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Aries Guineagrass (*Megathyrsus maximus* Jacq cv. Aries) pasture establishment without chemical control in an environmentally protected area

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This study aimed to evaluate the Aries Guineagrass (*Megathyrsus maximus* sin. *Panicum maximum* Jacq. cv. Aries) and the weed community dynamics under different soil tillage and sowing methods in Southern Brazil, to create alternatives for sustainable farming in areas where weed chemical control is restricted. The experiment was carried out in split-plot design with randomized blocks and four replications; the main plots were three tillage methods: I) conventional, II) reduced tillage with moldboard plow, and III) reduced tillage with harrow plow; and the split-plots included two sowing methods: in line, (a) with seeds placed into the drill and (b) with seeds deposited on the soil surface. Aries Guineagrass and weeds were analyzed for phytosociological parameters during the pasture establishment. Lower weed densities and relative frequencies were found where the Aries Guineagrass was established under reduced tillage with moldboard plow and seeding on the soil surface. The Guineagrass establishment was effective as verified by the high plant survival rates (>75%) in the summer following the one that the pasture was sown. The results showed that, adequate soil tillage and sowing methods can further promote Aries Guineagrass development in areas where chemical control with herbicides is not allowed.

Key words: Perennial pastures, phytosociology, tillage, weeds.

INTRODUCTION

The current concern to achieve abundant and safe food production, with minimal impact on the environment, indicates that some sustainable agricultural practices, as conservation tillage with minimum soil disturbance, are essencial. In this way, in response to society demands, agricultural production systems must associate the increase in agricultural production with environmental quality (Lipper et al., 2014), thus promoting greater efficiency in the use of resources (Lemaire et al., 2014). Environmentally protected areas have been established by law to protect and conserve environmental resources or ecosystems, but they allow for human occupation, provided that this occurs in a sustainable and orderly manner. In a fair and non-exclusive way of the human component present, the knowledge of agricultural practices that attend to the activities that already occur in these areas is essential, since adaptations in the way of conducting these practices must be governed by sustainable principles and be pesticide-free.

The soil tillage method and crop sowing system can alter the seed bank dynamics (Palm et al., 2014; Schutte et al., 2014; Indoria et al., 2017) and, consequently, weed emergence. Soil tillage increase the concentration of seed of small plants at greater depths in the soil profile and reduce their germination (Vidal et al., 2007). Conventional preparation mixes the soil and weed seeds, concentrating soil aggregates larger than two centimeters near the soil surface, while weed seeds and finer soil particles are congregated at greater depths (Colbach et al., 2014).

In livestock systems, understanding how the weed community responds to soil tillage and forage management is an important conditioning to successful pasture development. These actions can alter the soil seed bank dynamics and provide a competitive forage species advantage in relation to weeds, mainly with no chemical control. The seed bank dynamics depends on environmental conditions and anthropic actions (Gardarin et al., 2012); also, agronomic practices should be understood as filters that determine the composition and abundance of functional characteristics of weeds in agroecosystems (Deiss et al., 2018).

In Brazil, the species *Panicum maximum* is considered one of the most widespread and important grass for livestock due to its high dry matter production, forage quality and ease of establishment (Oliveira et al., 2016). The Aries Guineagrass (*Megathyrsus maximus* sin. *P. maximum* Jacq. cv. Aries) is an F1 apomictic hybrid resulting from the artificial cross of *M. maximus* cv. Centauro with *M. maximus* cv. Aruana (Euclides et al., 2010). It is established by seeds, not affected by the severity of the cold and frost, typical of the winter climate in the Brazilian subtropical region.

The hypothesis of this work is that different soil preparation and sowing methods will alter the weed composition in the development of Aries guineagrass (*M. maximus* sin. *P. maximum* Jacq. cv. Aries) promoting a competitive advantage of the forage species in relation to weeds. Thus, alternative weed control practices can favor agricultural development in a sustainable way in environmentally protected areas where there are constraints to the use of agricultural pesticides. In this context, this study was evaluate to know how soil tillage and sowing methods affect the weed community and the establishment of Aries Guineagrass in environmentally protected areas of subtropical region of Brazil.

