http://journal.unoeste.br/index.php/ca/index
DOI: 10.5747/ca.2021.v17.n6.a467
ISSN on-line 1809-8215

Colloquium Agrariae

Submetido: 03/08/2020 Revisado: 10/04/2021 Aceito: 17/11/2021

Effect of weed interference in the production components of 'Lucy Brown' american lettuce

José de Anchieta Alves de Albuquerque, Luane Pinheiro Pereira, Dalhas Nascimento de Sousa, Leandro Torres de Souza, João Luiz Lopes Monteiro Neto, Thaís Santiago Castro, Anderson Carlos de Melo Gonçalves, Edgley Soares da Silva

Universidade Federal de Roraima - UFRR, RR. E-mail: anchietaufrr@gmail.com

Abstract
One of the main challenges faced by lettuce producers is the interference of weeds which affects crop development and productivity. The aim of this study was to evaluate the occurrence of programmed weeding on the growth and production of Lucy Brown American lettuce. The experiment was carried out between March and May 2017 at the Federal University of Roraima Cauamé campus, in Boa Vista, Roraima, Brazil. The experimental design used was randomized blocks with six treatments, four replications and four lettuce plants per experimental unit. The treatments tested were as follows: 100% weed control (100% WC); weed control 5 days after transplanting (WC 5 DAT); weed control 10 days after transplanting (WC 10 DAT); weed control 15 days after transplanting (WC 15 DAT); weed control 20 days after transplanting (WC 20 DAT) and 100% without weed control (100% WWC). The following variables were evaluated: shoot height, stem height, stem diameter, number of leaves, leaf length, leaf width, root length, shoot fresh weight, total fresh weight, shoot dry weight and productivity. The 'Lucy Brown' lettuce crop must be weed-free after 5 days of transplanting the seedlings to avoid productivity losses. The lack of weed control in the cultivation of 'Lucy Brown' lettuce causes a 71.88% decrease in its productivity.
Keywords: competition; leaf vegetables; *Lactuca sativa* (L.); invasive plants; productivity.

Efeito da interferência de plantas daninhas nos componentes de produção da alface americana 'Lucy Brown'

Resumo
Um dos principais desafios enfrentados pelos produtores de alface é a interferência das plantas daninhas que afetam o desenvolvimento e produtividade das culturas. Objetivou-se com este trabalho avaliar a ocorrência de capinas programadas de plantas daninhas sobre o crescimento e a produção da cultura da alface americana Lucy Brown. O experimento foi desenvolvido entre os meses de março e maio de 2017, no Campus do Cauamé, da Universidade Federal de Roraima, Boa Vista, Roraima, Brasil. O delineamento experimental foi blocos casualizados, com seis tratamentos e quatro repetições com quatro plantas de alface por unidade experimental. Foram testados os tratamentos: 100% controle de plantas daninhas (100% CPD), controle de plantas daninhas 5 dias após transplantio (CPD 5 DAT), controle de plantas daninhas 10 dias após transplantio (CPD 10 DAT), controle de plantas daninhas 15 dias após transplantio (CPD 15 DAT), controle de plantas daninhas 20 dias após transplantio (CPD 20 DAT) e 100% sem controle de plantas daninhas (100% SCPD); sobre as variáveis: altura de planta, altura do caule, diâmetro do caule, número de folhas, comprimento da folha, largura da folha, comprimento da raiz, massa fresca da parte área, massa fresca total da planta, massa seca da parte aérea e produtividade. A alface americana "Lucy Brown" deve estar sem convivência das plantas daninhas a partir dos 5 dias do transplantio das mudas para evitar perdas de rendimento. No cultivo da alface americana "Lucy Brown", a ausência de controle das plantas daninhas causa decréscimo de 71,88% na sua produtividade.
Palavras-chave: competição; hortaliças folhosas; *Lactuca sativa* (L.); plantas invasoras; produtividade.

