YIELD AND MORPHOLOGICAL CHARACTERISTICS OF CORN AND Brachiaria brizantha cv. PIATÃ CULTIVATED IN CONSORTIUM SYSTEM

MASSA DE FORRAGEM E CARACTERÍSTICAS MORFOLÓGICAS DO MILHO E DA *Brachiaria brizantha* CV. PIATÃ CULTIVADOS EM SISTEMA DE CONSÓRCIO

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SUMMARY

This study was conducted during the 2010 off-season, from January to June, and focused primarily on assessing the morphological characteristics of a variety of corn (MAXIMUS-TL) cultivated under no-tillage consortium system with *B. brizantha* cv. Piata at three sowing rates. The experiment was carried out at the Setor de Forragicultura, FCAV, UNESP, Jaboticabal, in a completely randomized design in a 3 x 1 factorial. Corn was harvested when dry matter content was above 30%. No significant differences were observed either for some traits or morphological characteristics, except for height and placement of plants, percent and total dry matter production and total production as well. In the case of pasture, there was also no statistical difference in some production traits, although there was difference of up to 1144.4 kg ha-1 total dry matter production between sowing rates. The number of tillers, percentage and total dry matter production and total production also varied. Corn production is positively influenced by the high sowing rate treatment and the cultivar *Brachiaria brizanth* was established in the area. Thus, the seeding rate of two rows of *Piata* grass alternating with one row of corn is indicated, since it provides better pasture conditions and maximizes corn production.

KEY-WORDS: Stems. Leaves. Spikes. Tillers. Percentage. Production

RESUMO

O trabalho em questão se desenvolveu durante a safrinha do ano de 2010, que compreendeu o período de janeiro a junho, e como foco principal avaliou as características morfológicas de uma da variedade de milho (MAXIMUS –TL) e três densidades de semeadura de *B. brizantha* cv. Piatã semeadas em consórcio, em sistema de plantio direto. O experimento foi conduzido no setor de Forragicultura, UNESP, Faculdade de Ciências Agrárias e Veterinária, Campus de Jaboticabal, adotando-se o delineamento experimental inteiramente casualizado, em esquema fatorial 3 x 1, sendo os tratamentos a combinação das três intensidades de semeadura ((1) (600 pontos de VC), (2) (750 pontos de VC) e (3) (900 pontos de VC) de *B. brizantha* cv. Piatã) com o milho. As plantas do milho foram colhidas quando apresentavam mais de 30% de matéria seca. Não Houve diferença significativa em relação a algumas características avaliadas, nem quanto às características morfológicas, exceto na altura e inserção de plantas, porcentagem e produção de matéria seca total e produção total. No caso da pastagem também não houve diferença estatística, em algumas características de produção, embora tenha ocorrido diferença de até 1144,4 kg ha-1 de produção de matéria seca total entre as densidades. Houve variações no número de perfilhos, porcentagem e produção de matéria seca total e produção total. A produtividade do milho é influenciada positivamente pelo tratamento com maior densidade e o cultivar de *B.brizantha* se estabeleceu na área. Assim, a densidade de semeadura do capim-piatã com duas linhas plantadas na entrelinha do milho deve ser indicada por propiciar melhor formação do pasto e maximizar produção do milho.

PALAVRAS-CHAVE: Colmos. Folhas. Espigas. Perfilhos. Porcentagem. Produção.

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INTRODUCTION

Despite sometimes being contradictory, issues such as maximizing production, increasing productivity, high technology in the field, environmental awareness and sustainability are increasingly discussed in meetings and conferences in our country. This discussion aims at determining how much humans can increase food production and the profits per area without compromising nature. It becomes, therefore, very important to study methods that allow us to achieve these goals. The focus of this study is to research the integration between crops and livestock, using Piata grass planted in consortium with silage corn. Due to corn versatility and its use in animal production, the culture of corn is economically and socially important within the Brazilian agricultural production (FREITAS, 2008).

