Revista Brasileira de Zootecnia
© 2011 Sociedade Brasileira de Zootecnia
ISSN 1806-9290
www.sbz.org.br

R. Bras. Zootec., v.40, n.7, p.1397-1404, 2011

Development of maize and palisadegrass plants cultivated in intercrop under water deficit

Leandro Coelho de Araujo[1], Patrícia Menezes Santos[2], Fernando Campos Mendonça[2], Nino Rodrigo Cabral de Barros Lima[3]

[1] *Universidade de São Paulo/ESALQ, Departamento de Zootecnia, Piracicaba, SP, Brasil.*
[2] *Embrapa Pecuária Sudeste, São Carlos, SP, Brasil.*
[3] *Agência de Desenvolvimento Agrário e Extensão Rural, Nioaque, MS, Brasil.*

ABSTRACT - The objective of this work was to evaluate the development and productive traits of palisadegrass single cultivated or intercropped with corn, in addition to corn intercropped with pasture, under water deficit at different development stages of the plants. It was used a complete block experimental design with split plots and three replicates. Periods of water deficit were placed in the plots and types of cultivation were placed in the subplots. Irrigation was stopped at germination and initial tillering of palisadegrass and at V4 and V15 stages of corn and returned when soil moisture was 40% of available water capacity. Tiller density and palisadegrass height were evaluated weekly. Dry matter (DM) of fractions of herbage mass as well as leaf area of the plants were evaluated at corn tasseling and when grains reached physiological maturity. Components of corn production were determined in the second sampling. In palisadegrass, water influenced only tillering, which was reduced in the plots in which water defict was forced at the moment of germination or at the beginning of tilering, in both cultivation systems. Plant height and DM production were affected only by cultivation, reducing when intercropped with corn. Evaluated production components did not influence corn grain productivity, which was similar in all treatments (average of 10,145 kg/ha). Palisadegrass plants produce more DM in single cultivation than intercropped with corn. Water deficit during germination and initial tillering reduces tillering of palisadegrass during establishment phase. Water deficit, applied in this trial, does not reduce DM yield in palisadegrass or corn.

Key Words: *Brachiaria brizantha*, integration, tiller, Zea mays

Introduction

Nowadays, approximately 50 million hectares of land in Brazilian “Cerrado” are used for agriculture, representing around ¼ of the total area of this biome, in which 80% are degraded (Kluthcouski et al., 2003). Thus, the integration between agriculture and cattle rearing can be an alternative for these regions because it intensifies the cattle raising as well as increases the grain, meat and milk productivity, and it also has the objective to recover the cultivated area in degradation process, in addition to reducing the necessity of deforestation (Kluthcouski et al., 2003).

Studies performed with maize in single cultivated system (Magalhães & Durães, 2006; Matzenauer et al., 2002) have proved that this production has critical periods during its cycle when the dry spell can cause the reduction of grain productivity, mainly when the water stress happens during tasseling-silking phase (Matzenauer et al., 1995; Bergamaschi et al., 2004).

Regarding the forage grass, few studies are performed concerned water deficit and when it occurred, plants already established are used in a single production system (Mattos et al., 2005; Guenni et al., 2002). Therefore, the effect of water deficit during the establishment of the forage plants was not still characterized, as well as the existence of critical periods of lower tolerance to drought, as it has already been defined for the maize production.

By knowing the rainfall offer, the water variation in the soil and the consequences of these factors in the development of integrated system productions is important for the efficient management and the success of these systems. Thus, the objective of this work was to evaluate the development and the productive characteristics of palisadegrass when cultivated in single or intercropped with maize and maize in integrated system with palisadegrass under water deficit.

Material and Methods

The trial was developed on the experimental field at Embrapa Pecuária Sudeste, in São Carlos, São Paulo state, Brazil (21°57’42"S, 47°50’28"W and 860 m of altitude) from

Received February 25, 2010 and accepted December 22, 2010.
Corresponding author: lc_araujo@yahoo.com.br

April 4th, 2007 to September 16th, 2007. The local climate is denominated as a humid subtropical climate with a hot weather and dry winter (Koeppen's classification: Cwa). The annual average values of maximum and minimum temperature were 27.1°C and 15.9°C, average air temperature was 21.5°C and the accumulated precipitation of the local is 1,356 mm. The local soil is classified as Oxisol (US, 1999). Results of soil analysis (0-20 cm) presented organic matter, sand, clay and silt content corresponding to 2.7; 66.4; 31.8; and 1.8%, respectively. Values of the chemical composition are the following: pH $CaCl_2$ = 5.5; pH H_2O = 6.6; P-resin = 8.0 mg/dm³; K = 0.25; Al^{3+} = 0.0; H+Al^{3+} = 1.8; Ca^{2+} = 2.3 and Mg^{2+} = 1.3 $cmol_c/dm^3$; S-sulfate = 7.0 mg/dm³; B = 0.23; Cu = 0.6; Fe = 33.0; Mn = 8.3 and Zn = 1.2 mg/dm³.

