Dynamics of the weed community during pineapple growth in the Brazilian semi-arid region

Dinámica de la comunidad de malezas a lo largo del crecimiento de piña en la región semiárida brasileña

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ABSTRACT

The pineapple belongs to the family Bromeliaceae and is a slow-growing succulent monocot with a reduced superficial root system. For this reason, the interference of weeds in competition with this crop can cause significant losses to the production. One of the bases to elaborate a control strategy is the knowledge of the diversity of weeds that occur in the cultivated areas. The objective of this study was to identify the weed community during pineapple growth in a semi-arid climate region of Brazil. Weeds were collected 60, 120, 180, 240, 300, and 360 days after planting (DAP) the pineapple. These collections were made in three different plots every two months until floral induction, composed of three pineapple cultivars. The weed community found in the irrigated pineapple field, in semi-arid climate conditions, was mostly composed by species belonging to the families Amaranthaceae, Asteraceae, Convolvulaceae, Fabaceae, Malvaceae, and Poaceae. The highest diversity of weed species was found at 60 DAP. The species *Ipomoea acuminata* was present throughout the development of the pineapple and showed the highest importance value index in most of the periods evaluated during the pineapple growth.

Key words: *Ananas comosus* var. comosus, phytosociological survey, IAC Fantastic, Perola, Smooth Cayenne.

RESUMEN

La piña pertenece a la familia Bromeliaceae y es una monocotiledónea suculenta de crecimiento lento con un sistema radical superficial reducido. Por este motivo, la interferencia de las malezas en competencia con el cultivo puede provocar pérdidas importantes para la producción. Una de las bases para la elaboración de una estrategia de control es el conocimiento de la diversidad de malezas que se dan en las áreas cultivadas. El objetivo de este trabajo fue identificar la comunidad de malezas durante el crecimiento de la piña en una región de clima semiárido de Brasil. Las malezas se recolectaron 60, 120, 180, 240, 300 y 360 días después de la siembra (DDS) de la piña. Estas recolecciones se realizaron en tres parcelas diferentes cada dos meses hasta la inducción floral, compuestas por tres cultivares de piña. La comunidad de malezas que se encontró en el campo de piña irrigado, en condiciones climáticas semiáridas, estaba compuesta principalmente por especies pertenecientes a las familias Amaranthaceae, Asteraceae, Convolvulaceae, Fabaceae, Malvaceae y Poaceae. La mayor diversidad de especies de malezas se encontró a los 60 DDS. La especie *Ipomoea acuminata* estuvo presente durante todo el desarrollo de la piña y mostró el índice de valor de importancia más alto en la mayoría de los períodos evaluados durante el crecimiento de la piña.

Palabras clave: *Ananas comosus* var. comosus, estudio fitosociológico, IAC Fantástico, Perola, Cayena lisa.

Introduction

The pineapple (*Ananas comosus* var. comosus) is the third most cultivated tropical fruit in the world, and Brazil is the third largest producer with 2.2 million t in an area of 62,116 ha (FAO, 2018).

The semi-arid zones in the world occupy around 15% of the global land surface, including the hot and cool semi-arid regions. These zones are characterized by low average annual rainfall which corresponds to between one-fifth and one-half of the potential evapotranspiration. Hot semi-arid regions have a mean annual temperature above 18°C (Scholes, 2020); therefore, the Brazilian semi-arid zone is classified as hot semi-arid.

As a plant with slow vegetative growth, small size and superficial root system, the pineapple suffers intense competition with weeds, especially in the first months after planting. This contributes to delay the development of the

crop and reduces productivity and quality of the fruits (Maia *et al.*, 2012; Maia *et al.*, 2018).

Weeds compete with agricultural crops for water, light and nutrients, and can release allelopathic substances that inhibit crop growth (Zimdahl, 2008; Ghanizadeh *et al.*, 2014; Maia *et al.*, 2018). Additionally, they can host pests and diseases, thus, hindering crop management and harvesting as well as impairing the quality of the market-able product (Swanton *et al.*, 2015; Mureithi *et al.*, 2017; Ocimati *et al.*, 2018).

The degree of weed interference depends on the weed community, environment and the period and time of the crop's coexistence with weeds. In this sense, it is essential to identify the species present in the cultivation areas and determine the main periods of interference, indicating the appropriate time to carry out weed control in the fields (Zimdahl, 2008; Swanton *et al.*, 2015; Marques *et al.*, 2017).

The knowledge of the diversity of weeds in the cultivation areas is the basis for the elaboration of a weed control proposal. In addition to the identification of weed species, a survey needs to include a quantitative analysis of these species, *i.e.,* a phytosociological study or method (Braun-Blanquet, 1979; Swanton *et al.*, 2015). This method provides data that are specific to the species present, such as frequency, density, and abundance, and their relationship with the whole weed population. This tool allows making many inferences about the weed in question to define what will be done, how and when.

