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Sustainable production of 'Comum' tannia in the hilling and function of seedling types in three crop seasons

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ABSTRACT. This study aims to discover the agro-economic yield of the 'Comum' tannia, which was propagated with five seedling types (Extra, Large, Medium, Small and Tiny) and grown both with and without a hilling operation during three crop seasons. In each agricultural year, the treatments were arranged as a 5 x 2 factorial in a randomized complete block design with four replications. The harvests were conducted 238 (2007-08), 231 (2008-09) and 237 (2009-10) days after planting. The data were submitted to an analysis of variance each year. The plants produced from large seedlings and RM-corms had a higher fresh leaf weight. Additionally, the dry weight of the RFC-commercial cormels and RFNC-non-commercial cormels was higher with extra seedlings. The plants grown during 2008-2009 had a higher fresh weight of RM and of RFNC than the plants grown during 2009-10. The interaction between the seedling types and crop seasons significantly influence the yield and dry weight of the leaves of RM and RFC, the leaf length of RM and RFC and the leaf diameter of RFC. According to the economic analysis, a net income of R$ 2,234.08 was obtained when the tannia were cultivated without a hilling operation using extra propagated seedlings.

Keywords: *Xanthosoma mafaffa*, propagation materials, cultural treatments, yield, income.

Produção sustentável do mangarito 'Comum' em função de amontoas e de tipos de mudas, em três anos agrícolas

RESUMO. O objetivo deste trabalho foi conhecer a produtividade agroeconômica do mangarito 'Comum', propagado com cinco tipos de mudas (Extra, Grande, Médio, Pequeno e Muito pequeno), cultivado sem e com amontoa, em três anos agrícolas. Os tratamentos foram arranjados como fatorial 5 x 2 no delineamento experimental de blocos casualizados, com quatro repetições, em cada ano. As colheitas foram realizadas aos 238 (2007-08), 231 (2008-09) e 237 (2009-10) dias após o plantio. Os dados foram submetidos à análise de variância em cada ano. A maior massa fresca de folhas foi das plantas provenientes de mudas Grande e as dos rizoma-mãe-RM, rizoma-filho comercial-RFC e a massa seca de rizoma-filho não-comercial-RFNC foram maiores nas do tipo Extra. As plantas cultivadas em 2008-2009 produziram mais massa fresca de RM e de RFNC que as de 2009-10. As produtividades de massa seca de folhas, RM e RFC; os comprimentos de RM e RFC e o diâmetro de RFC foram influenciados significativamente pela interação tipos de mudas e anos agrícolas. Pela análise econômica, foi melhor cultivar o mangarito sem amontoa e propagado usando mudas do tipo Extra, obtendo-se renda líquida de R$ 2.234,08.

Palavras-chave: *Xanthosoma mafaffa*, propágulos, trato cultural, produtividade, renda.

Introduction

The increase of agriculturally produced income, especially in familiar agriculture, is dependent on the implementation of technician-management implantation practices that allow for the possibility of better organization and the exploitation of productive activity. In addition to preserving and improving the productive environment, these practices must promote the reduction of costs, the addition of values to production and/or yield increases (DOMIT et al., 2008). In vegetable production, concerns about sustainability are derived from reflections on the relationship between humankind and the environment. Thus, the challenge of sustainability is not solely restricted to the generation of environmentally appropriate solutions; sustainability must also be lucrative and socially desirable (TERRA et al., 2006).

The Araceae family includes approximately 104 genders and 3700 species. Although this family occurs naturally on all continents (except in Antarctica), it is predominantly tropical (FOGAÇA et al., 2007). Tannia (*Xanthosoma mafaffa* Schott), also known as yautia, is consumed by the 'indigenous populations', and it is highly appreciated because of its rhizomes and leaves. All of the available information indicates that Tannia originated in Northeastern South America and then expanded to other regions like Africa, which is currently the world's leading Tannia producer. Tannia is also found in Mexico, Venezuela, Colombia, Panama, Costa Rica, Peru and Brazil, where it was cultivated by the early colonizers and is found in the states of Goiás, Rio de Janeiro, Mato Grosso do Sul, Minas Gerais and São Paulo (SILVA et al., 2011). Because of the peculiar culinary characteristics of its rhizomes, tannia is seasonally commercialized close to production areas. The flavor of its young leaves is comparable to spinach (COSTA et al., 2008).

Technological progress that leads to an increase in the production and commercial quality of the tannia rhizomes will allow it to become a popular product in the national market of farm products (HEREDIA ZÁRATE et al., 2006). However, it is necessary to establish a rational basis for its cultivation, and there exist previous studies that refer to tannia's fertilization, plantation depth, spacing and the type and size of its rhizomes-seed (LEITE et al., 2007).

