Revista Agrogeoambiental, Pouso Alegre, v. 13, n. 2, p. 242-251, jun. 2021. DOI: http://dx.doi.org/10.18406/2316-1817v13n220211589

Ginger extract as an alternative to thrips (*Thrips tabaci*) control in hydroponic lettuce

Synara Silva[1], Marcelo Antônio de Sousa Gouvêia[2], Sylmara Silva[3], Luciano Donizete Gonçalves[4], Rafael Pereira[5]

[1] Universidade Federal de Lavras (UFLA). Mestranda em Fitotecnia. synarasilv@gmail.com.

[2] Instituto Federal de Educação, Ciência e Tecnologia de Minas Gerais (IFMG) - *Campus* Bambuí. Discente no curso em Agronomia. marcelogouveiatc@gmail.com.

[3] UFLA. Doutoranda em Fitotecnia. sylmara-silva@hotmail.com

[4] IFMG - *Campus* Bambuí. Professor orientador e pesquisador. lucianogoncalves@ifmg.edu.br.

[5] UFLA. Laboratorista. rafaell.pereira@ufla.br.

Received in: November 18, 2020 | **Accepted in:** March 30, 2021

Abstract

Ginger has a large number of essential oils, zingiberene is the major substance found in it, which may be linked to the insecticidal activity of the plant. Therefore, it can be a viable alternative to replace the use of pesticides for pest control. The objective of this work was to evaluate the use of this ginger-based extract in hydroponic lettuce as an alternative to thrips control. The experiment was carried out in a randomized block design, with five treatments and four replications. The treatments used were the concentrations of 0 %, 20 %, 40 %, 60 %, and 80 % weight/volume of aqueous extract. After 45 days of sowing, the ginger plant extract was applied to the lettuce plants every seven days. A population of thrips was monitored using adhesive traps attached above each experimental plot once a week until harvest. In addition, fresh mass weight, shoot height, and incidence of direct damage to the crop were evaluated. Regarding thrips monitoring, no differences were observed indicating the uniformity of the population level among the lettuce parcels. For the evaluation of weight and fresh mass, no differences were observed regarding the treatments. However, from the concentration of 60 %, it was observed the lowest averages of plants with direct damage, showing that the higher the concentration of the solution the lesser insect feeding. Accordingly, the use of ginger plant extract in hydroponic lettuce becomes a promising alternative for reducing thrips feeding on lettuce.

Keywords: Natural insecticides. Alternative control. Protected cultivation. Hydroponics. Insecticidal property.

Introduction

Lettuce (*Lactuca sativa* L.) is considered the leafy vegetable with the highest consumption by the world population, with widespread cultivation in several countries around the world both in cultivated area and in productivity (LOBO, 2018). Among the largest producers, China stands out followed by the United States, India, Spain, Italy, Japan, Iran, Belgium, Mexico, and Turkey (FAO, 2019).

In Brazil, lettuce has great economic, social, and nutritional relevance. According to the Brazilian Horticulture Yearbook (2018), the national volume produced in 2018 was 575.5 thousand tons, in an area of 86,800 hectares. The cultivation is usually carried out by family farming, which gives it social relevance with the creation of jobs and income during the year for the families, increasing the local purchasing power (AGUIAR; DELGROSSI; THOMÉ, 2018). Regarding nutritional importance, the daily consumption of lettuce provides the intake of several nutrients with low caloric value (SUINAGA *et al.*, 2013), preventing cardiovascular diseases and cancer (SILVEIRA, 2018).

Nevertheless, during the development of the crop, there are several phytosanitary problems caused by pests. Thrips (*Thrips tabaci*) is considered one of the main agricultural pests and on lettuce, it is one of the main vectors of viruses. The virus transmission occurs during thrips feeding, in which the infected plants present wrinkled leaves and, consequently, the commercial devaluation of the product (BRANDÃO FILHO *et al.*, 2011). The attack of this pest can also increase the susceptibility to the penetration of fungi and bacteria due to leaf lesions, in addition to making seed production unfeasible (CARVALHO, 2017; ZAWADNEAK *et al.*, 2015).

