EDITORA VERDE

Revista Verde de Agroecologia e Desenvolvimento Sustentável
Green Journal of Agroecology and Sustainable Development

GVAA GRUPO VERDE DE AGROECOLOGIA E ABELHAS

Aromatic plants and chili pepper intercropping as a pest management strategy

Consórcio de plantas aromáticas com pimenta malagueta como estratégia no manejo de pragas

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A R T I C L E
Received: 14 sept. 2020
Accepted: 24 aug 2021

Key words:
Arthropods
Ocimum basilicum
Coriandrum sativum
Capsicum frutescens

A B S T R A C T

The cultivation of peppers in northern Brazil has grown recently influenced by the increase in consumption, culinary usefulness, and medicinal features. However, pest insects damage plants and fruits, impairing production. This work investigates the management of pepper pests by intercropping plants that provide multiple ecosystem services, especially conservative biological control of pests. The experiment was carried out at the Federal Institute of Pará, Campus Rural de Marabá, Pará. The experimental design consisted of randomized blocks, with four treatments and five replications. Each plot contained thirty plants. The sampling of arthropods was carried out weekly in the useful portion of each treatment, through direct counting (visual analysis) and tapping plants on a white tray. The average abundance of arthropods in each functional group was calculated over the sampling weeks. We counted the number of fruits and bored fruits per plant to evaluate the effect of treatments on pepper yield. The abundance of pollinators differed significantly among treatments. Intercropping may favor the establishment of natural enemies and reduce the impacts of chemical insecticides.

Palavras-chave:
Artrópodes
Ocimum basilicum
Coriandrum sativum
Capsicum frutescens

R E S U M O

O cultivo de pimentas comerciais na região Norte vem crescendo nos últimos anos influenciado pelo consumo e sua versatilidade na culinária e pelas suas características medicinais. Entre os entraves à sua produção está o ataque de insetos-praga, os quais causam danos à planta e aos frutos. Neste trabalho foi estudada uma estratégia para o manejo de pragas da pimenta, através da associação de plantas provedoras de múltiplos serviços ecossistêmicos, com ênfase ao controle biológico conservativo de pragas. O experimento foi conduzido no Instituto Federal do Pará, Campus Rural de Marabá (PA). Utilizou-se o delineamento experimental de blocos casualizados, com quatro tratamentos e cinco repetições. Cada parcela continha trinta plantas. As amostragens dos artrópodes foram realizadas semanalmente na parcela útil de cada tratamento, através de contagem direta (análise visual) e batidas das plantas na bandeja branca. Foram calculadas as médias de indivíduos de cada grupo funcional ao longo das semanas de amostragem. Para avaliar o efeito dos tratamentos sobre a produtividade da pimenta, foi calculado o número de frutos por planta e o número de frutos brocados. Houve diferença significativa de polinizadores nos tratamentos consorciados. Foi observado que a presença de consórcios pode contribuir, positivamente, ao estabelecimento de inimigos naturais, inclusive, reduzindo os impactos associados à aplicação de inseticidas químicos no manejo de artrópodes-praga.

INTRODUCTION

The chili pepper (*Capsicum frutescens*) belongs to the Solanaceae family. The *Capsicum* botanical genus includes chili peppers and bell peppers, horticultural plants originating in Central and South America. Brazil is the second-largest producer of peppers in the world (RISTORI et al., 2002), presenting crops in all regions, mainly in southeastern and midwestern regions. Peppers (*Capsicum* spp.) comprise a relevant part of the fresh vegetable market in Brazil and worldwide as spices, seasonings, and preserves (DUTRA et al., 2010). The production of peppers suits family farming and small agribusinesses, thus the cultivation of peppers has socio-economic value (GUIMARÃES et al., 2014), generating income for small rural producers and their families. However, arthropod-pest attacks damage plants and fruits, limiting pepper production in the country (VENZON et al., 2011).