The lack of plantation material is one of the factors that limits the expansion of tannia cultivation in several vegetatively propagated species. Thus, the efficient exploitation of seedlings is recommended. For these species, the type and quality of the plantation material determines the differences in rooting speed, growth and, consequently, in the production and extension of the vegetative cycle (HEREDIA ZÁRATE; VIEIRA, 2003). Some aspects of the seedlings have not been studied or, when they were studied, the results were not conclusive. As cited by Monteiro and Peressin (1997), Vasconcelos (1972) found that the primary type of the tannia rhizomes-seed (corms), which had a fresh weight varying from 13 to 40 g, were more productive (by 1.5 to 4.5 g) than secondary rhizomes-seed (cormels). The same author also indicated that, beyond their health problems, the primary rhizomes obtained in a previous culture were hardly sufficient, in numerical terms, for the implantation of a new culture. Heredia Zárate et al. (2006) evaluated the productive capacity of 'Comum' tannia plants by examining the secondary rhizomes-seed of different sizes grown under three or four rows of plants in the plot. When considering the total and commercial production, these researchers concluded that it was better to cultivate 'Comum' tannia under three rows of plants in a plot and by planting rhizomes with 3.0 g of fresh weight.

Hilling is a cultural practice used by the producers of some vegetables. During hilling, land is moved to cover part of a stem base and/or a plant root (HEREDIA ZÁRATE et al., 2010b). The practice is highly valued and considered to be an essential operation to optimize technologies and to obtain a high yield. The true necessity and accomplishment of hilling has been questioned, and there have been several previous experiments related to the results found in this study. In the consulted literature, there were no recommendations based on the experimental studies that indicate the execution time and the hilling height. However, these studies do indicate that the results depend on the species, stage of plant growth and execution form, whether manual or mechanized (HEREDIA ZÁRATE et al., 2010a; TERRA et al., 2006). Puiatti (2002) suggests that to lower the production cost of taro (*Colocasia esculenta* (L.) Schott), which is in the same botanical family as tannia, slight hillings during each weeding should be made. One hilling should occur at either 45 to 60 days or only at 120 days after plantation.

As in any economic activity (but especially for the agriculturist), the accompaniment of costs is essential; in addition to the knowledge of the total operational cost, it is necessary to know the participation of the item in the effective operational cost because this interaction reflects the variable costs or the expenses that are effectively carried. It is equally important to know the structure of the fixed costs (the indirect great expenses), which are represented by the costs and administrative incumbencies in a form that details the remuneration attributed to other important production factors, without which the profitability calculation is incorrect (MELO et al., 2009). In the consulted literature, there was no study that examined the effect of hilling on tannia.

The aim of this work was to determine the 'Comum' tannia agro-economic yield, which was propagated with five seedling types and cultivated both with and without hilling during three crop seasons.

Material and methods

The experiment took place during three crop seasons between September 2007 and April 2010, and it was conducted at the Medicinal Plants Garden of the Faculty of Agrarian Science-FCA, of the Federal University of the Grande Dourados, in Dourados, Mato Grosso Sul State, Brazil, which is located at 22°11'44"S of latitude, 54°56'07"W of longitude and 452 m of altitude. According to Köppen, the climate of Dourados is mesothermal humid, Cwa type, with an average temperature and annual rainfall ranging from 20 to 24°C and 1250-1500 mm, respectively.

The soil of the area was classified as a dystrophic red oxisol of clayey texture, and it contained the following chemical characteristics: 5.9 of pH in H_2O; 28.9 g dm^{-3} of organic matter; 38.0 mg dm^{-3} of P; 0.0; 3.5; 46.0; 22.0; 53.0; 71.5 and 124.5 mmol$_c$ dm^{-3} of Al^{+3}, K, Ca, Mg, H+Al, SB and CTC, respectively, and 57.0% of base saturation. Considering the physical properties, the sieve method indicated a soil composed by 80 g kg^{-1} of sand, 130 g kg^{-1} of fine sand, 160 g kg^{-1} of silt and 630 g kg^{-1} of clay.

The factors in this study were the seedling types (Extra, Large, Medium, Small and Tiny) and the number of hilling operations (zero and one, at 47 days after planting). The treatments were arranged in a 5 x 2 factorial fixed in a completely randomized block with four replications. The plots had a total area of 4.5 m^2 (3.0 m in long and 1.50 m in width). The plots had a width of 1.0 m and contained four rows spaced 25.0 cm apart. There was a spacing of 17.5 cm between the plants, which established a population of 150,744 plants ha^{-1}.

Two weeks prior to planting, the soil of the experimental area was prepared by plowing, harrowing and then elevating the plots with a bedshaper rotary cultivator offset. Lime was not used for the soil amendment. Additionally, there was no fertilization technique used during the crop cycle because the results of the soil analysis indicated that this necessity did not exist.

Rhizomes-seed were used as propagating material in the planting, and they were harvested in the area of the Medicinal Plants Garden of the UFGD. The rhizomes-seed were detached from the plant-mother and visually chosen for types. The fresh weight was then determined (Table 1). On the planting day, four furrows for planting were dug in the plot; each furrow was approximately 0.05 m wide x 0.05 m deep. A direct form of planting was conducted; the rhizomes were embedded manually with the top as the apex (HEREDIA ZÁRATE et al., 2005).

Table 1. Average fresh weight (g) of five seedling types used in the propagation of the 'Comum' tannia, in three crop seasons.

Seedling types	Crop seasons			
	2007-08	2008-09	2009-10	Average
Extra	5.51	7.84	3.82	5.72
Large	3.41	5.83	3.14	4.13
Medium	2.44	4.98	2.67	3.36
Small	1.80	4.55	2.40	2.92
Tiny	1.67	3.97	2.10	2.58
Average	2.97	5.43	2.83	3.74

During the crop cycle, the cultural treatments consisted of irrigation using a sprinkler system. The irrigations were applied to each plot for two to three days and aimed to maintain the ground at 70% of the field capacity (SANGALLI et al., 2011). In the two final months, the irrigations were applied two times per week. When the weeds indicated ± 5.0 cm of height, spontaneous vegetation was controlled by weeding between the plots and by manual removal within the plots. There was no damage from the attack of pests or diseases.

