

Intercropping sorghum and grasses during off-season in Brazilian Cerrado

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ABSTRACT: Sorghum (*Sorghum bicolor* (L.) Moench) may be harmlessly intercropped with *Urochloa* species during the off-season in the Brazilian Cerrado. At the end of the sorghum cycle, forages can be used for straw production for soybean (*Glycine max* L.) as the summer crop. This study aimed to evaluate sorghum cultivated during the off-season, intercropped with palisade grass (*Urochloa brizantha* cv. 'Marandu' (Hochst. ex A. Rich). R. D. Webster) and Congo grass (*Urochloa ruziziensis* (R. Germ. and Evrard) Crins) in two row spacings (0.5 and 0.7 m) for their effect on plant growth, dry mass production, sorghum yield and soybean grain yield. The experiment was a randomized block design: a 3 × 2 factorial scheme, with three levels of intercropping (palisade grass, Congo grass or sole cropping) and two levels of row spacing (0.5 or 0.7 m) with four replicates. Several physiological growth indexes were estimated from 10 to 60 days after emergence (DAE), including dry matter production and sorghum agronomic performance. Sorghum accumulated 0.22 g of dry matter d⁻¹ at 10 to 60 DAE, and was not affected by intercropping. The dry mass gain of forages (0.04 g d⁻¹ on average) was not affected by sorghum either. Higher sorghum grain yield (2,922 kg ha⁻¹) was observed under the 0.5-m row spacing when compared to the 0.7-m spacing. The results indicate that palisade or Congo grass may be used as companion crops for sorghum with no grain yield loss, be it to improve soybean grain yield, soil cover or integrated crop systems, aiming at sustainable intensification.

Keywords: *Sorghum bicolor*, *Urochloa brizantha*, *Urochloa ruziziensis*, physiological growth indexes, companion crops

Introduction

Intercropping crops and pasture systems have been widely recommended for the Cerrado region in Central Brazil, as an alternative to problems caused by monoculture based on soybean (*Glycine max* L.), especially for improving soil quality (Crusciol et al., 2015), and nutrient efficiency use (Eberhardt et al., 2021). In this context, it is essential to understand the behavior of the intercropped species, especially when using sorghum (*Sorghum bicolor* (L.) Moench) with *Urochloa*, for there is no consensus on their development under off-season intercroppings in the Cerrado. Off-season is defined by a short planting window, normally from Jan to Feb, when climate conditions are more restrictive due to the end of the rainy season and lower minimum temperatures (Sato et al., 2017; Kichel et al., 2019).

Sorghum is usually grown in the Cerrado as a second crop when rainfall rates decline, mainly since it is well adapted to different soil fertility and drought conditions (Oliveira et al., 2020). Grass species and spacing between rows may affect its dry matter and grain production (Silva et al., 2017), and the ideal row spacing for intercropping has yet to be determined (Sousa-Junior et al., 2020). Best crop practices, such as selection of forage species and row spacing, are still necessary to optimize intercropping systems.

Palisade grass (*Urochloa brizantha* cv. 'Marandu' (Hochst. ex A. Rich). R. D. Webster) is commonly used in intercropping systems, due to its superior adaptability to shaded conditions in early growth stages (Santos et al., 2018a), and to its high dry matter production (Catuchi et

al., 2019). Congo grass (*Urochloa ruziziensis* (R. Germ. and Evrard) Crins) is another forage found extensively in the Cerrado, and it is easily controlled and desiccated under no-tillage planting to soybean in succession (Nakao et al., 2019; Sodré-Filho et al., 2020). Despite their slow initial development and low plant height, these species produce high amounts of dry matter during the dry season and show significant potential for straw production (Carvalho et al., 2017). They may be cultivated off-season, before the main crop – soybean, for instance – in the Cerrado region.

