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Productive Yield of Cowpea and Maize in Single Crop and Mixtures in an Agroforestry System

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Abstract: The investigation for one of alternatives that allow the expansion of agricultural and forest products associated with environmental preservation, one option would be the adoption of agroforestry. The objective of this study was to evaluate the productive yield of cowpea and maize in single crop and mixtures in an agroforestry system in the southern state of Tocantins. The experimental design was randomized complete blocks with four replications. The treatments were arranged in a factorial design to varying characteristics of maize and cowpea in different previous treatments. The average productivity of maize of the experiment was 3.279 kg ha^{-1}, the predecessor treatment with legumes was higher statistically producing 3.635 kg ha^{-1}. Was observed average production of cowpea of 752 kg ha^{-1}, higher than the national average in the same year. According to the index of efficiency of land use, it was found that the intercroping systems gave the best results than monoculture systems in agroforestry system.

Key words: *Zea mays* · *Vigna unguiculata* · Production · Agroecosystem

INTRODUCTION

In the Cerrado region, specifically in the state of Tocantins, small farmer predominates related to the other crop systems and maize, cowpea and manioc crops almost always used in mixtures consisting in the simultaneous plantation of two or more species cultivated in a same area. This practice is common among the tropical regions' farmers all over the world, practiced along the years whether by cultural tradition or by the advantages that worked on its ecological adaptation.

Santos *et al.* [1] when evaluating the cowpea and maize cultivated in single and mixtures system, verified that the mixtures production system is an excellent alternative to small farmers. In the mixtures systems it's common the association of gramineous with leguminous because they present complementarity in the use of production factors, where the nitrogen immobilization reduced and the mineralization favors the availability and absorption of this nutrient by plants. Most crop systems are characterized by intensive monoculture production and continuous withdrawal without practices that return nutrients exported by plants, causing deterioration of the soil characteristics of the soils due to the decrease in soil organic matter and nutrients.

In this sense, various species of plant families can be used as cover crops for green manure, however legumes have been the most used [2]. The main reason is the fixation of atmospheric nitrogen by bacteria. Using the SAF's has been considered as an alternative to optimize the use of land for forest production reconcile with food, conserving soil, reducing the impact of farming practices and encouraging cycling of nutrients through increased litter production [3].

Thus, the agroforestry systems are considered promising because they request lower use of external input than single crops, because they are similar to the natural ecosystems [4]. The arboreal species require the same resources than the mixtures crops, which can result in positive (complementarity) and negative (competition)

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interactions. Among the competitive interactions of the tree-cultivation association, it's highlighted the demand by light, water and nutrients and the possible allelopathic relations [5]. Among the complementarity interactions, it's highlighted the supply of nutrients within the root zones of the crops through the entrance to N_2 by biological fixation, the reduction of the nutrients losses by lixiviation due to their absorption of deeper layers and the recycling of organic residues coming from the litter deposition or, also, of the biomass incorporation through green fertilization [6].

The maize (*Zea mays* L.) is the main crop cultivated in mixtures system by Brazilian farmers and, the Brazilian productivity is growing with technological advancementin, in 2009 occupying the third place in the world production of the grain [7]. Although the maize cultivation has great expression in what concerns the national or world production, it's considered subsistence cultivation and, in general, cultivated mixed with other grains. Teófilo *et al.* [8] reported that cowpea (*Vigna unguiculata* L. Walp.), is an activity of great importance to the North and Northeast, both in economics with the nutrition, it's the staple food in the diet of the poor, exerting social function. Cowpea is tolerant to the shadowing according to the results from Cavalcante *et al.* [9] that do not find decrease on the assimilation of carbon by cowpea cultivated in mixture with manioc. Besides, because it's a leguminous, it converts atmospheric nitrogen in nutrient available in the soil can be leveraged by the culture in the consortium.

In general, the maize and cowpea cultivation in mixtures systems follows the arrangement of alternated rows. This disposition did not affect the production of the cowpea cultivated in interlineations of maize in the studies developed by Vieira *et al.* [10], but obtained a reduction in the production of maize and cowpea cultivations when cultivated in mixtures in relation with the single cultivation can be expected due to the competition established by the cultivations.

In mixtures systems, the Land Efficiency Index (UET) is used for evaluating if the mixture is compensatory or not regarding the production of single cultivations. When the UET is higher than one the mixture is advantageous, even with, a reduction obtained on the mixed cultivations production. Based on the UET, Silva [11] analyzed the mixture of different maize and cowpea cultivations and did not find differences between the UET of the maize cultivations.

