

Intercropping Pineapple With Rice or Cowpea: An Alternative for Family Farming in the State of Tocantins, Brazil

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Abstract

Pineapple is commonly planted in monoculture systems. It is a long-cycle crop that takes time to monetize, which hinders its cropping by small farmers. The objective of this work was to evaluate the production and quality of pineapple with short-cycle crops, at the beginning of the growing period, as an alternative for family farming in the state of Tocantins. The experimental design was randomized complete block with three treatments and four replications. The pineapple was intercropped with rice and cowpea. The treatments consisted of T1: pineapple + rice; T2: pineapple + cowpea and T3: pineapple in monoculture. The evaluated variables of the pineapple fruit were pH, soluble solids, titratable acidity, yield, fruit mass, fruit length with crown, fruit length without crown and fruit circumference. For the rice and cowpea, the yield and the Area Equivalence Index (AEI) were determined. The cropping system did not influence the pineapple fruits quality. The pineapple yielded less. Cowpea yielded more when intercropped with pineapple. The AEI of the pineapple + rice intercropping was 2.07, being feasible for increasing the use of the area by 100%. The AEI of the pineapple + cowpea intercropping was 2.48, being feasible as it increased the use of the area by 148%. The results obtained showed that it is possible to intercrop pineapple with rice or cowpea at the beginning of pineapple cultivation, and it can be a viable alternative for family farming.

Keywords: *Ananas comosus*, *Oryza sativa*, *Vigna unguiculata*, subsistence

1. Introduction

The pineapple is commonly grown in a monoculture system, but is also used by small farms, in family farming system. As it is a long-cycle crop, the economic return also occurs in the long term, which ends up hampering the cultivation by small farmers who make limited use of mechanization on their properties and require complementary incomes during the crop implantation phase. Thus, intercropping pineapple with other crops of economic interest may be a viable alternative, therewith, maximizing the use of environmental resources and labor is fundamental, especially for the sustainability of family farming (Asten et al., 2011). Intercropping also increases income and improves soil properties. These systems have sought not only to increase the production and yield of the cultivated products, but also to adopt production systems that better adapt to the ecological and socioeconomic conditions of certain regions (Cordeiro et al., 2009; Albuquerque et al., 2012; Maciel et al., 2013). When intercropped, crops will always compete for water, nutrient, light and other factors that are directly linked to the plant development. The competition depends on the species involved, their root systems and the availability of water, nutrients and oxygen (Costa & Silva, 2008). According to Cunha (2004), the second crop must have good acceptance in the regional commerce and allow the good development of the pineapple.

Cunha and Reinhardt (2004), and Cunha et al. (2005) mention that pineapple is a crop that is easily adapted to intercropping systems, due to its slow initial growth and to the double-row planting system. In Tocantins state, the spacings adopted between the double-rows are larger than those used in other regions and the soil remains uncovered in the first six months of the crop implantation during the rainy season. Intercropping pineapple with short-cycle crops can enable small local farmers to sustainably produce pineapple. Rice and cowpea were chosen as secondary crops because of their importance in subsistence agriculture in Brazil, with the main grains consumed in the Brazilian diet. In this way, the objective of this work was to evaluate the pineapple production and quality intercropped with rice or cowpea, at the beginning of the growth cycle.

2. Method

The experiment was conducted from January 2008 to June 2009, at a family farm near Gurupi, Tocantins, Brazil, located at 11°51'58" S and 48°59'17" W, at 287 m of altitude.

According to the Köppen classification, the local climate is type B1wA'a 'humid, with moderate water deficiency. The average annual temperature varies from 22 to 32 °C, with average relative air humidity around 76% and an average annual rainfall of 1400 mm.

The experimental design was a randomized complete block with three treatments and four replications. The treatments tested were: T1: Pineapple + rice; T2: Pineapple + cowpea and T3: Pineapple in monoculture. Three replications were performed for pineapple fruit quality traits.

The pineapple variety was 'Pérola'. The second crops cultivars adopted were: rice 'BRS Spring', recommended for uplands (Embrapa, 2013); and cowpea 'Vinagre', which presents medium cycle, prostrate habit, indeterminate growth and red color grains, with great economic and cultural value in the State of Tocantins, being cultivated mainly in family agriculture.