Currently, the phytosanitary management of thrips in the lettuce crop is based especially on intensive applications of chemical pesticides to reduce the insect population level, even though its indiscriminate use generates numerous problems (MARANGONI; MOURA; GARCIA, 2012). Consumers are increasingly concerned about the management of pests and diseases in agricultural crops, and the constant search for more sustainable production strategies is important.

Therefore, the integrated pest management (IPM) emerged in response to the use of pesticides aiming at the simultaneous use of various managements in an economical and harmonious way with the environment through less exposure of farmers to insecticides and, consequently, reduction of rates of toxic residues in vegetables (PEREIRA; PINHEIRO; CARVALHO, 2013).

Within the IPM, the use of plant extracts is an old practice and becomes an important control strategy. The extracts are obtained from renewable resources, and they have favorable toxicological properties, cause less effect on non-target organisms, rapid degradation in the soil, not accumulating in the environment, besides offering greater safety for the consumer (VASCONCELOS; GODIM; BARROS, 2006).

Plant extracts have the possibility of being produced by the producers themselves, reducing production costs, in addition to being accepted within organic production systems. Despite the great diversity of existing plants in Brazil, which makes the country prosperous in identifying natural sources for the development of new products, there is a lack of characterization given the high number of species.

The species belonging to the Zingiberaceae family have great insecticidal potential (ALMEIDA, 2012). Among the plants of the family, ginger (*Zingiber officinale roscoe*) is a plant that has the ability to produce essential oils in large quantities. Ergo, it has the potential as an insecticidal plant to be used in production systems (LOPES *et al.*, 2011).

Accordingly, it is extremely important that selective insecticides are used for a particular pest promoting the preservation of species that are beneficial to the agroecosystem and environmental interactions. Despite its importance as a natural control alternative, currently, there are few studies on the use of these compounds in agricultural crops.

The use of an alternative defensive made from ginger can be an option for the control of thrips in hydroponic lettuce, which allows the reduction of agrochemicals, with more sustainable production, in addition to generating higher quality food and less contamination.

Thus, the objective of this work was to evaluate the use of different concentrations of aqueous extract based on ginger in hydroponic lettuce as an alternative to thrips (*Thrips tabaci*) control.

Material and methods

The work was held in the Horticulture Sector of the Federal Institute of Education, Science, and Technology of Minas Gerais (IFMG) - *Campus* Bambuí, between July and October 2018. The institution is located in the municipality of Bambuí-MG, in geographic coordinates, latitude 20°02'13" S, longitude 46°00'34" W, and altitude 681 meters (GOOGLE EARTH, 2021).

The experiment was accomplished on plants grown in an NFT (Nutrient Film Technique) hydroponic system and a greenhouse. The nutrient solution had a pH between 5.5 to 6.5 to maximize the absorption of nutrients by the lettuce. The composition of the nutrient solution and the adjustment solution are reported below as shown in Tables 1 and 2.

Table 1 – Quantity of salts for the preparation of 2,000 liters of nutrient solution.IFMG – *Campus* Bambuí. Bambuí/MG, 2018.

N°	Fertilizers	Nutrients	g/ 2,000 L
1	Calcium nitrate	N, Ca	2,500
2	Potassium chloride	K	760
3	Monoammonium phosphate - MAP	N, P	300
4	Magnesium sulfate	Mg e S	800
5	Micronutrients	B, Cu, Fe, Mn, Mo, Ni e Zn	50

B = Boron; Ca = Calcium; Cu = Copper; Fe = Iron; K = Potassium; Mg = Magnesium; Mn = Manganese; Mo = Molybdenum; N = Nitrogen; Ni = Nickel; P = Phosphorus; S = Sulphur; Zn = Zinc.

Source: Furlani (1997).

Table 2 – Nutritional adjustment solution. IFMG - Bambuí *Campus*. Bambuí/MG, 2018.

