Ciência Rural, Santa Maria, v.47: 02, e20151371, 2017
http://dx.doi.org/10.1590/0103-8478cr20151371
ISSNe 1678-4596
BIOLOGY

Pindo Palm fruit yield and its relationship with edaphic factors in natural populations in Rio Grande do Sul

Gilson Schlindwein[1] Adilson Tonietto[1*] André Dabdab Abichequer[1] Augusto Cruz de Azambuja[1] Bruno Brito Lisboa[1] Luciano Kayser Vargas[1]

[1]Fundação Estadual de Pesquisa Agropecuária (FEPAGRO), 90130-060, Porto Alegre, RS, Brasil. E-mail: tonietto@fepagro.rs.gov.br.
[*]Corresponding author.

ABSTRACT: *The objective of this study was to evaluate the fruit yield of naturally occurring populations of Pindo palms (**Butia odorata**) in different habitats and agricultural ecosystems. Three areas were selected in the municipalities of Barra do Ribeiro, Tapes and Arambaré, all of which are located on the Litoral Médio in the state of Rio Grande do Sul, Brazil. Eleven 25x100m² plots were selected in the aforementioned areas, and fruit yield was evaluated in the 2008 and 2009 seasons. Chemical conditions of the soil in each plot, elevation of terrain, height, and density of the reproductive Pindo palms were also assessed. Data analysis revealed a strong correlation between the edaphic conditions and the yield from the Pindo palms. Tapes Pindo palms exhibited higher fruit yield as a result of an increase in the number of bunches produced per plant, along with highly fertile soils and greater availability of calcium and magnesium. The lowest fruit yields were linked to nutrient-poor soils in Brachiaria pastures, as well as sandy plains containing high levels of sodium. Changes in the characteristics of the soils associated with habitat and management influenced the fruit yield of Pindo palms.*
Key words: ***Butia odorata***, ***Arecaceae***, *chemical characteristics of the soil; fruit yield, sustainable management.*

Produção de frutos de butiazeiro e sua relação com fatores edáficos em populações naturais do Rio Grande do Sul

RESUMO: *O objetivo deste trabalho foi avaliar a produtividade de butiazeiros (**Butia odorata**) em áreas de ocorrência natural sob a influência de diferentes habitats e agroecossistemas. Três áreas correspondentes aos Municípios de Barra do Ribeiro, Tapes e Arambaré, situados no Litoral Médio do Estado do Rio Grande do Sul foram selecionadas. Nessas áreas, foram distribuídas 11 parcelas de 25x100m² e avaliada a produção nas frutificações de 2008 e 2009. Em cada parcela, também foram avaliadas as condições químicas do solo, a elevação do terreno, a altura e a densidade de butiazeiros reprodutivos. As análises dos dados revelaram uma forte relação entre as condições edáficas e a produtividade dos butiazeiros. O butiazal de Tapes apresentou maior produção de frutos, resultante do aumento de cachos produzidos por planta, estando associada aos solos mais férteis e com maior disponibilidade de cálcio e magnésio. A menor produção de frutos foi relacionada com solos pobres em nutrientes, cobertos com pastagens de braquiária, assim como em planícies arenosas, com elevados teores de sódio. Mudanças nas características do solo, associadas com o habitat e o manejo, influenciam na produção de frutos de butiazeiro.*
Palavras-chave: ***Butia odorata***, ***Arecaceae***, *características químicas do solo, produtividade de frutos, manejo sustentável.*

INTRODUCTION

The Pindo palm (***Butia odorata***) is a native palm whose territory extends from the State of Rio Grande do Sul in Brazil to the city of Rocha in Uruguay (NOBLICK, 2010), where these palm trees form extensive groves known as "palmares" or "butiazais" (WAECHTER, 1985). These groves form a pivotal ecosystem for various species of flora and fauna, making it one of the key areas for the conservation of the Pampa biome's biodiversity (MMA, 2007). During the past few decades, Pindo palm groves have; however, been disappearing, as their areas are replaced for farming and forestry.