To obtain the characteristic curve of water retention in the soil, undisturbed samples from every 0.10 m to 0.60 m depth were collected for the determination of the field capacity (FC) and the permanent wilting point (PWP) of the soil, considered from these curves (Table 1).

Maize sowing and bottom fertilization were performed simultaneously and mechanically (April 4th, 2007), after the conventional preparation of the soil. The plot between the rows of maize was 0.80 m, aiming to a density corresponding to 5 plants/ linear meter.

Palisadegrass was sowed on 0.27 plots rows. One row was sowed mechanically next to the maize row (mixed with fertilizer) and two other ones were sowed manually between the maize rows (April 4, 5 and 6, 2007). The density of the sowing used for the forage plants was approximately 8.0 kg of viable pure seeds per hectare.

The amount of fertilizer applied at the moment of the sowing corresponded to 15 kg N, 100 kg P_2O_5, 50 kg K_2O and 30 kg/ha of micronutrients as urea, simple super phosphate, potassium chloride and FTE BR12, respectively. In addition to this fertilization, covering fertlization was done with urea on May 30th, 2007 (70 kg N/ha), followed by irrigation (8 mm) throughout the plots (van Raij et al., 1996).

When the maize crops presented around two expanded leaves, all the crops were retrieved (April 18th/2007) from the subplots reserved for the exclusive palisadegrass cultivation.

All the experimental area was irrigated and the water applied was determined by the "EPS" method (Rassini, 2002). The used irrigation system was the conventional spraying, compounded by impact sprinkler of low pressure service (0.2-0.3 MPa) with sectorial circuit gadget and wet ray of 11 m and spaced by 12 m.

The trial was conducted in a complete block design, arranged in split plots (water conditions in the plots and cultivation in the subplots) and three repetitions. In the experimental plots (12 × 12 m), the effects of the water deficit were evaluated (with and without deficit, stopping the irrigation in 4 phases of the maize and palisadegrass crops) as well as for the intercrop and exclusive palisadegrass: control = without water deficit during the experimental period (soil humidity kept closer to field capacity); Pasture-G = water deficit from the beginning of the palisadegrass germination in an exclusive cultivation; Pasture-T = water deficit from the beginning of the exclusive palisadegrass tillering; Maize-4 = water deficit from four completely expanded leaves of the maize crop, Maize-15 = water deficit from 15 completely expanded leaves of the maize crop.

The initial tillering of the palisadegrass coincided with the phenological phase of four expanded leaves of the maize, and consequently, at the moment the irrigation of the Pasture-T and Maize-4 treatment was interrupted. Therefore, the subplots Maize-4 were adopted in order to evaluate the influence of the water deficit in both stages. So, the plot Pasture-T was not used during the trial any longer and it was described only for discussion about this treatment.

This interruption of the water deficit period took place when the content of the water in the soil corresponded to approximately 40% of the available water capacity (AWC) on the 0-0.40 m layer, for the Pasture-G, Pasture-T and Maize-4 treatments, and 0-0.60 m for the Maize-15, according to the equation: θ critical = [(θ FCi - θ PWPi) × 0.4] + θ PWPi; in which: θ critical = soil humidity (%) approximately 40% of the AWC in the depth i; θ FCi = humidity of the soil (%) to FC in the depth i; θ PWPi = humidity of the soil (%) corresponding to the PWP in the depth i (Table 2). Before and after the introduction of the

Table 1 - Soil physical properties

Physical property	Depth (cm)					
	0-10	10-20	20-30	30-40	40-50	50-60
Bulk density (g/cm^3)	1.30	1.36	1.40	1.44	1.53	1.56
Field capacity (-0.01 MPa, g/100 g)	20.42	16.67	15.98	16.29	16.53	16.31
Permanent wilting point (-1.5 MPa, g/100 g)	10.9	9.5	9.2	8.7	9.1	8.3
Available water capacity (mm)	10.98	9.66	8.94	8.49	8.79	8.43

water deficit treatments, all the plots were irrigated according to the control.

The subplots (12 × 6 m) presented the floor area corresponding to 16 m² (4 × 4 m) and the production systems were allocated in them, maize (*Zea mays* L.) Hybrid Pionner simple 30S40 intercropped with palisadegrass [*Brachiaria brizantha* (A. Rich) Stapf cv. Marandu] and the exclusive cultivation of palisadegrass.

Content of water in the soil of subplots was determined by the gravimetric method (cylindrical drilling rig) in each subplot of the treatment which was order water deficit. At first, some samples were provided in two-day interval and from April 27th 2007, this interval was increased for four days to reduce the walking on the plots and the excess of holes due to the soil samples which were oven-dried (Souza et al., 2002).

In order to avoid interference of the rain in the experimental conduction, green houses were set up on the plots under water deficit. The greenhouses were made by PVC pipes, transparent plastic film for greenhouses and concrete poles, with plastics in the sides to avoid high temperatures inside them.

