BIOSCIENCE JOURNAL

EFFECT OF *Urochloa brizantha* DENSITY ON COMPETITION WITH *Myracrodruon urundeuva*

Murilo Antônio Oliveira RUAS[1], Leonardo David Tuffi SANTOS[2], Luan Mateus Silva DONATO[2]
José Ângeles Moreira de OLIVEIRA[1], Victor Augustus Vasconcelos de OLIVEIRA[2],
Rodinei Facco PEGORARO[2]

[1]Postgraduate program in Plant Production/Doctorate, Institute of Agricultural Sciences, Universidade Federal de Minas Gerais, Montes Claros, MG, Brazil.
[2]Institute of Agricultural Sciences, Universidade Federal de Minas Gerais, Montes Claros, MG, Brazil.

How to cite: RUAS, M.A.O., et al. Effect of *Urochloa brizantha* density on competition with *Myracrodruon urundeuva*. *Bioscience Journal*. 2025, **41**, e41016. https://doi.org/10.14393/BJ-v41n0a2025-76005

Abstract

Cultivating *Myracrodruon urundeuva* seedlings in forest restoration or intercropped areas is significantly challenging due to the competition with weeds, especially forage grasses. This study evaluated the influence of *Urochloa brizantha* density on the initial growth, physiological response, and macronutrient utilization of *M. urundeuva* seedlings. The experiment used randomized blocks with six replications. It included different densities of the *U. brizantha* competitor, where 0 (control), 14, 28, and 42 individuals/m² corresponded to 0, 1, 2, and 3 competitor plants per pot, respectively. *U. brizantha* competition reduced the photosynthetic rate (> 35%), water use efficiency (> 23%), and shoot dry mass (> 24%) of *M. urundeuva* compared to the controls. *U. brizantha* also affected *M. urundeuva*'s P and K absorption more than other macronutrients. Regardless of competitor density, the coexistence of *U. brizantha* influences the photosynthesis, water use, and macronutrient absorption, especially P and K, by *M. urundeuva*, providing lower biomass of the tree species. The *U. brizantha* competitor, grown at low densities, stimulated root growth, height gain, and the accumulation of N, S, and Mg in the shoot, as well as all macronutrients in *M. urundeuva* roots.

Keywords: Absorption efficiency. Aroeira. Coexistence. Macronutrients. Weed grass.

Corresponding author:
Leonardo David Tuffi Santos
ltuffi@yahoo.com.br

Received: 13 November 2024
Accepted: 11 June 2025
Published: 11 August 2025

1. Introduction

The Brazilian Cerrado is renowned for its rich biodiversity (Critical Ecosystem Partnership Fund 2018; Rodrigues et al. 2022) and is home to Brazil's agricultural use area (Russo et al. 2018). However, changes in land use, particularly the conversion of forest formations and savannas into agricultural and pasture areas, pose a significant threat. These changes increase greenhouse gas emissions and disrupt regional climate stability (Rodrigues et al. 2022). Notably, these human interventions in the biome jeopardize the survival of forest species, including those typical of the Cerrado and transition areas, such as *Myracrodruon urundeuva* (M. Allemão) Engl.

This species belongs to the Anacardiaceae family and is native to Brazil. However, it is not endemic, also occurring in Mexico, Trinidad and Tobago, Colombia, Venezuela, Ecuador, Bolivia, Guyana, Paraguay, and Argentina (Carvalho 2003; Capo et al. 2022). Its wood has high environmental durability, density, and mechanical resistance (Lorenzi 2008), and humans use it extensively in rural and urban areas. The species has pharmaceutical potential, and its flowering is highly valued for the provision of high-quality honey (Santos et al. 2018; Gardoni et al. 2022). The implementation of the Brazilian Forest Code, or the Brazilian Native Vegetation Protection Law (Brasil 2012), has promoted reforestation projects in several regions of the country. Consequently, areas inadequately occupied by pastures and crops are undergoing readaptation. Besides cultivation in reforestation projects, the species has the potential for commercial exploitation due to the multipurpose nature of its products.

The establishment and initial growth of *M. urundeuva* face significant challenges related to competition with grasses, particularly *Urochloa brizantha*, one of Brazil's most cultivated forages and a relevant invasive species in natural environments. The presence of *U. brizantha* as an invasive plant complicates the implanting of timber species of commercial interest (Medeiros et al. 2016; Colmanetti et al. 2019; Maciel et al. 2022) and the environmental preservation of trees in the African Savanna and the Brazilian Cerrado. However, the literature on the coexistence of *U. brizantha* with *M. urundeuva* and its effects on growth, physiology, and nutrient absorption by tree species shows a unique gap. Our research aims to fill this gap and provide valuable insights into this understudied interaction.

The literature addresses the competition between *U. brizantha* and trees of interest, considering growth (Medeiros et al. 2016; Maciel et al. 2022), survival (Toledo et al. 2003), physiology (Santos et al. 2015; Alencar et al. 2021), and mineral nutrition (Medeiros et al. 2016; Maciel et al. 2022). Additionally, assessments of physiological variables may help understand the competitive behavior of *U. brizantha* weeds against *M. urundeuva*.

Thus, this study evaluated the competitive aspects of *U. brizantha* at different densities, considering *M. urundeuva* physiological responses, macronutrient absorption, and initial growth.

2. Material and Methods

Study location and used material

The experiment was conducted in an open area at the Institute of Agricultural Sciences of the Federal University of Minas Gerais, an Experimental Farm in Montes Claros (MG, Brazil) (16°40'3.17" south latitude, 43°50'40.97" west longitude, and 618 meters of altitude). The region's climate is Aw-type (tropical savannah), characterized by high annual temperatures and a rainfall regime noted by rainy summers and dry winters (Climate Data 2023).

The plants coexisted for 150 days after seedling transplanting to pots with a 12L capacity filled with soil and sand in the proportion of 3:1. The soil to prepare the substrate had the following characteristics: pH (water) = 6.1; organic matter = 2.26 dag kg^{-1}; sand = 63.2 dag kg^{-1}; silt = 12.8 dag kg^{-1}; clay = 24.0 dag Kg^{-1}; Mehlich P = 8.1 mg dm^{-3}; remaining P = 21.6 mg L^{-1}; K = 214.5 mg dm^{-3}; Ca = 10.45 cmolc dm^{-3}; Mg = 0.87 cmolc dm^{-3}; Al = 0.0 cmolc dm^{-3}; H + Al = 1.27 cmolc dm^{-3}; SB = 11.87 cmolc dm^{-3}; t = 11.87 cmolc dm^{-3}; T = 13.14 cmolc dm^{-3}; V = 90.31%. The substrate was fertilized with simple superphosphate (18% P_2O_5, 16% calcium, and 14% sulfur), according to the fertilizer recommendation for growing plants in pots (Novais et al. 1991). Figure 1 presents average temperatures and precipitation over 150 days of coexistence of the studied plants.