Solution	Fertilizers	Nutrients	g/ 50 L
A	Calcium nitrate	N, Ca	3,000
	Micronutrients	B, Cu, Fe, Mn, Mo, Ni e Zn	75
B	Potassium chloride	K	4,500
	Monoammonium phosphate - MAP	N, P	1,000
	Magnesium sulfate	Mg e S	1,200

Source: Furlani (1997).

The purchase of ginger took place on a family farm, near the municipality of Bambuí – MG. The collection of rhizomes was carried out weekly, every seven days. To prepare the plant extract, 600 grams of crunched ginger were placed in two liters of distilled water. The solution was sieved and diluted at concentrations of 0 %, 20 %, 40 %, 60 %, and 80 % weight/volume, using distilled water. The plant extract was stored in dark-colored glass containers for one day.

The experiment was implemented in a randomized block design, consisting of five treatments, four replications, and 20 plants per plot. The treatments tested were the concentrations: T1 – 0 %, T2 – 20 %, T3 – 40 %, T4 – 60 % and T5 – 80 % weight/volume. Each plot received an adhesive trap in the central part attached 20 cm above the plants to capture adult insects.

Lettuce seedlings of the Vanda cultivar were produced in styrofoam trays with 128 cells, containing Maxfertil commercial substrate that has composted pine bark, vermiculite, and basic fertilizer. About 30 days after sowing, the seedlings presented good vegetative development, relating to the aerial part and root system. Thus, the lettuce seedlings were transplanted to the hydroponic system and an adhesive trap was implanted per experimental plot (Bio Trap Adhesive Plates - Blue), with a dimension of 10 cm x 12.5 cm, centered in the plot and fixed above the plants by a ribbon.

The traps were placed to quantify the insect population during the development of the culture, in addition to observing the population increase in a certain stage of the culture. Accordingly, seven days after transplanting a quantitative survey of the initial incidence of thrips in the lettuce crop was conducted, in which the traps were removed by manually counting thrips in each experimental plot. Then, new adhesive plates were placed and these were not removed until the moment of harvesting the lettuce.

The application of the ginger plant extract was performed, after transplanting, every seven days with the aid of a spray bottle spraying on all lettuce leaves until full leaf coverage by the product, totaling 21 days. Before each application, the thrips population was manually counted to assess the increase in pest incidence during the production cycle.

The evaluations were undertaken during harvest, analyzing only the central plants, totaling six plants per plot. The analyzes consisted of quantifying the number of thrips in the traps during vegetative development, fresh mass weight (g), plant height (cm), and the incidence of direct damage from thrips feeding on the leaves.

To determine the fresh mass weight, a precision scale was used. As for the height assessment, the measurement was performed from the base of the plant to the maximum point of the lettuce head, with the aid of a graduated ruler.

The evaluation of thrips incidence consisted of counting plants from each useful plot that showed direct symptoms on lettuce leaves due to thrips feeding. Subsequently, the average number of plants with symptoms per treatment was performed and the values transformed into a percentage of incidence, following the methodology used by Borges (2006).

Data were subjected to analysis of variance. The significant variables in the F test were submitted to regression analysis at 5 % probability, using the statistical program SISVAR 5.6 (FERREIRA, 2014). In addition, Pearson's correlations between the means of all evaluated characteristics were estimated. The hypothesis that the Pearson correlation coefficient is equal to zero (H0: P = 0) was evaluated by the T-test. Correlations were performed using the computer program GENES (CRUZ, 2006).

Results and discussion

In monitoring the quantification of the number of thrips present in the adhesive trap, the average of the four counts during the experiment was 252.75 insects. The values obtained from the insect pest population in each count can be seen in Table 3.

It is observed that, when performing the first count of thrips in the traps to analyze the population present in the greenhouse, there was an average initial population density in the treatments of 140.10 insects.

The mean values obtained in the second, third, and fourth counts were 164.30, 326.40, and 380.20 medium insects, respectively. There was no significant difference between the plots, indicating that the thrips infestation rate was uniform within the experimental area.

During lettuce vegetative development, thrips can be found in all phenological stages and

Table 3 – Average number of thrips regarding the treatments assessed in the lettuce considering different periods of assessment. IFMG – *Campus* Bambuí. Bambuí/MG, 2018.

