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Growth and productivity of okra intercropped with kale in direct planting under organic management

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Abstract

The cultivation of vegetables in intercropping and direct planting are alternatives with greater economic, social and environmental efficiency. In this sense, the objective of this study was to evaluate the effect of different plant arrangement systems on the intercropping of okra and kale, as well as on the efficiency of use of the area. The experiment was conducted at the experimental station belonging to Unioeste, from May 2017 to March 2018 in direct planting, under organic management, using a randomized block design, containing seven treatments and four replications. The treatments consisted of the following arrangements of okra and kale plants in a consortium, T1 = three rows of kale with okra between the lines; T2 = three rows of kale with okra between the lines; T3 = three rows of kale with okra dense between the lines; T4 = three rows of kale with okra dense spaced between alternating lines; and monoculture T5 = three rows of kale; T6 = three rows of okra; T7 = three rows of dense okra. Assessments began 50 and 73 days after transplanting for kale and okra, respectively. Biometric and productivity variables were evaluated. The data were subjected to variance analysis and, when significant, regression analysis depending on the evaluation periods or compared using the Tukey test at 5% probability. It is concluded, that the okra crop showed greater productivity when grown in dense monoculture, and all intercropping systems promoted greater efficiency in land use.

Keywords: *Abelmoschus esculentus*, densification, plant arrangement, Brassica oleracea var. acephala, efficiency of use of the area

Introduction

The agricultural sector faces major challenges in response to the greater demand for food caused by the growth of the world population. In this sense, one of the current concerns is to guarantee rational, diversified and healthy production, with the promotion of food security (Sousa et al., 2019; Cecílio Filho et al., 2021).

The current vegetable cultivation system is characterized by the intensive use of soil, causing environmental impacts due to the high mobility and exposure of the soil, continuous irrigation and extensive use of fertilizers and chemical pesticides (Alves et al., 2020). As a result, the search for sustainable forms of cultivation has gained prominence over time with the aim of minimizing environmental impacts. The cultivation of vegetables in direct planting and the intercropping technique can provide greater efficiency in the production system, from an economic, social and environmental point of view.

Direct planting provides advantages such as satisfactory productivity, erosion control and reduced operating costs (Coutinho et al., 2017), the need for fertilizers and can promote greater efficiency in water use (Tivelli et al., 2013).

The intercropping technique of plant species can be defined as the cultivation of two or more crops with different architectures simultaneously in the same area, so that they coexist for a significant period of their cycle (Alves et al., 2020; Guerra et al., 2022).

The practice of intercropping can provide several advantages to the cultivation system, such as increased productivity, reduced use of inputs per unit of food produced (Alves et al., 2020), improvement of soil physical properties and reduction of erosion processes (Weisany et al., 2015), greater resistance to pests and diseases (Frison et al. 2011) and reducing the risk of total production loss (Lepse et al., 2017; Alves et al., 2020).

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Furthermore, the use of cultivation systems with high plant densities and the modification of the spatial arrangement in the field are strategies that promote economic gains in annual and perennial crops (Prata et al., 2018). The density of cultivation directly influences plant development, architecture, product weight and productivity of the crops inserted in the system (Tavares et al., 2016). However, the viability of dense cultivation systems must be evaluated, as when poorly planned, it can cause greater competition for growth factors and reduce productivity and product quality (Alves et al., 2020).

Studies related to the productivity of okra intercropped with kale in an organic direct planting system are scarce. The work is based on the hypothesis that the consortium promotes better use of the cultivation space. The objective of the work was to evaluate the effect of different plant arrangement systems in the okra and kale intercrop on okra growth and productivity, as well as on the efficiency of use of the area.

Material and methods

The experiment was conducted from May 2017 to March 2018, in the organic horticulture sector of the experimental station Professor Antônio Carlos dos Santos Pessoa (240 33' 22" S; 540 31' 24" W; 420 m altitude), belonging to the nucleus of experimental stations at the State University of Western Paraná, Campus Marechal Candido Rondon-PR. The soil is classified as Eutroferric RED LATOSSOLO (LVef) (Santos et al., 2013).