In addition to playing a vital role within the ecosystem, Pindo palms (***Butia*** spp.) are highly prized for the quality and yield of their fruit. In a review of the genus ***Butia***, HOFFMANN et al. (2014) highlighted the fruit's antioxidant properties and its potential use in the food and pharmaceutical industries. According to BÜTTOW et al. (2009), the Pindo palm fruit is the part of the plant most used in its consumption either *in natura* or in the preparation of liquor, juice, jelly, and other products.

Received 10.01.15 Approved 08.23.16 Returned by the author 11.14.16
CR-2015-1371.R1

Naturally occurring populations of Pindo palms have high phenotypic variability, which is partially associated with the tree's fruiting properties, as well as being influenced by genetic and environmental factors. How environmental factors influence the reproductive performance species of the genus ***Butia*** is not; however, well understood. Studies on other taxa of the ***Arecaceae*** family are also scarce. ROSA et al. (2014) compared different habitats of the Amazon forest and revealed that water availability in the soil affected the fruit yield of the ***Mauritia flexuosa*** palm. In the Atlantic Forest, BRANCALION et al. (2012) reported that changes in the chemical and physical properties of the soil between areas of restinga and hill side forests influenced the vegetative growth and the fruit yield of the juçara-palm (***Euterpe edulis***).

In addition to these factors, pasture management within Pindo palm groves might also affect the dynamic and reproductive processes of these populations. The interactions between these factors on the fruiting of Pindo palms are; however, still unknown. In recent years, variations in the fruiting yield of ***B. odorata*** have been described in some of the areas where the palm occurs (RIVAS & BARILANI, 2004; AZAMBUJA, 2009; NUNES et al., 2010; SCHWARTZ et al., 2010). The environmental factors involved have not; however, been accounted for. Understanding these relationships will help to determine the probable reproductive needs of the plant, its production capacity in different habitats, and the effects of livestock management on those parameters.

The objective of this study was; therefore, to evaluate the relationship between Pindo palm fruit yield and environmental variables, comparing different habitats and management conditions within areas of its natural occurrence.

MATERIALS AND METHODS

This study was conducted in naturally occurring ***B. odorata*** areas, which were located within the Litoral Médio region of the coastal plains of Rio Grande do Sul and near the west coast of the Laguna dos Patos. The regional climate is characterized as humid subtropical, with no periods of drought, an average annual rainfall ranging from 1284 to 1322mm, and average temperatures ranging between 18 and 19°C (MORENO, 1961). The study area was located within the neighboring municipalities of Arambaré, Barra do Ribeiro and Tapes (Table 1). In the Pindo palm groves of Barra do Ribeiro and Tapes, argisols are prevalent in the undulating terrains situated on the geomorphological unit known as "Coxilha das Lombas." In naturally occurring areas of Arambaré, Pindo palms occur along sandy strands of quartzarenic neosols soil from geologically younger terrain, which are associated with the formation of restingas. The naturally occurring Pindo palm groves studied occurred within an area ranging from 100 to 300 hectares. These were associated with the following livestock management systems: Tapes – native field pasture, Barra do Ribeiro – Brachiaria cultivation (***Urochloa brizantha***), and Arambaré – pangola-grass cultivation (***Digitaria racemosa***), which constitutes a sparse herbaceous covering among the Pindo palms.

To evaluate these areas, eleven 25x100m plots were set up with a minimum distance of 50 meters between each one. There were four plots in the municipality of Arambaré, four in Tapes, and three in Barra do Ribeiro. The following measurements were taken at each plot: fruit yield, soil characteristics, terrain elevation, number of individuals at each reproductive stage, and height of each palm.

Fruit bunches for all reproductive specimens were evaluated for two consecutive years (2008 and 2009) during the fruiting period. In weighing the bunches, only those fruits removed from the rachilles during the three harvesting periods of January and March of each year were considered. There was a total of six harvests. All palm trees that displayed bunches at the time of harvest were sampled and subsequently identified by the color and timing of fruit drop. From the average weight of the fruits per bunch, and the number of bunches produced per plot, fruit yield (kg ha^{-1}) was calculated based on the area (2500m²) evaluated, multiplied by four. Fruit yield per tree was derived by dividing the number of fruit by the number of fully-grown Pindo palms in each plot.