Brachiaria brizantha cv. Piatã was launched by Embrapa as one of the most anticipated material of Brazilian agriculture. This grass is recommended for pasture diversification in various types of cultivation, especially due to high rate of leaf growth, high leaf/stem ratio and nutritive value. It tolerates drought well and yields an average 9.5 tonnes of dry matter/ha/year, with 57% leaves, of which 30% is obtained in the dry season (May to November) (EMBRAPA, 2005).

The ILP production system in Brazil is supported by the fact that we currently have 100 million hectares of cultivated pastures, and 80% of those are degraded to some extent. This fact reflects on the low stocking rate per unit area, where the national average does not exceed 0.4 animal unit (AU). Thus, the consortium system allows to produce forage in the dry season, with good enough quality to maintain nutritional status of herds and straw production for tillage, without the need for cover crops. In addition, it breaks the cycle of pests and plant diseases, fixes n² from the atmosphere into the soil (avoiding erroneous fertilization and environment contamination) and makes the grass more digestible due to competition (BARDUCCI, 2009).

Thus, this study aimed to evaluate the forage mass and morphological characteristics of corn and *Brachiaria brizantha* cv. Piata cultivated in consortium system at three different grass sowing rates.

MATERIAL AND METHODS

The experiment was conducted at the Setor de Forragicultura, of the Departamento de Zootecnia, of Faculdade de Ciências Agrárias e Veterinárias, UNESP, Jaboticabal, SP, located at 21° 15' 22" S, longitude 48° 18' 58" W, 595 m altitude, from January to June, 2010.

The treatments consisted of intercropping *Brachiaria brizantha* (Hochst. ex A. Rich.) Stapf cv. Piatã and corn (Híbrido Simples (Maximus TL) – Agrisure – Syngenta, genetically modified against fall armyworm) at three grass sowing rates. The experimental design was completely randomized, with five repetitions. The seeds of Piata grass had 60 % of culture value (CV) and sowing rates were: (1) 10.0 kg/ha of seeds (600 CV points), with 8,0 kg in the corn row and 2,0 kg in one row, between corn rows; (2) 12,5 kg/ha of seeds (750 CV points), with 8.0 kg in the corn row and 4.5 kg by solid seeding between corn rows; and (3) 15.0 kg/ha of seeds (900 CV points), with 8.0 kg in the corn row and 7.0 kg in two rows in between the corn rows. The experiment covered a 3,300 m² area, with 220 m² per plot.

The soil of the experimental area was classified as red Latosol, sandy phase (ANDRIOLI & CENTURION, 1999). Before the experimental period, in December 2009, chemical analyzes were carried out for determining soil fertility at depth 0-20 cm (Table 1). The soil was limed with dolomitic limestone (90% PRNT) to raise the base saturation to 70%, as recommended by Andrioli & Centurion (1999).

The local climate is tropical Aw, mesothermal with wet summer and dry winter, according to Köppen, with annual precipitation about 1340 mm, relative humidity 80% and maximum and minimum temperatures, 32.2 and 12°C, respectively. Average monthly temperature and rainfall for the experimental period are presented in Table 2.

In January 2010, eight days before sowing, the area was dried with a mixture of glyphosate systemic herbicide + 2,4-D (750 g/ha glyphosate + 840g/ha of 2.4-D with mixture volume of 100 L/ha) in order to deploy the corn crop on January 20, 2010.

Table 1 - Chemical analysis of the experimental area, before trial period.

Sample	pH	MO	Presina	K	Ca^{2+}	Mg^{2+}	H+Al	SB	T	V%
	CaCl2	g/dm3	mg/dm3	-----------------------mmolc/dm³----------------------						
1	5,3	35	14	4,7	44	12	48	60,2	103,1	54

Table 2 – Maximum, minimum and average temperatures, and precipitation in the first half of 2010 in Jaboticabal, São Paulo.

year	month	rainfall	Maximum temperature	Minimum temperature	Average temperature
		mm		ºC	
	January	240,7	30,4	20,8	24,4
	February	150,7	32,2	20,4	25,3
2010	March	183,0	31,4	20,0	24,6
	April	95,5	29,2	17,1	22,2
	May	10,6	27,1	14,1	19,5
	June	7,8	27,4	12,0	18,4

Data from the weather station of the Departamento de Ciências Exatas, FCAV/UNESP.