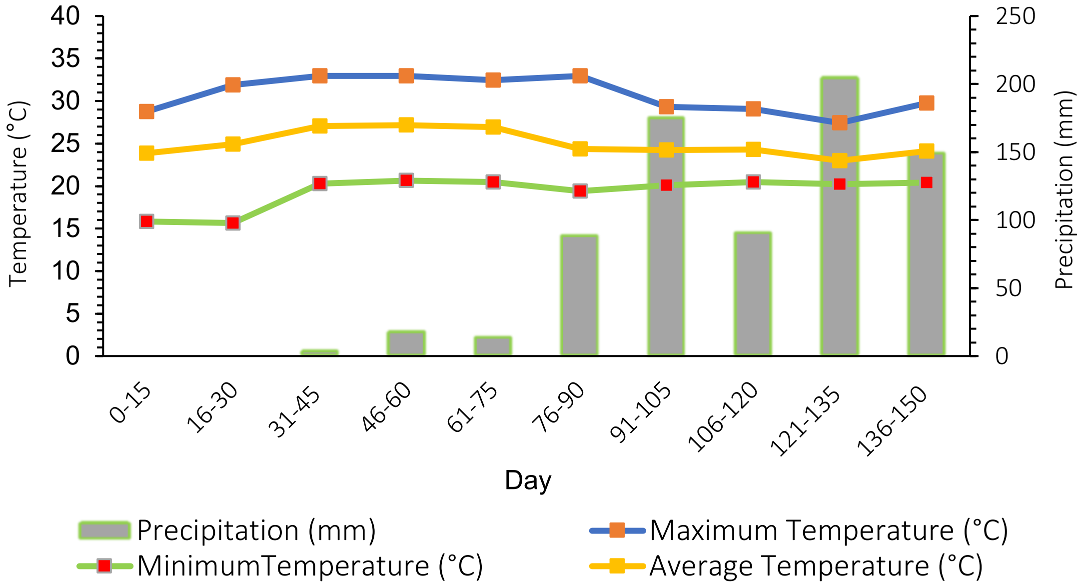

Figure 1. Biweekly averages of precipitation and temperature in the area over the 150 days of coexistence of the studied plants in Montes Claros, Minas Gerais, Brazil. The data originated from the meteorological station located approximately 670 meters from the experimental area.

The *M. urundeuva* seedlings used in the experiment are of seminiferous origin and had an average height of 30.4 cm and a collar diameter of 3.3 mm when transplanted into pots. *U. brizantha* seedlings were produced in styrofoam trays filled with the same substrate of the pots and transplanted with an average height of 5 cm at the beginning of tillering, with around three to four leaves.

Experimental design and treatments

The experiment was conducted in randomized blocks with six replications, with each pot representing an experimental plot. The treatments considered different densities of the *U. brizantha* competitor, where 0 (control), 14, 28, and 42 plants/m^2 corresponded to 0, 1, 2, and 3 competitor plants/pot, respectively. *Myracrodruon urundeuva* was planted in the center of the pot. Conversely, *U. brizantha* seedlings in the competition treatments were planted approximately 10 cm from the tree plant (Figure 2).

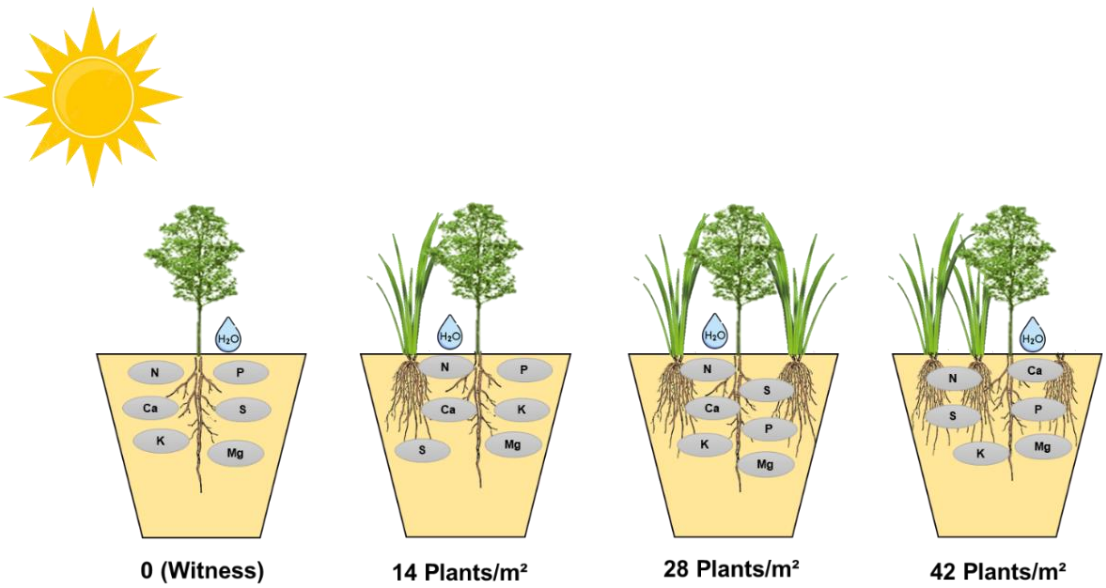

Figure 2. Scheme of experimental plots with the distribution of *Myracrodruon urundeuva* and *Urochloa brizantha* plants and their densities.

After transplanting the plants into pots, they remained on open benches for 150 days. During this time, manual weeding was performed periodically to remove other plants that were germinating in the pots. Daily irrigation using a watering can maintained soil moisture between 80% and 100% of field capacity.

Response variables, data collection, and analysis

On the day of transplanting and after 150 days of coexistence, the height (cm) and diameter (mm) of the stem of *M. urundeuva* seedlings were measured. These data enabled the calculation of height and diameter gains of the plants of the tree species. A ruler determined the height of the main stem of *M. urundeuva* plants between the base and the apical meristem. Conversely, a caliper measured the stem diameter, approximately 1.5 cm above the ground.