We hypothesized that a narrower (0.5 m) or wider (0.7 m) row spacing would influence grain yield, which is normally affected by grass species and row spacing, in off-season sorghum intercropped with *Urochloa*. Thus, we aimed to test both the companion grasses' potential for dry matter production in the off-season, the effects on soybean grain yield, and the possibility of planting sorghum using the same row spacing commonly used for soybean (0.5 m), which would offer practical benefits to farmers.

Materials and Methods

The experiment was carried out from Mar 2010 until Feb 2012, in Planaltina, Distrito Federal (15°35'54" S, 47°42'29" W, altitude of 1,008 m), in Central-West Brazil. The same area and treatments were tested on both years. Prior to the experiment, the area were left fallow for two years. The soil at the experimental area, Typical Acrustox (Soil Survey Staff, 2014), was subjected to physical analysis and the following chemical analyses at the 0-0.4 m layer: pH (H₂O) at a soil:solution ratio of 1:1; Al³⁺, Ca²⁺ and Mg²⁺ extracted by KCl mol L⁻¹;

K and P extracted by the Mehlich method; cation exchange capacity at pH 7.0; organic matter, determined according to the Walkley-Black method (Table 1). The region's climate is tropical Aw (Köppen), with dry winter and rainy summer seasons, with average annual air temperatures ranging from 22 °C to 27 °C (Alvares et al., 2013). Rainfall, and minimum/maximum temperatures were recorded in a local experimental station during both years (Figure 1).

Experimental design and treatments

The experiment was conducted in a randomized block design in a 3 × 2 factorial scheme, with three levels of intercropping (palisade grass, Congo grass or sole cropping) and two levels of row spacing (0.5 or 0.7 m) with four replicates. The treatments comprised sorghum off-season cropping systems under two row spacings, before soybean as the summer crop. The plot was 5 × 8 m (28 m²). Plots were separated by 1.5-m wide carriers.

Sorghum and grasses were sown on 15 Mar 2010 and on 17 Mar 2011 under a no-tillage system. Sorghum 'BRS 304' was sown using a drag seeder at a rate of 18 and 22 seeds m⁻², under row spacings of 0.5 m and 0.7 m respectively, in order to yield a sorghum plant population of 300,000 plants ha⁻¹ in both situations; 200 kg ha⁻¹ of NPK 30-10-20 were applied to sorghum during sowing.

Palisade and Congo grasses were sown using a drag seeder at a rate of 14 kg of pure and viable seeds ha⁻¹ (81 % and 82 % germination rate for both species respectively), with row spacings of 0.25 m, regardless of the row spacing

used for the sorghum or the intercropping system. Fifteen days later, 200 kg ha⁻¹ of the formulated NPK 30-10-20 fertilizer was manually applied by topdressing. The experimental plots were evaluated over two years.

Soybean (*Glycine max* L.) 'BRS Favorita RR' was sown on 13 Oct 2010 and 10 Oct 2011, under no-tillage in a row spacing of 0.50 m, with 400 kg ha⁻¹ of NPK 00-20-20, obtaining a population of 320,000 plants ha⁻¹. A peat-based powder with *Bradyrhizobium japonicum* (SEMIA 5079 and SEMIA 5080) was added in the proportion of 500 g of this inoculant to 50 kg of soybean seeds. Glyphosate (1,800 g a.e. ha⁻¹) was sprayed at the volume of 400 L ha⁻¹ in all plots at 28 days after soybean emergence (DAE). Fungicides and insecticide were sprayed in the experimental area, in order to prevent the occurrence of diseases and pests. Soybean was desiccated at 128 DAE, at the R8 stage (beginning of grain drying in the pods and senescence of the leaves), with paraquat dichloride (400 g ha⁻¹ a.i., at a spray volume of 200 L ha⁻¹).

Plant physiological indexes

In order to evaluate plant development, one sorghum plant was randomly collected from each of the five central plant lines per plot at 10, 20, 30, 40, 50 and 60 days after emergence (DAE). The plants were cut off at the soil level, and the ones adjacent to previous cuts were avoided. Five plants per plot of the palisade and Congo grasses were also randomly sampled on the same dates and using the same method.