Corn was sown at density of approximately 7.6 seeds per meter. The spacing was 0.90 m, with a total plant population of approximately 84,445 units/ha. The tractor used was a Massey Ferguson 620, with 105hp and planter Jumil Exacta PD 2040, approximately 2.25 m wide, each plot was passed three times thus completing a total of nine rows. The sowing depth of grass seeds was 2 cm average (sown in rows with the fertilizer; when sown by solid seeding, the seeds were not incorporated in the soil). The Piata grass was sown between the rows of corn using a drill Fankhauser and a 4600 Ford tractor and solid seeding between corn rows was done using a manual rice seeder, with capacity for 5.0 kg of seeds. Corn and Piata grass emerged on January, 27 and 30, respectively.

Sowing fertilization was done using superphosphate with 18% phosphorus and 3% nitrogen, at a rate of 300 kg/ha. On February 3, 2010, 14 days after sowing, fertilization was performed using 20-0-20 (NPK) fertilizer, also at the rate of 300 kg/ha, distributed with the manual rice seeder.

Corn and Piata grass height, number of corn and Piata grass plants, as well as Piata grass tillers were evaluated at 50, 65, and 90 days before corn harvest, in order to monitor experimental conditions. Other evaluations were carried out shortly before the point of corn silage, that is, from 95 to 100 days after sowing. Three destructive corn samples were randomly collected per plot, using a 1 m² square, all corn plants in that square were cut at ground level.

The samples were weighed and separated into sub-samples. The plants of each sub-sample were separated into leaves, stems (with tassel), cobs and straw. These fractions were stored in paper bags, weighed and taken to a forced air oven to dry at 55°C for 72 hours. After drying, the fractions were weighed again to calculate dry matter content of each fraction and productivity data.

The heights of plants and ears were determined in 20 randomly selected plants per plot using a measuring cane. The following corn characteristics were evaluated: height, ear height, number of plants and ears/ha, dry matter content, dry weight in kg/ha, as well as production and percentage of morphological components (leaf, stem, cob and straw .)

Three samples of Piata grass were randomly collected per plot between the rows of corn, eliminating borders and the weeds, if present. These samples were cut at ground level, using a 0.25 m² square. The number of tillers was determined during the cutting of samples. Each sample was weighed and divided in two sub-samples, one was used to calculate total dry matter and the other to separate other morphological components (leaves, stems and dead material). Another 0.25-m² sample was collected to determine leaf area. Subsequently, the samples were dried in a forced air circulation oven at 55°C for 72 hours and weighed. The dry weights were used to calculate the percentage of dry matter and forage mass.

Height, total dry matter (kg/ha), percentage of dry matter, leaf area index (LAI), tiller number, percentage of morphological components (leaf, stem and dead material) were evaluated for Piata grass. Leaf area was determined using the leaf area meter LICOR LI-3000 and LAI calculated based on the data collected.

Statistical analyzes were performed using SAS software (2009) and means were compared by Tukey test at 5%.

RESULTS AND DISCUSSION

Corn height for sowing densities 3 and 2 was similar and greater than density 2 (Table 3). Thus, corn plants intercropped with Piata grass planted in either one or two rows developed more compared to solid seeding method. Corroborating the results of EMBRAPA (2005), where increased competition between corn and forage plants resulted in taller plants. According to Piana et al. (2008) average corn height in annual culture is not more than 2.20 meters, therefore, lower than that observed in this experiment, even though this number varies among cultivars and growing conditions.

