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Entomofauna associated with the cultivation of creeping tomato trees under different shading meshes

Entomofauna asociada a un cultivo de tomate rastrero bajo diferentes mallas de sombreamento

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ABSTRACT

This study aimed to determine the effects of protected and unprotected tomato cultivation on the insect population at the order level. The creeping tomato cv. Lampião was grown on white plastic mulching during the dry season and at high temperatures. Unprotected and protected tomato cultivation under different meshes, i.e., tunnels covered with agrotextile, organza, red, silver, and black shading, were evaluated. Pitfall traps buried at ground level were used to monitor insects inside the medium. We found 16 orders and one class (Arachnid) in the cultivation of creeping tomato, totaling 6,895 individuals collected in 36 traps in an area of 385.2 m^2. The orders Hymenoptera, Coleoptera, and Diptera were the most representative, with relative frequencies of 59.4%, 10.4%, and 8%, respectively. The open field cultivation had the highest number of insects collected, totaling 2,639 individuals, with the order Hymenoptera representing 72.5% of the insects collected in this environment. The environments covered with organza and agrotextile provided fewer insects, 665 and 646 individuals, respectively. The reason for this was the increased physical barrier provided by these meshes, i.e., they presented a tighter mesh. Among the tomato development stages, the fruit maturation stage showed a higher number of insects collected.
Keywords: Colored meshes, insects, organza fabric, *Solanum lycopersicum*.

RESUMEN

Este estudio tuvo como objetivo determinar los efectos del cultivo de tomate protegido y no protegido sobre la población de insectos a nivel de orden. El tomate rastrero cv. Lampião se cultivó en mantillo plástico blanco durante la estación seca ya altas temperaturas. Se evaluó el cultivo de tomate sin protección y el cultivo de tomate protegido bajo diferentes mallas, es decir, túneles cubiertos con agrotextil, organza y sombreado rojo, plateado y negro. Usamos trampas de caída enterradas a nivel del suelo para monitorear insectos en el medio ambiente. Encontramos 16 órdenes y una clase (Arácnido) en el cultivo de tomates rastreros, totalizando 6.895 individuos recolectados en 36 trampas en un área de 385,2 m^2*. Los órdenes Hymenoptera, Coleoptera y Diptera fueron los más representativos, con frecuencias relativas de 59,4%, 10,4% y 8%, respectivamente. El cultivo a campo abierto tuvo el mayor número de insectos recolectados, totalizando 2.639 individuos, representando el orden Hymenoptera el 72,5% de los insectos recolectados en este ambiente. Los ambientes cubiertos con organza y agrotextil proporcionaron menos insectos, 665 y 646 individuos, respectivamente. Esto ocurrió debido a la mayor barrera física que brindaban estas mallas, es decir, presentaban una red más cerrada. Entre las etapas de desarrollo del tomate, la etapa de maduración del fruto tuvo el mayor número de insectos colectados.*
Palabras Clave*: Mallas de color, insectos, tela de organza,* Solanum lycopersicum.

Introduction

The tomato tree is the greenery with the most economic importance in the world. In Brazil, Brazilian production went from 3.73 million tons in 2016 to 4.23 million tons in 2017, in an area of 58.548 thousand hectares to 61.6 thousand hectares (FAOSTAT, 2019).

The cultivation of tomato trees is affected by the high infestation of pest insects that cause direct and indirect damage to the plant and its fruits; however, these insects suffer from countless trophic and ecological interactions that influence the balance of the agroecosystem, interfering with the level of economic damage in the cultivation (Picanço *et al*., 2010).

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The damage caused by pests can cause losses of up to 100% in production, making cultivation unfeasible (Moura *et al.*, 2015). The main pest insects in the cultivation of tomato trees are the tomato tree moth (*Tuta absoluta*), borers (*Neoleucinodes elegantalis* and *Helicoverpa zea*), white fly (*Bemisia tabaci*), and aphids (*Myzus persicae*), all belonging to arthropods. These arthropods infest all plant development stages (Moura *et al.*, 2014). However, in this phylum, many natural enemies act as predators and parasitoids, such as *Macrolophus basicornis* (Stal) (Hemiptera: Miridae) and *Trichogramma pretiosum* Riley (Hymenoptera Trichogrammatidae) (Ferracini *et al.*, 2019; Van Lenteren *et al.*, 2016).