Soil correction was performed based on the soil analysis and the fertilizers were applied individually by crop, following the regional recommendations. The planting of pineapple and the second crops was carried out together in January 2008. The pineapple was planted in double-rows with the following spacing: 1.80 × 0.50 × 0.40 m. The rice and cowpea were sown between the double rows according to the spacings adopted for each crop in the region. Weed control was performed manually when necessary. The experiment was not irrigated.

Harvesting of the rice and cowpea was carried out in April/May 2008, and pineapple floral induction and harvest were carried out in January and June 2009, respectively. The following variables were evaluated: a) pH; Soluble solids (SS; °BRIX); b) titratable acidity (TA,%); c) yield (t ha⁻¹); d) fruit mass (g); e) crownless fruit length (CFL; cm); f) fruit length with crown (FLC; cm); g) fruit circumference (CIRC; cm); h) cowpea yield and h) rice yield.

The pineapple fruits were weighted on a digital scale and measured for class determination (length and diameter). Each fruit was peeled, chopped and crushed to obtain the juices used for the physicochemical analysis. The pH was determined using a table pH meter; the soluble solids (SS) contents with portable refractometer; and the titratable acidity (AT) by titration with 0.1M NaOH solution, being the result expressed as % of citric acid.

To determine the cowpea yield, the pods were harvested as they matured. For rice yield, the panicles were harvested at maturity. Both cowpea and rice had their samples weighted on a digital scale and the values transformed in ton per hectare.

The data were submitted to analysis of variance ($p < 0.05$) test F. The means were compared by the Tukey test. Individual analyzes of variance were also performed for single and intercropped systems for rice and cowpea; the means were compared by the Tukey test at ($p < 0.05$) F test.

For the intercropped treatments, the area equivalence index (AEI) was determined using the formula: AEI (pineapple + rice) = (intercropped pineapple yield/pineapple yield in monoculture) + (intercropped rice yield/rice in the monoculture) and AEI (pineapple + cowpea) (intercropped pineapple yield/pineapple yield in monoculture) + (intercropped cowpea yield/cowpea yield in monoculture). The intercropping is considered efficient when the AEI is higher than 1.0 and harmful to production when less than 1.0 (Teixeira et al., 2011).

3. Results and Discussion

3.1 Fruit Quality of Intercropped Pineapple

The intercropping did not interfere with the pineapple fruits quality (Table 1) and (Figure 1). No difference was observed between the values of pH, soluble solids and titratable acidity between the monoculture crop and the intercropping conditions. The values found are within the established standards for the state of Tocantins according to Conceição et al. (2004), except for the titratable acidity that presented slight lower values.

Table 1. Analysis of variance of pineapple fruit quality-pH, SS; °BRIX and TA (%) in a intercropping system with rice, cowpea, and monoculture. Gurupi-TO, Brazil

SV	DF	Average square		
		pH	SS °BRIX	TA (%)
Treatment	2	0.000011 ^{ns}	0.253333 ^{ns}	0.000078 ^{ns}
Block	2	0.000078 ^{ns}	1.720000 ^{ns}	0.000144 ^{ns}
Error	4	0.000178	0.173333	0.000261
Mean		3,76	14,60	0.61
CV(%)		0.35	0.17	0.75

Note. ^{ns} not significant by the F test.

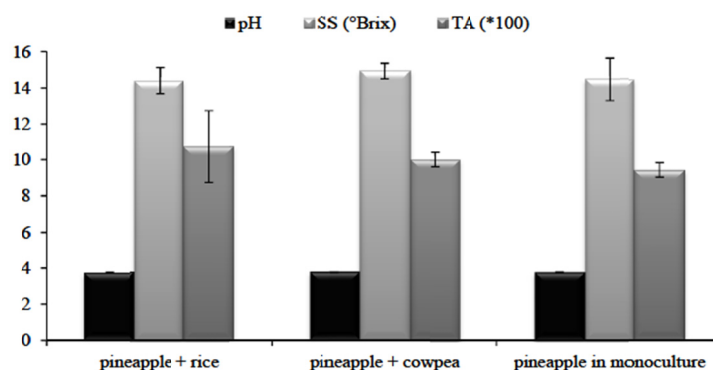


Figure 1. Pineapple fruits quality characteristics in a system of intercropping with rice, cowpea, and monoculture. Gurupi-TO, Brazil

3.2 Agronomic Characteristics of Intercropped Pineapple

There was a significant difference between the cultivation systems adopted for pineapple for all evaluated variables, except crownless fruit length (CFL) (Table 2). These results demonstrate that the pineapple responded to cropping systems for fruit weight (FW), fruit length with crown (FLC), fruit circumference (Circ) and yield.