The harvests were performed at 238 (2007-08), 231 (2008-09) and 237 (2009-10) days after planting, when the plants showed more than 50% of the dry leaves in the plants had symptoms of senescence, and the fresh and dry weight of the leaves, corms-RM, commercial cormels-RFC and non-commercial cormels-RFNC was evaluated. The cormels that weighed more than 5 g were considered to be commercial. The diameter and length of RM, RFC and RFNC were also determined. The data were submitted to an analysis of variance using the totals of the treatments in each year and when significance was detected by the F test. The averages were compared using Tukey's test at 5% probability.

To determine sustainability, an agro-economic analysis was performed according to the method of Terra et al. (2006) for sweet corn (*Zea mays* L.) and of Rezende et al. (2009) for vegetables grown in a monocrop and intercropping system. This analysis related the factors studied (productive) with the likely returns (economics), i.e., the determination of variable costs (manpower and rental of machinery) and fixed costs (rent of land and improvements), and the contingency reserve, the spending on administration and the payment of interest on capital. For the calculation of gross income, the value of R$1.20 kg^{-1} (the average of the price paid to producers in Dourados, Mato Grosso do Sul State, Brazil, by kg of commercial cormels) was used. Subsequently, the conversions were made per hectare using the obtained yields in each treatment. The net income was calculated by subtracting the production costs relative to the gross income.

Results and discussion

Agronomic analysis

Based on the analysis of variance, it is clear that the interaction between the seedling types and crop seasons significantly influenced the yield of the fresh and dry weight of leaves, corms-RM, commercial cormels-RFC and non-commercial cormels-RFNC. Additionally, this interaction influenced the length and the diameter of RM, RFC e RFNC of 'Comum' tannia. Significant differences were also observed in the yield of the crop from one season to another. The seedling type induced significant differences in the yield, and hilling did not significantly influence any of the evaluated characteristics. These responses might have occurred because the plants were vegetatively propagated. Moreover, these results are not derived from propagating material obtained from a plant, and they only demonstrate the phenotypic behavior of heterogeneous populations. Moreover, these results are consistent with the results of Larcher (2006), who suggested that ecological systems are capable of self-control because of the balance of the interference relations, and that they have the capacity to adapt to the individual organism and to populations.

In relation to the leaf fresh weight (Table 2), the plants produced from Large type seedling had the highest yield. The yield of the Large type seedlings was similar to the yields of the Extra, Small and Tiny types but different from the plants produced from Medium type seedlings. The Medium type was less productive; in comparison with the highest yield, it demonstrated the smallest value (0.50 ton ha^{-1}). The differences in the leaf fresh weight production occurred because plants of heterogeneous populations can present variable growth rates and morphology characteristics, with modifications at the end of growing season because of environmental factors. However, the response pattern is dependent on the genetic component (HEREDIA ZÁRATE et al., 2003b). Puiatti et al. (2004) had suggested that the propagation material of taro with a higher reserve (seedlings of type corms and large cormels) favored more vigorous plants, with higher values of height (data not shown) and an index of the foliar area.

Regarding the crop season, the plants cultivated in 2008-2009, which consisted of 0.76 ton ha^{-1} (+ 61.79%), statistically surpassed the lower yield obtained in 2009-2010. In trying to determine the reason for the productive differences of the 'Chines' taro at different times of cultivation, Puiatti et al. (2004) indicated that the plants installed in a field during the initial period of temperature increase (such as the winter) grew better than the plants installed during the period with less propitious temperatures.

The fresh weight of RM, RFC and RFNC and the dry weight of RFNC (Table 2) were higher in plants produced from the seedlings of the Extra type. Additionally, these values were similar to the fresh and dry weight of RM and RFNC in plants produced from Large, Small and Tiny types and to the weights of RFC in plants produced from the Large and Small types (Table 2). Compared with plants produced from the less productive Medium type seedlings, the productive differences in the fresh weight of plants produced from Extra type seedlings was 0.73 (+ 37.63%), 1.17 (+ 29.77%) and 1.42 (+ 51.08%) ton ha^{-1} and the difference in the dry weight was 0.31 ton ha^{-1} (+ 46.97 ton ha^{-1}). The evidence suggests that the type of seedling exerts a direct influence on the growth and vigor of the plants, and that the amount of rhizome reserves should not be the only factor considered when attempting to produce vigorous plants (PUIATTI et al., 2003).

Table 2. Fresh weight of leaves, corms, commercial cormels, non-commercial cormels; non-commercial cormels dry weight, corms diameter and diameter and length of non-commercial cormels proceeding from plants propagated with five seedling types, with and without hilling, in three crop seasons.