Studies on entomofauna in different environments are usually performed in cultivations of agricultural interest, looking to obtain information about biodiversity and ecological relations that subsidize the integrated management of pests by the recognition of pests and natural enemies, pollinators, and insects that indicate environmental quality (Teixeira; Comerio, 2017; Costa *et al.*, 2016; Walker *et al.*, 2011).

The high level of pests and diseases can limit the cultivation of the tomato tree in some times and regions of the country due to the lack of effective control and high application of pesticides, significantly increasing the cost of production (Lopes; Ávila, 2005). The physical barriers can be used in the management of pests in the cultivation of tomato trees; between these, it is possible to name the cultivation protected with the use of meshes that reduce the infestation of pest insects and reduce the environmental risks, such as radiation and excessive rainfall (Fufa *et al.*, 2009).

Few studies have evaluated the effect of protected environments covered with meshes in the presence of insects in the tomato tree and the use of organza to cover the low tunnels to agricultural cultivation; this was only reported in kale cultivation, which showed promising results (Seabra *et al.*, 2019). However, there are no reports on tomato tree cultivation, so this paper evaluated the protection of the covering mesh in the cultivation of creeping tomato trees under white plastic mulching, an option for managing pest insects.

However, studies are reporting the effect of black and colored shading meshes on insects, i.e., these cause changes in the spectrum of transmitted and reflected radiation, which influences the disorientation and attraction or repellency of insects (Shahak *et al.*, 2008).

A more specific understanding of the effect of different covering meshes in the presence of insects in the creeping tomato tree crop is important to understand the population dynamics and to catch a glimpse of the technical viability of applying this technology. In this way, this paper's goal is to determine the effects of protected and unprotected cultivation of tomato trees on infestation by insects.

Materials and methods

The experiment was conducted in the dry season, with high temperatures, from June to October 2018, in Nova Mutum, MT, located at the coordinates 13º 05' 04" South latitude and 56º 05' 16" West longitude. The soil is classified as Ferralsol, and the climate is Aw, tropical, according to the Köppen climate classification.

For planting, the Italian tomato hybrid of a determined habit, Lampião (Agristar), was used in a creeping system over double-face mulching, white/black, with the white face exposed. The plants were spaced with 0.40 x 1.70 m spacing and a density of 14705 plants per hectare.

The treatments were unprotected and protected tomato tree crops. For the protected environments, a low tunnel was used, with a thickness of 1.3 m and a length of 8 m, completely sealed with mesh. Five different meshes were evaluated: the white agrotextile in polyethylene with a grammage of 15 g/m², white organza without shine (47 g/m²), and three shading meshes with approximately 35% light blockage, in colors red (Chromatinet®), silver (thermal reflective screen Aluminet®) and black (Sombrite®) (Figure 1a and 1b).

Drip irrigation and fertilization were performed by fertigation according to the needs of the tomato crop. During the experimental period, maintenance cultural treatments were carried out by applying phytosanitary products when the infestation of pests and the incidence of diseases reached the level of control in each environment, according to the IPM (integrated pest management) for the tomato crop.

The monitoring of the presence of insects was performed by Pitfall traps, consisting of hard transparent acrylic cups with a 350 mL capacity and 10 cm diameter, which were buried at ground level (Figura 2a and 2b). The cups contained a solution of salted water (5%) and a few drops of neutral detergent to break the surface tension of the water. Two traps were installed per environment,

Figure 1. Partial view of two cultivation environments with no weed cover for the cultivation of the rasteiro tomato.

Figures 2. Pitfall-type cabinets installed in low tunnel-type environments with different covers.

with four replications totaling 48 traps distributed in the experimental area.

Insect collection was carried out at different phenological stages of the tomato tree, with the vegetative phase 27 to 41 DAS, reproductive 46 to 60 DAS, fruit filling 61 to 75 DAS, and maturation 95 to 104 DAS. In each stage, the traps remained for 21 days and were changed at intervals of 7 days in each cultivation environment.

Insect collections were carried out with the aid of sieves made of voile fabric, packed with plastic tubes, duly labeled (date, production environment, and replication), and filled with 70% alcohol. The samples were sent to the entomology laboratory at Mato Grosso State University, Tangará da Serra Campus, for screening and identification of orders.

