Comunicata Scientiae
Horticultural Journal

ORIGINAL ARTICLE
published: 07 August 2023
https://doi.org/10.14295/CS.v14.3949

Phytosociology and periods of weed interference in pineapple cv. Pérola according to spacing

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Abstract

The degree of weed interference depends on factors related to the crop, the weed community, the environment, the period of coexistence, and the available resources (water, nutrients, and light). Thus, the period of coexistence between the crop and weeds is a crucial factor in defining the potential for loss of productivity. This research aimed to carry out a phytosociological study and determine the periods of weed interference in the pineapple crop as a function of spacing. The evaluated variables of the weed community were frequency, density, abundance, importance value index, and weed dry mass. Pineapple productivity and °Brix of fruits were determined for the periods of interference. The botanical families Asteraceae and Poaceae presented the highest number of weed species. *Digitaria insularis*, *Richardia grandiflora*, *Panicum maximum*, *Cyperus rotundus*, and *Cenchrus echinatus* were the main weeds found. The pre-interference period, total interference prevention period, and critical interference prevention period were 35 days, 35 to 365 days, and 330 days after planting, respectively. The reduction in productivity due to weed interference throughout the cycle can be higher than 80% for the pineapple crop.

Keywords: Ananas comosus (L.) Merril, weed competition, yield losses

Introduction

Pineapple (*Ananas comosus* (L.) Merril) is a non-climacteric multiple fruit belonging to the family Bromeliaceae. Originating in Brazil, this species was introduced in several regions of the globe, becoming the third most consumed tropical fruit in the world, behind only bananas and citrus, and contributing with amounts higher than 20% of the global production of tropical fruits (Dahunsi et al., 2021). The main commercially produced pineapple varieties are classified into three main groups: Cayenne, Queen, and Spanish (Todkar & Patil, 2019).

This species stands out for its multiple uses, mainly regarding its fruit, which has a pleasant flavor and can be consumed fresh, dried, or processed. Its leaves and crop residues can also be used as a feed supplement for livestock. Furthermore, pineapple is used for various pharmaceutical purposes and cosmetics production (Casabar et al., 2019).

The pineapple crop is an expanding agricultural segment in Brazil, which ranks as the world's third-largest producer of this fruit (Silva et al., 2020), with an important role in the economy and the generation of employment and income and the absorption of labor in the producing regions (Ponciano et al., 2006). The world's largest pineapple producers are Costa Rica, the Philippines, Brazil, Thailand, and Indonesia, which together account for about 46% of global production (Silva et al., 2020). Globally, pineapple production is approximately 24.8 million tons (Dahunsi et al., 2021).

Pineapple is harmed by factors that can interfere with its productivity, among which stands out weed interference, which negatively affects its productivity. The importance of knowing the phytosociological indices of the species present in each environment, as well as the times and length of periods of interference, stands out in the development of integrated weed management

Received: 10 March 2022
Accepted: 10 April 2023

programs, allowing to determine the impacts that management systems and agricultural practices have on the different agricultural ecosystems (Sarkar et al., 2017).

Studies on the diversity of species in the weed community, as well as their interference in agricultural crops, aim to determine the critical periods of interaction between crops and weed communities. These periods can be defined as pre-interference period (PIP), total interference prevention period (TIPP), and critical interference prevention period (CIPP), the latter being the period in days, weeks, or months in which the crop must be free of competition from these weeds (Pitelli & Durigan, 1984).

Pineapple is a fruit crop planted in all regions of the world and Brazil ranks third in its production. Studies on weed interference are scarce and restricted to crops of greater economic interest such as soybean, cotton, corn, and rice. Thus, there is a gap to be filled with studies focused on fruit crops. These studies should be carried out in different producing regions, as well as at different times and cultivation practices, given the variability present between locations and practices adopted in different regions that cultivate these species (Carvalho et al., 2008). In this sense, this research aimed to carry out a phytosociological study of the weed community and determine the periods of weed interference on pineapple cv. Pérola, as it is one of the most commercially important cultivars in Brazil, according to the spacing under the Coastal Tablelands conditions of Alagoas.

Material And Methods

The experiment was conducted from June 2016 to December 2017 in the experimental area of the Center for Agricultural Sciences of the Federal University of Alagoas (CECA-UFAL), located at BR 104 Norte Km 85 in the municipality of Rio Largo, Alagoas. The municipality is located at latitude 9°27′ S, longitude 35°27′ W, and an altitude of 127 m. The climate is A's (tropical hot and humid with dry spring-summer and rainy autumn-winter seasons) according to Köppen, with annual rainfall ranging from 1,500 to 2,000 mm, an average temperature of 26 °C, and relative humidity of 80 % (Souza et al., 2004). The soil is classified as an Argisolic Cohesive Yellow Latosol (Oxisol), with a sandy loam texture (Santos et al., 2006). Meteorological data during the experimental period are shown in (**Figure 1**).