Introduction

Lettuce (*Lactuca sativa* L.) is an herbaceous plant of the Asteraceae family widely consumed by the Brazilian population as a leaf vegetable. The length of its life cycle depends on the variety and growing region, but it takes approximately 40 days to mature from seed germination through harvest, and optimum temperatures for growth ranges from 20 to 25 °C (SALA; COSTA, 2012; ZIECH *et al.*, 2014).

Among the several lettuce cultivar groups, the American type is one of the most cultivated and accepted by Brazilian consumers. The American lettuce presents imbricated and crunchy yellow or white internal leaves and stands out for its improved postharvest conservation and resistance to processing and transport (BRZEZINSKI *et al.*, 2017). China, The United States, Brazil, Spain and Italy are the world's largest lettuce producers (NIE *et al.*, 2017). Lettuce is the most consumed leaf vegetable in Brazil, where its production reaches around 1.6 million tons per year, amounting about R$8 billion/year in the retail market alone, according to data from the Brazilian Association of Seeds and Seedlings (ABRASEM) (KIST *et al.*, 2018).

Faced with the rapid world population growth, producers have been looking for improvements in agriculture to meet the increasing food demand. Thus, it is necessary to improve productivity of food crops (PERES *et al.*, 2016). With the advances in lettuce breeding programs in Brazil, new cultivars were made available to producers. In this sense, knowing the crop behavior in the cultivation environment is essential to plan a proper weed management schedule (BRANDÃO *et al.*, 2016; CAMARGO *et al.*, 2020).

A weed is an undesirable native or non-native plant species that spontaneously establishes itself in the farm field. Weeds are undesirable because they compete for nutrients, water and physical space with agricultural crops of economic interest (PITELLI, 2015).

The degree of weed interference on crops depends on factors related to the cultivated species, the environment, the weed species, and the duration of the competition. Thus, it is possible to order the importance of these weed species, enabling quantitative interpretation at a given time and space (ALBUQUERQUE *et al.*, 2012; CUNHA *et al.*, 2014).

To outline weed management strategies in lettuce cultivation environments it is essential to assess the weed influence on lettuce growth and production (FERREIRA *et al.*, 2013). In each weed sampling, some species stand out due to several factors, such as: species characteristics, climate, seed bank, crop development, and control period (ALBUQUERQUE *et al.*, 2017; SILVA *et al.*, 2018; TEIXEIRA JUNIOR *et al.*, 2020).

Among the several factors that influence lettuce production, the optimum time for weed control deserves to be highlighted, as it affects growth and, consequently, production and quality. Weed control methods include hoeing, a widely used technique that still lacks information on the ideal times to be performed during lettuce production cycle.

The aim of this study was to evaluate the occurrence of programmed weeding on the growth and production of 'Lucy Brown' American lettuce.

Material and Methods

The experiment was carried out between March and May 2017 at the Federal University of Roraima Agricultural Sciences Center experimental field, located in the municipality of Boa Vista, Roraima, Brazil. The geographical reference coordinates are 2° 49' 11" N, 60° 40 '24" W and altitude of 90 m. According to the Köppen's classification, the region's climate is Aw with two well-defined climatic seasons, a rainy one (April-September) and a dry one (October-March), with annual averages of precipitation, relative humidity and temperature of 1.678 mm, 70% and 27.4 °C, respectively (EMBRAPA, 2018).

The experimental design used was randomized blocks with four replications and four lettuce plants per experimental unit. The treatments consisted of weed management in lettuce field by means of programmed weeding, as follows: 100% weed control (100% WC); weed control 5 days after transplanting (WC 5 DAT); weed control 10 days after transplanting (WC 10 DAT); weed control 15 days after transplanting (WC 15 DAT); weed control 20 days after transplanting (WC 20 DAT) and 100% without weed control (100% WWC).

Prior to the installation of the experiment, spontaneous weeds were completely removed from the beds, the soil was turned and leveled, and clods that could compromise the development of lettuce plants were eliminated.