Treatments	1st Count	2nd Count	3rd Count	4th Count
0%	130.00	159.25	303.75	401.75
20%	122.25	132.50	307.50	361.25
40%	124.75	135.00	309.50	346.50
60%	171.25	212.25	389.50	414.75
80%	152.25	182.50	321.75	376.75
Average	140.10	164.30	326.40	380.20
CV (%)	32.86	45.72	29.23	25.18

Source: Authors' elaboration (2021).

it is important to monitor the area to observe the insect population. However, there are few works related to production in a protected environment which demonstrate the level of control of the insect pest (GAERTNER; BORBA, 2014).

For the fresh mass height and weight variables, the application of different concentrations of the ginger-based extract had a similar behavior when subjected to analysis of variance, which can be seen in Table 4.

Table 4 – Averages of the variables analyzed regarding the treatments tested in lettuce during the harvest. IFMG – *Campus* Bambuí. Bambuí/MG, 2018.

Treatments	Hight (cm)	Weight (g)
0 %	31.70	287.08
20 %	31.54	268.33
40 %	31.42	297.49
60 %	30.91	271.66
80 %	32.70	301.66
CV (%)	6.76	10.24

Source: Authors' elaboration (2021).

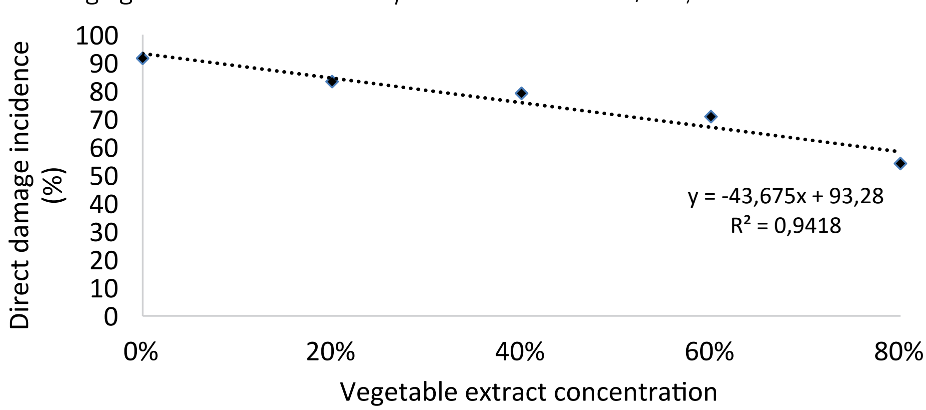
Regarding the variable height, the average of the plants was 31.65 cm, ranging from 30.91 cm to 32.70 cm. While the average weight of fresh mass was 285.24 grams, in a range of 268.33 grams to 301.66 grams.

Shoot fresh mass data were superior to those found by Patekoski and Pires-Zottarelli (2010) in which Vera lettuce presented 158.8 g in an experiment carried out in the spring and 182.2 g in an experiment conducted in the summer. However, the results of the experiment corroborate those obtained by Santos *et al.* (2010), who working with Vera lettuce in a hydroponic system found an average of 244.78 g at 47 days after sowing for the plants.

In the greenhouse, it was not possible to observe lettuce plants with viral symptoms, a result of indirect damage, with virus transmission. According to Domiciano, Ota, and Tedardi (1993), the incidence of damage caused by thrips and the lower production of a crop is changeable according to factors that interfere in the insect-plant relationship, such as cultivars, climatic conditions, phenological stages, season of planting and infestation level.

In the analysis of direct damage, the results demonstrate the efficacy of the ginger-based extract with a concentration of 80 % and 60 % in the control of thrips in lettuce, having an average of 54.16 % and 70.83 % of plants with symptoms, respectively, according to Figure 1. In this way, by using the solution from a concentration of 60 % weight/volume ,the farmer can obtain beneficial results in the control of thrips in lettuce.