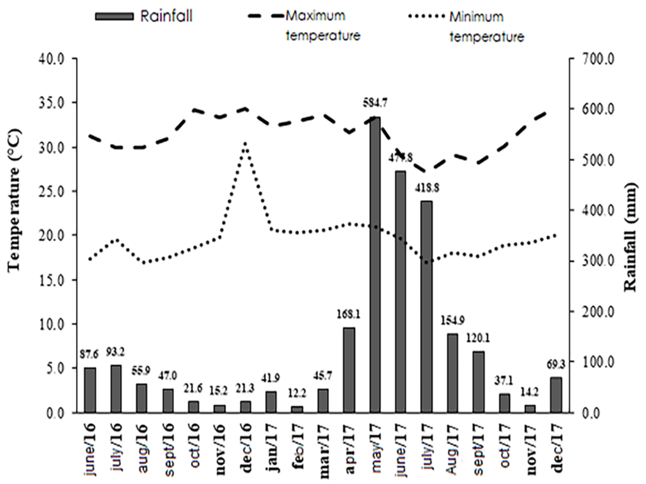

Figure 1. Monthly summary of meteorological data on rainfall (mm) and air temperature (°C) from June 2016 to December 2017, collected at the Agrometeorological Station located at the Center for Agricultural Sciences (CECA/UFAL), in the Municipality of Rio Largo, AL, Brazil, 2016/2017.
Source: Laboratory of Agrometeorology and Solar Radiometry – LARAS-UFAL (2018).

The experiment was conducted under field conditions, using a randomized block experimental design in a 2 x 20 factorial scheme with four blocks, consisting of two spacings (single row and double row) and 20 periods of interference with weeds. The periods consisted of 10 periods of control from which weeds were controlled (30, 60, 90, 120, 150, 180, 240, 300, 360, and 420 days after planting – DAP) and 10 coexistence times between pineapple and weeds, in which weeds emerged after these intervals were no longer controlled (30, 60, 90, 120, 150, 180, 240, 300, 360, and 420 DAP), as shown in (**Table 1**).

The experimental plots consisted of four rows of 6 m in length, with 20 plants per row spaced 0.90 x 0.30 m, totaling 80 plants per plot (simple row), and eight rows of 6 m in length, with 15 plants per row spaced 0.90 x 0.45 x 0.40 m, totaling 120 plants per plot. The two central rows were considered as the useful area of the plots, leaving two plants at the ends as a border. The total experimental area was 4,718 m^2 with 37,037 plants per hectare in the two spacings used.

Soil samples were taken from the experimental area at a depth of 20 cm for chemical analysis, which indicated a soil with the following chemicals: pH 6.2; 22.00 mg dm^{-3} of P; 73.00 $cmol_c$ dm^{-3} of K; 3.86 $cmol_c$ dm^{-3} Ca+Mg; 30.00 $cmol_c$ dm^{-3} of Na; 3.02 $cmol_c$ dm^{-3} of H^++Al^{3+}; 0.00 $cmol_c$ dm^{-3} of Al^{3+}; sum of bases of 4.12 $cmol_c$ dm^{-3}; CEC of 7.14 $cmol_c$ dm^{-3}; and base saturation of 58%, but base saturation was not raised to 70%.

The soil was tilled with one plowing and two cross-harrowing operations, and the rows were opened manually with hoes. Placement and topdressing fertilization were based on the soil analysis. Planting was carried out manually in June 2016, using slip and sucker seedlings of the Cultivar Pérola (Branco de Pernambuco).

Table 1. Treatments established to characterize the periods of weed interference with pineapple cv. Pérola in single and double rows. Rio Largo, AL, Brazil, 2018

TREATMENT	PERIOD OF CONTROL (Days after planting)	PERIOD OF COEXISTENCE (Days after planting)
1	0–30	
2	0–60	
3	0–90	
4	0–120	
5	0–150	
6	0–180	
7	0–240	
8	0–300	
9	0–360	
10	0–420	
11		0–30
12		0–60
13		0–90
14		0–120
15		0–150
16		0–180
17		0–240
18		0–300
19		0–360
20		0–420

Topdressing fertilizations were split into three applications in August and December 2016 and March 2017 (2, 6, and 9 months after planting).