The average value of the maximum, minimum temperatures and the average air temperature in adittion to accumulated pluvial precipitation during the water deficit period, according to the treatments were 27.42ºC; 16.75ºC; 22.08ºC and 39.6 mm for Pasture-G, 26.07ºC; 14.87ºC; 20.48ºC and 30 mm for Pasture-T and Maize-4 and 25.99ºC; 12.62ºC; 19.30ºC and 0.0 mm for Maize-15, respectively.

For palisadegrass, the number of total tiller was counted in the exclusive and intercrop production system, counting all the tillers with, at least, one expanded leaf, present in two rectangles of 1.0 × 0.8 m, set by subplot, and disposed with its length in the longitudinal direction of the rows so they overlapped on three rows of palisadegrass and one of maize. The tillers were counted six times in a seven-day interval until the fifth evaluation and 21 days between the fifth and sixth evaluation; the first and the sixth evaluations took place on May 18th and July 6th 2007, respectively. In this same period, the height of the plant was measured by measuring the distance from the soil to the curve of the recently expanded leaf (n = 5).

To evaluate dry matter (DM) yield and the morphological composition of the palisadegrass, two samples were provided, using the phenological phase of the maize as reference. Therefore, the first sample took place next to the maize flowering (July 9th) and the second one, close to the physiological ripeness (September 14th).

In both samples, palisadegrass was cut at the soil level, in an area delimited by two rectangles of 1.0 × 0.8 m per subplot. After sampling, the fresh forage was weighed still on the field and the sub-samples afterwards (around 500 g), referring to each rectangle, and oven-dried (65ºC for 72 hours) for DM analyses, after the morphological separation.

The morphological separation was made in green leaf blade (ligule height), green stems (stems + sheaths) and senescent material (tissue with over 50% of senescence), denominating the total of these three fractions as herbage mass. The production of senescence material in the first evaluation was insignificant and it was not quantified.

The leaf area index (LAI) was gotten from green leaf blade (ligule height) by using the integrator of the leaf area, model LI-3100C (Li-Cor, Lincoln, Nebraska, USA). As the area where forage was collected from was known, as well as the respective matter of the existing green leaf blade, it was possible to have the LAI determined as well as the specific leaf area (SLA cm²/g.DM of leaf blade).

Maize crop sampling was performed concomitantly to the production evaluation of the palisadegrass (two samples), inasmuch as the morphological composition, the determination of DM, LAI and SLA were determined only in the first sample, according to the methodology previously described for the palisadegrass, including the reproductive organs (male + female), getting five plants per sub plot. But, in the first sample, the height of the plant was also determined (from the soil to the top part of the maize tassel in 10 plants randomly chosen per subplot).

Table 2 - Period of water deficit, maize phenological phase and water content in the soil at the end of the water deficit period (2007)

Treatment	Period of water deficit				Moisture	
	Beginning		End		%	
	Date	Phenology	Date	Phenology	Exclusive	Intercrop
Pasture-G	04/17	V2	05/02	V6	14.44	14.50
Pasture-T, Maize-4	04/27	V4	05/21	V9	12.97	10.44
Maize-15	06/15	V15	07/01	VT*	13.75	11.96

V_n = number of expanded leaves and VT = flowering.
*100% of the maize plants flowered.

By evaluating the leaf area of the collected plants, as well as the knowledge of the maize crop density (counted in two 3-m central rows), it was possible to determine LAI of the maize production.

The compounds of the maize production were determined in the second sample when the grains reached the physiological ripeness. Harvest was done manually in two 3-m central rows, harvesting all the corn on the cob with straw. Afterwards, other variables were estimated, such as corn on the cob index (corn on the cob per plant), average amount of rows per corn on the cob, average weight of the grains per corn on the cob, matter of one thousand grains and total productivity of grains (kg/ha). The presented calculations considered the humidity of the grains corrected to 13% (Brasil, 1992).

For characterization of the phenological stage of the maize crops, the number of expanded leaves was counted every two days in 10 plants per subplot.

The data were submitted to the analysis of the variance through the statistic program SAS. The variables regarding the palisadegrass were analyzed by using a complete block design with casual split plots where the periods of water deficit were allocated in plots and the production system in the subplots. For the variables regarding the maize, the design in casual complete blocks was used.

The number of tillers and the height of palisadegrass plants, measured along the time, were analyzed by using the MIXED procedure, so the treatment and the evaluations represented the fixed effects and, the blocks, the random effects. For other characteristics, the GLM procedure was used.

All the variables analyzed and presented in this article presented the residual variance homogeneity. The averages were compared by Tukey test at 10% of probability, the presented values are the adjusted averages obtained through the method of minimum squared numbers. The average error-standard are presented as dispersion measurements.