Temperature and precipitation data during the experimental period were obtained at the Marechal Candido Rondon Automatic Surface Observation Meteorological Station (**Figure 1**).

The experiment was divided into two stages, the first stage consisted of cultivating oats (*Avena sativa*) as a cover plant and the second stage in the implementation and management of okra intercropped with kale, in

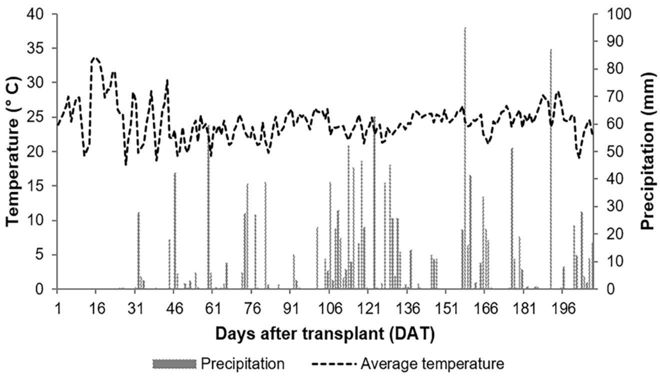

Figure 1. Average air temperature and rainfall levels for the period during which crops were grown. Unioeste – Marechal Cândido Rondon, September 2017 to March 2018.

organic direct planting.

To implement the oat crop, the soil was prepared mechanically through plowing and harrowing. During this period, liming and organic fertilization were also carried out, applying 4.6 kg m^{-2} of organic compost.

Oat sowing was carried out mechanically at a depth of 5 cm with the aid of a winter crop seeder, set at a spacing of 20 cm between the crop rows. The oat plants were mowed close to the ground at the beginning of the reproductive period. At the time of management, the accumulated biomass of the aerial part was determined by randomly placing a metal frame with an area of 0.25 m^{-2}, in which the plants were collected within the frame. The samples were placed in paper bags and subjected to forced air circulation at 65 °C, until they reached a constant mass.

Furthermore, the percentage of the area covered by the cover plant was determined, using a 10 m long measuring tape as an aid, counting the presence or absence of straw every 0.10 m. From this, the percentage of coverage was estimated.

After oat management, soil was collected for chemical analysis according to the methodology proposed by Silva et al. (2009), at a depth of 0 to 0.2 m. The soil presented the following chemical attributes: pH (CaCl2) =5.33; MO= 21.87 g dm^{-3}; P (Mehlich-1) = 195.78 mg dm^{-3}; Mg+2= 3.05 $cmol_c$ dm^{-3}; K (Mehlich-1) = 1.37 $cmol_c$ dm^{-3}; Ca^{2+} =11.25 $cmol_c$ dm^{-3}; Al^{3+}=0.00 $cmol_c$ dm^{-3}; SB= 15.67 $cmol_c$ dm^{-3}; CTC= 19.75 $cmol_c$ dm^{-3}; H +Al= 4.08 $cmol_c$ dm^{-3} and V= 79.34%.

The experiment was conducted in direct planting, under organic management using a randomized block experimental design (DBC), with seven treatments and four replications. The treatments consisted of the following arrangements of okra and kale plants, in a consortium T1 = three rows of kale with okra between the lines; T2 = three rows of kale with okra between the lines; T3 = three rows of kale with okra dense between the lines, T4 = three rows of kale with okra dense spaced between alternating lines; and monoculture T5 = three rows of kale; T6 = three rows of okra; T7 = three rows of dense okra. The following densities of okra plants per ha^{-1} were established: T1 (8,890); T2 (4,440); T3 (17,780); T4 (8,890); T6 (13,330), T7 (26,670). In all treatments, the kale plant density was 13,330 plants ha^{-1}.

The okra intercropped with kale was trained in single lines at 0.60 m from the kale line, and the spacing between plants for kale was 0.50 m and for okra 0.50 m and 0.25 m (dense okra) between plants, respectively. In monoculture, the spacing between rows for both crops was 1.20 m and between plants the same as those used in intercropping. Each experimental plot was 7 m long x 3.60 m wide, totaling 25.2 m^2.