MATERIALS AND METHODS

The experiment was conducted in Pinhais, State of Parana (25°24'S and 49°07'E, 900 m altitude), Brazil. It was located in the Rio Iraí Environmentally protected area, which is a territorial unit created by State Decree 1753/96 (PARANA, 1996), according to Law 6938/81 (BRASIL, 1981), which prohibits the use of herbicides, insecticides, acaricides, fungicides and nematicides in farming, but without restrictions as to the use of exotic species nor tillage and fertilizers.

The climate is humid subtropical, Cfb. The annual average rainfall is 1,400 to 1,600 mm and mean temperatures below 18°C in the coldest month and below 22°C in the warmer months (IAPAR, 2014). The soil is classified as Cambisol dystrophic tipic (USDA, 2014); the chemical profile of the soil collected at 20 cm depth showed the following values: pH ($CaCl_2$) = 5.1; P = 1.8 mg dm^{-3}; K = 0.16 cmolc dm^{-3}; Ca = 5.1 cmolc dm^{-3}; Mg = 3.6 cmolc dm^{-3}; Al = 0.0 cmolc dm^{-3}; H + Al = 4.8 cmolc dm^{-3}; SB = 8.86 cmol dm^{-3}; CTC = 13.6 cmolc dm^{-3}; V% = 64.5; and C = 31.8 g dm^{-3}.

The pasture species was the perennial summer Aries Guineagrass (*M. maximus* sin. *P. maximum* Jacq. cv. Aries). The soil was tilled on January 14, 2013 and forage was sown on January 17, 2013, with a density of 9 kg pelleted seeds per hectare, using base fertilization of 40 kg ha^{-1} P_2O_5 (single superphosphate). Fifteen days after sowing, 300 kg K_2O and 200 kg N in the form of potassium chloride and urea were applied, respectively. The survival of the Aries Guineagrass plants in the beginning of the next summer was evaluated by random marking of 108 plants, which were recounted in the month of September, 258 days after sowing, with the plants clumped.

The split plot design was performed with randomized blocks and four replications, totaling 24 experimental units. Soil preparation methods in the plots consisted of: 1) conventional tillage, consisting of tilling with a moldboard plow, followed by plowing with a harrow and a disc; 2) reduced tillage (chisel plow) with a moldboard plow, and 3) reduced tillage (chisel plow) with a harrow plow, and line forage sowing methods in the subplots by 1) seeds deposited in the soil within the sowing drill, and 2) seeds deposited on the soil surface. The plots had a 10 × 5 m size and were divided longitudinally for subplots allocation. In order to facilitate identification during the seedling phase, as well as to better evaluate the behavior of the forage species (Aries Guineagrass) in relation to other Poaceae, the "Poacea" group was created. This group included the species *Urochloa decumbens, Urochloa plantaginea*, *Cynodon dactylon* and *Digitaria horizontalis*.

For the plant community sampling, three 0.25 m^2 sites were randomly delimited in each experimental unit throughout the experimental period. Aries Guineagrass and weeds were properly identified and counted three times at 15, 33 and 58 days after forage sowing. The methodology used was proposed by Mueller-Dombois and Ellemberg (1974) and Braun-Blanquett (1979) to determine the total number of individuals (N), absolute frequency

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(AF), relative frequency (RF), absolute density (AD), relative density (RD), importance value index (IVI) and relative importance (RI). Data were submitted to analysis of the normality of residues as a conditioning factor to the analysis of variance (Anova). Duncan's test was used to compare values that were affected by significant factors and interaction (p <0.05). Statistica 8.0 software was used for the statistical analysis (Dell Software, 2007).