Results and Discussion

Tillering of the palisadegrass was influenced by the treatments. There was an effect of the water deficit interaction with the cultivation system (Table 3; $P<0.0001$) and the evaluation season with the cultivation system (Table 4; $P<0.0001$).

The water deficit imposed at the moment of the germination and the tillering of the palisadegrass were sufficient to reduce grass tillering of the palisadegrass during the evaluation period, in both cultivation systems. When the water deficit was imposed at the moment of the maize tasseling, the large number of tillers density was lower only in the plots in exclusive cultivation (Table 3).

In study done in field with *Panicum maximum* Jacq cv. Tanzania, Cunha et al (2007) compared resprouting plants under distinct levels of water in the soil (50; 75 and 100% of the AWC) and observed the increase of approximately 10% in the tillering of the plants in the highest humidity soil.

The reduction of the tillering in plants submitted to some water deficit occurs, especially, for the cell expansion reduction in the growth points and in the absorption of nutrients, mainly the nitrogen (Taiz & Zeiger, 2004).

When observed along the evaluations, tillering differed among cultivation systems (Table 4). The plots of palisadegrass in exclusive cultivation had a distinctive behavior to one of the growth curve, already described by the literature for this variable (Gomide & Gomide, 2000; Alexandrino et al., 2005) considering that the number of tillers increased until to be established, 52 days after the germination.

The tillering standard of the palisadegrass plants in intercropped cultivation has not presented differences along the evaluations and the average of 251 tillers/m² was kept (Table 4). This result agrees with the ones found by

Table 3 - Total number of palisadegrass tillers in exclusive cultivation system or intercropped with maize

Treatment	System[1]	
	Exclusive	Intercrop
	tillers/m²	
Control	683 (26.34)Aa	333 (26.34)Ba
Pasture-G	557 (26.34)Ab	188 (26.34)Bb
Pasture-T	490 (26.34)Ab	221 (26.34)Bb
Maize-15	505 (26.34)Ab	262 (26.34)Bab

[1]Palisadegrass cultivated single and on integrated system with maize.
Averages followed by the same letter, capital letter in the line and lower case letter in the column do not differ among themselves by Tukey test at 10% of probability. The values outside and inside the parenthesis correspond to the average and average error-standard, respectively.

Table 4 - Total number of tillers of palisadegrass in exclusive cultivation system and intercropped with maize

Evaluation (Days after the palisadegrass germination)	System (Palisadegrass in exclusive cultivation system and intercropped with maize)	
	Exclusive	Intercrop
	tillers/m²	
31	408 (17.69)Ac	243 (17.69)Ba
38	459 (21.35)Ac	240 (21.35)Ba
45	507 (32.44)Abc	241 (32.44)Ba
52	620 (27.22)Aab	269 (27.22)Ba
49	634 (27.85)Aa	278 (27.85)Ba
80	725 (26.65)Aa	235 (26.65)Ba

Averages followed by the same letter, capital letter in the line and lower case letter in the column do not differ among themselves by Tukey test at 10% of probability. The values outside and inside the parenthesis correspond to the average and average error-standard, respectively.

Portes et al. (2000), who compared the exclusive cultivation system with the intercrop and observed higher density of palisadegrass tillers when there were not crop. It was still observed the shading was the main factor for this occurrence which also interfered in the height of the plants in this trial, occurring only the effect of the cultivation interaction with the evaluation (Table 5; P<0.0001).

Regarding the LAI and SLA values for the palisadegrass in the first sample, significant differences were not identified because of the water deficit imposed, obtaining the average value corresponding to 2.6 (P = 0.1841) and 205.26 cm²/g.DM of the leaf blade (P = 0.1842), respectively.

By evaluating the DM production, the treatments only influenced the first sample for the stem components (P = 0.0633) and the herbage mass (P = 0.0926) of the palisadegrass, in which the greatest productions were for the control treatment, when compared to the Pasture-G and Maize-15 treatments (Figure 1). As the effects in the production of leaf blade in these samples were not identified, it is clear the differences observed in the DM production of the herbage mass were caused by the stem component. Water availability can explain the highest production of stems for the control, because palisadegrass plants developed intra-specific competition mechanisms through light, providing higher stem growth, due to its extension (Sbrissia & Silva, 2001), which occurred in a less intense way for the Pasture-G and Maize-15 treatments.

The long recovery period was also sufficient so there was not effect on the characteristics evaluated during the second sample because the plants were under optimal water conditions for 136; 116 and 75 days for the Pasture-G, Pasture-T and Maize-15 treatments respectively.

Among the cultivation systems, only the effects on SLA (P = 0.2204) in the second sample were not observed (478.6 cm²/g average DM of leaf blade) whereas the other characteristics were influenced by the annual production (P<0.0001) in both samples (Table 6).

Plants in intercropped cultivation had higher SLA in the first sample (Table 6). These results confirm the ones found by Dias-Filho (2000). By studying the behavior of *Brachiaria* sp. species, in artificial shading this author verified the palisadegrass presented phenotypic plasticity regarding the seize of radiation in response to the shading, with the SLA increase, being able to keep the growth even with light limitation.