Crop fertilization was carried out based on soil analysis and the recommendations of Trani et al. (2013).

The butter kale seedlings cv. "Georgia" and okra cv. "Santa Cruz 47" were produced in a greenhouse using 200-cell polyethylene trays, containing commercial organic substrate.

To plant the seedlings, the furrows were opened mechanically and on this occasion seven t ha^{-1} of organic compost was applied. Transplantation occurred simultaneously for both species at 30 days after sowing (DAS).

Pest control was carried out using natural products such as: garlic (*Allium sativum* L.) and tobacco (*Nicotiana tabacum* L.) extract for the owl (*Ascia monuste*). Smoke syrup at 40% v v^{-1} for aphids (*Brevicoryne brassicae*) and whiteflies (*Bemisia tabaci*). Disease control was carried out for powdery mildew (*Erysiphe diffusa*) on okra, with the application of cow's milk at 10% v v^{-1}.

Assessments began 50 and 73 days after transplantation (DAT) for kale and okra, respectively. The height of the okra tree and diameter of the crown were evaluated at 30, 60, 90, 120, 150 and 180 DAT with the aid of a measuring tape. The number of fruits accumulated per plant, accumulated fresh mass of fruits per plant, accumulated productivity, average length and average diameter of fruits were evaluated every three days and the values were expressed biweekly at 88, 103, 118, 133, 148, 163, 178, 193 and 208 DAT.

For the kale crop, the leaves were harvested at regular intervals of 30 days, at 50, 80,110 and 140 DAT. For productivity, the accumulated result for the entire period was considered.

Based on the productivity values of each crop, the Equivalent Land Use Index (UET) was estimated using the following formula: UET = (C culturaA/MculturaA) + (CculturaB/MculturaB), where C and M represent, respectively, the productivity of the consortium and single cultivation, referring to species A (okra) and B (kale). The consortium will be efficient when UET is greater than 1.00 and harmful when lower (Willey, 1979).

After tabulating, the data were subjected to variance analysis and when significant, the means were subjected to regression analysis depending on the evaluation periods or compared using the Tukey test at 5% probability, using the SISVAR statistical software (Ferreira, 2014).

Results and discussion

The unsatisfactory dry matter production of *Avena sativa* in relation to the present study may be related to the low volume of precipitation that occurred in July (**Table 1),** coinciding with the period of high water demand for the crop, high evaporative demand and low availability of water. water in the soil, negatively interfering with the dry matter accumulation of the cover crop.

Table 1. Average air temperature and monthly accumulated rainfall, referring to the oat cultivation cycle. Marechal Cândido Rondon-PR, Unioeste, 2018.

Month	May	June	July	August
Air temperature (°C)	20.00	18.00	18.00	20.00
Rainfall (mm)	177.00	54.40	1.00	104.60

It is noted in the analysis of variance (**Table 2**) that there was an interaction between the cultivation systems and evaluation periods for the characteristics of shoot length, crown diameter and accumulated okra productivity. Statistical differences between cultivation systems were observed for the analyzed characteristics, except for fruit length and diameter and kale crop productivity.

The length of the aerial part of okra plants showed an increasing linear behavior throughout the cultivation cycle (**Figure 2**A), regardless of the cultivation system. Statistical differences were observed at 150 DAT, with single okra cultivation in adequate spacing (T6) showing 10.25% more height in relation to the dense okra cultivation inserted between each row of the kale crop (T3), not differing from other plant arrangements.

Table 2. Summary of analysis of variance for length of aerial part (LAP), crown diameter (DC), number of accumulated fruits (NAF), accumulated fresh mass of fruits (AFMF), fruit length (FL), fruit diameter fruits (FDF) and accumulated productivity (AP) of okra and kale productivity (P) depending on different cropping systems. Marechal Cândido Rondon-PR, Unioeste, 2018.

