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Agro-economic yield of taro clones in Brazil, propagated with different types of cuttings, in three crop seasons

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ABSTRACT

The experimental studies were conducted in 2007-2008, 2008-2009 and 2009-2010 crop seasons, in order to know the agro-economic yield of 'Chinês' and 'Macaquinho' taro clones, propagated using huge, extra, large, medium, small and tiny cormels. The harvest was done on average on 202 days after planting, in three crop seasons. Based on the joint analysis of variance carried out, it was observed that taro clones showed significant differences in the yield of fresh and dry weight of leaves, cormels, and commercial and non-commercial comels; besides, there were significant differences in yield of a crop season to another and the size of the cuttings induced significant differences in yield. In the conditions that the experiments were conducted, and considering the highest average yield of fresh weight of commercial cormels (28.69 $t.ha^{-1}$) and highest net income (US $14,741.14) correspondent to the three crop seasons, it is recommended to cultivate 'Macaquinho' clone using small cuttings in propagation.

Key words: *Colocasia esculenta*, rhizome, production, income.

INTRODUCTION

More than 800 species of Araceae have economic (ornamental, edible or medicinal) or ethnobotanic importance, and about 10% of the world population use as food ingredient the taro rhizome *Colocasia esculenta* (L.) Schott, popularly known in most countries like "taro" (Pedralli et al. 2002). Due to peculiar characteristics such as rusticity and nutritional values, taro is a tuberous species suggested by FAO (Food and Agriculture Organization) as an alternative crop to increase the food base in developing countries (Pereira et al. 2004). In 2007, around the planet, were cultivated 1.633 million ha of taro, with production of 11.267 million tons and yield of 6.9 $t.ha^{-1}$ (Faostat 2009).

For its nutritional characteristics, taro presents possibilities for human use in different forms of preparation, and can replace, in whole or in part, potato, cassava, corn, wheat and other starch-producing species (Vilpoux 2001, Heredia Zárate et al. 2005). It also can be used in animal feed, especially for broilers (Heredia Zárate et al. 2005).

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Taro has common occurrence in the humid tropics and it is used in tropical agriculture as food in developing countries, due to its rich contents of starch, large production per unit area and low manpower demand (Heredia Zárate et al. 2009). It is vegetatively propagated crop and the base of the main stem, suckers or cormels are used as propagules (Lebot 2009, Sardos et al. 2012). So it stands out as a culture of low production cost, undemanding in soil fertility and inputs and easy maintenance, making it an appropriate culture for farmers with low technological level, a fact often observed at the level of family farming. However, these producers have in common limitation of the physical area, which hampers the exploitation of the species because of the long crop cycle, on average nine months (Gondim et al. 2007).

The literature review on taro, done by Heredia Zárate et al. (2004), mentions that, although in Hawaii the number of varieties reaches 100, only five or six are commercial. In Brazil, in the Minas Gerais State, are grown the ‘Chinês’, ‘Japonês’ and ‘Macaquinho’ clones (Gondim et al. 2007). In the Rio de Janeiro State, especially in the highlands, are grown the ‘Branco’, ‘Chinês’, ‘Japonês’, ‘Rosa’ and ‘Roxo’ clones (Oliveira et al. 2007, 2008). The Espírito Santo State stands out as a traditional producer of taro, with a predominant of planting of ‘Chinês’ clone and recently ‘São Bento’ clone, which presents high yield, superior to the others (Carmo and Puiatti 2004). For Brazil, average yields of commercial cormels between 12 $t.ha^{-1}$ in Rio de Janeiro and 20 $t.ha^{-1}$ in the region of Inhapim, Minas Gerais (Heredia Zárate et al. 2004) are reported. For marketing, the rhizomes most appropriate are those with 100-200 grams each (Kurozawa 2009).

Taro propagation, in the commercial exploitation of rhizomes, is exclusively vegetative, in which are used mainly the cormels, in most cases, the only product to market. Although in the classic work of Silva (1970) response in the production of rhizomes with the increase in the size of cuttings of cormel type has not been observed, according to Puiatti et al. (2003), in the works of many researchers it was found an increase in rhizomes yield with an increase in size of cuttings of cormel type (Puiatti et al. 2004).

As in any economic activity, especially in agriculture, the monitoring of expenses is essential; thus, beyond the knowledge of the total operating cost, it becomes necessary to know the relative share of items of effective operational cost, reflecting the variable costs or expenditures effectively done. Equally, it is important to know the structure of fixed costs, or indirect expenses, represented by the administrative costs and burdens as a form of detailing the remuneration paid to other important production factors, without which the calculation of profitability is impaired (Melo et al. 2009).

According to the previously stated, this study aimed to know the agro-economic yield of two taro clones, propagated using six types of cuttings grown in three crop seasons.

MATERIALS AND METHODS

The experimental works were conducted in three crop seasons between September 2007 and April 2010, and carried out at the Medicinal Plants Garden of the Faculty of Agrarian Science-FCA, of the Universidade Federal da Grande Dourados, in Dourados-MS, Brazil, located at 22°11'44 "S of latitude, 54°56'07" W of longitude and 452 m of altitude. The climate of Dourados, according to Köppen, is mesothermal humid, Cwa type, with temperature and annual rainfall averages ranging from 20° to 24°C and 1,250 mm, respectively.