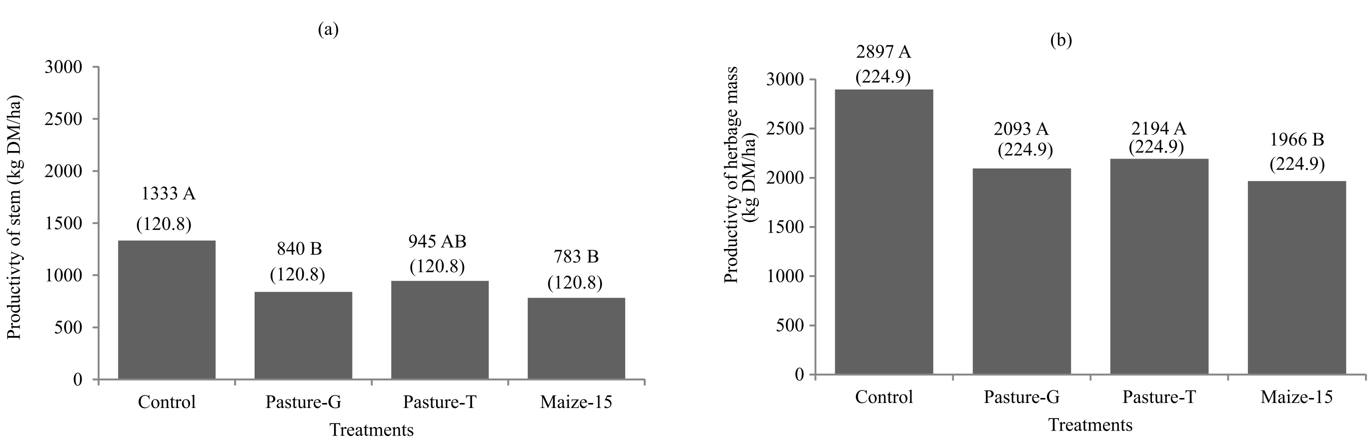
Between the two cultivation systems, the DM production of the herbage mass of the palisadegrass was lower in the intercrop cultivation system, corresponding to 69.73 and 79.36% for the first and second samples respectively (Table 6).

The DM lowest productivity of cultivated grasses during the intercrop period, concerning the exclusive

Table 5 - Average height of palisadegrass in exclusive cultivation system and intercropped with maize

Evaluation (Days after the palisadegrass germination)	Systems (Palisadegrass in exclusive cultivation system and intercropped with maize)	
	Exclusive	Intercrop
	plant height (cm)	
31	13.6 (0.468)Be	21.1 (0.468)Ae
38	16.8 (0.794)Bd	33.5 (0.847)Ad
45	15.6 (0.938)Bde	37.0 (0.938)Ad
52	21.3 (0.913)Bc	45.1 (0.913)Ac
49	27.5 (1.180)Bb	59.1 (1.180)Ab
80	59.9 (1.521)Ba	75.4 (1.521)Aa

Averages followed by the same letter, capital letter in the line and lower case letter in the column do not differ among themselves by Tukey test at 10% of probability. The values outside and inside the parenthesis correspond to the average and average error-standard, respectively.



Sampling performed 83 days after the palisadegrass emergency. The values outside and inside the parenthesis correspond to average and the average error-standard, respectively. Averages followed by the same letters do not differ among themselves by Tukey test at 10% of probability.

Figure 1 - Dry Matter (DM) productivity of stems (a) and the herbage mass (b) of the palisadegrass under water deficit.

Table 6 - Dry matter yield (DM) of the herbage mass and its fractions, leaf area index and specific leaf area of the palisadegrass in two sampling periods

Variable	Systems (Palisadegrass in exclusive cultivation and intercropped with the maize)	
	Exclusive	Intercrop
	First sample (83 days after the palisadegrass germination)	
Leaf blade (kg/ha)	2040 (87.9)A	585 (87.9)B
Stem (kg/ha)	1472 (85.4)A	478 (85.4)B
Herbage mass (kg/ha)	3512 (158.9)A	1063 (158.9)B
Leaf area index	3.8 (0.28)A	1.3 (0.28)B
Specific leaf area (cm^2/g.DM of leaf blade)	181.72 (10.05)B	228.34 (10.05)A
	Second sample (150 days after the palisadegrass germination)	
Leaf blade (kg/ha)	1729 (68.8)A	459 (68.8)B
Stem (kg/ha)	3083 (181.8)A	439 (181.8)B
Senescent tissue (kg/ha)	910 (146.9)A	282 (146.9)B
Herbage mass (kg/ha)	5722 (257.8)A	1181 (257.8)B
Leaf area index	7.2 (0.36)A	2.1 (0.36)B

Averages followed by the same letter in the line, in the sample, do not differ among themselves by Tukey test at 10% of probability. The values outside and inside the parenthesis correspond to the average and the error-standard average, respectively.

cultivation, is already reported in the literature (Portes et al., 2000; Cobucci et al., 2001) and the effect of the shading is the factor which most contributes for this reduction, according to the authors. The density of maize plants did not differ among the water deficit levels, demonstrating an average density corresponding to 65,712 plants/ha (P = 0.4126). This density is considered within a critical zone, where there is not competition among the plants in such condition (Dourado Neto et al., 2001).