A phytosociological study for weed management is justified as infestation conditions are varied and the management possibilities are diverse (Sarmento *et al.*, 2017; Santos *et al.*, 2019) since the establishment and dynamics of a weed community depend on edaphoclimatic conditions, crop practices, seed bank, etc. (Adegas *et al.*, 2010; Swanton *et al.*, 2015; Korres *et al.*, 2019). As phytosociological studies in irrigated crops in the hot semi-arid region showing weed community fluctuations along the year are scarce, especially in the pineapple crop, the objective of this study was to identify the dynamics of the weed community during pineapple growth in a semi-arid climate region of Brazil.

Materials and methods

The experiment was carried out in the municipality of Janaúba, MG, under the geographical coordinates of 15°43'48" S, 43°19'23" W and 533 m a.s.l. The region has "Aw" climate (Sá Júnior *et al.*, 2012). The climatic conditions during the period of the experiment are shown in Figure 1.

Weeds were collected 60, 120, 180, 240, 300, and 360 days after planting (DAP) of pineapple, in a plot composed of three pineapple cultivars (Perola, IAC Fantastic, and Smooth Cayenne) planted in double rows spaced 1.2 x 0.3 x 0.20 m, totaling 66,666 plants ha^{-1}. The three cultivars occupied the same proportion in the sample plot.

The area was prepared by plowing at a depth of 0.40 m with two harrowings, furrowing and pre-planting fertilization with chemical and organic fertilizers. Before planting, a composite soil sample from the 0-20 cm layer was collected to determine the soil chemical properties.

The soil of the area was an eutrophic Red Latosol (Oxisol), medium/clayey texture (EMBRAPA, 2006), and the physical and chemical properties in the 0-20 cm layer were as follows: pH(H$_2$O) = 6.5; organic matter = 15 g kg^{-1}; P = 8 mg dm^{-3}, K = 374 mg dm^{-3}, Ca^{2+} = 3.2 cmol$_c$ dm^{-3}; Mg = 1.2 cmol$_c$ dm^{-3}; Al^{3+}= 0 cmol$_c$ dm^{-3}; H+Al = 1.4 cmol$_c$ dm^{-3}; Zn = 1.5 mg dm^{-3}; Fe = 23.4 mg dm^{-3}; Mn = 33.3 mg dm^{-3}; Cu = 0.9 mg dm^{-3}; B = 0.3 mg dm^{-3}; sum of base cations (SB) = 5.5 cmol$_c$ dm^{-3}; base saturation (V) = 80%; aluminum saturation (m) = 0%; effective cation exchange capacity (CEC) = 5.5 cmol$_c$ dm^{-3}; total CEC = 6.8 cmol$_c$ dm^{-3} and remaining phosphorus (P- rem) = 33.3 mg L^{-1}.

The crop was planted in August 2017 at a depth of 0.20 m and, after furrowing, a micro-sprinkler irrigation system was implemented. After the adjustments and adaptations of the irrigation system, preliminary tests were carried out to determine the flow rate of the micro-sprinklers and the water distribution uniformity coefficient. Slip, slip-sucker, and sucker propagules were used for planting with the same kind of propagule in the same plot to maintain crop uniformity.

For weed collection, the standard method of the square inventory (0.5 m x 0.5 m) was employed, randomly thrown once in the useful area of each plot. The square was thrown three times per collection, collecting all plants as described by several authors (Curtis & McIntosh, 1950; Odum, 1971; Braun-Blanquet, 1979; Swanton *et al.*, 2015). Only the weed shoots were collected. The identification of the species in each square was carried out by comparison, according to the classification of Lorenzi (2008) and quantified by family, genus and species, with later determination of the phytosociological values.

The samples of each species were then packed in paper bags and put into a forced air circulation oven (model TE 394/3, Tecnal, Piracicaba, Brazil) at 65°C for 72 h, for later weighing of the dry matter mass on a precision scale,
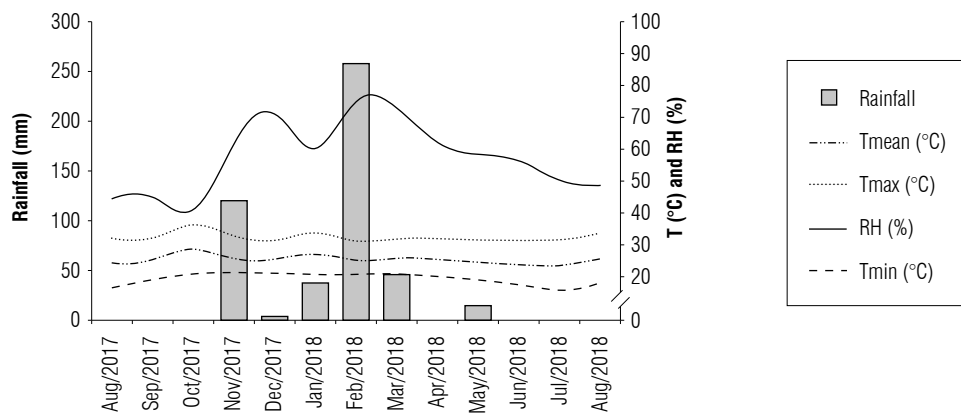
FIGURE 1. Rainfall, minimum, maximum, and mean temperatures (T, °C) and relative humidity (RH, %) during the experiment.