However, besides different works Távora *et al.* [12], Ferreira *et al.* [13] and Blanco *et al.* [14] had been performed for evaluating maize in single or mixed cultivation with cowpea, that is, already consolidated. Studies to evaluate the cultivation of these species in agroforestry systems are scarce and given the need for food production with environmental preservation becomes an option of cropping system. Thus, this study aimed to evaluate the yield of maize and cowpea in sole crops and intercropping, under agroforestry.

MATERIALS AND METHODS

The study was developed in the experimental area from Federal University of Tocantins, at Gurupi-TO, 11° 43' S and 49° 04'W and 280m height. The according to Köppen classification, the weather is type B1wA'a" humid with moderated water deficiency (April to September) and the annual average temperature is 26.7 °C. The soil was characterized as Dystrophic Haplic Plinthosol and the characterization of its fertility is presented on Table 1.

The experimental area is a SAF's with more than 20 arboreous species *Acacia Mangium*, *Inga* cf. alba Willd., *Enterolobium contortisiliquum* (Vell.) *Morong, Piptocarpha macropoda* (DC.) *Baker*, *Machaerium scleroxylon* Tull., *Shizolobium amazonicum*, *Dalbergia miscolobium* Benth. abd *Jacaranda caroba* (Vell.) DC., *Dipteryx alata* Vog., *Tabebuia chrysotricha* (Mart. ex DC.) *Standl.*, *Hymenaea courbaril* L. var. *stilbocarpa* (Hayne) *Lee et Lang, Oenocarpus bacaba*, *Parkia pendula* Benth, *Anacardium humile*, *Azadirachta indica*, *Hevea brasiliensis*, *Bixa orellana, Syzygium jambos* L., *Artocarpus heterophyllus, Eugenia uniflora* L and *Tectona grandis*, spaced four meters between the plants and between the rows with six years of implantation, occupying an area of around 3000 m^2.

Table 1: Chemical attributes of a Distrophic Haplic Plinthosol under agroforestry system in three uses of soil: natural vegetation (NV), previous cultivation (CA) and area with residues of leguminous from previous crop (LEG), Gurupi County - TO.

	Ca	Mg	Al	H+Al	t	T	SB					
Treatments	---------- $mmol_c\ dm^{-3}$ ----------							V (%)	P mg dm^{-3}	K (g dm^{-3})	O.M. (H_2O)	pH
NV	2.50	0.40	0.10	6.10	3.01	9.01	2.91	32.20	6.00	3.91	18.77	5.90
CA	1.69	0.22	0.20	5.48	2.12	7.40	1.92	28.37	14.85	3.12	21.94	5.58
LEG	2.28	0.57	0.33	6.10	3.08	9.11	2.98	32.55	44.57	50.83	21.29	6.02

t: CEC effective; T: CEC; SB: sum of bases; V: saturation by bases; O.M.: organic matter

The maize and cowpea seeding was performed in the day of December 15th, 2011. The liming and the fertilizations were made according to the soil analyses and demands from the cultivations. Fertilizers applied at sowing was done with 30 kg ha^{-1} of P_2O_5, 40 kg ha^{-1} of K_2O and 30 kg ha^{-1} of N for maize and cowpea and the coverage fertilization for maize using 20 kg ha^{-1} of N, after 30 days.

It was used the experimental delineation of randomize complete blocks design with four repetitions, resulting from two cultivation systems (single and mixtures) of cowpea (*Vigna unguiculata* L. Walp.) and maize (BR 106 cultivation) over three previous treatments: leguminous (*Crotalaria juncea, Crotalaria spectabilis, velvet cowpea, faba cowpea*), previous cultivation (cowpea and manioc) and spontaneous vegetation (*Diodia teres, Euphorbia heterophylla, Cyperus rotundus, Cenchrus echinatus, Commelina benghalensis andropogon sp, Eleusine indica, Mimosa pudica, Ageratum conyzoides, Brachiaria decumbens* and *teak litter*), in a total of 36 experimental plots in the agroforestry system.

The portions of single crop of maize were constituted by four rows of 4 m length and spaced in 0.9 m between rows and 0.20 m between plants and for cowpea, compound by four rows of 4 m length, spaced of 0.45 m between rows and 0.30 m between plants. In a mixed system, the portions were formed by four alternated rows (maize and cowpea) with 4 m length spaced 0.5 m between line and between plants of 0.2 m for maize and 0.3 m for cowpea. Both in the pure and mixed cultures, the two central lines were considered for being evaluated.