Soil samples were taken from each plot at the same time that fruiting assessments began. These were taken from around the Pindo palms at depths of 0-20cm and 20-40cm, yielding 12 sub-samples for each one. The samples were analyzed at the State Foundation for Agricultural Research (FEPAGRO) in Porto Alegre, RS, where they were tested for pH, clay content, organic matter, macro and micronutrients. These analyses were performed according to methods described by TEDESCO et al. (1995).

To compare the data, a two-way analysis of variance (ANOVA) was conducted in order to verify the effect of the areas and the year on fruiting parameters. An ANOVA was also conducted to compare the chemical parameters of the soil between the different study areas. In cases where the ANOVA was statistically significant (a=0.05), a least significant

Table 1 - Mean (± standard error) plant density per hectare (pl/ha), mean plant height (m), number of bunches produced per plant, fruits mass per bunch (kg) and yield estimates per plant (kg) and yield (kg ha^{-1}), which were obtained from assessments in ***B. odorata*** performed during two years (2008-2009) in 11 plots located in three localities of the Litoral Médio in the RS.

Year	Locality	--------------Plants--------------		--Fruit yield--------------------------------------			
		Density (pl ha^{-1})	Height (m)	Number of bunches per plant	Fruits Mass per bunch (kg)	Yield per plant (kg)*	Yield (kg ha^{-1})*
2008	Arambaré	-	-	2.1±0.19	5.7±0.22	11.9±1.78	1.983±562.4
	B. Ribeiro	-	-	1.8±0.05	6.1±0.45	11.2±3.80	2.301±852.0
	Tapes	-	-	2.9±0.11	6.3±0.57	18.5±3.21	3.728±827.8
2009	Arambaré	-	-	1.5±0.21	5.4±0.16	8.2±1.16	1.312±254.4
	B. Ribeiro	-	-	2.0±0.03	5.3±0.41	10.3±2.63	2.095±608.9
	Tapes	-	-	3.2±0.14	6.3±0.45	20.4±3.30	4.047±795.2
Total	Arambaré	159±46.3[a]	2.3±0.13[b]	1.8±0.39[b]	5.6±0.37[a]	10.1±2.62[b]	1.647±312.9[b]
	B. Ribeiro	199±28.9[a]	5.0±0.96[a]	1.9±0.09[b]	5.7±0.78[a]	10.8±2.08[b]	2.198±534.8[b]
	Tapes	202±55.7[a]	4.3±0.50[a]	3.1±0.23[a]	6.3±0.85[a]	19.5±2.15[a]	3.887±225.8[a]

*Data estimated from the number of bunches and average weight of fruits per bunch in each plot. Averages followed by different letters in the column differ by LSD test at 5% probability.

difference (LSD) test was conducted for means separation. The statistical package, Sigmaplot version 11.0 (SPSS Inc.), was used for all statistical analyses.

In addition, an ordination analysis (PCOA) was conducted to detect correlation patterns between the productive characteristics of ***B. odorata*** species and the environmental parameters evaluated within the plots. This analysis was performed from the data transformation (centralization and standardization) necessary to compare variables of different scales and a dissimilarity matrix (Euclidean distance) between the plots (PODANI, 1994). Only variables with a minimum correlation of 0.5 with at least one of the axes were plotted in the diagram.

RESULTS AND DISCUSSION

During the two fruiting cycles, the Pindo palms located in Tapes exhibited an average fruit yield per plant and a bunch number that was significantly higher compared to those located in the areas of Arambaré and Barra do Ribeiro (Table 1). There were no significant differences in bunch weights between the different areas and fruiting year. No significant effect was observed with respect to the year the palms bore their fruit and the interaction of this factor and area on other parameters. RIVAS AND BARILANI (2004) estimated variations in Pindo Palm fruit yield in a comparative evaluation between two palms located in Castilhos and São Luis in Uruguay. They reported that significant differences were detected between the two areas. The estimated average yield per plant was 36.9kg in Castilhos and 5.3kg in Sao Luis; respectively yielding 11.070 and 265kg of fruit per hectare.