RESULTS

Twenty-seven weed species distributed in fourteen families were identified (Table 1). *Euphorbia heterophylla*, *Raphanus raphanistrum* and Poaceae were the most relevant as to the botanical composition during Aries Guineagrass development, as they obtained higher frequency and relative density values (Table 2). The population with the highest relative density in the weed community belonged to the Poaceae group, followed by *E. heterophylla* and *R. raphanistrum*. On the other hand, the population showing the lowest relative density was *Richardia brasiliensis*, followed by *Sida rhombifolia* and *Ipomoea grandifolia*. Relative frequency indicated that plants from the Poaceae, *E. heterophylla, R. raphanistrum* and *Cyperus rotundus* groups were the most frequent species in all experimental area; *R. brasiliensis* showed the lowest frequency.

Soil preparation methods mobilized the seed bank dynamically, causing some weed species to show different densities and relative importance, while others were affected in their spatial distribution (i.e., frequency), as presented in Tables 3, 4 and 5.

The soil tillage management influenced (P<0.05) the relative density and importance of *E. heterophylla*, independently of sowing methods, only at 15 days after sowing. The sowing methods had no effect on the relative density and importance of *E. heterophylla* but they favored (P<0.05) the relative density and importance for Aries Guineagrass, regardless of soil preparation method (Table 3).

There was interaction (P<0.05) between soil tillage and sowing methods as for *R. raphanistrum* relative density and Poaceae relative frequency, represented by *U. decumbens*, *U. plantaginea* and *D. horizontalis* (Tables 4 and 5). *R. raphanistrum* density was not influenced (P>0.05) by soil tillage management when the Guineagrass was sown into the drill. Otherwise, the conventional tillage increased (P<0.05) this relative density if sowing was superficial (Table 4).

As shown in Table 5, when Aries Guineagrass was sown in the drill, the Poaceae relative frequency was higher (P<0.05) in conventional tillage as compared to reduced tillage with moldboard plow (Table 5). On the other hand, in-line surface sowing did not show differences (P>0.05) between the soil preparation methods.

Table 6 shows the absolute densities (plants.m^2) of Aries Guineagrass and the most relevant weed plants until 58 days after pasture establishment. As shown in Table 1, *R. raphanistrum, E. heterophylla* and Poaceae were the most relevant during Aries Guineagrass development, with evident decreasing of *E. heterophylla* at 58 days after sowing.

DISCUSSION

According to the botanical composition (Table 1) at the Guineagrass establishment, it is possible to affirm that these plants are commonly present in the region. Kruchelski et al. (2019) studied the weed species in the establishment of Aries Guineagrass in same area and similar species (Table 2) were identified.

R. raphanistrum (wild radish) is an important weed (Cici and van Acker, 2009; Costa and Rizzardi, 2014) which has a large competition ability due to its largely viable seed production. According to Tricault et al. (2018), it is a highly competitive weed in winter crops.

Because of the importance of this weed, suitable methods of soil preparation and sowing may be an alternative to favor Aries Guineagrass development under unfavorable climatic conditions in environmentally protected areas that do not allow the use of chemical control for weeds. In this way, the conventional method, by promoting a larger number of weed seeds at greater depths (Mangin et al., 2018), may contribute to the establishment of Aries Guineagrass by reducing competition with weeds. From the 0.10 m depth, some weed seeds can germinate, however, they can become chlorotic, and consequently more susceptible to any method of management (Orzari et al., 2013).

Reduced tillage with a single harrow plowing favored the presence of *E. heterophylla* in relation to tillage with a moldboard plow; however, these two types of tillage did not affect the weed behavior when compared with conventional tillage. This fact is due to the deeper seed burial promoted by the moldboard plow tillage. Swanton et al. (2000) found a less uniform vertical distribution of weed seeds than the ones obtained by other methods of soil preparation, with most seeds buried at greater depths in the soil profile, 66% of which at 0.10 to 0.15 m.