The soil in area is classified as a dystrophic red oxisol of clayey texture, with the following chemical characteristics: 5.9 of pH in H2O; 28.9 $g.dm^{-3}$ organic matter; 38.0 $mg.dm^{-3}$ P; 0.0; 3.5; 46.0; 22.0; 53.0; 71.5 and 124.5 $mmolc.dm^{-3}$ of Al^{+3}, K, Ca, Mg, H+Al, SB and CTC, respectively, and

57% of saturation. Considering physical properties, the sieve method showed a soil composed of 8% sand, 13% fine sand, 16% silt and 63% clay.

Taro clones studied were ‘Macaquinho’ and ‘Chinês’ grew in plots, using cormels of six types for the propagation (Table I) as follow: huge, extra, large, medium, small and tiny. The types corresponded to each group of cormels classified visually for size differences. Treatments were arranged in a 2x6 factorial as completely randomized block design with six replications. Plots had a total area of 4.5 m^2 (3.0 m long and 1.50 m in width) and useful area of 3.0 m^2 (3.0 m long and 1.00 m in width). Spaces were 0.20 m between plants, 0.60 m between simple rows in plots and 0.90 m between double rows, which established a population of 66,000 plants.ha^{-1}.

The soil of the experimental area was prepared by plowing, harrowing and elevation of plots with a bedshaper rotary cultivator offset. On the planting day, in the plot, two furrows of planting with approximately 0.05 m wide x 0.05 m deep were open, where the cuttings were placed, consisting of whole cormels (Heredia Zárate et al. 2003a), and covered with the soil excavated when the furrows were opened. It was not used lime for soil amendment and no fertilization technique during the crop cycle.

During the crop cycle, the cultural treatments consisted of irrigations using the sprinkler system, with daily frequency until 60 days after planting and every two days after that period until harvest. The volume of water added was equal to 70–75% of field capacity of soil, by visual observations and using the touch (Heredia Zárate et al. 2010), which induced the irrigation frequency to every three days. Spontaneous vegetation was controlled by weeding between plots and manually within plots. There was no damage from the attack of pests or diseases.

TABLE I
Average weight of six types of cuttings used for propagation of two clones of taro grown in three crop seasons. Dourados, MS, Brazil, 2007-2010.

Clone	Crop year	Average weight of cuttings (g)					
		Huge	Extra	Large	Medium	Small	Tiny
	2007-08	45.77	25.69	23.93	12.60	10.29	5.61
‘Chinês’	2008-09	47.61	38.06	33.14	26.43	22.57	16.65
	2009-10	51.71	40.03	30.46	28.75	24.93	16.16
Average (g)		48.36	34.59	29.18	22.59	19.26	12.81
Spent.ha^{-1} ($kg.ha^{-1}$)		3,191.76	2,282.94	1,025.88	1,490.94	1,271.16	845.46
	2007-08	37.38	26.49	20.71	14.04	9.14	5.13
‘Macaquinho’	2008-09	42.40	34.96	27.54	23.06	19.63	12.21
	2009-10	64.84	51.09	40.49	34.56	27.69	14.45
Average (g)		48.21	37.51	29.48	23.89	18.82	10.60
Spent.ha^{-1} ($kg.ha^{-1}$)		3,181.64	2,475.88	1,945.68	1,576.74	1,242.12	699.60

The harvest of plants was done when more than 50% of the leaves of plants from different plots showed, as symptoms of senescence, yellow, wilt and dry outer leaves (Heredia Zárate et al. 2006), happening on average 202 days after planting in the three crop seasons. In harvest, the fresh weight of leaves (blade + petiole), corms (RM), commercial cormels (RFC) and non-commercial cormels (RFNC) were evaluated. Cormels with more than 25 g of weight were considered commercial. Data were submitted to joint analysis of variance using the totals of treatments in each year (Banzato and Kronka 2006) and when significance was detected by the F test, averages were compared by Tukey test at 5% probability.

The economic analysis was done as suggested by calculation of Heredia Zárate et al. (1994) for taro, cited by Terra et al. (2006), and by Terra et al. (2006) for sweet corn (Zea mays L.), which allowed to relate the factors studied (productive) with the likely returns (economics), i.e., the determination of variable costs (supplies, manpower and rental of machinery) and fixed costs (rent of land and improvements), and the contingency reserve, spending on administration and payment of interest on capital. For the calculation of gross income, the value of US \$ 0.6211.kg^{-1} (average of prices paid to producers in Dourados-MS, Brazil, by kg of commercial cormels) was used and subsequently, the conversions were conducted per hectare with the average of the crop season in three years obtained in each treatment. Net income was calculated by subtracting production costs relative to gross income.

RESULTS

Agronomic Analysis

Based on the analysis of joint variance carried out, it was observed that taro clones showed significant differences for yield of fresh and dry weight of leaves, corms, commercial cormels and non-commercial cormels. Moreover, there were significant differences for yield of one crop season to another and the type of cutting induced significant differences for yield.

TABLE II
Fresh and dry weight of leaves of two taro clones propagated using six types of cuttings, grown in three crop years. Dourados, MS, Brazil, 2007-2010.