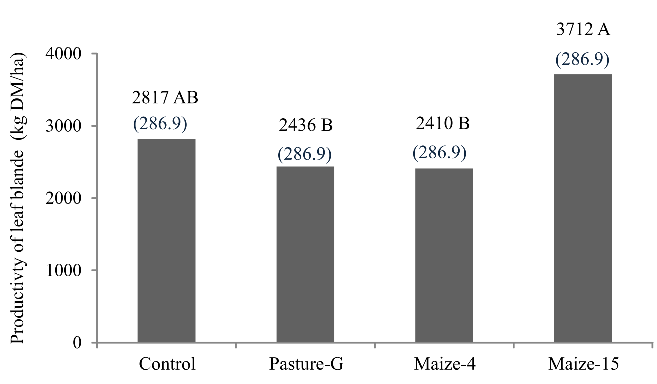
Water deficit did not influence plant height (276.9 cm; P = 0.3792), for the DM yield of stems(5,841 kg DM/ha; P = 0.2267), DM yield of reproductive organs (2,242 kg MS/ha; P = 0.2293), DM yield of the herbage mass (10,979 kg DM/ha; P = 0.1529), LAI (4.9; P = 0.4286) and SLA (168.7 cm^2/g.DM of leaf blade; P = 0.8372) but it affected the DM yield of leaf blade (Figure 2; P = 0.0394).

The differences in the production of leaf blade occurred only among the Maize-15 treatments when compared to the Pasture-G and Maize-4 treatments. Difference for the components of grains/corn on the cob (102.3 g; P = 0.3920), weight of a thousand grains (210.2 g; P = 0.6010), number of grains/corn on the cob (485.5; P = 0.1897) and number of grains/row (36.3; P = 0.1086) were not observed, as well as the grains productivity (10,145 kg/ha; P = 0.7696), except the corn components on the cob index (P = 0.0859) and amount of rows per corn on the cob (P = 0.0907; Figure 3).

These results for the maize crops are contrary to the ones reported in the literature in which the water deficit in critical periods significantly reduce the production of grains (Bergamaschi et al., 2004; Magalhães & Durães, 2006; Matzenauer et al., 1995 and 2002), mainly for the reduction of the production components such as amount of corn on the cob/plant and amount of grains/corn on the cob (Santos & Carlesso, 1998).

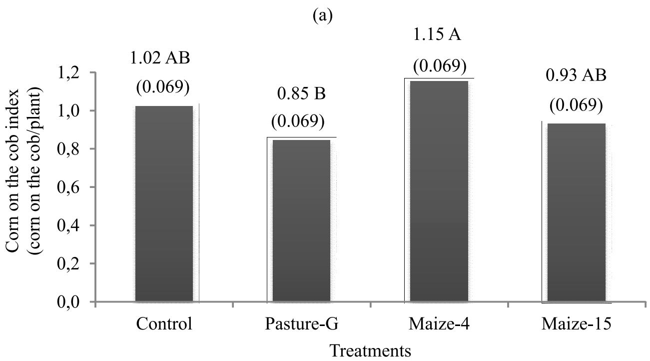
However, Matzenauer et al. (1995) reported that these reductions are more significant when the water deficit is extended after the flowering, mainly during the grain filling which did not happen in this study.

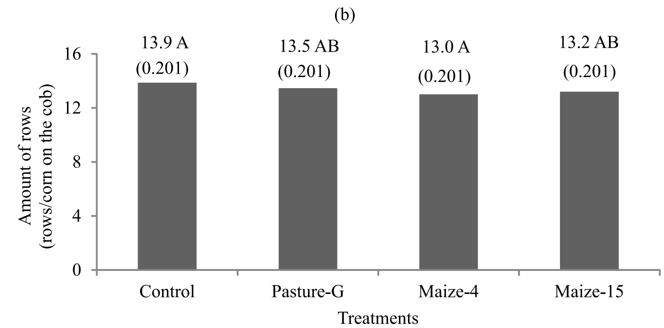
The maize water demand, like any other crop, is performed in order to satisfy the evaporating claim of the atmosphere and it depends on the predominant weather factors in the region, the variety, the phase of the production development, the type of soil and the adopted irrigation system (Araujo et al., 1999),therefore varying over time and space (Carvalho et al., 2006).



Harvest performed 91 after maize emergency. The values inside and outside the parenthesis correspond to the average and the average error-standard, respectively. Averages followed by the same letter do not differ among themselves by Tukey test at 10% of probability.