with the result expressed in g. The total dry matter of the weed community was used to adjust a growth model and estimate the absolute and relative growth rate of the weed community as a function of growth sampling dates in the pineapple crop (Hunt, 2012; Soltani & Sinclair, 2012).

The number of individuals per species in each plot and the total number per collection were determined. From the identification and counting of species, we carried out the calculations and descriptive analysis of the following phytosociological variables: frequency (FR), density (DE), abundance (AB), relative frequency (FRR), relative density (DER), relative abundance (ABR), relative dominance (DOR), importance value index (IVI) and coverage value index (CVI) (Mueller-Dombois & Ellenberg, 1974; Braun-Blanquet, 1979; Tuffi Santos *et al.*, 2004).

The relative indexes were used to calculate the importance value indexes expressed as constants. To perform the calculations, the following formulas were used:

FR = number of squares containing the species / total number of squares obtained;

FRR = FR of the species × 100 / total frequency of all species;

DE = total number of individuals per species / total area occupied by the squares;

DER = DE of the species × 100 / total density of all species;

AB = total number of individuals per species / total number of squares containing the species;

ABR = AB of the species × 100 / total abundance of all species;

DOR = biomass of the species / Σ of total biomass of all species × 100;

IVI = FRR + DER + ABR;

CVI = DOR + DER.

All results were presented using descriptive statistics done with Microsoft Excel. The graphs were made using the software Sigma Plot 12.5 Demo Version.

Results and discussion

Throughout the pineapple growth cycle, the weed community obtained by the surveys showed a distribution of 22 species and 12 families. Among the species, a population of 68.2% of dicotyledonous plants and 31.8% of monocotyledonous plants was found (Tab. 1). As for the carbon fixation process, 54.6% were plants with C_3 metabolism and 45.4% were with C_4 metabolism. No plants with CAM metabolism were observed.

Regarding the number of species, among the dicots, the families Amaranthaceae, Asteraceae, Convolvulaceae, Fabaceae and Malvaceae stood out. These families corresponded to 45.5% of the identified species. Among the monocotyledonous plants, the family Poaceae stood out, with five species, equivalent to 22.7% of the identified species (Tab. 1). Sarmento *et al.* (2017) cultivated pineapple under similar climatic conditions in the spring-summer period of Brazil and identified ten weed species distributed in nine genera and eight families, with the families Euphorbiaceae and Poaceae standing out, with two individuals each. In the autumn-winter period, nine species, seven genera and six families were identified, with Euphorbiaceae and Poaceae standing out again with three and two individuals, respectively.

Model *et al.* (2008) reported that 40 weed species were identified in an area of pineapple cultivation in Maquiné (RS, Brazil), a region with a humid subtropical climate. The authors highlighted the presence of the families Asteraceae

(27.5%), Poaceae (25%), Cyperaceae (7.5%), Fabaceae (7.5%), Apiaceae (5%) and others with 2.5% each. In the following year, Model and Favreto (2009) identified 74 weed species belonging to 25 botanical families, with the families Poaceae (23%), Asteraceae (28%), Cyperaceae (5%), and Fabaceae (5%) standing out. Similar results were found in pineapple areas located in the humid tropics of India (Kerala) (Girija & Menon, 2019).

The high number of species and families shows the great botanical diversity of the weed flora with the potential to compete with the pineapple. The favorable climate, soil productive potential, pH, and nutrient corrections are factors that can influence the diversity of species and the development of weeds (Model & Favreto, 2009). In addition to these factors is the use of irrigation, which allows for the germination and growth of weeds to occur in all months of the year.

The Asteraceae and Poaceae families have been commonly reported and found in several weed studies (Jakelaitis *et al.*, 2003; Erasmo *et al.*, 2004; Murphy *et al.*, 2006; Duarte *et al.*, 2007; Maia *et al.*, 2018). This is certainly because they show high dissemination and colonization of different environments (Pedrotti & Guarim Neto, 1998).

Most of the species of the family Poaceae are perennial and produce large amounts of seeds, which considerably increases their dissemination power and the colonization of different types of environments, even under adverse conditions (Holm *et al.*, 1991).