Factors in study	Fresh weight (ton ha^{-1})				Dry weight RFNC (ton ha^{-1})	Diam. RM (mm)	Diam. RFNC (mm)	Length RFNC (mm)
	Leaves	RM	RFC	RFNC				
				Seedling types				
Extra	1.63 ab	2.67 a	5.10 a	4.20 a	0.97 a	29.90 a	11.21 a	18.29 a
Large	1.94 a	2.34 ab	4.34 ab	3.54 ab	0.82 ab	28.61 a	10.78 a	16.57 a
Medium	1.44 b	1.94 b	3.93 b	2.78 b	0.66 b	26.97 a	11.65 a	18.68 a
Small	1.55 ab	2.42 ab	4.67 ab	3.46 ab	0.77 ab	29.15 a	10.84 a	18.25 a
Tiny	1.72 ab	2.16 ab	4.06 b	3.47 ab	0.78 ab	27.71 a	10.83 a	17.49 a
				Hilling				
Without	1.63 a	2.41 a	4.34 a	3.63 a	0.84 a	28.93 a	10.99 a	17.77 a
With	1.67 a	2.20 a	4.50 a	3.35 a	0.76 a	27.96 a	11.13 a	17.94 a
				Agricultural year				
2007-08	1.75 a	1.86 b	2.69 c	3.71 a	0.99 a	31.36 a	11.00 a	15.12 b
2008-09	1.99 a	3.22 a	6.55 a	4.68 a	0.87 a	25.17 c	11.37 a	21.77 a
2009-10	1.23 b	1.84 b	4.02 b	2.07 b	0.54 b	28.80 b	10.82 a	16.68 b
C.V. (%)	45.83	16.27	20.35	18.95	20.62	7.81	7.23	9.18
Average	1.65	2.30	4.42	3.49	0.80	28.44	11.06	17.86

RM = corm; RFC = commercial cormel; RFNC = non-commercial cormel; Diam. = Diameter. Averages followed by the same letters in the columns, inside from type of seedling and of crop seasons, do not differ for the Tukey test, and for hilling, by F test, at 5% of probability.

Moreover, the results are consistent with the findings of Heredia Zárate et al. (2004), who indicated that plants with exuberant growth are not good producers because they lose many photo-assimilated compounds in the maintenance of the shoot. This loss of compounds delays the maturity and the beginning of the senescence process of the oldest leaves because of the delay in the translocation of the photo-assimilated compounds of the rhizomes.

Plants grown in 2008-09 produced more fresh weight of RM (+ 1.38 ton ha^{-1}) and of RFNC (+ 2.61 ton ha^{-1}) than those plants grown in 2009-10. Additionally, the plants grown in 2008-0 had a higher fresh weight of RFC (3.86 ton ha^{-1}) than the plants grown in 2007-08. In terms of compensation, the highest dry weight of RFNC was obtained in 2007-08. This value surpassed the dry weight in 2008-09 and 2009-10 by 17.86 and 83.33%, respectively.

The diameter of RM and RFNC and the length of RFNC were neither significantly influenced by the types of seedlings nor by the hilling operations, but were instead influenced by the time of planting during the crop season. The highest values for diameter of RM and RFNC and the length of RFNC occurred in 2007-2008 and 2008-09. These productive behaviors of the 'Comum' tannia plants, which were produced by different types of seedlings and from plants grown in different years, are similar to the behaviors in taro. The plants of Taro can differ with regard to the time it takes to reach maturity, to the amount of photo-assimilated compounds stored in the leaves (limbs and petioles). The compounds stored in the leaves can be translocated for the corms and cormels when the leaves initiate senescence (HEREDIA ZÁRATE et al., 2003a).

The lack of significant differences induced by hilling suggests that the vegetal systems have self-control mechanisms. The self-control mechanism is based on either the capacity of the individual organism and the total populations to adapt or to the balance of the interference relations, as competition for nutrients, water and other elements (LARCHER, 2006).

The average yields of leaves in RM, RFC and RFNC, which represented 13.91, 19.39, 37.27 and 29.43% of the total yield of the plant, indicates that these plants already had reached their maturity and maximum growth. Additionally, these plants experienced a probable increase of the translocation of the photo-assimilated compounds of the shoot to the RM and of RM directly to the cormels, or that a balance of translocation occurred between the shoot and rhizomes (HEREDIA ZÁRATE et al., 2006). According to several authors cited by Heredia Zárate et al. (2009), the sugars synthesized in the limb of the taro are translocated in the rhizomes, passing to a 'temporary storage' in the petiole. Thus, the storage of reserves in rhizomes is highly dependent on the integrity of the aerial structures (limb and petiole). Any morph-physiologic alteration of these structures will affect the synthesis, amount and speed of translocation of the assimilated compounds, which impacts the growth and yield of the rhizomes.

The average total yield of the rhizomes obtained in this experiment (10.21 ton ha^{-1}) and of plants produced from seedlings with an average weight of 3.74 g was inferior to the 16.24 ton ha^{-1} obtained by Silva et al. (2011), who used corms with an average weight of 55 g. However, the average total yield of the rhizomes was similar to the 10.34 ton ha^{-1} obtained with seedlings formed from type 1 cormels (average weight of 10 g), and the rhizomes had a superior yield to the 6.46 ton ha^{-1} of seedlings formed from the type 2 cormels (average weight of 5.0 g).