F.V	LAP	CD	NAF	AFMF	FL	FDF	AP	P
				Values F				
Systems(S)	5.5**	6.5**	19.4**	22.2**	0.2^{ns}	1.7ns	247.5**	2.4^{ns}
Periods(P)	2253.7**	1933.1**	340.0**	268.7**	19.1**	53.3**	218.7**	-
S x P	2.2**	2.2**	1.3^{ns}	1.5^{ns}	1.0^{ns}	1.1^{ns}	10.5**	-
Block	4.0**	0.3^{ns}	14.5**	14.2**	2.8*	0.6ns	15.7**	4.13*
Average	1.34	0.84	68.99	739.45	12.94	14.89	9.65	20.30
CV (%	7.26	5.55	17.88	20.10	7.50	3.89	21.84	10.58

CV = coefficient of variation. *, ** = significant at 5% and 1% by F test, respectively. ns = not significant by the 5% F test.

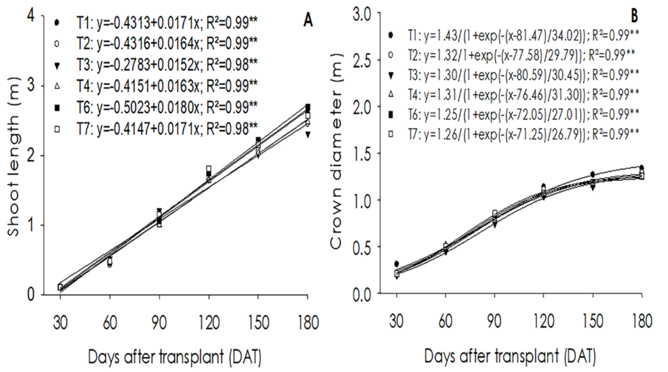

Figure 2. Length of the aerial part (A) and diameter of the crown (B) of okra plants in different cultivation systems. Marechal Cândido Rondon-PR, Unioeste, 2017-2018.

The highest plant heights were observed at 180 DAT for all systems evaluated. The cultivation of single okra in both plant populations (T6 and T7) and the system in which the okra was inserted between each row of the kale crop (T1) showed a superiority of 14.63% in plant height in relation to the system in which dense okra was inserted between each row of the kale crop (T3), and the reduction in this variable can be justified by the greater intraspecific competition of the okra crop and interspecific competition with the kale crop. Since high plant densities influence the quality of irradiance input inside the canopy (Fiorucci and Fankhauser, 2017), causing competition for some resources such as light.

In evaluations carried out by Almeida et al. 2018, it was observed that from 240 days after transplanting, plant height was higher for açaí monoculture compared to açaí + banana intercropping systems, partially corroborating the present work.

However, opposite results were observed by Costa et al., (2014), where intercropping of beet + cabbage promoted greater plant heights for beet compared to the single cropping system in a substrate containing 100% compost. Therefore, the practice of consortium can cause a higher rate of shading, inducing plants to resort to physiological mechanisms, including increasing height for greater light interception and consequently the occurrence of etiolation.

Increasing exponential responses depending on the days of cultivation were observed for the crown diameter of the okra crop in all treatments evaluated (Figure 2B). Statistical differences were observed 120 days after transplanting the seedlings, with the okra tree in adequate spacing inserted between each row of the kale crop (T1) showing 9.90% superiority in relation to the okra densely inserted between each row of the kale crop (T3).

Similar effects were observed 150 days after transplantation, where T1 showed an average of 9.79% superiority in the transverse diameter of the crown when compared to T2, T3, T4 and T6.

The okra plants reached the largest transverse diameter of the crown 180 days after transplanting, measuring an average of 1.29 m. During this period, no statistical differences were observed between the treatments evaluated.

The greater expression of the crown diameter in okra plants may present advantages from a photosynthetic point of view, since plants with a larger crown diameter intercept a greater amount of light. According to Taiz and Zeiger (2017), the photosynthetic process depends directly on the interception of light energy by leaves and its conversion into chemical energy.

The variable number of fruits accumulated per plant showed increasing linear behavior as a function of time for all treatments evaluated (**Figure 3**).