The species of the family Asteraceae have similar characteristics and are easily established in different environments, being the first weeds in the cultivation area after soil preparation (Lorenzi, 2008). The species of this family are considered among the most infesting plants of annual and perennial crops (Holm *et al.*, 1991; Zimdahl, 2008). The identification of weed species is important and necessary, as each species has the potential to establish itself in the area and can interfere differently, depending on the crop (Korres *et al.*, 2019).

The dry matter of the weed community increased during the entire survey period. There was an exception at 180 d, with dry matter of 1,780.58 g m^{-2}, *i.e.*, slightly lower than

TABLE 1. Botanical and photosynthetic classification of weeds found during pineapple cultivation in the semi-arid climate region of Brazil.

Family	Genus	Scientific name	Class	Photosynthesis
Malvaceae	*Sida*	*S. rhombifolia*		C_3
Amaranthaceae	*Amaranthus*	*A. viridis*		C_4
	Bidens	*B. pilosa*	Magnoliopsida	C_3
Apocynaceae	*Calotropis*	*C. procera*		C_3
Asteraceae	*Galinsoga*	*G. parviflora*		C_4
	Acanthospermum	*A. hispidum*		C_3
Commelinaceae	*Commelina*	*C. benghalensis*	Liliopsida	C_3
Convolvulaceae	*Merremia*	*M. aegyptia*		C_3
	Ipomoea	*I. acuminata*		C_3
Euphorbiaceae	*Euphorbia*	*E. hirta*	Magnoliopsida	C_4
Fabaceae	*Senna*	*S. obtusifolia*		C_3
	Mimosa	*M. pudica*		C_4
Malvaceae	*Malva*	*M. sylvestris*		C_3
	Brachiaria	*B. plantaginea*		C_4
	Sorghum	*S. bicolor*		C_4
	Cenchrus	*C. echinatus*		C_4
Poaceae	*Panicum*	*P. maximum*	Liliopsida	C_4
	Eleusine	*E. indica*		C_3
	Brachiaria	*B. decumbens*		C_3
	Dactyloctenium	*D. aegyptum*		C_4
Portulacaceae	*Portulaca*	*P. oleracea*	Magnoliopsida	C_4
Turneraceae	*Turnera*	*T. subulata*		C_3

the previously evaluated period. As a result, the maximum accumulated dry matter (3,436.77 g m^{-2}) of the weed community was reached 360 DAP (Tab. 2). This is probably due to the greater adaptation and competition potential of these species compared to the pineapple plants.

Weed species can harm the crop by competing for the essential resources for plant development (water, light, and nutrients), especially nutrient extraction. Considering the highest value of dry matter obtained at 360 DAP (3,436.77 g m^{-2} = 34.4 t ha^{-1}), it can be estimated that 515.5 kg of N

TABLE 2. Dry matter (DM, g m^{-2}) and number of individuals per species (NIS) of weeds found during pineapple cultivation in the semi-arid climate region of Brazil.

Sampling moments					
60 d after planting			**120 d after planting**		
Weed	**DM**	**NIS**	**Weed**	**DM**	**NIS**
Amaranthus viridis	92.26	7	*Amaranthus viridis*	49.45	6
Brachiaria plantaginea	3.45	92	*Calotropis procera*	52.6	7
Cenchrus echinatus	53.59	5	*Cenchrus echinatus*	206.2	26
Commelina benghalensis	42.3	5	*Galinsoga parviflora*	61.12	8
Eleusine indica	15.4	3	*Ipomoea acuminata*	1173.5	35
Ipomoea acuminata	849.8	16	*Merremia aegyptia*	156.3	3
Malva sylvestris	10.36	3	*Panicum maximum*	125.9	5
Merremia aegyptia	264.05	14	*Portulaca oleracea*	31.2	6
Mimosa pudica	53.3	9	*Sida rhombifolia*	37.9	5
Senna obtusifolia	12.69	53			
Sida rhombifolia	115.23	6			
Sorghum bicolor	233.9	2			
Turnera subulata	37.6	2			
Total	1783.93	217		1894.2	101
180 d after planting			**240 d after planting**		
Weed	**DM**	**NIS**	**Weed**	**DM**	**NIS**
Amaranthus viridis	13.9	5	*Amaranthus viridis*	36.5	26
Cenchrus echinatus	128	18	*Bidens pilosa*	0.06	1
Euphorbia hirta	43.92	3	*Commelina benghalensis*	3.62	4
Ipomoea acuminata	1395	41	*Ipomoea acuminata*	1718.9	37
Malva sylvestris	35.1	7	*Malva sylvestris*	18.66	4
Merremia aegyptia	79.6	12	*Merremia aegyptia*	215.8	13
Mimosa pudica	31.96	3			
Sida rhombifolia	53.1	2			
Total	1780.58	91		1993.54	85
300 d after planting			**360 d after planting**		
Weed	**DM**	**NIS**	**Weed**	**DM**	**NIS**
Amaranthus viridis	5.6	2	*Brachiaria decumbens*	1021	69
Cenchrus echinatus	199.5	6	*Ipomoea acuminata*	1997.21	27
Ipomoea acuminata	1937.8	41	*Acanthospermum hispidum*	6.2	1
Merremia aegyptia	142.5	6	*Bidens pilosa*	0.9	1
Calotropis procera	369.4	1	*Malva sylvestris*	85.8	8
			Dactyloctenium aegyptum	315.3	39
			Senna obtusifolia	10.36	3
Total	2654.8	56		3,436.77	148