The yield of the dry weight of leaves of RM and RFC, the length of RM and RFC and the diameter of RFC were significantly influenced by the interaction between seedlings types and crop seasons (Table 3). The highest values for leaf dry weight were in plants produced from all types of seedlings and grown in the 2007-2008-crop season. The lowest values were of the plants grown in 2009-2010 and propagated with Extra, Large, Small and Tiny seedlings. In relation to the effect of the seedling, the results indicated that the sprout capacity of the seedlings is an intrinsic character of the clone, and that it probably had modifying responses that adapted the plants to the environmental conditions during the sprout and growth of the shoot (HEREDIA ZÁRATE et al., 2002).

Variable responses in relation to the interactions between seedling type and agricultural year were observed in the dry weight of RM. The highest values were observed in 2009-2010 in plants propagated with Extra seedlings, and in the Large and Medium seedling during the 2008-2009 crop season. Excluding the plants produced from the Extra seedlings in 2009-2010, the highest yields of RFC dry weight were from the plants grown from all types of seedlings in the 2008-2009 crop season.

Among the reasons for the variable yields, the environmental variations can be cited. Environmental variations normally occur during the cultivation times, and they influence the capacity of the phenotypic expression of the plants in response to the genetic differences inside of a population and in response to the effect of the seedling type used in the propagation.

Table 3. Dry weight of leaves, corms (RM) and commercial cormels (RFC), length of RM and diameter and length of RFC proceeding from plants propagated with five seedling types, in three crop seasons.

Factors in study		Dry weight (ton ha^{-1})			Length RM (mm)	Diameter RFC (mm)	Length RFC (mm)
Seedlings	Year	Leaves	RM	RFC			
Extra	2007-08	1.92 a	0.43 c	1.19 b	32.16 c	20.49 a	32.63 b
	2008-09	0.21 b	0.62 b	1.29 b	54.89 a	18.92 a	39.23 a
	2009-10	0.06 b	0.91 a	1.65 a	40.45 b	20.39 a	35.53 ab
Large	2007-08	1.04 a	0.37 b	0.54 c	32.76 b	20.60 ab	34.10 a
	2008-09	0.23 b	0.73 a	1.22 a	53.23 a	21.55 a	34.30 a
	2009-10	0.12 b	0.40 b	0.90 b	38.70 b	18.90 b	30.63 a
Medium	2007-08	1.04 a	0.46 a	0.61 b	34.10 b	20.14 a	31.14 ab
	2008-09	0.19 b	0.61 a	1.23 a	45.83 a	21.33 a	35.63 a
	2009-10	0.26 b	0.24 b	0.56 b	33.46 b	18.15 b	28.92 b
Small	2007-08	1.00 a	0.44 a	0.70 b	36.23 b	21.84 a	32.52 ab
	2008-09	0.19 b	0.56 a	1.25 a	50.62 a	18.72 b	36.98 a
	2009-10	0.10 b	0.45 a	0.90 b	36.74 b	17.89 b	30.88 b
Tiny	2007-08	1.16 a	0.43 a	0.91 ab	34.67 b	18.16 ab	27.34 b
	2008-09	0.18 b	0.45 a	1.09 a	47.69 a	16.85 b	33.02 a
	2009-10	0.17 b	0.33 a	0.76 b	37.11 b	19.16 a	28.85 b
C.V. (%)		15.19	15.81	29.10	6.44	3.73	6.19
Average		0.51	0.49	0.99	40.59	19.54	32.74

RM = corm; RFC = commercial cormel. Averages followed by the same letters in the columns, inside from type of seedling and of crop seasons, do not differ for the Tukey test at 5% of probability.

This fact coincides with the non-sequential variability observed in the length of RM and RFC and in the diameter of RFC, all of which are dependent on the translocation of photo-assimilated compounds of the leaves to the rhizomes.

In studying the effect of two sizes of rhizomes-seed (large and small, 5 and 2 g, respectively) and of three times of planting of tannia (beginning, middle and end of October 1985), Monteiro and Peressin (1997) observed that, in general, the large type rhizomes-seed surpassed the small type rhizomes-seed in production. Moreover, there was interaction between the size of the rhizomes-seed and the plantation time, and the effect of the size of the seedling was always more evident during the first planting time.

Economic analysis

The production costs per hectare varied between the highest cultivation costs of R$ 892.31 (+ 18.27%) and the lowest cost of R$ 592.32 (+ 10.83%). The highest cultivation costs were associated with the use of Extra seedlings, and the lower costs were associated with the use of Tiny seedlings for cultivation without (Table 4) and with (Table 5) a hilling operation. These results indicate that a higher average weight of the cormels used as seedling correlates with the higher weight of this component in the production cost. The results also indicate that the increment in the average weight of seedlings (Table 1) does not always lead to the proportional increment in the yield of the rhizomes' fresh weight (Table 2).

In relation to the total cost, in the cultivation without hilling, the variable costs represented 73.35 and 71.73% between the use of Extra and Tiny seedlings, respectively. In the cultivation with the hilling operation, the variable costs represented between 77.83 and 72.85%. The costs of the seedlings indicated a variation of R$ 733.67 between the cost of Extra seedlings, which weighed the most (average of 5.72 g), and the cost of the Tiny seedlings (average of 2.58 g), which weighed the least. In relation to the total cost, the cost of the Large seedlings represented between 22.06 and 23.14%, while the cost of the Tiny seedlings represented between 11.03 and 12.34% in relation to the cultivation with and without hilling, respectively. The increase of the total costs of production in response to the increase of the weight of the seedling type used in the tannia propagation cultivated with and without hilling confirms that as the average weight of the cormel used as the seedling increases, then the participation of this component in the production cost will be higher (PUIATTI et al., 2004).

