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Cultivation arrangements for taioba under a banana orchard

Arranjos de cultivo para taioba sob pomar de bananeira

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Highlights

Use of unconventional vegetables (taioba) in diversification of production systems.
Planting density management and development of taioba under a banana orchard.
Increased spacing resulted in greater taioba biomass production.
Diversifying production represented a real income alternative for the farmer.

Abstract

Research on biodiversity management in production systems involves various aspects, including selecting optimal population arrangements for cultivated plants. The utilization of unconventional vegetables, such as taioba (*Xanthosoma sagittifolium* (L.) Schott), in the diversification of production systems offers a promising alternative to enhance food security and income generation for producers. However, limited information exists in the literature regarding its management and production. Thus, the present study aimed to assess different planting densities of taioba cultivated in intercropping under banana orchards by evaluating its development and yield. The experiment was conducted at the Federal University of Espírito Santo (UFES), located in Alegre, ES, Brazil. The experimental design employed randomized blocks with six replications, following a split-plot arrangement. The plots consisted of single and double rows of planting systems, while the subplots were comprised of between-plant spacings of 30, 40, and 50 cm. Various parameters were evaluated, namely, leaf area, number of leaves, leaf fresh and dry matter, chlorophyll indices, flavonoids, and nitrogen balance. Additionally, gross income was determined by estimating the production capacity of leaves and converting it into the production capacity

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of commercial leaf bundles, considering a 1.0 ha taioba cultivation area based on the intercropping arrangements with banana trees. The highest fresh and dry matter yields of taioba were achieved with the largest spacing between plants (50 cm) in both single and double rows. The number of leaves produced by the plants remained unaffected by the studied arrangements. Consequently, the highest gross yield was obtained with the highest plant density, achieved through a planting spacing of 30 cm between plants in double rows. These findings underscore the viability of diversifying production within banana orchards by incorporating taioba planting in alternating rows, providing a genuine opportunity for additional income for farmers.
Key words: PANCs. Planting densities. Polyculture. Shading. *Xanthosoma sagittifolium* (L.).

Resumo

As pesquisas associadas ao tema de manejo da biodiversidade em sistemas de produção englobam diversos aspectos, dentre eles a escolha dos melhores arranjos populacionais das plantas cultivadas. A utilização de hortaliças não convencionais, como a taioba *Xanthosoma sagittifolium* (L.) Schott, na diversificação dos sistemas produtivos é uma ótima alternativa do ponto de vista de segurança alimentar do produtor e também para a geração de renda. Contudo, na literatura ainda são escassas as informações sobre seu manejo e produção. Nesse sentido, objetivou-se avaliar diferentes densidades de plantio de taioba cultivada em consórcio, sob pomar de bananeiras, verificando seu desenvolvimento e produção. O experimento foi realizado na área experimental da Universidades Federal do Espírito Santo (UFES), localizado no município de Alegre ES. O delineamento foi em blocos casualizados, com seis repetições, no esquema de parcelas subdivididas. As parcelas foram compostas pelos sistemas de plantio em linha simples e duplas. As subparcelas foram compostas pelos espaçamentos entre plantas de 30, 40 e 50 cm. Foram avaliadas a área foliar, número de folhas, matéria fresca e matéria seca de folhas, índices de clorofila, flavonoides e balanço de nitrogênio. Adicionalmente estimou-se a Renda Bruta, através da estimativa da capacidade de produção de folhas, transformada em capacidade de produção de maços de folhas comerciais, que seriam produzidos em 1,0 hectare de taioba, a partir dos arranjos adotados no consórcio com bananeiras. As maiores produções de matérias fresca e seca da taioba foram observadas quando se adotou o maior espaçamento entre plantas (50 cm), tanto em linha simples quanto em linhas duplas. Os arranjos estudados não influenciaram no número de folhas emitidas pelas plantas, por isso, o maior rendimento bruto foi obtido com a maior densidade de plantas, alcançada com o plantio no espaçamento de 30 cm entre plantas, em linhas duplas. Sendo assim, os resultados demonstram que a diversificação da produção do pomar de bananeira, com plantio de taioba em entrelinhas alternadas, representou uma real alternativa de renda extra ao agricultor.
Palavras-chave: Densidades de plantio. PANCs. Policultivo. Sombreamento. *Xanthosoma sagittifolium* (L.).

