle (Dawo *et al.*, 2009). Growers manage thrips by applying insecticides several times in a growing season. However, most insecticides are ineffective because of the cryptic lifestyle of onion thrips, and many thrips individuals are always protected between the inner leaves of the onion plant. Moreover, *T. tabaci* is a prolific species with many overlapping

generations (Nault and Shelton, 2010). Therefore, the current study aimed to evaluate the impact of additive intercropping kidney beans with some aromatic plants on the thrips population.

## Materials and Methods

### Experimental site

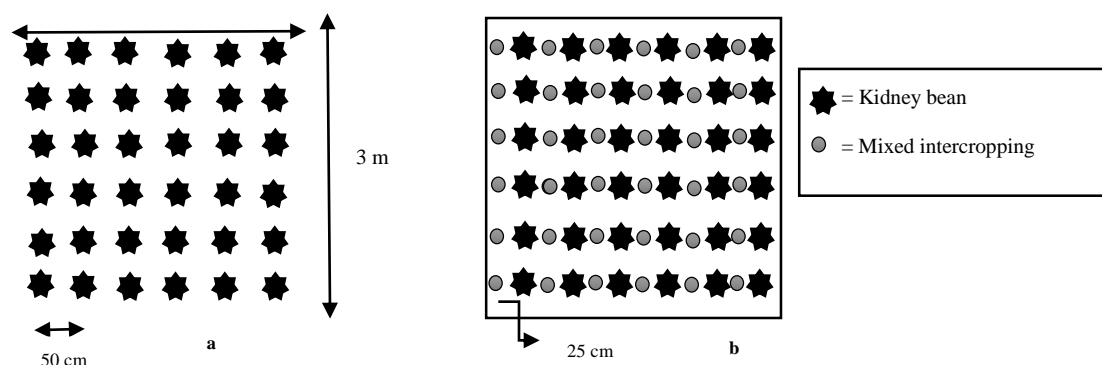
The field experiment was conducted on the Malekabad Research Farm (Alashtar, Lorestan province, Iran; 33°83' N latitude, 48°24' E longitude, 1620 m above mean sea level), in 2020. Irrigation was scheduled for every 6-7-days. The study was conducted under clay soil conditions characterized by pH = 7.5, 0.95% organic matter, 0.88, 9.5, and 190 mg kg<sup>-1</sup> available N, P, and K, respectively. According to soil analysis and common recommendations for kidney bean production in the area, phosphorus was added once during bed preparation at 80 kg ha<sup>-1</sup> as a superphosphate-triple. 100 kg ha<sup>-1</sup> nitrogen (based on urea, like ammonium nitrate) was divided into three equal parts and applied to the experimental plots after seedling emergence, weeding, and pod filling (top-dressed). Ultimately, all treatments received the same fertilization regime regarding soil analysis results. This site has an average annual precipitation of 440.30 mm and is classified as a semi-arid climate. The yearly mean temperature of the region is recorded at 12.7 °C, and during the experiment was 21.67 °C.

### Design and cultivation practices

The experiment was carried out in a randomized complete block design (RCBD) with five treatments and three replications. The size of plots was 3 × 2.5 m. The treatments included kidney bean sole crop *Phaseolus vulgaris* L. c. v. Dadfar, 100 + 50 kidney bean + Coriander, 100 + 50 kidney bean + Ajwain, 100 + 50 kidney bean + Basil, and 100 + 50 kidney bean + Dill (intercropping pattern) was as additive series; in this intercropping, one crop is the main or base crop, and another is intercrop. Also, the population of accompanied plant crops is less than their recommended pure stand). Local cultivars of additive intercropped plants were used in the study. The density of kidney beans was 20 plants/m<sup>2</sup> and coriander, ajwain, basil, and dill were sown between kidney bean rows (one row in between) at 8, 6, 10, and 20 cm distance from each other on the ridge, respectively (Fig. 1).

After sterilization by Rosalaxyl 72%, WP (Ridomil-Mancozeb) for 15 min, kidney beans and other intercropped seeds were planted at the stack side (width ca. 50 cm) on 24 May 2020. Kidney bean seeds were sown at a depth of 5 cm, and seeds of four additive intercropped plants were sown at 1 cm soil depth. Irrigation and weed control were carried out as required. After bean pod ripening, yield per hectare was calculated, and the Land Equivalent Ratio (LER) regarding seed yield was evaluated according to equation 1.

$$LER = \frac{Y_b}{Y_a} \quad \text{equation 1}$$



**Figure 1** Schematic illustration of kidney bean sole plot (a) and mixed intercropping between kidney bean lines plots (b).

Where  $Y_b$  is the kidney bean yield in intercropping and  $Y_a$  is the yield in sole-crop treatment.

LER < 1, meaning less than expected (adverse)

LER = 1, meaning the same as monoculture

LER > 1, meaning more than expected (favorable)

According to equation 1, if LER is greater than one, the multiple-crop system works, but sole-crop cultivation will be more profitable if LER is less than one.

### Sampling method

Samples were taken once the onion thrips emerged in the plots, and there were six sampling dates at weekly intervals. Because of the marginal effect, no sample was taken from lines one and six and 50 cm up and down the plots. Onion thrips sampling randomly selected six plants and four leaves from the middle part in four geographical directions in each sampling period. The kidney bean leaf was selected as the sampling unit. After transfer to the laboratory, both lower and upper leaf surfaces were

examined under a digital loop (40x magnification).