Several pests attack pepper plants. The sucking pests cause direct damage and transmit viruses, for example, the broad mite *Polyphagotarsonemus latus* Banks (Acari: Tarsonemidae), the aphids *Aphis gossypii* Glover and *Myzus persicae* Shulzer (Hemiptera: Aphididae), the whiteflies Gennadius (Hemiptera: Aleyrodidae), and the thrips *Frankliniella schultzei* Trybom and *Thrips palmi* Karny (Thysanoptera: Thripidae). Some insects directly damage the fruit, such as the borers: the pepper fly *Neosilba* sp. (Diptera: Lonchaeidae) and the pepper-fruit-borer *Symmetrischema dulce* Povolný (Lepidoptera: Gelechiidae) (VENZON et al., 2011).

The pepper-fruit-borer (*Symmetrischema dulce* Povolný) is a severe pest of peppers (VENZON et al., 2011). The larvae bore the fruit, feed on pulp and seeds and, when leaving the fruit, they open a hole that favors rotting by fungi, bacteria, and fruit fly larvae (VENZON et al., 2011). Like other pests of the Gelechiidae family, the pepper-fruit-borer penetrates internal plant tissues and pupate in the soil, which hampers the control by conventional integrated pest management practices (Perez, 2012).

The increased demand for chemical-free products and the environmental problems caused by agrochemicals stimulates the search for alternative pest control methods to protect human health and environmental safety (MEDEIROS et al., 2012). From an agroecological perspective, intercropping is among the most suitable methods for horticulture, providing environmental, productive and economic benefits. This strategy seeks greater production per area, through the combination of different plant species that will use space, nutrients, light, and provide advantages such as the control of weeds, pests, and diseases (SOUZA, 2006).

The correct choice of plant species to share the environment with the commercial crop comprises a key point of intercropping. Requiring an environment planning to maximize the supply of resources. The introduced plant species must provide alternative foods to entomophagous insects such as pollen, nectar, and prey (LANDIS et al., 2000).

Basil (*Ocimum basilicum* L.) is an aromatic plant of the Lamiaceae family commercially cultivated in family farming (CARVALHO; CAMPOS, 2012). Basil stands out for its insecticidal and repellent properties due to the production of chemical compounds such as linalool, estragole, eugenol and cineol (FERNANDES et al., 2004; MARTINEZ-VELAZQUEZ et al., 2011). Studies show that, when used as an intercropping plant, basil helps in colonization and maintenance of natural enemies (MEDEIROS et al., 2009; TOGNI et al., 2009), contributing to integrated pest management.

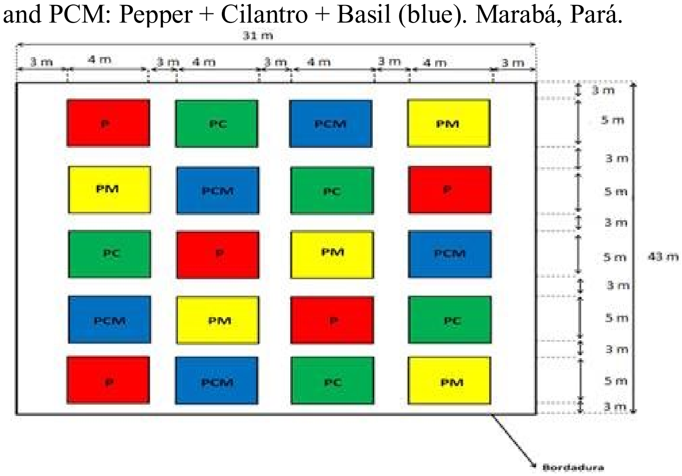
The use of basil in agroecological production models has several benefits, especially for intercropping with vegetables (CARVALHO et al., 2009; VIEIRA et al., 2012), insect vector repellency (TOGNI et al., 2009; GUIMARÃES et al., 2012) and diversity of pests and predatory arthropods (MEDEIROS et al., 2009). This work aims to identify the potential of basil and cilantro as plants intercropped with pepper to enhance biological pest control based on a conservative biological control strategy.