The corn cultivated in consortium system with grass sown by solid seeding resulted in lower insertion height of ear corn (Table 3), as a result of shorter plants. The treatments with one and two rows (densities 1 and 3, respectively) of Piata grass with corn had greater insertion heights and were not different. This result confirms the influence of competition between plants. According to Piana et al. (2008), the mean height of ear insertion is not more than 1.10 m for single corn crop; however, other factors such as genetics also influence this parameter.

The number of corn plants did not differ among sowing rates (Table 3), indicating that different intensities of the forage treatments employed did not influence the number of corn plants, and compared with single corn crop, competition between plants had an influence. The average value of plants obtained in this experiment (8 plants/m²) was lower than that observed by Piana et al. (2008), where the density of corn plants exceed an average of 11 plants/m² for single corn crop in Rio Grande do Sul

It is important to mention that for corn mass production, taller plants are interesting since the higher leaf area yields greater amounts of green mass (FORNASIERI, 1992). However, if the objective is silage production this high leaf are is not interesting any longer, since the green mass ratio increases and the nutritional value of the product decreases (RESTLE et al. 1999). This could be solved by increasing crop cutting height.

Rezende (2003) compared the influence of plant population and determined plant height and the effect on ear insertion height. The author reported that in the plots were plant competition was higher; grain yield, height and insertion height all increased.

Table 3 - Height, placement and number of corn plants in intercropping with Piata grass, at different sowing densities.

Treatment	Com Height (m)	Insertion height (m)	Number of plants (plants/ha)
600 points VC(1)	2,51 ab	1,36 a	80500 a
750 points VC(2)	2,37 b	1,11 b	82100 a
900 points VC(3)	2,60 a	1,33 a	80000 a

Means followed by same letter in columns do not differ statistically by Tukey test at 5%.

Table 4 - Percentage of dry matter (DM%) and total dry matter production (DMP) of corn in intercropping with Piata grass, at different sowing densities.

Treatment	DM (%)	Total dry matter (kg/ha)
600 points VC(1)	30,56 b	22763 a
750 points VC(2)	35,17 a	18338 b
900 points VC(3)	32,71 ab	24328 a

Means followed by same letter in columns do not differ statistically by Tukey test at 5%.

The percentage of total dry matter of corn (Table 4) was greater for the solid seeding of grass (750 points CV) and did not differ from two-row sowing of grass Piata (900 points CV). The average dry matter yield shows that corn harvest point was adequate (average dry matter 32.5%), because according to the literature (Marques, 2003), the right time to harvest silage corn is when the plant has 30% to 35% dry matter.

Corn total dry matter yields (PDM) (Table 4) for the densities 1 and 3 of Piata grass did not differ and were higher than density 2 (solid seeding, 750 points VC). This suggests that solid seeding does not form a homogeneous stand, which may have affected negatively the development of corn plants resulting in lower total PDM.

Total PDM data of corn for the three grass densities were higher (mean 21.8 tMS/ha) than those reported by LEONEL et al. (2009), who studied single corn crop; single xaraés grass crop; two rows of xaraés grass between corn rows; xaraés grass sown by solid seeding between the rows of corn. The authors reported average total corn production of 17.0 tMS /ha.

Melo et al. (1999) in a study conducted during the 95/96 growing season, achieved productivity of 18.2 tMS/ha of corn. The authors reportedly performed two fertilization coverages, the first, 30 days after plant emergence and the second, 45 days after emergence.

The percentage of leaves, stems, straw and corn ears (Table 5) did not differ between treatments, which indicated that different grass sowing densities did not influence corn morphological characteristics.

Cunha Neto et al. (2009) also found no difference in the percentage of leaves, stalks and straw of corn cultivated in consortium system with three cultivars of *Brachiaria brizantha* (Xaraés, Marandu and Piata). The authors stated that the morphological development of different parts of corn were not affected by competition with grass. However, soil high fertility and the fertilization practiced may have favored the results.