The BR 106 cultivation is a rustic variety, with lower cost of seed, presenting good production stability and adaptability to all the Brazilian regions, resistance to lodging and to the attack of the main plagues. The cowpea cultivated was the commercial class white and sub-commercial class blackeye cowpea, which is a variety that presents a very important economical and cultural value in the state of Tocantins, Brazil, mainly cultivated by family farmers.

In the culture of maize, it was evaluated: i) plant height (distance between soil surface to the end of leaf flag, cm), ii) height of the ear (distance from the soil surface to the insertion of the first ear, cm), iii) unhusked ear length (measure from the base to the end of the ear, with husk, mm), iv) length of husked ear (measure from the base to the end of the ear, unhusked, mm), v) ear diameter (mm), vi) weight of 5 commercializable husked ears (ears with good looks for the commercialization and length equal or superior to 20 cm), vii) weight of the unhusked ears, commercializable (ears with length equal or superior to 15 cm), viii) production of green mass of plants (kg ha^{-1}), production of total green mass (kg ha^{-1}). The crop was performed when 70% of the ears presented grains in the point of "sweetcorn" and with satisfactory weight and sanity.

In cowpea cultivation, it was evaluated: i) productivity, determined by the total production of grains in the useful area of the portion (kg ha^{-1}), ii) average weight of 100 grains, iii) number of grains per pod, obtained by the average of five pods randomly taken out, iv) average length of the pod, based on five pods randomly taken out from each portion (cm), iv) grains index, obtained by the percentage of the weight of grains regarding to the total weight of the pod, based on five pods randomly collected from each portion.

The data obtained were submitted to the analysis of variance and submitted to Tukey test 0.05 of probability by the statistic program SISVAR [15].

The Index of the Efficient Use of the Land (UET) was calculated according to procedures described by Mead and Willey (1980), taking into account that MC, MS, FC and FS are yields from M cultivations, mixed (C) and single (S) and F mixed and single, respectively, the UET is equal to (MC/MS) + (FC/FS).

RESULTS AND DISCUSSION

According to the results from the analysis of variance presented in Table 2, the significant differences among the cultivation systems, mainly about the plant height (AP), unhusked ear length (CED), weight of the husked ear (PEE) and unhusked ear (PED). In lower probability ($p<0.05$) for ear height (AE) and total green mass (MVT). In what concerns the ear (DE), length of the unhusked ear (CEE) and total green mass (MVT) of plants, the treatments evaluated are not different from each other.

In what concerns the previous treatments for test F at 5% of probability, statistic difference to AP, DE, CED, PEE, PED and CEE, but they were not significant to AE, MVP and MVT. The interaction between cultivation system and previous treatments in the studied characteristics was also significant, showing the independence between the factors evaluated.

Average value of AP to the single cultivation systems (=178 cm) and mixed (=185 cm) differed in a significant way with the cultivation system (Table 3).

Table 2: Summary of the joint analysis of variance for the characteristics: plant's height (AP), ear's height (AE), ear's diameter (DE), unhusked ear's length (CEE), husked ear's length (CED), weight of unhusked ear (PEE), weight of husked ear (PED), green mass of plants (MVP), total green mass (MVT), of the maize cultivation over three previous treatments in two cultivation systems.

Mean square									
Souce of variation	AP	AE	DE	CEE	CED	PRODE	PRODED	MV	MVT
Cultivation	28.5**	5.8*	1.8^{ns}	0.3^{ns}	38.7**	62.9**	84.9**	3.9^{ns}	8.1*
Trataments	12.9**	2.2^{ns}	11.1**	5.7*	27.9**	11.9**	8.6**	0.5^{ns}	0.7^{ns}
Treat x cult	2.8^{ns}	1.7^{ns}	0.5^{ns}	0.3^{ns}	0.3^{ns}	0.6^{ns}	0.1^{ns}	0.3^{ns}	0.2^{ns}
Average	182,0	80,7	46,0	22,4	17,5	3279	2548	14630	17913
C.V	1,7	7,9	1,5	1,8	1,9	8,5	8,5	16,5	13,7

** and * - Significant at the 1 and 5% level of probability, respectively. ^{ns} – Non significant.

Table 3: Average values for the characteristics height of the plant (cm), height of the ear (cm), of three previous treatments, cultivated in single cultivation and cultivation mixed with cowpea, in Agroforestry system.