The number of individuals was counted within each order, and the relative frequencies (RF) were calculated for the orders detected in the survey of each environment. In this way, the following formula was used:

$RF\% = n/Nx100$

Where:

RF = Frequency percentage;

n = number of individuals in the order;

N = total number of captured individuals.

The captured insects were organized in a 6 x 4 factorial scheme, with six production environments divided by periods consistent with four phenological stages of the tomato tree (vegetative, reproductive, fruit filling, and maturation). The averages obtained were submitted to an analysis of variance, homogeneity, and normality of the data; when significant, they were submitted to the Scott–Knott test ($p < 0.05$) using SISVAR 5.3 software.

Results and discussion

In the total area of tomato cultivation (385,2 m^2), 6895 arthropods were collected in 36 traps, composing 16 orders: Hymenoptera, Coleoptera, Diptera, and Hemiptera divided into two suborders (Heteroptera and Homoptera), Dermaptera, Orthoptera, Thysanoptera, Lepidoptera, Diplopoda, Isopoda, Quilopoda, Isoptera, Neoroptera, Odonata and Blattodea, in addition to the Arachnid class (Table 1).

The orders Hymenoptera, Coleoptera, and Diptera were the most representative, with relative frequencies of 59.4%, 10.4% and 8%, respectively. The predominance of these orders can be explained by the large number of species that compose them, as well as their wide geographical distribution (Gallo *et al.*, 2002).

The unprotected cultivation area, i.e., in the open field, exposed the most significant number of individuals collected (2639) since this environment did not have any protection barrier (Table 1). In the protected cultivation areas covered with agrotextile and organza, the smallest number of insects, 646 and 665 individuals, respectively, were captured. Agrotextile mesh has been used in the cultivation of melon and watermelon, aiming to protect the plants against attacks of pest insects since its use has effective results in improving the quality and reducing the use of agrochemicals (Medeiros *et al.*, 2008).

The protected environment covered with red mesh presented the highest number of collected insect orders (16), which means greater diversity (Table 1). Insects can be attracted to colors, which act as a way of recognizing resources, as they have long photoreceptor fibers that are able to perceive them. (Skorupski; Chittka, 2010; Wanga *et al.*, 2013).

Agrotextile is made from long polypropylene filaments that are layered and welded, constituting a light material and enough strength for its use in agriculture (Barros Júnior *et al.*, 2004). Organza is a novelty in agricultural use, made of 100% polyester, has a delicate, light, and transparent texture, and recently began to be used as a plant covering (Seabra Júnior *et al.*, 2019). Both materials mentioned above contributed to the smaller amount of insects collected in these environments, as they act as a physical barrier due to the closed mesh. In addition, clear surfaces reflect light, inhibiting insect infestation (Simmons *et al.*, 2010).

The order Hymenoptera, which constitutes one of the most significant orders of Insecta and includes wasps, bees, and ants, had the highest number of

Table 1. Number of individuals (Nº ind.) and relative frequency (RF (%)) of the orders of two collated insects in the culture of tomato rasteiro, in different cultivation environments.

