



Productivity and Economic Viability of Intercropping of Cucumber and Lettuce, in Southern Tocantins, Brazil

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Authors' contributions

This work was performed in collaboration among all authors. Author APS was responsible for preparing the research project and execution and data analysis. Author SCS assisted in the execution and interpretation of the data. Author MCSM was responsible for the elaboration and execution of the project. Author EVS assisted in the execution and harvest of the experiment. Author RBM assisted in the harvest and statistical analysis. Author MFRS harvest of the experiment. Author MMCR assisted in the elaboration of the project. Author MAAS helped in the elaboration of the article. Author MO helped in the elaboration of the article. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2019/v30i230173

Editor(s):

(1) L.S Ayeni, Department of Agricultural Science, Adeyemi College of Education, PMB 520, Ondo, Ondo State, Nigeria.

Reviewers:

(1) Olutosin A. Otekunrin, Federal University of Agriculture, Nigeria.

(2) Hussin Jose Hejase, Al Maaref University, Lebanon.

Complete Peer review History: <https://sdiarticle4.com/review-history/51716>

Short Communication

Received 11 July 2019
Accepted 28 September 2019
Published 17 October 2019

ABSTRACT

In Brazil, vegetable consumption grows every year, as it has many advantages, from the supply of food to the medicinal value, which makes it necessary to optimize the use of land by producers, and an alternative used is the intercropping. Therefore, this study aimed to analyze the productivity and economic viability of cucumber (*Cucumis sativus* L.) and lettuce (*Lactuca sativa* L.) in two different cropping systems (intercropped and monoculture). The production of seedlings was held at UFT —

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Gurupi Campus and the experiment conducted in a given area featuring 13m wide and 23 m in length, totaling 299 m², in the period between June and August of 2018. The area mentioned was used for the production of Lucy Brown lettuce, and the 'Caipira' variety of cucumber. The experiment was conducted in a randomized block with four replications and three treatments, which were incorporated in: monoculture of cucumber (T1), monoculture of lettuce (T2), and consortium of lettuce with cucumber (T3). Lettuce and cucumber in monoculture presented the best answers for all variables analyzed when compared with the consortium. The index of equivalence area (IEA) was calculated to assess the efficiency of crops in both production systems. And the value found for the IEA showed that the consortium is efficient within the production system. According to the technical coefficients relating to deployment, conducting plants and their production costs, the Consortium has proven economically viable.

Keywords: *Lactuca sativa*; *Cucumis sativus*; *intercropping*; *monoculture*; *equivalence index*; *horticulture*.

1. INTRODUCTION

Vegetable consumption has grown significantly in Brazil, because they present many advantages extending from food supply to medicinal value, and it is important even in disease prevention. The national production of oleraceous is intense, with heightened investment by area and an economic return that attracts mainly small producers, and that matches 60% of this production [1,2].

The lettuce (*Lactuca sativa* L.) is a vegetable produced and consumed throughout the Brazilian territory, presents short cycle (45 to 60 days), belongs to the family Asteraceae and probably originated in the Mediterranean region. The lettuce commercialized in Brazil can be classified into six groups according to the type of leaf: butter lettuce, iceberg lettuce, looseleaf lettuce, curly type, mimosa and romaine type. [2].

The cucumber (*Cucumis sativus* L.) is a common vegetable in Brazil belonging to the Cucurbitaceae family, composed of 95% water and rich in fiber. Has great socioeconomic importance, because your production Generates chain jobs, directly and indirectly, from cultivation to commerce. The market currently offers four types of cucumber: 'caipira' lines, pickling cucumber, Aodai or common, and japanese or Aonaga, and the predominance of other several hybrid cultivars [3].

According to Telles et al. [4], the intercropping is a practice that provides the best use of the same area and environmental resources, such as nutrients, water, solar radiation. That factors can increase productivity, optimize production,

improve the protection and soil conservation, and ensure a financial return to the producer.

Intercropping can be a simultaneous conjunction of two or more species, and the literature shows evidence that intercropping is viable for various vegetables, for example lettuce and tomato [5], garlic and cucumber [6], strawberry and cucumber [7], and lettuce and cucumber [8,9]. According to Santos et al. [10], crop consortia have advantages such as reduced risk caused by climate variations, lower weed spending, pest and disease control, better distribution of work and greater food diversity for the small producer, producing more efficient mainly in family agriculture. Although one of the main disadvantages is the difficulty of mechanization in specific field operations.

