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Cultivation of cassava and cowpea in intercropping systems held in Roraima's savannah, Brazil[1]

Consórcio de mandioca com feijão-caupi cultivados na savana de Roraima

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ABSTRACT - The objective of this work was to assess the cultivation of cassava and cowpea in different systems and arrangements of plants in Roraima's savannah, Brazil. The experiment was performed at the experimental field of the Department of Soil and Climate at the UFRR, Boa Vista (Roraima). The experimental design adopted was in randomized blocks, with seven treatments and four replications. The treatments were: 1) a single row of cassava in monoculture; 2) a single row of cassava plus a row of cowpea; 3) a double row of cassava in monoculture; 4) a double row of cassava plus a row of cowpea; 5) a double row of cassava plus two rows of cowpea; 6) a double row of cassava plus three rows of cowpea; and 7) cowpea in monoculture. For the cassava were assessed the following variables: yield of roots, fresh weight of shoot, harvest index, number of roots per plant, roots length, roots diameter, root dry matter, starch content and index of area equivalence. For the cowpea were assessed: yield of the grains (kg ha^{-1}), number of pods per plant, number of seeds per pod, weight of 1000 seeds, and index of area equivalence. The double rows cropping systems of cassava with two and three rows of cowpea allow obtaining equivalent yield to the monoculture of cassava in single rows. The intercropping, regardless of the arrangement, reduces grain yield of cowpea. All treatments in intercropping systems exhibit a satisfactory area equivalence index, with an average of 1.55.

Key words: *Manihot esculenta* Crantz. *Vigna unguiculata* (L.) Walp. Area equivalent index. Single and double rows.

RESUMO - Objetivou-se com este trabalho avaliar o consórcio de mandioca com feijão-caupi, cultivados na savana de Roraima. O experimento foi realizado no campo experimental do Departamento de Fitotecnia da UFRR, Boa Vista-Roraima. O delineamento experimental adotado foi em blocos casualizados, com sete tratamentos e quatro repetições. Os tratamentos foram: 1) fileira simples da mandioca em monocultivo; 2) fileira simples de mandioca mais uma linha de feijão-caupi; 3) fileira dupla de mandioca em monocultivo; 4) fileira dupla de mandioca mais uma linha de feijão-caupi; 5) fileira dupla de mandioca mais duas linhas de feijão-caupi; 6) fileira dupla de mandioca mais três linhas de feijão-caupi, e 7) feijão-caupi em monocultivo. Na mandioca foram avaliadas: produção de raízes, massa fresca da parte aérea, índice de colheita, número de raízes por plantas, comprimento de raízes, diâmetro de raízes, matéria seca de raízes, teor de amido e índice de equivalência de área. No feijão-caupi avaliaram-se: produtividade de grãos (kg ha^{-1}), número de vagens por planta, número de sementes por vagem e massa de 1.000 sementes e índice de equivalência de área. Os sistemas de cultivos em fileiras duplas de mandioca com duas e três linhas de feijão-caupi permitiram obter produções equivalentes ao monocultivo de mandioca em fileiras simples. A produtividade de grãos do feijão-caupi em fileira simples (monocultivo) foram superiores aos tratamentos consorciados. Todos os tratamentos em sistemas de cultivos consorciados apresentaram índice de equivalência de área satisfatório, com média de 1,55.

Palavras-chave: *Manihot esculenta* Crantz. *Vigna unguiculata* (L.) Walp. Índice de equivalência de área. Fileira simples e dupla.

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INTRODUCTION

Cassava has a wide adaptation to different soil and climatic conditions being grown in Brazil since the states of Roraima to Rio Grande do Sul (ALBUQUERQUE *et al*., 2014). In Roraima, cassava is the more traditional culture, being cultivated on 6,210 ha, mainly by small farmers, involving monoculture and intercropping with cowpea (ALVES *et al*., 2009), with an average yield of 13.5 t ha^{-1} (INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA, 2014). Considering the cost of cassava yield, it is believed that a significant portion is due to weed control; however, this value depends on several factors, including the plantation system (ALBUQUERQUE *et al*., 2008).