	Open field		Agrotextile		Organza		Black		Silver		Red		Total	
	Nº ind.	FR (%)	Nº ind.	FR (%)	Nº ind.	FR (%)	Nº ind.	FR (%)	Nº ind.	FR (%)	Nº ind.	FR (%)	Nº ind.	FR (%)
Hymenoptera	1912	72,5	274	42,4	340	51,1	570	55,4	544	61,1	455	44,4	4095	59,4
Coleoptera	214	8,1	93	14,4	86	12,9	120	11,7	91	10,2	110	10,7	714	10,4
Diptera	114	4,3	76	11,8	73	11,0	122	11,9	52	5,8	139	13,6	576	8,4
Hemiptera Heter.	111	4,2	32	5,0	33	5,0	54	5,2	47	5,3	78	7,6	355	5,1
Hemiptera Hom.	39	1,5	31	4,8	18	2,7	34	3,3	40	4,5	26	2,5	188	2,7
Aracnideo	99	3,8	69	10,7	41	6,2	49	4,8	43	4,8	54	5,3	355	5,1
Dermaptera	60	2,3	30	4,6	24	3,6	32	3,1	30	3,4	24	2,3	200	2,9
Orthoptera	25	0,9	21	3,3	18	2,7	16	1,6	12	1,3	57	5,6	149	2,2
Thysanoptera	22	0,8	3	0,5	7	1,1	6	0,6	7	0,8	34	3,3	79	1,1
Lepidóptera	22	0,8	7	1,1	13	2,0	9	0,9	6	0,7	19	1,9	76	1,1
Diplopoda	9	0,3	4	0,6	3	0,5	6	0,6	9	1,0	16	1,6	47	0,7
Isopoda	6	0,2	3	0,5	0	0,0	7	0,7	7	0,8	3	0,3	26	0,4
Quilopoda	3	0,1	3	0,5	3	0,5	3	0,3	3	0,3	3	0,3	18	0,3
Isoptera	0	0,0	0	0,0	6	0,9	0	0,0	0	0,0	0	0,0	6	0,1
Neoróptera	3	0,1	0	0,0	0	0,0	1	0,1	0	0,0	1	0,1	5	0,1
Odonata	0	0,0	0	0,0	0	0,0	0	0,0	0	0,0	3	0,3	3	0,0
Blattodea	0	0,0	0	0,0	0	0,0	0	0,0	0	0,0	3	0,3	3	0,0
Total	2639	100	646	100	665	100	1029	100	891	100	1025	100	6895	100,0

insects for all environments cultivated with tomato trees (Table 1). In the open field, these insects were prevalent, with 1912 individuals, representing 72.5% of the total. When soils are disturbed or there is no ecological balance, this group can manifest changes in its population to express these disturbances. According to Rovedder (2009), its presence can be related to the low natural fertility of the studied soil.

Hymenopterans are highly abundant in nature and occupy several types of environments (Hanson; Gauld, 2006), perform a wide variety of ecological functions, and can act as herbivores, pollinators, predators, and parasitoids (Lasalle; Gauld, 1993; Hanson; Gauld, 2006). The order Hymenoptera stands out for its functional aspects, influencing the regulation of the ecological balance (Assad, 1997).

The order Coleoptera was the second largest number of individuals collected during the present study (714 individuals), with more relative frequency in the environment covered with agrotextile, representing 14.4% (Table 1). Insects of this order have different ecological functions, both in forests and in agricultural areas, as they feed on leaves, plant remains, and other arthropods, so their diverse eating habits attribute survival conditions to different habitats (Gullan; Craston, 2008). Coleopterans can help control pests and weeds; however, some species can cause damage to several crops of agronomic importance, such as tomatoes, soybeans, and corn (Adjei *et al.*, 2006; Silva *et al.*, 2010).

The environments covered with red and black mesh had the most significant number of individuals collected of the order Diptera (139 and 122 individuals, respectively) and a higher relative frequency totaling 13.6% and 11.9%, respectively (Table 1). This order is essential to the restoration of areas, performing a crucial role in colonizing environments and the cycling of nutrients through its phytoprophagous, microphagous, and mycophagous larvae (Correia, 2002).

In the tomato tree, dipterans can compromise the production and quality of the fruit because most of the insects belonging to this order are suckers or miners, affecting the photosynthetic capacity of the plant by sap suction (Villas Bôas *et al.*, 1997).

The collected individuals belonging to the order Hemiptera were also significant since most of the members of this order are considered tomato tree pests and, therefore, are attracted according to the availability of food and location for reproduction (Gallo *et al.*, 2002). The environment covered with red mesh had a higher relative frequency of individuals belonging to the orders Hemiptera, Heteroptera, and Hemiptera homoptera (10.1%) (Table 1).

In the tomato trees in the open field, the largest number of individuals belonging to the Arachnid class (99 individuals) was collected. However, in the agrotextile-covered environment, the relative frequency of these arthropods was higher, representing 10.7% of all arthropods collected in this environment. Spiders are effective agents in biological control and act directly on the pest arthropods, feeding on part or all of the prey's body (Gazzoni; Yoriniori, 1995).