Factors in study		Fresh weight (t.ha^{-1})			Dry weight (t.ha^{-1})		
Clones	Cuttings	2007-08	2008-09	2009-10	2007-08	2008-09	2009-10
'Chinês'	Huge	22.72 a*	11.91 ab	13.75 a	2.06 b	1.30 b	1.90 a
	Extra	17.56 ab	9.74 ab	1.52 b	1.39 b	1.36 b	0.30 b
	Large	17.03 b	8.31 b	12.19 a	1.45 b	1.01 b	2.46 a
	Medium	18.67 ab	14.74 a	5.34 b	1.81 ab	1.89 a	0.72 b
	Small	20.18 ab	13.77 ab	14.35 a	1.76 ab	1.79 ab	2.23 a
	Tiny	13.29 b	9.48 b	1.66 b	1.26 b	1.11 b	0.41 b
'Macaquinho'	Huge	7.87 a	7.93 a	6.86 a	0.85 ab	1.01 a	1.31 a
	Extra	10.31 a	8.24 a	1.96 b	1.11 a	0.97 a	0.40 b
	Large	10.86 a	7.24 a	7.74 a	1.14 a	0.83 ab	1.29 a
	Medium	10.56 a	9.56 a	2.61 b	1.26 a	1.12 a	0.61 b
	Small	9.81 a	8.43 a	7.18 a	1.04 ab	1.02 a	1.29 a
	Tiny	5.62 a	4.32 a	0.71 b	0.56 b	0.50 b	0.28 b
Standard deviation		1.08	1.15	0.72	0.10	0.09	0.12
Δq		5.30	5.62	3.54	0.49	0.44	0.59
Average		13.71	9.47	6.32	1.31	1.16	1.10
C.V. (%)		7.88	12.14	11.39	7.63	7.76	10.91

*Average followed by same letters, in columns, for cuttings within each clone and each year, did not differ among each other by Tukey test, at 5% of probability.

In relation to yield of fresh and dry weight of leaves (Table II), 'Chinês' clone had the highest yield in the three crop seasons. Crop season of 2007-2008 had the highest value for fresh weight (22.72 $t.ha^{-1}$) with the use of huge cuttings, and 2009-2010 crop season had for dry weight (2.46 $t.ha^{-1}$) with large cuttings. For 'Macaquinho' clone, 2007-2008 crop season had the highest yield of fresh weight of leaves (10.86 $t.ha^{-1}$), when large cuttings were used, and 2009-2010 crop season had the highest yield of dry weight (1.31 $t.ha^{-1}$) with huge cuttings. These highest yields for 'Macaquinho' clone were lower, respectively, in 109.21% and 57.25%, 35.73% and 44.27%, and 32.14% and 87.79%, compared to the highest yields of 'Chinês' clone in the 2007-2008, 2008-2009 and 2009-2010 crop seasons.

The yields of fresh and dry weight of corms (Table III) were highest for 'Macaquinho' clone in 2009-2010 crop season, with the use of small cuttings (14.16 $t.ha^{-1}$ and 2.83 $t.ha^{-1}$, respectively) which exceeded in 64.84% and 10.55%, respectively, to the highest fresh weight of the 'Chinês' clone. 'Chinês' yield of fresh weight were also obtained in 2009-2010 crop season, with small cuttings. Plants of the 'Chinês' clone showed the highest yield of fresh and dry weight in 2008-2009 crop season, with medium cuttings, exceeding, respectively, in 35.02% and 116.13% for fresh and dry weight obtained for 'Macaquinho' clone, with medium and extra cuttings, respectively. 'Macaquinho' clone had the highest yield of fresh weight in 2007-2008 crop season with small cuttings, exceeding in 34.24% to the higher yield achieved by 'Chinês' clone with huge cuttings, and 'Chinês' clone had the highest yield of dry weight with huge cuttings, exceeding in 20.0% to the highest yield of 'Macaquinho' with extra cuttings.

TABLE III
Fresh and dry weight of corms of two taro clones propagated using six types of cuttings, grown in three crop seasons. Dourados, MS, Brazil, 2007-2010.

Factors in study		Fresh weight ($t.ha^{-1}$)			Dry weight ($t.ha^{-1}$)		
Clones	Cuttings	2007-08	2008-09	2009-10	2007-08	2008-09	2009-10
'Chinês'	Huge	5.21 a*	5.86 b	6.93 a	1.56 a	1.41 b	1.65 b
	Extra	5.13 a	2.92 c	4.12 b	1.37 ab	0.68 c	0.70 c
	Large	4.09 ab	3.21 c	7.20 a	1.17 b	0.66 c	1.34 bc
	Medium	4.10 ab	6.94 a	6.08 ab	1.10 b	2.01 a	1.31 bc
	Small	4.53 ab	3.66 c	8.59 a	1.27 a	1.26 b	2.56 a
	Tiny	3.25 b	3.44 c	3.72 b	0.97 b	0.87 c	0.78 c
'Macaquinho'	Huge	5.34 b	3.46 b	12.98 ab	0.86 b	0.60 b	2.50 a
	Extra	6.99 a	4.51 a	5.31 cd	1.30 a	0.93 a	0.86 c
	Large	6.89 a	4.34 ab	10.89 b	1.17 ab	0.80 ab	2.07 b
	Medium	5.06 bc	5.14 a	6.45 c	0.91 b	0.85 ab	1.10 c
	Small	7.15 a	4.58 a	14.16 a	1.19 ab	0.81 ab	2.83 a
	Tiny	3.73 c	2.55 b	3.82 d	0.65 b	0.56 b	0.67 c
Standard deviation		0.29	0.20	0.44	0.06	0.06	0.12
Δq		1.42	0.98	2.16	0.29	0.29	0.59
Average		5.12	4.22	7.52	1.13	0.95	1.53
C.V. (%)		5.66	4.74	5.85	5.31	6.32	7.84

*Average followed by same letters, in columns, for cuttings within each clone and each year, did not differ among each other by Tukey test, at 5% of probability.