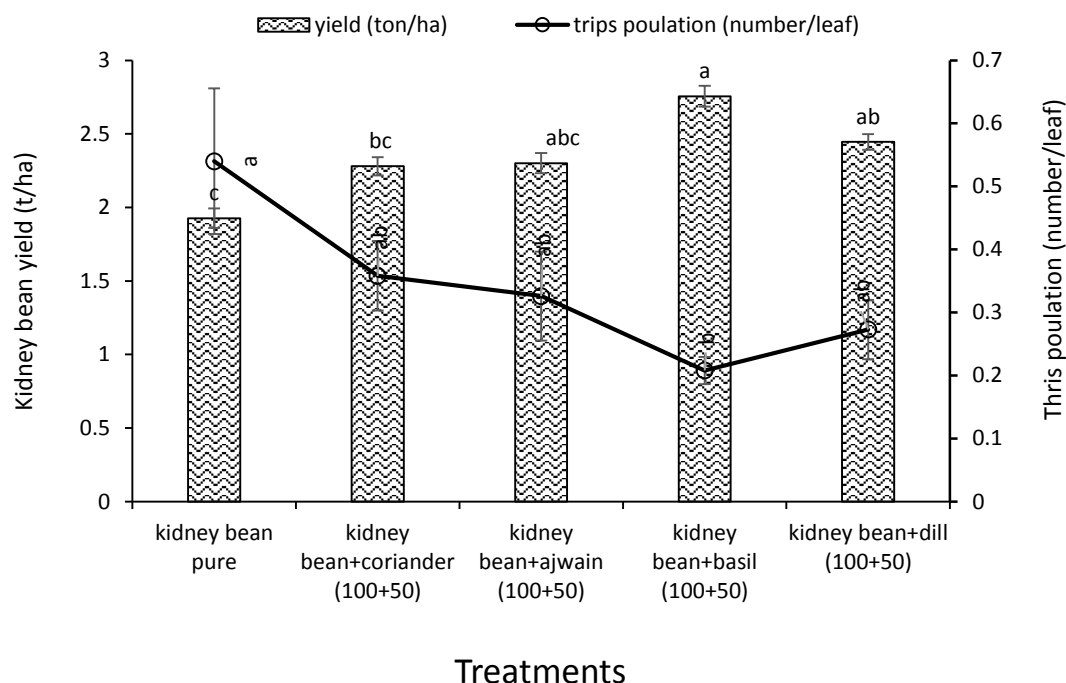
### Statistical analysis

Data normality was checked, and if the distribution met the normality requisite, the number of thrips among treatments was tested by one-way analysis of variance (ANOVA). Means were compared using Tukey's multiple range test at  $p < 0.05$ . Moreover, the Pearson correlation coefficient test assessed the relationships between independent variables.

### Results

#### Effect of intercropping on thrips population

It was revealed that intercropping components significantly influenced the thrips population ( $F = 4.51$ ,  $df = 4, 8$ ,  $P < 0.05$ ). Mean comparison showed the highest (0.540 thrips/leaf) and the lowest (0.208 thrips/leaf) number of thrips in sole kidney bean and 100 + 50 kidney bean + basil treatments (Fig. 2).



**Figure 2** Mean  $\pm$  SE comparisons of thrips population and kidney bean yield at experimental treatments (Tukey at 5%).

Accordingly, all intercropping treatments have a lower thrips population than kidney bean monoculture. However, there were no significant differences between other intercropping treatments (e. g., kidney bean + coriander, kidney bean + ajwain, and kidney bean + dill) in the thrips population (Fig. 2).

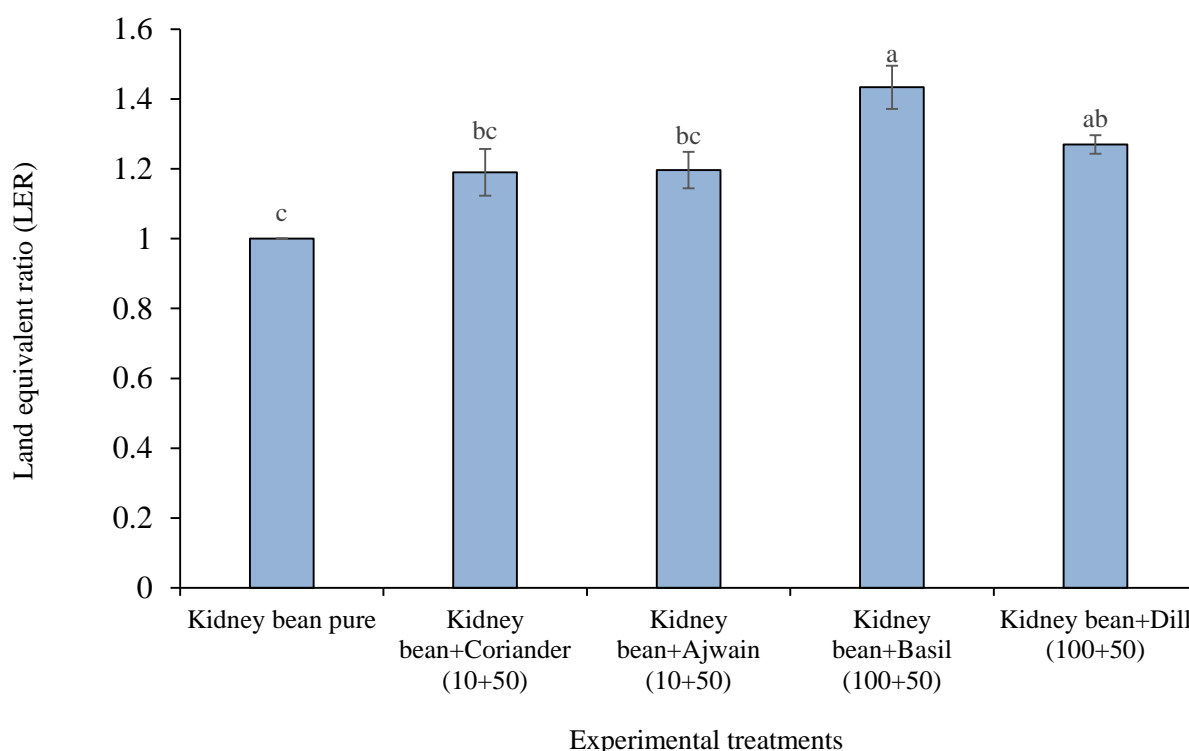
### Kidney bean yield and Land Equivalent Ratio (LER)