	Cultivation System					
Previous Treatments	Single Maize	Mixed Maize	Average	Single Maize	Mixed Maize	Average
	Height of the Plants (cm)			Ear's Height (cm)		
Leguminous Crops	192aA	181aA	186a	91Aa	78Ab	85a
Spontaneous vegetation	185Ba	178Aa	181b	79Ba	78Aa	78a
Previous cultivation	180Ba	177Ab	178b	81ABa	77Aa	79a
Average	185A	178B	-	84 a	78B	-
CV(%)	1.74			7.88		

Averages followed by the same minuscule letter in the line and capital letter in the columns do not differ by Tukey test 5% of probability.

Table 4: Average values for the characteristics diameter of the plant (mm), length of unhusked ears (mm) and length of husked ears (mm) of three previous treatments, cultivated in single cultivation and mixed cultivation with cowpea, in Agroforestry system.

	Single	Mixed	Average	Single	Mixed	Average	Single	Mixed	Average
Previous treatments	Ear's Diameter (mm)			Length of Unhusked Ear (cm)			Length of Husked Ear (cm)		
Leguminous	47.6Aa	46.6Aa	46.8a	22.6Aa	22.6Aa	22.6a	18.6Aa	17.8Ab	18.2a
Spontaneous vegetation	46.0ABa	46.0ABa	46.1ab	22.7Aa	22.4Aa	22.5a	17.7Ba	16.7Bb	17.2b
Previous cultivation	45.6Aa	44.9Aa	45.2b	22.0Aa	22.0Aa	22.0b	17.4Ba	16.6Bb	17.0b
Average	46.25A	45.87A	-	22.4A	22.3A	-	17.9A	17.0B	-
CV(%)	1.5			1.7			1.9		

Averages followed by the same minuscule letter in the line and capital letter in the columns do not differ by Tukey test 5% of probability.

These values are within the range of the one obtained by Bertalot *et al.* [16] when evaluating the maize performance after black oat in agroforestry systems, where they reported AP of 1.95 and 1.83 cm, respectively.

When AE was evaluated, the treatment with leguminous in the single cultivation system obtained the higher average (AE = 192 cm). To AE, significant difference between the averages of the cultivation systems occurred, with values from 84 to 78 cm for single and mixed cultivation, respectively. The treatment with leguminous as previous cultivation presented bigger averages regarding the cultivation systems, with 91 cm (single) and 78 cm (mixed). Lower values, but close to the ones found by Bertalot *et al.* [16], that obtained height of 98 cm on their witness and 114 cm with black oat biomass.

The DE presented lower variation (variation coefficient (CV) = 1.5% Table 1), with average value of 46 mm (Table 4), close to the ones obtained by Santos *et al.* [17] (=50.4 mm), Barbieri *et al.* [18] (= 48 mm) and Devide *et al.* [19] (= 43.5 mm), which indicates a conformity of the data obtained in the state of Tocantins, with the ones found in other regions for DE. These DE values are within the commercialization standard (DE ± 30 cm) considered by Santos *et al.* [17].

Regarding CEE, the values ranged from 22.02 to 22.62 cm among the previous treatments, with average value of 22.4 cm. This reduced variation of CEE is associated to the fact that a single cultivation is not used. The average value of CED was 17.5 cm with variation from 16.6 to 18.6 cm. Santos *et al.* [17], evaluating the sweetcorn production mixed with jack cowpeas, obtained 24 (CEE) and 17 cm (CED), being the CED ± 15 cm according to the sweetcorn commercialization standard [20], although the consumers prefer larger ears for natural consumption [20], with ± 20 cm, as the ones obtained in the treatments evaluated in the present work.

Table 5: Average value of the unhusked ear's weight (PEE, kg ha^{-1}), husked ear's weight (PED, kg ha^{-1}), productivity of green mass of plants (MVP, kg ha^{-1}) and productivity of total green mass (MVT, kg ha^{-1}) of three previous treatments, in single or mixed cultivation with cowpea, in agroforestry system.