The cost of the manpower in the cultivation without hilling represented 36.36% when seedlings of Extra type were used and 43.00% when the Tiny seedlings were used. With the same types of seedlings, the percentages varied between 42.58 and 47.19% in the cultivation with hilling. In relation to the total cost, the high percentages of the production costs related with manpower used in tannia cultivation highlight the importance of this practice as a source that generates agricultural employment.

Using the productive averages of commercial cormels from the 2007-2008, 2008-2009 and 2009-2010 crop seasons, the economic analysis for the tannia cultivation that was propagated using five types of seedlings indicated that it was better to cultivate tannia without hilling and to propagate with seedlings of Extra type, which netted an income of R$ 2,234.08 (Table 6).

Table 4. Yield cost of one hectare of 'Comum' tannia, propagated with five seedling types, without hilling operation. Average of 2007-08, 2008-09 and 2009-10 crop seasons.

Cost components	Cost in function of the seedling type (R$)				
	Extra	Large	Médium	Small	Tiny
		1. Variable costs			
Inputs: [1]Seedlings	1,293.39	933.86	759.75	660.26	583.38
[2]Transport	43.11	31.13	25.33	22.01	19.45
	1,336.50	964.99	785.08	682.27	602.83
		[3]Manpower			
Planting	300.00	300.00	300.00	300.00	300.00
Irrigation	360.00	360.00	360.00	360.00	360.00
Weeding	540.00	540.00	540.00	540.00	540.00
Harvest	900.00	900.00	900.00	900.00	900.00
	2,100.00	2,100.00	2,100.00	2,100.00	2,100.00
		Machinery			
Irrigation pump	560.00	560.00	560.00	560.00	560.00
Tractor	240.00	240.00	240.00	240.00	240.00
	800.00	800.00	800.00	800.00	800.00
Subtotal 1 (R$)	4,236.50	3,864.99	3,685.08	3,582.27	3,502.83
		2. Fixed costs			
Boon	352.50	352.50	352.50	352.50	352.50
Remuneration of land	160.00	160.00	160.00	160.00	160.00
Subtotal 2 (R$)	512.50	512.50	512.50	512.50	512.50
		3. Other costs			
Contingency (10% ST1 + ST2)	474.90	437.75	419.76	409.48	401.53
Administration (5% ST1+ ST2)	237.45	218.88	209.88	204.74	200.77
Subtotal 3	712.35	656.68	629.64	614.22	602.30
Total	5,461.35	5,034.12	4,827.22	4,708.99	4,617.63
Quarterly interest (0,72%)	314.57	289.97	278.05	271.24	265.98
Total Geral	5,775.92	5,324.09	5,105.27	4,980.23	4,883.61

Adapted of Terra et al. (2006) and Rezende et al. (2009). ST1 = Subtotal 1; ST2 = Subtotal 2. [1]Cost of 1.0 kg of seedling = R$ 1.50. [2]Cost of transport of 1.0 t of seedling = R$ 50.00. [3]Manpower = R$ 30.00 day man^{-1} (D H^{-1}). Harvest = 30 D H^{-1}. Hour of tractor = R$ 60.00. Hour of irrigation pump = R$ 10.00. Land rent year^{-1} = 240.00.

Table 5. Yield cost of one hectare of 'Comum' tannia, propagated with five seedling types, with hilling operation. Average of 2007-08, 2008-09 and 2009-10 crop seasons.

Cost components	Cost in function of the seedling type (R$)				
	Extra	Large	Médium	Small	Tiny
		1. Variable costs			
Inputs: [1]Seedlings	1,293.39	933.86	759.75	660.26	583.38
[2]Transport	43.11	31.13	25.33	22.01	19.45
	1,336.50	964.99	785.08	682.27	602.83
		[3]Manpower			
Planting	300.00	300.00	300.00	300.00	300.00
Irrigation	480.00	480.00	480.00	480.00	480.00
Weeding	360.00	360.00	360.00	360.00	360.00
Harvest	540.00	540.00	540.00	540.00	540.00
Planting	900.00	900.00	900.00	900.00	900.00
	2,580.00	2,580.00	2,580.00	2,580,00	2,580.00
		Machinery			
Irrigation pump	560.00	560.00	560.00	560.00	560.00
Tractor	240.00	240.00	240.00	240.00	240.00
	800.00	800.00	800.00	800.00	800.00
Subtotal 1 (R$)	4,716.50	4,344.94	4,165.08	4,062.27	3,982.83
		2. Fixed costs			
Boon	352.50	352.50	352.50	352.50	352.50
Remuneration of land	160.00	160.00	160.00	160.00	160.00
Subtotal 2 (R$)	512.50	512.50	512.50	512.50	512.50
		3. Other costs			
Contingency (10% ST1 + ST2)	522.90	485.75	467.76	457.48	449.53
Administration (5% ST1+ ST2)	261.45	242.88	233.88	228.74	224.77
Subtotal 3	784.35	728.63	701.64	686.22	674.30
Total	6,013.35	5,586.12	5,379.22	5,260.99	5,169.63
Quarterly interest (0,72%)	346.37	321.76	309.84	303.03	297.77
Total Geral	6,059.72	5,907.88	5,689.06	5,564.02	5,467.40

Adapted of Terra et al. (2006) and Rezende et al. (2009). ST1 = Subtotal 1; ST2 = Subtotal 2. [1]Cost of 1.0 of kg seedling = R$ 1.50. [2]Cost of transport of 1.0 t of seedling = R$ 50.00. [3]Manpower = R$ 30.00 day man^{-1} (D H^{-1}). Hilling = 16 D H^{-1}. Harvest = 30 D H^{-1}. Hour of tractor = R$ 60.00. Hour of irrigation pump = R$ 10.00. Land rent year $^{-1}$ = 240.00.