The intercropping is interesting in relation to sole cropping, for several reasons: intensive use of the area, vegetative soil protection against erosion and improvement of weed control. The disadvantages are due to the increase of skilled labor and competition between the species (BAUMANN; BASTIAANS; KROPFF, 2001). According to Alves *et al*. (2009) in the intercrops occur reduction of the incidence of pests and diseases, providing, with greater frequency, greater profits for small farmers, besides diversifying the sources of income and food. Because of the few studies on this subject, therefore, in the scientific area, occurs the challenging of information about results found in intercropping systems and spatial arrangements. Flesch (2002) states that intercropping provides more agronomic and economic advantages than the sole crops. Albuquerque *et al*. (2012) state that usually the yield in sole culture is superior to intercropping.

The planting of beans intercropped with other crops is common practice in Brazil, being carried out mainly by small farmers (ANDRADE *et al*., 2001). In Minas Gerais State, for exemplo, it is estimated that about 60% of the crop of beans are associated with corn and other crops (COSTA; SILVA, 2008). The intercropping cassava and cowpea (bean) is possible due to the relatively wide spacing between rows of cassava, the lower speed of cassava settling and forming the canopy, the relatively short cycle and obtaining of cowpea crop, besides the contribution to the supply of organic matter and nitrogen to the soil (DEVIDE *et al*., 2009), as well as the protection of the soil. According to Martinotto *et al*. (2012) the species in the initial growth phase, in intercropping, do not alter the fresh weight yield of cassava shoot.

In cassava crops, planting can be done with plants arranged in single rows and double rows (SCHONS *et al*., 2009). According to Albuquerque *et al*. (2012) in monocropping of cassava no difference in root yield was observed when grown in rows single or double. The double rows, associated to the intercropping, reduce the area available for the weeds. Results showed that the losses in the productivity of roots in the culture caused by the competition of weeds, in extreme situations, were quite significative, almost 100% (JOHANNS; CONTIERO, 2006). There is controversy in the literature on the yield gain as to the use of double rows in sole crop or intercropped (GABRIEL FILHO; STROHHAECKER; FEY, 2003). Considering these aspects, the research has been using more often an index that assesses the efficiency of intercropping systems, based on acreage (MATTOS *et al*., 2005a, 2005b).

Studies on the combinations of the spatial distribution of plants in the canopy seeking to maximize biological and economic yield in both sole cropping and intercropping system, are relevant, given the availability of new cultivar processes (ALBUQUERQUE *et al*., 2012).

The objective of this work was to assess the cultivation of cassava and cowpea (*Vinga unguiculata* (L.) Walp.) in different systems and arrangements of plants in conditions of the Roraima's savannah, Brazil.

MATERIAL AND METHODS

Experiment location

The experiment was installed, at beginning of the rainy season, in a dystrophic cohesive Yellow Latosol, located in the Cauamé *Campus*, of the Centro de Ciências Agrárias (Center for Agricultural Sciences) of the Universidade Federal de Roraima, in the Boa Vista city, Roraima State, Brazil (Latitude 2º 52' 20,7''N, Longitude 60º 42' 44,2", mean altitude of 90 m). According to Köppen classification, the climate corresponds to the Aw category, with two e well-defined climate seasons, a rainy season (April-August) and a dry season (Octuber-March). The results of the chemical and physical attributes of the local soil of the experiment are shown in Table 1.

The data relating to rainfall (mm), relative humidity of the air (%) and mean temperature (°C), in the period in which the experiment was conducted, are presented in Figure 1.

Experimental design and treatments

The experimental design adopted was in randomized blocks, with seven treatments and four replications. The treatments consisted of crops of cassava and cowpea planted in intercropping and monoculture, as shown in Table 2.

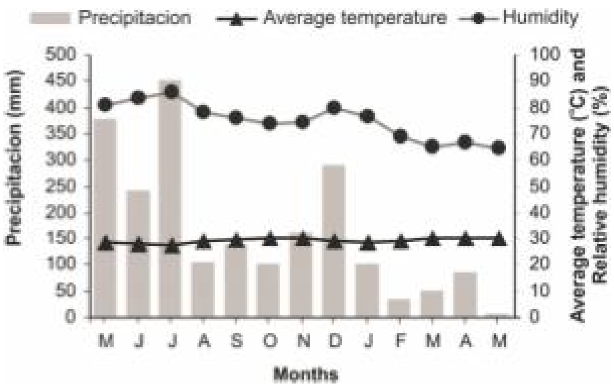
The plots consisted of 6.0 m long by 6.0 m wide, totaling 36 m^2. The soil area was formed by the two central rows, eliminating 1.0 m at each end as front borders, with a soil area of 8 m^2 for T1 and T2; 10 m^2 for T3, T4, T5