Three applications were carried out with the fungicide thiophanate-methyl according to the product leaflet (100g cp/100 L water) to control fusariosis (*Fusarium subglutinans*) and the insecticide imidacloprid according to the product leaflet (30 g cp/100L water) by applying 50 mL of spray solution per plant to control mealybug (*Dysmicoccus brevipes*). The artificial induction of the pineapple was carried out 14 months after planting (420 days after planting – DAP), using the commercial product 2-chloroethyl) phosphonic acid (670 mL cp/ha), with 36 mL of 2-chloroethyl) phosphonic acid + 400 g of urea being applied using a 20-L capacity knapsack sprayer, with the application of 30 mL of this solution per pineapple plant.

The weed community was evaluated at the end of the periods of coexistence (30, 60, 90, 120, 150, 180, 240, 300, 360, and 420 DAP) for treatments with initial periods of weed control and 420 DAP for treatments that remained in competition with the weeds all the time.

A square frame measuring 0.25 m^2 (0.50 x 0.50 m) was randomly placed in the useful area of each plot to collect the weeds. The weeds were collected close to the ground in each sampling and identified according to family, species, and common name, determining the number of individuals. Subsequently, the plants were taken to a forced-air circulation oven at 65 °C for 72 hours, until constant dry mass.

The weed community was identified based on (Lorenzi, 2006). Frequency (F), relative frequency (Fr), density (D), relative density (Dr), abundance (A), relative abundance (Ar), and importance value index (IVI) were calculated after the identification and quantification of the species (number of plants m^{-2}) and determination of the shoot dry mass (grams $plant^{-1}$), according to the methodology proposed by (Mueller-Dombois & Ellemberg, 1974).

Frequency (F) allows evaluating the intensity of occurrence of a species in an area, density (D) allows evaluating the number of individuals of a species per unit area, and abundance (A) allows evaluating the distribution of species in the area. Relative indices, such as relative frequency (Fr), relative density (Dr), and relative abundance (Ar), provide information on the relationship of each species with others found in the area. The importance value index (IVI) is the sum of the relative indices (Fr + Dr + Ar) and expresses the importance of one species relative to another in the community.

Productivity estimate (t ha^{-1}) was carried out 540 days after planting. For this purpose, five fruits were harvested and weighed per plot, and the average fruit weight was determined, which was multiplied by the number of plants per hectare. The Brix was measured using a refractometer during this period, aiming to generate information on the quality of harvested fruits.

Density, dry mass, brix, and productivity data were submitted to analysis of variance, using the F-test at 5% probability, and regression, using the polynomial model that best fitted the biological phenomenon. The Sisvar statistical program was used for this purpose (Ferreira, 2011). For productivity, based on the regression equation, the periods of weed interference (PIP, TIPP, and CIPP) were determined for the arbitrary level of tolerance of a 5% reduction in productivity relative to the treatment maintained in the absence of weeds.

Results And Discussion

The results showed the same weed community in the pineapple crop, regardless of the spacing used. It was composed of 24 species, of which 66.67% were eudicots and 33.33% monocots. The species were distributed into 13 families, of which Asteraceae (6) and Poaceae (5) were the families with the highest expression, followed by Fabaceae and Euphorbiaceae, with two species each, and the others: Cyperaceae, Molluginaceae, Commelinaceae, Rubiaceae, Solanaceae, Turneraceae, Cleomaceae, Malvaceae, and Amaranthaceae, with only one species (**Table 2**).

Table 2. Species of weeds collected at the end of each coexistence and control period in the pineapple crop. Rio Largo, AL, CECA/UFAL, Brazil, 2018

COMMON NAME	SCIENTIFIC NAME	FAMILY	CLASS
Sourgrass	*Digitaria insularis (L.) Fedde*	Poaceae	Monocot
Guineagrass	*Panicum maximum Jacq.*		
Southern sandbur	*Cenchrus echinatus L.*		
Indian goosegrass	*Eleusine indica (L.) Gaertn.*		
Spreading liverseed grass	*Urochloa decumbens (Stapf) R.D. Webster*		
Nutgrass	*Cyperus rotundus L.*	Cyperaceae	
Green carpetweed	*Mollugo verticillata L.*	Molluginaceae	
Jio	*Commelina benghalensis L.*	Commelinaceae	
Largeflower Mexican clover	*Richardia grandiflora Gomes*	Rubiaceae	
Picão-grande	*Blainvillea dichotoma (Muuray) Stewart*	Asteraceae	Eudicot
Canela-de-urubu	*Blainvillea rhomboidea Cass.*		
Tropical whiteweed	*Ageratum conyzoides L.*		
Scarlet tasselflower	*Emilia coccinea (Sims) G. Don*		
Hairy beggarticks	*Bidens pilosa L.*		
Horseweed	*Conyza spp.*		
Calopo	*Calopogonium mucunoides Desv.*	Fabaceae	
Fourvalve mimosa	*Mimosa candollei R. Grether*		
Hyssopleaf sandmat	*Chamaesyce hyssopifolia (L.) Small*	Euphorbiaceae	
Prostrate sandmat	*Chamaesyce prostrata (Aiton) Small.*		
Jurubeba	*Solanum paniculatum L.*	Solanaceae	
Chanana	*Turnera subulata L.*	Turneraceae	
Prickly spiderflower	*Hemiscola aculeata (L.) Raf.*	Cleomaceae	
‘Ilima	*Sida cordifolia L.*	Malvaceae	
Redroot amaranth	*Amaranthus retroflexus L.*	Amaranthaceae	