'Macaquinho' clone had the highest yields of fresh and dry weight of commercial cormels (Table IV) in the three crop seasons. Yields were highest in 2007-2008 crop season with the use of small cuttings (43.52 $t.ha^{-1}$ and 7.34 $t.ha^{-1}$, respectively) exceeding in 120.69% and 67.58%, respectively, to the highest fresh and dry weight of 'Chinês' clone, which were obtained in 2009-2010 crop season with medium and huge cuttings, respectively. In general, average yield of fresh weight of commercial cormels (28.69 $t.ha^{-1}$) in three crop seasons was higher for 'Macaquinho' clone using small cuttings (Table IV).

TABLE IV
Fresh and dry weight of commercial cormels of two taro clones propagated using six types of cuttings, grown in three crop seasons. Dourados, MS, Brazil, 2007-2010.

Factors in study		Fresh weight ($t.ha^{-1}$)			Dry weight ($t.ha^{-1}$)		
Clones	Cuttings	2007-08	2008-09	2009-10	2007-08	2008-09	2009-10
'Chinês'	Huge	13.84 a*	13.38 a	17.67 a	3.90 a	3.79 a	4.38 a
	Extra	11.33 ab	3.92 b	7.44 c	3.41 b	0.84 c	1.81 f
	Large	12.00 ab	3.04 b	13.28 b	2.96 c	0.85 c	3.26 c
	Medium	8.95 ab	9.44 a	19.72 a	2.30 d	2.66 b	3.68 b
	Small	6.49 ab	3.21 b	10.36 bc	1.56 e	0.87 c	2.59 d
	Tiny	4.11 b	1.48 b	9.12 c	1.08 f	0.40 d	2.27 e
'Macaquinho'	Huge	30.05 b	14.76 b	27.00 a	6.17 b	3.65 bc	4.95 a
	Extra	36.61 ab	19.41 a	16.00 c	6.38 b	3.61 c	2.90 c
	Large	39.84 a	18.41 ab	15.63 c	6.98 a	2.81 d	2.98 c
	Medium	27.00 bc	19.54 a	16.66 c	4.61 c	3.75 b	2.96 c
	Small	43.52 a	20.41 a	22.15 b	7.34 a	3.90 a	4.55 b
	Tiny	21.46 c	10.06 c	11.35 d	3.49 d	1.99 e	2.24 d
Standard deviation		1.62	0.78	0.83	0.08	0.02	0.03
Δq		7.95	3.83	4.08	0.39	0.10	0.15
Average		21.27	11.42	15.53	4.18	2.43	3.21
C.V. (%)		5.64	6.83	5.34	1.91	0.82	0.93

*Average followed by same letters, in columns, for cuttings within each clone and each year, did not differ among each other by Tukey test, at 5% of probability.

In relation to yields of fresh weight of non-commercial cormels (Table V), 'Macaquinho' clone had the highest yields in 2009-2010 crop season with the use of huge cuttings (17.77 $t.ha^{-1}$), exceeding in 26.57% to higher yield of 'Chinês', propagated with medium cuttings in 2008-2009 crop season. Regarding to the dry weight, 'Chinês' clone had the highest yield (3.79 $t.ha^{-1}$), obtained in 2008-2009 crop season with medium cuttings, which exceeded in 13.47% the highest yield of 'Macaquinho', in 2009-2010 crop season with huge cuttings.

Economic Analysis

The production costs per hectare ranged from US $ 1,942.16 (+ 70.47%) to US $ 2,033.59 (+ 77.12%) among the highest costs of cultivation, with the use of huge cuttings, and lowest costs, with tiny cuttings for the 'Chinês' (Table VI) and 'Macaquinho' clones, respectively (Table VII). The variable costs, in relation to the total cost, represented, respectively, 77.90% and 74.47% between the use of huge and tiny cuttings, for cultivation of 'Chinês' clone and between 77.88% and 74.09% for cultivation of 'Macaquinho'.

TABLE V
Fresh and dry weight of non-commercial cormels of two taro clones propagated using six types of cuttings, grown in three crop seasons. Dourados, MS, Brazil, 2007-2010.

Factors in study		Fresh weight ($t.ha^{-1}$)			Dry weight ($t.ha^{-1}$)		
Clones	Cuttings	2007-08	2008-09	2009-10	2007-08	2008-09	2009-10
'Chinês'	Huge	9.42 ab*	5.37 c	11.20 a	2.55 a	1.57 c	2.38 a
	Extra	9.53 a	6.64 bc	7.82 bc	2.58 a	1.88 b	1.87 b
	Large	6.33 b	5.31 c	9.54 ab	1.73 bc	1.46 c	2.30 ab
	Medium	10.03 a	14.04 a	9.25 b	2.67 a	3.79 a	2.30 ab
	Small	7.12 b	7.80 b	9.68 ab	1.88 b	2.21 bc	2.45 a
	Tiny	4.96 b	5.65 bc	6.26 c	1.27 c	2.29 b	1.53 b
'Macaquinho'	Huge	9.53 ab	5.28 b	17.77 a	1.76 b	1.09 a	3.34 a
	Extra	10.31 ab	6.10 ab	7.75 d	1.98 a	1.20 a	1.51 d
	Large	11.56 a	5.91 ab	13.97 b	2.31 a	1.16 a	2.57 b
	Medium	8.82 b	7.79 a	11.33 c	1.58 bc	1.53 a	2.06 c
	Small	10.97 ab	6.42 ab	16.47 a	1.91 a	1.34 a	3.33 a
	Tiny	6.86 b	5.54 ab	7.81 d	1.21 c	1.07 a	1.54 d
Standard deviation		0.47	0.49	0.39	0.10	0.13	0.10
Δq		2.31	2.41	1.91	0.49	0.64	0.49
Average		8.79	6.82	10.74	1.95	1.72	2.27
C.V. (%)		5.35	7.18	3.63	5.13	7.56	4.41

*Average followed by same letters, in columns, for cuttings within each clone and each year, did not differ among each other by Tukey test, at 5% of probability.