Figure 1 – Direct damage incidence by the thrips attack in lettuce plants according to the application of different concentrations of the ginger extract. IFMG – *Campus* Bambuí. Bambuí/MG, 2018.



Source: Authors' elaboration (2021).

Hamada *et al.* (2018) found that from the concentration of 50 % of ginger extract there is a reduction in egg viability, interference in the development of pupae, and the fertilization of *Spodoptera littoralis*.

Pearson's correlation was performed to prove the relationship between the studied characteristics. The data obtained can be observed in Table 5.

Table 5 - Pearson correlation estimates between the variables evaluated in lettuce plants sprayed with ginger plant extract. IFMG – *Campus* Bambuí. Bambuí/ MG, 2018.

Pearson's Correlation	
Contrast	**Estimate**
CG *vs* AL	0.50
CG *vs* PE	0.55
CG *vs* DD	-0.95*
AL *vs* PE	0.67
AL *vs* DD	-0.53
PE *vs* DD	-0.40

CG – Ginger extract concentration; AL – Height (cm); PE – Weight (g); DD – Direct damage. *Significant at 5% probability by t-test.

Source: Authors' elaboration (2021).

In the present study, the estimated correlation of ginger extract concentration and direct damage was -0.95 and significant (TABLE 5). This correlation is negative or inverse and indicates a reduction in the direct damage due to the increase in the concentration of ginger extract solution. The other correlation estimates obtained were not significant.

The reduction of direct damage can be explained by the occurrence of antixenosis or non-food preference, characterized by a plant resistance process, induced by chemical or morphological factors. The cultivated plant is not used for feeding, due to the fact that the method makes it difficult to locate the insects, especially in insects with sucking habits, reducing the selection of the host plant and the place where the insect normally feeds (GALLO *et al.*, 1988).

The application of ginger extract may have influenced the antixenosis process in lettuce plants, which consequently promoted the repellence to thrips during feeding and caused the lowest levels of damage to the crop. The efficacy of non-food preference to a given insect can be caused by the bioactivity of the compounds of the plant extract commonly found in greater abundance in the solution (MEDEIROS, 2017; CRUZ, 2014).

Zingibereno is the main constituent substance of ginger, identified in high levels in plants and may be linked to the insecticide activity of the vegetable (NEIVA; MALUF; MACIEL, 2013). Nevertheless, the concentration of bioactive compounds in rhizomes may vary due to factors such as age, cultivation conditions, environmental factors (ABDULHAY; YONIUS, 2019).

Several results show a link between the insecticide activity and the higher concentration of ginger plant extract. Merlotto *et al.* (2018), when evaluating the effect of insecticide of different hydroalcoholic extracts of plants on aphid *Myzus Persicae* in scarlet eggplant culture, verified that ginger extract was the one that showed the greatest potential for insect mortality when compared to other extracts.

Rohde *et al.* (2013) evaluated the effect of extracts prepared with different fresh and dry vegetables on larvae, pupae, and adults of *C. capitata*, he verified that chinaberry and ginger had an insecticide effect on adults of *C. capitata*.

Chaubey (2011) found that fumigation with ginger essential oils significantly reduced the oviposition potential of adults and inhibited the development of larvae for pupae and adult pupae of *Tribolium castaneum*. In another study, Chaubey (2013) found that the essential oils of ginger and *P. cubeba* caused toxicity both by fumigation and by contact in adult *Callosobruchus chinensis*.

The use of ginger has also been reported as an ingredient of biopesticides along with other medicinal plants. Arora *et al.* (2012) evaluated a biopesticide formulation containing onion (*Allium cepa*) and ginger (*Zingiber officinale*) regarding the efficacy against *Helicoverpa armigera* and recorded a control of 70 % to 80 %, in addition to an increase in production in plants treated with the formulation compared to untreated plants.

Gomes (2016), when evaluating the effects of essential oils of fresh and dry ginger, found that the highest concentrations showed the best results for repellency and oviposition of the mite *T. urticae*. This data corroborates the hypothesis that the higher the concentration of the extract the greater the number of bioactive compounds in the solution and a high propensity to insecticide activity of the vegetable.

