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Article

GOOSEGRASS: MORPHOPHYSIOLOGICAL CHARACTERIZATION UNDER WATER EXCESS CONDITIONS

Capim Pé-de-Galinha: Caracterização Morfofisiológica em Condições de Excesso Hídrico

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ABSTRACT - *Eleusine indica* (L.) Gaertn. (goosegrass) is a grass species that has global prominence as a weed in areas typical of the soybean crop. However, its dispersion in recent years has been reported expressively for areas of poorly drained soil, in which irrigated rice is cultivated (lowlands). Little is known on its behavior and biology in this different ecosystem. This study aimed to evaluate if *Eleusine indica* can survive and withstand flooding. The experimental design was a completely randomized (two-way), in which two *E. indica* biotypes, one from the uplands (without flooding) and the other from the lowlands (with flooding), were submitted to three soil water conditions: 50 and 100% water retention capacity and soil under water depth. Photosynthetic and gas exchange parameters (photosynthetic rate, stomatal conductance, intercellular CO_2 concentration, transpiration, water use efficiency, and assimilation rate by Rubisco) were determined. Morphological diversity of biotypes was evaluated through descriptors. The existence of typical lowland biotype could not be characterized. However, both biotypes were able to survive, develop, and generate seeds in a flooded environment in the irrigated rice system.

Keywords: adaptation, *Eleusine indica*, *Oryza sativa*, invasiveness.

*RESUMO - A espécie **Eleusine indica** (L.) Gaertn. (capim-pé-de-galinha) é uma gramínea que possui destaque global como infestante em áreas típicas de cultivos agrícolas da soja. Entretanto, nos últimos anos sua dispersão vem sendo relatada expressivamente para áreas de solo mal drenado, em que é cultivado arroz irrigado (terras baixas). Nesse diferente ecossistema, pouco se conhece sobre seu comportamento e biologia. O objetivo deste trabalho foi avaliar se **E. indica** realmente consegue sobreviver e suportar alagamento. O delineamento experimental utilizado foi o inteiramente casualizado, bifatorial, em que dois biótipos de **E. indica**, um oriundo de terras altas (sem alagamento) e outro oriundo de terras baixas (com alagamento), foram submetidos a três condições hídricas do solo: 50%; 100% da capacidade de retenção de água; e solo sob lâmina d'água. Como avaliações, foram determinados parâmetros fotossintéticos e de trocas gasosas (taxa fotossintética, condutância estomática, concentração de* CO_2 *intercelular, transpiração, eficiência do uso da água e a relação de assimilação pela rubisco). Também se avaliou a diversidade morfológica dos biótipos, através de descritores. Não foi possível caracterizar a existência de um biótipo típico de terras baixas. Contudo, ambos os biótipos se mostraram capazes de sobreviver, desenvolver e gerar sementes em ambiente alagado no sistema arroz irrigado.*

Palavras-chave: adaptação, *Eleusine indica*, *Oryza sativa*, invasividade.

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INTRODUCTION

Eleusine indica (L.) Gaertn. is an annual monocot popularly known as goosegrass, usually found in areas typical of soybean cultivation without flooding (Radosevich et al., 2007; Chauhan and Johnson, 2008; Vargas et al., 2013; Wandscheer, 2013). This plant is considered of great importance as a weed because it has high competitive power and easy adaptation to almost all regions worldwide, with several cases of resistance to different mechanisms of herbicidal action, such as EPSPs and ACCase inhibitors (Kissmann, 2007; Kraehmer et al., 2016; Heap, 2017). However, this species has been reported in areas of poorly drained soil, typical of irrigated rice production, demonstrating to withstand the conditions imposed by this differentiated habitat (Erasmo et al., 2004; Rao et al., 2007).

Its presence in lowlands, typical of the irrigated rice system, subjects the species to different conditions of the edaphic environment (flooding). Areas with high concentrations of water in the soil present hypoxia, i.e., a low oxygen (O_2) content, or anoxia, the total absence of O_2, as a function of its total consumption by submerged organs of plants or microorganisms (Shiono et al., 2008). Therefore, a stress condition for species susceptible to the harmful effects of flooding is characterized.