Introduction

The decline in consumption of conventional vegetables, which are among the most popular and commercially available, has led to an increase in the consumption of "unconventional" horticultural food plants (UHFP), as reported by the Brazilian Institute of Horticulture (Ibrahort), primarily due to the reduced purchasing power of the population (Kist et al., 2022). This trend presents an opportunity for promoting the production of UHFP, a category derived from the inclusion of these vegetables in the concept of Unconventional Food Plants (in Portuguese: *Planta Alimentícia Não Convencional,* PANC) that encompasses vegetables not yet fully recognized by the technical-scientific community and society as a whole. As a result, localized consumption is fostered in certain regions, states, or localities (Tuler et al., 2019).

Among the UHFP, taioba (*Xanthosoma sagittifolium* (L.) Schott) deserves particular attention as an edible plant with ease of propagation and apparent adaptability. It stands out as an alternative for leafy green consumption (Pérez et al., 2007). Taioba leaves are rich in dietary fiber, which remains mostly undigested by human intestinal enzymes, allowing it to reach the large intestine intact or undergo some degree of fermentation by the intestinal microbiota. These characteristics have been well-documented in the literature, demonstrating positive physiological effects such as decreased blood glucose and cholesterol levels, and modulation of the intestinal microbiota (Gibson et al., 2004; Jackix et al., 2013). Furthermore, taioba exhibits considerable potential for therapeutic cancer treatments (Caxito et al., 2015).

The cultivation of UHFP in Brazil is primarily carried out by family farmers, who often rely on these crops not only as a source of food but also as an additional income generator. To make taioba cultivation a profitable venture for farmers, one approach is to incorporate it into diversified systems (intercropping) alongside economically valuable crops. Among the possible consortium options, cultivation under banana orchards stands out as *Araceae* (taioba family) plants adapt well to humid and shaded environments (Gomes, 2021).

Brazil ranks as the world's fourth-largest banana producer, trailing only behind India, China, and Indonesia. Nearly the entire banana production caters to the domestic market, with only 1% exported (Kist et al., 2022). In certain states, such as Espírito Santo, banana cultivation represents a significant agricultural activity (Cruz & Assis, 2019; Galeano et al., 2022), with many family-based farmers relying on it for their livelihoods. Introducing taioba production in banana orchards can potentially enhance profitability for these farmers.

The success of intercropping systems relies on essential aspects such as selecting suitable species for the system, optimizing arrangement options, determining planting times for each species, and defining plant populations (Teixeira et al., 2020). These factors play a crucial role in achieving desired technological levels for intercropping, optimizing land utilization, and increasing farmers' income.

Therefore, this study aims to assess the development and production of taioba cultivated at different densities under banana orchards.

Material and Methods

The experiment was conducted from May 2021 to April 2022 at the experimental area of UFES (Federal University of Espírito Santo) in Rive, district of Alegre, state of Espírito Santo, Brazil (20°45' S, 41°29' W, and an altitude of 113 m). The area is situated in the Itapemirim River valley, characterized as a warm tropical microregion (lowlands) with higher temperatures (Pezzopane et al., 2012). Throughout the experiment, the maximum temperatures ranged from 30.09 ºC to a minimum of 13.03 ºC, with data collected from the automatic meteorological station of the National Institute of Meteorology of Brazil-INMET, Alegre/ES, situated near the experimental site.

The soil in the experimental area was classified as Red-Yellow Oxisol ("latossolo") with a medium texture (Santos et al., 2018). Soil samples were collected from the top 20 cm and subjected to analysis at the Soil Laboratory, Center for Agricultural Sciences and Engineering/UFES. The soil analysis revealed the following chemical and particle characteristics: pH (water) - 4.98; phosphorus - 2.0 mg dm^{-3}; potassium - 48.2 mg dm^{-3}; calcium - 0.67 cmolc dm^{-3}; magnesium - 0.46 cmolc dm^{-3}; aluminum - 0.40 cmolc dm^{-3}; sum of bases - 2.36 cmolc dm^{-3}; effective CEC - 1.8 cmolc dm^{-3}; base saturation - 32.6%; total organic carbon - 1%; total nitrogen 0.1%; sand - 60%; silt - 5%; and clay - 35%. Based on these results, liming was required, and dolomitic limestone was used accordingly.