Then, 30 kg of decomposing rice husk and 60 kg of cattle manure were placed in the entire experimental area, wetting, and mixing it for one week. Lettuce seedlings of the 'Lucy Brown' variety were produced in 128 cells polyethylene trays. At 15 days after sowing, the best quality seedlings with a defined size pattern were selected. 16 plants were sown per plot with a spacing of 0.30 x 0.30 cm, totaling 384 plants in the experimental area. Each experimental plot had the dimensions of 1.20 m x 1.20 m, distributed in 4 masonry beds of 7.2 meters long, 1.20 m wide and 0.5 m high.

Irrigation was carried out daily throughout the whole crop cycle in two irrigation shifts (morning and afternoon), with the aid of a watering can, to maintain the soil in the field capacity.

At 40 days after transplanting, the four central plants of each plot were harvested and taken to the Federal University of Roraima Laboratory of Large Cultures. The following variables were evaluated: shoot height (SH), stem height (STH), stem diameter (SD), number of leaves (NLP), leaf length (LL), leaf width (LW), root length (RL), shoot fresh weight (SFW), total fresh weight (TFW), shoot dry weight (SDW) and productivity (PROD).

The SH was determined using a graduated ruler by measuring from the plant neck to the highest point of the plant's leaves. STH was determined by measuring from the neck to the apex of the plant stem using a graduated ruler. The SD, in millimeters, was evaluated with the aid of a digital caliper. The NLP was determined by counting the fully expanded leaves. The LL and LW, in centimeters, were estimated by measuring three randomly selected leaves from each plant. The RL, in centimeters, was determined using a graduated ruler by measuring from the plant's neck to the root apex. The roots were carefully detached using a gardening shovel, trying to preserve their integrity as much as possible (MACHADO *et al.* 2009; FREITAS *et al.* 2013; SOUZA *et al.* 2013).

The data were submitted to analysis of variance and the means compared by the Tukey test at 5% probability. For the statistical analyzes, the SISVAR software was used (FERREIRA, 2011).

Results and Discussion

The analysis of variance (Tables 1 and 2) revealed significant statistical differences between treatments for all the variables analyzed, indicating that management of programmed weeding directly influenced the development of lettuce plants.

Table 1. ANOVA summary table for the variables shoot height (SH), stem height (STH), stem diameter (SD), number of leaves per plant (NLP), leaf length (LL), leaf width (LW) and root length (RL) of American lettuce 'Lucy Brown'. Boa Vista-RR, Brazil, 2021.

SV	DF	Mean Square						
		SH	STH	SD	NLP	LL	LW	RL
Treatment	5	28.83**	2.74**	15.54**	66.71**	35.24**	61.74**	15.2**
Blocks	3	0.05	0.04	0.28	1.17	0.49	5.60	0.37
Residual	15	0.51	0.00	0.19	0.48	0.37	6.98	0.10
CV (%)		4.34	3.95	5.39	3.43	4.17	18.51	5.2

** Significant at 1% probability by the F test.

Table 2. ANOVA summary table for the variables shoot fresh weight (SFW), total fresh weight (TFW), shoot dry weight (SDW) and productivity (PROD) of American lettuce 'Lucy Brown'. Boa Vista-RR, Brazil, 2021

		Mean Square			
SV	DF	SFW	TFW	SDW	PROD
Treatment	5	7915.50**	24357.79**	61.21**	21890.67**
Blocks	3	106.70	1267.87	1.29	641.05
Residual	15	337.55	607.10	0.29	409.38
CV (%)		12.16	13.85	1.51	12.76

** Significant at 1% probability by the F test.

The highest values for shoot height (SH), stem height (STH) and stem diameter (SD) were observed in the treatments with 100% weed control (100% WC) and weed control 5 days after transplanting (WC 5 DAT) (Table 3). Shoot height is an important variable that can be influenced by weed interference, and it depends on the lettuce cultivar, the growth habit, and the competition period (SALA; COSTA, 2012). Alongside the leaf area, the crop shoot height can negatively influence the competitive ability of invasive weeds by impairing light incidence, which can reflect in lower yield losses. Usually, the shoot height of lettuce plants ranges from 16 to 25 cm (SALA; COSTA, 2012; BRANDÃO *et al.*, 2016; BRZEZINSKI *et al.*, 2017).