MATERIAL AND METHODS

The experiment took place in the Didactic Garden of the Federal Institute of Pará, Rural Campus of Marabá, Pará (5°34’39” S and 49°5’63” W; 22 m altitude). Soil samples were taken from the 0-20 cm layers to carry out fertility analyses. The soil presented the following chemical characteristics: pH (water) = 5.2; P = 1.42 mg.dm^{-3}; K = 39.76 mg.dm^{-3}; Ca^{2+} = 1.09 cmolc.dm^{-3}; Mg^{2+} = 0.16 cmolc.dm^{-3}; Al^{3+} = 0.70 cmolc.dm^{-3}; (H+Al) = 4.04 cmolc.dm^{-3}; SB = 1.35 cmolc.dm^{-3}; CTC = 2.05 cmolc.dm^{-3}; V = 25.08%; and MO = 2.41 g.kg^{-1}.

The experiment occurred from June 2017, beginning of seedling production, to April 2018, the end of harvests. We applied a randomized block experimental design, with four treatments and five replications: T1 - intercropped pepper and cilantro; T2 - intercropped pepper and basil; T3 - intercropped pepper, cilantro, and basil; and T4 - single pepper crop. The plots covered 5 x 4 m, with an area of 20 m². The spacing between pepper plants was 1 x 1 m, transplanted in 30 x 30 cm pits. Each plot contained thirty pepper plants. The plots were 3 m apart from each other (Figure 1). In the intercropping treatments, both cilantro and basil were planted 50 cm from the pepper and arranged in the same lines, longitudinally to the length of bed, with 0.5 m from cilantro and 0.5 m from basil.

Figure 1. Field experiment schematic drawing. P: Pepper (red), PC: Pepper + Cilantro (green), PM: Pepper + Basil (yellow); and PCM: Pepper + Cilantro + Basil (blue). Marabá, Pará.



The region has an Aw/As climate according to the Köppen classification, semi-humid tropical climate, with average annual temperatures above 26°C and average annual rainfall around 1,976 mm. During the study, the average maximum temperatures were 37°C, the minimum of 22°C, 70% humidity, and 97.6 mm precipitation. Climate data were obtained from the Meteorological Station of Rural Marabá Campus/IFPA.

Basil and pepper seedlings were produced in plastic cups filled with a substrate based on earthworm humus (60%) and vegetable soil (40%). After 30 days, the pepper and basil (15 to 20 cm tall) seedlings were transplanted. At the same week of pepper and basil transplantation, the cilantro was sown directly in furrows prepared in the soil, which was previously turned over and fertilized with 1-liter cattle manure. Due to the shorter cilantro crop cycle (70 days), we performed three consecutive cycles. We used drip irrigation in two watering shifts a day.

Arthropod sampling began six weeks after transplanting the pepper seedlings, lasting 32 weeks in 60 plants. Sampling occurred weekly in the useful plot of each treatment, randomly evaluating three plants. Arthropods were sampled by direct counting (visual analysis) and tapping the plant on a white tray (Figure 2). All arthropods in sampling plants were collected and we tapped three times the shoot over the tray to remove arthropods. The collected arthropods were preserved in 70% alcohol and taken to the biology laboratory of the Rural Marabá Campus for screening and identification.

Figure 2. Tapping of the pepper plant over the white tray, Marabá, Pará.

In each plot, three pepper plants were evaluated for the production of ripe fruits every fortnight until March 2018. The peppers were collected, measured in liters, and taken to the laboratory to evaluate the number of bored fruits. Fruits with bores or other symptoms of insect attack were placed in plastic pots (500 mL) containing sterile sand as a substrate to observe the pupation of larvae. They were inspected daily to record the number of borers.

The abundance of phytophagous, predators, and pollinators insects was calculated by the average number of individuals in each functional group per plant over the weeks of sampling. The effect of treatments on abundance was tested by Analysis of Variance (ANOVA). When ANOVA identified a significant difference between treatments, post-hoc Tukey tests were applied. Before each analysis, the data distribution was verified for normality.

To evaluate the effect of treatments on pepper yield, the number of fruits per plant was calculated for each week of evaluation. Data were compared using ANOVA as described above for the insect analyses. All analyzes were performed in Software R (R Core Team, 2017).

RESULTS AND DISCUSSION

Most arthropod records comprised phytophagous insects from the Chrysomelidae family, several species of bugs (Hemiptera), and the pepper-fruit-borer (*Symmetrischema dulce* Povolný). Mites occurred two months after transplanting the peppers but were controlled with wettable sulfur. Other phytophagous insects were observed in very low numbers and frequencies.