Analysis of variance showed that kidney bean yield ( $F = 17.87$ ,  $df = 4,8$ ,  $P < 0.01$ ) and LER ( $F = 17.14$ ,  $df = 4,8$ ,  $P < 0.01$ ) are significantly influenced by intercropping. Mean comparisons concerning kidney bean yield showed a significant difference between sole cropping and Multiple-crop treatments (Fig. 2).

In all intercropping treatments, the yield was more than kidney bean sole culture (1926 kg/ha). Moreover, among the intercropped

treatments, the highest kidney bean actual seed yield (2756 kg/ ha) was obtained from 100 + 50 kidney bean + basil treatment, and the lowest belonged to 100 + 50 kidney bean + coriander (2280 kg/ha) (Fig. 2). As shown in figure 2, there is no yield difference between sole kidney bean, kidney bean + coriander, and kidney bean + ajwain treatments.

The LER of all intercropping treatments was more than one, which indicated an advantage of intercropping over kidney bean monoculture (Fig. 3). Also, a 100 + 50 kidney bean + basil ratio among intercropped treatments had a higher value (1.433 per unit of land). Similar to the thrips population, there was no difference between three intercropping treatments (kidney bean + coriander, kidney bean + ajwain, kidney bean + dill) and sole cropping of kidney bean in terms of LER (Figs. 2 and 3).



**Figure 3** Mean  $\pm$  SE comparisons of Land Equivalent Ratio (LER) (Tukey 5%) at different experimental treatments.

### The relationship between the onion thrips population and kidney bean yield

In the present study, the correlation test results show that the relationship between kidney bean yield and the number of thrips was significantly negative, which means treatments with high yield have a lower thrips population (Table 1).

**Table 1** Correlation coefficient between onion thrips population and yield at different intercropped treatments.

|                   | Thrips population | Yield     | LER      |
|-------------------|-------------------|-----------|----------|
| Thrips population | 1                 | -0.717 ** | -0.027 * |
| Yield             |                   | 1         | 0.951 ** |
| LER               |                   |           | 1        |

\*\* and \* are significant at 1% and 5% probability levels, respectively.

LER: Land Equivalent Ratio.

Consistently, the number of thrips per leaf and yield in sole cropping of kidney beans were 0.54 and 1.926 t/ha, respectively; by contrast, all intercropping treatments had a lower thrips population with higher outputs (Fig. 2). The treatment 100 + 50 kidney bean + basil with 0.208 thrips per leaf and 2.756 (t/ha) yield showed the highest performance (Fig. 2).

### Discussion

It is widely known that diversifying agriculture systems (e.g., through intercropping) prevents pest outbreaks and increases the sustainability of agroecosystems (El-Wakeil *et al.*, 2020). Intercropping brings species diversity to the cropping systems and makes the systems more resilient against environmental perturbations, thus enhancing food security (Frison *et al.*, 2011).

In an investigation of crop species diversification's impact on the presence of 198 pest species, a decrease in their number was confirmed in 59% of cases (Risch *et al.*, 1983). Intercropping with non-preferred hosts, which affects the pest's ability to discriminate between volatiles and disrupt host plant findings, may reduce damages to preferred host plants.

Finch and Collier (2000) discussed how both chemical and visual stimuli affect insects' behavior during the period before accepting a plant as a suitable host (theory based on appropriate/inappropriate landings). Two central hypotheses for the intercropping mode of action are the resource concentration hypothesis and the natural enemies hypothesis. The first one emphasizes decreasing pest availability and retention in the preferred crop (Van Driesche *et al.*, 2008). Finding a host plant may be more difficult when non-host plants surround it. However, the outcomes are varied because of variations in the plant species selected for intercropping.

The underlying mechanism most likely involves the repellent chemicals hypothesis (Uvah and Coaker, 1984), in which the volatile organic compounds (VOCs) emanate from aromatic plants interfere with the ability of a herbivore to find a host plant, feed, migrate and breed, collectively preventing pest population build-up (Finch *et al.*, 2003). Indeed, VOCs have insecticidal, antifeedant, and repellent effects on insect arthropods (Song *et al.*, 2010).

Several studies have demonstrated that the odors from aromatic plants are most effective at repelling, feeding, and mating pests on host plants (Lu *et al.*, 2007; Tajmiri *et al.*, 2017; Midega *et al.*, 2018; Zarei *et al.*, 2019).

One study showed that compared with the non-intercropped plots, the cotton-basil intercropping system significantly reduced total pest infestation and led to a 50% reduced abundance of the pink bollworm *Pectinophora gossypiella* Saund. Basil, known for its repellent effect on various insect pests (Schader *et al.*, 2005; Basedow *et al.*, 2006), also affected the movement and abundance of the beneficial epigeic fauna (e. g., Coleoptera, Araneae, Gryllidae). Aharoni *et al.* (2003) indicated that the volatile organic compounds emitted from plant tissues could directly affect herbivore physiology and behavior due to their potentially toxic, repellent, or deterrent properties. Bennison *et al.* (2001) found that rosemary *Rosmarinus officinalis* L. has repellent effects on

*Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae).