The okra monoculture systems in recommended spacing (T6) and its insertion between each row of the kale crop (T1) showed an average of 27.61% superiority in number of fruits per plant in relation to the dense okra monoculture (T7) , dense okra inserted between each row of kale (T3) and dense okra inserted between alternating rows of kale (T4).

Cultivating okra at the recommended population density may have provided greater space for the emission of new productive branches and consequently new fruits, and may also have enabled an increase in the number of fruits per plant.

Cavichioli et al. (2014) also observed a lower number of fruits in the dense cultivation of *Passiflora edulis grafted* on *Passiflora gibertii* in relation to the cultivation in lower spacings, believing that the dense cultivation provided greater intraspecific self-shading due to the larger population of plants in the area, the which may have harmed the number of flowers and consequently

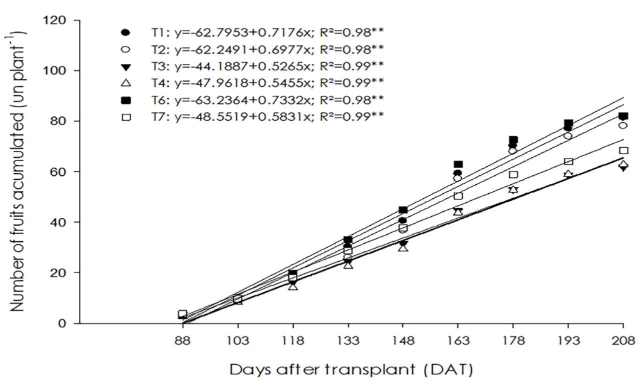

Figure 3. Number of fruits accumulated per okra plant in different cultivation systems. Marechal Cândido Rondon-PR, Unioeste, 2017-2018.

the number of fruits per plant.

There was no interaction between cultivation systems and evaluation periods for accumulated fresh fruit mass. Okra plants accumulated the highest amounts of fresh fruit mass at 208 DAT when compared to the other periods, with the exception of 193 DAT, where no statistical differences were observed (**Figure 4**).

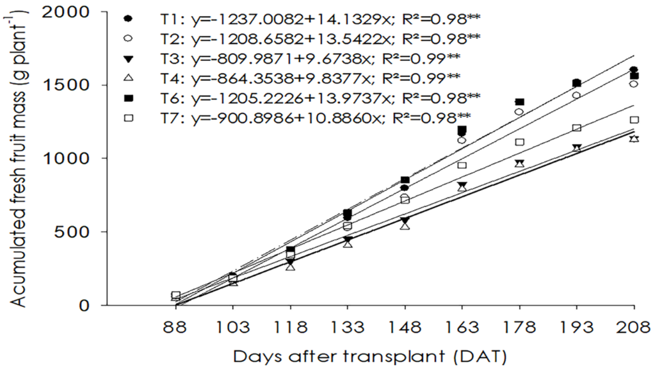

Figure 4. Fresh mass of fruits accumulated per okra plant in different cultivation systems. Marechal Cândido Rondon, UNIOESTE, 2017-2018.

The cultivation systems with single okra (T6) and intercropped okra inserted in each row of the kale crop (T1), both at recommended densities, promoted greater accumulation of fresh fruit matter per plant when compared to dense okra monoculture systems. (T7), okra inserted between each row (T3) and every two rows of the kale crop (T4). In other words, the production per plant when cultivating okra in adequate spacing corresponded to 33.93% superiority in relation to the other dense systems evaluated.

Similar results were obtained by Ferreira (2016) when evaluating different plant densities in organic lettuce (*Lactuca sativa*) cultivation, with linear reductions in the accumulation of fresh matter per plant as population density increased. However, these same authors showed compensatory effects, with increases in the commercial productivity of packs m^{-2}.

The cultivation systems did not promote statistical differences in the length and diameter of the fruits, possibly due to considering a certain fruit pattern as a criterion at the time of harvest. However, effects depending on the evaluation periods were observed, with increases in these variables in the last evaluation periods (**Figure 5**).