Among the desirable characteristics of a cultivar, the stem height and diameter are related to the final development of the produce. Larger stem diameters are desirable for the American lettuce, and this variable is one of the main parameters on the qualitative development of plants. According to Vaz *et al.* (2019), stem height is associated with cultivar tolerance to early bolting, however, weed competition also interferes with its growth. When the stem diameter is quite small, as well as its length, it results in lesser compact heads, which impairs the processing and final quality (FAVARATO *et al.*, 2017).

Table 3. Averages of the shoot height (SH), stem height (STH) and stem diameter (SD) of American lettuce 'Lucy Brown'. Boa Vista-RR, Brazil, 2021

Treatments	SH (cm)	STH (cm)	SD (mm)
100% WC	19.32 a	2.94 a	10.87 a
WC 5 DAT	19.29 a	2.89 a	9.89 ab
WC 10 DAT	17.16 b	2.46 b	8.96 b
WC 15 DAT	15.95 bc	1.81 c	7.53 c
WC 20 DAT	14.75 c	1.44 d	6.62 cd
100% WWC	12.46 d	0.89 e	5.76 d

Means followed by the same letters do not differ by Tukey's test at 5% probability.
* 100% weed control (100% WC); weed control at 5 (WC 5 DAT), 10 (WC 10 DAT), 15 (WC 15 DAT) and 20 days after transplanting (WC 20 DAT); and 100% without weed control (100% WWC).

The 100% WC treatment was efficient in increasing all the variables presented in Table 4 (NLP, LL, LW and RL). Likewise, except for root length (RL), the WC 5 DAT treatment favored the increase of all parameters analyzed, indicating that weed contr ol is essential when seeking to increase leaf growth of lettuce plants. In an intermediate way, the 15 and 20 DAT WC treatments showed superiority in the increase of the variables when compared to the control treatment (100% WWC).

Leaf growth can be considered one of the main indicators of the weed control treatments influence on the lettuce crop, since the leaves constitute the commercial product and, in physiological terms, it is the major plant structure linked to the photosynthetic processes, for intercepting light energy and convert it to chemical energy (SHIMADA *et al.*, 2017). In this sense, the best WC treatments have reduced weed interference and provided better conditions for the development of lettuce plants. According to Monteiro Neto *et al.* (2014), weed suppression is an essential factor for the productive increase of lettuce plants, and a non-weed-interference crop provided by programmed weed control can exponentially affect yield of lettuce cultivars (GIANCOTTI *et al.*, 2010).

For the root length variable, the 100% WC treatment provided the greatest value (8.66 cm) (Table 4). It was verified that when a crop does not suffer from any weed interference during its entire cycle, it has a good root development, as there is no competition for water, nutrient, and other essential elements. A well-developed root system is an important feature for crops, since larger roots promote greater nutrient uptake and, consequently, a thriving shoot system. There was a roughly 50% reduction in the lettuce root length when the crop remained 20 days without weed control (Table 2). According to Camargo and Martinez (2020), the lettuce root system is highly branched and superficial, exploring only the first 0.25 m of the soil depth when the crop is

transplanted. When lettuce is direct-seeded, its taproot can reach up to 0.60 m in depth. According to Rima *et al.* (2011), a more developed root system has a greater capacity to explore the soil and, consequently, absorbs more nutrients (RIMA *et al.*, 2011).

Table 4. Averages of the number of leaves per plant (NLP), leaf length (LL), leaf width (LW) and root length (RL) of American lettuce 'Lucy Brown'. Boa Vista-RR, Brazil, 2021

Treatments	NLP	LL (cm)	LW (cm)	RL (cm)
100% WC	25.35 a	18.29 a	17.91 a	8.66 a
WC 5 DAT	23.84 a	17.25 a	17.74 a	7.52 b
WC 10 DAT	21.84 b	15.57 b	16.55 a	5.98 c
WC 15 DAT	19.14 c	13.91 c	14.52 ab	5.06 d
WC 20 DAT	16.70 d	12.08 d	9.58 b	4.43 d
100% WWC	14.94 e	10.64 e	9.31 b	3.47 e

Means followed by the same letters do not differ by Tukey's test at 5% probability.
* 100% weed control (100% WC); weed control at 5 (WC 5 DAT), 10 (WC 10 DAT), 15 (WC 15 DAT) and 20 days after transplanting (WC 20 DAT); and 100% without weed control (100% WWC).