Allam *et al.* (2009), studied the effect of intercropping of aromatic plants on the population of three main pests and their associated predators with three bean varieties at Fayoum and Gharbia Governorates, Egypt. They proved that each mint, fennel, and black cumin significantly reduced the *Tetranychus urticae* population on *P. vulgaris*. A significantly higher thrips population was observed in the monocropping system rather than in mixed cropping (Pankeaw *et al.*, 2011). Intercropping onion crops achieved up to 15.7% thrips reduction with spider plants *Chlorophytum comosum* Thunberg. (Gachu *et al.*, 2012).

Gombac and Trdan (2014) also found the least thrips damage to leek plants when intercropped with birdsfoot trefoil *Lotus corniculatus* L. Other intercropping systems that 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). Thrips injury in the carrot-onion mixed cropping system is not as economically damaging as injury to the monoculture of onions (Alston and Drost, 2008). The current study results align with the previous documents; thus, aromatic plant volatiles was responsible for decreasing *T. tabaci* population as thrips adults were supposedly being repelled by volatiles from non-host plants.

The main advantage of intercropping is the more efficient utilization of the available resources and the increased productivity compared with monoculture cropping (Mucheru-Muna *et al.*, 2010). Yield increase occurs because environmental factors such as light, water, and nutrients are more efficiently absorbed and converted to crop biomass by the intercrop over time and space. This could be assigned to differences in competitive ability for resources between crops, which originate from the character variations of the mixed crops such as canopy development rates, final canopy size (width and height), a photosynthetic adaptation

of canopies to irradiation conditions, and root taking depth (Tsubo *et al.*, 2001).

The more efficient resource exploitation in mixed cropping happens because of inconsistency in resource exploitation temporally and locally (Echarte *et al.*, 2011). Akhtar *et al.* (2015) reported increased productivity of 35.24 to 62.64% in the maize-leafy vegetables intercropping system. Similarly, Islam *et al.* (2014) reported 11.17 to 26.67% yield increase in the brinjal-leafy vegetables/legume intercropping system, and Ahmed *et al.* (2013) found 28 to 45% yield advantages in okra-leafy vegetables intercropping design.

It has been proposed that LER is an index of combined yield to evaluate the effectiveness of all intercropping combinations (Willey and Osiru, 1972). Hayder *et al.* (2003) reported that the LER range was 1.39 to 1.52 in intercropping of corn with soybean. In the intercropping system, root interaction could increase the root activity and microbial quantity in the rhizosphere (Zhang, 2013). Interspecific interaction between species in the rhizosphere can also enhance nutrient availability and uptake in intercropping (Li *et al.*, 2010).

Mixed cropping than monocrops reduced production risk when one cultivated crop in a mixed system. It also reduces disease and pest incidences (Lithourgidis *et al.*, 2011; Vasilakoglou *et al.*, 2008), severe drawbacks of the monocropping system. Moreover, it also helps the farmers to maximize water use efficiency (Yang *et al.*, 2011), maintain soil fertility (Ilany *et al.*, 2010), improve soil conservation, minimize soil erosion, provide resistance against lodging, enhance weed control (Corre-Hellou *et al.*, 2011).

Trdan *et al.* (2006) also obtained similar results of thrips suppression and higher onion bulb yield when onion was intercropped with white clover. Therefore, it can be stated that a mixture of several plants could be investigated as an alternative and a more profitable approach to pest management. The significant reduction of the thrips population on kidney beans with these aromatic plants intercrop in the current study

concur with previous findings by Waiganjo *et al.* (2007).

Finally, our results showed that the intercropping system reduced the thrips population. Additionally, all intercropped treatments had higher yield and LER than common bean sole-crop culture; however, chemical control is still the most common method against thrips. We propose that intercropping should be considered with other thrips control strategies within an IPM context.

### Acknowledgments

This study was funded by Bu-Ali Sina University, Hamedan, Iran, as a part of the Ph.D. thesis of the first author.

### Statement of Conflicting Interests

The authors state that there is no conflict of interest.

### References

- Aharoni, A., Giri, A. P., Deuerlein, S., Griepink, F., De Kogel, W. J., Verstappen, F.W. and Bouwmeester, H. J. 2003. Terpenoid metabolism in wild-type and transgenic Arabidopsis plants. *Plant Cell*, 15: 2866-2884. doi: <https://doi.org/10.1105/tpc.016253>.
- Ahmed, F., Islam, M. N., Alom, M. S., Sarker, M. A. I. and Mannaf, M. A. 2013. Study on intercropping leafy vegetables with okra (*Abelmoschus esculentus* L. Moench). *Bangladesh Journal of Agricultural Research*, 38(1): 137-143. doi: 10.3329/bjar.v38i1.15199.
- Akhtar, S., Zaman, M. S., Sultana, N., Khan M. A. H., Zaman, M. M., Sultana, S. and Alam, M. K. 2015. Intercropping of short duration vegetables with hybrid maize. *International Journal of Applied Research*, 1(2): 113-116.
- Allam, S.A., Nadia, H., Habashi, H., Neinaei, M. and Yassin, E. M. A. 2009. Effect of intercropping of four aromatic plants on the population of three main pests and their associated predators with three Bean varieties a Fayoum and Gharbia Governorates, Egypt. *Minufiya Journal of Agricultural Research*, 34 (1-2): 215-230.
- Alston, D. G. and Drost, D. 2008. Onion Thrips (*Thrips tabaci*). Utah State University Extension, Available from <http://extension.usu.edu/files/publications/factsheet/ENT-117-08PR.pdf>. [Accessed 05th September 2011].
- Andow, D. A. 1991. Vegetational diversity and arthropod population response. *Annual Review of Entomology*, 36: 561-568. <https://doi.org/10.1146/annurev.en.36.010191.003021>.
- Aswathanarayanareddy, N., Ashok, K. C. T. and Gowdar, S. B. 2006. Effect of intercropping on population dynamics of major pests of chili, *Capsicum annuum* L. *Indian Journal of Agricultural Research*, 40(4): 294-297.
- Basedow, T., Hua, L. and Aggarwal, N. 2006. The infestation of *Vicia faba* L. (Fabaceae) by *Aphis fabae* (Scop.) (Homoptera:Aphididae) under the influence of Lamiaceae (*Ocimum basilicum* L. and *Saturejahortensis* L.). *Journal of Pest Science*, 79: 149-154. <https://doi.org/10.1007/s10340-006-0128-7>
- Belder, E., Elderson, J. and Vereijken, P. F. G. 2000. Effects of undersown clover on hostplant selection by *Thrips tabaci* adults in leek. *Entomologia Experimentalis et Applicata*, 94(2): 173-182.
- Bennison, J., Maulden, K., Dewhirs, S., Pow, E., Slatter, P. and Wadhams, L. J. 2001. Towards the development of a push-pull strategy for improving biological control of western flower thrips on chrysanthemum. In: Marullo, R. and Mound, L.(Eds.) *Thrips and Tospoviruses: Proceedings of the 7<sup>th</sup> International symposium on Thysanoptera*, 2-7 July, Calabria, Italy. Australian National Insect Collection, Canberra. pp.199-206.
- Burkett-Cadena, M., Kokalis-Burelle, N., Lawrence, K. S., Van Santen, E. and Kloepper, J. W. 2008. Suppressiveness of root-knot nematodes mediated by rhizobacteria. *Biological Control*, 47(1): 55-59. <https://doi.org/10.1016/j.biocontrol.2008.07.008>.