In general, consortium systems are adopted by family farmers seeking high quality products without losing economic viability. Júnior et al. (2009) [11] found that the use of lettuce in consortium with Cucumber may be an alternative to reduce the costs of implantation, especially in low-priced times, when the cultivation in monoculture can be economically unviable and the Increase in the profitability of the crop.

It is necessary to evaluate the system, because some factors can negatively affect profitability, such as lower quality of vegetables and reduced market value. Thus, the index equivalence area (IEA) defined by Teixeira et al. (2005), is used to evaluate the efficiency of the Consortium in relation to the monoculture system. For the IEA to be valid, the authors report that the management level should be the same for both systems. In addition to optimizing small agricultural areas, the consortium is an

alternative to reduce the cost of implementation and increase the profitability of crops.

This study aimed to analyze the economic viability and yield of cucumber (*Cucumis sativus* L.) and Lettuce-American (*Lactuca sativa* L.), in two cropping systems, consortium and monoculture.

2. MATERIALS AND METHODS

The production of lettuce and cucumber seedlings in greenhouse was carried out at the Federal University of Tocantins (UFT), Gurupi campus, so that they were subsequently taken to the field. After the seedling formation, the experiment was conducted in a private farm of small producer, Mr. Edson da Silva, located in the Spring Park sector, city of Gurupi, Tocantins. The sowing was carried out in June of 2018 in plastic trays 200 cells containing substrate consisting of rice straw + black land + poultry manure. The seedlings were transplanted at 25 days after sowing (DAS), in beds with 13 meters wide by 23 meters in length, totaling 299 m². We used the American lettuce cultivar Lucy Brown and the cucumber of the red neck type. Soil samples were collected in the experimental area and sent for analysis to determine the soil chemical attributes (Table 1). After data interpretation, liming and fertilization were performed according to the need of the crops.

The planting of seedlings in the field was carried out in July 2018. The experiment was conducted in randomized blocks with four replications and three treatments, distributed as follows: T1: Lettuce monoculture, T2: Cucumber and monoculture, T3: Consortium of lettuce with cucumber. Each experimental monoculture unit was 1.0 m wide and 1.5 m long, represented by a single row of six cucumber plants spaced 0.60 × 0.60 m and four rows of American lettuce with 0.25 × 0.25 m. In the cultivation of the consortium, three rows of lettuce and four cucumber plants were established.

For the correction of soil acidity, 68 kg of limestone was used, distributed manually in the

area. At 15 to 30 days after transplantation (DAT) of the seedlings were applied in coverage with 100 mg. M of nitrogen (N), phosphorus (P) and potassium (K), in the formulation (5-25-15). The cultural tracts for pests, diseases and weed control were performed as needed.

After 60 DAT, the characteristics of the lettuce plants were evaluated (plant height, fresh and dry mass of the aerial part, number of leaves and diameter of the head), considering the central plants in each plot. The cucumber harvest began in 40 DAT and harvested in alternating days up to 80 DAT in which only the weight of the fruits was analyzed.

During the experiment, the production costs of the crops, technical coefficients related to the implantation and conduction of the plant were analyzed to evaluate whether the crop consortium presented economically viable results. The area equivalence index (IEA) was calculated to evaluate the efficiency of intercropping and monoculture crops. When the index is greater than 1 the consortium is efficient and when inferior, inefficient [11].

The IEA is a parameter used to compare the consortium with the monoculture, applying the following equation:

$$IEA = \frac{C \text{ lettuce}}{S \text{ lettuce}} + \frac{C \text{ cucumber}}{S \text{ cucumber}}$$

Where:

- C lettuce: productivity of lettuce in intercropping;
- S lettuce: productivity of lettuce in monoculture;
- C cucumber: productivity of cucumber in intercropping;
- S cucumber: productivity of cucumber in monoculture [12].

Data were subjected to analysis of variance (P<0.05) of the F test and means were compared by Tukey test in the Sisvar statistical program [13]. Tables and graphs were obtained based on the Excel program, version 2010.