Significant differences between treatments were observed for the shoot fresh weight (SFW), total fresh weight (TFW), shoot dry weight (SDW) and productivity (PROD), where 100% WC and WC 5 DAT presented the greatest values (Table 5).

A significant reduction in productivity was observed in the treatment without weed control, a result corroborated by other authors that also recorded reduced lettuce yields in weedy cropping fields (GIANCOTTI *et al.* 2010; BRANDÃO *et al.* 2016; GALON *et al.* 2016). When studying weed interference in flat and curly lettuce cultivars, Galon *et al.* (2016) found that the flat ones are more competitive than curly when grown with inadequate weed control. Giancotti *et al.* (2010) registered a 25% reduction in the productivity of the curly lettuce cultivar 'Solaris' and state that this yield reduction was smaller than that found in studies with American lettuce.

Varied results are commonly found due to the competitive capacity of each cultivar, in addition to the characteristics of the infesting weed community in the experimental area, which may be less or more aggressive.

Table 5. Averages of the shoot fresh weight (SFW), total fresh weight (TFW), shoot dry weigth (SDW) and productivity (PROD) of American lettuce 'Lucy Brown'. Boa Vista-RR, Brazil, 2021

Treatments	FMAP(g)	MFTP(g)	DMAP(g)	PROD (g/m^2)
100% WC	217.87 a	262.70 a	39.95 a	251.03 a
WC 5 DAT	183.43 ab	286.67 a	39.71 a	238.62 a
WC 10 DAT	151.56 bc	155.70 b	37.58 b	166.98 b
WC 15 DAT	137.20 c	140.71 bc	35.09 c	123.84 bc
WC 20 DAT	125.03 cd	127.93 bc	32.83 d	100.36 cd
100% WWC	91.79 d	93.93 c	30.18 e	70.59 d

Means followed by the same letters do not differ by Tukey's test at 5% probability.
* 100% weed control (100% WC); weed control at 5 (WC 5 DAT), 10 (WC 10 DAT), 15 (WC 15 DAT) and 20 days after transplanting (WC 20 DAT); and 100% without weed control (100% WWC).

CONCLUSIONS

The incidence of weeds influences the growth and productivity of the lettuce crop var. 'Lucy Brown'. The programmed weeding management is necessary to suppress the presence of weeds after 5 days of transplanting the seedlings, to avoid productivity losses of up to 71.88%.

REFERENCES

ALBUQUERQUE, J. A. A.; SANTOS, T. S.; CASTRO, T. S.; MELO, V. F.; ROCHA, P. R. R. Weed incidence after soybean harvest in no-till and conventional

tillage croprotation systems in Roraima's Cerrado. **Planta Daninha**, v.35, p.1, 2017. https://doi.org/10.1590/s0100-83582017350100034

ALBUQUERQUE, J. A. A.; SEDIYAMA ; SILVA ; ALVES, J. M. A. ; CARNEIRO, J. E. S. ; CECON, P. R. Desenvolvimento da cultura de mandioca sob interferência de plantas daninhas. **Planta Daninha,** v.30, p.37-45, 2012. https://doi.org/10.1590/S0100-83582012000100005

BRANDÃO, A. A.; RIBEIRO, E. C.; FIORINI, C. V. A.; MACHADO, A. F. L.; LOPES, H. M. Dinâmica populacional de plantas daninhas em cultivares de alface produzidas no verão em Seropédica-RJ. **Revista Agrogeoambiental,** v.8, n.1, p.67-77, 2016. https://doi.org/10.18406/2316-1817v8n12016782

BRZEZINSKI, C. R.; ABATI, J.; GELLER, A.; WERNER, F.; ZUCARELI, C. Produção de cultivares de alface americana sob dois sistemas de cultivo. **Revista Ceres,** v.64, n.1, p.83-89, 2017. https://doi.org/10.1590/0034-737x201764010012

CAMARGO, L.A.A.; MARTINEZ, A.L.A. Cobertura morta no manejo de plantas daninhas em alface. **Global Science Technology,** v.13, n.1, p.142-149, 2020.