A randomized-block experimental design was adopted, including six replications, in a split-plot arrangement in space. The main plots consisted of two planting systems: single rows and double rows. The subplots were defined by the spacing between plants, namely, 30, 40, and 50 cm.

The experiment was conducted in a banana orchard, with cultivar BRS Vitória subgroup Prata, planted at a spacing of 3 x 2 m and aged 48 months (planted in April/2017). Fertilization and management practices followed the recommendations for banana cultivation (Lima et al., 2012).

The taioba (*Xanthosoma* spp.) was incorporated into the intercropping system with banana trees, with alternating rows, without affecting the management of the banana plantation. In the intercropped system with double rows, a spacing of 0.8 m was maintained between taioba rows. The plant density of taioba was determined for each planting arrangement as follows: in single rows, with a spacing of 6 m between plants, the densities were estimated at 5,555 plants ha^{-1} (at 30 cm), 4,166 plants ha^{-1} (at 40 cm), and 3,333 plants ha^{-1} (at 50 cm). In the case of double rows, the density was doubled, resulting in 11,110 plants ha^{-1} (at 30 cm), 8,332 plants ha^{-1} (at 40 cm), and 6,666 plants ha^{-1} (at 50 cm).

Taioba rhizomes, weighing between 100, 150, and 200 g, were used for planting. Planting holes were prepared at a depth of 25 cm to facilitate root development. Taioba fertilization was conducted based on the recommendations by Filgueira (2008), which involved adding 1,000 kg ha^{-1} of cattle manure per planting hole. The cattle manure used had the following composition: 24.40 g kg^{-1} nitrogen, 3.07 g kg^{-1} phosphorus, 4.51 g kg^{-1} magnesium, 12.87 g kg^{-1} calcium, and 13.60 g kg^{-1} potassium. Topdressing was applied 120 days after planting, providing 500 kg/ha of poultry manure per plant. The poultry litter contained: 8.40 g kg^{-1} nitrogen, 30.10 g kg^{-1} phosphorus, 10.30 g kg^{-1} magnesium, 302.27 g kg^{-1} calcium, and 34.19 g kg^{-1} potassium (both analyses were conducted at the Laboratory of Chemical and Microbiological Analyses in Manhuaçu "Água Limpa").

Monthly assessments were carried out starting 70 days after planting. The assessments focused on leaf area, number of leaves, leaf fresh and dry matter, chlorophyll indices, flavonoids, and nitrogen balance. Only leaves measuring at least 25 cm in the AA' dimension (distance between petiole insertion and leaf blade apex) were selected for evaluation, as they represented the commercial size. Leaf area (LA) was calculated using the following equations (Oliveira et al., 2011):

$$LA = 242.0\ T^{0.6656};\ T = (AA'.AB.AB')/1000,$$

where AA' = distance (cm) between points A (petiole insertion) and A' (extreme apex of the leaf blade); AB = distance (cm) between points A and B' (apex of the right lobe of the adaxial face of the leaf); and AB' = distance (cm) between points A and B' (apex of the left lobe of the adaxial face of the leaf).

For evaluating chlorophyll indices, flavonoids, and nitrogen balance, the DUALEX® SCIENTIFIC+ device was used. These evaluations were conducted on the two most developed leaves among those meeting the commercial size criteria (minimum 25 cm in the AA' measurement). Subsequently, the collected leaves were dried in a forced circulation oven at 65°C until reaching a constant weight.

The obtained data were subjected to analysis of variance and F-test. When significant differences were observed, Tukey's mean test at a 5% probability level was applied. Data analysis was performed using Sisvar 5.6 software (Ferreira, 2014).

Additionally, the gross income (GI) for each treatment was estimated by calculating the production capacity of leaves and transforming it into the production capacity of bundles of commercial leaves that could be obtained from 1.0 ha of taioba, based on the intercropping arrangements with banana trees. A local survey of stores revealed that each commercial bundle contained an average of five leaves and was priced at USD 0.50 (considering the dollar exchange rate at BRL 5.00 on May 25, 2023).