	Cultivation System					
Previous Treatments	Single Maize	Mixed Maize	Average	Single Maize	Mixed Maize	Average
	PEE (kg ha^{-1})			PED (kg ha^{-1})		
Leguminous	4.17Aa	3.09Ab	3.63a	3.18Aa	2.34Ab	2.76a
Spontaneous vegetation	3.63Ba	2.86ABb	3.24b	2.94ABa	2.17ABb	2.56ab
Previous cultivation	3.39Ba	2.51Bb	2.95b	2.73Ba	1.90Bb	2.31b
Average	3.73A	2.82B	-	2.95A	2.14B	-
CV(%)	8.53			8.48		
	MVP (kg ha^{-1})			MVT (kg ha^{-1})		
Leguminous	15.15Aa	13.75Aa	14.45a	19.33Aa	16.85Aa	18.09a
Spontaneous vegetation	16.80Aa	13.77Aa	15.29a	20.43Aa	16.64Aa	18.54a
Previous cultivation	14.85Aa	13.44Aa	14.14a	18.24Aa	15.96Aa	17.10a
Average	15.60A	13.65A	-	19.33A	16.48B	-
CV(%)	16.52			13.68		

Averages followed by the same minuscule letter in the line and capital letter in the columns do not differ by Tukey test 5% of probability.

The average of productivity of unhusked ears (PEE) regarding the previous treatment of leguminous was superior to the other two with 3.635 kg ha^{-1} (Table 5), fact that can be explained by the better soil fertility under this treatment provided by the use of leguminous, showing the importance of the same in the agroecosystem. The average values of PEE differed in a significant way with the cultivation system, with PEE of 3.732 kg ha^{-1} in the single system and 2.826 kg ha^{-1} in the mixed system.

The average productivity of the experiment was 3.279 kg ha^{-1}. Cancellier *et al.* [21] evaluated the performance in 160 genotypes of maize populations for the natural consumption in the South of Tocantins regarding the productivity. Among these genotypes, two groups were different: one of bigger productivity (with 89 genotypes producing from 4.555 to 6.726 kg ha^{-1}) and other one of lower productivity (with 71 genotypes presenting average productivity of 2.903 to 4.527 kg ha^{-1}). On the evaluation of Cancellier *et al.* [21], the variety of BR 106 cultivated in single system showed an average productivity of 4.364 kg ha^{-1}, as long as in the present work, 4.175 kg ha^{-1} were obtained in average in the treatment with leguminous in single cultivation in agroforestry system.

Silva [11] studying green grains maize and cowpea production in RN single and mixed, obtained average of maize production of 5.140 kg ha^{-1} mixed with cowpea, in other words 36% higher regarding the present work. This fact can be explained by the biggest competition exerted by the cowpea when the maize is designated to the production of green ears, because there is a difference on the development cycle of cultivations in field.

The average values of PED from previous treatments of leguminous and spontaneous vegetation were superior to the previous cultivation, evidencing that this treatment may have exported many nutrients from the soil to the plant, because they provide improvements on the chemical, physical and biological characteristics of the soil, due to the increase of the organic matter and soil coverage. The average productivity of maize in the single cultivation system (= 2.954 kg ha^{-1}) differed in a significant way from the one cultivated in mixed system (= 2.141 kg ha^{-1}).

To PMV, there was no significant difference for previous treatments and cultivation systems, obtaining an average value of 15.601 kg ha^{-1} in the single cultivation and 13.658 kg ha^{-1} in the mixed cultivation. The average value of PMV in the previous treatments ranged from 14.148 to 15.290 kg ha^{-1} and the bigger average value found for spontaneous vegetation as previous one.

The average production of MVT in the single system (=19.338 kg ha^{-1}) differed significantly ($p<0.05$) from the one obtained in the mixed system (16.488 kg ha^{-1}). These values are close to the ones obtained by Cruz *et al.* [22] (=19.37 to 33.61 kg ha^{-1}), that has evaluated the maize MVT produced for silage.

Regarding the cultivation of cowpea, significant differences between the single and mixed systems of production were not found, according to the results presented at Table 4. Regarding the treatments, the weight of the 100 grains differed at 5% of probability. The interaction between the cultivation system and previous treatments was not significant for none of the characteristics studied.

Table 6: Average values for the characteristics number of grains/pods (NGV), grains indexes (IG, %), pod length (COV, cm) of three previous treatments, in single and mixed system of production in agroforestry system.