The abundance of phytophagous bugs did not differ significantly among treatments ($F = 0.888$; DF. = 3; $P = 0.45$). Most Chrysomelidae insects were from *Diabrotica* sp. and *Charidotis* sp. genus. Although the leaf beetles' abundances were similar among treatments, severe infestations may kill plants (QUINTELA, 2004).

Table 1. Average abundance of phytophagous insects on single and intercropped pepper production systems, Marabá, Pará. P (pepper), P+C (pepper and cilantro), P+M (pepper and basil), and P+C+M (pepper, cilantro, and basil).

Insects	P	P + C	P + M	P + C + M
Chrysomelidae	0.71±0.36a[1]	0.46±0.42a	0.64±0.35a	0.46±0.32a
Bugs	2.42±0.60a	2.43±0.53a	2.29±0.61a	2.55±0.62a

[1]Equal letters do not differ significantly from each other.

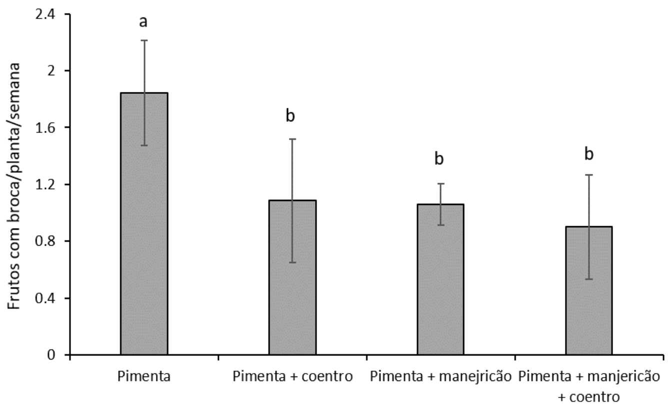
The number of bored fruits differed between treatments and control ($F = 20.78$; DF = 3; $P < 0.0001$; Figure 3). Peppers cropped in a single system had more bored fruits than the intercropped ones. The number of bored fruits was similar among the different types of intercropping.

Cilantro and basil attracted different groups of phytophagous insects. Although the effect of intercropping on the insect abundance was not verified, the incidence of pepper-fruit-borer was higher in non-intercropped peppers.

The chili pepper has a long fruiting period (PEREIRA, 2004; PINTO, 2006), providing abundant fruit for several generations of pepper-fruit-borer larvae. However, the cultivation of pepper intercropped with basil and cilantro improved the management of the pepper-fruit borer, reducing the attacks and decreasing the larvae population. The aromatic compounds in associated plants may affect host selection and reduce pest populations in the main crop.

Volatile oils (secondary metabolites) produced by aromatic plants may influence the selection of host plants by insects. Such metabolites have insecticidal, phagodeterrent, and repellent action (SONG et al. 2010; LETOURNEAU et al. 2010; LETOURNEAU et al., 2011). Also, the increase in plant diversity may attract beneficial insects (pollinators) and natural enemies, allowing maintenance of production and management of pest populations in the main crop (ROCHA et al., 2012). Carvalho et al. (2009) found that basil and rue intercropped with tomato reduced fruit loss by boring and, consequently, increased productivity.

Figure 3. Number of peppers attacked by the pepper-fruit-borer, *Symmetrischema dulce* Povolný (Lepidoptera: Gelechiidae), as a function of the different treatments (single pepper, pepper + cilantro, pepper + basil, pepper + basil + cilantro). Bars with different letters differ from each other by Tukey's test at α = 0.05.



Predators of the families Reduviidae, Cantharidae, Syrphidae, Vespidae, and Aranea were equally abundant in all treatments (Table 2): Syrphidae (F = 0.01; DF = 3; P = 0.9), Reduviidae (F = 0 .8; DF=3; P = 0.4), Cantharidae (F = 0.8; DF=3, P = 0.4), Vespidae (F = 1.3; 3 DF=3; P = 0. 2), and Aranae (F = 1.09; DF=3; P = 0.3). Probably the proximity of the plots interfered on sampling independence, impairing the perception of differences between treatments. Even so, the increase in plant diversity promoted by intercropping had no negative effects on natural enemies, which can benefit biological control of several pests.