Comparing the afore-mentioned differences with those obtained in the present study, these values exceeded the variations reported in 2009, when fruit yield in Tapes was twice as much as that of Arambaré. In 2009, SCHWARTZ et al. (2010) studied three Pindo palm areas in Santa Vitória do Palmar and estimated an overall average of 56kg of fruit per plant. In an assessment by those researchers, as well as in this study, variability in fruit yield between naturally occurring groves of this species resulted mainly from differences in the number of bunches produced per plant. That is, variations in the weight of bunches had little influence on the yield difference between areas. The weight of bunches becomes relevant; however, when comparing the 5.8kg average obtained in this study with that obtained by SCHWARTZ et al. (2010), which exceeded 13kg. Thus, the number of bunches produced per plant may be related to variations in the environment on a smaller spatial scale, as edaphic variations, type of management and crop year. Conversely, the differences in size and bunch weight occurred in a wider geographical scale, and might be influenced by genetic factors.

From the ordination analysis, it was possible to determine the associations between different variables through its correlations with axis I and II, which explain 65.2% of the total variability in the data. Through this analysis, we were able to separate the plots corresponding to the areas of the three municipalities and group them according to different soil and fruit yield variables (Figure 1). Furthermore, it was also possible to verify a strong influence from the chemical variables in the soil on fruit yield variations, which was expressed by the number of bunches per plant produced between the different areas. Thus, the four plots evaluated in Tapes were associated with increased fruit yield in the 2008 and 2009 evaluations, as well as greater CEC of the soil (T) and its base saturation (V%). This was in addition to higher levels of calcium (Ca) and magnesium (Mg) assessed at the two soil layers evaluated.

At the other end of the diagram, and away from these variables, were the points corresponding to the plots in Arambaré. These were associated with higher levels of sodium (Na) and phosphorus (P). The plots in Barra do Ribeiro were close to the largest aluminum saturation in the CEC of the soil (Al%). BRANCALION et al. (2012), in a comparative study of the palm tree ***Euterpe edulis*** in two coastal environments in the Southeast region of Brazil, also reported a strong correlation between increased fruit yield and improved soil conditions. In that study, they reported that the Juçara palm produced four times more fruit in the soils of the Atlantic slope, where the availability of Ca and Mg was higher compared to an area of restinga, which had higher concentrations of Na and P. Those findings were similar to data obtained in our study, which revealed that fruit yield was also strongly correlated with the availability of those minerals.

Significant variations in soil properties between the areas were observed (Table 2) especially in Tapes, which exhibited higher base saturation, lower aluminum occupation in the CEC of the soil, and higher levels of Ca and Mg. In the soil samples of Arambaré, the levels of P and Na were significantly higher than those found in other areas. The effective saturation of Na was 7.78% in the CEC and above 15% in the layers between 0-20 and 20-40cm, respectively. Levels that high may limit the development of some plants, due to water and nutrient soil limitation, added to the weak colloidal properties resulting from low clay content in this soil. In those conditions, Na may compete with K, resulting in a deficiency of this mineral (SCHACHTMAN & LIU 1999), which AWAD et al. (2014) suggested was the most important element for fruit yield in date palm cultivations. Thus, higher concentrations of Na in Arambaré may also be limiting Pindo palm fruit yield in this area.