Table 1 - Chemical and physical attributes of two depths 0-20 and 20-40 cm of the dystrophic cohesive Yellow Latosol soil of the experimental area[1/]

Layer	pH H_2O	P[2/]	K[2/]	Ca[3/]	Mg[3/]	Al[3/]	H+Al[4/]	ECEC[5/]	BS[6/]	O.M[7/]
		mg dm^{-3}	------------------------- cmol$_c$ dm^{-3} --------------------------------						(%)	g kg^{-1}
0-20	5.16	0.6	62	0.84	0.10	0.20	1	2.16	53.9	6.1
20-40	5.06	0.5	70	0.24	0.03	0.51	1.2	1.65	27.3	4.0
Layer	Thick sand	Fine sand	Silt	Clay	Textural Class					
---------- g kg^{-1} ----------										
0-20	400	300	70	220	Franco-Clay-Sandy					
20-40	360	290	90	260	Franco-Clay-Sandy					

[1/]Analysis performed at the Laboratory of Soils of UFV; [2/] Available P and K - Mehlich Extractor – 1;[3/] Extractor KCl 1 mol L^{-1}; [4/] Extractor Ca(OAC)$_2$ 0.5 mol L^{-1}, pH 7.0; [5/] ECEC - Total cation exchange capacity - obtained by summation of the exchangeable cations and potencial acidity (K, Ca, Mg, H+Al), Base saturation (%); [6/]Organic Matter - derived by multiplying Organic carbon (determined by Walkey-Black method) by factor 1.72

Figure 1 - Rainfall (mm), average temperature (°C) and relative humidity of the air (%) during the period of performance of the experiment. Data obtained from the meteorological station of the Department of Soils and Agricultural Engineering of the CCA-UFRR. Boa Vista, Roraima state 2012



and T6, in the latter, the three central rows of the culture of cowpea were considered, and 4 m^2 for treatment T7.

Experiment conduction

At the stage of tillage, plowing and harrowing were held, proceeding to liming (1 t ha^{-1} dolomitic limestone) and fertilization (N-30 kg ha^{-1}, urea source; P_2O_5-90 kg ha^{-1}, triple superphosphate source; and K_2O-60 kg ha^{-1}, potassium chloride source). The cassava cultivar used was Aciolina, being the most planted in the State of Roraima because it presents the best set of desirable characteristics for both fresh consumption and for the industry, justifying is intense cultivation and marketing (ALVES *et al*., 2009; OLIVEIRA *et al*., 2011; OLIVEIRA *et al*., 2012). The cultivar of cowpea was UFRR grão verde due to high yield and good adaptability to the intercropping with cassava, as evidenced by Alves *et al*. (2009).

The planting of cassava was held simultaneously with cowpea on May 15, 2008. The cuttings-seeds

Table 2 - Description of the seven treatments with their respective spacings

Treatment	Description	Spacing (m)
T1	Single row of cassava in monoculture	(1.0 x 0.5)
T2	Single row of cassava + 1 row of cowpea between rows of cassava	(1.0 x 0.5)
T3	Double row of cassava in monoculture	(2.0 x 0.5 x 0.5)
T4	Double row of cassava + 1 row of cowpea between double rows of cassava	(2.0 x 0.5 x 0.5)
T5	Double row of cassava + 2 rows of cowpea between double rows of cassava	(2.0 x 0.5 x 0.5) (0.75 m among rows)
T6	Double row of cassava + 3 rows of cowpea between double rows of cassava	(2.0 x 0.5 x 0.5) (0,50 m among rows)
T7	Single row of cowpea in monoculture	(0.50 m among rows)

were 25 cm long, planted horizontally in furrows 10 cm deep, with spacings as described in Table 2.

Determination of yield and yield components

The cassava harvest was performed at 12 months after planting, on May 20, 2009, and the characteristics assessed were: number of roots per plant, root length and diameter (cm), root yield (kg ha^{-1}), fresh weight of shoot (kg ha^{-1}), root dry matter (%), starch content (%) and harvest index. The dry matter and starch content were determined by the method of hydrostatic balance (GROSSMANN; FREITAS, 1950) and the harvest index (HI) using the formula: IC = (fresh weight of the roots)/(plant total fresh weight) x 100.

Planting was performed in furrows spaced 0.5 m, at a depth of 3-5 cm, with eight seeds per meter. The harvest of cowpea was performed in four times, between 50 and 57 days after planting (June 15 to 22, 2008). The following characteristics were assessed: yield of the grains (kg ha^{-1}), number of pods per plant, number of seeds per pod and weight of 1,000 seeds (g).