The most frequent natural enemies were equally abundant overtime in the single crop (F = 0.7; DF = 3; P = 0.5), in intercrop with cilantro (F = 1.6; DF = 3; P = 0.1), and intercrop with cilantro and basil (F = 0.6; DF = 3; P = 0.5). The abundance of Reduviidae and Vespidae was higher in the intercropping with basil (F = 2.8; DF = 3; P = 0.03) (Table 2). Most species of these natural enemies are generalist predators, contributing to the management by preying on different insect types such as *Diabrotica speciosa*, *Epicauta* spp., moths, pest bugs, leafhoppers, aphids, and whiteflies. Therefore, generalist natural enemies directly impact the population of different pests through their total or partial consumption or indirectly through the immobilization of their prey, as in the case of spiders (VENZON et al., 2011).

Table 2. Average abundance of natural enemies per plant per week in single and intercropped pepper crops. Marabá, Pará. P = Pepper, C = Cilantro, M = Basil.

Natural enemies	P	P + C	P + M	P + C + M
Reduviidae	0.83±0.31Aa	0.83±042Aa	0.71±0.27Aa	0.75±0.41Aa
Cantharidae	0.33±0.21Aa	0.28±0.21Aa	0.26±0.17Ab	0.31±0.20Aa
Syrphidae	0.53±0.23Aa	0.56±0.40Aa	0.58±0.55Ab	0.51±0.31Aa
Araneae	0.45±0.48Aa	0.45±0.48Aa	0.45±0.35Ab	0.61±0.41Aa^{ns}
Vespidae	0.77±0.43Aa	0.95±0.42Aa	0.92±0.41Aa	0.97±0.49Aa

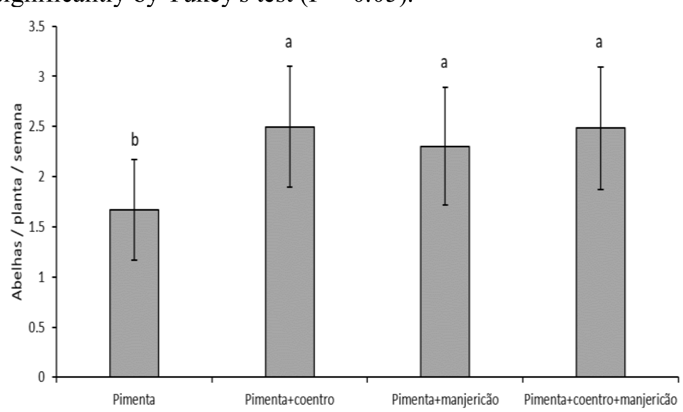
^{ns} not significant by F test (P > 0.05) for line comparisons. Means followed by the same uppercase letters in the line and lowercase letters in the column did not differ by the F test (P > 0.05).

Aromatic plants, such as basil, are promising for intercropping, as they are attractive and nutritious for parasitoids and predators due to their nutrients and the fragrance of essential oils (SONG et al., 2010). Basil facilitates the establishment of *Orius laevigatus* Fieber (Hemiptera: Anthocoridae), a predator of thrips, aphids, whiteflies, and mites, in sweet pepper cultivation (Montserrat et al., 2012). Flowers provide these insects with resources such as nectar and pollen that are essential for survival, development, sexual maturation, and egg production (LEE and HEIMPEL, 2008; LUNDGREN, 2009a; LUNDGREN; SEAGRAVES, 2011; SEAGRAVES et al., 2011; AMARAL et al., 2013).

In this way, the proper handling of the habitat increases the provision of alternative and supplementary resources (e.g., pollen and nectar) and, as a consequence, increases the effectiveness of natural enemies in the biological control of pests. Also, the diversity of plants favors the presence and permanence of natural enemies by providing food, refuge and microclimatic conditions that are suitable for different species (LIN et al., 2003).