Table 6. Economic analysis of two taro clones propagated with six types of seedlings. Average of 2007-2008, 2008-2009 and 2009-2010 crop seasons.

Seedling types	Hilling	Commercial production (ton ha^{-1})	Gross income (R\$ ha^{-1})	Total cost (R\$ ha^{-1})	Net income (R\$ ha^{-1})
Extra	Without	5.34	8,010.00	5,775.92	2,234.08
	With	4.86	7,290.00	6,059.72	1,230.28
Large	Without	3.69	5,535.00	5,324.09	210.93
	With	4.99	7,485.00	5,907.88	1,577.12
Medium	Without	4.79	7,185.00	5,105.27	2,079.73
	With	3.08	4,620.00	5,689.06	-1,069.06
Small	Without	4.28	6,420.00	4,980.23	1,439.77
	With	5.06	7,590.00	5,564.02	2,025.98
Tiny	Without	3.59	5,385,00	4,883.61	501.39
	With	4.52	6,780.00	5,467.40	1,312.60

This higher net income surpassed the lower income by R$ 3,303.14, and the lowest income used the Medium type seedlings and hilling operation as a cultural treatment.

These results confirm that the determination of some indices of the economic result should be made known in more detail to structure productive activity and to make the necessary changes to increase efficiency (PEREZ JÚNIOR et al., 2006). In general, profitability is determined by the comparison of proceeds with the production cost. The activity will only be productive if it provides a return that exceeds the alternative cost or opportunity (VILELA; MACEDO, 2000).

Conclusion

Under the conditions in which the experiments were conducted during the 2007-2008, 2008-2009 e 2009-2010 crop seasons, and in considering the higher average yield of commercial cormel fresh weight and the higher net income, it is recommended that the 'Comum' tannia should be produced from seedlings of the Extra type and without a hilling operation.

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References

COSTA, C. A.; RAMOS, S. J.; ALVES, D. S.; FERNANDES, L. A.; SAMPAIO, R. A.; MARTINS, E. R. Nutrição mineral do mangarito num Latossolo Vermelho Amarelo. **Horticultura Brasileira**, v. 26, n. 1, p. 102-106, 2008.

DOMIT, L. A.; DALBOSCO, M.; SANTOS, R. M. S.; GUIMARÃES, M. F. Transferência de tecnologia para a cultura da soja – a experiência da COPACOL 61-63. **Semina: Ciências Agrárias**, v. 29, n. 2, p. 255-264, 2008.

FOGAÇA, C. M.; CORDEIRO, D. C.; CORREIA, T. D.; LAURIANO, M. P.; SANT'ANNA-SANTOS, B. F.; FINGER, F. L.; OTONI, W. C. Microtuberização de *Colocasia esculenta* L. Schott (Araceae) *in vitro*. **Revista Brasileira de Biociências**, v. 5, supl. 1, p. 123-125, 2007.

HEREDIA ZÁRATE, N. A.; VIEIRA, M. C. Produção de clones de taro em função dos tipos de mudas. **Horticultura Brasileira**, v. 21, n. 4, p. 646-648, 2003.

HEREDIA ZÁRATE, N. A.; VIEIRA, M. C.; MARTINS, F. M. Produção de massa fresca dos inhames 'Cem/Um' e 'Macaquinho', em três densidades de plantas. **Horticultura Brasileira**, v. 21, n. 1, p. 119-122, 2003a.

HEREDIA ZÁRATE, N. A.; VIEIRA, M. C.; MINUZZI, A. Brotação de seis tipos de mudas dos clones de inhame Roxo e Mimoso. **Ciência e Agrotecnologia**, v. 26, n. 4, p. 699-704, 2002.

HEREDIA ZÁRATE, N. A.; VIEIRA, M. C.; HELMICH, M.; MARIA, M. A. Tamanho de rizoma semente e fileiras de plantas no canteiro na produção do mangarito 'Comum'. **Ciência e Agrotecologia**, v. 30, n. 5, p. 907-913, 2006.

HEREDIA ZÁRATE, N. A.; VIEIRA, M. C.; OLIVEIRA, A. C. P.; LIMA, A. A. Produção e renda bruta de dois cultivares de taro, em cultivo solteiro e consorciado com alface. **Semina: Ciências Agrárias**, v. 26, n. 3, p. 283-290, 2005.

HEREDIA ZÁRATE, N. A.; VIEIRA, M. C.; ROSA JÚNIOR, E. J.; ALVES, J. C. Cama-de-frango de corte semidecomposta na produção dos taros Chinês e Macaquinho. **Acta Scientiarum. Agronomy**, v. 25, n. 1, p. 177-181, 2003b.