- Corre-Hellou, G., Dibet, A., Hauggaard-Nielsen, H., Crozat, Y., Gooding, M., Ambus, P., Dahlmann, C., Von Fragstein, P., Pristeri, A., Monti, M. and Jensen, E. S. 2011. The competitive ability of pea-barley intercrops against weeds and the interactions with crop productivity and soil N availability. *Field Crops Research*, 122(3): 264-272. <http://doi: 10.1016/j.fcr.2011.04.004>.
- Dawo, M. I., Wilkinson, J. M. and Pilbeam, D. J. 2009. Interactions between plants in intercropped maize and common bean. *Journal of the Science of Food and Agriculture*, 89(1): 41-48. <https://doi.org/10.1002/jsfa.3408>.
- Dhima, K. V., Lithourgidis, A. S., Vasilakoglou, I. B. and Dordas, C. A. 2007. Competition indices of common vetch and cereal intercrops in two seeding ratio. *Field Crops Research*, 100 (2-3): 249-256. <https://doi.org/10.1016/j.fcr.2006.07.008>.
- Echarte, L., Della Maggiora, A., Cerrudo, D., Gonzalez, V. H., Abbate, P., Cerrudo, A., Sadras, V. O. and Calvino, P. 2011. Yield response to plant density of maize and sunflower intercropped with soybean. *Field Crops Research*, 121(3): 423-429. <https://doi.org/10.1016/j.fcr.2011.01.011>.
- El-Wakeil, N., Saleh, M. M. E., Gaafar, N. M. F. and Elbeheri, H. A. 2020. New aspects and practices of biological control conservation. *Mitteilungen der Deutschen Gesellschaft für Allgemeine und Angewandte Entomologie*, 22: 39-44.
- Ferreira, R. B., Teixeira, I. R., Reis, E. F., Silva, A. G. and Silva, G. C. 2014. Management of top-dressed nitrogen fertilization in the common bean/castor intercropping system. *Australian Journal of Crop Science*, 8(7): 1086-1092.
- Finch, S. and Collier, R. H. 2000. Host-plant selection by insects-a theory based on "appropriate/inappropriate landings" by pest insects of cruciferous plants. *Entomologia Experimentalis et Applicata*, 96(2): 91-102. <https://doi.org/10.1046/j.1570-7458.2000.00684.x>.
- Finch, S., Billiald, H. and Collier, R. H. 2003. Companion planting-do aromatic plants disrupt host-plant finding by the cabbage root fly and the onion fly more effectively than non-aromatic plants? *Entomologia Experimentalis et Applicata*, 109(3): 183-195. <https://doi.org/10.1046/j.0013-8703.2003.00102.x>.
- Frison, E. A., Cherfas, J. and Hodgkin, T. 2011. Agricultural biodiversity is essential for a sustainable improvement in food and nutrition security. *Sustainability*, 3(1): 238-253. doi: 10.3390/su3010238.
- Gachu, S. M., Muthomi, J. W., Narla, R. D., Nderit, J. H. and Olubayo, F. M. 2012. Management of thrips, *Thrips tabaci* in bulb onion by use of vegetable intercrops. *International Journal of AgriScience*, 2(5): 393-402.
- Gill, H. K., Garg, H., Gill, A. k., Gillett-Kaufman, J. L. and Nault, B. A. 2015. Onion Thrips (Thysanoptera: Thripidae) Biology, Ecology, and Management in Onion Production Systems *Journal of Integrated Pest Management*, 6 (1): 1085-1091. <https://doi.org/10.1093/jipm/pmv006>.
- Gombac, P. and Trdan, S. 2014. The efficacy of intercropping with birdsfoot trefoil and summer savoury in reducing damage inflicted by onion thrips *Thrips tabaci*, (Thysanoptera: Thripidae) on four leek cultivars. *Journal of plant Disease Protection*, 121: 117-124. <https://doi.org/10.1007/BF03356499>.
- Hayder, G., Mumtaz, S., Khan S. A. and Khan, A. 2003. Maize and Soybean intercropping under various levels of Soybean seed rates. *Asian Journal of Plant Sciences*, 2(3): 339-341. doi: 10.3923/ajps.2003.336.338.
- Heuzé, V. 2013. Common Bean (*Phaseolus vulgaris*), [Feedipedia.org](http://www.feedipedia.org)–Animal Feed Resources Information System–A programme by INRA, CIRAD, AFZ and FAO, Available on-line at: <http://www.feedipedia.org/node/266> [Accessed on 23 March 2015].
- Ilany, T., Ashton, M. S., Montagnini, F. and Martinez, C. 2010. Using agroforestry to improve soil fertility: effects of intercropping on *Ilex paraguariensis* (yerba mate)