The cost of manpower for cultivation of 'Chinês' clone represented of the total cost between 34.44%, when tiny cuttings were used, and 24.79% with the use of huge cuttings. For 'Macaquinho' clone, the percentages varied between 41.22% and 24.94%, with the same types of cuttings.

Economic analysis for cultivation two taro clones, propagated using six types of cuttings, using the average yield of commercial cormels of 2007-2008, 2008-2009 and 2009-2010 crop seasons, showed that was better to cultivate the 'Macaquinho' clone, especially using small cuttings for propagation, resulting in a net income of US $ 14,741.14 (Table VIII). This highest net income was superior in 136.26% than the lowest income with 'Macaquinho' clone, propagated with tiny cuttings. It also exceeded in 220.87% to 5,128.10% to the highest (US $ 4,594.07) and to the lowest (US $ 287.46) net income obtained from 'Chinês' clone propagated with huge and tiny cuttings, respectively.

DISCUSSION

AGRONOMIC

The results obtained in the analysis of joint variance indicated that there was modified response of the plants that have adapted to environmental conditions during their growth period (Larcher 2006). This

TABLE VI
Costs of producing one hectare of 'Chinês' taro propagated with six types of cuttings, average of 2007-08, 2008-09 and 2009-10 crop seasons. Dourados, MS, Brazil*.

Cost components	Cost depending on the type of cutting (US $)					
	Huge	Extra	Large	Medium	Small	Tiny
1. Variable costs						
Inputs:						
[1]Cuttings	1,982.56	1,418.05	1,196.26	967.09	789.58	525.16
[2]Transport	99.13	71.79	59.81	48.36	39.48	26.26
	2,081.69	**1,489.84**	**1,256.07**	**1,015.45**	**829.06**	**551.42**
[3]**Manpower**						
[4]Planting	232.93	217.40	201.87	186.35	170.72	155.29
Irrigation	186.35	186.35	186.35	186.35	186.35	186.35
Weeding	279.52	279.52	279.52	279.52	279.52	279.52
Harvest	465.86	465.86	465.86	465.86	465.86	465.86
	1,164.66	**1,149.13**	**1,133.60**	**1,118.08**	**1,102.55**	**1,087.02**
Machinery						
Irrigation pump	289.87	289.87	289.87	289.87	289.87	289.87
Tractor	124.23	124.23	124.23	124.23	124.23	124.23
	414.10	414.10	414.10	414.10	414.10	414.10
Subtotal 1 (R$)	**3,659.93**	**3,052.97**	**2,803.77**	**2,547.62**	**2,345.71**	**2,052.54**
2. Fixed costs						
Boon	156.84	156.84	156.84	156.84	156.84	156.84
Remuneration of land	72.47	72.47	72.47	72.47	72.47	72.47
Subtotal 2 (R$)	**229.31**	**229.31**	**229.31**	**229.31**	**229.31**	**229.31**
3. Other costs						
Unforeseen (10% ST1 + ST2)	388.97	328.23	303.31	277.70	257.50	228.18
Administration (5% ST1+ ST2)	194.49	164.11	151.65	138.85	128.75	114.09
Subtotal 3	**583.46**	**492.34**	**454.96**	**416.55**	**386.25**	**342.27**
TOTAL	**4,473.21**	**3,774.62**	**3,488.04**	**3,193.47**	**2,961.27**	**2,624.11**
Quarterly interest (2.16%)	225.13	189.97	175.55	160.72	149.03	132.07
TOTAL GERAL	**4,698.34**	**3,964.59**	**3,663.59**	**3,354.19**	**3,110.30**	**2,756.18**

Adapted of Heredia Zárate et al. (1994), cited by Terra et al. (2006), and of Terra et al. (2006).
*Taxes of exchange between Brazilian Real (BRL) and American Dolar (USD) in the period of 19/5/2012 to 20/4/2012. (http://pt.exchange-rates.org/history/BRL/USD/G/30)
[1]Cost of 1.0 kg of cutting= US $ 0.6211
[2]Transportation cost of 1.0 t of cutting= US $ 25.8813
[3]Manpower = US $ 15.5288 day man^{-1} (D H^{-1}).
[4]Increase in day man^{-1} for planting of each type of cuttings, by increasing the cutting weight, from very small cutting
Harvest= 30 D H^{-1} Hours of tractor= US $ 31.0575 Hours of irrigation pump= US $ 5.1763
Land rent year^{-1} = US $ 124.2300.

TABLE VII
Costs of producing one hectare of 'Chinês' taro propagated with six types of cuttings, average of 2007-08, 2008-09 and 2009-10 crop seasons. Dourados, MS, Brazil*.