Stress caused to plants by the influence of an environment different from that to which they are adapted reflects in anatomical, morphological, and physiological changes (Gonçalves et al., 2012; Ismail et al., 2012). Thus, acclimatization capacity of a species is a key point in maximizing resources essential for survival under these conditions (Dias-Filho and Carvalho, 2000).

Some responses observed due to the low oxygen availability are the decrease in the photosynthetic rate, stomatal closure, photosynthetic collapse, inefficiency, and root death, followed by plant death (Ismail et al., 2012). Adapted species show initially for a short period, the exchange of metabolism, shoot elongation, adventitious root formation in the stem (grasses) and aerenchyma (Kraehmer and Baur, 2013; Wang et al., 2014).

Considering the scenario of occurrence, the frequency of *E. indica* in the flooded environment and its importance at a global level, it is believed that the species has evolved biotypes tolerant to water excess. Therefore, this study aimed to determine if *E. indica* could survive under flooded soil conditions without implications in its biology.

MATERIAL AND METHODS

The experiment was conducted in a greenhouse, with 6 × 20 m and 5 m of ceiling, in the municipality of Santa Maria, state of Rio Grande do Sul, from March to July 2016.

The experimental design was a completely randomized design with two factors: two *E. indica* biotypes and three soil water conditions, with five replications. Biotypes were SMI – Santa Maria (sensitive to flooding) from soybean cultivation (uplands); and ALI – Alegrete (tolerant to flooding) from irrigated rice cultivation (lowlands). The tested water conditions consisted of 50 and 100% soil-water retention capacity (WRC) and water depth (5 cm).

Biotypes were collected based on previous information on the species occurrence at each area. Ten collection points for sampling the areas were defined within a radius of 25 hectares georeferenced with an Etrex Garmin GPS (Santa Maria – 29°39’04.86" S, 53°57’25.70" W, and altitude of 177 m; Alegrete – 29°27’34.74" S, 56°07’15.88" W, and altitude of 75 m). A key to the Poaceae family was used to identify the species (Boldrini et al., 2008). Plants were conditioned in plastic trays after the collections and taken to the laboratory for seed reproduction. After the physiological maturation, around 70 to 100 g of seeds were collected from a single plant from each sampling area, chosen by lot, which provided the seeds for the experiment in a greenhouse.

The experimental units consisted of flexible plastic pots (Nutriplant) of 11 liters of volume, filled with 12 kg of dystrophic arenic Red Argisol, A horizon, with a 5 cm spare for treatments that received the water depth. The soil was sieved and corrected according to the chemical analysis, following the indications for irrigated rice cultivation (Sosbai, 2016).

On March 11, 2016, about 10 to 15 seeds of *E. indica* were sown after mechanical scarification to overcome dormancy on each experimental unit; 15 pots contained the SMI biotype and another 15 the ALI biotype, totaling 30 experimental units. Maintenance irrigations were carried out up to 75% WRC to promote seed germination. Total seedling emergence occurred on March 23, 2016, and thinning was performed three days later to maintain only one plant per pot.

The water condition factor was determined on April 7, 2016, when plants reached the three-leaf to the one-tiller stage.

Soil WRC was determined through the weighing method, using equations to obtain moisture contents of treatments (50 and 100% WRC):

$$WP100\% = (WPWRC \quad WPdry) \times 1 + WPdry$$

$$WP50\% = (WPWRC \quad WPdry) \times 0.5 + WPdry$$

where WPn% is the pot weight for each treatment, WPWRC is the pot weight at soil-water retention capacity, and WPdry is the pot weight filled with totally dry soil.

Each pot was weighed daily for the maintenance of moisture, and water added to reach the predetermined total weight.