HEREDIA ZÁRATE, N. A.; VIEIRA, M. C.; ROSA JÚNIOR, E. J.; SILVA, C. G. Desempenho de taro em função de doses de cama de aviário, sob sistema orgânico de produção. **Pesquisa Agropecuária Tropical**, v. 34, n. 2, p. 111-117, 2004.

HEREDIA ZÁRATE, N. A.; MATTE, L. C.; VIEIRA, M. C.; GRACIANO, J. D.; HEID, D. M.; HELMICH, M. Amontoas e cobertura do solo com cama-de-frango na produção de cebolinha, com duas colheitas. **Acta Scientiarum. Agronomy**, v. 32, n. 3, p. 449-454, 2010a.

HEREDIA ZÁRATE, N. A.; SANGALLI, C. M. S.; VIEIRA, M. C.; GRACIANO, J. D.; MUNARIN, E. E. O.; PAULA, F. S. Cobertura do solo com cama-de-frango, com e sem amontoa, na produção de beterraba. **Ciência e Agrotecnologia**, v. 34, p. 1598-1603, 2010b. (Edição Especial).

HEREDIA ZÁRATE, N. A.; VIEIRA, M. C.; GRACIANO, J. D.; FIGUEIREDO, P. G.; BLANS, N. B.; CURIONI, B. M. Produtividade de mandioquinha-salsa sob diferentes densidades de plantio e tamanho das mudas. **Ciência e Agrotecnologia**, v. 33, n. 1, p. 139-143, 2009.

LARCHER, W. **Ecofisiologia vegetal**. São Carlos: Rima-Artes e Textos, 2006.

LEITE, G. L. D.; SILVA, F. W. S.; JESUS, F. M.; COSTA, C. A.; GUANABENS, R. E. M.; GUAMÃO, C. A. G. Efeito da adubação orgânica, espaçamento e tamanho de rizomas-semente sobre artrópodes em mangarito *Xanthosoma mafaffa* Schott. **Arquivos do Instituto Biológico**, v. 74, n. 4, p. 343-348, 2007.

MELO, A. S.; COSTA, B. C; BRITO, M. E. B.; AGUIAR NETTO, A. O.; VIÉGAS, P. R. A. Custo e rentabilidade na produção de batata doce nos perímetros irrigados de Itabaiana. **Pesquisa Agropecuária Tropical**, v. 39, n. 2, p. 119-123, 2009.

MONTEIRO, D. A.; PERESSIN, V. A. Efeito do tamanho do rizoma-semente, da época e do local de plantio, na produção de rizomas de mangará. **Bragantia**, v. 56, n. 1, p. 155-161, 1997.

PEREZ JUNIOR, J. H.; OLIVEIRA, L. M.; COSTA, R. G. **Gestão estratégica de custos**. 5. ed. São Paulo: Atlas, 2006.

PUIATTI, M. Handling of the taro culture. In: CARMO, C. A. S. (Ed.). **Inhame e taro**: sistemas de produção familiar. Vitória: Incaper, 2002. p. 203-240.

PUIATTI, M.; PEREIRA, F. H. F.; AQUINO, L. A. Crescimento e produção de taro 'Chinês' influenciados por tipos de mudas e camadas de bagaço de cana-de-açúcar. **Horticultura Brasileira**, v. 22, n. 4, p. 722-728, 2004.

PUIATTI, M.; KATSUMOTO, R.; PEREIRA, F. H. F.; BARRELLA, T. P. Crescimento de plantas e produção de rizomas de taro 'Chinês' em função do tipo de muda. **Horticultura Brasileira**, v. 21, n. 1, p. 110-115, 2003.

REZENDE, L. A.; BARROS JÚNIOR, A. P.; CECÍLIO FILHO, A. B.; PÔRTO, D. R. Q.; MARTINS, M. I. E. G. Custo de produção e rentabilidade das culturas de alface, rabanete, rúcula e repolho em cultivo solteiro e consorciadas com pimentão. **Ciência e Agrotecnologia**, v. 33, n. 1, p. 305-312, 2009.

SANGALLI, A.; VIEIRA, M. C.; HEREDIA ZÁRATE, N. A.; SCALON, S. P. Q. Desenvolvimento e produção da carobinha (*Jacaranda decurrens* Cham. subsp.*symmetrifoliolata* Farias & Proença) cultivada sob dois arranjos de plantas, com ou sem cobertura de cama-de-frango no solo. **Revista Brasileira de Plantas Medicinais**, v. 13, n. 4, p. 439-446, 2011.

SILVA, A. C.; CALDEIRA JÚNIOR, C. F.; COSTA, C. A. Produção do mangarito, em função do tamanho do rizoma-semente. **Bioscience Journal**, v. 27, n. 5, p. 706-709, 2011.

TERRA, E. R.; HEREDIA ZÁRATE, N. A.; VIEIRA, M. C.; MENDONÇA, P. S. M. Proposta de cálculo e forma de adubação, com e sem amontoa, para a produção e renda do milho Superdoce 'Aruba'. **Acta Scientiarum. Agronomy**, v. 28, n. 1, p. 75-82, 2006.

VILELA, N. J.; MACEDO, M. M. C. Fluxo de poder no agronegócio: o caso das hortaliças. **Horticultura Brasileira**, v. 18, n. 2, p. 88-94, 2000.

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