The presence of other orders, even in smaller proportions, is also fundamental for the balance of production environments, mainly in the energy flow of the food chains. Dermapterans are known worldwide for having predatory species of other arthropods, and they are fundamental in programs of biological control of pests in agricultural systems (Pasini *et al.*, 2010; Pasini; Parra; Lopes, 2007), thus configuring themselves as potential biological control agents for tomato crops. Insects of the order Thysanoptera were collected in greater abundance in the environment covered with red mesh (34 individuals) (Table 1) and require studies on several aspects related to this group since it comprises both species considered pest insects as natural enemies (predators) (de Bortoli *et al.*, 2008; Azevedo; Nascimento, 2009; Giustolin *et al.*, 2009).

Lepidopterans, with the largest number of individuals collected in open fields (22 individuals), are considered the main pest insects for the tomato crop. In this group is the tomato moth (Tuta absoluta), which can cause losses of 100% if adequate control measures are not taken (Guedes; Picanço, 2012). The larvae of these insects attack plants in any stage of development, making galleries (mines) in the leaves, branches, and, mainly, in the apical buds, where they destroy sprouts, in addition to the fruits that are depreciated for commercialization (Gallo *et al.*, 2002). This insect has become a key threat to the world's production of tomatoes since it invaded Europe, Africa, and Asia in the last decade (Desneux *et al.*, 2010; Campos *et al.*, 2017).

Members of this order also directly attack the fruits of tomato trees, and because borers develop inside the fruits, detection, and control become very hard (Moraes; Foerster, 2015). The low relative frequency of Lepidopterans collected in this study is due to the type of trap used. Light traps and pheromones are ideal for capturing individuals of this order (Garlet, 2016; Specht *et al.*, 2005).

The open field had the highest averages of insect collection in all development stages of the tomato tree (Table 2). This result was already expected since this environment has no protection against insects. Several authors have already reported a higher incidence of insects in open fields than in environments covered with colored meshes (Gogo *et al.*, 2014; Caroline *et al.*, 2017).

The environments covered with agrotextile and organza did not show significant differences between themselves during tomato tree development (Table 2). These two environments had the lowest averages of individuals collected (98 and 79 individuals, respectively), mainly during the fruit maturation stage, the period with the highest number of individuals collected in the other environments. These coverings have closed mesh, a factor that prevents the entry of insects. In the food search, flying insects make probing landings, and when the covering mesh of the protected environments is more closed, they stay put for a while and move away; in addition, the smooth surfaces induce the rejection flight (Kring, 1972; Doëring *et al.*, 2004). Caroline *et al.* (2016) suggested that covering meshes of light colors (such as organza and agrotextile used in this study) causes insects disorientation, reducing the incidence inside the environment.

During the vegetative stage, the environments covered with agrotextile, organza, and red mesh were more efficient in reducing insects inside (Table 2). The environment covered with silver mesh also protected the entry of insects. The light diffusion provided by the silver mesh is an insect-repellency factor due to the reflective effect (POLYSACK, 2016).

During the fruit maturation stage, the most significant number of individuals was collected in all environments (Table 2). This fact is due to the higher food supply; in this period, the tomato trees are fully developed and have ripe fruits, which are attractive to insects. The leaf area and favorable microclimate created by the tomato tree provide an ideal environment for insect infestation (Naika *et al.*, 2006).

Colored meshes filter UV radiation between 280-400 nm, interfering in the insects' vision and, as a result, in the behavior related to the movement, also interfering in the localization capacity and its population parameters (Diaz Fereres, 2007).

Conclusion

The presence of 16 orders of arthropods and one class (Arachnid) was associated with creeping tomato cultivation, with 6,895 insects collected in total, revealing a wide diversity of entomofauna in this agroecosystem.

The open field presented the highest number of individuals collected, with 72.5%, represented by the order Hymenoptera.

The protected environments were more efficient in reducing the number of insects in tomato tree cultivation than the open field, and the environments covered with organza and agrotextile presented fewer insects, with 665 and 646 individuals, respectively.

Among the phenological stages of the tomato tree, the fruit maturation period presented a higher incidence of insects.

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Table 2. Number of individuals collected in four stages of development of the raster tomato cultivated in six environments (open field, agrotextile, organza, black, silver and vermelho).