CUNHA, J. L. X. L.; FREITAS, F. C. L.; COELHO, M. E. H.; SILVA, K. S.; NASCIMENTO, P. G. M. L. Fitossociologia de plantas daninhas na cultura do pimentão nos sistemas de plantio direto e convencional. **Revista Agro@mbiente**, v.8, n.1, p.19-126, 2014. https://doi.org/10.18227/1982-8470ragro.v8i1.1647

EMBRAPA. **Sistema Brasileiro de Classificação de Solos**. Brasília: EMBRAPA, 2018.

FAVARATO, L.F.; GUARÇONI, R.C.; SIQUEIRA, A.P. Produção de alface de primavera/verão sob diferentes sistemas de cultivo. **Revista Científica Intelletto,** v.2, n.1, p.16-28, 2017. https://doi.org/10.17648/intelletto-2525-9075-v2-n1-03

FERREIRA, D. F. Sisvar: a computer statistical analysis system. **Ciência & Agrotecnologia**, v.35, n.6, p.1039-1042, 2011. https://doi.org/10.1590/S1413-70542011000600001

FERREIRA, I. C. P. VAZ.; ARAÚJO, A. V. DE.; NASCIMENTO, A. L.; CAVALCANTI, T. F. M.; SANTOS, D. V. T. Comunicação Cobertura morta e adubação orgânica na produção de alface e supressão de plantas daninhas **Revista Ceres**, v.4, n.60, p.582-588, 2013. https://doi.org/10.1590/S0034-737X2013000400019

FREITAS, G. A. D.; SILVA, R. R. D.; BARROS, H. B.; VAZ-DE-MELO, A.; ABRAHÃO, W. A. P. Produção de mudas de alface em função de diferentes combinações de substratos. **Revista Ciência Agronômica**, v.44, n.1, p.159-166, 2013. https://doi.org/10.1590/S1806-66902013000100020

GALON, L.; FORTE, C. T.; GIACOMINI, J. P.; REICHERT JR, F. W.; SCARIOT, M. A.; DAVID, F. A.; PERIN, G. F. Habilidade Competitiva de Alface com Azevém. **Planta Daninha,** v.34, n.2, p.239-248, 2016. https://doi.org/10.1590/S0100-83582016340200005

GIANCOTTI, P. R. F.; MACHADO, M. H.; YAMAUTI, M. S. Período total de prevenção a interferência das plantas daninhas na cultura da alface cultivar Solaris. Semina: **Ciências Agrárias**, v.31, p.1299-1304, 2010. https://doi.org/10.5433/1679-0359.2010v31n4Sup1p1299

KIST, B. B.; SANTOS, C.E.; CARVALHO, C.; BELING, R. R. **Anuário brasileiro de hort&frut 2019.** Santa Cruz do Sul: Editora Gazeta Santa Cruz, 2018.

MACHADO, M. H.; ATHANÁSIO, J. C.; GIANCOTTI, P. R. F. Influência de diferentes períodos de controle das plantas daninhas em alface. **Horticultura Brasileira,** v.27, n.2, p.1762-1767, 2009.