The eudicot class grouped the largest number of families and species, represented by nine families and covering 16 species. In contrast, the monocot class was represented by four families and eight species. The higher specific richness of the eudicot class has also been verified in several studies on weed interference in other crops, such as sugarcane (Kuva et al., 2003), tomato (Nascente et al., 2004), peanut (Nepomuceno et al., 2007), soybean (Nepomuceno et al., 2007), and cotton (Cardoso et al., 2010).

Poaceae and Asteraceae are the two main families of weeds existing in Brazil (Oliveira & Freitas, 2008). Poaceae stands out for having several perennial species, in addition to having the ability to produce a large number of seeds, which contributes to increasing its power of dissemination and colonization of different environments, including the most hostile ones (Maciel et al., 2010). This behavior is also common to Asteraceae, one of the families of angiosperms that presents one of the highest diversities of invasive and problematic weeds, which is also due to its great dispersion of seeds favored by the wind, fast growth, short juvenile period, and high reproductive efforts (Yuan & Wen, 2018).

A higher relative frequency (Fr) of the species *Richardia grandiflora* Gomes (largeflower Mexican clover), *Panicum maximum* Jacq. (guineagrass), *Digitaria insularis* (L.) Fedde (sourgrass), *Solanum paniculatum* L. (jurubeba), and *Turnera subulata* L. (chanana), with 13.15, 12.54, 8.26, 7.95%, and 6.73%, respectively (**Table 3**).

The relative density (Dr), a variable that demonstrates the percentage of individuals of the same species relative to the total number of individuals in the community, also showed a predominance of *Digitaria insularis* (L.) Fedde (sourgrass), *Richardia grandiflora* Gomes (largeflower Mexican clover), *Panicum maximum* Jacq. (guineagrass), with values of 21.81, 14.01, 9.30, 7.50, and 7.30%, respectively. Regarding relative abundance (Ar), the species *Cyperus rotundus* L. (nutgrass), *Digitaria insularis* (L.) Fedde (sourgrass), *Blainvillea rhomboidea* Cass. (canela-de-urubu), *Cenchrus echinatus* L. (southern sandbur), and *Mollugo verticillata* L. (green carpetweed), with 11.48, 11.13, 8.50, 8.33, and 7.12%, respectively.

Table 3. Frequency (F), relative frequency (Fr), density (D), relative density (Dr), abundance (A), relative abundance (Ar), and importance value index (IVI) of weed species collected in the experimental area of pineapple in single spacing (0.90 x 0.30 m), 2018

SPECIES	F	Fr (%)	D (pl/m²)	Dr (%)	A	Ar (%)	IVI
Digitaria insularis (L.) Fedde	35.53	8.26	22.95	21.81	16.15	11.13	41.19
Richardia grandiflora Gomes	56.58	13.15	14.74	14.01	6.51	4.49	31.64
Panicum maximum Jacq.	53.95	12.54	9.79	9.30	4.54	3.13	24.97
Cyperus rotundus L.	11.84	2.75	7.89	7.50	16.67	11.48	21.74
Cenchrus echinatus L.	15.79	3.67	7.63	7.25	12.08	8.33	19.25
Urochloa decumbens (Stapf) R.D. Webster	21.05	4.89	7.68	7.30	9.13	6.29	18.48
Eleusine indica (L.) Gaertn	23.68	5.50	6.05	5.75	6.39	4.40	15.66
Solanum paniculatum L.	34.21	7.95	4.42	4.20	3.23	2.23	14.38
Blainvillea dichotoma (Muuray) Stewart	21.05	4.89	4.21	4.00	5.00	3.45	12.34
Turnera subulata L.	28.95	6.73	3.00	2.85	2.59	1.79	11.36
Blainvillea rhomboidea Cass.	3.95	0.92	1.95	1.85	12.33	8.50	11.27
Mollugo verticillata L.	3.95	0.92	1.63	1.55	10.33	7.12	9.59
Conyza spp. (L.) Cronquist	5.26	1.22	1.95	1.85	9.25	6.37	9.45
Ageratum conyzoides L.	18.42	4.28	2.00	1.90	2.71	1.87	8.05
Mimosa candollei R. Grether	21.05	4.89	1.42	1.35	1.69	1.16	7.41
Emilia coccinea (Sims) G. Don	15.79	3.67	1.42	1.35	2.25	1.55	6.57
Bidens pilosa L.	6.58	1.53	1.32	1.25	5.00	3.45	6.22
Chamaesyce prostrata (Aiton) Small.	3.95	0.92	0.84	0.80	5.33	3.67	5.39
Calopogonium mucunoides Desv.	13.16	3.06	0.95	0.90	1.80	1.24	5.20
Commelina benghalensis L.	10.53	2.45	1.00	0.95	2.38	1.64	5.03
Hemiscola aculeata (L.) Raf.	5.26	1.22	0.89	0.85	4.25	2.93	5.00
Amaranthus retroflexus L.	10.53	2.45	0.89	0.85	2.13	1.46	4.76
Chamaesyce hyssopifolia (L.) Small	6.58	1.53	0.37	0.35	1.40	0.96	2.84
Sida cordifolia L.	2.63	0.61	0.21	0.20	2.00	1.38	2.19