Cost components	Cutting types					
	Huge	Extra	Large	Medium	Small	Tiny
1. Variable costs						
Inputs:						
[1]Cuttings	1,976.28	1.537.90	1.208.56	979.39	771.54	434.56
[2]Transport	84.34	64.08	50.35	40.81	32.15	18.11
	2,058.62	**1,601.98**	**1,258.91**	**1,020.20**	**803.69**	**452.67**
[3]**Manpower**						
[4]Planting	232.93	217.40	201.87	186.35	170.72	155.29
Irrigation	186.35	186.35	186.35	186.35	186.35	186.35
Weeding	279.52	279.52	279.52	279.52	279.52	279.52
Harvest	465.86	465.86	465.86	465.86	465.86	465.86
	1,164.66	**1,149.13**	**1,133.60**	**1,118.08**	**1,102.55**	**1,087.02**
Machinery						
Irrigation pump	289.87	289.87	289.87	289.87	289.87	289.87
Tractor	124.23	124.23	124.23	124.23	124.23	124.23
	414.10	414.10	414.10	414.10	414.10	414.10
Subtotal 1 (R$)	**3,637.38**	**3,165.20**	**2,806.62**	**2,552.37**	**2,320.33**	**1,953.78**
2. Fixed costs						
Boon	156.84	156.84	156.84	156.84	156.84	156.84
Remuneration of land	72.47	72.47	72.47	72.47	72.47	72.47
Subtotal 2 (R$)	**229.31**	**229.31**	**229.31**	**229.31**	**229.31**	**229.31**
3. Other costs						
Unforeseen (10% ST1 + ST2)	386.67	339.45	303.07	278.17	254.97	218.31
Administration (5% ST1+ ST2)	193.34	169.73	151.54	139.9	127.49	109.16
Subtotal 3	**580.01**	**509.18**	**454.61**	**417.26**	**382.46**	**327.47**
TOTAL	**4,446.69**	**3,903.69**	**3,490.54**	**3,198.93**	**2,932.09**	**2,510.55**
Quarterly interest (2.16%)	223.80	196.46	174.64	161.00	147.56	126.35
GRAND TOTAL	**4,670.49**	**4,100.15**	**3,665.18**	**3,359.93**	**3,079.65**	**2,636.90**

Adapted of Heredia Zárate et al. (1994), cited by Terra et al. (2006), and of Terra et al. (2006).
*Taxes of exchange between Brazilian Real (BRL) and American Dolar (USD) in the period of 19/5/2012 to 20/4/2012. (http://pt.exchange-rates.org/history/BRL/USD/G/30)
[1]Cost of 1.0 kg of cutting= US $ 0.6211
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[3]Manpower = US $ 15.5288 day man^{-1} (D H^{-1}).
[4]Increase in day man^{-1} for planting of each type of cuttings, by increasing the cutting weight, from very small cutting
Harvest= 30 D H^{-1} Hours of tractor= US $ 31.0575 Hours of irrigation pump= US $ 5.1763
Land rent year^{-1} = US $ 124.2300.

TABLE VIII
Economic analysis of two taro clones propagated with six types of cuttings, average of 2007-08, 2008-09 and 2009-10 crop seasons. Dourados, MS, Brazil*.

Clones	Cutting Types	Commercial yield ($t.ha^{-1}$)	Gross income (US $\$.ha^{-1}$)	Total cost (US $\$.ha^{-1}$)	Net income (US $\$.ha^{-1}$)
‘Chinês’	Huge	14.96	9,292.41	4,698.34	4,594.07
	Extra	7.56	4,695.90	3,964.58	731.32
	Large	9.44	5,863.66	3,663.59	2,200.07
	Medium	12.70	7,888.61	3,354.19	4,534.42
	Small	6.69	4,155.49	3,110.30	1,045.19
	Tiny	4.90	3,043.64	2,756.18	287.46
‘Macaquinho’	Huge	23.94	14,870.33	4,670.49	10,199.84
	Extra	24.01	14,913.82	4,100,15	10,813.67
	Large	24.63	15,298.93	3,666.21	11,632.72
	Medium	21.07	13,087.63	3,359.93	9,727.70
	Small	28.69	17,820.80	3,079.65	14,741.15
	Tiny	14.29	8,876.24	2,636.90	6,239.34

*Taxes of exchange between Brazilian Real (BRL) and American Dolar (USD) in the period of 19/5/2012 to 20/4/2012. (http://pt.exchange-rates.org/history/BRL/USD/G/30)

occurs because the taro clones differ about to time to reach maturity and the amount of stored photosynthates in leaves (blade and petioles), which can be translocated to the corms, and from these to cormels, when the leaves begin the senescence (Heredia Zárate et al. 2003a). It can be evidenced, by these results of growth, that the rhizomes-cuttings have a direct effect on the growth and vigor of plants and that should not be limited only by the amount of reserves from the rhizome to obtain vigorous plants (Puiatti et al. 2003). Differences in producing fresh and dry weight of leaves (Table II) occurred because plants of different clones have variable growth rates and morphology characteristics, with modifications at the end of growing season, due to environmental factors, but with response pattern dependent on the genetic component (Heredia Zárate et al. 2003b). The variable yields obtained with the conducted experiments in three crop seasons were similar to those variations of the 36 taro accessions studied by Pereira et al. (2003), under environment conditions of Viçosa-MG. Regarding to the effect of the cuttings, by obtained results, it shows that the capacity of sprout of cuttings is an intrinsic character of the clone and that there was likely a modified response of the plants that have adapted theirselves to environmental conditions during their period of growth and development of the leaf part (Heredia Zárate et al. 2002).