At 193 days after transplanting, the fruits were shorter in length (Figure 5A) and larger in diameter (Figure 5B), regardless of the cultivation system used, compromising the visual appearance and commercial standard of the harvested fruits. This period corroborated the high infestation of brown stink bug (*Euschistus heros*) coming from recently harvested soybean (*Glycine max*) cultivation areas, located on the outskirts of the experimental area, in which okra plants were used as a survival strategy during these periods.

The productivity variable showed significant statistical interactions between treatments and evaluation periods. Accumulated productivity showed an increasing linear effect depending on the evaluation periods for all cultivation systems (**Figure 6**).

Accumulated productivity showed no statistical difference between cultivation systems until 103 DAT. However, dense okra monoculture (T7) promoted greater accumulated productivity in relation to other cultivation systems between the periods of 133 DAT and 208 DAT.

The densification technique, despite having harmed the number of fruits per plant and fruit mass per plant due to the greater potential for competition, generated a clear compensatory effect when considering the space used in cultivation. Due to the fact that there are twice as many plants in the same area In relation to the spacing commonly used, the effect of densification was positive on crop productivity, enabling higher

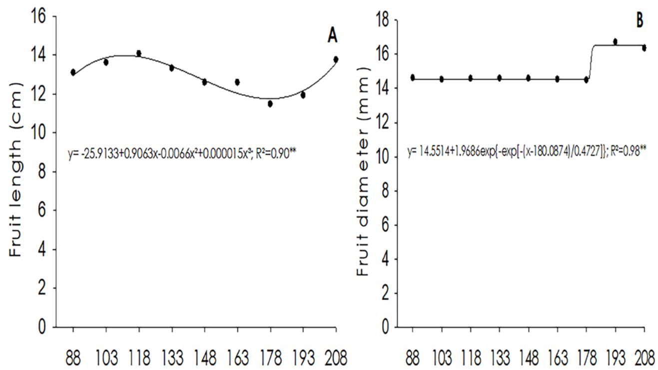

Figure 5. Length (A) and diameter (B) of the okra fruit depending on the evaluation periods. Marechal Cândido Rondon-PR, Unioeste, 2017-2018.

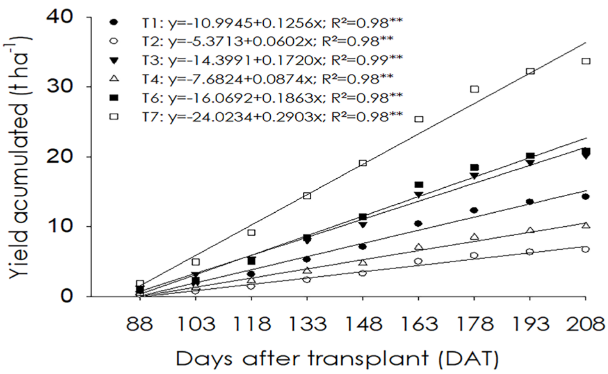

Figure 6. Accumulated productivity of okra fruits in different cultivation systems. Marechal Cândido Rondon-PR, Unioeste, 2017-2018.

productivity in okra cultivation in the same cultivation area.

Similar results were obtained by Paulus et al. (2015), when evaluating different spacings between plants and between cultivation lines in pepper cultivation, they found that the densification technique provides greater yields of fresh fruit mass when considering the area used for cultivation.

Considering the accumulation of all evaluation periods, the okra monoculture in the dense system (T7) provided increases of 61.61% in productivity in relation to the recommended plant population (T6), in this sense the culture density technique can be recommended for increasing fruit productivity.

The cultivation system in which densely packed okra was inserted between each kale row (T3) presented yields similar to the okra monoculture at recommended spacing (T6). In this sense, when using this intercropping system, in addition to the productivity of the okra equivalent to the recommended cultivation conditions, the productivity of the kale can be considered by promoting greater efficiency in the use of land, due to using the same cultivation space. (**Table 3**).

No statistical differences were observed for kale productivity between the intercropping systems. In this sense, the shading provided by the okra crop did not provide reductions or increases in productivity of the kale crop. However, when considering the efficiency in the use of the area, all systems promoted greater biological efficiencies.

These results demonstrate that the practice of intercropping is advantageous, as it guarantees greater food production per cultivated area, indicating greater use of the system's resources.