One hundred fifty days after transplanting, an infrared gas analyzer (IRGA; LCpro-SD model, ADC BioScientific, Hoddesdon, UK) measured the photosynthetic rate (Pn, µmol of CO_2 m^{-2} s^{-1}) and transpiration (E, µmol H_2O m^{-2} s^{-1}) of *M. urundeuva* leaves, and their water use efficiency (WUE, µmol CO_2 mol^{-1} H_2O) was also determined. The IRGA assessments took place in the morning, from 7:30 am to 11 am, evaluating one block at a time and providing attached artificial light corresponding to 1200 µmol m^{-2} s^{-1}. Overall, one fully expanded leaflet per *M. urundeuva* seedling was assessed in the middle third of the plants.

After the physiological evaluation, the shoot of *M. urundeuva* plants was cut close to the ground. Subsequently, the roots were removed, separated by species, and washed to remove the substrate. The shoots and roots of *M. urundeuva* plants were placed in paper bags and inserted in a forced circulation oven (Model SSDc 1152L, Solidsteel, Piracicaba, Brazil) at 65°C for 72 hours for weighing and dry mass calculation.

After drying, the shoots and roots of *M. urundeuva* were separately ground in a knife mill (CE-340, CienlaB, Campinas, Brazil) with a 1 mm mesh sieve. The dried and ground matter was used to identify the macronutrients. Defining the nitrogen (N) content in the root and shoot by the Kjedahl Method (Bataglia et al., 1983) was possible by using an aliquot of 0.2 g of the ground matter subjected to sulfuric digestion. The ground matter underwent nitric-perchloric digestion to determine the levels of phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S) (Tedesco et al. 1995). After digestion, the extracts were stored for subsequent S analysis using a UV-Vis spectrophotometer (Model B462, Micronal, Piracicaba), and P and K were assessed with a flame spectrophotometer (Model 1600uv, Nova instruments, Piracicaba). Conversely, Ca and Mg were defined by colorimetry (Silva 2009).

The nutrient content was estimated by multiplying the dry mass of the plants' shoot and root by the nutrient content. The relative nutrient content in the shoots and roots of *M. urundeuva* seedlings was also estimated in competition treatments, considering the reference content (100%) for plants maintained in monoculture (Control) and proportionally to the values from plants coexisting with the competitor at different densities.

The following formulas calculated the dry mass and nutrient accumulation of *M. urundeuva*, the nutrient use efficiency of the shoot (NUES, g^2 mg^{-1}) and the root (NUER, g^2 mg^{-1}), and total nutrient absorption (TA, mg g^{-1}) (Swiader; Chyan; Freiji, 2008):

$$\text{NUES}\ (\text{g}^2\ \text{mg}^{-1}) = \frac{(\text{Shoot DM})^2}{(\text{Total nutrient content})}$$

NUES = Nutrient use efficiency of the shoot.
Shoot DM = Shoot dry mass (g).
Total nutrient content in the plant (mg).

$$\text{NUER}\ (\text{g}^2\ \text{mg}^{-1}) = \frac{(\text{Root DM})^2}{(\text{Total nutrient content})}$$

NUER = Nutrient use efficiency of the root.
Root DM = Root dry mass (g).
Total nutrient content in the plant (mg).

$$\text{TA}\ (\text{mg g}^{-1}) = \text{Shoot} + \text{Root}$$

TA= Total nutrient absorption in the shoot and root.

The Shapiro-Wilk test verified the normality of data referring to the response variables of plant height and diameter gains, photosynthetic rate, evapotranspiration, water use efficiency, root dry mass, shoot dry mass, content, accumulation, and macronutrient use and absorption efficiency of *Myracrodruon urundeuva*. These data also showed homogeneity of variances by the O'Neill and Mathews test. Subsequently, the data for these variables underwent the analysis of variance ($p \leq 0.05$). These analyses used the ExpDes.pt package aided by R software (R Core Team 2023). The data of the relative macronutrient accumulation of *M. urundeuva* were presented descriptively based on the mean and standard error of the mean.

The variables of growth, physiology, and macronutrient use efficiency of *M. urundeuva* underwent a multivariate analysis and an association using a correlation matrix to the competitor's coexistence densities in the principal component analysis (PCA). The multivariate analysis was conducted in R studio software (R Core Team 2023).

3. Results

The coexistence of *U. brizantha* with *M. urundeuva* reduced the photosynthetic rate, shoot dry mass, and instantaneous water use efficiency of *M. urundeuva* plants, regardless of competitor density (Table 1). The height gain of *M. urundeuva* plants was higher when coexisting with a competitor plant, corresponding to 14 plants/m^2 of *U. brizantha*. Root dry mass values were higher in plants that maintained coexistence with 14 and 28 plants/m^2 of *U. brizantha*. Conversely, the transpiration and stem diameter gain of *M. urundeuva* showed no differences from weed density (Table 1).

Table 1. Photosynthetic rate (Pn - µmol of CO_2 m^{-2} s^{-2}), transpiration (E - µmol m^{-2} s^{-1}), instantaneous water use efficiency (WUE - µmol CO_2 mol^{-1} H_2O), height gain (HG – cm), stem diameter gain (SDG – mm), shoot dry mass (SDM – g), and root dry mass (RDM – g) of *Myracrodruon urundeuva* coexisting with *Urochloa brizantha* at different densities, 150 days after transplanting.

Density (plants/m²)*	Physiological and growth variables						
	Pn	*E*^{ns}	WUE	HG	SDG^{ns}	SDM	RDM
0	9.10^a	3.33	2.88^a	36.15^{ab}	4.83	23.56^a	13.50^b
14	5.94^b	3.05	2.14^{ab}	47.38^a	5.33	15.97 b	18.37^a
28	4.73^b	2.77	1.76^b	27.36^b	5.50	17.05 b	16.82^a
42	5.95^b	2.78	2.23^{ab}	29.43^{ab}	5.50	17.82 b	13.42^b
CV (%)	21.81	22.91	27.7	32.25	37.33	13.45	7.99

***Urochloa brizantha* density. Means followed by the same lowercase letter in the column do not differ by Tukey test at a 5% significance level. ns = not significant by the F test.