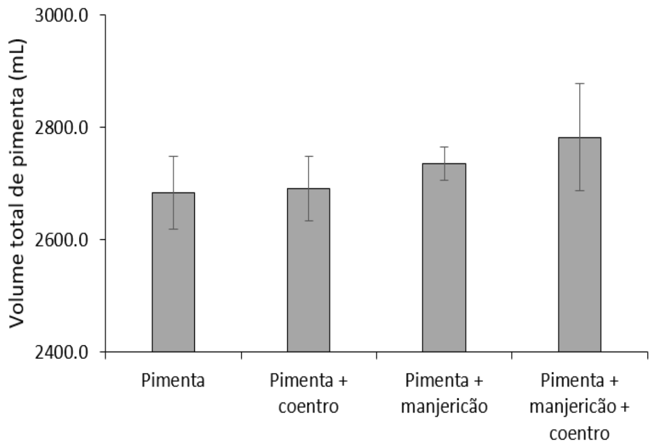
Intercropping of basil and cilantro with pepper significantly increased the abundance of *Apis mellifera* (Hymenoptera: Apidae; F = 10.9; DF = 3; P < 0.0001). Pollinators were equally abundant among all intercropping treatments but more abundant than in monoculture (Figure 4).

Figure 4. Bees abundance as a function of different treatments (single pepper; pepper + cilantro, pepper + basil, pepper + basil + cilantro). Bars followed by the same letters did not differ significantly by Tukey's test (P > 0.05).



The long flowering of basil, which lasts three to four months and produces nectar, probably attracted many bees and other pollinators, also benefiting the intercropped plants (PEREIRA et al., 2015). This fact was also observed by Pereira (2013) in the association of basil to bell pepper. However, intercropping did not interfere with pepper productivity (F = 0.41; P = 0.75).

Figure 5. Pepper yield as a function of different treatments (single pepper; pepper + cilantro; pepper + basil; pepper + basil + cilantro).



Although basil has a greater growth, there was no shading on the pepper trees. Therefore, the intercropping system proposed here can be used to favor natural enemies, reducing the incidence of pests and allowing the production of several crops simultaneously.

CONCLUSIONS

Chili pepper in single system crop had more bored fruits than the intercropped ones. There was a greater abundance of pollinating bees and insects in the intercropping treatments. Intercropping basil and cilantro with pepper contribute to the establishment of natural enemies, reducing the incidence of pests and favoring economic gains for family farmers. The intercropping of aromatic plants with pepper affects the interaction between pests and pepper crops, does not negatively affect the presence of natural enemies or crop productivity, being beneficial to pollinators.

REFERENCES

AMARAL, D. S. S. Non-crop vegetation associated with chili pepper agroecosystems promote the abundance and survival of aphid predators. 64, 338-346. 2013. 10.1016/j.biocontrol.2012.12.006

CARVALHO, L. M.; NUNES, M. U. C.; OLIVEIRA, R. O.; LEAL, M. L. S. Produtividade do tomateiro em cultivo solteiro e consorciado com espécies aromáticas e medicinais. Horticultura Brasileira, v.27, n.4, p.458-464, 2009. 10.1590/S0102-05362009000400010

CARVALHO, L. M.; CAMPOS, E. D. Cultivo consorciado do manjericão em sistema de produção orgânico. Aracajú: EMBRAPA-CPTAC. (Comunicado Técnico, 117). 2012. 7 p.

DENG, C. H.; GUOXIN, C.; HU, Y.; ZHANG, X. Determination of the volatile constituents of Chinese Coriandrum sativum L. by gas chromatography-mass spectrometry with solidphase microextraction. Chromatographia, v. 57, v. 5, p. 357–361, 2003. 10.1007 / BF02492408

DUTRA, F. L. A.; BRANCO, I. G.; MADRONA, G. S.; HAMINIUK, C. I. Avaliação Sensorial e Influência do Tratamento Térmico no Teor de Ácido Ascórbico de Sorvete de Pimenta. Revista Brasileira de Tecnologia Agroindustrial 4: 243-251. 2010.

FERNANDES, P. C.; FACANALI, R.; TEIXEIRA, J. P. F.; FURLANI, P. R.; MARQUES, M. O. M. Cultivo de manjericão em hidroponia e em diferentes substratos sob ambiente protegido. Horticultura Brasileira, Brasília, v.22, p.260-264, abr./jun. 2004. 10.1590/S0102-05362004000200019

FRANÇA F. H.; BARBOSA, S.; AVILA, A. C. Pragas do pimentão e da pimenta: características e métodos de controle. Informe Agropecuário 13: 61-67. 1984.