Table 2. Analysis of variance of the agronomic variables of pineapple ‘Pérola’ in monoculture and intercropping system with rice and cowpea, Gurupi-Tocantins, Brazil

SV	DF	Average square				
		FW (g)	FLC (cm)	CFL (cm)	Circ. (cm)	Yield (t ha ⁻¹)
Treatment	2	114483.73*	147.72*	1.826 ^{ns}	9.320*	22.798*
Block	3	10775.12 ^{ns}	5.70 ^{ns}	0.336 ^{ns}	0.896 ^{ns}	2.154 ^{ns}
Error	6	12890.32	13.76	0.917	1.537	2.567
Mean		941.38	42.34	6.83	32.72	13.98
CV (%)		11.46	8.76	6.83	3.79	11.46

Note. * Significant at $p \leq 0.05$; ^{ns} not significant.

FW: Fruit weight; FLC: Fruit with crown; CFL: crownless fruit length; Circ.: Fruit circumference.

Intercropping with annual plants at the beginning of the pineapple cultivation did not decrease the fruit circumference and its length without the crown. However, a decrease of the length of the fruit with the crown was observed, which was lower for pineapple plants intercropped with cowpea (Figure 2).

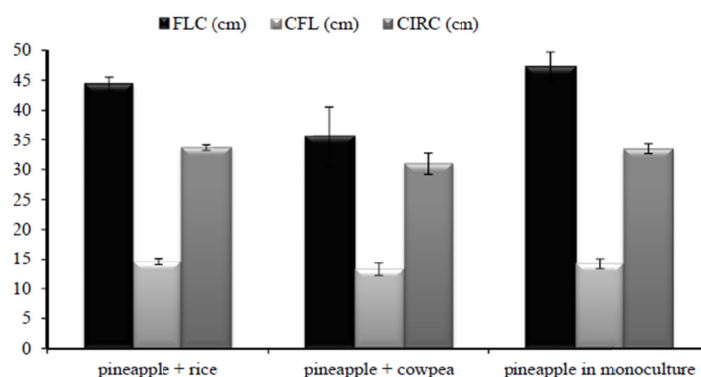


Figure 2. Fruit length with and without crown and circumference of pineapple fruits in the intercropping system with rice, cowpea, and monoculture. Gurupi-TO, Brazil

3.3 Agronomic Characteristics of Pineapple Intercropped With Rice

Intercropping pineapple with rice did not reduce the fruit mass and the yield. This response is probably related to the architecture of the rice plants (vertical) and its lower aggressiveness, so that the pineapple plants could develop satisfactorily without competition for light and nutrients in the soil in the initial phase of development (Figure 3).

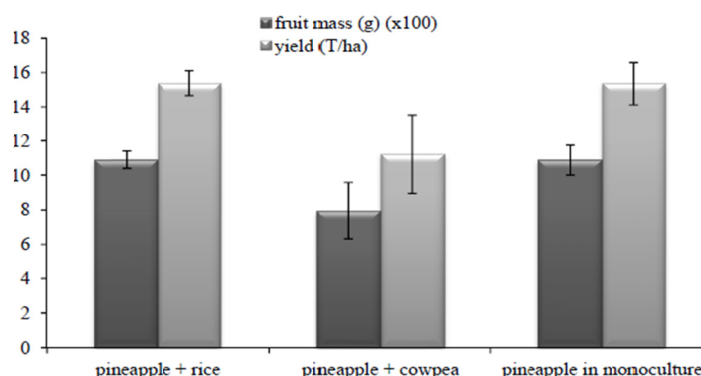


Figure 3. Fruit weight and yield of pineapple in the intercropped system with rice, cowpea, and monoculture. Gurupi-TO, Brazil