The leaf area (L) of the sampled plants was estimated by scanning each plant and calculating L using the AFSOFT software (2009) for all three species. The plants were then placed in paper bags and dried at 60 °C for 72 h, to obtain their dry mass weight (W). The leaf area ratio, in dm² g⁻¹, was calculated by dividing L by W. The absolute growth ratio (AGR), in g d⁻¹, the relative growth ratio (RGR), in g g⁻¹ d⁻¹, and the accurate assimilation ratio (AAR), in g dm⁻² d⁻¹, were estimated using the following formulas (Reis, 1978):

$$AGR = \frac{W_2 - W_1}{t_2} \quad (1)$$

$$RGR = \frac{\ln W_2 - \ln W_1}{t_2 - t_1} \quad (2)$$

$$AAR = \frac{W_2 - W_1}{L_2 - L_1} \times \frac{\ln L_2 - \ln L_1}{t_2 - t_1} \quad (3)$$

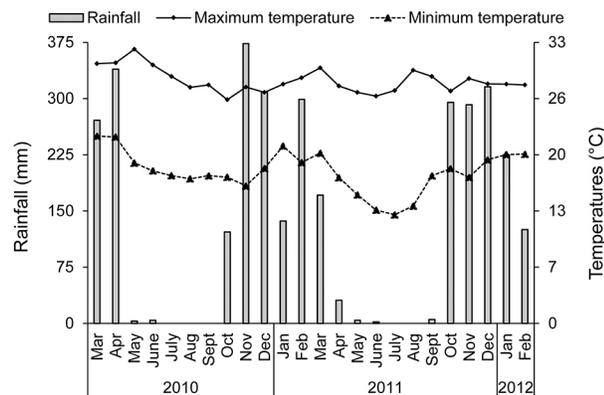


Figure 1 – Monthly accumulated rainfall and temperatures during the experimental period, in Planaltina, DF, Brazil.

Table 1 – Chemical and physical analysis of the soil at the experimental area in Mar 2010.

Soil layer	pH	Al ³⁺	Ca ²⁺	Mg ²⁺	K	P	CEC	BS	OM	sand	clay	silt
	H ₂ O	cmol _c dm ⁻³			mg dm ⁻³		cmol _c dm ⁻³	%	g kg ⁻¹			
0-0.2 m	5.84	0.14	2.76	0.97	52.42	6.48	8.53	45	2.47	334.7	563.4	101.8
0.2-0.4 m	5.74	0.30	2.05	0.60	31.25	1.11	8.19	34	2.14	365.5	531.0	103.4

CEC = cation exchange capacity; BS = base saturation; OM = organic matter.

in which W_2 = dry weight of the plant at a given period, W_1 , the initial dry weight of the plant (10 DAE), t_2 , the period of evaluation, t_1 , the initial period (10 DAE), L_2 , the leaf area at a given period, and L_1 , the initial leaf area (10 DAE).

Plant total dry mass production

Total dry weight for both years was estimated in July for sorghum plants, at the end of the crop cycle and before harvesting, and in Sept for the grasses, at 166 DAE and before their desiccation. The plants were collected within a 1-m² areas in each plot, and placed in paper bags at 60 °C for 72 h. Glyphosate (1,800 g a.e. ha⁻¹, spray volume of 400 L ha⁻¹) was sprayed to desiccate the grasses before soybean sowing, which took place in Oct.

Sorghum plant height and yield, and soybean grain yield

Each year, in June, the height of sorghum plants was measured after flowering, from the soil surface to the apex of the panicle, in five randomly chosen plants per plot. Grain yield was weighed in 1-m high plants within the five central rows of each plot after grain maturation, in July of both years. Grain yield was estimated by adjusting moisture content to 13 % (wet basis) and then measuring the weight of 1,000 grains.