By observed results for fresh and dry weight of corms (Table III), we can infer that they had reached maturity and maximum growth, with probable increase in translocation of assimilates of the shoots to corms and of corms directly to the cormels or we can infer that there was a balance translocation in time between shoots and rhizomes (Heredia Zárate et al. 2006). As it was not used any type of seasoning or of form of fertilization, among the reasons for the obtained variable yields, the environmental changes that normally occur between the growing seasons and that influence the ability of phenotypic expression of clones in response to genetic differences between clones and the effect of the type of cuttings used in propagation may be mentioned. Puiatti et al. (2004), among the justifications for the productive differences of the ‘Chinês’ clone, in two growing seasons, mentions that, by being installed at the field in the early period of temperature increments (late winter), plants of experiment II achieved, compared to the first experiment, about 70 days of period with temperatures more propitious to growth. According to Heredia Zárate et al. (2002), as the higher yields of fresh and dry weight of corms were obtained with the use of small cuttings, for propagation, it is showed that there is a size limit of the cuttings and that this limit should be related to the amount of peel and fresh weight of these cuttings.

As the fresh and dry weight production of commercial corms were highest for 'Macaquinho' clone (Table IV), it is assumed that the partition of photoassimilates is a function of the used genotype and of the source-sink relationships and that the corms had already reached maturity and maximum growth, with a probable increase in the translocation of photosynthates from the leaves directly to the corms and of these to cormels (Heredia Zárate and Vieira 2003). As the highest yields were obtained when small cuttings were used, this indicates that the amount of reserves present in cuttings influenced the capabilities of sprouting of the rhizomes and cutting survival, besides the production of rhizomes of plants from each type of cutting.

The obtained results for yield of fresh and dry weight of non-commercial cormels (Table V) indicate that the sugars synthesized in limbo taro were translocated to the rhizomes, passing through a 'temporary storage' in the petiole (Gondim et al. 2007, Heredia Zárate et al. 2009). Thus, the storage of reserves in the rhizomes is highly dependent on the integrity of aerial structures (blade and petiole), and any morphophysiological change may affect the synthesis, amount and speed of translocation of assimilates, resulting in growth and yield of rhizomes.

The highest yield of fresh weight of leaves and non-commercial cormels and the lowest fresh weight of corms and commercial cormels of 'Chinês' taro plants in relation to the 'Macaquinho' are consistent with the statement of Heredia Zárate et al. (2004) that taro cultivars differ greatly regarding the time to reach maturity and that the plants with lush growth may not produce very well, since they may have to spend many photoassimilates to the maintenance of shoot, therefore, delaying the maturity and beginning of the process of senescence of older leaves, and late in the translocation of assimilates of reserve to the rhizome.

Economic

The direct relationship of production costs (Table VI and VII) with the gross income, which gives the net income for each treatment (Table VIII), was possible with the use of economic analysis, which lists the factors under study (production) with the likely economic returns.

The increase in total production costs in response to the increase of weight of the type of cutting used for propagation of 'Chinês' (Table VI) and 'Macaquinho' (Table VII) clones confirms that as higher the average weight of cormel used as cuttings, higher is the participation of this component in production costs (Puiatti et al. 2004).

The high percentage of the value of production costs related to manpower used in the cultivation of taro, in relation to the total cost, emphasizes the importance of taro culture, as employment generating activity in rural areas, through the use of its manpower.

By the results of net obtained income in this work (Table VIII), it was possible to conclude that the economic analysis, i.e., the determination of some indices of economic output, should be done to know in more detail the structure of productive activity, and make the necessary changes to increase their efficiency (Perez Junior et al. 2006). Because of that, the profitability is, in general, the comparison of proceeds with the cost of production, which determines the profit. It only will be profitable if the productive activity provide return that exceeds the alternative cost or of opportunity (Vilela and Macedo 2000).

Under the conditions that the experiments were conducted in 2007-2008, 2008-2009 and 2009-2010 crop season, and considering the highest average yield of fresh weight of commercial cormels (28.69 t.ha-1) and the highest net income (US $ 14,741.14), it is recommended to cultivate the 'Macaquinho' clone using small cutting for propagation.

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RESUMO

Os trabalhos experimentais foram realizados nos anos agrícolas de 2007-2008, 2008-2009 e 2009-2010, com o objetivo de conhecer a produtividade agroeconômica dos clones de taro Chinês e Macaquinho, propagados usando rizomas-filhos graúdos, extras, grandes, médios, pequenos e muito pequenos. A colheita foi realizada em média aos 202 dias após o plantio, nos três anos agrícolas. Com base nas análises de variância conjuntas realizadas, observou-se que os clones de taro apresentaram diferenças significativas quanto à produtividade de massas frescas e secas de folhas, rizomas-mãe, rizomas-filho comerciais e rizomas-filho não-comerciais; que existiam diferenças significativas de produtividade de um ano agrícola para o outro; e o tamanho das mudas induziu diferenças significativas na produtividade. Nas condições em que foram conduzidos os experimentos e considerando a maior produtividade média de massa fresca de rizomas-filho comerciais (28,69 t.ha^{-1}) e a maior renda líquida (US $ 14,741.14) correspondente aos três anos agrícolas recomenda-se cultivar o clone Macaquinho, utilizando mudas pequenas na propagação.

Palavras-chave: *Colocasia esculenta*, rizoma, produção, renda.

REFERENCES

Banzato DA and Kronka SN. 2006. Experimentação agrícola. Funep, Jaboticabal, 236 p.

Carmo CAS and Puiatti M. 2004. Avaliação de clones de taro para cultivo no Estado do Espírito Santo. Hortic Bras 22. (CD-ROM).

Faostat©FAO. 2009. Statistics Division 2009. http://faostat.fao.org.

Gondim ARO, Puiatti M, Cecon PR and Finger FL. 2007. Crescimento, partição de fotoassimilados e produção de rizomas de taro cultivado sob sombreamento artificial. Hortic Bras 25: 418-428.