Figure 2 - Dry matter (DM) yield of maize leaf blade submitted to the water deficit.





Harvest performed 91 after the maize emergency. The values inside and outside the parenthesis correspond to the average and error-standard, respectively. Averages followed by the same letter do not differ among themselves by Tukey test at 10% of probability.

Figure 3 - Corn on the cob index (a) and amount of rows per corn on the cob (b) in maize crops submitted to water deficit.

By evaluating the productivity of maize grains produced in lysimeter, in two sowing seasons (September 25th and October 15th, 2001), in Santa Maria, RS, Brazil (29°41´2"S, 53°48´25"W), Michelon et al. (2003) observed the fraction of water available in the soil during the cycle was distinct in the sowing seasons which were associated to lower atmospheric demand when sowing was done in September. The content of water in the soil was sufficient for the normal development of the production regardless of the sowing period.

Possibly, the season when this trial was performed also interfered in the expected results inasmuch as the climate conditions are milder if compared to the harvest period in this region.

During the water deficit periods in this trial, any visual indications of stress in the plants were not observed, such as wilt and twisted leaves (Santos & Carlesso, 1999). So, even if there was a water limitation period, this deficit was not enough for the plants, even in intercrop production, they suffered strong stress about to reduce the profit of the grains.

In this work, the water content in the soil was considered as an element in order to restart the irrigation after the water deficit, but, it is known that the critical values of humidity in the soil for the production development are dynamic and depend on the soil, the period of the year and the production which are being studied (Santos & Carlesso, 1999). The results of this work suggest the necessity to perform new studies in the field, involving intercropped systems and joining to other elements in order to distinguish the water deficit of the plant, such as the physiological ones (e.g. water potential of the leaves) to identify the level of water stress during the period of water restriction imposed to the productions.

Conclusions

Established palisadegrass plants intercropped with the maize crop produce less dry matter of herbage mass compared to the same plants in exclusive cultivation. The water deficit in the germination and initial tillering periods reduces the palisadegrass tillering during the establishment period. Production of maize grains is not influenced by the reduction of soil humidity up to the level of 40% of the water capacity available in the conditions evaluated in this work. The content of water in the soil itself is not a suficient parameter to point out the water stress in intercropped maize crops.

References

ARAÚJO, W.F.; SAMPAIO, R.A.; MEDEIROS, R.D. Irrigação e adubação nitrogenada em milho. **Scientia Agricola**, v.56, n.4, p.909-914, 1999.

ALEXANDRINO, E.; GOMIDE, J.A.; GOMIDE, C.A.M. Crescimento e desenvolvimento do dossel de *Panicum maximum* cv. Mombaça. **Revista Brasileira de Zootecnia**, v.34, n.6, p.2164-2173, 2005 (supl.)

BERGAMASCHI, H.; DALMAGO, G.A.; BERGONCI, J.I. et al. Distribuição hídrica no período crítico do milho e produção de grãos. **Pesquisa Agropecuária Brasileira**, v.39, n.9, p.831-839, 2004.

BRASIL. Ministério da Agricultura e Reforma Agrária. **Regras para análise de sementes**. Brasília: Ministério da Agricultura e Reforma Agrária, Secretaria Nacional de Defesa Agropecuária, 1992. 365p.

CARVALHO, D.F.; CRUZ, E.S.; SILVA, W.A. et al. Demanda hídrica do milho de cultivo de inverno no Estado do Rio de Janeiro. **Revista Brasileira de Engenharia Agrícola e Ambiental**, v.10, n.1, p.112-118, 2006.

COBUCCI, T.; KLUTHCOUSKI J.; AIDAR, H. Sistema Santa Fé: produção de forragem na entressafra. In: WORKSHOP INTERNACIONAL PROGRAMA DE INTEGRAÇÃO AGRICULTURA E PECUÁRIA PARA O DESENVOLVIMENTO SUSTENTÁVEL DAS SAVANAS TROPICAIS SULAMERICANAS, 2001, Santo Antonio de Goiás. **Anais...** Santo Antonio de Goiás: Embrapa Arroz e Feijão, 2001. p.125-135. (Documentos, 123).

CUNHA, F.F.; SOARES, A.A.; PEREIRA, O.G. et al. Características morfogênicas e perfilhamento do *Panicum maximum* Jacq. cv. Tanzânia irrigado. **Ciência Agrotécnica**, v.31, n.3, p.628-635, 2007.

DIAS-FILHO, M.B. Growth and biomass alocation of the C4 grasses *Brachiaria brizantha* and *Brachiaria humidicola* under shade. **Pesquisa Agropecuária Brasileira**, v.35, n.12, p.2335-2341, 2000.

DOURADO NETO, D.; FANCELLI, A.L.; LOPES, P.P. Milho: população e distribuição de plantas. In: FANCELLI, A.L.; DOURADO NETO, D. (Eds.). **Milho**: tecnologia e produtividade. Piracicaba: ESALQ, 2001. p.120-125.