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(1.5%), 61.85 kg of P (0.18%), 580.79 kg of K (1.69%), 154.6 kg of Ca (0.45%), 164.96 kg of Mg (0.48%), and 68.73 kg of S (0.20%) are extracted from the soil by weeds at the expense of pineapple plants.

Those values were estimated based on a study by Souza *et al.* (1999), who evaluated the levels of macro and micronutrients and the C:N ratio of various weed species of the families Commelinaceae, Poaceae, Cyperaceae, Amaranthaceae, Compositae, Convolvulaceae, Euphorbiaceae, Malvaceae, and Rubiaceae.

The accumulation of dry matter in the weed community over the periods of evaluation showed exponential growth, with an increase in the amount of dry matter accumulated as a function of time. The highest dry matter value ($3,436.77$ g m^{-2}) was observed on the last collection date. An increment of 0.0128 g per d was observed from the sampling times of the weed community in the pineapple crop (Fig. 2A).

From the adjusted model, the absolute and relative growth rates of the weed community were estimated. The absolute growth rate (AGR) is a physiological index used to obtain the average growth speed over the observation period (Hunt, 2012; Soltani & Sinclair, 2012). On the other hand, the relative growth rate (RGR) expresses the increase in dry matter per unit of the initial weight over a period of time (g g^{-1}/d) (Hunt, 2012; Soltani & Sinclair, 2012).

The relative and absolute growth rates showed the same exponential behavior observed for dry matter accumulation (Fig. 2B). The maximum observed AGR value was 22.29 g m^{-2}/d, while the maximum observed RGR was 0.00644 g g^{-1} m^{-2}/d, both observed on the last collection date.

The growth rate is an important feature to describe the ecological strategies of plants. Weeds, in general, show rapid initial growth, allowing them to absorb mineral nutrients and develop in environments without limitations, thus, being able to stabilize in the environment (Ravindra *et al.*, 2008; Korres *et al.*, 2019).

In the analysis of plant growth, the absolute growth rate usually shows an increase until it reaches a peak, with a subsequent fall. The relative growth rate, in turn, decreases over the time of collection. The higher the values of this rate and the longer the time it remains high, the greater the competition capacity of the species in question. Therefore, the weed community showed great competitive capacity with the studied species (pineapple) and that this capacity increased over time. This indicates that, the longer the pineapple is subjected to weed competition, the greater the competition capacity of these species.

During the pineapple growth period, the species that showed the best carbon fixation capacity, in terms of dry matter, were *Ipomoea acuminata*, *Merremia aegyptia*, and *Brachiaria decumbens* (Tab. 2). The other species collected showed the lowest number of individuals and lower dry matter values than those previously mentioned. However, these values can be considered representative since the capacity to extract resources from the soil tends to increase possibly with the higher number of individuals.

Ipomoea acuminata and *Merremia aegyptia* have a climbing habit, which can make certain growing practices and pineapple harvesting difficult. *Brachiaria decumbens*, being a C$_4$ metabolism plant, tends to be more efficient in the use of scarce resources, especially water, considering the semi-arid climate conditions (Zimdahl, 2018).
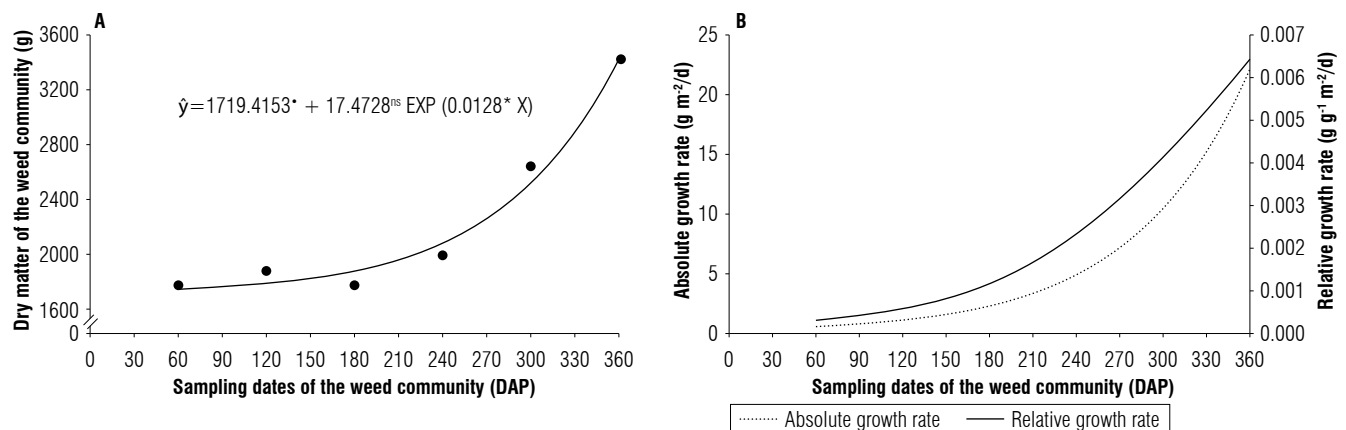