Madreseh-Ghahfarokhi *et al.* (2018), when evaluating the effect of ginger essential oils on *Culex theileri,* verified that the treatments had both insecticide and repellency effects, being promising substitutes for chemical pesticides.

Therefore, despite the high population level of thrips in the conduction of the experiment, the solution that had the highest concentration of bioactive compounds obtained beneficial results, preventing the insect present in the area from feeding and, consequently, reducing direct damage. Given the assumption, the results obtained in the present study indicate the promising potential of the use of ginger extract through the lower attractiveness of the crop, enabling the reduction of thrips feeding in lettuce cultivation and, consequently, reducing the transmission of viral disease.

Conclusion

The use of ginger extract with concentrations higher than 60 % weight/volume proved to be effective in reducing thrips feeding, as it reduced direct damage to lettuce culture. On the other hand, it did not promote the greater development of plants in relation to the height and weight of the fresh mass.

Acknowledgments

To the Federal Institute of Education, Science, and Technology of Minas Gerais (IFMG) - *Campus* Bambuí for the project financing.

References

ABDULHAY, H. S.; YONIUS, M. I. *Zingiber officinale* an alternative botanical insecticide against black bean aphid (*Aphis fabae Scop*). **Bioscience Research**, v. 16, p. 2315- 2321, 2019. Disponível em: https://www.isisn.org/BR16(2)2019/2315-2321-16(2)2019BR19-227.pdf. Acesso em: 18 mar. 2021.

AGUIAR, L. C.; DELGROSSI, M. E.; THOMÉ, K. M. Short food supply chain: characteristics of a family farm. **Ciência Rural**, v. 48, n. 5, 2018.

ALMEIDA, M. C. **Efeitos do processamento por radiação em espécies da família Zingiberaceae:** açafrão (*Curcuma longa* L.), gengibre (*Zingiber officinale* Roscoe) e zedoária (*Curcuma zedoaria* (Christm.) Roscoe). 2012. 108f. Tese de Doutorado (Tecnologia Nuclear - Aplicações) – Instituto de Pesquisas Energéticas e Nucleares, São Paulo, 2012.

ANUÁRIO BRASILEIRO DE HORTIFRUTI. **Muita Gente:** Setor de folhosas envolve o maior número de produtores em pequenas áreas, mas soma mais de 170 mil hectares nos cinturões verdes das cidades. Editora Gazeta Santa Cruz. p. 92-93. 2018.

ARORA, S.; KANOJIA, A. K.; KUMAR, A.; MOGHA, N.; SAHU, V. Biopesticide formulation to control tomato lepidopteran pest menace. **Current science**, p. 1051-1057, 2012.

BORGES, L. M. **Controle de viroses em alface por meio de métodos integrados de manejo da cultura**. 2006. 128f. Tese de Doutorado (Programa de Pós-Graduação em Agronomia) – Faculdade de Ciências Agronômicas da UNESP – *Campus* Botucatu, Botucatu, 2006.

BRANDÃO FILHO, J. U. T.; SANTOS, H. S. MARAUS, P. F.; SANTOS, S. S.; BUZANINI, A. C. Eficiência de diferentes inseticidas aplicados no controle de *Frankliniella occidentalis* na cultura da alface (*Lactuca sativa* L.). **Horticultura Brasileira 29**, p. 1037-1042, 2011.

CARVALHO, R. G. de. **Atividade de inseticidas em diferentes modalidades de aplicação no controle de insetos vetores de viroses na cultura da alface (*Lactuca sativa* L.).** 2017. 20f. Trabalho de Conclusão de Curso (Agronomia) – Universidade Federal de Uberlândia, Uberlândia, 2017.

CHAUBEY, M. K. Biological activities of *Zingiber officinale* (Zingiberaceae) and *Piper cubeba* (Piperaceae) essential oils against pulse beetle, *Callosobruchus chinensis* (Coleoptera: Bruchidae). **Pakistan journal of biological sciences: PJBS**, v. 16, n. 11, p. 517-523, 2013.