Table 1. Results of the chemical analysis of the soil at 0-20 cm layer of depth of experimental area. Gurupi, Tocantins, 2018 (Source: author himself)

pH	MO	P meh	K	Ca	Mg	Al	H+Al	SB	T	V
(CaCl ₂)	dag kg ⁻¹	mg dm ⁻³		----- cmol c dm ⁻³ -----						%
5.00	1.30	16.90	23.00	1.50	0.40	0.00	3.10	1.96	5.06	39.00

Extractors: P e K: Mehlich; Ca, Mg e Al: KCl 1M

3. RESULTS AND DISCUSSION

Lettuce grown in monoculture showed better results for all evaluated parameters (Table 2). According to Teller et al. [4], the relationship between monoculture and intercropping lettuce with bertalha and yam showed no significant difference for the variables fresh weight, dry mass, height, circumference and diameter in the two evaluated systems. These results can be attributed to competition for water, light, nutrient and space in the pool. This technique contributed positively to the increase of biodiversity in the area and the agronomic performance of lettuce, which was satisfactory. Corroborating the results obtained in this study.

In the production of single lettuce, Damasceno et al. [1] observed higher averages of dry and fresh mass of the aerial part, when compared to the consortium with radish, as the plant population increases. This is due to the fact that competition is reduced and there is a greater distribution of plants, contributing to a better culture development.

Algeri et al. [14] verified that lettuce cultivation presented the highest average of total fresh mass when intercropped with cabbage and the lowest average at the lettuce monoculture. Demonstrating that simultaneous cultivation between crops is positive, since the plants showed better development and productivity in the intercropping system.

Even though both crops were superior in the monoculture for the analyzed parameters, the IEA found was 1.25, being higher than the required average (1.0), this proves that the use of the consortium is efficient within the production system. However, some planting adjustments, such as plant population, spatial arrangement, planting season, and crop monitoring, can be performed to improve yield.

A similar result was observed by Algeri et al. [14], in which the consortium between cabbage and lettuce presented an average IEA of 1.44, with the area being better utilized and the intercropping system viable. Differently from the result obtained by Carvalho et al. [15], in which the consortium between lettuce and chives is not recommended because the IEA presented was less than 1.0, showing that there was no advantage in the utilization of the area.

The productivity of the cucumber cultivation system single presented greater values for the weight of the fruits when compared to the consortium with lettuce (Fig. 1). This factor can be explained due to competition for nutrients, water, solar radiation, and the arrangement of population of plants, which may have interfered with to the result obtained.

Ribas [16] observed that, independently of the cultivation system adopted for 'Lucy Brown' lettuce and 'Soldier' cucumber, in monoculture and intercropping between crops, cucumber productivity (per plant and per area) did not suffer significant interference with the presence of lettuce. The increasing population density of cucumber affected lettuce. That indifference can be attributed to how the cucumber was conducted (tutored), causing shade and competition for light by reducing the passage of solar radiation. It is considered that the amount of light available, is the main factor of competition between cultures when grown on consortium. In the present work, the cultivation of cucumber was not tutored, so it can be said that there was competition for water, nutrients and space, probably, except light.

Rezende [17] observed that the productivity obtained from the cucumber in monoculture did not show significant difference in relation to the intercropping with curly and american lettuce. And the absence of negative interference can be

Table 2. Plant height (PH) and plant diameter (PD), number of leaves per plant (NF), shoot dry mass (SDM) and fresh shoot mass (FSM) as a function of intercropping systems (lettuce x cucumber) and monoculture (Source: author himself)

	FSM (g)	SDM (g)	PH (cm)	PD (cm)	NF
Monoculture of lettuce	472 a	15.5 a	15.2 a	17.8 a	32.1 a
Consortium (lettuce x cucumber)	305 b	8.75 b	11.9 b	12.5 b	22.1 b
CV %	28.2	27.2	26.8	28.6	31.4
QM	224897.45	364.5	87.21	220.50	810.03
IEA		1.25			

Means followed by different letters in the column differ significantly from each other by the Tukey test at 5% probability. IEA: Area equivalence index - consortium efficiency