GUIMARÃES, S. S.; POTRICH, M.; SILVA, E. R. L.; WOLF, J.; PEGORINI, C. S.; OLIVEIRA, T. M. Ação repelente, inseticida e fagoinibidora de extratos de pimenta dedo-de-moça sobre o gorgulho do milho. Arquivos do Instituto Biológico, v. 81, n. 4, p.322- 328. 2014. 10.1590/1808-1657000172013

GURR, G. M.; WRATTEN, S. D.; ALTIERI, M. A. (Eds). 2004. Ecological Engineering for Pest Management: Advances in Habitat Manipulation for Arthropods. Wallingford, UK, CABI Publishing, 232 p. 10.1079 / 9780851999036.0000

JONSSON, M.; WRATTEN, S. D.; LANDIS, D. Habitat manipulation to mitigate the impacts of invasive arthropod pests. Biological Invasions 12, 2933–2945. 2010. 10.1007 / s10530-010-9737-4

LEE, J. C.; HEIMPEL, G. E. Floral resources impact longevity and oviposition rate of a parasitoid in the field. Journal of Animal Ecology 77: 565-572. 2008. 10.1590/S0085-56262009000300022

LETOURNEAU, D. K.; ARMBRECHT, I.; RIVERA, B. S.; LERMA, J. M.; CARMONA, E. J.; DAZA, M. C.; ESCOBAR, S.; GALINDO, V.; GUTIÉRREZ, C.; LÓPEZ, S. D.; MEJÍA, J. L.; RANGEL, A. M. A.; RANGEL, G. H.; RIVERA, L.; SAAVEDRA, C. A.; TORRES, A. M.; TRUJILLO, A. R. Does plant diversity benefit agroecosystems? A synthetic review. Ecological Applications, v. 21, n. 1, p. 9–21, 2011. 10.1890/09-2026.1

LIN, R.; LIANG, H.; ZHANG, R. Impact of alfalfa ⁄cotton intercropping and management on some aphid predators in

China. Journal of Applied Entomology 127, 33-36. 2003. 10.1046 / j.1439-0418.2003. 00672.x

LUNDGREN, J. G. Nutritional aspects of non-prey foods in the life histories of predaceous Coccinellidae. Biological Control 51, 294–305. 2009a. 10.1016 / j. biocontrol.2009.05.016

LUNDGREN, J. G.; SEAGRAVES, M. P. Physiological benefits of nectar feeding by a predatory beetle. Biological Journal of the Linnaean Society 104, 661–669. 2011. 10.1007 / s10526-012-9501-z

MACIEL, A. D.; ARF, O.; SILVA, M. G.; SÁ, M. E.; RODRIGUES, R. A. F.; BUZETTI, S.; SOBRINHO, E. B. Comportamento do feijoeiro em cultivo consorciado com milho em sistema de plantio direto. Acta Scientiarum Agronomy. Maringá, V. 26, n. 3, p. 273-278, 2004. 10.4025/actasciagron. v26i3.1827

MARTINEZ-VELAZQUEZ, G. A.; CASTILHO, G.; CRUZ, R. R.; FERNÁNDEZ, J. M. F. Acaricidal effect and chemical composition of essential oils extracted from *Cuminum cyminum*, Pimenta dioica and *Ocimum basilicum* against the cattle tick *Rhipicephalus* (*Boophilus*) *microplus* (Acari: Ixodidae). Parasitology Research, Berlim, v. 108, n. 2, p. 481-487, 2011. 10.1007 / s00436-010-2069-6

MEDEIROS, M. A.; TOGNI, P. H. B.; RESENDE, F. V.; SUJII, E. R. Efeito do Consórcio Cultural no Manejo Ecológico de Insetos em Tomateiro. Brasília: Embrapa Hortaliças. 9p. (Embrapa Hortaliças. Comunicado Técnico,65). 2012.