3.4 Agronomic Characteristics of Pineapple Intercropped With Cowpea

Intercropping pineapple and cowpea at the beginning of the cycle reduced the mass of the pineapple fruit and, consequently, also the yield, demonstrating that the intercropping with cowpea did not provide good performance, reducing the pineapple productive potential. This reduction can be justified by the aggressiveness of the cowpea and the planting system, since two rows of the cowpea were planted between the double rows of the pineapple. Cowpea presents undetermined and rapid growth, with long and climbing branches, projecting its branches into the pineapple double-rows, which may have promoted competition with the main crop.

These results differ from Karanja et al. (2014) who observed lower development and yield of cowpea when it was intercropped with sorghum in Kenya, Africa, and from Santos et al. (2014) that obtained lower cowpea yield when intercropped with maize, in Tocantins, Brazil.

According to Aguiar et al. (2011), the pineapple yield reduction can be associated with plant density, since competition for light occurs. Higher plant densities may cause self-shading, reducing light availability and decreasing photosynthetic activity (Santos et al 2014). One alternative could be the use of a single-row of cowpea between the double-row pineapple, thus, the competitive effect between the two crops may be attenuated.

A negative effect of intercropping pineapple with cowpea was also observed by Souza et al. (2010) with banana cropping, where the intercropping promoted a delay in the production cycle of the crop. The authors argued that cowpea present indeterminate and fragile growth plant, with greater soil cover, in intensity and time, which may

have caused competition with the banana plants. The same was observed in our experiment, so probably the competition was the reason that fruit weight and yield of pineapple in the intercropped system was lower.

3.5 Area Equivalence Indices (AEI)

The yield means and individual relative index (AI) and area equivalence indexes (AEI) for pineapple, rice and bean crops in single and intercropping are shown in Table 3.

The rice yield did not differ significantly between the cropping systems studied. However, cowpea was yielded better when intercropped with pineapple, possibly because cowpea is more rustic and benefited from the pineapple fertilization. According to Barreiro Neto et al. (2017), in an intercropping system, plants compete mainly for light, water and nutrients.

Table 3. Mean test for yield and relative individual index (AI) and area equivalence indexes (AEI), calculated based on yield of crops grown in Gurupi-Tocantins, Brazil

Cropping system	Prod. (t ha ⁻¹)	AI	AEI
Pineapple			
Pineapple	15.35 a	-	-
Pineapple + Rice	15.38 a	1.00	2.07*
Pineapple + Cowpea	11.23 b	0.73	2.48
CV(%)	14		
Rice			
Rice	2.65 a	-	-
Rice + Pineapple	2.84 a	1.07	-
CV(%)	20		
Cowpea			
Cowpea	1.00 b	-	-
Cowpea + Pineapple	1.75 a	1.75	-
CV(%)	25		

Note. * The intercropping is considered efficient when the AEI is greater than 1.0 and harmful to production when less than 1.0.

The area equivalence indexes (IEA) (Table 3) were 2.07 for pineapple + rice and 2.48 for the pineapple + cowpea, indicating the efficiency of intercropping. However, single cropping required 100% and 148% more of planted area for rice and cowpea, respectively, to equate the yield obtained in intercropping with pineapple.

The AEI, although positive, should not be considered sufficient for a decision making (Moura, 1984). The yield of each crop component of the intercropping should be taken into account. In this case, both rice and cowpea appeared to be suitable for planting in intercropping with pineapple, under the soil and climatic conditions of Gurupi, Tocantins, Brazil.

The results obtained in the present work demonstrated that there is a possibility of intercropping pineapple at the beginning of its cultivation with rice, being a viable alternative for family farming.

4. Conclusions

The cropping system did not influence the pineapple fruits quality but reduced the yield when was intercropped with cowpea.

The intercropping pineapple + rice is the best cropping system.

The cropping system with pineapple and rice or cowpea is viable for family farming.

The AEI of the intercropping pineapple + rice was 2.07, being viable as it increases the use of the area by 100%.

The AEI of the intercropping pineapple + cowpea was 2.48, being viable as it increased the use of the area by 148%.

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