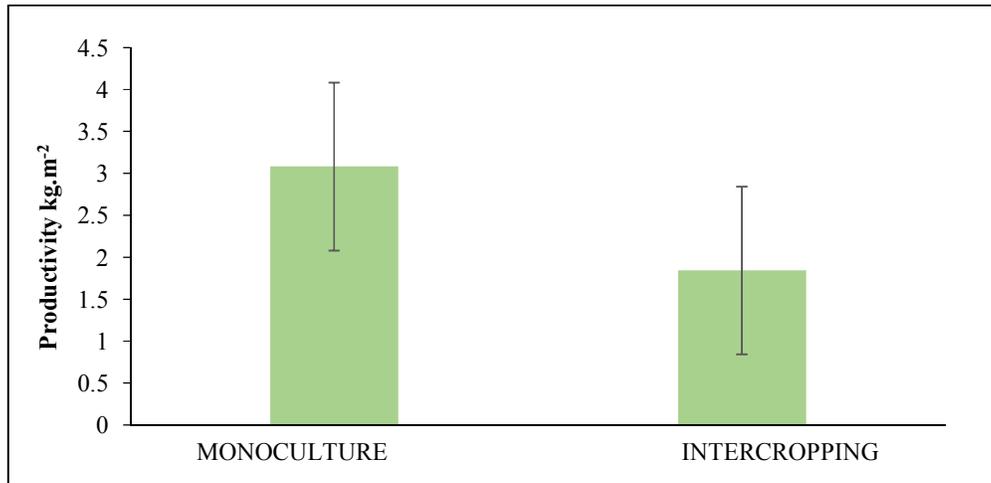


Fig. 1. Productivity of cucumber in monoculture and intercropping with lettuce. (Source: author himself)

Table 3. Technical coefficients and total operating cost for the production of American lettuce and ‘caipira’ cucumber in a system of monoculture and consortium in the city of Gurupi, Tocantins (Source: author himself)

Items	Monoculture			Consortium		
	----- Technical coefficients (18 m ²) -----					
	CL	ML	M+I	CL	ML	M+I
1. Operations						
Cleaning the ground	20.00	-	-	20.00	-	-
Harrowing	-	15.00	50.00	-	15.00	50.00
Seedlings bed preparation	-	15.00	50.00	-	15.00	50.00
Assembly (irrigation)	9.54	-	-	9.54	-	-
Irrigation	4.77	-	-	4.77	-	-
Harvest and post-harvest	9.54	-	-	9.54	-	-
Subtotal – operating cost	43.85	30.00	100.00	43.85	30.00	100.00
2. Supplies and materials	Quant.	Value (R\$)		Quant.	Value (R\$)	
Formulation NPK 05-25-15 (kg)	3.00	7.50		3.00	7.50	
Limestone (kg)	2.4	1.50		2.4	1.50	
Pelleted lettuce seeds (kg)	0.0004	4.00		0.0003	4.00	
Cucumber seeds (kg)	0.0003	3.00		0.0002	3.00	
Hoses for irrigation (m)	100	150		100	150	
Ballerina type sprinklers	5	12.5		5	12.5	
Plastic trays 200 cells	2	8.00		2	8.00	
Substrate for seedling production (kg)	5	7.00		5	7.00	
Subtotal	193.5			191.5		
Total cost	367.35			365.35		

CL – Common labor; ML– Mechanized Labour; M+I – Expenses with machines and implements. In the cost hours-machine were considered fuel and implement rent

attributed to the difference between the species in terms of architecture, growth velocity and land occupation.

Table 3 shows the amounts spent in the implantation of two cultivation systems in the

property, considering the technical coefficients obtained. It is observed that the consortium of cultures is feasible, because the cost for implantation and conduction of the two systems is similar, this being a strategy that demonstrates greater productivity in the area. Therefore, a

better use of soil, water and maximization of space, besides economic return.

Nascimento et al. [18] carried out their study to evaluate the economic viability of the consortium of lettuce and arugula, it was observed that in this system it was possible to optimize operations, use of inputs and increase profitability in relation to Monoculture, corroborating the one found in the present study.

4. CONCLUSION

The lettuce monoculture system was more efficient for fresh and dry production, height, diameter and number of leaves. In addition, a higher production of cucumber was obtained in the monoculture system.

From the references it is remarkable that the use of stoning in cucumber will favor the culture, not being recommended for the cultivation in consortium.

The evaluated index equivalence area (IEA) was 1.25, which proves the efficiency of the production in both systems. The consortium is an economically viable alternative to compare the production costs between the two cultivation systems, in addition to increasing soil biodiversity.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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The peer review history for this paper can be accessed here:
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