The importance value index (IVI), which consists of the sum of the relative frequency, relative density, and relative abundance of the weed species, explained the prominence of *Digitaria insularis* (L.) Fedde (sourgrass), *Richardia grandiflora* Gomes (largeflower Mexican clover), *Panicum maximum* Jacq. (guineagrass), *Cyperus rotundus* L. (nutgrass), and *Cenchrus echinatus* L. (southern sandbur), with 41.19, 31.64, 24.97, 21.74, and 19.25%, respectively. These species were responsible for composing 46.26% of the IVI in single-row spacing in the pineapple crop.

The cultivation of pineapple in double rows showed a behavior for the relative frequency (Fr) similar to that observed in single spacing, with higher Fr for the species *Richardia grandiflora* Gomes (largeflower Mexican clover) (15.95%) and *Panicum maximum* Jacq. (guineagrass) (10.96%), followed by *Urochloa decumbens* (Stapf) R.D. Webster (Spreading liverseed grass), *Digitaria insularis* (L.) Fedde (sourgrass), and *Solanum paniculatum* L. (jurubeba), with 7.31, 6.98, and 6.31%, respectively (**Table 4**).

Digitaria insularis (L.) Fedde (sourgrass) stood out regarding the relative density (Dr) (37.68%) and relative abundance (29.07%), showing better results than other weeds. This species represents a serious problem for annual and perennial crops in South America, including resistance to herbicides such as glyphosate (Takano et al., 2020).

The importance value index (IVI) of weeds in the double rows of pineapple evidenced the importance of the same species observed in the single rows, with *Digitaria insularis* (L.) Fedde (sourgrass), *Richardia grandiflora* Gomes (largeflower Mexican clover), *Panicum maximum* Jacq. (guineagrass), *Cyperus rotundus* L. (nutgrass), and *Cenchrus echinatus* L. (southern sandbur) with IVI values of 73.73, 39.95, 23.34, 18.81, and 17.03%, respectively (Table 4). However, these five species were responsible for 57.62% of the final composition of the importance value index at this spacing, a result higher than that verified in single-row spacing.

The analysis of the weed community density in single-row spacing in response to the coexistence periods (**Figure 2**) showed that the weeds reached the maximum density (471 plants m^{-2}) 30 days after planting (DAP) of the pineapple crop, reducing to 10 plants m^{-2} at 420 days after planting, which corresponds to the control treatment.

The maximum weed density in double-row spacing (**Figure 3**) was obtained 90 days after planting, with 619 plants m^{-2}. The control treatment (420 DAP) had a density of 8 plants m^{-2}. Higher values of weed density in the initial period of development of the crop in double-

Table 4. Frequency (F), relative frequency (Fr), density (D), relative density (Dr), abundance (A), relative abundance (Ar), and importance value index (IVI) of weed species collected in the experimental area of pineapple in double spacing (0.90 x 0.45 x 0.40), 2018