The cultivation systems in which the okra tree at the recommended spacing was inserted between each row of the kale crop was 69.00% more efficient compared to the species implemented in monoculture. However, the cultivation of okra in dense spacing between each kale row showed 45.00% production efficiency. Similarly, the insertion of okra rows in alternate rows of kale crops promoted efficiency of 37.00% and 22.00% under recommended and dense population conditions, respectively.

Menezes et al. (2022) when evaluating the efficiency of land use in a lettuce and radish (Raphanus sativus) intercropping system, they found increases of 156% in the production of lettuce and radish per square meter in the intercropped system, when compared to the same cultivated area under monoculture conditions.

The results indicate the possibility of using a consortium of okra and kale in an organic cultivation system in direct planting as a strategy for intensifying crops, with greater production and diversification of food per cultivated area, thus increasing profitability.

Table 3. Kale productivity and land use efficiency in different cropping systems intercropped with okra.

Treatments	Productivity (t ha^{-1})	UET
T1	20.76a	1.69
T2	22.20a	1.37
T3	17.90a	1.45
T4	19.38a	1.22
T5	21.24a	-
T6	-	-
T7	-	-
CV (%)	10.58	-
DMS	4.84	-

Means followed by the same letter do not differ according to the Tukey test at 5% probability. **significant at 1% using the F test. T1 (three rows of kale with okra between the lines), T2 (three rows of kale with okra between the lines alternated), T3 (three rows of kale with okra dense between the lines), T4 (three rows of kale with okra dense spaced between alternating lines), T5 (three rows of kale), T6 (three rows of okra), T7 (three rows of dense okra).

Conclusion

The okra crop showed greater productivity when grown in monoculture at a denser plant density. All consortium systems promote greater efficiency in land use.

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References

Almeida, U.O., Neto, R.C.A., Lunz, A.M.R., Costa, D.A., Araújo, J.M., Rodrigues, M.J.S. 2018. Growth of assai (*Euterpe precatoria* mart.) intercropping with banana. *South American Journal of Basic Education, Technical and Technological* 5: 154-166.

Alves, T.N., de Moraes, Echer, M., Sackser, G.A.B., Black, A.V., Klosowski, É. S., Júnior, E.K.M., Coutinho, P.W.R. 2020. Performance the kale (*Brassica oleracea* L. var. *acephala*) intercropped with okra in the organic system. *Pesquisa, Sociedade e Desenvolvimento* 9: e34891210943-e34891210943.

Cavichioli, J.S., Kasai, F.S., Nasser, M.D. 2014. Productivity and physical characteristics of fruits of *Passiflora edulis* grafted *Passiflora gibertii* in different planting densities. *Revista Brasileira de Fruticultura* 36: 243-24.

Cecílio Filho, A.B., Medelo, M.J.Y., Pontes, S.C., Nascimento, C.S. 2021. Chicory and arugula in intercropping with collard greens. *Revista Caatinga* 34: 772-779.

Costa, L.A. de M., Pereira, D.C., Costa, M.S.S. de M. 2014. Alternative substrates for the production of cabbage and beetroot in consortium and monoculture systems. *Revista Brasileira De Engenharia Agrícola E Ambiental* 18: 150–156.

Coutinho, P.W.R., Oliveira, P.S.R.D., Echer, M.D.M., Cadorin, D.A., & Vanelli, J. 2017. Establishment of intercropping of beet and chicory depending on soil management. *Agricultural Science*48: 674-682.

Ferreira, D.F. 2014. Sisvar: a guide for its bootstrap procedures in multiple comparisons. *Science and Agrotechnology* 38: 109-112.

Ferreira, R.L.F., Neto, S.E.A., Pereira, F.E.B., Souza, A.O. 2016. Yield of organic lettuce in different plants density. *Pernambuco Agricultural Research* 21: 12-16.

Fiorucci, A. S., Fankhauser, C. 2017. Plant strategies for enhancing access to sunlight. *Current Biology* 27: 931-R940.