	Cultivation System								
	Single cowpea	Mixed cowpea	Average	Single cowpea	Mixed cowpea	Average	Single cowpea	Mixed cowpea	Average
Previous Treatments		NGV			IG, %			COV, cm	
Leguminous Crops	15.2Aa	14.0Aa	14.6a	83Aa	76Aa	79a	20.7Aa	20.9Aa	20.8a
Spontaneous vegetation	13.5Aa	13.3Aa	13.4a	81Aa	80Aa	81a	20.4Aa	19.9Aa	20.2a
Previous cultivation	13.1Aa	13.9Aa	13.5a	89Aa	83Aa	86a	20.3Aa	19.9Aa	20.1a
Average	13.9A	13.7A	-	84A	80A	-	20.5 A	20.2A	-
CV(%)	----------6.9----------			----------7.9----------			----------5.9----------		

Averages followed by the same minuscule letter in the line and capital letter in the columns do not differ by Tukey test 5% of probability.

Table 7: Average values for the characteristics weight of 100 grains (P100G, g) and productivity (PROD, kg ha^{-1}) of three previous treatments, in single and mixed system of production in agroforestry system.

	Cultivation System					
	Single cowpea	Mixed cowpea	Average	Single cowpea	Mixed cowpea	Average
Previous Treatments	P100G, g			PROD, kg ha^{-1}		
Leguminous Crops	16.84Aa	17.35Aa	17.09a	947Aa	611Aa	779a
Spontaneous vegetation	15.89Aa	16.64ABa	16.26ab	907Aa	722Aa	815a
Previous cultivation	16.03Aa	15.54Ba	15.78b	637Aa	690Aa	664a
Average	16.25A	16.51A	-	769A	736A	-
CV(%)	----------4.53----------			----------28.37----------		

Averages followed by the same minuscule letter in the line and capital letter in the columns do not differ by Tukey test 5% of probability.

The effect of the previous treatments was shown as less significant for all the characters studied for the cowpea (Table 6), which can be explained by using only one cowpea genotype and by the possible biological fixation of nitrogen exerted by the same, making the cultivation less dependent on previous treatments.

The average COV and NGV were 20.36 cm and 13.84 grains, respectively and did not differ between treatments predecessors nor between cropping systems (Table 4). The average COV and NGV obtained in this work are within the average values obtained by Silva and Neves [23] (= 19.68 cm and 14.26 VOC NGV).

When the harvest is manual, a bigger COV is desirable, because as bigger is the pod, bigger is the NGV. For semi-mechanized and mechanized harvests, big pods and high number of grains are not so important. Currently, for these two types of harvest, smaller pods with lower number of grains and, therefore, lighters, are preferred, because they allow better plant support, reducing the possibility of folding and break of the peduncle [23].

In what concerns IG, it was observed an average value considered high (= 82%) and close to the one obtained by Silva and Neves [23] (= 79,5%). The P100G characteristic presented a amplitude from 15,54 to 17,35 g with average of 16,38 g (Table 5) The average value of P100G differed between the previous treatments, among which the leguminous and the spontaneous vegetation were superior. According to Silva and Neves [23] there is a preference by grains with P100G around 18 g, with reniform or rounded shape, by the part of the dealers and consumers [24].

The PROD ranged from 611 to 947 kg ha^{-1}, with average value of 752 kg ha^{-1}, without statistic difference between the previous treatments and the cultivation systems (Table 7). The average value of PROD obtained in the present work is above the national average (= 300 kg ha^{-1}) [25].

Silva and Neves [23], evaluating twenty genotypes of cowpea in Teresina-PI, obtained PROD ranging from 658.2 to 1070.3 kg ha^{-1}, values close to the ones obtained in the present work. Teixeira *et al.* [26] obtained a PROD of 1.307 kg ha^{-1}, using fertilization of 400 kg (05-25-20) when evaluating the agronomic performance and the quality of seeds from cowpea cultivations in woodsy-pastures region. The average PROD obtained in the present work, as well as the values found by Teixeira *et al.* [26], Bezerra *et al.* [27] (=1.705 kg ha^{-1}) and Machado *et al.* [28] (= 1.399 kg ha^{-1}), showed that there are genotypes with good productive capacities.

Table 8: Efficient use of the land (UET), in the single cultivation systems (UET maize and UET bean) and mixed of corn + cowpea over previous treatments.