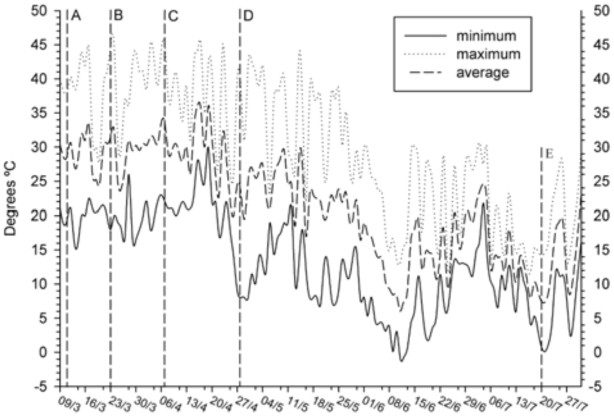
On April 28, 2016, physiological evaluations were carried out in the middle third of the last fully expanded leaf of the stem (flag leaf) at the stage of inflorescence emission (booting). The evaluation was carried out using a portable LI-COR infrared gas analyzer (IRGA) model LI-6400 XT, with photosynthetic radiation of 1,000 $\mu mol\ m^{-2}\ s^{-1}$ and CO_2 concentration of 400 $\mu mol\ mol^{-1}$.

On that occasion, the following variables were determined: photosynthetic rate (A, $\mu mol\ CO_2\ m^{-2}\ s^{-1}$); stomatal conductance of water vapor (Gs, $mol\ H_2O\ m^{-2}\ s^{-1}$); internal CO_2 concentration (Ci, $\mu mol\ CO_2\ mol\ air^{-1}$); transpiration (E, $mol\ H_2O\ m^{-2}\ s^{-1}$); water use efficiency (WUE, $mol\ CO_2\ mol^{-1}\ H_2O$); and carboxylation efficiency of Rubisco enzyme (A/Ci). Evaluations were performed from 9 am to 11 am on a sunny day. The number of tillers per plant was determined on the same day as the photosynthetic evaluation.

Morphological descriptors were evaluated at the end of the cycle in order to analyze the morphological diversity (Table 1). For a higher assertiveness in the morphological distance analysis, additional biotypes of the species *Eleusine tristachya* (CAT – Cruz Alta and JCT – Júlio de Castilhos), and *E. indica* (SCI – Santa Catarina), which were not the subject of the main study and were only used as a positive control, were grown in parallel under the same treatments.

Table 1 - Morphological descriptors used for the analysis of morphological diversity among *Eleusine* spp. biotypes and their respective metric scale. Santa Maria, RS, 2016

Descriptor	Scale
1. Stem length	cm
2. Higher stem diameter	mm
3. Lower stem diameter	mm
4. Flag leaf sheath length	cm
5. Flag leaf blade length	cm
6. Flag leaf blade width	cm
7. Number of tillers per plant	–
8. Number of inflorescences per plant	–
9. Inflorescence length	cm
10. Peduncle length	cm
11. Number of branches per inflorescence	–
12. Branch length	cm
13. Number of spikelets per branch	–
14. Spikelet length	cm
15. Number of seeds per plant	–



A – biotype sowing (March 11); B – total plant emergence (March 23); C – input of the water condition factor (April 7); D – physiological evaluation and counting of the number of tillers (booting) (April 28); E – total end of plant cycle. Santa Maria, RS, 2016.

Figure 1 - Maximum, average, and minimum air temperature (°C) inside the greenhouse during the experiment, with emphasis on the main events.

In addition, the following variables were also determined: shoot, root, and total dry matter accumulation of each plant; number of seeds per plant = (number of inflorescences per plant) × (number of branches per inflorescence) × (number of spikelets per branch) × (2.5 seeds per multifloral spikelet); length of the main stem (mother plant); and the total cycle time in days. Plants were removed from pots, washed, and oven-dried at 70 ºC until constant weight for dry matter evaluations. Events occurring in the experiment, as well as the daily temperature measurements, are shown in Figure 1.