SPECIES	F	Fr (%)	D (pl/m²)	Dr (%)	A	Ar (%)	IVI
Digitaria insularis (L.) Fedde	27.63	6.98	45.63	37.68	41.29	29.07	73.73
Richardia grandiflora Gomes	63.16	15.95	21.74	17.95	8.60	6.06	39.95
Panicum maximum Jacq.	43.42	10.96	10.05	8.30	5.79	4.08	23.34
Cyperus rotundus L.	13.16	3.32	7.16	5.91	13.60	9.58	18.81
Cenchrus echinatus L.	18.42	4.65	6.95	5.74	9.43	6.64	17.03
Eleusine indica (L.) Gaertn	11.84	2.99	4.74	3.91	10.00	7.04	13.94
Urochloa decumbens (Stapf) R.D. Webster	28.95	7.31	3.53	2.91	3.05	2.14	12.37
Blainvillea dichotoma (Muuray) Stewart	21.05	5.32	3.05	2.52	3.63	2.55	10.39
Blainvillea rhomboidea Cass.	6.58	1.66	2.42	2.00	9.20	6.48	10.14
Solanum paniculatum L.	25.00	6.31	1.84	1.52	1.84	1.30	9.13
Calopogonium mucunoides Desv.	19.74	4.98	1.68	1.39	2.13	1.50	7.88
Ageratum conyzoides L.	10.53	2.66	2.00	1.65	4.75	3.35	7.65
Emilia coccinea (Sims) G. Don	13.16	3.32	1.74	1.43	3.30	2.32	7.08
Turnera subulata L.	11.84	2.99	1.53	1.26	3.22	2.27	6.52
Mimosa candollei R. Grether	17.11	4.32	1.00	0.83	1.46	1.03	6.17
Hemiscola aculeata (L.) Raf.	13.16	3.32	1.16	0.96	2.20	1.55	5.83
Mollugo verticillata L.	9.21	2.33	1.26	1.04	3.43	2.41	5.78
Sida cordifolia L.	15.79	3.99	0.79	0.65	1.25	0.88	5.52
Bidens pilosa L.	5.26	1.33	0.95	0.78	4.50	3.17	5.28
Commelina benghalensis L.	7.89	1.99	0.79	0.65	2.50	1.76	4.41
Amaranthus retroflexus L.	5.26	1.33	0.74	0.61	3.50	2.46	4.40
Chamaesyce hyssopifolia (L.) Small	3.95	1.00	0.21	0.17	1.33	0.94	2.11
Conyza spp. (L.) Cronquist	2.63	0.66	0.11	0.09	1.00	0.70	1.46
Chamaesyce prostrata (Aiton) Small.	1.32	0.33	0.05	0.04	1.00	0.70	1.08
TOTAL	**396.1**	**100.0**	**121.1**	**100.0**	**142.0**	**100.0**	**300.0**

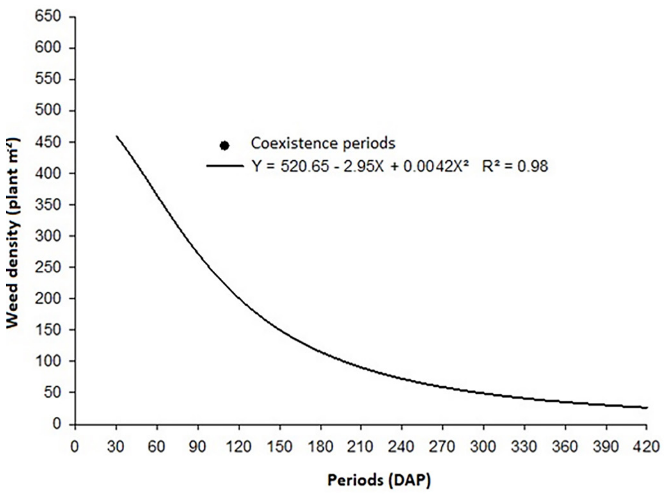

Figure 2. Weed density in single-row spacing (0.90 x 0.30 m) in response to coexistence periods.

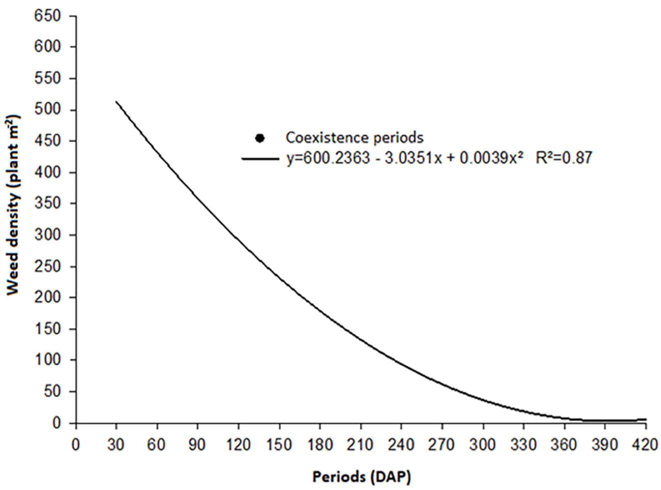

Figure 3. Weed density in double-row spacing (0.90 x 0.45 x 0.40) in response to coexistence periods.

row spacing are related to their higher emergence due to a higher space available (Vitorino et al., 2017).