Soybean grain yield was obtained by harvesting all the grains of each of the five central rows of the plots, in Feb of both years, at 133 DAE. Grain yield was estimated by adjusting moisture content to 13 % (wet basis).

Statistical analyses

Data were subjected to analysis of variance using the PROC GLM in SAS (Statistical Analysis System, version 9.3) and considering interactions between years, row spacing and intercropped species. The following general linear model equation was used:

$$y_{ij} = \mu u + S_i + C_j + SC_{ij} + u_{ijk} + e_{ijk} \quad (4)$$

where y_{ij} = response variable, μu , the general mean for the years, S_i , the row spacing effect, C_j , the intercropping species effect, SC_{ij} , the interaction, and u_{ijk} and e_{ijk} , the random effects; e_{ijk} considers residual variation, and u_{ijk} , variation over time (two years of assessment), in which $u_{ijk} \sim N(0, \sigma_u^2)$ and $e_{ijk} \sim N(0, \sigma^2)$, when null effects could be considered.

Because the data comprised measurements spanning two years (longitudinal data), a random effect was incorporated to accommodate possible dependence between repeated measurements. When this dependence was not statistically significant ($\sigma_u^2 = 0$), the data were treated as independent measurements. Whenever significant effects were observed, treatments were compared by the Tukey test ($p \leq 0.05$).

The absolute growth ratio (AGR) of the variables, relative growth ratio (RGR) and accurate assimilation ratio (AAR) for each species were adjusted to the sampling dates - 10, 20, 30, 40, 50 and 60 days after emergence (DAE) - using the following non-linear power-model regression:

$$y = aX^b \quad (5)$$

In this step, to estimate the parameters of the power function, the logarithms (decimal or neperian) are applied to the function, as follows:

$$\log(y) = \log(a) + b \log(X) \quad (6)$$

Regression modeling was carried out using the R software package (version 3.6.0).

Results and Discussion

Sorghum was not affected by the intercropping grasses, regardless of the row spacing tested, and its initial dry matter accumulation, from 10 to 60 DAE, was 0.22 g d⁻¹. For Congo grass and palisade grass, the dry mass gain was 0.04 g d⁻¹ over the same period. The 0.5-m row spacing induced a grain yield of 2,922 kg ha⁻¹ for sorghum. Soybean grain production was increased by the systems using forage grasses, either in intercropping or in sole cultivation.

During the two years of the experiment, weather conditions were similar between the growing off-seasons: maximum rainfall values (339 mm) in May 2010 and 0 mm rainfall in July for both years (Figure 1). This condition is typical for the Cerrado region: abundant rainfall in spring/summer, usually from Oct until Apr, followed by a drought period in May (Sato et al., 2017). A minimum temperature of 13 °C was also observed in July of 2011, which is a limiting condition to tropical grass growth and development. Therefore, these are the most important characteristics to consider when cultivating crops in soybean succession during the off-season in the Cerrado region.

Growth and development of sorghum and grasses

Sorghum development was not affected by the grasses under intercropping systems ($p > 0.01$): dry matter accumulation and growth rate of sorghum plants were similar in the presence or in the absence of the forage grasses at 10 to 60 days after emergence (DAE) (Figures 2, 3 and 4), as well as between intercropping systems. The plant development pattern for sorghum in the presence or absence of forage grasses confirmed the observations made by Santos et al. (2019), who concluded that dry matter accumulation rate in sorghum is low in its early development stages, increases until grain maturation, stabilizes and then decreases.