- plantations with *Araucaria angustifolia*. Agroforestry systems, 80(3): 399-409. doi:10.1007/s10457-010-9317-8.
- Islam, M. R., Rahman, M. T., Hossain, M. F. and Ara N. 2014. Feasibility of intercropping leafy vegetables and legumes with brinjal. Bangladesh Journal of Agriculture Research, 39(4): 685-692. doi: 10.3329/bjar.v39i4.22548.
- Kucharczyk, H. and Legutowska, H. 2002. *Thrips tabaci* as a pest of leek cultivated in different conditions. In: Marullo, R. and Mound, L. (Eds.) Thrips and Tospoviruses: Proceedings of the 7<sup>th</sup> International symposium on Thysanoptera, 2-7 July, Calabria, Italy. Australian National Insect Collection, Canberra. pp. 211-213.
- Li, H. G., Shen, J. B., Zhang, F. S., Marschner, P., Cawthray, G. and Rengel, Z. 2010. Phosphorus uptake and rhizosphere properties of intercropped and monocropped maize faba bean and white lupine acidic soil. Biology and Fertility of Soils, 46: 79-91. https://doi.org/10.1007/s00374-009-0411-x.
- Lithourgidis, A. S., Dhima, K. V., Vasilakoglou, I. B., Dordas, C. A. and Yiakoulaki, M. D. 2007. Sustainable production of barley and wheat by intercropping common vetch. Agronomy for Sustainable Development, 27: 95-99. https://doi.org/10.1051/agro:2006033.
- Lithourgidis, A. S., Dordas, C. A., Damalas, C. A. and Vlachostergios, D. 2011. Annual intercrops: an alternative pathway for sustainable agriculture. Australian Journal of Crop Science, 5(4): 396-410.
- Lithourgidis, A. S., Vasilakoglou, I. B., Dordas, C. A. and Yiakoulaki, M. D. 2006. Forage yield and quality of common vetch mixtures with oat and triticale in two seeding ratios. Field Crops Research, 99(2-3): 106-113. https://doi.org/10.1016/j.fcr.2006.03.008.
- Lu, W., Hou, M. L., Wen, J. H. and Li, J. W. 2007. Effects of plant volatiles on herbivorous insects. Plant Protection, 33: 7-11.
- MacIntyre Allen, J. K., Scott-Dupree, C. D., Tolman, J. H. and Ron Harris, C. 2005. Resistance of *Thrips tabaci* to pyrethroid and organophosphorus insecticides in Ontario, Canada. Pest Management Science, 61(8): 809-815. doi: 10.1002/ps.1068.
- Malik, M. F., Nawaz, M. and Hafeez, Z. 2003. Inter and intra row spacing effect on thrips *Thrips* spp. population in onion *Allium cepa*. Asian Journal of Plant Sciences, 2(29): 713-715. doi: 10.3923/ajps.2003.713.715.
- Martin, N. A., Workman, P. J. and Butler R. C. 2003. Insecticide resistance in onion thrips (*Thrips tabaci*) (Thysanoptera: Thripidae). New Zealand Journal of Crop and Horticultural Science, 31(2): 99-106. https://doi.org/10.1080/01140671.2003.9514242.
- Midega, C. A. O., Pittchar, J. O., Pickett, J. A., Hailu, G. W. and Khan, Z. R. 2018. A climate-adapted push-pull system effectively controls fall armyworm, *Spodoptera frugiperda* (J E Smith), in maize in East Africa. Crop Protection, 105: 10-15. https://doi.org/10.1016/j.cropro.2017.11.003.
- Mucheru-Muna, M., Pypers, P., Mugendi, D., Kung'u, J., Mugwe, J., Merckx, R. and Vanlauwe, B. 2010. A staggered maize legume intercrop arrangement robustly increases crop yields and economic returns in the highlands of Central Kenya. Field Crops Research, 115(2): 132-139. https://doi.org/10.1016/j.fcr.2009.10.013.
- Muoneke, C. O. and Mbah, E. U. 2007. Productivity of cassava/okra intercropping systems as influenced by okra planting density. African Journal of Agricultural Research, 2(5): 223-231.
- Naderi Darbaghshahi, M., Banitaba, A. and Bahari, B. 2012. Evaluating the possibility of saffron and chamomile mixed culture. African Journal of Agricultural Research, 7(20): 3060-3065. doi: 10.5897/AJAR11.999.
- Nault, B. A. and Shelton, A. M. 2010. Impact of insecticide efficacy on developing action thresholds for pest management: a case study of onion thrips (Thysanoptera: Thripidae) on onion. Journal of Economic Entomology, 103(4): 1315-1326. doi: 10.1603/EC10096.
- Pankeaw, K., Ngampongsai, A., Permkam, S. and Rukadee, O. 2011. Abundance and distribution of thrips (Thysanoptera:

- Thripidae) in mangosteen, *Garcinia mangostana* L. grown in single- and mixed-cropping systems. Songklanakarin Journal of Science and Technology, 33(3): 263-269.
- Rao, M. S., Rama-Rao, C. A., Srinivas, K., Pratibha, G., Vidya-Sekhar, S. M., Sree-Vani, G. and Venkatswarlu, B. 2012. Intercropping for management of insect pests of castor, *Ricinus communis*, in the semi-arid tropics of India. Journal of Insect Science, 12(14): Article 14. doi: 10.1673/031.012.1401.
- Rehman, Z., Salariya, A. M. and Zafar, S. I. 2001. Effect of processing on available carbohydrate content and starch digestibility of kidney beans (*Phaseolus vulgaris* L.). Food Chemistry, 73(3): 351-353. [https://doi.org/10.1016/S0308-8146\(00\)00311-3](https://doi.org/10.1016/S0308-8146(00)00311-3).
- Riley, D. G. and Pappu, H. R. 2004. Tactics for management of Thrips (Thysanoptera: Thripidae) and tomato spotted wilt virus in tomato. Journal of Economic Entomology, 97(5): 1648-1658. Available from: 10.1603/0022-0493-97.5.1648.
- Riley, D. G., Joseph, S. V., Srinivasan, R. and Diffie, S. 2011. Thrips vectors of Tospoviruses, Journal of Integrated Pest Management, 2 (1): 11-110. <https://doi.org/10.1603/IPM10020>.
- Risch, S. J., Andow, D. A. and Altieri, M. A. 1983. Agroecosystems diversity and pest control: data, tentative conclusions and new research direction. Environmental Entomology, 12(3): 625-629. <https://doi.org/10.1093/ee/12.3.625>
- Rueda, A., Badenes-Perez, F. R. and Shelton, A. M. 2007. Developing economic thresholds for onion thrips in Honduras. Crop Protection, 26(8): 1099-1107. <https://doi.org/10.1016/j.cropro.2006.10.002>.
- Schader, C., Zaller, J. G. and Kopke, U. 2005. Cotton-basil intercropping: effects on pests, yields and economical parameters in an organic field in Fayoum, Egypt. Biological Agriculture & Horticulture, 23(1): 59-72. <https://doi.org/10.1080/01448765.2005.9755308>.
- Sodiya, A. S., Akinwale, A. T., Okeleye, K. A. and Emmanuel, J. A. 2010. An integrated decision support system for intercropping. International Journal of Decision Support System Technology, 2(3):51-66. 10.4018/jdsst.2010070104.
- Song, B. Z., Wu, H. Y., Kong, Y., Zhang, J., Du, Y. L., Hu, J. H. and Yao, Y. C. 2010. Effects of intercropping with aromatic plants on diversity and structure of an arthropod community in a pear orchard. BioControl, 55: 741-751. <https://doi.org/10.1007/s10526-010-9301-2>.
- Sujatha, S., Bhat, R., Kannan, C. and Balasimha, D. 2011. Impact of intercropping of medicinal and aromatic plants with organic farming approach on resource use efficiency in arecanut (*Areca catechu* L.) plantation in India. Industrial Crops and Products, 33(1): 78-83. <https://doi.org/10.1016/j.indcrop.2010.09.001>.
- Tajmiri, P., Fathi, S. A. A., Golizadeh, A. and Nouri-Ganbalani, G. 2017. Strip-intercropping canola with annual alfalfa improves biological control of *Plutella xylostella* (L.) and crop yield. Int J Trop Insect Sci 37: 208-216 <https://doi.org/10.1017/S1742758417000145>.
- Tang, G. B., Song, B. Z., Zhao, L. L., Sang, X. S., Wan, H. H., Zhang, J. and Yao, Y. C. 2013. Repellent and attractive effects of herbs on insects in pear orchards intercropped with aromatic plants. Agroforestry Systems, 87: 273-285. <https://doi.org/10.1007/s10457-012-9544-2>.
- Trdan, S., Žnidari, D., Vali, N., Rozman, L. and Vidrih, M. 2006. Intercropping against onion thrips, *Thrips tabaci* Lindeman (Thysanoptera: Thripidae) in onion production: on the suitability of orchard grass, lacy phacelia, and buckwheat as alternatives for white clover. Journal of Plant Diseases and Protection, 113(1): 24-30.
- Tsubo, M., Walker, S. and Mukhala, E. 2001. Comparisons of radiation use efficiency of mono-/inter-cropping systems with different row orientations. Field Crops Research, 71(1): 17-29. [https://doi.org/10.1016/S0378-4290\(01\)00142-3](https://doi.org/10.1016/S0378-4290(01)00142-3).