Although the Pindo palms of Tapes and Barra do Ribeiro have similar characteristics, such as density and height (Table 1), there were significant differences in the fertility parameters of those areas. This was despite them belonging to the same geomorphological unit and having physically similar soils (Table 2). These differences may be related to the management systems adopted in the different areas. The greater availability of Ca and Mg, as reported in the plots of Tapes, may be related to the application of lime in the soil, a technique widely used for improving pasture conditions in native pastures (OLIVEIRA et al., 2005). The proper use of lime in the soil may promote plant growth by neutralizing elements, such as iron and exchangeable aluminum; thus, optimizing the effective cation exchange capacity and availability of micronutrients, in addition to serving as a source of Ca and Mg (RAIJ, 2011). This process may; therefore, be contributing to the fruit production of those Pindo palms. Despite only few studies evaluating this correlation, a literature review by NATALE et al. (2012) revealed that an increase in Ca and Mg, as well as in the cation exchange capacity of the soil through liming, may improve vegetative growth and fruit yield of different species of tropical fruit plants.

In contrast, the Pindo palm fields located at the Barra do Ribeiro area were characterized almost exclusively by the use of ***Urochloa brizantha*** pastures. SOUZA et al. (2006) concluded that the dry mass incorporation of this species in the soil has a restrictive effect on the development of different cultures due to nitrogen immobilization during decomposition of waste materials, and the presence of allelochemicals. These factors, together with excessive nutrient extraction, may have contributed to the impoverishment of the soils in this area. This was due to successive cycles of spontaneous seeding of these pastures, in addition to losses of the soil's bases by heap leaching without replenishment by liming and fertilization.

In general, the Pindo palm displays adaptive characteristics that enable it to grow on open environments with limiting edaphic conditions. However, data from this study revealed that the limitation of some of these resources can also affect the fruit yield of this palm in naturally occurring areas. Thus, in order to establish criteria to include a harvesting management system of naturally occurring Pindo palms, the specific characteristics of these environments need to be considered. In Pindo palms associated with restinga vegetation, where limitations in fruit yield resulted from edaphic factors inherent