For the intercropping treatments was determined the Equivalence index of area (EIA), using the formula: EIA = (intercropping cassava yield ÷ monoculture cassava yield) + (intercropping cowpea yield ÷ monoculture cowpea yield).

Statistical analyses

Statistical analysis was performed separately for the two cultures. The results were submitted to analysis of variance using the F test at 5% probability and the averages compared by the test of Tukey at 5% probability.

RESULTS AND DISCUSSION

Summaries of analyses of variance for the assessment of different systems and arrangements of cultivation of cassava and cowpea, of the variables related to cassava and cowpea culture are presented in Tables 3 and 4. Only for root yield (kg ha^{-1}) there was statistical difference between their averages (Table 3). In works performed by Albuquerque *et al*. (2012) in the city of Coimbra, Minas Gerais state, at the experimental campus of UFV, where yield components were assessed in various spacial arrangements between ordinary beans and cassava and verified that in fresh weight of shoot, harvest index, root length, root dry matter and starch content characters were not found significant differences between their treatments.

Related to the characteristics of the cowpea, the average of the treatments of the weight of 1,000 seeds and number of seeds per pod did not differ statistically among themselves (Table 4). According to these results, it can be inferred that the behavior of the cassava culture did not affect cowpea in these characteristics. As for the characteristics number of pods per plant, pod length and grain yield there was a statistical difference between their averages, i.e., the intercropping treatments affected the culture of cowpea in these characteristics. Similar results regarding the negative effect of the intercropping in the yield of beans were observed by Albuquerque *et al*. (2012) in Yellow-Red Argissol in Minas Gerais state, Brazil.

The Table 5 presents the averages of the variables assessed in culture cassava. The fresh weight of shoot, number of roots per plant, root length, root dry matter, starch content of the roots and harvest index did not differ statistically among themselves. Statistical difference was observed for the variables diameter of the root and yield, which infers that the arrangements of the cassava and cowpea intercropping did not affect these characteristics.

For the characteristic fresh weight of shoot, the average of its treatments was 14,738 kg ha^{-1} (Table 5). The foliage yield is an important factor in the cassava culture for it is related to the yield of material for spreading and to the use

Table 3 - Summary of analysis of variance of the data regarding the yield of roots (YIELD - kg ha^{-1}), fresh weight of shoot (FW - kg ha^{-1}), harvest index (HI - %), number of roots per plant (NRP), root length (RL - cm), roots diameter (RD - cm), roots dry matter (RDM - %) and starch content (SC - %) of the cassava root of the cultivar "Aciolina" harvested at twelve months after planting. Boa Vista, Roraima state, 2012

FV	GL	Average squares							
		YIELD	FW	HI	NRP	RL	RD	RDM	SC
Blocks	3	3,681,512	1,774,896	22.68	5.98	0.82	0.61	2.96	3.01
Treatments	5	24,155,900*	$1,401,205^{ns}$	60.63^{ns}	1.69^{ns}	10.94^{ns}	1.41**	0.62^{ns}	0.62^{ns}
Residue	15	2,726,216	3,248,057	20.45	0.98	9.45	0.24	0.47	0.48
Average		15.068	14.738	50.30	3.83	22.71	5.09	33.10	28.45
CV (%)		10.96	12.23	8.91	25.85	13.54	9.70	2.08	2.42

ns, **, * Not significant, Significant at 0.1; 1 and 5% probability, respectively, by test F of the culture as fodder (VIDIGAL FILHO *et al*., 2000). The cassava shoot can be reused by the cassava farmers for feeding animals, being a good consumption alternative in the dry season (DANTAS *et al*., 2010). It is observed that the intercropped treatments did not interfere in the characteristics: fresh weight of shoot, number of roots per plant, roots length, roots dry matter, root starch content and harvest index (Table 5).

The average of the treatments of the harvest index characteristic was 50.30% (Table 5). According to Nonetheless, Cock and El-Sharkaway (1991) show that the optimal value for harvest index is between 50 and 65%. Therefore, the average harvest index obtained was not negatively influenced by the arrangements of the intercropping between cassava and cowpea. Similar results of the intercropping of cassava with cowpea and corn were obtained by Devide *et al*. (2009).

The number of root per average plant was 3.83, which is within the limits shown in the literature. A cassava adult plant presents, in average, 3 to 12 roots per plant (ALBUQUERQUE *et al*., 2009).