Scheren et al. (2013) demonstrated that *E. heterophylla* shows a high emergence potential under satisfactory environmental conditions, which can damage the main crop, making it an important weed. *E. heterophylla* have great ability to absorb nitrogen, calcium and sulfur from the soil, which is intensified in the conventional method due to the greater mineralization of the organic matter provided by the soil rotation (Fontes and Morais, 2015). This has contributed to the higher relative density and frequency in conventional tillage.

Soil management by the use of a moldboard plow results in the presence of larger aggregates and increased macroporosity resulting from soil tillage, which reduces soil-seed contact thus reducing weeds' emergence (Colbach et al., 2014). In this way, the disc

Table 1. Weed species identified during the Aries Guineagrass (*Megathyrsus maximus* Jacq. cv. Aries) pasture establishment, Pinhais-PR, Brazil.

Family	Scientific name	Common name	Life cycle
Asteraceae	*Bidens pilosa*	Hairy beggarsticks	Annual
Asteraceae	*Galinsoga parviflora*	Eclipta	Annual
Asteraceae	*Vernonia polysphaera*	Ironweed	Perennial
Asteraceae	*Xanthium strumarium*	Dandelion	Annual
Asteraceae	*Artemisia vulgaris*	Mugwort	Perennial
Brassicaceae	*Raphanus raphanistrum*	Wild radish	Annual
Brassicaceae	*Neslia paniculata*	Ball mustard	Annual
Cariophillaceae	*Silene gálica*	English catchfly	Annual
Convolvulaceae	*Ipomoea grandiflora*	Morningglory	Annual
Cyperaceae	*Cyperus rotundus*	Purple nutsedge	Perennial
Euphorbiaceae	*Euphorbia heterophylla*	Milkweed	Annual
Fabaceae	*Trifolium repens*	White clover	Perennial
Fabaceae	*Trifolium pratense*	Red clover	Biennial
Lamiaceae	*Stachys arvensis*	Fieldnelttle bentony	Annual
Malvaceae	*Sida rhombifolia*	Wire weed	Perennial
Oxalidaceae	*Oxalis oxiptera*	Woodsorrel	Annual
Papaveraceae	*Argemone mexicana*	Mexican prickle poppy	Perennial
Poaceae	*Avena strigosa*	Black oat	Annual
Poaceae	*Cynodon dactylon*	Bermuda grass	Perennial
Poaceae	*Urochloa decumbens*	Braquiária decumbens	Perennial
Poaceae	*Digitaria horizontalis*	Large cabgrass	Annual
Poaceae	*Urochloa plantaginea*	Alexander grass	Annual
Poaceae	*Sorghum halepense*	Jhonsongrass	Perennial
Poaceae	*Paspalum urvillei*	Vaseygrass	Perennial
Poaceae	*Paspalum paniculatum*	Capim-milhã	Perennial
Poligonaceae	*Rumex obtusifolius*	Curly dock	Perennial
Rubiaceae	*Richardia brasiliensis*	Brazil callality	Annual

Table 2. Relative density, frequency and importance (%) of weed species, Aries Guineagrass (*Megathyrsus maximus* Jacq. cv. Aries) and the Poaceae family during the pasture establishment, Pinhais - PR, Brazil.