The results show a reduction in the population density of weeds at the end of the pineapple crop cycle in both spacings. It is probably due to the non-uniformity of the germination flow, the senescence of some short-cycle annual species, and the predominance of larger plants and higher leaf architecture. In addition, the low weed density allowed the emergence of new individuals, which developed and increased the weed dry mass, accumulated throughout the crop cycle.

Weed dry mass in single-row spacing in response to increasing periods of coexistence between the pineapple crop and the weed community (**Figure 4**) showed a temporal increase, going from 106 g m^{-2} at 30 days after planting the crop to 1466 g m^{-2} at 420 DAP.

The double-row spacing (**Figure 5**) had a behavior of the weed dry mass similar to that verified in the single-

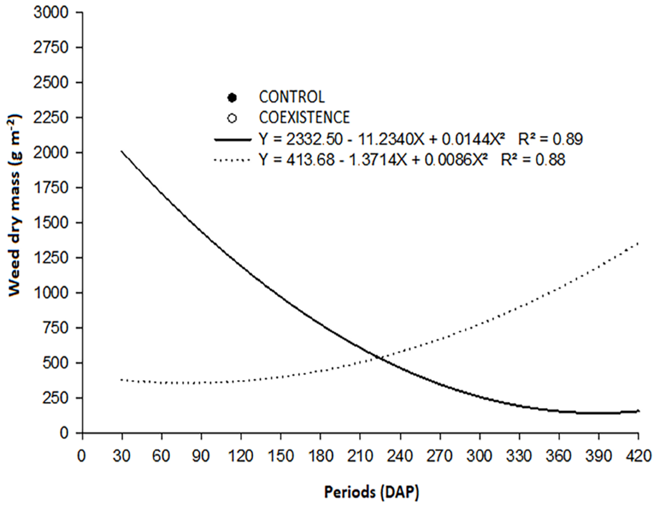

Figure 4. Weed dry mass in the control and coexistence in single-row spacing (0.90 x 0.30 m).

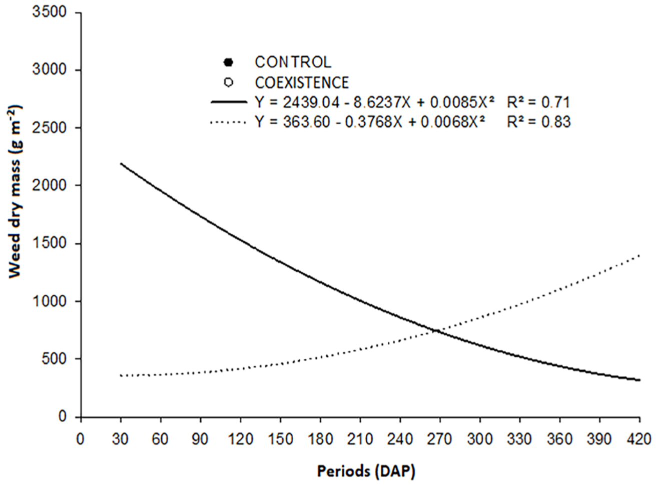

Figure 5. Weed dry mass in the control and coexistence in double-row spacing (0.90 x 0.45 x 0.40).

row spacing at the same periods of coexistence. The weed dry mass in this spacing increased from 126 g m^{-2} at 30 days to 1566 g m^{-2} at 420 DAP.

Results similar to those observed here for the behavior of density and dry mass of weeds are also reported in the literature in other crops, such as rice (Silva & durigan, 2006), bean (Salgado et al., 2007), watermelon (Silva et al., 2013), and sorghum (Rosa et al., 2018).

Importantly, the occurrence of inter-and intraspecific competition intensifies as the weed community density and development increase, notably weeds that germinated and emerged right at the beginning of the pineapple crop cycle, which grows relatively slowly in the first months, leading to the dominance of taller and more developed weed species to the detriment of smaller species, which are suppressed or die. This behavior of the weed community illustrates the inversely proportional correlation of the reduction in density with an increase in weed dry mass for the periods of development of the pineapple crop (Radosevich & Holt, 1996; Merino et al., 2019).

In the present study, the main weed species that justify this correlation are *Digitaria insularis*, *Richardia grandiflora*, *Panicum maximum*, and *Urochloa decumbens*, which comprised the lowest density and highest dry mass accumulation. Also noteworthy is the cultural control exerted by the pineapple crop, which, by shading the inter-rows, made it difficult to establish populations of some species such as *Cyperus rotundus*, *Cenchrus echinatus*, and *Eleusine indica*.

An adjustment by the logistic sigmoidal model is observed for the productivity curves of pineapple as a function of the periods of weed control and coexistence (**Figure 6**). Considering a 5% loss in crop productivity, regardless of the used spacing, the coexistence with weeds began to affect the pineapple (pre-interference period – PIP) at 35 days after planting, extending the control until 365 days after planting (total interference prevention period – TIPP). The critical interference prevention period – CIPP was characterized by the interval of 35 to 365 days after planting the crop, totaling 330 days or 11 months, in which the pineapple crop under the experimental conditions should not suffer interference from weeds, that is, the pineapple crop must be with no weeds during this period.