The relative accumulation of N, S, and Mg was higher in the shoot of *M. urundeuva* maintained in competition with *U. brizantha*, regardless of the competitor's density, compared to the control (Table 2). However, the relative accumulation of P and K was lower in *M. urundeuva* plants competing with *U. brizantha* in the three competitor's density conditions compared to the control (Table 2). The relative macronutrient accumulation in the roots of *M. urundeuva* plants maintained in competition with 14 plants/m^2 of *U. brizantha* was higher than the treatment without competition. In comparison, the relative accumulation of Ca was higher in *M. urundeuva* plants maintained in competition. Conversely, when competing with 28 and 42 plants/m^2 of *U. brizantha*, the relative accumulations of N, P, K, and Mg in the root of *M. urundeuva* plants were lower than the control (Table 2).

The principal component analyses (PCA 1 and PCA 2) of the physiological and morphological data supported our findings, explaining 67.13% and 26.63% of the variance, respectively (Figure 3). *M. urundeuva* plants presented higher Pn, WUEi, SDM, and TDM in the absence of competition (T0). The highest mean values for RDM and SDG regarding treatments with 14, 28, and 42 plants/m^2 occurred in the presence of competition (Figure 3). The higher biomass of *U. brizantha* (GSDM and GRDM) is inversely correlated to Pn, WUE, SDM, and TDM in *M. urundeuva* (Figure 3). The competition using 14 plants/m^2 of *U. brizantha* stimulated root growth (RDM) in *M. urundeuva.*

The PCA on the variance of total nutrient absorption x total dry mass of *M. urundeuva* plants was 66.01% for PCA 1 and 22.65% for PCA 2 (Figure 4). The absence of interspecific competition (T0) demonstrated higher total P absorption (TPA) and biomass of *M. urundeuva*. The 28 plants/m^2 treatment showed higher N (TNA), K (TKA), and S (TSA) absorption values (Figure 4A). Figure 4B shows that PCA 1 and PCA 2 explain 72.82% and 16.94% of the variance, respectively, in nutrient use efficiency x total biomass of *M. urundeuva*. Macronutrient use efficiency was always higher in *M. urundeuva* without competition (T0), indicating a reduction in this characteristic regardless of the competitor's density (Figure 4B).

Table 2. Relative macronutrient accumulation (%) in the shoot and root of *Myracrodruon urundeuva* competing with *Urochloa brizantha* at different densities 150 days after transplanting.

Density (plants/m²)*	N	P	K	Ca	Mg	S
			Shoot			
0	100	100	100	100	100	100
14	112	71	82	77	113	114
28	117	80	93	85	129	118
42	102	83	96	129	128	128
			Root			
0	100	100	100	100	100	100
14	119	113	135	239	187	171
28	60	75	93	152	66	55
42	74	76	98	183	96	117

**Urochloa brizantha* density.

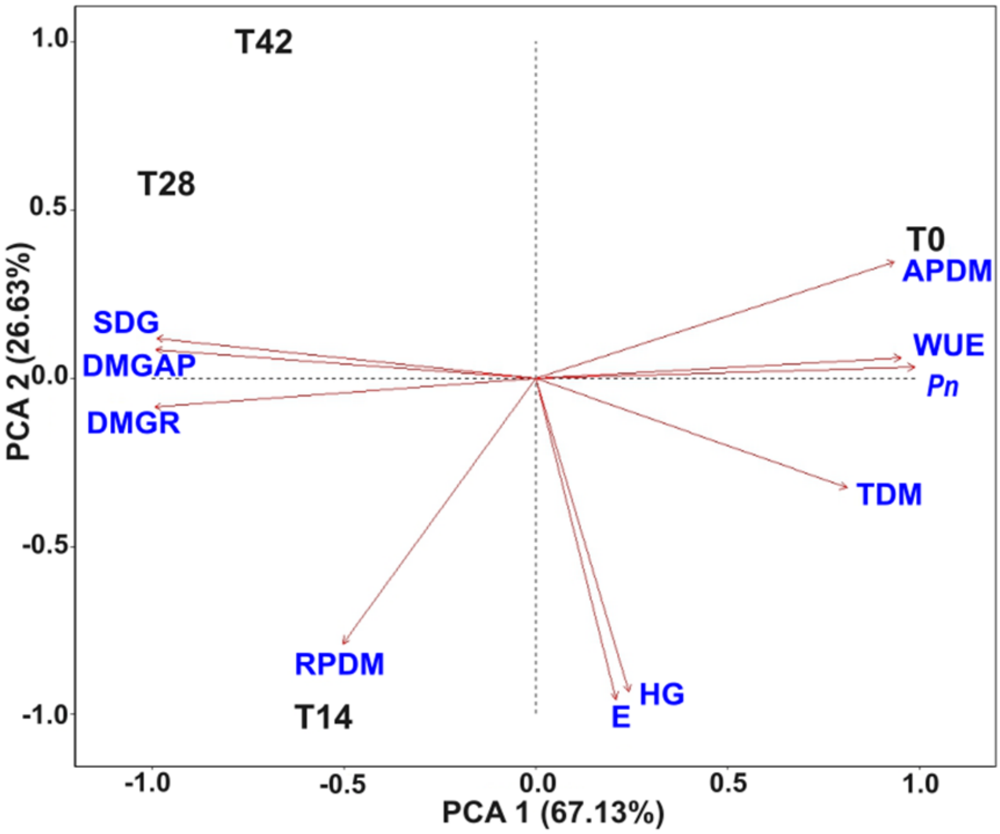

Figure 3. Photosynthetic rate (Pn), transpiration (E), instantaneous water use efficiency (WUE), height gain (HG), stem diameter gain (SDG), shoot dry matter (APDM), root dry matter (RPDM), total dry matter (TDM), grass shoot dry mass (DMGAP), and grass root dry mass (DMGR). T0 = the absence of interspecific competition, T14 = 14 plants/m^2, T28 = 28 plants/m^2, T42 = 42 plants/m^2.

Table 3 – Content (g kg^{-1}), accumulation (mg/plant), nutrient use efficiency (NUE, g^{2} mg^{-1}) in the shoot and root, and macronutrient absorption efficiency (AE, mg g^{-1}) of *Myracrodruon urundeuva* plants coexisting with *Urochloa brizantha* at different densities 150 days after transplanting.