GOMIDE, C.A.M.; GOMIDE, J.A. Morfogênese de Cultivares de *Panicum maximum* Jacq. **Revista Brasileira de Zootecnia**, v.29, n.2, p.341-348, 2000.

GUENNI, O.; MARÍN, D.; BARUCH, Z. Responses to drought of five *Brachiaria* species. I. Biomass production, leaf growth, root distribution, water use and forage quality. **Plant and Soil**, v.243, p.229-241, 2002.

KLUTHCOUSKI, J.; STONE, L.F.; AIDAR, A. **Integração lavoura-pecuária**. Santo Antonio de Goiás: Embrapa Arroz Feijão, 2003. 570p.

MAGALHÃES, P.C.; DURÃES, F.O.M. **Fisiologia da produção de milho.** Sete Lagoas: Embrapa Milho e Sorgo, 2006. 10p. (Embrapa Milho e Sorgo. Circular Técnica, 76).

MATTOS, J.L.S.; GOMIDE, J.A.; HUAMAN, C.A.M. Crescimento de espécies do gênero *Brachiaria*, sob déficit hídrico, em casa de vegetação. **Revista Brasileira de Zootecnia**, v.34, n.3, p.746-754, 2005.

MATZENAUER, R.; BERGAMASCHI, H.; BERLATO, M.A. et al. Relações entre rendimento de milho e variáveis hídricas. **Revista Brasileira de Agrometeorologia**, v.3, p.85-92, 1995.

MATZENAUER, R.; BERGAMASCHI, H.; BERLATO, M.A. et al. **Consumo de água e disponibilidade hídrica para milho e soja, no Rio Grande do Sul**. Porto Alegre: Fepagro, 2002. 105p. (Boletim Fepagro, 10).

MICHELON, C.J.; FIORIN, T.T.; CARLESSO, R. et al. Disponibilidade de água no solo e rendimento de grãos de milho semeado em duas épocas. In: CONGRESSO BRASILEIRO DE CIÊNCIA DO SOLO/ SOLO: ALICERCE DOS SISTEMAS DE PRODUÇÃO, 29., 2003, Ribeirão Preto. **Anais...** Viçosa, MG: SBCS, 2003. (CD-ROM).

PORTES, T.A.; CARVALHO, S.I.C.; OLIVEIRA, I.P. et al. Análise do crescimento de uma cultivar de braquiária em cultivo solteiro e consorciado com cereais. **Pesquisa Agropecuária Brasileira**, v.35, n.7, p.1349-1358, 2000.

RASSINI, J.B. **Irrigação de pastagens**: freqüência e quantidade de aplicação de água em latossolos de textura média. São Carlos: Embrapa Pecuária Sudeste, 2002. 7p. (Circular Técnica, 31).

SANTOS, R.F.; CARLESSO, R. Déficit hídrico e os processos morfológico e fisiológico das plantas. **Revista Brasileira de Engenharia Agrícola e Ambiental**, v.2, n.3, p.287-294, 1998.

SANTOS, R.F.; CARLESSO, R. Enrolamento e expansão das folhas de milho submetidas a déficit hídrico em diferentes solos. **Revista Brasileira de Engenharia Agrícola e Ambiental**, v.3, n.1, p.1-6, 1999.

SBRISSIA, A.F.; Da SILVA, S.C. O ecossistema de pastagens e a produção animal. In: REUNIÃO ANUAL DA SOCIEDADE BRASILEIRA DE ZOOTECNIA, 37., 2001, Piracicaba. **Anais...** Piracicaba: FEALQ, 2001. p.731-754.

SOUZA, G.B.; NOGUEIRA, A.R.A; RASSINI, J.B. **Determinação de matéria seca e umidade em solos e plantas com forno de microondas doméstico**. São Carlos: Embrapa Pecuária Sudeste, 2002. 13p. (Circular Técnica, 33).

STATISTICAL ANALYSES SYSTEM - SAS. **SAS: system for Microsoft windows**; release 9.1. Cary, 2003. (1 CD-ROM).

TAIZ, L.; ZEIGER, E. **Fisiologia vegetal**. Tradução de E.R. Santarém et al. 3.ed. Porto Alegre: Artmed, 2004. 719p.

UNITED STATES. Department of Agriculture. Soil Survey Division. Soil Conservation Service. Soil Survey Staff. **Soil taxonomy**: a basic system of soil classification for making and interpreting soil surveys. 2.ed. Washington, 1999. 169p. (USDA. Agriculture Handbook, 436).

VAN RAIJ, B.; CATARELLA, H.; QUAGGIO, J.A. et al. **Recomendações de adubação e calagem para o Estado de São Paulo**. 2.ed. Campinas: Instituto Agronômico; Fundação IAC, 1996. 258p. (Boletim Técnico, 100).