Frison, E.A., Cherfas, J., Hodgkin, T. 2011. Agricultural biodiversity is essential for a sustainable improvement in food and nutrition security. *Sustainability* 3: 238-253.

Guerra, N.M., Bezerra Neto, F., Lima, J.S.S., Santos, E.C., Nunes, R.L.C., Porto, V.C.N., Queiroga, R.C.F., Lino, V.A.S., Sá, J.M. 2022. Agro-economic viability of lettuce-beet intercropping under green manuring in the semi-arid region. *Brasilian Horticulture* 40: 82-91.

Lepse, L., Dane, S., Zeipina, S., Domínguez-Perles, R., Rosa, E.A.S. 2017. Evaluation of vegetable–faba bean (*Vicia faba* L.) intercropping under Latvian agro-ecological conditions. *Journal of the science of food and agriculture* 97: 4334- 4342.

Menezes, C.S.L., Rezende, R., Terassi, D.S., Hachmann, T.L., Saath, R. 2022. Lettuce and radish grown in single crop and intercropping systems under different irrigation water depths in a protected evironment. *Revista Caatinga* 35: 658-666.

Nascimento, C.S., Cecílio Filho, A.B., Mendonza-Cortez, J.W., Nascimento, C.S., Bezerra Neto, F., Grangeiro, L.C. 2018. Effect of population density of lettuce intercropped with rocket on productivity and land-use efficiency. *PloS one* 13: e0194756.

Paulus, D., Valmorbida, R., Santin, A., Toffoli, E., Paulus E. 2015. Growth, yield and fruit quality of pepper (*Capsicum annuum*) at different spacings. *Brasilian Horticulture* 33: 91-100.

Prata, R.C.; Silva, J., Lima, Y.B., Anchieta, O.F.A., Dantas, R.P., Lima, M.B. 2018. Density of planting on the growth and production of plantain cv. D'Angola in the Chapada do Apodi. *Technical Agricultural* 39: 15-23.

Santos, H.G., Jacomine, P.K.T., Anjos, L.H.C., Oliveira, V.A., Oliveira, J.B., Coelho, M.R., Lumbreras, J.F., Cunha, T.J.F. 2013. Brazilian Soil or Classification Systems. EMBRAPA, Distrito Federal, Brazil. 355 p.

Silva, M.B., Costa, C. R., Costa, A.S.V., Prezzoti, L. 2009. 101 Crops: Handbook of agricultural technologies. Epamig, Belo Horizonte, Brazil. 653 p.

Sousa, Á.P., Siebeneichler, S.C., Martins, M.C.S., Santos, E.V., Marques, R.B., Santos, M.F.R., Ribeiro, M.M.C., Sugai, M.A.A., Oliveira, M. 2019. Productivity and Economic Viability of Intercropping of Cucumber and Lettuce, in Southern Tocantins, Brazil. *International Journal of Plant & Soil Science* 30: 1-7.

Taiz, L., Zeiger, E. 2017. Plant physiology. Artemed, Porto Alegre, Brazil. 719 p.

Tavares, A.E.B., Claudio, M.T.R., Nakada-Freitas, P.G., Cardoso, A. 2016. Plant density in the production of edible pod pea. *Brasilian Horticulture* 34: 289-293.

Tivelli, S.W., Kano, C., Purquerio, L.F.V., Wutke, E.B., Ishimura, I. 2013. Okra performance intercropped with small size and erect green manure in two production systems. *Brasilian Horticulture* 31: 483-488.

Trani, P. E., Terra, M. M., Tecchio, M. A., Teixeira, L. A. J., Hanasiro, J. 2013. Organic fertilizer for vegetables and fruit trees. Campinas Agronomic Institute, Campinas, Brazil.16 p.

Weisany, W., Raei, Y., Pertot, I. 2015. Changes in the essential oil yield and composition of dill (*Anethum graveolens* L.) as response to arbuscular mycorrhiza colonization and cropping system. *Industrial Crops and Products* 77: 295-306.

Willey, R.W. 1979. Intercropping: its importance and research needs. Part 1, competition and yield advantages. *Field Crop Abstracts* 32: 1-10.

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