The analysis of variance for the data was performed according to the mathematical model in a completely randomized design with a two-factor arrangement. The experimental errors were tested using the Shapiro-Wilk test and homogeneity of variances through the Bartlett test using the software Action (ESTATCAMP, 2011). Box-Cox transformation was used to the data that did not meet the assumptions. Subsequently, analysis of variance (ANOVA) and Scott-Knott test for grouping of means were performed at 5% probability error ($p<0.05$) by the statistical program Sisvar® 5.3 (Ferreira, 2011). The morphological distances were calculated based on the Mahalanobis method (distance measure based on correlations between variables, invariant to scale, which analyzes and identifies patterns by the similarity between an unknown and a known sample) to evaluate the morphological diversity. Dendrograms were constructed by the UPGMA (unweighted pair group method using arithmetical averages) grouping analysis using the statistical software Genes (Cruz, 2013).

RESULTS AND DISCUSSION

The biotype Alegrete, supposedly tolerant to soil flooding, responded with a higher photosynthetic rate (μmol CO_2 m^{-2} s^{-1}) under conditions of high-water availability (100% WRC and water depth). However, it presented a reduction in the photosynthetic rate when submitted to a low soil water availability, demonstrating to be less tolerant to water deficit (Table 2). The biotype Santa Maria presented lower photosynthetic rates when compared to Alegrete but did not differ statistically within the three water conditions (50 and 100% WRC and water depth) (Table 2).

The biotype Alegrete showed less tolerance for water scarcity. The parameters Gs, Ci, E, WUE, and A/Ci showed an interaction between conditions, with a reduction in the stomatal conductance and hence a lower internal CO_2 concentration (Ci) and transpiration (E), which led to a better water use efficiency (WUE). However, the ratio of carboxylation of Rubisco (A/Ci) remained stable for all means, i.e., without effects on the atmospheric carbon fixation (Table 3).

In cases of water stress, *E. indica* closes the stomata as a first reflex, thus reducing its stomatal conductance at about 0.15 mol H_2O m^{-2} s^{-1} (Pereira et al., 2015). Under these conditions, the lower photosynthetic rate is due to the stomatal restriction (Dias-Filho and Carvalho, 2000; Arcoverde et al., 2011). A negative interference can occur in the biomass accumulation because of this decrease in the stomatal flow through the lower ratio of carboxylation of Rubisco (A/Ci) (Scalon et al., 2015). Plants susceptible to flooding also have stomatal closure as an osmotic equilibrium and critical response to leaf dehydration prevention (Ashraf, 2003).

Table 2 - Means of photosynthetic rate (A, μmol CO_2 m^{-2} s^{-1}) of the interaction between two biotypes of *Eleusine indica* under different soil water conditions at the inflorescence elongation (booting) stage. Santa Maria, RS, 2016

Soil water condition	Biotype	
	Santa Maria	Alegrete
50% WRC	18.52 a A	17.25 a C
100% WRC	21.91 b A	27.39 a A
Water depth	20.29 b A	23.81 a B
CV (%)	10.37	
F-test of the biotype (B)	9.98*	
F-test of the water condition (C)	23.31*	
F-test of the interaction A x C	6.03*	

Means followed by the same uppercase letter in the column and lowercase letter in the row do not differ from each other by the Scott-Knott test at 5% probability. WRC: soil-water retention capacity. ^{ns} not significant and * significant at 5%.