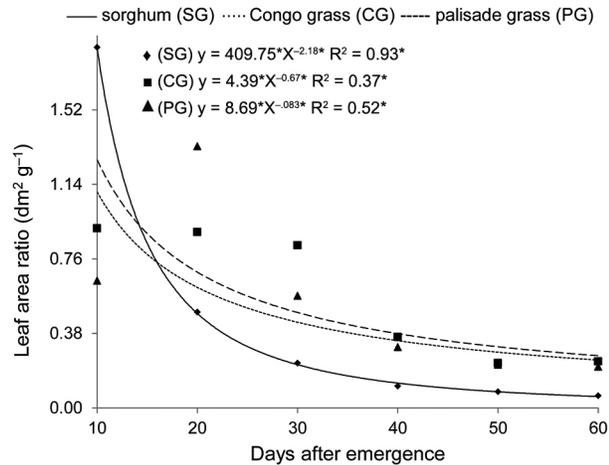


Figure 2 – Means of two years of assessment of leaf area ratio for sorghum and grasses from 10 to 60 days after emergence. Data on intercropped and sole species. *Significant coefficients of power-model regression ($p < 0.05$).

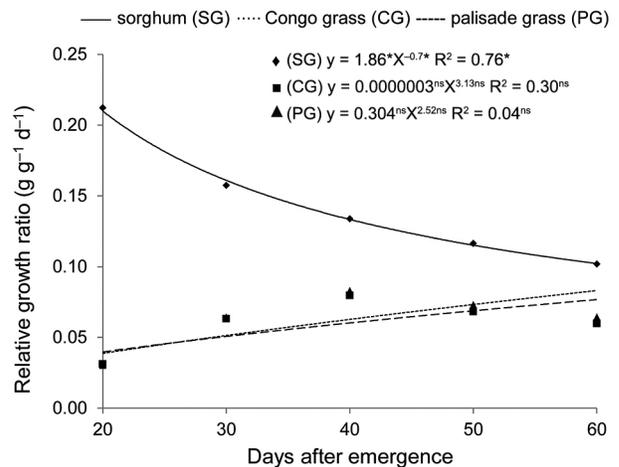


Figure 4 – Means of two years of assessment of relative growth ratio (RGR) for sorghum and grasses from 20 to 60 days after emergence. Data on intercropped and sole species. *, ^{ns}Significant ($p < 0.05$) and non-significant ($p > 0.05$) coefficients, respectively, of power-model regression.

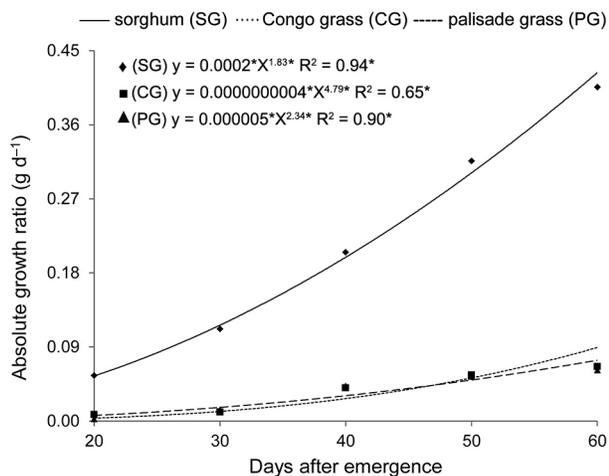


Figure 3 – Means of two years of assessment of absolute growth ratio (AGR) for sorghum and grasses from 20 to 60 days after emergence. Data on intercropped and sole species. *Significant coefficients of power-model regression ($p < 0.05$).

Sorghum leaf area ratio was not affected by the presence of forage grasses, particularly from 30 DAE onwards (Figure 2). This behavior may be explained by the production of allelopathic compounds under optimum temperatures (25 °C to 35 °C) (Dayan, 2006) (Figure 1), as a response to competition, and reflects adequate agronomic characteristics (grain yield, plant height and dry mass) even under intercropping situations – i.e. under direct competition between plants.