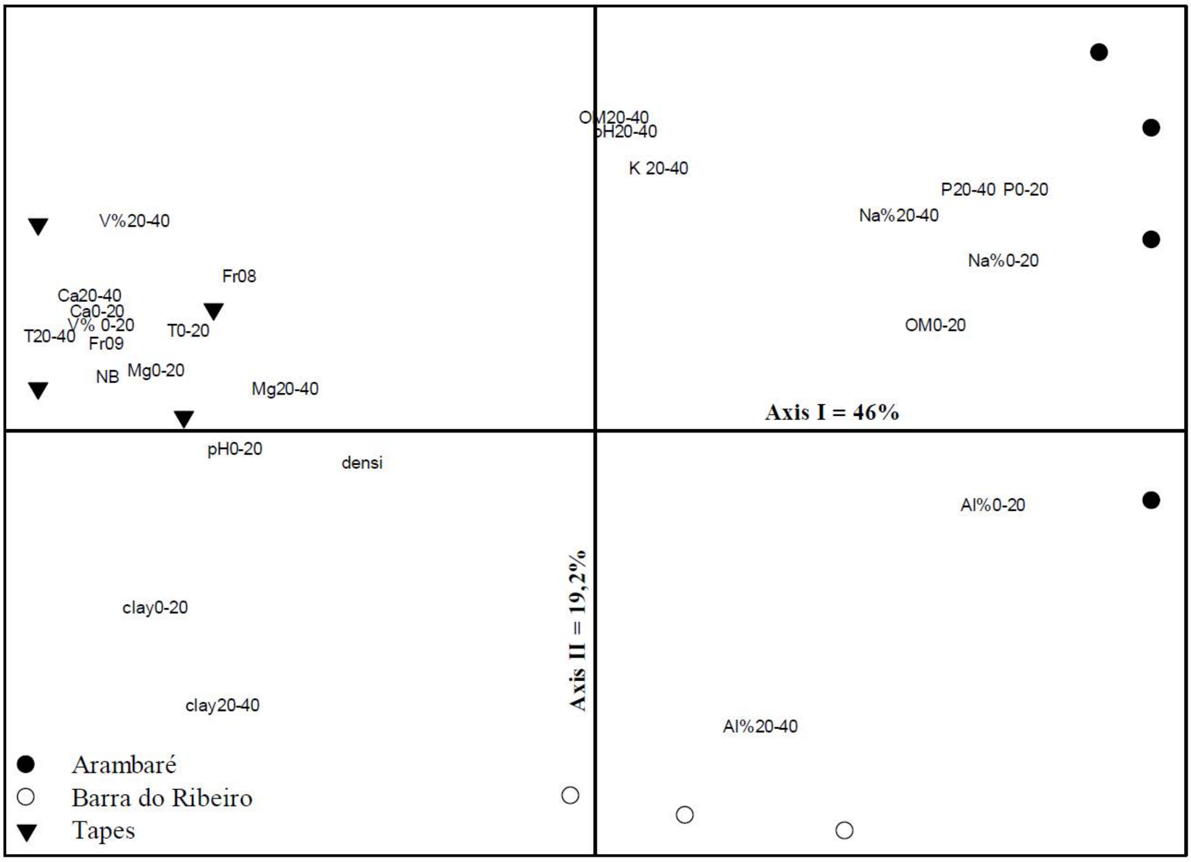

Figure 1 - Scatter plot generated by principal coordinates analysis (PCOA) from correlated variables (>0.5) with at least one axis obtained during the evaluation of the 11 plots within areas of Pindo palm groves that were located in the three municipalities of Litoral Médio in the Rio Grande do Sul. Percentages indicate the representation of each axis in the total variation of the data.
Densi (density of reproductive trees per hectare); 0-20 and 20-40 (variable depths of the soil ranging from 0 to 20 and 20 to 40cm, respectively); Al% (effective aluminum saturation of CEC); clay (clay percentage); Ca (calcium); T (cation exchange capacity in CTC); K (potassium); Mg (magnesium); MO (organic matter); Na% (effective sodium saturation of CEC); P (phosphorous); pH (potential of hydrogen); V% (base saturation of CEC at pH 7.0); Fr08 and Fr09 (weight of the fruits produced by the plant in 2008 and 2009, respectively); NB (Average number of bunches produced by the plant in the 2008 and 2009 harvesting seasons).

to the habitat, a more conservative and restrictive management strategy needs to be adopted. This is in order not to compromise the natural regeneration of the species or the dynamic processes present in these environments. However, when considering such limitations, controlled extraction of the palm's fruit could be a low-impact economical alternative compared to the current system with livestock, and also considering the limitations that the sandy soil has on the establishment of pastures in areas of restinga. The fruits harvest, combined with the maintenance of livestock systems on native pastures, is an alternative to the Pindo palm groves reported in the more developed soils of Tapes and Barra do Ribeiro. However, this system requires the establishment of criteria, aiming to minimize its impacts; thus, ensuring the maintenance of the Pindo palm populations and soil fertility parameters. This also maintains the biological diversity associated with those areas. Along with the processing of fruits, Pindo palm seeds can also be utilized in the production of seedlings in nurseries, assisting the maintenance activities and recovery of Pindo palms.

CONCLUSION

Pindo palm fruit yield varies according to the chemical characteristics of the soil conditioned by the habitat and its management. The increase in Pindo palm fruit yield is associated with higher base saturation in CEC of the soil, and higher Ca and Mg concentrations in the soil in areas containing native pasture.

Table 2 - Mean chemical parameters of the soil samples collected from two different depths and of 11 plots distributed within the Pindo palm groves in three municipalities.