To evaluate the yield of the banana trees, the bunches were collected at the end of their production cycle. The bunches were weighed using a digital scale, and the number of hands (fruit clusters) was counted manually.

Results and Discussion

The variables of leaf area, number of leaves per plant, and chlorophyll index did not exhibit significant differences, with mean values of 19.94 cm^2, 0.99, and 28.89, respectively. These results suggest that the various planting densities used for taioba may not significantly affect the leaf area, number of leaves, or chlorophyll indices. The ability of the crop to adapt its development based on population density can be attributed to specific characteristics of the species. Studies conducted by Gonçalves (2011), and Cavalcanti et al. (2015) on species within the genus *Xanthosoma* have shown phenotypic plasticity, indicating the crop's capability to adapt and regulate its development in response to changes in the growing environment. In other words, the crop is able to adjust to changing environmental conditions, which allows for a better regulation of its development in response to changes in population density.

Regarding the variables of fresh matter, dry matter, flavonoids, and nitrogen balance, there was a significant interaction between the factors of row planting system (single and double) and spacing between plants (30, 40, and 50 cm). The average results for fresh and dry matter are presented in Table 1, showing the breakdown of the interaction.

Table 1
Fresh and dry matter weights of taioba leaves in different planting arrangements, under a banana orchard

Spacing (cm)	Planting system			
	Fresh matter (g/plant)		Dry matter (g/plant)	
	Single row	Double row	Single row	Double row
30	240.14 b[1]A[1]	206.80 bA	40.02 bA	36.56 bA
40	268.88 bA	286.50 aA	40.93 bB	56.08 aA
50	353.75 aA	281.31 aB	56.57 aB	60.33 aA
CV 1 (%)	7.95		2.27	
CV 2 (%)	8.96		5.68	

[1]Means followed by the same uppercase letter in the rows or lowercase letter in the columns do not differ according to Tukey's test at 5% probability. CV: coefficient of variation.

For fresh matter, the mean of the single-row planting system was higher than that of the double-row system only when the spacing between plants was 50 cm. Within the single-row system, the 50 cm spacing resulted in superior weight compared to the other spacings. In the double-row system, the smallest spacing of 30 cm yielded the lowest mean weight. These results suggest that greater spacing led to increased weight gain. One possible explanation for this phenomenon is reduced competition between plants, allowing each plant to receive more light and nutrients, resulting in better development and biomass production. This hypothesis finds support in studies conducted on other vegetables, such as broccoli, which also demonstrated higher biomass production at smaller spacings (Schiavon, 2008).

Dry matter weight showed a higher mean in the double-row planting system with spacings of 40 and 50 cm. Within the single-row system, the 50 cm spacing outperformed the others. In the double-row system, only the smallest spacing of 30 cm resulted in a lower mean compared to the other spacings. Overall, these results indicate that larger spacings contribute to greater dry matter production per plant. These findings align with the conclusions of Hunger (2013), who investigated onion development under different planting densities and found that increasing the

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spacing between plants provided more room for growth and development, leading to increased productivity per plant.

The utilization of double planting rows can enhance plant density in the cultivated area, leading to increased yield per unit area (Szarvas et al., 2018). In this study, we observed that combining double planting rows with spacing of either 50 cm or 40 cm proved to be an effective strategy in increasing the dry matter yield of taioba.

Table 2 presents the decomposition of the interaction for physiological variables. Regarding the flavonoid index, the mean value of the single-row planting system was higher than that of the double row with a spacing of 30 cm between plants. Within the single planting row, the 30 cm spacing performed better than the other spacings. However, no significant differences were found among the different spacings within the double row.

Table 2
Flavonoids and nitrogen balance in taioba leaves from different planting arrangements, under a banana orchard

Spacing (cm)	Planting system			
	Flavonoids		Nitrogen balance	
	Single row	Double row	Single row	Double row
30	0.225 a[1]A[1]	0.135 aB	142.23 bA	146.96 aA
40	0.155 bA	0.155 aA	188.63 aA	139.39 aB
50	0.172 bA	0.157 aA	138.62 bA	144.73 aA
CV 1 (%)	14.37		5.33	
CV 2 (%)	9.87		4.46	

[1]Means followed by the same uppercase letter in the rows or lowercase letter in the columns do not differ according to Tukey's test at 5% probability. CV: coefficient of variation.