Density (plants/m²)*	Content		Accumulation		NUE		AE
	shoot	root	shoot	root	shoot	root	
				N			
0	4.79	6.71	84.50	77.63	1.28	1.00^{b}	13.35
14	4.70	4.95	75.18	53.98	2.62	5.16^{a}	5.06
28	4.81	4.04	71.22	115.78	2.16	1.52^{b}	11.64
42	4.00	4.07	76.27	78.83	4.37	2.78^{ab}	9.16
CV (%)	24.48	43.22	37.47	42.74	76.65	33.66	39.46
				P			
0	2.25	2.40^{a}	26.35	31.51	3.65	2.70^{b}	4.65
14	1.56	1.63^{ab}	32.58	23.22	5.86	12.48^{a}	2.19
28	1.57	1.66^{ab}	31.51	31.52	6.40	4.52^{b}	3.92
42	1.54	1.52^{b}	21.30	31.02	12.40	7.95^{ab}	3.10
CV (%)	24.59	16.21	30.34	32.44	21.60	34.12	28.26
				K			
0	1.83	2.00^{a}	21.67	30.49	3.90	3.00^{b}	4.29
14	1.40	1.56^{b}	20.90	21.71	7.83	15.83^{a}	1.67
28	1.47	1.47^{b}	32.63	27.01	6.69	4.60^{b}	3.64
42	1.50	1.62^{ab}	23.82	25.66	12.65	8.15^{b}	2.94
CV (%)	17.83	8.50	23.16	34.44	71.44	30.36	30.94
				Ca			
0	0.51	0.25	7.15	4.30^{b}	17.94^{ab}	13.66	0.94
14	0.46	0.47	10.00	11.93^{a}	14.76^{b}	33.94	0.87
28	0.27	0.34	6.00	5.89^{b}	24.53^{a}	23.13	0.71
42	0.54	0.47	8.82	8.53^{ab}	21.64^{ab}	17.90	1.01
CV (%)	31.68	36.64	38.98	23.82	21.61	32.51	24.04
				Mg			
0	0.97	0.72	12.08	13.71	7.89	6.07^{b}	2.11
14	0.85	0.90	13.90	10.82	14.91	26.58^{a}	0.96
28	1.15	0.52	19.26	10.26	14.26	9.44^{b}	1.75
42	0.96	0.65	17.46	11.76	19.74	12.96^{b}	1.73
CV (%)	24.16	22.49	34.35	51.06	67.97	25.98	33.01
				S			
0	1.41	1.56	22.78	29.23	4.09	3.21^{b}	4.27
14	1.49	1.53	19.56	18.99	9.34	17.02^{a}	1.50
28	1.48	1.39	28.79	18.97	8.35	5.77^{b}	2.92
42	1.47	1.47	23.84	24.91	12.21	7.94^{b}	2.98
CV (%)	13.74	24.82	32.36	42.20	70.00	28.06	39.69

**Urochloa brizantha* density. Means followed by the same lowercase letter in the column do not differ by Tukey test at a 5% significance level. Means without letters indicate no difference by the F test at a 5% significance level.

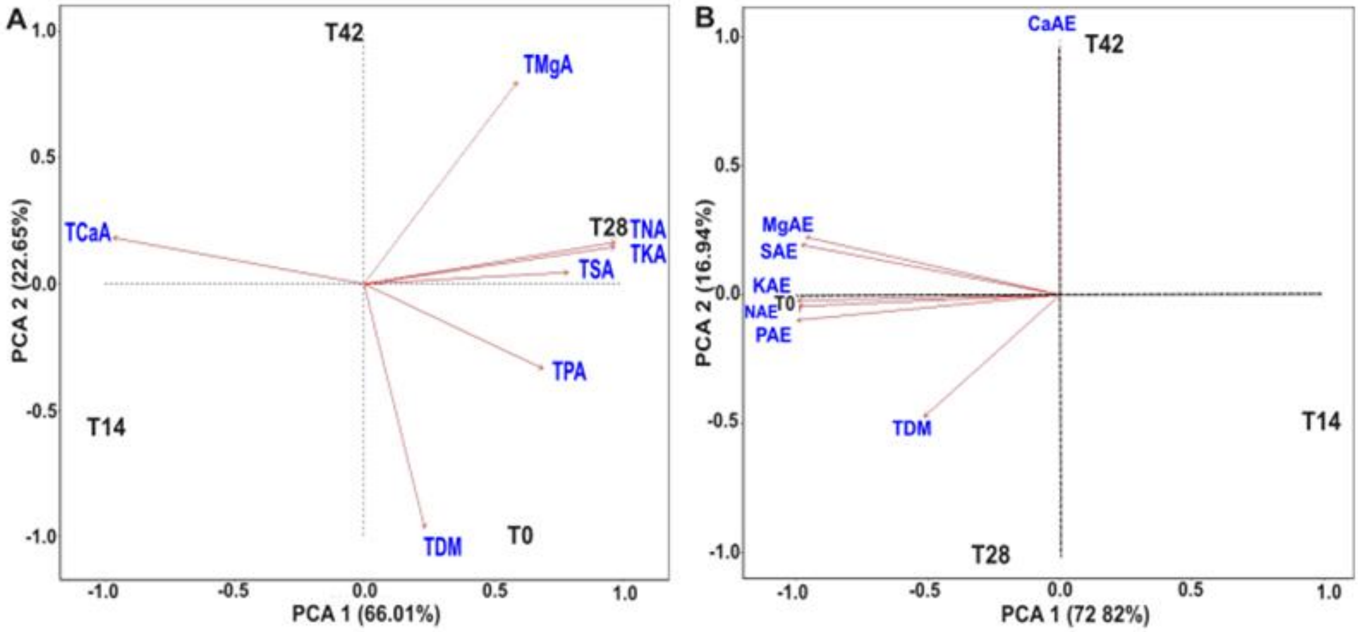

Figure 4. A and B. Principal component analysis (PCA) – Correlation matrix for the following characteristics: A) Total dry matter and total nutrient absorption in the shoot and root; B) Nutrient use efficiency of the shoot (PANUE); C) Nutrient use efficiency of the root (RPNUE); and D) Absorption efficiency; related to treatments T0, T14, T28, and T42. TDM = Total dry matter, TNA = total N absorption, TPA = Total P absorption, TKA = Total K absorption, TMgA = Total Mg absorption, TSA = total S absorption, NAE: N absorption efficiency, PAE= P absorption efficiency, KAE = K absorption efficiency, CaAE = Ca absorption efficiency, MgAE = Mg absorption efficiency, SAE = S absorption efficiency, T0 = the absence of interspecific competition, T14 = 14 plants/m^2, T28 = 28 plants/m^2, T42 = 42 plants/m^2.