Average leaf area ratios for the grasses were not affected by the presence of sorghum ($p \leq 0.05$). The relative growth ratio over time was different between sorghum and the grasses (Figure 4). The growth and development of the forage grasses was slower during their early stages

of development, especially from 10 to 20 DAE. When comparing sole or intercropped systems, there was no difference in the relative growth ratio of palisade and Congo grasses ($p > 0.05$) because their dry matter accumulation over time showed similar patterns between crop systems. There was a period of slow growth rate at the beginning of the grasses' cycle, followed by fast growth when compared to sorghum's relative growth ratio, which can be explained by the minimum temperature observed during the Cerrado off-season (Figure 1). Minimum temperatures can explain a reduction in Congo and palisade grass development, even under favor soil humidity conditions. These grasses express their whole growth potential during the tropical spring/summer period, characterized by high temperatures (Kichel et al., 2019).

During the assessment period, sorghum's accurate assimilation ratio showed an ascending pattern – either when sole or intercropped with grasses – with constant development and growth until 60 DAE (Figure 5). Sorghum's growth is directly related to the plants' ability to accumulate sugar, as a response of the accurate assimilation ratio, which results in greater amounts of tissue for its physical structures (Borges et al., 2018) and, consequently, for dry matter production. It is associated with leaf growth area as well, as some intercropping systems may lead to stronger competition between plants over space, light and other resources (Santos et al., 2018a). The presence of forage grasses did not affect the sorghum's development pattern, despite the competition and the grasses' high growth rates.

At the end of the evaluated period (60 DAE), the forage plants had access to more light and produced higher amounts of dry matter at the end of their cycle (Table 2), which was confirmed by the power-models (Figures 2, 3 and 5). From 60 DAE onwards, the sorghum leaf area naturally decreases (senescence), and the grasses' growth

may be intensified. Therefore, as shown by the growth ratios for the forage grasses, the main limiting factor for forage biomass production is light, which is essential to the photosynthesis process (Santos et al., 2018b). Thus, the higher light interception results in higher dry matter accumulation and growth indexes for the forage species, which is confirmed by the final dry matter production (Table 2), although in the off-season in the Cerrado there are limited conditions for the grasses to develop (Sato et al., 2017). *Urochloa* species have a high carbon/nitrogen ratio in their leaves and stems, a reason why they are interesting options for the production of straw (Andrade et al., 2017; Hirata et al., 2018).

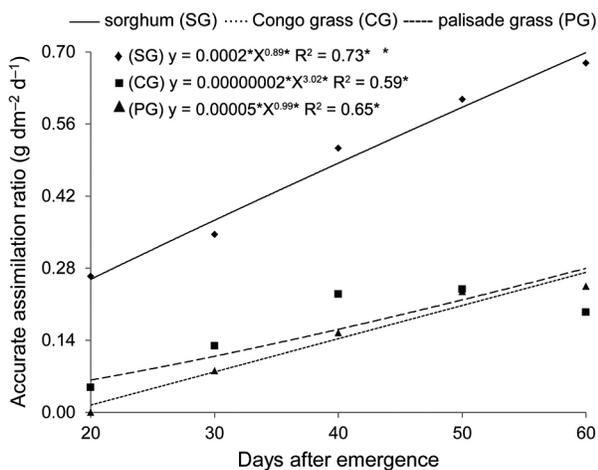


Figure 5 – Means of two years of assessment of accurate assimilation ratio (AAR) for sorghum and grasses from 20 to 60 days after emergence. Data on intercropped and sole species. *Significant coefficients of power-model regression ($p < 0.05$).

Dry mass production for sorghum and grasses

The highest total amount of dry matter per area was observed in systems containing sorghum intercropped with grasses. Sole crops of sorghum, palisade grass or Congo grass showed the lowest dry mass production values.

Off-season dry mass production for sole palisade grass was 3,920 kg ha⁻¹ (Table 2). According to Catuchi et al. (2019), the high amounts of dry mass produced by this species are very useful for straw production for no-till purposes. Even when grown during the dry season or under partially shaded conditions – such as intercropping systems – palisade grass produced 3,884 kg ha⁻¹ and 2,709 kg ha⁻¹ of dry matter at 0.5 and 0.7 m row spacing’s respectively (Table 2), thus confirming its adaptability to intercropping systems at early growth stages (Santos et al., 2018b).