As flavonoids are secondary metabolites of the polyphenol class, generated in response to biotic or abiotic stress (Demotes-Mainard et al., 2008), bioactive compounds of taioba, such as phenolic compounds, can act to capture free radicals, preventing cell damage and benefiting human health by strengthening the immune system (Araújo et al., 2019; Benevides et al., 2022; Jordan et al., 2021). Consequently, competition for resources might influence flavonoid production, with smaller spacing between plants potentially increasing resource competition and leading plants to produce more flavonoids as a defense mechanism against stress (Silva, 2020).

Nitrogen balance represents a crucial indicator of plant nutritional status and is employed in numerous studies to assess the nitrogen status of plants (Fan et al., 2022; Fontes et al., 2016; Saravia et al., 2016; Zakeri et al., 2015; Zheng et al., 2015), including the prediction of yield in economically important crops like sweet potato (Milagres et al., 2018). The Dualex instrument was used in this study to determine the real-time nitrogen state in plants, providing chlorophyll indices, flavonols, and nitrogen balance (Coelho et al., 2012; Muñoz-Huerta et al., 2013). In terms of nitrogen balance, the mean of the single-row planting system was superior to the double-row planting system when a spacing of 40 cm between plants was used. Within the single planting row, the spacing of 40 cm was superior to the others for this variable.

A plant in good nutritional status has a higher chlorophyll content and, consequently, a lower polyphenol content in the leaves (Muñoz-Huerta et al., 2013). Several studies report the existence of a positive correlation between chlorophyll indices and nitrogen balance, and a negative correlation between flavonoids and N content (Cartelat et al., 2005; Coelho et al., 2010, 2012; Gil et al., 2002). Therefore, it is worth mentioning that in the present study, no significant differences were detected for the chlorophyll index. Therefore, in general, the different planting arrangements did not influence the taioba plants. However, a higher content of flavonoids found for the 30 cm spacing of the single row indicates a possible physiological disturbance related to the smaller spacing, favoring the synthesis of secondary metabolites of this group.

Additionally, we analyzed the gross income that would be obtained from taioba cultivation under different arrangements. The results showed that the highest gross income per hectare was achieved with a spacing of 30 cm between plants, regardless of whether it was in single rows or double rows. Adopting double rows led to an approximately 76% increase in gross income (Table 3).

Table 3
Gross income from taioba cultivation, in different planting arrangements, intercropped with banana trees

[1]Spc (cm)	Planting system							
	[1]SR	[1]DR	SR	DR	SR	DR	SR	DR
	Leaves/plant		Plants ha^{-1}		Bundles ha^{-1}		[2]USD ha^{-1}	
30	0.60	1.25	5,555	11,110	666.60	2,777.50	333.3	1,388.75
40	0.50	1.50	4,166	8,332	416.60	2,499.60	208.3	1,249.80
50	0.65	1.46	3,333	6,666	433.29	1,946.47	216.65	973.24

[1]Spc.: spacing between plants; SR: single row; DR: double row. [2]Considering the dollar exchange rate at BRL 5.00 on May 25, 2023.

These findings underscore the importance of understanding the influence of planting arrangements on crop behavior. In this case, the arrangement did not significantly affect the number of leaves generated by the plant, although smaller accumulations of fresh and dry matter were observed (Table 1) with denser plantings (30 cm spacing between plants, both in one and two rows). As a result, the planting density (number of plants per hectare) played a key role in determining net yield, as the number of leaves directly correlates with the commercial yield of the crop.

It is noteworthy that the banana crop showed no significant response to the presence of taioba, yielding an average of 5.89 t ha^{-1} (considering that the crop was already in production), with a bunch weight of 4 kg, six hands per bunch, and 11 fruits per hand.

Overall, the results demonstrate that diversifying production in the banana orchard by incorporating taioba planting in alternating rows represents a viable alternative for generating extra income for the farmer.

Conclusions

The maximum fresh and dry matter yields of taioba were observed when the widest spacing between plants (50 cm) was utilized, both in single and double rows.