The highest seeding rate, two sowing rows of Piata grass (900 points CV), resulted in the highest DMP of leaves and ears. However, this treatment did not differ from one-row Piata grass (600 points VC) treatment, even though this treatment had less competition between plants. Corn productivity parameters found for solid seeding (750 points CV) were lower compared to other densities, as shown in Table 6, again suggesting that solid seeding resulted in less uniform distribution and possibly impaired corn growth. Finally, ear productivity was higher than that reported by Pariz (2010), who found average grain yield of 9118.4 kg/ha for corn intercropping.

Table 5 - Percentage of leaves, stems, straw and corn ears cultivated in intercropping with Piata grass, at different sowing densities.

Treatments	Leaves (%)	Stems (%)	Straw (%)	Ears (%)
600 points VC(1)	21,26 a	25,53 a	7,24 a	45,96 a
750 points VC(2)	22,20 a	24,86 a	7,41 a	45,53 a
900 points VC(3)	21,64 a	25,91 a	7,43 a	45,02 a

Means followed by same letter in columns do not differ statistically by Tukey test at 5%.

Table 6 - Dry matter production (DMP) of leaves, stems, straw and corn ears in a system of grass-Piata consortium, managed with different plant densities.

Treatment	DMP leaves (Kg / ha)	DMP ears (kg / ha)	DMP stems (kg / ha)	DMP straw (Kg/ha)
600 points VC(1)	4832,85 a	10660,8 a	5914,5 a	1737,56 a
750 points VC(2)	4298,96 b	8676,75 b	4589,4 b	1481,93 b
900 points VC(3)	5028,81 a	11293,4 a	5390,5 a	1708,71 a

Means followed by same letter in columns do not differ statistically by Tukey test at 5%.

Although different seeding densities changed corn yield characteristics, the number of ears (Table 7) was similar (8 ears/m²) between treatments and to the results reported by (PIANA et al. 2008), who reported 6-11 ears/m² for corn monoculture, concluding that competition among cultivars neither helped nor hindered number of corn ears. The number of ears produced influenced directly the amount of grain produced, according to this work.

Regarding ear size (Table 7), the one-row treatments of Piatã grass (600 points VC) and 900 points VC were not different, but corn ears were longer compared to solid seeding treatment (750 points VC). This may be due to the homogeneity of row sowing compared to solid seeding that improved corn development and the production of larger ears. This can also be related with better transport of water and nutrients to the ear, since when these nutritional requirements are fully met, larger ears result in larger amount of grains per ear and therefore, higher productivity.

Piata grass height (Table 8) did not differ between treatments, thus showing that different plant densities did not affect this feature.

In cropping systems where there is concomitant growth of corn and forage, the priority is the early development of corn. After corn harvest, forage develops without competition and grazing will form, which is favored by improving soil fertility. This temporary consortium reduces the cost of forming pasture, since corn production offsets the expenses with seeds and inputs (FERREIRA et al., 1990).

According to Macedo & Zimmer (1993) the final height of Piatã grass should be between 0.85 and 1.10 meters, depending on the shading of the grass. Thus, it is observed that in this study the grass and corn intercropping affected negatively grass growth rate, since the grass reached maximum height 0.61 m. However, those authors conducted the experiment in the savannah, where the temperature accelerates grass growth.

Table 7 - Number and size of corn ears in intercropping with Piata grass, managed with different plant densities.

Treatment	Number of ears (number/ha)	Ear size (cm)
600 points VC(1)	84400 a	12,39 a
750 points VC(2)	84200 a	10,62 b
900 points VC(3)	85400 a	11,73 ab

Means followed by same letter in columns do not differ statistically by Tukey test at 5%.

Table 8 - Height and number of tillers of Piatã grass in intercropping with corn at different sowing densities.

Treatment	Height (m)	Number of tillers (m²)
600 points VC(1)	0,48 a	88,43 b
750 points VC(2)	0,61 a	87,20 b
900 points VC(3)	0,59 a	105,65 a

Means followed by same letter in columns do not differ statistically by Tukey test at 5%.