Heredia Zárate NA and Vieira MC. 2003. Produção de clones de taro em função dos tipos de mudas. Hortic Bras 21: 646-648.

Heredia Zárate NA, Vieira MC, Graciano JD, Giuliani AR, Helmich M and Gomes HE. 2009. Produção e renda bruta de quatro clones de taro cultivados em Dourados, Estado do Mato Grosso do Sul. Acta Sci Agron 31: 301-305.

Heredia Zárate NA, Vieira MC, Helmich M, Heid DM and Menegati CT. 2010. Produção agroeconômica de três variedades de alface: cultivo com e sem amontoa. Rev Ciênc Agron 41: 646-653.

Heredia Zárate NA, Vieira MC, Helmich M and Maria MA. 2006. Tamanho de rizoma semente e fileiras de plantas no canteiro na produção do mangarito 'Comum'. Ciênc Agrotec 30: 907-913.

Heredia Zárate NA, Vieira MC and Martins FM. 2003a. Produção de massa fresca dos inhames 'Cem/Um' e 'Macaquinho', em três densidades de plantas. Hortic Bras 21: 119-122.

Heredia Zárate NA, Vieira MC and Minuzzi A. 2002. Brotação de seis tipos de mudas dos clones de inhame Roxo e Mimoso. Cienc Agrotec 26: 699-704.

Heredia Zárate NA, Vieira MC, Oliveira ACP and Lima AA. 2005. Produção e renda bruta de dois cultivares de taro, em cultivo solteiro e consorciado com alface. Semina: Ciências Agrárias 26: 283-290.

Heredia Zárate NA, Vieira MC, Rosa Júnior EJ and Alves JC. 2003b. Cama-de-frango de corte semidecomposta na produção dos taros Chinês e Macaquinho. Acta Sci Agron 25: 177-181.

Heredia Zárate NA, Vieira MC, Rosa Júnior EJ and Silva CG. 2004. Desempenho de taro em função de doses de cama de aviário, sob sistema orgânico de produção. Pesq Agropec Trop 34: 111-117.

Kurosawa C. 2009. Inhame. http://www.globoruraltv.globo.com/GRural/0,27062,LTP0-4373-0-L-I,00.html

Larcher W. 2006. Ecofisiologia vegetal. RiMa Artes e Textos, São Carlos, 531 p.

Lebot V. 2009. Tropical Root and Tuber Crops: Cassava, Sweet potato, Yams and Aroids. Crop production Science in Horticulture: 17. CABI, UK, 440 p.

Melo AS, Costa BC, Brito MEB, Aguiar Netto AO and Viégas PRA. 2009. Custo e rentabilidade na produção de batata-doce nos perímetros irrigados de Itabaiana-Sergipe. Pesq Agropec Trop 39: 119-123.

Oliveira FL, Guerra JGM, Almeida DL, Ribeiro RLD, Silva ED, Silva VV and Espindola JAA. 2008. Desempenho de taro em função de doses de cama de aviário, sob sistema orgânico de produção. Hortic Bras 26: 149-153.

Oliveira FL, Guerra JGM, Ribeiro RLD, Almeida DL, Silva EE, Urquiaga S and Espindola JAA. 2007. The use of sunn hemp as Green manure intercropped with taro. Hortic Bras 25: 562-566.

Pedralli G, Carmo CAS, Cereda MP and Puiatti M. 2002. Uso de nomes populares para as espécies de Araceae e Dioscoreaceae no Brasil. Hortic Bras 20: 530-532.

Pereira FHF, Puiatti M, Miranda GV, Silva DJH and Finger FL. 2003. Caracterização agronômica da produção de rizomas de clones de taro. Hortic Bras 21: 99-105.

Pereira FHF, Puiatti M, Miranda GV, Silva DJH and Finger FL. 2004. Divergência genética entre acessos de taro. Hortic Bras 22: 55-60.

Perez Junior JH, Oliveira LM and Costa RG. 2006. Gestão estratégica de custos. Atlas, São Paulo, 378 p.

Puiatti M, Katsumoto R, Pereira FHF and Barrella TP. 2003. Crescimento de plantas e produção de rizomas de taro 'Chinês' em função do tipo de muda. Hortic Bras 21: 110-115.

Puiatti M, Pereira FHF and Aquino LA. 2004. Crescimento e produção de taro 'Chinês' influenciado por tipos de mudas e camadas de bagaço de cana-de-açúcar. Hortic Bras 22: 722-728.

Sardos J, Noyer J-L, Malapa R, Bouchet S and Lebot V. 2012. Genetic diversity of taro (*Colocasia esculenta* (L.) Schott) in Vanuatu (Oceania): an appraisal of the distribution of allelic diversity (DAD) with SSR markers. Genet Resour Crop Evol 59: 805-820.

Silva JF. 1970. Espaçamento, adubação e tamanho de mudas na produção de inhame (Colocasia esculenta Schott). Viçosa: UFV, 1970. 40 p.

Terra ER, Heredia Zárate NA, Vieira MC and Mendonça PSM. 2006. Proposta de cálculo e forma de adubação, com e sem amontoa, para a produção e renda do milho Superdoce 'Aruba'. Acta Sci Agron 28: 75-82.

Vilela NJ and Macedo MMC. 2000. Fluxo de poder no agronegócio: o caso das hortaliças. Hortic Bras 18: 88-94.

Vilpoux O. 2001. Produção e uso do amido. In: CEREDA MP (Ed), Propriedades gerais do amido. Fundação Cargill, São Paulo, p. 7-28.