The studied planting arrangements did not have a significant impact on the number of leaves generated by the plants. Consequently, the highest net yield was achieved with 30 cm spacing between plants, in double rows. This approach offers a promising alternative for generating additional income for banana growers.

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References

Araújo, S. S., Araújo, P. S., Giunco, A J., Silva, S. M., & Argandoña, E. J. S. (2019). Bromatology, food chemistry and antioxidant activity of *Xanthosoma sagittifolium* (L.) Schott. *Emirates Journal of Food and Agriculture, 31*(3), 188-195. doi: 10.9755/ejfa.2019.v31.i3.1924

Benevides, J. C. M., Silva, H. B. M. da, Lopes, M. V., Montes, S. S., Silva, A. S. L., Matos, R. A., Santos, A. F., Jr., Souza, A. C. S., & Bezerra, M. A. (2022). Multivariate analysis for the quantitative characterization of bioactive compounds in "Taioba" (*Xanthosoma sagittifolium*) from Brazil. *Journal of Food Measurement and Characterization, 16*(1), 1901-1910. doi: 10.1007/s11694-021-01265-2

Cartelat, A., Cerovic, Z. G., Goulas, Y., Meyer, S., Lelarge, C., Prioul, J. L., Barbottin, A., Jeuffroy, M. H., Gate, P., Agati, G., & Moya, I. (2005). Optically assessed contents of leaf polyphenolics and chlorophyll as indicators of nitrogen deficiency in wheat (*Triticum aestivum* L.). *Field Crops Research, 91*(1), 35-49. doi: 10.1016/j.fcr.2004.05.002

Cavalcanti, T. F. M., Costa, C. A., Brandão, A. A., Alves, C. C., & Martins, E. R. (2015). Produtividade de cinco acessos de mangarito em Montes Claros MG. *Horticultura Brasileira, 33*(2), 272-275. doi: 10.1590/S0102-053620150000200022

Caxito, M. L., Correia, R. R., Gomes, A. C., Justo, G., Coelho, M. G., Sakuragui, C. M., Kuster, R. M., & Sabino, K. C. (2015). In Vitro Antileukemic Activity of *Xanthosoma sagittifolium* (Taioba) Leaf Extract. *Evidence-based Complementary and Alternative Medicine, 2015,* 384267. doi: 10.1155/2015/384267

Coelho, F. S., Fontes, P. C. R., Finger, F. L., & Cecon, P. R. (2012). Avaliação do estado nutricional do nitrogênio em batateira por meio de polifenóis e clorofila na folha. *Pesquisa Agropecuária Brasileira, 47*(4), 584-592. doi: 10.1590/S0100-204X2012000400015

Coelho, F. S., Fontes, P. C. R., Puiatti, M., Neves, J. C. L., & Silva, M. C. C. (2010). Dose de nitrogênio associada à produtividade de batata e índices do estado de nitrogênio na folha. *Revista Brasileira de Ciência do Solo, 34*(4), 1175-1183. doi: 10.1590/S0100-06832010000400017

Cruz, S. F., & Assis, T. R. P. (2019). Contribuições de três organizações para a comercialização da agricultura familiar no PNAE, no território sul litorâneo do Espírito Santo. *Interações, 20*(3), 737-752. doi: 10.20435/inter.v20i3.2063

Demotes-Mainard, S., Boumaza, R., Meyer, S., & Cerovic, Z. G. (2008). Indicators of nitrogen status for ornamental woody plants based on optical measurements of leaf epidermal polyphenol and chlorophyll contents. *Scientia Horticulturae, 115*(4), 377-385. doi: 10.1016/j.scienta.2007.10.006

Fan, Y., Feng, H., Jin, X., Yue, J., Liu, Y., Li, Z., Feng, Z., Song, X., & Yang G. (2022). Estimation of the nitrogen content of potato plants based on morphological parameters and visible light vegetation indices. *Frontiers in Plant Science,13*, 1-15. doi: 10.3389/fpls.2022.1012070

Ferreira, D. F. (2014). Sisvar: um guia para seus procedimentos Bootstrap em comparações múltiplas. *Ciência e Agrotecnologia, 38*(2), 109-112. doi: 10.1590/S1413-70542014000200001

Filgueira, F. A. R. (2008). *Novo manual de olericultura* (3a ed.). UFV.