Previous Treatments	UET CORN	UET BEAN	UET
Leguminous	0.74	0.65	1.39
Spontaneous vegetation	0.79	0.80	1.59
Previous cultivation	0.74	1.08	1.82

Taking into account that the cultivation of cowpea in the present work was made in an agroforestry system, the results found were promising, because the general average of PROD was close to the ones obtained by Freire Filho *et al.* [24] that found PROD ranging from 794 and 846 kg ha^{-1}, in single system of cultivation of different cowpea genotypes.

The UET indexes of the mixed systems are presented in Table 8, where it's observed that UET indexes in the different mixed systems between the previous factors-treatments were bigger than, indicating that in these systems the use of the environmental resources was more efficient, when compared to the single system.

Several factors may have significant impact over the yield and over the growth rate of component cultivation in mixing. Among them, there are the competitions between cultivations, the type of seed cultivation, the spatial arrangement of plantations, among others [29].

This advantage in the UET in the mixed systems studied ranged from 39% to 82% (Table 8), actually occurred probably due to increased efficiency in the use of environmental resources. As consequence, there is an increase on the total biological productivity per unit of land area and sustainability.

The UET values of 1.39 and 1.83 obtained with the previous treatments indicate that, in average, the single cultivations required from 39 to 82% more land than the mixing so that they produce the same that one hectare of mixing. In the system where the soil was already cultivated, there was a lower difference for the cowpea that better tolerate the presence of maize, elevating the UET, which can be explained by a possible residual of the previous cultivation.

CONCLUSIONS

The previous treatment of leguminous is highlighted because it provides improvements of agronomical characteristics of maize and cowpea relative to the productivity of these cultivations.

For cowpea cultivated in the mixed system, the average productivity obtained was superior to the national average and, since it's an agroforestry system, the productivities obtained were satisfying, showing that the productive agrosystem with agroecological basis studied is viable.

The land efficiency index confirms the productive advantage of the mixed cultivation regarding the single one in the agroforestry system.

REFERENCES

1. Santos, N.C.B., M.A.A. Tarsitano and G.P. Mateus, 2009. Economic analysis of maize (for rgreen corn production) and common bean intercropping. Revista Brasileira de Milho e Sorgo, 8: 1-12.
2. Teodoro, R.B., F.L. Oliveira, D.M.N. Silva, C. Fávero and M.A.L. Quaresma, 2011. Agronomic aspects of leguminous to green fertilization in the Cerrado of the high Jequitinhinha valley. Revista Brasileira de Ciência do Solo, 35(2): 635-640.
3. Lima, S.S., L.F.C. Leite, F.C. Oliveira, A.A.J.F. Castro, D.B. Costa and R.M.R. Gualter, 2007. Nutrient contents in the litter and in the soil under agroforestry system in the north Piaui state transition area. Revista Brasileira de Agroecologia, 2(2): 1.
4. Altieri, M.A., 2002. Agroecology: the science of natural resource management for poor farmers in marginal environments. Agriculture, Ecosystems and Environment, 93: 1-24.
5. Schroth, G. And J. Lehmann, 1995. Contrasting effects of roots and mulch from three agroforestry tree species on yields of alley cropped maize. Agriculture, Ecosystem and Environment, 54: 89-101.
6. Rowe, E.C. and G. Cadisch, 2002. Implications of heterogeneity on procedures for estimating plant 15N recovery in hedgerow intercrop systems. Agroforestry Systems, 54: 61-70.
7. Oliveira, F., L. Cavalcante, I. Silva, W. Pereira, J. Oliveira and J. Costa Filho, 2009. Grown of corn fertilized with nitrogen and phosphorus in a Yellow Latosol. Revista Brasileira de Ciências Agrárias, 4: 238-244.
8. Teófilo, E.M., A.S. Dutra, J.B. Pitombeira, F.T.C. Diaz and F.S. Barbosa, 2008. Physiological potential of cowpea seeds produced in two regions of th State of Ceará. Revista Ciência Agronômica, 39: 443-448.