Weed competition is negatively reflected in the productivity of crops, especially when it occurs during the period from planting to flower differentiation and, even more intensely when this competition coincides with the first 5 or 6 months of crop development (Reinhardt & Cunha, 1984; Singh et al., 2016).

The losses generated by the presence of weeds in the pineapple plantation were quite expressive under the conditions of this study. In percentage terms, losses were higher than 80% relative to the control, which was maintained free of weed interference throughout the pineapple crop cycle.

Importantly, different productivity reduction potentials and the extent of losses caused by weed communities are related to and dependent on several factors, such as the specific composition of this community, weed emergence relative to the crop emergence, infestation density in the cultivation area, intensity, growth stage of the crop relative to the period of highest competition, and infestation duration (Singh et al., 2016). The interference imposed by weeds present in the community is dependent on the intrinsic growth potential of each species and the interference

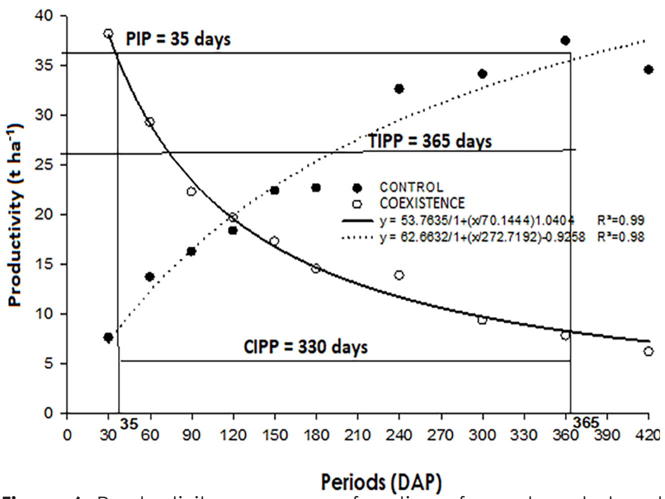

Figure 6. Productivity curves as a function of weed control and coexistence periods.

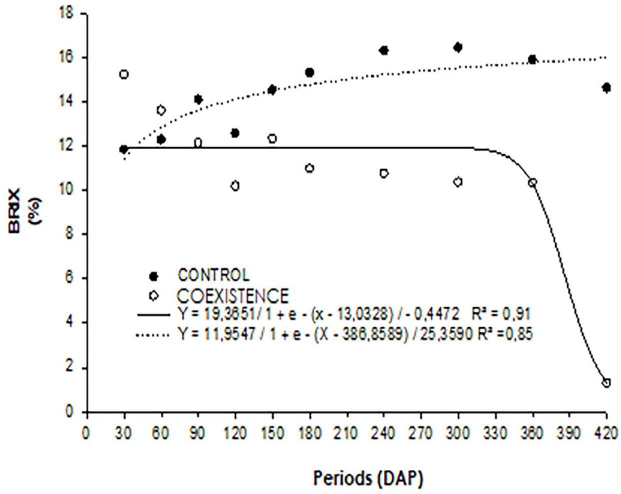

Figure 7. Soluble solids (Brix) curves as a function of weed control and coexistence periods.

interactions between individuals of this weed community (Bachega et al., 2013).

The soluble solids (Brix) of pineapple fruits strongly responded to the period of coexistence with the weeds, with marked losses compared to the control treatments, mainly at 420 DAP (**Figure 7**). This variable reached mean values of 14.15° and 8.26° for the control treatment and coexistence with weeds, respectively.

The reduction in the soluble solid's concentration in treatments with weed interference is due to the competition for nutrients and mainly light. The presence of weeds such as *Panicum maximum*, *Urochloa decumbens*, and *Solanum paniculatum*, which are larger than pineapple plants, promotes the extinction of photosynthetically active luminosity throughout the canopy of this crop, reducing the photosynthetic rate and, consequently, the production of photoassimilates (Jiang et al., 2017).

Conclusions

The weed flora did not change as a function of the adopted spacings.

Digitaria insularis, *Richardia grandiflora*, *Panicum maximum*, *Cyperus rotundus*, and *Cenchrus echinatus* are the most important weed species for pineapple.

The adoption of single or double rows does not change the pineapple interference periods.

The pre-Interference period (PIP) was 35 days, the total interference prevention period (PIPP) was 35 to 365 days, and the critical interference prevention period (CIPP) was 330 days in the two adopted spacings.

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Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.