Species	Relative density (%)	Relative frequency (%)	Relative importance (%)
E. heterophylla	15.7	10.3	13.0
R. raphanistrum	13.5	10.1	11.8
B. pilosa	9.3	9.7	9.5
S. rhombifolia	1.5	4.9	3.2
G. parviflora	7.8	9.4	8.6
I. grandiflora	6.1	9.5	7.8
R. brasiliensis	0.9	3.6	2.3
C. rotundus	9.7	10.1	9.9
Aries Guineagrass Aries	9.6	9.3	9.5
Poaceae*	19.7	10.3	15.0

*Poaceae (*Urochloa decumbens, U. plantaginea, Cynodon dactylon* and *Digitaria horizontalis*).

plow may have contributed to maintain the *E. heterophylla* seed bank closer to the soil surface in relation to the moldboard plow, thus intensifying its potential interference ability on Aries Guineagrass. According to Gruber et al. (2012), the disc plow, mobilizes the soil less intensely than conventional tillage

Table 3. Relative density (%) and relative importance (%) of *Euphorbia heterophylla* and Aries Guineagrass (*Megathyrsus maximus* Jacq. cv. Aries), 15 days after sowing, under different soil preparation and sowing methods, Pinhais - PR, Brazil.

Species	Soil preparation methods			Sowing methods	
	Conventional tillage	Reduced tillage + moldboard plow	Reduced tillage + harrow plow	Into the drill	On soil surface
			Relative density (%)		
E. heterophylla	19.25^{ab}	15.38^{b}	24.77^{a}	21.82	17.78
Aries Guineagrass	10.30	12.55	12.23	7.97^{B}	15.42^{A}
			Relative importance (%)		
E. heterophylla	15.43^{ab}	13.19^{b}	18.11^{a}	16.80	14.36
Aries Guineagrass	10.10	11.77	10.69	8.54^{B}	13.17^{A}

Within each species, different uppercase letters between soil preparation methods and lowercase letters between sowing methods indicate difference by the Duncan test ($p < 0.05$).

Table 4. Relative density (%) of *Raphanus raphanistrum* under different soil preparation and sowing methods of Guineagrass cv. Aries (*Megathyrsus maximus* Jacq. cv. Aries), Pinhais - PR, Brazil.

Soil preparation methods	Sowing methods	
	Into the drill	On soil surface
	Relative density (%)	
Conventional tillage	12.56^{Ab}	20.28^{Aa}
Reduced tillage + moldboard plow	15.73^{Aa}	9.57^{Bb}
Reduced tillage + harrow plow	11.68^{Aa}	11.26^{Ba}

Different uppercase letters between soil preparation methods and lowercase letters between sowing methods indicate difference by the Duncan test ($p < 0.05$).

Table 5. Relative frequency of the Poaceae family (*Urochloa decumbens, U. plantaginea, Cynodon dactylon* and *Digitaria horizontalis*) under different soil preparation and sowing methods of Guineagrass cv. Aries (*Megathyrsus maximus* cv. Aries), Pinhais - PR, Brazil.

Soil preparation methods	Sowing methods	
	Into the drill	On soil surface
	Relative frequency (%)	
Conventional tillage	11.02^{Aa}	10.08^{Ab}
Reduced tillage + moldboard plow	9.76^{Ba}	10.36^{Aa}
Reduced tillage + harrow plow	10.50^{ABa}	10.06^{Aa}

Different uppercase letters between soil preparation methods and lowercase letters between sowing methods indicate difference by the Duncan test ($p < 0.05$).

and the use of the moldboard plow exclusively.

Surface in-line seeding showed higher values of relative importance for Aries Guineagrass as compared to drill sowing. This may have occurred because the seeds remained on the surface, thus favoring their development, as opposed to the seeds deposited in the drill, which may have been buried at greater depths in the soil profile during the disaggregation and accommodation of soil clods after sowing, and therefore had delayed plant emergence.

Thus, *R. raphanistrum* seeds move to greater depths may have prevented their emergence, either due to the environmental conditions that may have inhibited their germination, such as variations in temperature and light (Copeland and McDonald, 2001) or because of the depletion of reserves by the plants that germinated but did not emerge to begin their growth. The high absolute density of *R raphanistrum* at 15 days after sowing (Table

Table 6. Absolute density (plants.m^{-2}) of *Megathyrsus maximus* Jacq. cv. Aries, weeds and the Poaceae family at 15, 33 and 58 days after sowing, Pinhais - PR, Brazil.