	------------Arambaré (n=4)------------		----------B. do Ribeiro (n=3)----------		----------------Tapes (n=4)----------------	
	0-20cm	20-40cm	0-20cm	20-40cm	0-20cm	20-40cm
Clay (%)	5.0[b]	5.3[b]	13.0[a]	15.0[a]	12.5[a]	12.5[a]
OM (%)	1.7[a]	1.3[a]	1.4[a]	0.8[b]	1.4[a]	1.2[a]
CEC	2.3[a]	1.8[b]	2.4[a]	2.0[b]	3.2[a]	3.0[a]
pH	5.1[b]	5.4[a]	5.2[ab]	5.1[b]	5.4[b]	5.3[ab]
P (mg L^{-1})	4.0[a]	4.2[a]	1.1[b]	0.9[b]	1.1[b]	1.1[b]
------------Sorption complex (cmolc dm^{-3})------------						
K	0.08[a]	0.06[a]	0.07[a]	0.07[a]	0.08[a]	0.06[a]
Ca	0.15[b]	0.15[b]	0.20[b]	0.17[b]	0.78[a]	0.60[a]
Mg	0.10[b]	0.10[b]	0.13[b]	0.10[ab]	0.53[a]	1.70[a]
Al	0.45[a]	0.20[a]	0.15[a]	0.35[a]	0.40[a]	0.43[a]
------------CEC Saturation (%)------------						
Bases	16.9[b]	22.3[b]	17.8[b]	16.4[b]	43.2[a]	40.8[a]
Al*	47.5[a]	27.2[a]	45.4[a]	53.7[a]	6.9[b]	22.8[a]
Na*	7.78[a]	15.83[a]	1.43[b]	1.48[b]	2.17[b]	2.47[b]

*Effective. Means followed by different letters in the row display significant differences (P=0.05) between the areas assessed at the same depth, as according to the LSD test.

ACKNOWLEDGEMENTS

We offer thanks to the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) of Brazil for the financial resources and grants to conduct this study. We would also like to thank the owners of the study areas for their consent and collaboration. Finally, we would like to acknowledge the Fundação Estadual de Pesquisa Agropecuária (FEPAGRO) laboratory technicians for their support during chemical analyses.

REFERENCES

AWAD, M.A. et al. Effect of potassium soil and foliar spray fertilization on yield, fruit quality and nutrient uptake of 'Seweda' date palm grown in sandy loam soil. **Journal of Food, Agriculture & Environment**, v.12, n.1, p. 305-311, 2014. Available from: <http://world-food.net/category/journals/2014-issue_1/2014-issue_1-agriculture/a41.pdf>. Accessed: Oct. 20, 2014.

AZAMBUJA, A.C. **Demografia e fenologia reprodutiva de *Butia capitata* (Mart.) Becc. (*Arecaceae*) em Arambaré - Rio Grande do Sul**. 2009. 46f. Dissertação (Mestrado em Botânica) - Universidade Federal do Rio Grande do Sul, Porto Alegre, RS.

BRANCALION, P.H.S. et al. Soil-mediated effects on potential ***Euterpe edulis*** (***Arecaceae***) fruit and palmheart sustainable management in the Brazilian Atlantic Forest. **Forest Ecology and Management**, v.284, p.78-85, 2012. Available from: <http://dx.doi.org/10.1016/j.foreco.2012.07.028>. Accessed: Mar. 17, 2013. doi: 10.1016/j.foreco.2012.07.028.

BÜTTOW, M.V. et al. Conhecimento tradicional associado ao uso de butiás (***Butia*** spp., ***Arecaceae***) no Sul do Brasil. **Revista Brasileira de Fruticultura**, v.31, n.4, p.1069-1075, 2009. Available from: <http://dx.doi.org/10.1590/S0100-29452009000400021>. Accessed: Nov. 25, 2013. doi: 10.1590/S0100-29452009000400021.

HOFFMANN, J.F. et al. ***Butia*** spp. (***Arecaceae***): an overview. **Scientia Horticulturae**, v.179, p.122-131, 2014. Available from: <http://www.sciencedirect.com/article/pii/S030442381400449X>. Accessed: Sept. 12, 2014. doi: 10.1016/j.scienta.2014.08.011.

MMA (MINISTÉRIO DO MEIO AMBIENTE. **Áreas prioritárias para conservação, uso sustentável e repartição de benefícios da biodiversidade brasileira**: atualização. Portaria MMA n.9, de 23 de janeiro de 2007. Brasília: Secretaria de Biodiversidade e Florestas, 2007. 300p.