MONTEIRO NETO, J. L. L.; SILVA, A. C. D.; SAKAZAKI, R. T.; TRASSATO, L. B.; ARAÚJO, W. F. Tipos de coberturas de solo no cultivo de alface (*Lactuca sativa* L.) sob as condições climáticas de Boa Vista, Roraima. **Boletim do Museu Integrado de Roraima,** v.8, n.2, p.47-52, 2014. https://doi.org/10.24979/bolmirr.v8i02.767

NIE, C.; ZHU, P.; WANG, M.; MA, S.; WEI, Z. Optimization of water-soluble polysaccharides from stem lettuce by response surface methodology and study on its characterization and bioactivities. **International Journal of Biological Macromolecules,** v.105, p.912-923, 2017. https://doi.org/10.1016/j.ijbiomac.2017.07.125

PERES, J.G.; BOSCHI, R.S.; SOUZA, C.F.; MENDONÇA, T.G. Produtividade da água para seleção de cultivares de alface. **Revista Ciência, Tecnologia & Ambiente,** v.3, n.1, p.59-65, 2016.

PITELLI, R. A. O termo planta daninha. **Planta Daninha,** v.33, n.3, 2015. https://doi.org/10.1590/S0100-83582015000300025

RIMA, J. A. H.; MARTIM, S. A.; DOBBSS, L. B.; EVARISTO, J. A. M.; RETAMAL, C. A.; FAÇANHA, A. R.; CANELLAS, L. P. Adição de ácido cítrico potencializa a ação de ácidos húmicos e altera o perfil protéico da membrana plasmática em raízes de milho. **Ciência Rural**, v.41, n.4, p.614-620, 2011. https://doi.org/10.1590/S0103-84782011000400011

SALA, F. C.; COSTA, C. P. Retrospectiva e tendência da alfacicultura brasileira. **Horticultura Brasileira,** v.30, n.2, p.187-194. 2012. https://doi.org/10.1590/S0102-05362012000200002

SHIMADA, A.; KUBO, T.; TOMINAGA, S.; YAMAMOTO, M. Effect of Temperature on Photosynthesis Characteristics in the Passion Fruits 'Summer Queen' and 'Ruby Star'. **The Horticulture Journal,** v.86, n.2, p.194–199, 2017. https://doi.org/10.2503/hortj.OKD-023

SILVA, D. A.; ALBUQUERQUE, J. A. A.; ALVES, J. M. A.; ROCHA, P. R. R.; MEDEIROS, R. D.; FINOTO, E.L.; MENEZES, P. H. S. Caracterização de plantas daninhas em área rotacionada de milho e feijão-caupi em plantio direto. **Science Agropecuaria,** v.9, p.7-15, 2018. https://doi.org/10.17268/sci.agropecu.2018.01.01

SOUZA, E. G. F.; BARROS JÚNIOR, A. P.; SILVEIRA, L. M.; CALADO, T. B.; SOBREIRA, A. M. Produção de mudas de alface babá de verão com subst. ratos base esterco. **Revista Caatinga,** v.26, n.4, p.63-68, 2013.

VAZ, J. C.; TAVARES, A. T.; HAESBAERT, F. M.; REYES, I. D. P.; ROSA, P. H. L.; FERREIRA, T. A.; NASCIMENTO, I. R. Adubação NPK como promotor de crescimento em alface. **Revista Agri-Environmental Sciences,** v.5, e019003, 2019. https://doi.org/10.36725/agries.v5i0.1215

TEIXEIRA JUNIOR, D. L.; ALVES, J. M. A.; ALBUQUERQUE, J. A. A.; ROCHA, P. R. R.; CASTRO, T. S.; BARRETO, G. F. Ocorrência de plantas daninhas na cultura do feijão-caupi sob quatro manejos na Amazônia Ocidental. **Nativa**, v.8, p.427-435, 2020. https://doi.org/10.31413/nativa.v8i3.8949

ZIECH, A. R. D.; CONCEIÇÃO, P. C.; LUCHESE, A. V.; PAULUS, D.; ZIECH, M. F. Cultivo de alface em diferentes manejos de cobertura do solo e fontes de adubação. **Revista Brasileira de Engenharia Agrícola e Ambiental**, v.18, n.9, p.948-954, 2014. https://doi.org/10.1590/1807-1929/agriambi.v18n09p948-954