Congo grass produced 5,620 kg ha⁻¹ of dry matter as a sole crop and from 4,643 kg ha⁻¹ to 4,947 kg ha⁻¹ when intercropped with sorghum, which are considered high dry mass production levels (Ferreira et al., 2018; Hirata et al., 2018). *Urochloa* forage species tend to produce large amounts of dry matter in off-season crops in the Cerrado region (Carvalho et al., 2017).

No significant effects of competition were observed between the intercropped species, since there were no differences between systems in terms of sorghum grain yield or forage dry matter production (Table 2). The right combination of crops in intercropping systems does not affect these parameters (Borges et al., 2018; Santos et al., 2018b). Furthermore, even when certain *Urochloa* species may compete and become weeds to crops due to their high regrowth ability (Nakao et al., 2019), the use of an herbicide at the desiccation operation is effective to control palisade and Congo grasses before the summer crop (Sodré-Filho et al., 2014).

Table 2 – Plant height, weight of 1,000 grains and grain yield for sorghum (114 DAE) grown in two row spacings (0.5 and 0.7 m), sole or intercropped with palisade grass or Congo grass, their total dry matter (166 DAE), and grain yield of soybean (133 DAE). Data evaluated at the end of the plants’ cycle.

Sorghum row spacing	Intercropping	Sorghum			Sorghum	Grasses	Soybean
		Plant height m	Weight of 1,000 grains g	Grain yield	Dry matter kg ha ⁻¹	Grain yield	
0.5 m	-	0.119 a*	23.11 a	3,229 a	13,685 a	-	2,877 c
	Palisade grass	0.112 a	20.32 a	2,927 a	14,818 a	3,884 bc	2,920 bc
	Congo grass	0.114 a	20.93 a	2,611 a	7,862 b	4,947 ab	3,349 a
0.7 m	-	0.113 a	21.88 a	3,462 a	14,140 a	-	2,870 c
	Palisade grass	0.118 a	22.37 a	2,248 a	13,651 a	2,709 c	2,976 abc
	Congo grass	0.117 a	20.96 a	2,184 a	11,071 ab	4,643 abc	3,043 abc
-	Palisade grass	-	-	-	-	3,920 bc	2,905 c
-	Congo grass	-	-	-	-	5,620 a	3,317 ab
Means							
0.5 m		0.115 B	21.45 B	2,922 A	12,122 B	4,415 A	-
0.7 m		0.117 A	21.74 A	2,631 B	12,954 A	3,676 B	-

*Means followed by different lowercase and capital letters in the columns differ by the Tukey test ($p \leq 0.05$) and F-test ($p \leq 0.05$), respectively.

Sorghum and soybean grain yield

Sorghum's average grain yield was overall higher under the 0.5-m row spacing when compared with the 0.7-m row spacing, regardless of intercropping system (Table 2). The higher number of leaves per area under the 0.5-m row spacing contributes to a higher photosynthetic rate and therefore to increasing the accumulation of assimilates (Silva et al., 2017). The reduced row spacing maintaining the same plant density also led to a better distribution of sorghum plants in the area, with a faster initial growth rate in comparison to the forage grasses. Reduced row spacing also increases the distance between plants in the row, and may reduce the competition between plants over water, light and nutrients (Borges et al., 2018; Francisquini-Junior et al., 2020).

There were no differences between systems intercropped with sorghum, neither in the interactions of the species, nor in row spacing ($p > 0.05$), in terms of sorghum plants' height, weight of 1,000 grains and yield (Table 2). Sorghum plants may adapt easily to negative factors during development, such as the effects of direct competition with other species (Santos et al., 2019). This is an important aspect to consider when selecting species for intercropping systems (Rigon et al., 2018), since many crop species are sensitive to competition, at least during their early stages of development (Cordeiro et al., 2015).