FIGURE 2. A) Dry matter and B) absolute growth rate (g m^{-2}/d) and relative growth rate (g g^{-1} m^{-2}/d) of the weed community as a function of growth sampling dates in the pineapple crop. DAP - days after planting.

At 60 DAP, 217 weed specimens were identified (Tab. 2), with *Brachiaria plantaginea* and *Senna obtusifolia* having the highest number of individuals per species (NIS) and, consequently, the highest relative density (DER), relative abundance (ABR) and importance value index (IVI) (Fig. 3). However, *Ipomoea acuminata* and *Merremia aegyptia* showed higher dry matter compared to the other species.

When the pineapple reached 120 and 180 DAP, 101 and 91 weed specimens were observed, respectively, with the largest number of individuals and amount of dry matter observed for the species *I. acuminata* and *Cenchrus*

echinatus (Tab. 2). For these two species, higher values of DER, ABR and IVI were also observed (Fig. 3). However, the highest relative frequency (FRR) was observed only for *I. acuminata*, 180 DAP. At 240 and 300 DAP, there was a reduction in the number of specimens. However, *I. acuminata* remained with a larger number of individuals and showed higher dry matter in this period. This behavior remained similar for FRR, DER, ABR, and IVI (Fig. 3).

Sarmento *et al.* (2017) observed higher frequency (FR) values for the species *Euphorbia heterophylla*, *Cynodon dactylon*, *Dactyloctenium aegyptium*, and *Amaranthus hybridus*
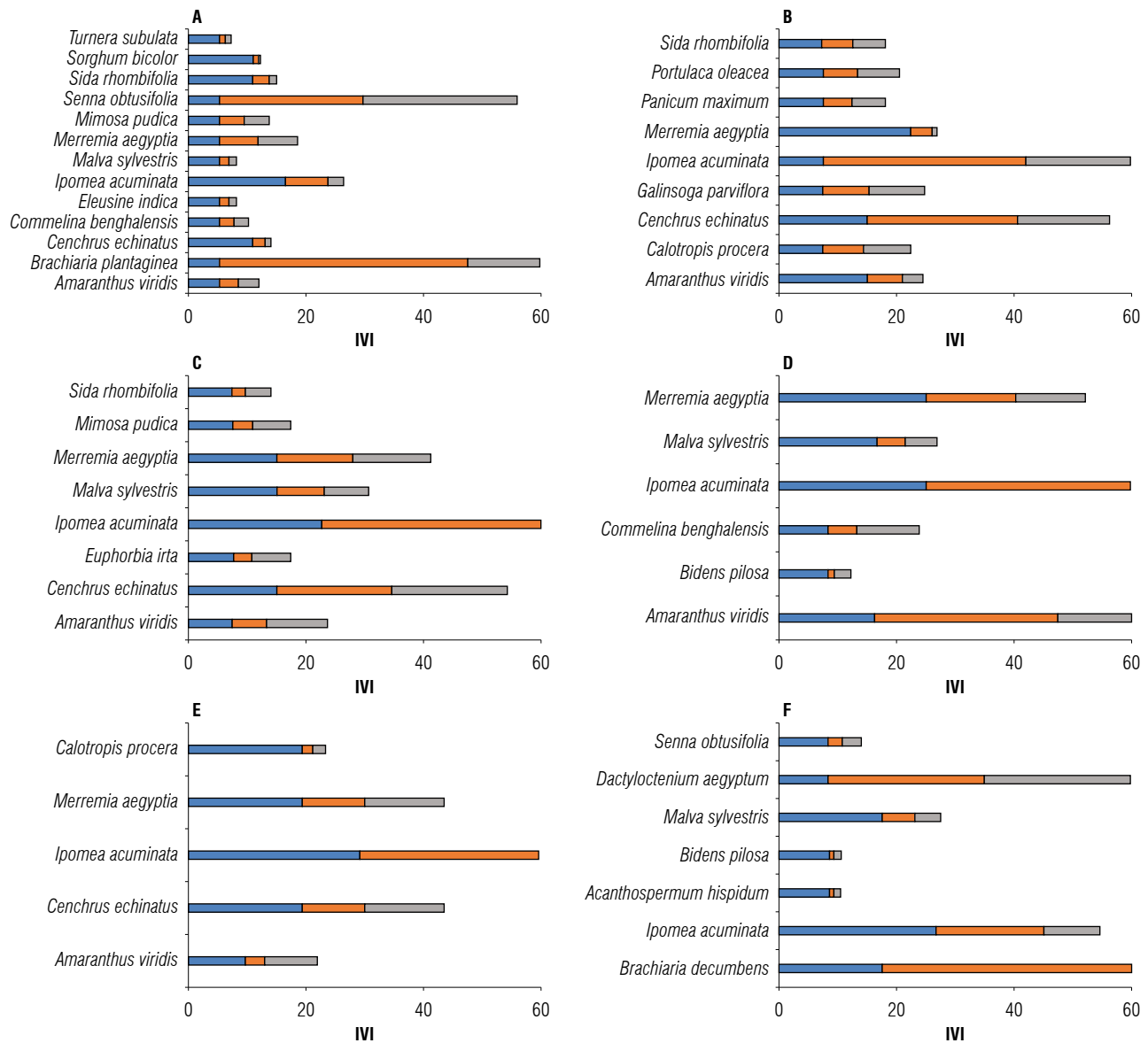