The condition of high availability (100% WRC) and water excess (water depth) on the parameters of gas exchange did not indicate differences between *E. indica* biotypes (Santa Maria and Alegrete), which responded similarly to conditions of 100% WRC and water depth (Table 3). Flooding may favor the photosynthetic rate of adapted plants, but without interfering with stomatal conductance (Baruch, 1994) and transpiration (Mollard et al., 2008). Studies with *Paspalum* have shown the possibility of classifying a lowland biotype, which responded

Table 3 - Means of photosynthetic parameters of two biotypes of *Eleusine indica* (goosegrass) under different soil water conditions during the inflorescence elongation (booting) stage. Santa Maria, RS, 2016

Physiological parameters without interaction biotype x soil water condition										
Biotype	Gs		Ci		E		WUE		A/Ci	
	SMI	ALI	SMI	ALI	SMI	ALI	SMI	ALI	SMI	ALI
50% WRC	0.19 ^{ns}	0.14 b	211.97 b	196.33 b	2.60 ^{ns}	2.03 b	7.39 a	7.94 a	0.08	0.08
100% WRC	0.27	0.34 a	232.72 a	243.70 a	3.73	4.53 a	6.00 b	5.65 b	0.09	0.10
WD	0.25	0.25 a	241.51 a	232.68 a	3.64	3.92 a	5.52 b	5.21 b	0.08	0.08
CV (%)	21.43		8.23		28.30		10.25		18.62	
$F_{biotype}$ (B)	0.10^{ns}		0.43^{ns}		0.22^{ns}		0.02^{ns}		0.20^{ns}	
$F_{water\ condition}$ (C)	9.22*		10.76*		9.94*		35.76*		2.95^{ns}	
F(A) x F(C)	1.74^{ns}		1.37^{ns}		1.28^{ns}		1.53^{ns}		0.46^{ns}	

Means followed by the same uppercase letter in the column and lowercase letter in the row do not differ from each other by the Scott-Knott test at 5% probability. SMI: Santa Maria; ALI: Alegrete. WRC: soil-water retention capacity; WD: water depth. Stomatal conductance (Gs, mol H_2O m^{-2} s^{-1}); intercellular CO_2 concentration (Ci, µmol CO_2 mol^{-1}); transpiration rate (E, mmol H_2O m^{-2} s^{-1}); water use efficiency (WUE, mol CO_2 mol^{-1} H_2O); and instantaneous carboxylation efficiency of Rubisco (A/Ci, µmol m^{-2} s^{-1} Pa^{-1}) Gs – Data transformed by Box-Cox. ^{ns} not significant and * significant at 5%.

with a photosynthetic rate 35% higher under excess water, but without restricting the stomatal conductance in the flooded soil (Mollard et al., 2008).

Morphological evaluations showed that the biotype Alegrete produced more tillers than the Santa Maria under water depth condition, suggesting its higher adaptation to this environment, or a higher resilience after stress caused by water depth (Table 4). Saturated soils suppress the physiological processes of plants, initially changing the aerobic by the anaerobic metabolism with the fermentation process (alcoholic fermentation) (Liao and Lin, 2001). Processes such as cytoplasmic acidification, rise in cytosolic Ca^{2+}, changes in redox potential, decrease of membrane barrier, and production of reactive oxygen species (EROS) occur as a consequence of this change (Blokhina et al., 2003; Fukao and Bailey-Serres, 2004).

This stress can be observed by the reduced tillering (Gun Won et al., 1999) of rice as water depth increases (Ismail et al., 2012). Energy is directed to the production of other structures, such as the cell elongation in leaves (Dias-Filho and Carvalho, 2000) and stem (Ismail et al., 2012). This elongation is already molecularly described in improved rice varieties for deep-water cultivation by the SNORKEL 1 and SNORKEL 2 genes (Hattori et al., 2009).

The biotype Santa Maria had a higher root dry matter accumulation at 100% WRC, increasing the mean of the total dry matter (Table 5). The biotype Alegrete was indifferent regarding root dry matter accumulation in the slicing within the three water conditions.

Table 4 - Means of the number of tillers from the base of two biotypes of *Eleusine indica* under different soil water conditions at the inflorescence elongation (booting) stage. Santa Maria, RS, 2016

Soil water condition	Biotype	
	Santa Maria	Alegrete
50% WRC	14.60 a B	14.40 a C
100% WRC	26.60 a A	28.80 a A
Water depth	8.20 b C	19.80 a B
CV (%)	19.79	
F-test of the biotype (B)	11.21*	
F-test of the water condition (C)	43.90*	
F-test of the interaction A x C	7.07*	

Means followed by the same uppercase letter in the column and lowercase letter in the row do not differ from each other by the Scott-Knott test at 5% probability. WRC: soil-water retention capacity. ^{ns} not significant and * significant at 5%.