CHAUBEY, M. K. Insecticidal properties of *Zingiber officinale* and *Piper cubeba* essential oils against *Tribolium castaneum* Herbst (Coleoptera: Tenebrionidae). **Journal of Biologically Active Products from Nature**, v. 1, n. 5-6, p. 306-313, 2011.

CRUZ, S. V. M. V. **Efeito da aplicação de extratos aquosos de plantas na redução de injúrias da traça-das-crucíferas em plantas de repolho.** 2014. 50f. Dissertação de Mestrado (Programa de Pós-Graduação em Agronomia) - Universidade de Brasília, Brasília - DF, 2014.

CRUZ, C. D. **Programa Genes: estatística experimental e matrizes.** UFV, 2006.

DOMICIANO, N. L.; OTA, A. Y.; TEDARDI, C. R. Momento adequado para controle químico de tripes, *Thrips tabaci* Lindeman, 1888 em cebola, *Allium cepa* L. **Anais da Sociedade Entomológica do Brasil**, v. 22, n. 1, p. 77-83, 1993.

FAO. FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATION. **Data about production quantities of lettuce and chicory**. 2019. Disponível em: http://www.fao.org/home/en/. Acesso em: 18 mar 2021.

FERREIRA, D. F. **Sisvar**: a Guide for its Bootstrap procedures in multiple comparisons. Ciência agrotecnológica. v. 38, n. 2, 2014.

FURLANI, P. R. Instruções para o cultivo de hortaliças de folhas pela técnica de hidroponia-NFT. **EMBRAPA Amazônia Ocidental: Boletim Técnico 168**. Campinas, 1997.

GAERTNER, C.; BORBA, R. da S. Diferentes cores de armadilhas adesivas na cultura da alface hidropônica. **Revista Thema**, v. 11, n. 1, p. 4-11, 2014.

GALLO, D.; NAKANO, O.; NETO, S. S.; CARVALHO, R. P. L.; BAPTISTA, G. C. de; FILHO, E. B.; PARRA, J. R. P.; ZUCCHI, R. A.; ALVES, S. B.; VENDRAMIM, J. D.; MARCHINI, L. C.; LOPES, J. R. S.; OMOTO, C. **Manual de entomologia agrícola.** São Paulo: Agronômica Ceres. v. 10. 920 p. 1988.

GOMES, A. C. S. **Efeito de óleos essenciais de gengibre e acilaçúcares sintéticos sobre artrópodes-praga**. 2016. 110f. Dissertação de Mestrado (Programa de Pós-Graduação em Agroquímica) – Universidade Federal de Lavras, Lavras, 2016.

GOOGLE EARTH. Disponível em: https://earth.google.com/web/. Acesso em: 22 mar. 2021.

HAMADA, H. M.; AWAD, M.; EL-HEFNY, M.; MOUSTAFA, M. A. M. Insecticidal activity of garlic (*Allium sativum*) and ginger (*Zingiber officinale*) oils on the cotton leafworm, *Spodoptera littoralis* (Boisd.) (Lepidoptera: Noctuidae). **African Entomology**, v. 26, n. 1, p. 84-94, 2018.

LOBO, L. das D. **Custo de produção e rentabilidade do cultivo de alface (*Lactuca sativa* L.) em Silvânia-GO**. 2018. 32f. Trabalho de Conclusão de Curso (Bacharelado em Agronomia) – Centro Universitário de Anápolis UniEvangélica, Anápolis – GO, 2018.

LOPES, F. S. C.; FARIAS, E. S.; LOPES, M. C.; PICANÇO, M. C.; BLANK, A. F.; SANTOS, A. C. C.; PEREIRA, R. M.; BACCI, L. Inseticidas botânicos no controle da broca das cucurbitáceas *Diaphania hyalinata* (Lepidoptera: Crambidae). In: CONGRESSO BRASILEIRO DE OLERICULTURA, 51. **Anais...** Viçosa. 2011.