FIGURE 3. Importance value index (IVI) of the main species of weeds collected during the development of pineapple, in days after planting (DAP), cultivated in the semi-arid climate region of Brazil. Blue bar = relative frequency (FRR); orange bar = relative density (DER); gray bar = relative abundance (ABR). A) 60 DAP; B) 120 DAP; C) 180 DAP; D) 240 DAP; E) 300 DAP; F) 360 DAP.

in the spring-summer period of Brazil. The greatest distribution in the autumn-winter period was observed in the species *Euphorbia hirta*, *Amaranthus hybridus*, *Euphorbia heterphylla*, and *Portulaca oleracea*. Unlike this study, the same authors found that the species that showed the highest IVI values were *Cyperus iria*, *Cynodon dactylon*, *Euphorbia heterophylla*, *Amaranthus hybridus*, *Euphorbia hirta*, and *Boerhavia diffusa*. This is because, although the study was conducted under similar climatic conditions, the spatial variation in the distribution of weed species was large, confirming that other factors influence the diversity of the weed community.

Brachiaria decumbens and *Dactyloctenium aegyptum* were found only at 360 DAP, while *I. acuminata* was identified at all survey times (Tab. 2). A greater number of individuals at 360 DAP was observed in the species *B. decumbens*, *D. aegyptum,* and *I. acuminata*, respectively, as well as the greater FRR, DER, ABR, and IVI (Fig. 3).

The highest weed density during the pineapple development cycle was verified at 60 DAP, when 217 individuals per m^2 were counted. The lowest density was observed at 300 DAP, with 56 individuals per m^2 (Tab. 2). According to Radosevich *et al.* (2007), as the density and development of weeds that germinate and emerge at the beginning of the crop cycle increases, interspecific and intraspecific competition intensifies, so that more developed weeds become dominant, and the rest are suppressed or die.

The diversity and density of weeds were higher in the first days after planting, *i.e.*, crop still establishing itself. At this stage, the plant has not yet reached the ideal height of the shoot; therefore, its potential to shade the soil is low, allowing weeds to receive sunlight. Additionally, the pineapple has a slow growth pattern, which makes it uncompetitive against weeds.

At 360 DAP, weed diversity was reduced, as in other survey periods, compared to the first 60 DAP. This probably occurred due to competition between weeds, as some are more aggressive than others, resulting in reduced emergence and/or growth of weeds.

The species that stand out from the others generally have high seed production (to supply the soil seed bank), combined with other mechanisms, such as dispersion, longevity, and dormancy for a long period. Species developing these mechanisms can survive even under adverse conditions (Zimdahl, 2008; 2018; Korres *et al.*, 2019).

Regarding relative dominance (DOR), *I. acuminata* stood out in relation to the other species in all survey periods, except for 300 DAP, when *M. aegyptia* showed the highest DOR value (Tab. 3). At 360 DAP, the species *I. acuminata* (58.11), *B. decumbens* (29.70), and *D. aegyptum* (9.17) stood out. These same species produced a higher number of individuals per species and higher dry matter in the same period.

TABLE 3. Relative dominance (DOR) and weed cover value index (CVI) during the pineapple cultivation cycle in the semi-arid climate region of Brazil.