Fontes, P. C. R., Braun, H., Silva, M. C. C., Coelho, F. S., Cecon, P. R., & Partelli, F. L. (2016). Tuber yield prognosis model and agronomic nitrogen use efficiency of potato cultivars. *Australian Journal of Crops Science, 10*(7), 933-939. doi: 10.21475/ajcs.2016.10.07.p7404

Galeano, E. A. V., Lazzarini, A. L., Ventura, J. A., Caetano, L. C. S., Padovan, M. P., & Dias, R. Q. (2022). *Cadeia produtiva da banana no Espírito Santo.* Incaper.

Gibson, G. R., Probert, H. M., Loo, J. V., Rastall, R. A., & Roberfroid, M. B. (2004). Dietary modulation of the human colonic microbiota: updating the concept of prebiotics. *Nutrition Research Reviews, 17*(2), 259-275. doi: 10.1079/NRR200479

Gil, P. T., Fontes, P. C. R., Cecon, P. R., & Ferreira, F. A. (2002). Índice SPAD para o diagnóstico do estado de nitrogênio e para o prognóstico da produtividade de batata. *Horticultura Brasileira, 20*(4), 611-615. doi: 10.1590/S0102-05362002000400020

Gomes, V. (2021). Taioba *(Xanthosoma sagittifolium) no manejo de nematoide-das-galhas.* Tese de doutorado, Universidade Estadual Paulista, Faculdade de Ciências Agronômicas, Botucatu, SP, Brasil.

Gonçalves, E. G. (2011). The commonly cultivated species of *Xanthosoma Schott* (Araceae), including four new species. *Aroideana, 34,* 3-23. https://api.semanticscholar.org/CorpusID:87916935

Hunger, H. (2013). *Produtividade e análise econômica da cultura da cebola sob diferentes densidades de plantio e níveis de adubação.* Dissertação de mestrado, Universidade Estadual do Centro-Oeste, Guarapuava, PR, Brasil. https://bdtd.ibict.br/vufind/Record/UCEN_a9e1a3f442126f66f7327c9cd6f2280 1

Jackix, E. A., Monteiro, E. B., Raposo, H. F., & Amaya-Farfán, F. (2013). Cholesterol reducing and bile-acid binding properties of taioba (*Xanthosoma sagittifolium*) leaf in rats fed a high-fat diet. *Food Research International, 51*(2), 886-891. doi: 10.1016/j.foodres.2013.02.017

Jordan, R. A., Sanjinez-Argandoña, E. J., Ferreira, O. M., Quequeto, W. D., Siqueira, V. C., Mendoza, V. S., Antunes, B. M., Flozino, G. K. M., Sanches, I. S., Sanches, É. S., & Antunes, B. M. (2021). Efeito de sistemas e condições de secagem sobre o consumo específico de energia e os compostos bioativos da taioba (Xanthosoma sagittifolium Schott). *Research, Society and Development, 10*(7), e21610716512. doi: 10.33448/rsd-v10i7.16512

Kist, B. B., Carvalho, C., & Beling, R. R. (2022). *Anuário brasileiro de Horti & Fruti 2022.* Editora Gazeta. https://www.editoragazeta.com.br/sitewp/wp-content/uploads/2022/04/HORTIFRUTI_2022.pdf

Lima, M. B., Silva, S. O., & Ferreira, C. F. (2012). *Banana: o produtor pergunta, a EMBRAPA responde.* (Coleção 500 perguntas, 500 respostas). EMBRAPA Mandioca e Fruticultura. https://ainfo.cnptia. embrapa.br/digital/bitstream/item/101787/1/500perguntasbanana.pdf

Milagres, C. C., Fontes, P. C. R., Silveira, M. V., MoreiraIza, M. A., & Lopes, P. C. (2018). Índices de nitrogênio e modelo para prognosticar a produção de tubérculos de batata. *Revista Ceres, 65*(3), 261-270. doi: 10.1590/0034-737X201865030006

Muñoz-Huerta, R. F., Guevara-Gonzalez, R. G., Contreras-Medina, L. M., Torres-Pacheco, I., Prado-Olivarez, J., & Ocampo-Velazquez, R. V. (2013). A review of methods for sensing the nitrogen status in plants: advantages, disadvantages and recent advances. *Sensors, 13*(8), 10823-10843. doi: 10.3390/s130810823