Table 5 - Means of root dry matter (g) of two biotypes of *Eleusine indica* under different soil water conditions at the end of the cycle. Santa Maria, RS, 2016

Soil water condition	Biotype	
	Santa Maria	Alegrete
50% WRC	13.20 a B	9.30 a A
100% WRC	19.50 a A	11.60 b A
Water depth	13.00 a B	12.10 a A
CV (%)	27.2	
F-test of the biotype (B)	10.2*	
F-test of the water condition (C)	3.90*	
F-test of the interaction A x C	2.50^{ns}	

Means followed by the same uppercase letter in the column and lowercase letter in the row do not differ from each other by the Scott-Knott test at 5% probability. WRC: soil-water retention capacity. ^{ns} not significant and * significant at 5%.

A similar response was observed in the evaluations of the shoot (Table 6) and total dry matter (Table 7). The biotype Alegrete presented a higher total dry matter accumulation at the end of the plant cycle under conditions of high-water availability (100% WRC and water depth).

The mean stem length was lower under the 50% WRC condition for both biotypes, probably related to the stress due to lack of water. Tissue elongation for *E. indica* is only affected under conditions of higher depth (Table 8).

A reduction in the accumulation of root, stem, and branch biomass, formation of adventitious roots and aerenchyma/pneumatophores, leaf expansion, or induction of leaf abscission are some of the main responses evidenced by water stress on susceptible plants (Colmer and Pedersen, 2008). Susceptible species at more advanced stages submitted to soil flooding showed more intense stress symptoms, such as leaf yellowing related to the degradation or decrease of their synthesis by low nitrogen uptake in the roots, which leads to photoinhibition, necrosis, and tissue death (Gonçalves et al., 2012).

The biotype Alegrete had a shorter cycle in the overall mean (94 days), which is justified by its 30 days shortening in water scarcity (50% WRC) when compared to 114 days of the biotype Santa Maria (Table 9). It indicates that the biotype Alegrete probably tolerates less the lack of water in the soil. *E. indica* finishes its cycle after 120 days under upland conditions, with fast initial development, emitting inflorescences in less than 30 days after emergence (Takano et al., 2016).

Table 6 - Means of shoot dry matter (g) of two biotypes of *Eleusine indica* under different soil water conditions at the end of the cycle. Santa Maria, RS, 2016

Soil water condition	Biotype	
	Santa Maria	Alegrete
50% WRC	42.04 a B	28.22 a B
100% WRC	86.94 a A	75.76 a A
Water depth	63.50 a B	57.50 a A
CV (%)	27.97	
F-test of the biotype (B)	2.90^{ns}	
F-test of the water condition (C)	19.66*	
F-test of the interaction A x C	0.15^{ns}	

Means followed by the same uppercase letter in the column and lowercase letter in the row do not differ from each other by the Scott-Knott test at 5% probability. WRC: soil-water retention capacity. ^{ns} not significant and * significant at 5%.

Table 7 - Means of total dry matter (g) of two biotypes of *Eleusine indica* under different soil water conditions at the end of the cycle. Santa Maria, RS, 2016

Soil water condition	Biotype	
	Santa Maria	Alegrete
50% WRC	55.21 a B	37.55 a B
100% WRC	106.46 a A	87.38 a A
Water depth	76.39 a B	69.80 a A
CV (%)	25.88	
F-test of the biotype (B)	4.48*	
F-test of the water condition (C)	18.34*	
F-test of the interaction A x C	0.33^{ns}	

Means followed by the same uppercase letter in the column and lowercase letter in the row do not differ from each other by the Scott-Knott test at 5% probability. WRC: soil-water retention capacity. ^{ns} not significant and * significant at 5%.