MORENO, J.A. **Clima do Rio Grande do Sul**. Porto Alegre, RS: Secretaria da Agricultura, 1961. 42p.

NATALE, W. et al. Acidez do solo e calagem em pomares de frutíferas tropicais. **Revista Brasileira de Fruticultura**, v.34, n.4, p.1294-1306, 2012. Available from: <http://dx.doi.org/10.1590/S0100-29452012000400041>. Accessed: Jan. 02, 2013. doi: 10.1590/S0100-29452012000400041.

NOBLICK, L.R. ***Butia***. In: LORENZI, H. et al. **Flora brasileira Lorenzi**: ***Arecaceae*** (palmeiras). Nova Odessa: Instituto Plantarum, 2010. 384p.

NUNES, A.M. et al. Caracteres morfológicos e físico-químicos de butiazeiro (***Butia capitata***) na região de Pelotas, Brasil. **Interciencia**, v.35, n.7, p.500-505, 2010. Available from: <http://www.interciencia.org/v35_07/50>. Accessed: Dec. 21, 2012.

OLIVEIRA, P.P.A. et al. Fertilização com N e S na recuperação de pastagem de ***Brachiaria brizantha*** cv. 'Marandu' em Neossolo Quartzarênico. **Revista Brasileira de Zootecnia**, v.34, n.4, p.1121-1129, 2005. Available from: <http://dx.doi.org/10.1590/S1516-35982005000400005>. Accessed: Oct. 10, 2013. doi: 10.1590/S1516-35982005000400005.

PODANI, J. **Multivariate data analysis in ecology and systematics**. The Hague: SPB Academic Publishing, 1994. 316p.

RAIJ, B. van. **Fertilidade do solo e manejo de nutrientes**. Piracicaba: IPNI, 2011. 420p.

RIVAS, M.; BARILANI, A. Diversidad, potencial productivo y reproductivo de los palmares de ***Butia capitata*** (Mart.) Becc. de Uruguay. **Agrociencia**, v.8, n.1, p.11-20, 2004.

ROSA, R.K. et al. Which factors explain reproductive output of ***Mauritia flexuosa*** (***Arecaceae***) in forest and savanna habitats of northern amazonia? **International Journal of Plant Sciences**, v.175, n.3, p.307-318, 2014. Available from: <http://www.jstor.org/stable/full/10.1086/674446>. Accessed: Dec. 11, 2014. doi: 10.1086/674446.

SCHACHTMAN, D.; LIU, W. Molecular pieces to the puzzle of the interaction between potassium and sodium uptake in plants. **Trends in Plant Science**, v.4, p.281-287, 1999. Available from: <http://www.sciencedirect.com/science/article/pii/S1360138599014284>. Accessed: Apr. 29, 2013. doi: 10.1016/S1360-1385(99)01428-4.

SCHWARTZ, E. et al. Avaliação de populações de ***Butia capitata*** de Santa Vitoria do Palmar. **Revista Brasileira de Fruticultura**, v.32, n.3, p.736-745, 2010. Available from: <http://dx.doi.org/10.1590/S0100-29452010005000089>. Accessed: Oct. 01, 2011. doi: 10.1590/S0100-29452010005000089.

SOUZA, L.S. et al. Efeito alelopático de capim-braquiária (***Brachiaria decumbens***) sobre o crescimento inicial de sete espécies de plantas cultivadas. **Planta Daninha**, v.24, n.4, p.657-668, 2006. Available from: <http://dx.doi.org/10.1590/S0100-83582006000400006>. Accessed: Mar. 03, 2013. doi: 10.1590/S0100-83582006000400006.

TEDESCO, M.J. et al. **Análise do solo, plantas e outros materiais**. Porto Alegre: Universidade Federal do Rio Grande do Sul, 1995. 74p.

WAECHTER, J.L. Aspectos ecológicos da vegetação de restinga do Rio Grande do Sul. **Comunicação ao Museu de Ciências: PUCRGS**, sér. Bot. v.33, p.49-68, 1985.