Species	Days after sowing		
	15	33	58
Megathyrsus maximus cv. Aries	9.6	9.7	7.1
Euphorbia heterophylla	16.1	15.2	11.3
Raphanus raphanistrum	18.6	12.9	6.5
Bidens pilosa	5.3	13.1	8.6
Sida rhombifolia	0.4	2.1	1.8
Galinsoga parviflora	3.5	10.3	8.3
Ipomoea grandiflora	4.4	5.8	6.4
Richardia brasiliensis	0.0	2.1	0.9
Cyperus rotundus	5.7	10.7	9.6
Poaceae*	13.5	19.7	21.2

*Poaceae (*Urochloa decumbens, U. plantaginea, Cynodon dactylon* and *Digitaria horizontalis*).

6) may have triggered, over time, allelopathic action on the surrounding weeds, similarly to the behavior observed in the southeastern region of the United States (Norsworthy, 2003), contributing to the reduction of the absolute density values of most of the weeds.

The greater soil mobilization in the conventional tillage with sowing in the drill provided greater Poaceae occurrence in the plant community. Favreto and Medeiros (2006) also found high presence of Poacea *U. plantaginea* in conventional tillage compared to the direct sowing in range pasture area in the Central Depression of Rio Grande do Sul, Brazil. With the superficial sowing of the Guineagrass, the relative frequency of the Poaceae family (*U. decumbens, U. plantaginea, C. dactylon* and *D. horizontalis*) was not influenced by the soil preparation methods, probably because there was no opening of sowing drill and the exposure of seeds to environment was similar between the different tillage methods.

The Aries Guineagrass absolute density with no use of herbicides for weed chemical control was similar to that observed by other authors under conventional management (with chemical weed control). Gerdes et al. (2002) reported 9.0, 11.0 and 10.0 plants m^{-2} (absolute density, AD) for Guineagrass cv. Tanzania at 7, 14 and 21 days after sowing under soil tillage conditions and use of desiccant herbicide for the elimination of *U. decumbens* and other weeds. This points out to a possibility of success in the development of Aries Guineagrass without the use of herbicides.

The adoption of competitive crops, changes in sowing dates and soil fertilization are cultural practices that must be implemented in conservation agriculture (Nichols et al., 2015). In this sense, the survival of Aries Guineagrass was 75%, estimated for 258 days after sowing, with a standard error deviation of 4.2. This highlights the ability of Aries Guineagrass to survive even under weed competition conditions. Because it is an exotic summer perennial species of C4 metabolism, developing in late summer and early fall, Aries Guineagrass had to compete with weeds adapted to the climatic conditions at this time of year, which are less favorable to the development of this group of forage species, and more favorable to the group of weeds studied, as we have emphasized for *R. raphanistrum* weed. However, Aries Guineagrass development was effective, which demonstrated the viability of the management practice used.

In addition to this, the pasture was sown relatively late when compared with the common sowing periods for tropical grasses in that region (the middle of summer vs. spring, respectively). Late sowing of this species may be a disadvantage for pasture development, which may be due to the high competitiveness of the weed community that settles at the beginning of the hot season, especially in areas where no chemical control is allowed. In addition, in subtropical and temperate regions, the growing season is followed by lower temperatures of fall, which are associated with the slow development of the grass and the rapid growth of other weed species, more adapted to these environmental conditions.

Conclusion

From the results of the present study, it was concluded that the conventional tillage, reduced with moldboard plow as reduced with disc plow methods, allows Aries Guineagrass development, especially in the case of in-line sowing on the soil surface. Reduced soil tillage with single moldboard plow allows better weed management and greater competitive advantage of Aries Guineagrass for pasture establishment. The use of adequate soil tillage and sowing methods is an alternative to benefit Aries Guineagrass development in environmentally protected areas where the chemical control with herbicides is not allowed.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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