Table 8 - Means of the main stem length (cm) (mother plant) of two biotypes of *Eleusine indica* under different soil water conditions at the end of the cycle. Santa Maria, RS, 2016

Soil water condition	Biotype	
	Santa Maria	Alegrete
50% WRC	25.78 a B	24.76 a B
100% WRC	34.74 a A	35.12 a A
Water depth	35.14 a A	36.40 a A
CV (%)	9.85	
F-test of the biotype (B)	0.03^{ns}	
F-test of the water condition (C)	34.30*	
F-test of the interaction A x C	0.33^{ns}	

Means followed by the same uppercase letter in the column and lowercase letter in the row do not differ from each other by the Scott-Knott test at 5% probability. WRC: soil-water retention capacity. ^{ns} not significant and * significant at 5%.

Table 9 - Means of cycle time (days) of two biotypes of *Eleusine indica* under different soil water conditions at the end of the cycle. Santa Maria, RS, 2016

Soil water condition	Biotype	
	Santa Maria	Alegrete
50% WRC	114 a A	84 b A
100% WRC	103 a A	87 a A
Water depth	119 a A	109 a A
CV (%)	18.48	
F-test of the biotype (B)	6.81*	
F-test of the water condition (C)	2.54^{ns}	
F-test of the interaction A x C	0.75^{ns}	

Means followed by the same uppercase letter in the column and lowercase letter in the row do not differ from each other by the Scott-Knott test at 5% probability. WRC: soil-water retention capacity. ^{ns} not significant and * significant at 5%.

Both biotypes produced few seeds under situations of low water availability (50% WRC). A lower number was also observed under water depth condition (Table 10). The biotype Alegrete under a condition of 100% WRC showed a high seed production rate (161,246), which is above the mean for this species (140,000) under ideal development conditions (Chauhan et al., 2008; Takano et al., 2016).

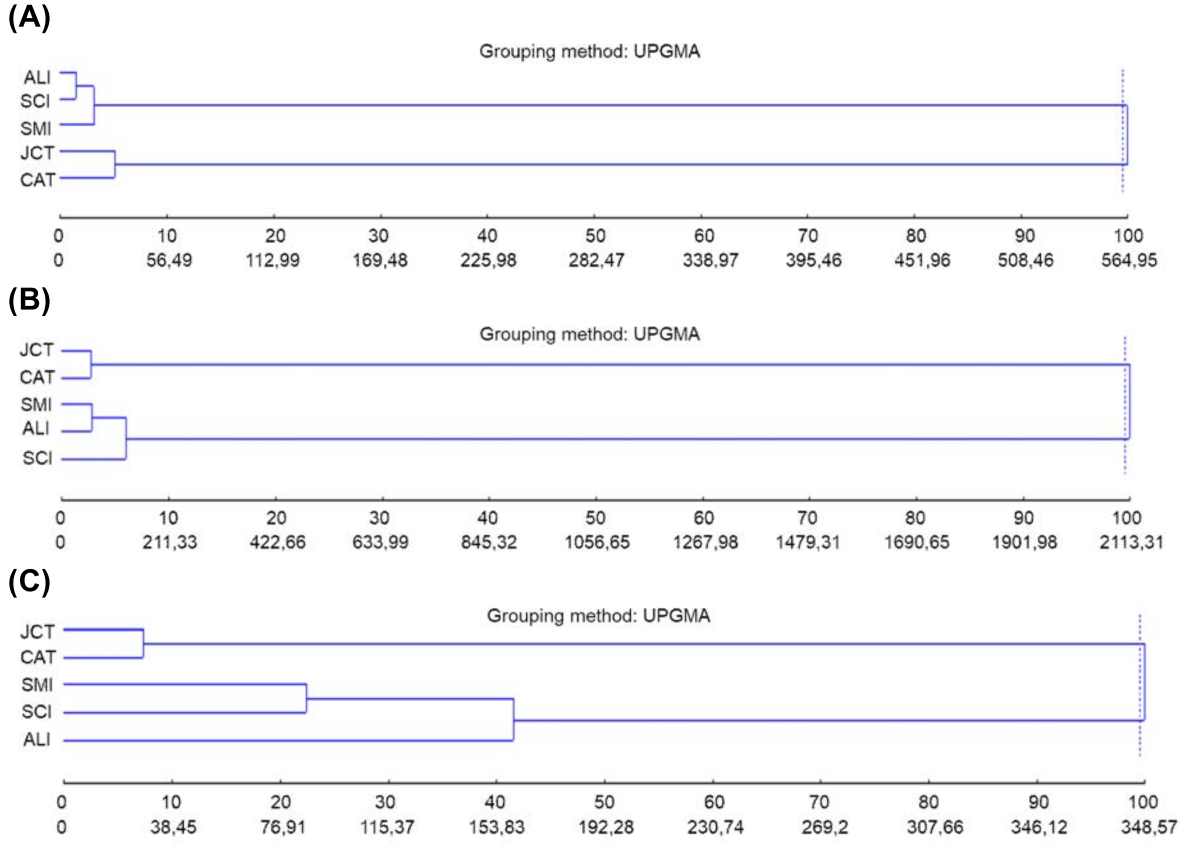
The evaluation of morphological diversity showed that *E. indica* biotypes remained without morphological differentiation. Significant cut-offs were verified only in the separation of species *E. indica* (object of study) and *E. tristachya* (additional species or positive control) (Figure 2).