9. Cavalcante, F.S., I.F. Silva and M.C.S.P. Araújo, 2005. Assessing the viability of cassava consortium and bean in the Swamp Yellow Latosol Paraiba. Revista Agropecuária Técnica, 26: 23-97.
10. Vieira, R.F., C. Vieira and G.V. Miranda, 2003. Arrangements and fertilization of common bean intercropped with maize cultivation simultaneously. Revista Ceres, 50: 605-619.
11. Silva, P.S.L., 2001. Intercropping maize with cowpea for green ears and green grain production. Horticultura Brasileira, 19: 04-10.
12. Távora, F.J.A.F., C.S.A. Silva and E. Bleicher, 2007. Maize, shorgum and cowpea intercropping system in a series of substitutions. Revista Brasileira Agrociência, 13: 311-317.
13. Ferreira, V.M., A.S. Andrade Júnior, M.J. Cardoso, V.Q. Ribeiro and E.L.C. Morais, 2010. Yield performance of the maize-cowpea intercropping system in relation to the soil moisture availability. Revista Brasileira de Ciências Agrárias, 5: 177-186.
14. Blanco, F.F., M.J. Cardoso, F.R. Freire Filho and M.E.C. Veloso, 2011. Green maize intercropped with cowpea under different irrigation depths and phosphorus doses. Pesquisa Agropecuária Brasileira, 46: 524-530.
15. Ferreira, D.F., 2000. Statistical analysis systems for balanced data. Lavras: UFLA/ DEX/SISVAR, pp: 145.
16. Bertalot, M.J.A., I.A. Guerrini, E. Mendoza and M.S.V. Pinto, 2010. Maize performance (Zea mays L.) in succession with oats (Avena stigosa Schreb.) under agroforestry management systems and traditional. Revista Árvore, 34: 597-608.
17. Santos, I.C., G.V. Miranda, A.V. Melo, R.N. Matos, L.R. Oliveira, J.S. LIMA and J.C.C. Galvão, 2005. Performance of organically produced maize cultivars and correlations amog traits of green ears. Revista Brasileira de Milho e Sorgo, 4: 45-53.
18. Barbieri, V.H.B., J.M.Q. Luz, C.H. Brito, J.M. Duarte, L.S. Gomes and D.G. Santana, 2005. Sweet corn hybrids productivity and industrial yield as a function of spacing and plant population. Horticultura Brasileira, 23: 826-830.
19. Devide, A.C.P., R.L.D. Ribeiro and T.L. Valle, 2009. Yield of cassava roots intercropped with corn and cowpea in na organic system. Bragantia, 68: 145-153.
20. Paiva Junior, M.C., R.G.V. Pinho, E.V.R.V. Pinho and S.G. Resende, 2001. Cultivars of performance for the production of corn at different times and seeding rates in Lavras-MG. Ciência e Agrotecnologia, 25: 1235-1247.
21. Cancellier, L.L., F.S. Afferri, O.S. Cruz, J.M. Peluzio and A.V. Melo, 2011. Performance of corn populations for grain yield and in natura consumption in Tocantins State. Revista Ciência Agronômica, 42: 542-553.
22. Cruz, J.C., F.T.F. Pereira, I.A. Pereira Filho, A.C. Oliveira and P.C. Magalhães, 2007. Maize cultivars response to variation in spacing and density. Revista Brasileira de Milho e Sorgo, 6: 60-73.
23. Silva, J.L.A. and J.A.A. Neves, 2011. Production of semi-prostrate cowpea bean in dry and irrigated cultivation. Revista Brasileira Ciência Agrária, 6: 29-36.
24. Freire, F.R., V.Q. Ribeiro, M.M. Rocha and A.C.A. Lopes, 2002. Adaptability and stability of grain yield in climbing cowpea. Revista Ceres, 49: 383-393.
25. Leite, L.F.C., A.S.F. Araujo and C.N. Costa, 2009. Nodulation and grain yield of cowpea in response to molybdenum. Revista Ciência Agronômica, 40: 492-497.
26. Teixeira, I.R., G.C. Silva, J.P.R. Oliveira, A.G.P. Silva and A. Pela, 2010. Agronomic performance and quality of seeds of cowpea cultivar in the brazilian "cerrado" region. Revista Ciência Agronômica, 41: 300-307.
27. Bezerra, A.A.C., F.J.A.F. Távora, F.R. Freire Filho and V.Q. Ribeiro, 2008. Morphology and grain yield in modern lines of cowpea under different planting densities. Revista de Biologia e Ciência da Terra, 8: 85-92.
28. Machado, C.F., N.J. Teixeira, F.R. Freire Filho, M.R. Rocha and R.L. Gomes, 2008. Identification of cowpea genotypes for earliness, plant architecture and grain yield. Revista Ciência Agronômica, 39: 114-123.
29. Dima, K.V., A.S. Lithourgidis, I.B. Vasilakoglou and C.A. Dordas, 2007. Competition indices of common vetch and cereal intercrops in two seeding ratios. Field Crops Research, 100: 249-256.