- Uddin, R. O. and Odebiyi, J. A. 2011. Influence of intercropping on incidence, abundance and severity of pest damage on okra (*Abelmoschus esculentus* (Linn.) Moench) (Malvaceae) and chilli pepper (*Capsicum frutescens* Linn.) (Solanaceae). *Journal of Agricultural Science*, 3(3): 63-66. doi: 10.5539/jas.v3n3p63.
- Ullah, A., Ashraf-Bhatti, M., Gurmani, Z. A. and Imran, M. 2007. Studies on planting patterns of maize (*Zea mays* L.). Facilitating legumes intercropping. *Journal of Agricultural Research*, 45(2): 113-118.
- Uvah, I. I. I. and Coaker, T. H. 1984. Effect of mixed cropping on some insect pests of carrots and onions. *Entomologia Experimentalis et Applicata*, 36(2): 159-167. <https://doi.org/10.1111/j.1570-7458.1984.tb03422.x>.
- Van Driesche, R., Hoddle, M. and Center, T. 2008. *Control of Pests and Weeds by Natural Enemies*. Wiley-Blackwell.
- Vasilakoglou, I. B., Dhima, K. V., Lithourgidis, A. S. and Eleftherohorinos, I. 2008. Competitive ability of winter cereal-common vetch intercrops against sterile oat. *Experimental Agriculture*, 44(4): 509-520. <https://doi.org/10.1017/S0014479708006728>.
- Waiganjo, M. M., Mueke, J. M. and Gitonga, L. M. 2008. Susceptible onion growth stages for selective and economic protection from onion thrips infestation. *Acta Horticulturae*, 767: 193-200. doi: 10.17660/ActaHortic.2008.767.19.
- Waiganjo, M. M., Muriuki, J. and Mbugua, G. W. 2007. Potential of indigenous leafy vegetables as companion crops for pest management of high-value legumes: a case study of *Gynandropsis gynandra* in Kenya. *Acta Horticulturae*, 752: 319-321. doi: 10.17660/ActaHortic.2007.752.54.
- Wiley, R. W. and Osiru, D. S. O. 1972. Studies on mixtures of maize and beans (*Phaseolus vulgaris*) with particular references to plant population. *The Journal of Agricultural Science*, 79(3): 519-529. <https://doi.org/10.1017/S0021859600025909>.
- Yang, C., Huang, G., Chai, Q. and Luo, Z. 2011. Water use and yield of wheat/maize intercropping under alternate irrigation in the oasis field of northwest China. *Field Crops Research*, 124(3): 426-432. doi: 10.1016/j.fcr.2011.07.013.
- Zakka, U., Chinaru Nwosu, L., and Peace Nkue, L. 2018. Effectiveness of maize as an intercrop in the management of insect pests of okra: Is there a better intercrop pattern than random intercrop practiced by farmers? *Journal of Crop Protection*, 7 (1): 65-72 doi: 10.13140/RG.2.2.36503.73126.
- Zarei, E., Fathi, S. A. A., Hassanpour, M., and Golizadeh, A. 2019. Assessment of intercropping tomato and sainfoin for the control of *Tuta absoluta* (Meyrick). *Crop Protection*, 120: 125-133. doi: 10.1016/j.cropro.2019.02.024
- Zhang, X., Huang, G., Bian, X. and Zhao, Q. 2013. Effects of root interaction and nitrogen fertilization on the chlorophyll content root activity photosynthetic characteristics of intercropped soybean and microbial quantity in the rhizosphere. *Plant Soil and Environment*, 59(2): 80-88. <https://doi.org/10.17221/613/2012-PSE>.

## تأثیر کشت مخلوط افزایشی لوبیا *Phaseolus vulgaris* با تعدادی از گیاهان دارویی بر جمعیت تریپس پیاز *Thrips tabaci*

وهاب رحیمی و حسین مددی\*

گروه گیاه پزشکی، دانشکده کشاورزی، دانشگاه بوعلی سینا، همدان، ایران.  
پست الکترونیکی نویسنده مسئول مکاتبه: hmadadi@basu.ac.ir  
دریافت: ۲۰ مهر ۱۴۰۰؛ پذیرش: ۱۷ فروردین ۱۴۰۱

**چکیده:** کشت مخلوط به صورت کشت هم زمان دو یا چند محصول زراعی در کنار یکدیگر در یک مزرعه تعریف می شود. این روش مزایای زیادی از جمله کاهش جمعیت آفات را در پی دارد که متعاقباً سبب افزایش عملکرد خواهد شد. این مطالعه با هدف مقایسه اثر کشت مخلوط افزایشی لوبیا *Phaseolus vulgaris* L. با تعدادی از گیاهان دارویی شامل گشنیز، زنیان، ریحان و شوید روی جمعیت تریپس پیاز *Thrips tabaci* L. انجام شد. تیمارها شامل کشت خالص لوبیا قرمز، کشت ۵۰ + ۱۰۰ لوبیا قرمز + گشنیز، کشت ۵۰ + ۱۰۰ لوبیا قرمز + زنیان، کشت ۵۰ + ۱۰۰ لوبیا قرمز + ریحان و کشت ۵۰ + ۱۰۰ لوبیا قرمز + شوید بود. پس از ظهور نخستین علائم تغذیه تریپس پیاز، نمونه برداری در شش مرحله با فاصله یک هفته انجام شد. برگ های جمع آوری شده در هر تاریخ نمونه برداری به آزمایشگاه منتقل و تعداد لاروها و حشرات کامل تریپس در تیمارهای مختلف ثبت شد. نتایج نشان داد که جمعیت تریپس به صورت معنی داری تحت تأثیر سیستم کشت مخلوط است. کمترین و بیشترین تعداد تریپس ها در هر برگ به ترتیب در تیمارهای کشت مخلوط لوبیا قرمز + ریحان و تیمار لوبیای خالص (۲۰۸/۰ و ۵۴۰/۰ تریپس در هر برگ) ثبت شد. به علاوه، یک رابطه منفی و معنی دار بین تعداد تریپس ها و عملکرد لوبیا برقرار بود بدین صورت که کمترین تعداد تریپس با ۲/۰ در هر برگ و بیشترین میزان عملکرد با ۲۷۵۶ کیلوگرم در هکتار در تیمار کشت مخلوط لوبیا + ریحان ثبت شد. هم چنین، مشخص شد کشت مخلوط سبب افزایش شاخص LER (Land Equivalent Ratio) در مقایسه با تک کشتی لوبیا قرمز می شود. برای نمونه، در تمام تیمارهای کشت مخلوط شاخص LER نسبت به تک کشتی لوبیای قرمز بالاتر بود که در این میان، تیمار لوبیا قرمز + ریحان دارای LER بیشتری بود. در نهایت، کشت مخلوط لوبیا با تعدادی از گیاهان دارویی می تواند به عنوان یک راهبرد دوستدار محیط زیست در مدیریت کنترل آفات (IPM) مورد توجه قرار گیرد.

**واژگان کلیدی:** تک کشتی، چند کشتی، LER، حفاظت، کشاورزی پایدار