The evaluation of morphological variation based on descriptors can be manipulated to select superior biotypes for differential traits, as observed for genetic improvement (Khan et al., 2011; Umar and Kwon-Ndung, 2014). This type of classification has already been observed for *Cyperus rotundus*, in which high- and lowland ecotypes were classified by differentiating them into tolerant and intolerant to oxygen deficiency in the soil (Peña-Fronteras et al., 2009). Thus, information from the group on specific traits will help in the future to find more biotypes of the same group, with similar or closely related traits, which would facilitate the indication of a lowland biotype (Upadhyaya et al., 2007).

Table 10 - Means of the number of seeds per plant of two biotypes of *Eleusine indica* under different soil water conditions at the end of the cycle. Santa Maria, RS, 2016

Soil water condition	Biotype	
	Santa Maria	Alegrete
50% WRC	63230 a A	54130 a B
100% WRC	81431 b A	161246 a A
Water depth	63946 a A	59890 a B
CV (%)	42.71	
F-test of the biotype (B)	3.12^{ns}	
F-test of the water condition (C)	10.48*	
F-test of the interaction A x C	5.25*	

Means followed by the same uppercase letter in the column and lowercase letter in the row do not differ from each other by the Scott-Knott test at 5% probability. WRC: soil-water retention capacity. ^{ns} not significant and * significant at 5%.



Significant cut-off at position 100 for all conditions. (A) and (B): 50 and 100% soil-water retention capacity (WRC), respectively; (C) water depth. ALI: Alegrete; CAT: Cruz Alta; JCT: Júlio de Castilhos; SCI: Santa Catarina; SMI: Santa Maria. Santa Maria, RS, 2016.

Figure 2 - Dendrogram obtained from the morphological Mahalanobis distance and UPGMA method.

Considering the above, it is incorrect to state the existence of a lowland ecotype or morphotype for *E. indica*. However, this species survived under water depth conditions because both biotypes supported flooding and were similar in all evaluated parameters, reinforcing the potential in the invasiveness within the irrigated rice system.

In the current agricultural scenario, the interference of this plant still needs to be measured for irrigated rice systems, in which it is pointed out the need to perform studies relating its population with yield losses generated for the crop. In addition, the integrated management of this grass should be studied together with the red rice (*Oryza sativa*) control program and rice-grass (*Echinochloa* spp.) complex.

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