The general average of the treatments of roots dry matter was of 33.10%. According to Fukuda *et al*. (2006) the cassavas culture presents, on average, 30% of dry matter in the roots, although there are records of up to 45%, and starch varies from 5 to 43%.

The main characteristic that defines the quality of the cassava roots yield for the industry is the dry matter content. The dry matter content presents a direct correlation with the starch content (BORGES; FUKUDA; ROSSETTI, 2002), raw material extracted by starch factories, flour mills and manufacturers of cassava alcohol. The starch content corresponds to approximately 85% of the roots dry matter

Table 4 - Summaries of the analyses of variance of data on grain yield (YIELD - kg ha^{-1}), weight of 1,000 seeds (WS - g), number of pod per plant (NPP), number of seeds per pod (NSP) and length of pod (LP) of cowpea, cultivar UFRR grão verde. Boa Vista, Roraima state, 2012

FV	GL	Average squares				
		YIELD	WS	NPP	NSP	LP
Blocks	3	468.18	22.85	5.00	0.43	5.93
Treatments	5	97,052.93***	2.68^{ns}	4.73 ***	2.33**	0.49^{ns}
Residue	12	1,415.73	23.14	0.57	0.57	1.65
Average		732.95	155.05	13.68	13.14	14.71
CV (%)		5.13	3.10	5.50	5.76	8.73

$^{ns,\ ***,\ **,\ *}$ Not significant, Significant at 0.1; 1 and 5% probability, respectively, by test F

Table 5 - Average values of fresh weight of shoot (FWS), number of roots per plant (NRP), root length (RL), root diameter (RD), root dry matter (RDM), roots starch content (RSC), roots yield (YIELD) and harvest index (HI), of cassava of the cultivar "Aciolina" in monoculture and intercropped with cowpea, harvested at 12 months after planting. Boa Vista, Roraima state, 2012

Treatment	FWS (kg ha^{-1})	NRP	RL (cm)	RD (cm)	RDM (%)	RSC (%)	YIELD (kg ha^{-1})	HI (%)
T1	15,746	4.95	20.50	3.90 b	33.77	29.12	18,265 a	51.69
T2	14,346	3.10	24.75	5.37 a	33.12	28.47	13,086 c	49.49
T3	14,152	3.74	24.25	5.17 a	33.24	28.60	14,225 bc	50.41
T4	15,125	4.12	23.25	5.30 a	32.63	27.98	11,900 c	49.60
T5	14,572	3.45	22.00	5.47 a	32.97	28.32	17,322 ab	51.10
T6	14,490	3.71	21.50	5.35 a	32.85	28.20	15,584 abc	50.80
T7	---	---	---	---	---	---	---	---
Average	14,738	3.83	22.71	---	33.10	28.45	---	50.30

Averages followed by the same letter in the column do not differ significantly at 5% probability by the test of Tukey; T1 = single row of cassava (monoculture); T2 = single row of cassava + 1 cowpea; T3 = double row of cassava (monoculture); T4 = double row of cassava + 1 cowpea; T5 = Double row of cassava + 2 cowpea; T6 = Double row of cassava + 3 cowpea; T7 = sole cowpea (monoculture) content and, since it is difficult to determine it analytically, in practical terms, it isestimated in the manufacturers from the dry matter (CARVALHO *et al*., 2007).

The single row treatment of cassava in monoculture (T1) has presented the largest yield (18,265 kg ha^{-1}), although it has not differed statistically from the double row treatments of cassava + 2 rows of cowpea (T5) and double row treatment of cassava + 3 rows of cowpea (T6), respectively 17,322 and 15,584 kg ha^{-1}. In similar works performed in Coimbra (MG), the cassava treatment in single row (1.0 x 0.5 m) obtained the largest yield of roots (19,093 kg ha^{-1}), although it has not differed statistically from the cassava double row treatments in monoculture and cassava double row plus one row of ordinary beans, respectively 17,675 and 16,625 kg ha^{-1} (ALBUQUERQUE *et al*., 2012). Gabriel Filho, Strohhaecker and Fey (2003) and Damasceno, Mattos and Caldas (2001) also obtained yield from roots statistically similar between the sole cassava cultivation in single row (1 x 0.6 m) and double row (2.0 x 0.5 x 0.5 m) with cowpea.