Environments	Table			
	Vegetative	Reproductive	Fruiting	Maturation
Open field	80,3 ± 15,3 aC	103,0 ± 12,0 aC	143,3 ± 21,2 aB	553,0 ± 65,7 aA
Agrotextile	27,3 ± 2,5 bB	35,0 ± 2,9 bB	55,0 ± 4,5 bB	98,0 ± 13,4 eA
Organza	40,3 ± 6,5 bB	55,3 ± 10,2 bB	47,0 ± 3,3 bB	79,0 ± 4,1 eA
Black	57,6 ± 8,7 aB	56,0 ± 7,1 bB	70,0 ± 2,2 bB	159,3 ± 11,9 cA
Silver	55,6 ± 4,8 aB	54,3 ± 5,9 bB	55,3 ± 9,9 bB	131,6 ± 13,3 dA
Red	40,3 ± 1,7 bB	53,3 ± 8,7 bB	53,0 ± 5,0 bB	195,0 ± 29,1 bA
CV (%)		17,93		

Means followed by a lowercase letter in the column and uppercase in the line do not differ from each other by Scott Knott's test at 5% probability.

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Litrature cited

Assad, M.L.L.
1997. Fauna do solo. En: Teixeira, M.; Hungria, M. (Ed.). Biologia dos solos dos Cerrados. Embrapa. Planaltina, Brasil. pp. 363-443.

Barros Júnior, A.P.; Grangeiro, L.C.; Bezerra Neto, F., Negreiros, M.Z.; Souza, J.O.; Azevedo, P.E.; Medeiros, D.C.
2004. Cultivo da alface em túneis baixos de agrotêxtil. *Horticultura Brasileira,* 22: 801-803.

Campos, M.R.; Biondi, A.; Adiga, A.; Guedes, R.N.; Desneux, N.
2017. From the Western Palaearctic region to beyond: Tuta absoluta 10 years after invading Europe. *Journal of Pest Science,* 90: 787-796.

Caroline, L.J.; Saidi, M., Opiyo, A.
2017. Effect of Coloured Agro-Net Covers on Insect Pest Control and Yield of Tomato (*Solanum lycopersicon* Mill). *Journal of Agricultural Science,* 9(12): 283-293.

Correia, M.E.F.
2002. Potencial de Utilização dos Atributos das Comunidades de Fauna de Solo e de Grupos Chave de Invertebrados como Bioindicadores do Manejo de Ecossistemas. Embrapa Agrobiologia-Documentos (INFOTECA-E). Brasilia, Brasil. 13 p.

Costa, E.M.; Araujo, E.L.; Fernandes, D.R.R.; Silva, P.; Junior, R.
2016. Diversidade e métodos de amostragem de Hymenoptera na cultura da melancia no semiárido. *Horticultura Brasileira* 34(2): 257-264.

Díaz, D.B.M.; Fereres, A.
2007. Ultraviolet-Blocking Materials as a Physical Barrier to Control Insect Pests and Plant Pathogens in Protected Crops. *Pest technology,* 1: 85-95.

FAOSTAT.
2019. Harvested area, yield and production in the main tomato producing countries (2019). Food and Agriculture Organization of the United Nations. Abailable at: http://faostat.fao.org/>. Consulted: 09/dic/2019.

Ferracini, C.; Bueno, V.H.P.; Dindo, M.L.; Ingegno, B.L.; Luna, M.G.; Salas Gervassio, N.G.; Sánchez, N.E.; Siscaro, G.; van Lenteren, J.C.; Zappalà, L.; Tavella, L.
2019. Natural enemies of *Tuta absoluta* in the Mediterranean basin, Europe and South America. *Biocontrol Science and Technology,* 29: 578-609.

Fufa, F., Hanson, P.; Dagnoko, S.; Dhaliwal, M.
2011. AVRDC - The world vegetable center tomato breeding in Sub-Saharan Africa: Lessons from the past, present work, and future prospects. *Acta Horticulturae,* 911: 87-98.

Gallo, D., Nakano, O., Silveira Neto, S., Carvalho, R.L., Batista, G.D., Berti Filho, E., Parra, J.R.P.; Zucchi, R.A.; Alves, S.B.;Vendramim, J.D.; Marchini, L.C.; Lopes, J.R.S.; Omoto, C.
2002. Entomologia agrícola. Agronômica Ceres. São Paulo, Brasil. 649 p.

Garlet, J.; Costa, E.C.; Boscardin, J.
2016. Levantamento da entomofauna em plantios de *Eucalyptus* spp. por meio de armadilha luminosa em São Francisco de Assis - RS. *Ciência Florestal*, 26(2): 365-374.