Sampling moments					
60 d after planting			**120 d after planting**		
Weed	**DOR**	**CVI**	**Weed**	**DOR**	**CVI**
Amaranthus viridis	5.17173	8.398	*Amaranthus viridis*	2.610656	8.55125
Brachiaria plantaginea	0.19339	42.59	*Calotropis procera*	2.776957	9.70765
Cenchrus echinatus	3.00404	5.308	*Cenchrus echinatus*	10.88609	36.62867
Commelina benghalensis	2.37117	4.675	*Galinsoga parviflora*	3.22676	11.14755
Eleusine indica	0.86326	2.246	*Ipomoea acuminata*	61.95306	96.60652
Ipomoea acuminata	47.6364	55.01	*Merremia aegyptia*	8.251679	11.22198
Malva sylvestris	0.58074	1.963	*Panicum maximum*	6.646746	11.59724
Merremia aegyptia	14.8016	21.25	*Portulaca oleracea*	1.647168	7.587762
Mimosa pudica	2.98779	7.135	*Sida rhombifolia*	2.000887	6.951382
Senna obtusifolia	0.71135	25.14			
Sida rhombifolia	6.45933	9.224			
Sorghum bicolor	13.1115	14.03			
Turnera subulata	2.10771	3.029			
Total	100	200		100	200

Continue

Sampling moments					
180 d after planting			**240 d after planting**		
Weed	DOR	CVI	Weed	DOR	CVI
Amaranthus viridis	0.780645	6.27515	*Amaranthus viridis*	32.4191	32.42
Cenchrus echinatus	7.188669	26.96889	*Bidens pilosa*	1.17948	1.179
Euphorbia hirta	2.466612	5.763315	*Commelina benghalensis*	4.88747	4.887
Ipomoea acuminata	78.34526	123.4002	*Ipomoea acuminata*	129.753	129.8
Malva sylvestris	1.971268	9.663575	*Malva sylvestris*	5.64191	5.642
Merremia aegyptia	4.470453	17.65727	*Merremia aegyptia*	26.1191	26.12
Mimosa pudica	1.794921	5.091624			
Sida rhombifolia	2.982174	5.179977			
Total	100	200		200	200
300 d after planting			**360 d after planting**		
Weed	DOR	CVI	Weed	DOR	CVI
Amaranthus viridis	5.624597	5.624597	*Brachiaria decumbens*	29.70813	76.32975
Cenchrus echinatus	10.71766	10.71766	*Ipomoea acuminata*	58.113	76.35624
Ipomoea acuminata	73.41792	73.41792	*Acanthospermum hispidum*	0.180402	0.856078
Merremia aegyptia	107.4045	107.4045	*Bidens pilosa*	0.026187	0.701863
Calotropis procera	2.835362	107.4045	*Malva sylvestris*	2.49653	7.901936
			Dactyloctenium aegyptum	9.174312	35.52566
			Senna obtusifolia	0.301446	2.328473
Total	200	200		100	200

The species that stood out in relation to the coverage value index (CVI) were *I. acuminata* and *B. plantaginea* (55.01 and 42.59) at 60 DAP. *Ipomoea acuminata* and *C. echinatus* showed higher CVI values (96.60 and 36.62, respectively) at 120 and 180 DAP. *Merremia aegyptia* showed CVI equal to 17.65 at 180 DAP. In the last survey period, 360 DAP, *I. acuminata* (76.35), *B. decumbens* (76.32), and *D. aegyptium* (35.52) showed higher CVI values compared to the other weeds. According to the CVI, the species *I. acuminata* covered most of the study area during the collection periods.

Known as a common morning-glory, the species *I. acuminata* was present on all collecting dates. This plant has a climbing growth habit, as do the species of the *Merremia* genus, which was also present in almost all surveys but in a smaller number. As these weeds are herbaceous climbing plants that reproduce by seeds and, in general, prefer tilled, fertile soils with good humidity, they can establish easily. As for competition for nutrients, the common morning-glories can be great extractors, as observed by Souza *et al.* (1999) in the sugarcane crop.

Conclusions

The weed community found in irrigated pineapple cultivation under semi-arid climate conditions was composed mostly of species belonging to the families Amaranthaceae, Asteraceae, Convolvulaceae, Fabaceae, Malvaceae, and Poaceae. The highest diversity of weed species was found 60 d after planting. The diversity of weed species decreased over the pineapple growth cycle. The species *Ipomoea acuminata* was present throughout the growth of the pineapple and showed a higher index of importance value in most periods evaluated.

Conflict of interest statement

The authors declare that there is no conflict of interest regarding the publication of this article.

Author's contributions

JRPS, VMM and IA conceptualized and designed the experiment; JRPS, BSS and PMD carried out the field experiment and laboratory analysis; VMM, JRPS, IA and GC contributed to the data analysis; VMM, JRPS, IA and GC

wrote the original draft; VMM, JRPS, IA and GC wrote, reviewed, and edited the article; VMM and IA supervised and managed the project. All authors reviewed the manuscript.

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