4. Discussion

Weed density influences the interference with species of interest (Bacha et al. 2016; Colmanetti et al. 2019) and competitors (Medeiros et al. 2016; Campbell et al. 2017; Maciel et al. 2022). In the present study, the density of *U. brizantha*, one of the principal weeds in natural environments (Rabelo et al. 2023), affected the physiology, growth, and macronutrient use efficiency of *M. urundeuva* seedlings. However, these adverse effects were indirectly proportional to the increase in *U. brizantha* density.

Urochloa brizantha is a C4 grass that is hard to eliminate, causing both economic and environmental damage (Santos et al. 2007; Silva et al. 2016; Lima et al. 2019). The species thrives in tropical and subtropical regions (GBIF 2023), posing a significant threat to natural environments and hindering the growth of valuable native species (Freitas et al. 2019). The characteristics of high tiller production, good soil coverage, and high biomass production found in *U. brizantha* (Santos et al. 2007; Valle et al. 2010) may have contributed to the absence of a direct relationship between plant density and the interference with *M. urundeuva*. The increase in the number of plants per pot may have promoted intraspecific competition for *U. brizantha*, affecting the grass's interference with *M. urundeuva*.

The *M. urundeuva* plants coexisting with *U. brizantha* showed a reduction in the photosynthetic rate, instantaneous water use efficiency, height gain, and shoot dry mass compared to plants maintained without competition (Table 1, Figure 3). The large size of *U. brizantha* resulted from the shading of *M. urundeuva* plants, indicating competition for light and reflecting on the photosynthetic rate and water use efficiency. Concenço et al. (2008) report that shading alters the balance of red and far-red ranges, with a consecutive drop in photosynthetic efficiency. Competition for light may also be proven by the greater height gain of *M. urundeuva* seedlings when coexisting with 14 plants/m^2 of *U. brizantha* compared to the control, indicating a morphological response of the plant to competition for this resource.

In the presence of competition for light, *M. urundeuva* plants also accumulated more root dry mass when coexisting with *U. brizantha* at its lowest densities (Table 1). That indicates that the root growth of *M. urundeuva* was stimulated to search for water and nutrients.

The more significant relative accumulation of N, S, and Mg in the shoot of *M. urundeuva* coexisting with *U. brizantha* and of all macronutrients in its roots coexisting with 14 plants/m^2 of the competitor (Table 2) indicate an ability of the tree species to bioaccumulate these nutrients. This condition leads to the luxury consumption reported in the literature as a response from plants in competition (Mazacort and Schwartz 2010). Conversely, the lower relative accumulation of P and K in the shoot of *M. urundeuva* and N, P, K, and Mg in its roots (Table 2) indicate the difficulty of this tree species to use these nutrients when competing with *U. brizantha*, as well as the competitive ability of the grass to obtain these resources. The literature reports a reduction in relative nutrient accumulation in tree species competing with grasses for eucalyptus (Lafetá et al. 2018; Maciel et al. 2022), attributing it to the higher efficiency of plants of the genus *Urochloa* in exploiting the soil and absorbing macronutrients, including luxury consumption (Mazacort and Schwartz, 2010; Riley et al. 2019; Amorin et al. 2020).

The higher relative accumulation of N and Mg, the main constituents of chlorophyll molecules (De Bang et al. 2021), did not provide a positive response in the photosynthetic rate of *M. urundeuva* (Table 1). However, the macronutrient content increase in *M. urundeuva* coexisting with 14 plants/m^2 of *U. brizantha* (Table 2) is directly associated with higher root biomass of the tree species (Table 3).

The differences in nutrient allocation between the shoot and root of *M. urundeuva* in competition may help explain the competitive behavior of the tree species. The literature presents nutritional diagnosis analyses of competing tree plants limited to foliar assessments (Medeiros et al. 2016; Matos et al. 2019; Maciel et al. 2022). *Urochloa brizantha* reduced the levels of P and K in the roots of *M. urundeuva* (Table 3, Figure 4). However, Ca accumulation and the significant macronutrient use efficiency in the roots *of M. urundeuva* increased compared to the absence of competition (Table 3, Figure 4). Conversely, there were no responses regarding macronutrient use in the shoot or the absorption by *M. urundeuva* in the competitor's presence. Therefore, assessments of nutritional characteristics and root biomass were relevant to identify the response of *M. urundeuva* to competition.

The PCA indicates the relationship between *U. brizantha* and the lowest average values of photosynthetic rate, water use efficiency, shoot dry mass, total dry mass, and macronutrient use efficiency of *M. urundeuva* (Figures 3 and 4). The plants' macronutrient use efficiency did not behave the same as the absorption efficiency of these elements. The biological nutrient use efficiency promotes a relationship between plant biomass and the amount of accumulated nutrients, measuring the conversion efficiency between the two variables (Rosim et al. 2016). The present study found a direct correlation between higher P use efficiency and higher dry mass production of *M. urundeuva* plants (Figure 4A).

Changes in nutrient absorption in competition have been studied for other species under the same condition (Cury et al. 2013; Medeiros et al. 2016; Maciel et al. 2022). Bean cultivation had a higher average N and P absorption efficiency under the interference of *B. plantaginea* and *Amaranthus spinosus* than treatments without plant competition (Cury et al. 2013). The authors inferred that the increase in N and P absorption capacity is the plant attempting to compensate for the limitation or unavailability of these nutrients by changing its nutrient absorption kinetics. The initial growth phase of *M. urundeuva* is slower than other species. Faster-growing species are expected to have more significant competition effects on mass accumulation and growth characteristics (Medeiros et al. 2016; Maciel et al. 2022).

The evaluated physiological characteristics and the variables related to nutrient use were promising in studies on the competition between *U. brizantha* and native tree species. The present study reinforces concerns about *U. brizantha* in areas of *M. urundeuva* growth, given its potential as an invasive grass in natural biomes (Oliveira et al. 2016; Campbell et al. 2017; Rabelo et al. 2023).