Sorghum's high seedling emergence due to the effective sowing time – middle of the rainy season –, enabled fast establishment of the plants (300,000 plants ha^{-1}), which did not affect the development of the forage grasses, although the environmental conditions varied from year to year. In the Brazilian Cerrado region, the practice of cultivating sorghum after the main crop at the end of the rainy season is increasing among farmers, mainly due to its better adaptability to irregular rainfall regimes in comparison to other crops, such as maize (Sodré-Filho et al., 2014; Cordeiro et al., 2015). Compared to other crops, sorghum's advantages include drought tolerance and adaptability to low-fertility and acid soils, common characteristics of the Cerrado region (Borges et al., 2018). The hypothesis that the presence of grasses would not affect sorghum performance was confirmed in the present study, although a number of authors concluded the opposite (Silva et al., 2017; Nakao et al., 2019) and observed losses in grain yield or dry matter production.

Sorghum's grain yield, grain weight and plant height were different over the years ($p \leq 0.05$) (Table 3), and showed higher values during the first year than during the second year of assessment (Table 3). Since the same sorghum cultivar was used in both years, this phenomenon may be mainly related to different rainfall regimes in these years (Figure 1).

The systems including forage grasses contributed to increase soybean grain yield, either in intercropping or in sole cultivation (Table 2), with results higher during the first year (3,228 kg ha^{-1}) compared to the second one (2,734 kg ha^{-1}) (Table 3). The intercropping systems including Congo grass also provided higher soybean grain yields compared to the sole system. The straw production of the forages can afford gains in soil fertility and soybean yield (Crusciol et al., 2015; Andrade et al., 2017). Furthermore, systems like these have the potential to keep the weed population below the economic injury level in soybean in succession, since controlled grass development is a strategy for reducing but not eradicating weeds (Sodré-Filho et al., 2020).

Sorghum showed adaptability to intercropping with grasses: plant height, grain weight and grain yield were not affected when intercropped with palisade grass or Congo grass. The 0.5-m row spacing resulted in higher grain yields when compared to the 0.7-m row spacing for sorghum plants. In this context, *Urochloa* proved viable for off-season intercropping with sorghum and for increasing the grain yield of soybean in succession. Dry mass production of the grasses was not affected by sorghum in the intercropping systems, and since these forage grasses do not reduce sorghum yield, this system may be recommended for agricultural renewal through techniques that use the soil during the whole year yielding both economic and agronomic benefits. These findings contribute to the accumulation of knowledge of intercropping systems for the Brazilian Cerrado region, especially to the selection of suitable species for integrated crop-pasture systems.

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Table 3 – Plant height, weight of 1,000 grains and grain yield for sorghum (114 DAE), total dry matter for sorghum and grasses (166 DAE), and grain yield of soybean (133 DAE), in two consecutive years. Data evaluated at the end of the plants' cycle.

Year	Sorghum			Sorghum	Grasses	Soybean
	Plant height	Weight of 1,000 grains	Grain yield	Dry matter		Grain yield
	m	g		kg ha^{-1}		
1	0.123 A*	23.70 A	3,324 A	15,760 A	2,632 B	3,228 A
2	0.108 B	19.49 B	2,230 B	9,316 B	4,761 A	2,734 B

*Means followed by different letters in the columns differ by the F-test ($p \leq 0.05$).

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Authors' Contributions

Conceptualization: Sodré-Filho, J.; Carmona, R.; Marchão, R.L. **Data acquisition:** Sodré-Filho, J.; Marchão, R.L.; Carvalho, A.M. **Data analysis:** Sodré-Filho, J.; Marchão, R.L.; Carmona, R.; Carvalho, A.M. **Design of methodology:** Sodré-Filho, J.; Carmona, R.; Marchão, R.L. **Writing and editing:** Sodré-Filho, J.; Carmona, R.; Marchão, R.L.

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