Oliveira, F. L., Araújo, A. P., & GUERRA, J. G. M. (2011). Crescimento e acumulação de nutrientes em plantas de taro sob níveis de sombreamento artificial. *Horticultura Brasileira, 29*(3), 292-298. doi: 10.1590/S0102-05362011000300006

Pérez, E. E., Gutiérrez, M. E., & Dedelahaye, E. P. (2007). Production and characterization of *Xanthosoma sagittifolium* and *Colocasia esculenta* flours. *Journal of Food Science, 72*(6), 367-371. doi: 10.1111/j.1750-3841.2007.00420.x

Pezzopane, J. E. M., Castro, F. S., Pezzopane, J. R. M., & Cecílio, R. A. (2012). *Agrometeorologia: aplicações para o Espírito Santo.* UFES.

Santos, H. G., Jacomine, P. K. T., Anjos, L. H. C., Oliveira, V. A., Lumbreras, J. F., Coelho, M. R., Almeida, J. A., Araujo, J. C., F., Oliveira, J. B., & Cunha, T. J. F. (2018). *Sistema* *brasileiro de classificação de solos* (5a ed.). EMBRAPA Solos. https://www.embrapa.br/busca-de-publicacoes/-/publicacao/1094003/sistema-brasileiro-de-classificacao-de-solos

Saravia, D., Farfán-Vignolo, E. R., Gutiérrez, R., Mendiburu, F., Schafleitner, R., Bonierbale, M., & Khan, M. A. (2016). Yield and physiological response of potatoes indicate different strategies to cope with drought stress and nitrogen fertilization. *American Journal of Potato Research, 93*(3), 288-295. doi: 10.1007/s12230-016-9505-9

Schiavon, A. A., Jr., (2008). *Produtividade e qualidade de brócolos em função da adubação e espaçamento entre plantas.* Dissertação de mestrado, Universidade Estadual Paulista "Julio de Mesquita Filho" Faculdade de Ciências Agrárias e Veterinárias Câmpus de Jaboticabal, Jaboticabal, SP, Brasil. https://www.fcav.unesp.br/Home/download/pgtrabs/pv/m/3455.pdf

Silva, A. (2020). *Intensidade da coloração verde foliar em genótipos de coffea canephora: divergência genética e relação com o desempenho fotossintético.* Dissertação de mestrado, Universidade Federal do Espírito Santo, Vitória, ES, Brasil. https://sappg.ufes.br/tese_drupal//tese_14138_Disserta%E7%E3o%20Final_Ang%E9lica%20Tomazeli.pdf

Szarvas, A., Herczeg, E., Papp, L., & Monostori, T. (2018). The effect of planting density on the yield of sweet potato [*Ipomoea batatas* (L.) Lam.] in south-east Hungary in 2017. *Research Journal of Agricultural Sciences, 50*(1), 159-163.

Teixeira, A. G., Oliveira, F. L., Parajara, M. C., Zucoloto, M., & Dalvi, L. P. (2020). Yacon planting density in intercropping with corn under banana orchard. *Horticultura Brasileira, 38*(1), 83-88. doi: 10.1590/S0102-053620200113

Tuler, A. C., Peixoto, A. L., & Silva, N. C. B. (2019). Plantas alimentícias não convencionais (PANC) na comunidade rural de São José da Figueira, Durandé, Minas Gerais, Brasil. *Rodriguésia, 70*, e01142018. doi: 10.1590/2175-7860201970077

Zakeri, H., Schoenau, J., Vandenberg, A., Aligodarz, M. T., & Bueckert, R. A. (2015). Indirect estimations of lentil leaf and plant n by SPAD chlorophyll meter. *International Journal of Agronomy, 2015,* 1-10. doi: 10.1155/2015/748074

Zheng, H., Liu, Y., Qin Y., Chen, Y., & Fan, M. (2015). Establishing dynamic thresholds for potato nitrogen status diagnosis with SPAD chlorophyll meter. *Journal of Integrative Agriculture, 14*(1), 190-195. doi: 10.1016/S2095-3119(14)60925-4