Intercropping work of cassava and corn performed by Devide *et al*. (2009) in Seropédica, in the Brazilian State of Rio de Janeiro, also showed that the corn did not interfere in the commercial yield of tubers of cassava and the harvest of green ears with industry standard, which means the potential for additional income to farmers, with better use of available resources, including justifying the use of irrigation. Including corn, cv. Eldorado, grown in alternating lines of cassava, after the first weeding, did not interfere in commercial yield of roots.

In contradiction to the results, found in studies conducted by Cavalcante, Silva and Araújo (2005) mention that the behavior of intercropped cultures is different from the one presented by sole cultivations.

From the components of yield assessed in the cowpea, the number of pods per plant (NPP), pod length (PL) and the grains yield (YIELD) presented significant differences between the treatments (Table 6), showing that the intercropping with the cassava impacted these characteristics.

As for the yield in the intercropping, the worst performance of cowpea was in the arrangement double rows of cassava with a row of cowpea (Treatment 4) (477 kg ha^{-1}), reduction of 52.82% compared to the monoculture of the cowpea (Treatment 7), with 903 kg ha^{-1} (Table 6).

The other treatments of double row intercropping did not provide significant differences in the yield of the cowpea (Table 6). Alves *et al*. (2009) also noticed reduction in the yield of different cultivars of cowpea in intercropping with two varieties of cassava.

A variable widely used in the assessment of the cultivation intercropping is the equivalence index of area (EIA). According to Vieira (1984), the intercropping will be efficient when the EIA is over 1.00 and harmful to the yield when below 1.00. The EIA calculated for the arrangements of intercropping studied have ranged from to 1.18 to 1.56, and the treatment of single row of cassava + 1 row of cowpea (T2) have presented the greater EIA (Table 6). These results show advantages for all the treatments intercropped used in this work. In works similar to this one, located in the city of Coimbra (MG), the EIA ranged from 1.28 to 1.54 and the treatment of double row of cassava + 3 rows of regular beans have presented the largest index, equal to 1.54 (ALBUQUERQUE *et al*., 2012).

Table 6 - Average values of the weight of 1,000seeds (WTS), number of pods per plant (NPP), pod length (PL), number of seeds per pod (NSP), yield of grains (YIELD) of cowpea intercropped with cassava and in monoculture and equivalence index of area (EIA) regarding the intercropping. Boa Vista, Roraima state, 2012

Treatment	WTS (g)	NPP	PL (cm)	NSP	YIELD (kg ha^{-1})	EIA
T1	---	---	---	---	---	---
T2	155	12.55 c	14.85 b	12.62	769 b	1.56
T3	---	---	---	---	---	---
T4	154	14.67 ab	15.62 a	13.50	477 c	1.18
T5	156	13.17 bc	14.25 c	13.02	751 b	1.77
T6	155	13.00 bc	13.67 d	13.15	763 b	1.69
T7	154	15.00 a	15.15 ab	13.42	903 a	---
Average	155	---	---	13.14	---	1.55

Averages followed by the same letter in the column do not differ significantly at 5% probability by the test of Tukey; T1 = single row of cassava (monoculture); T2 = single row of cassava + 1 beans; T3 = double row of cassava (monoculture); T4 = double row of cassava + 1 beans; T5 = double row of cassava + 2 beans; T6 = double row of cassava + 3 beans; T7 = sole beans (monoculture)

In works of intercropped systems with the cultivations of cassava and regular beans, Cavalcante, Silva and Araújo (2005) assessing the analysis of the area equivalence index, showed advantages for all the intercropped treatments, since they have reached values over 1.0. Damasceno, Mattos and Caldas (2001), assessing spacial arrangements of cassava in monoculture and intercropped with regular beans and corn in the city of Cruz das Almas (BA), concluded that the EIA of the intercropped treatments have presented values over 1.0.

CONCLUSIONS

1. The double rows cropping systems of cassava with two and three rows of cowpea allow to obtain equivalent yield to the monoculture of cassava in single rows;
2. The grains yield of the cowpea in single rows (monoculture) is superior to the intercropped treatments;
3. The results of the characteristics of the cassava: fresh weight of shoot, number of roots per plant, root length, root diameter, root dry matter, starch content of the roots and harvest index are not impacted by the intercropped systems;
4. The characteristics of weight of 1,000 seeds and number of seeds per pod of the cowpea are not impacted by the intercropped systems used;
5. All treatments in intercropping systems exhibit a satisfactory area equivalence index, with an average of 1.55.

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