Gazzoni, D.L.; Yoriniori, J.T.
1995. Manual de identificação de pragas e doenças da soja. Embrapa, Serviço de Produção de Informação. Brasilia, Brasil. 128 p.

Giustolin, T.A.; Lopes, J.R.S.; Querino, R.B.; Cavichioli, R.R; Zanol, K.; Azevedo Filho, W.S.; Mendes, M.A.
2009. Diversity of hemiptera auchenorrhyncha in citrus, coffee and a fragment of native forest of the state of são Paulo. *Neotropical entomology,* 38(6): 834-83441.

Guedes, R.N.C.; Picanço, M.C.
2012. The tomato borer *Tuta absoluta* in South America: Pest status, management and insecticide resistance. *EPPO Bulletin,* 42(2): 211-216.

Hanson, P.E.; Gauld, I.D.
2006. Hymenoptera de la región Neotropical. American Entomological Institute. Gainesville, FL,U.S. 994 p.

Seabra Júnior, S.; Ponce, F.S.; Toledo, C.A.L.; Zanuzzo, M.R.; Dallacort, R.; Pereira Lima, G.P.
2019. Does Knitted Shade Provide Temperature Reduction and Increase Yield Kale? *Journal of Agricultural Science,* 11: 103-111.

Kring, J.B.
1972. Flight Behavior of Aphids. *Annual Review of Entomology*, 17: 461-492.

Medeiros, E.V.; Serafim, E.C.S.; Granjeiro, L.C.; Sobrinho, J.E.; de Negreiros, M.A.; Júnior, R.S.
2008. Influência do agrotêxtil sobre a densidade populacional de *Monosporascus cannonballus* em solo cultivado com melancia (*Citrullus lanatus*). *Ciência e Agrotecnologia* 32(3): 797-803.

Moura, A.P.
2015. Manejo Integrado de Pragas: Estratégias e Táticas de Manejo para o Controle de Insetos e Ácaros-praga em Hortaliças. Circular Técnica 141. Embrapa Hortaliças. Brasilia, Brasil. 28 p.

Pasini, A.; Parra, J.R.P.; Nava, D.E.; Butnariu, A.R.
2010. Exigências térmicas de *Doru lineare* Eschs. e *Doru luteipes* Scudder em laboratório. *Ciência Rural*, 40(7): 1562-1568.

Rovedder, A.P.M., Eltz, F.L.F., Drescher, M.S., Schenato, R.B.; Antoniolli, Z.A.
2009. Organismos edáficos como bioindicadores da recuperação de solos degradados por arenização no Bioma Pampa. *Ciência Rural,* 39(4): 1061-1
2008. Photoselective shade netting integrated with greenhouse technologies for improved performance of vegetable and ornamental crops. *Acta Horticulturae,* 797: 75-80.

Silva, R.J.; Marques, M.I.; Battirola, L.D.; Lhano, M.G.
2010. Fenologia de *Cornops aquaticum* (Bruner) (Orthoptera: Acrididae) em *Eichhornia azurea* (Pontederiaceae) no Norte do Pantanal de Mato Grosso. *Neotrop entomol*, 39: 535-542.

Teixeira, A.F.R.; Comerio, E.F.
2017. Mirmecofauna associada ao cultivo de *Cocos nucifera* L. CV. anã verde em Linhares, ES. En: Congresso de Ecologia

do Brasil. Sociedade de Ecologia do Brasil. São Lourenço, Brasil.

Van Lenteren, J.C.; Hemerik, L.; Lins, J.C.; Bueno, V.H.P. 2016. Functional Responses of three neotropical mirid predators to eggs of *Tuta absoluta* on tomato. *Insects*, 7(34): 1-10.

Villas Bôas, G.L.; França, F.H., Ávila, A.C.; Bezerra, I.C. 1997. Manejo integrado da mosca-branca *Bemisia argentifolii*. Circular Técnica da Embrapa Hortaliças 9. EMBRAPA-CNPH. Brasilia, Brasil. 11 p.

Wang, H., Conchou, L., Bessière, J.M., Cazals, G.; Schatz, B.; Imbert. E. 2013. Flower color polymorphism in Iris lutescens (Iridaceae): Biochemical analyses in light of plant-insect interactions. *Phytochemistry* 94: 123-134.