MADRESEH-GHAHFAROKHI, S.; PIRALI, Y.; DEHGHANI-SAMANI, A.; DEHGHANI-SAMANI, A. The insecticidal and repellent activity of ginger (*Zingiber officinale*) and eucalyptus (*Eucalyptus globulus*) essential oils against *Culex theileri* Theobald, 1903 (Diptera: Culicidae). **Annals Parasitology**, v. 64, n. 4, p. 351-360, 2018.

MARANGONI, C.; MOURA, N. F.; GARCIA, F. R. M. Utilização de óleos essenciais e extratos de plantas no controle de insetos. **Revista de Ciências Ambientais,** Canoas, v. 6, n. 2, p. 95-112, 2012.

MEDEIROS, R. O. N. B. **Estudo da aplicação na área da saúde do gengibre, sua caracterização química**. 2017. 62f. Tese de Doutorado (Mestrado Integrado em Ciências Farmacêuticas) – Instituto Superior de Ciências da Saúde Egas Moniz, Portugal, 2017.

MERLOTTO, G. R.; TOSCANO, L. C.; SILVA, E. M.; ANDRADE, J. R.; SILVA, R. de S. M. Controle Alternativo de *Myzus persicae* na cultura do jiló com extratos de plantas. **Cadernos de Agroecologia**, v. 13, n. 2, p. 7-7, 2018.

NEIVA, I. P.; MALUF, W. R.; MACIEL, G. M. Resistência de linhagens de tomateiro à mosca-branca (*Bemisia argentifolii*), relacionada a aleloquímicos e densidade de tricomas. **Ciência e Agrotecnologia**, v. 37, n. 1, 2013.

PATEKOSKI, K. S.; PIRES-ZOTTARELLI, C. L. A. Patogenicidade de *Pythium aphanidermatum* a alface cultivada em hidroponia e seu biocontrole com *Trichoderma*. **Pesquisa Agropecuária Brasileira**, v. 45, n. 8, p. 805-810, 2010.

PEREIRA, R. B.; PINHEIRO, J. B.; DE CARVALHO, A. D. F. Diagnose e controle alternativo de doenças em alface, alho, cebola e brássicas. **Embrapa Hortaliças - Circular Técnica 120**. Brasília – DF, 2013.

ROHDE, C.; MOINO JUNIOR, A.; SILVA, P. K.; RAMALHO, K. R. de O. Efeito de extratos vegetais aquosos sobre a mosca-das-frutas *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae). **Arquivo do Instituto Biológico**, São Paulo, v. 80, n. 4, p. 407-415, 2013.

SANTOS, A. N.; SOARES, T. M.; SILVA, E. F. F.; SILVA, D. J. R.; MONTENEGRO, A. A. A. Cultivo hidropônico de alface com água salobra subterrânea e rejeito da dessalinização em Ibimirim, PE. **Revista Brasileira de Engenharia Agrícola e Ambiental,** v. 14, n. 9, p. 961-969, 2010.

SILVEIRA, A. J. da. **Potencial agronômico e dissimilaridade genética entre genótipos de alface ricos em carotenoides**. 2018. 16f. Trabalho de Conclusão de Curso (Agronomia) - Universidade Federal de Uberlândia, Monte Carmelo, 2018.

SUINAGA, F. A.; BOITEUX, L. S.; CABRAL, C. S.; RODRIGUES, C. S. Métodos de avaliação do florescimento precoce e identificação de fontes de tolerância ao calor em cultivares de alface do grupo varietal**. Embrapa Hortaliças-Comunicado Técnico (INFOTECA-E)**, mar. 2013.

VASCONCELOS, G. J. N. de; GONDIM, M., G. C.; BARROS, R. Extratos aquosos de *Leucaena leucocephala* e *Sterculia foetida* no controle de *Bemisia tabaci* biótipo B (Hemiptera: Aleyrodidae). **Ciência Rural**, v. 36, n. 5, p. 1353-1359, 2006.

ZAWADNEAK, M. A. C.; SCHUBER, J. M.; MEDEIROS, C.; SILVA, R. A. da. **Olericultura:** pragas e inimigos naturais. Curitiba: SENAR – PR, 70 p., 2015.