MONTSERRAT, C.; JANSSEN, D.; ACEDO, L. L.; SALVADOR, E.; NAVARRO, M. M. T. Utilización de *Mentha suaveolens* Ehrh y *Ocimum basilicum* L. como plantas refúgio para adelantar la instalación de *Orius laevigatus* F. (Hemiptera: Anthocoridae) en cultivo de pimiento. Boletín de Sanidad Vegetal, Plagas, v. 38, n. 2, p. 311-319, 2012.

LÚ, A.; PEREIRA, C.; TAINÁ, B.; TAQUES, C. The management of bee communities by intercropping with flowering basil (*Ocimum basilicum*) enhances pollination and yield of bell pepper (*Capsicum annuum*). Journal of Insect Conservation, v.19, n.3, p.479-486. (2015). 10.1007 / s10841-015-9768-3

PEREIRA, A. L. C. O manejo da fauna de abelhas pelo plantio associado de manjericão (*Ocimum basilicum* L.) e seu papel na produção de frutos e sementes do pimentão. 2013. 60 p. Dissertação (Mestrado em Bioengenharia) - Universidade Federal de São João Del Rei, São João Del Rei, 2013.

PEREZ, A. L. Bioecologia de *Symmetrischema dulce* (Lepidoptera: Gelechiidae) em pimenta. 52 f. Dissertação de mestrado. Universidade Federal de Viçosa. Viçosa, MG. 2012.

PINTO, C. M. F. Cultivo da pimenta. EPAMING, Belo Horizonte. 2006.

QUINTELA, E. D. Manejo integrado dos insetos e outros invertebrados pragas do feijoeiro. Informe Agropecuário, p. 113-136. 2004.

R Core Team. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria, 2017.

RISTORI, C. A.; PEREIRA, M. A. S.; GELLI, D. S. O efeito da pimenta do reino moída frente a contaminação in vitro com Salminella Rubslaw. Rev. Inst. Adolfo Lutz, v. 62, n. 2, p. 131-133, 2002

ROCHA, H. C. R.; ALVARENGA, C. D.; GIUSTOLIN, T. A.; BRANT, R. S.; SOUZA, M. D. C.; SARMENTO, H. G. S.; BRABOSA, M. G. Crescimento, produção de fitomassa e teor de óleo essencial de folhas de capim citronela (*Cymbopogon nardus* (L.) Rendle) em cultivo consorciado com algodoeiro colorido no semiárido mineiro. Revista Brasileira de Plantas Mededicinais, Botucatu, v.14, p.183-187, 2012. 10.1590/S1516-05722012000500010

SONG, B. Z.; WU, H. Y.; KONG, Y.; ZHANG, J.; DU, Y.; HU, J. H.; YAO, Y. C. Effects of intercropping with aromatic plantas on diversity and structure of na arthropod community in a pera orchard. BioControl, v. 55, n.6, p. 741-751. 2010. 10.1007 / s10526-010-9301-2

SOUZA, I. L. Controle biológico de pragas do pimentão (*Capsicum annuum* L.) orgânico em cultivo protegido associado a manjericão (*Ocimum basilicum* L.). 2014. 61 f. Dissertação (Mestrado em Entomologia) - Universidade Federal de Lavras, 2014.

TOGNI, P. H. B.; FRIZZAS, M. R.; MEDEIROS, M. A.; NAKASU, E. Y.; PIRES, C. S. S.; SUJII, E. R. Dinâmica populacional de *Bemisia tabaci* biótipo B em tomate monocultivo e consorciado com coentro sob cultivo orgânico e convencional. Horticultura Brasileira, Brasília, v. 27, n. 2, p. 183-188, 2009. 10.1590/S0102-05362009000200011

VENZON, M.; AMARAL, D. S. S. L.; PEREZ, A. L. Identificação e manejo ecológico de pragas da cultura da pimenta. Viçosa, MG: Unidade regional EPAMING Zona da Mata. 40 p. 2011.

VIEIRA, M. C.; CARLESSO, A.; ZÁRATE, N. A. H.; GONÇALVES, W. L. F.; TABALDI, L.A.; MELGAREJO, E. Consórcio de manjericão (*Ocimum basilicum* L.) e alface sob dois arranjos de plantas. Revista Brasileira de Plantas Medicinais, v.14, n.esp, p.169-174, 2012. 10.1590/S1516-05722012000500008