5. Conclusions

The different infestation densities of *U. brizantha* negatively affected photosynthetic rates and water use efficiency, altering the macronutrient levels and accumulation in *M. urundeuva* without affecting seedling dry mass. Furthermore, the adverse effects on *M. urundeuva* are indirectly proportional to the increase in *U. brizantha* density. The tree's morphophysiological responses, such as increased height gain, reduced photosynthetic rate, nutritional changes in relative accumulation, as well as macronutrient use efficiency, were relevant for understanding the competitive processes between *U. brizantha* and *M. urundeuva* seedlings.

Authors' Contributions: RUAS, M.A.O.; SANTOS, L.D.T.; DONATO, L.M.S.; OLIVEIRA, J.A.M.;, OLIVEIRA, V.A.V.; PEGORARO, R.F.: conception or design of the work; or the acquisition, analysis or interpretation of data for the work, prepare the work or revise it critically for important intellectual content, final approval of the version to be published, agreement to be accountable for all aspects of the work, ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Conflicts of Interest: The authors reported no potential conflict of interest.

Ethics Approval: Not applicable.

Acknowledgments: To the Minas Gerais State Research Support Foundation (FAPEMIG) and the National Council for Scientific and Technological Development (CNPq) for funding the studies.

References

AMORIM, S.P., et al. Grasses and legumes as covers crops affect microbial attributes in oxisol in the Cerrado (Savannah environment) in the northeast region. *Revista Caatinga*. 2020, **33**, 31-42. https://doi.org/10.1590/1983-21252020v33n104rc

BACHA, A.L., et al. Interference of seeding and regrowth of signal grass weed *(Urochloa decumbens*) during the initial development of *Eucalyptus urograndis* (*E. grandis* × *E. urophylla*). *Australian Journal of Crop Science.* 2016, **10**, 322-330. http://dx.doi.org/10.21475/ajcs.2016.10.03.p6995

BRASIL. Instrução Normativa n° 6, de 23 de setembro de 2008. Reconhecer como espécies da flora brasileira ameaçadas de extinção aquelas constantes do anexo I a esta Intrusão Normativa. *Diário Oficial da União*: seção 1, Brasília, DF. 185. 75-83, 24 set. Available from https://www.ibama.gov.br/sophia/cnia/legislacao/MMA/IN0006-230908.PDF (Accessed 08.10.2023).

BRASIL. Lei nº 12.651, de 25 de maio de 2012. Dispõe sobre a proteção da vegetação nativa [...]. *Diário Oficial da União*: seção 1, Brasília, DF, ano CXLIX, n. 102. 1, 28 de maio de 2012. Available from https://pesquisa.in.gov.br/imprea/jsp/visualiza/index.jsp?jornal=1&pagina=1&data=28/05/2012&totalArquivos=168 (Accessed 08.10.2023).

CAMPBELL, T.A. and HOLDO, R.M. Competitive response of savanna tree seedlings to C4 grasses is negatively related to photosynthesis rate. *Biotropica*. 2017, **49**. 774-777. https://doi.org/10.1111/btp.12484

CAPO L, F, M., et al. Natural distribution of *Myracrodruon urundeuva* Fr. All. in Brazil at current and future climate scenarios due to global climate change. *Revista Árvore*. 2022, **46**. 1-11. https://doi.org/10.1590/1806-908820220000009

CARVALHO PER. Espécies florestais brasileiras: Recomendações silviculturais, potencialidades e uso da madeira. Colombo: EMBRAPA-CNPF/SPI, 640p. 1994.

CLIMATE DATA. *Dados climáticos para cidades mundiais*. [S.l.]: CLIMATE DATA, c2023. Available from https://pt.climate-data.org/. (Accessed 11.02.2024).

COLMANETTI, M. A. A., et al. Effect of increasing densities of *Urochloa brizantha* cv. Marandu on *Eucalyptus urograndis* initial development in silvopastoral system. *Journal of Forestry Research*. 2019, **30**. (2), 537-543. DOI: https://doi.org/10.1007/s11676-018-0635-4

CONCENÇO, G., et al. Fotossíntese de biótipos de azevém sob condição de competição. *Planta Daninha*. 2008, **26**. (3), 595-600. DOI: https://doi.org/10.1590/S0100-83582008000300015

CURY, et al. Eficiência nutricional de cultivares de feijão em competição com plantas daninhas. *Planta Daninha*. 2023 **31**. 79-88. https://doi.org/10.1590/S0100-83582013000100009

Critical Ecosystem Partnership Fund. Ecosystem profile: Cerrado biodiversity hotspot full report. Supernova. 2018. https://www.cepf.net/our-work/biodiversity-hotspots/cerrado

FERREIRA et al. Aspectos fisiológicos de soja transgênica submetida à competição com plantas daninhas. *Revista de Ciências Agrárias/Amazonian Journal of Agricultural and Environmental Sciences*. 2015, **58** (2), 115-121. http://dx.doi.org/10.4322/rca.1745

FREITAS, A. F., MACIEL, J. C., SILVA, M. M., and SANTOS, J. B. *Urochloa brizantha* interference in the *Phaseolus vulgaris* radicular system fertilized with phosphorus. *Planta Daninha*. 2019, **37**. 1-11. https://doi.org/10.1590/s0100-83582019370100055

GARAU, A. M., GHERSA, C.M., LEMCOFF, J.H. and BARAÑAO, J.J. Weeds in *Eucalyptus* globulus subsp. maidenii (F. Muell) establishment: effects of competition on sapling growth and survivorship. *New Forests*. 2009, **37** (3), 251-264. https://doi.org/10.1007/s11056-008-9121-8

GARDONI, L.C., et al. (2022). Content of phenolic compounds in mono floral aroeira honey and in floral nectary tissue. *Pesquisa Agropecuária Brasileira*. 2022, **57** (022802). 1-9. https://doi.org/10.1590/S1678-3921.pab2022.v57.02802

GBIF. *Urochloa brizantha* (A. Rich.) R.D. Webster in Gbif Secretariat (2023) GBIF Backbone Taxonomy. Checklist dataset. 2023. Accessed via GBIF.org on (Accessed 13.05.2024) https://doi.org/10.15468/39omei

LAFETÁ, B. O., et al. A Eficiência de utilização de macronutrientes em eucalipto por método não destrutivo estimados por redes neurais artificiais. *Ciência Florestal*. 2018, **28** (2), 613-623. http://dx.doi.org/10.5902/1980509832049

LIMA, S. F., et al. Suppression of *Urochloa brizantha* and *U. ruzizieis* by glyphosate underdoses. *Revista Caatinga*. 2019, **32** (3). 581–589. https://doi.org/10.1590/1983-21252019v32n302rc

LORENZI, H. Árvores brasileiras. Árvores brasileiras: manual de identificação e cultivo de plantas arbóreas nativas do Brasil-Vol.**1** 5º Edição P,24. 2008.

MACIEL, J. C., et al. Growth, nutrient accumulation, and nutritional efficiency of a clonal *Eucalyptus hybrid* in competition with grasses. *Forests.* 2022, **13** (8), 1157. https://doi.org/10.3390/f13081157

MATOS, C. C., et al. Physiological characteristics of coffee plants in competition with weeds. *Bioscience Journal*. 2023, **29** (5), 1111-1119.

MAZANCOURT, C and SCHWARTZ, M.W. Starve a competitor: Evolution of luxury consumption as a competitive strategy. *Theoretical Ecology*. 2010, **5**, 37-49. https://doi.org/10.1007/s12080-010-0094-9

MEDEIROS, W. N., et al. Crescimento inicial e concentração de nutrientes em clones de *Eucalyptus urophylla* x *Eucalyptus grandis* sob interferência de plantas daninhas. Ciência Florestal. 2016, **26** (1), 147- 157. http://dx.doi.org/10.5902/1980509821099

NOVAIS, R.F., NEVES, J.C.L., and BARROS, N.F., (1991). Ensaio em ambiente controlado. IN: OLIVEIRA, A.J., GARRIDO, W.E., GRAÚJO, J.D. & LOURENÇO, s., eds. Métodos de pesquisa em fertilidade do solo. Brasília, Embrapa-SEA, p.189-254

OLIVEIRA, A.P.P., et al. Can allelopathic grasses limit seed germination and seedling growth of mutambo? A test with two species of brachiaria grasses. *Planta Daninha*. 2016, **34** (4), 639-648. https://doi.org/10.1590/S0100-83582016340400003

R CORE TEAM. R: A Language and Environment for Statistical Computing. Viena: R *Foundation for Statistical Computing*, (2023). Available from https://www.r-project.org/. (Accessed 11 Feb. 2024).
RABELO, B.S., et al. M Effects of native and invasive grasses on the survival. *Biological Invasions*. 2023, **25**, 2697–2711. https://doi.org/10.1007/s10530-023-03068-6

RILEY, R.C., et al. Resource allocation to growth or luxury consumption drives mycorrhizal responses. *Ecology Letters*. 2019, **22** (11), 1757–1766. https://doi.org/10.1111/ele.13353

RODRIGUES, A. A., et al. Cerrado deforestation threatens regional climate and water availability for agriculture and ecosystems. *Global Change Biology*. 2022, **28** (22), 6807–6822. https://doi.org/10.1111/gcb.16386

ROSIM, C.C, HISING, T.Y., and PAULA, R.C. Nutrient use efficiency in interspecific *hybrids* of *eucalypt*. *Revista Ciência Agronômica*. 2016, **47** (3), 540. https://10.5935/1806-6690.20160065

RUSSO, G., et al. Cerrado The Brazilian savanna's contribution to GHG emission and to climate solution (Issue December). Instituto de Pesquisa Ambiental da Amazônia (IPAM). 2018. https://ipam.org.br/wp-content/uploads/2018/12/Policy-Brief-Cerrado-COP24-en-1.pdf

SANTOS, E. M. S., SANTOS, H. O., and GONÇALVES, J. R. S. M (2018). Quali-quantitative characterization of the honey from *Myracrodruon urundeuva* Allemão (*Anacardiceae* - Aroeira): macroscopic, microscopic, physico-chemical and microbiological parameters. *African Journal of Biotechnology*. 2028, **17** (51), 1422-1435. https://doi.org/10.5897/AJB2018.16633

SANTOS, M. E. R., et al. Características estruturais de perfilhos vegetativos e reprodutivos em pastos diferidos de capim braquiária. Ciência Animal Brasileira. 2008, **11** (3), 492-502. https://doi.org/10.5216/cab.v11i3.4957

SANTOS, M. V., et al. Controle de Brachiaria brizantha, com uso do glyphosate, na formação de pastagem de Tifton 85 (*Cynodon* spp.). *Planta Daninha*. 2007, **25** (1), 149-155. https://doi.org/10.1590/S0100-83582007000100016

SANTOS, M. V., et al. Physiological aspects of acacia and *eucalyptus* in competition with *Brachiaria*. *Australian Journal of Crop Science*. 2015, **9**, 210-214.

SILVA, F. C. Manual de análises químicas de solos, plantas e fertilizantes. 2. ed. rev. ampl. Brasília: Embrapa Informação Tecnológica. 2009, 120-122

SILVA, D. V., et al. Glyphosate herbicide use in Urochloa brizantha management in intercropping with herbicide-resistant maize. *Planta Daninha*. 2016, **34** (1), 133-141. https://doi.org/10.1590/S0100-83582016340100014

Silva, W. D., et al. Taxa transpiratória de mudas de eucalipto em resposta a níveis de água no solo e à convivência com *Brachiaria brizantha*. *Pesquisa Agropecuária Brasileira*. 2000, **35** (5), 923-928, https://doi.org/10.1590/S0100-204X2000000500009

SWIADER, J. M., CHYAN, Y., and FREIJI, F. G. Genotypic differences in nitrate uptake and utilization efficiency in pumpkin hybrids. *Journal of Plant Nutrition*. 2008, **17** (10), 1687–1699. https://doi.org/10.1080/01904169409364840

TEDESCO, M. J., et al. Análise de solo, plantas e outros materiais. Ed. 2. Porto Alegre: Universidade Federal do Rio Grande do Sul. 1995.

TOLEDO, R. E. B., et al. Faixas de controle de plantas daninhas e seus reflexos no crescimento de plantas de eucalipto. *Scientia Forestalis*. 2003, **64**, 78-92

TOLEDO, R. E. B., et al. Effects of weed control periods on initial growth and development of *eucalypt. Planta Daninha*. 2000, **18,** 395-404. https://doi.org/10.1590/S0100-83582000000300002

ULBRICHT, F. R. C., et al. An Overview of the genetics and genomics of the *Urochloa* species most commonly used in pastures. *Frontiers in Plant Science*. 2021, **12**, 01-22 https://doi.org/10.3389/fpls.2021.770461