Table 9 - Percentage of dry matter (%) and forage mass (kg/ha) of Piata grass and corn in consortium system, sown at different densities.

Treatment	Dry matter (%)	Total forage mass (kg/ha)
600 points VC(1)	29,73 ab	1349,5 b
750 points VC(2)	38,00 a	2493,9 a
900 points VC(3)	21,54 b	2325,1 a

Means followed by same letter in columns do not differ statistically by Tukey test at 5%.

Table 10 - Percentage of leaves, stems and dead material of Piatã grass in intercropping with corn, managed at different plant densities.

Treatment	Leaves (%)	Stems (%)	Dead material (%)
600 points VC(1)	44,90 a	41,82 a	13,28 c
750 points VC(2)	39,63 b	40,82 a	19,56 a
900 points VC(3)	48,10 a	35,22 b	16,68 b

Means followed by same letter in columns do not differ statistically by Tukey test at 5% probability.

The two rows of Piata grass (900 points CV) yielded the greatest number of tillers per m² (Table 8). The other densities did not affect significantly this trait. These results show that the highest sowing density, 15 kg of seeds per hectare in two rows promoted a larger number of plants, as expected. GIACOMINI (2007) reports that environmental factors that influence tillering are: quantity and quality of incident light, photoperiod, water availability, temperature and mineral nutrition, which may act alone or together. In this case, increased competition among plants did not affect negatively stand formation, on the contrary, a greater number of tillers was observed.

Dry matter percentage (Table 9) was higher for Piata grass sown by solid seeding (750 points VC) between the rows of corn, and did not differ significantly from those plots where one grass row was cultivated between the rows of corn (600 points CV). Whereas the two rows of Piata grass (900 points VC) between the rows of corn yielded the lowest dry matter percentage 21.54%. This may have happened because one row sowing and solid seeding resulted in fewer tillers, diminished plant competition, accelerated tiller aging process and thus, increased dry matter percentage .

The total forage mass for the solid seeding and two sowing rows of Piata grass (densities of 750 VC and 900 points, respectively) between the rows of corn did not differ, and were higher than 600 point VC (one row). The results showed that the amount of seeds and their distribution influence the amount of forage produced. According to Cunha Neto et al. (2009), total dry matter production of Piata grass and corn added should yield about 12,500 kg per hectare, lower than the values reached in this study between 19,700 and 27,000 kg of total dry matter per hectare, this difference can be explained by the different planting time. Cunha Neto (2009) sowing was performed in February, which is considered late since rainfall starts to decrease from February, at planting depth of 8 cm (the maximum recommended for Piatã grass is 5 cm) and 4kg/ha seed, well below this experiment (15kg/ha).

The two rows of Piata grass (900 points VC) yielded a greater percentage of leaves compared to solid seeding (750 points VC), this is due to the greater number of plants and tillers resulting from the treatment (Table 8).

According to Cunha Neto et al. (2009) Piata grass tends to produce higher percentage of stem compared to other cultivars of *Brachiaria brizantha*, but higher than those displayed in this work, close to 55%.

Table 11 - Mass of leaves, stems and dead material of Piatã grass in intercropping with corn, managed at different plant densities.

Treatment	Mass of leaves (kg/ha)	Mass of dead material (kg/ha)	Stem mass (kg/ha)
600 points VC(1)	917,1 b	245,7 ab	363,20 b
750 points VC(2)	1378,0 a	409,35 a	482,18 ab
900 points VC(3)	1051,5 ab	166,52 b	603,12 a

Means followed by same letter in columns do not differ statistically by Tukey test at 5% probability.

Table 12 - Leaf area index of Piatã grass in intercropping with corn, managed at different plant densities.

Treatment	LAI
600 points VC(1)	4,94 a
750 points VC(2)	4,55 a
900 points VC(3)	4,04 a

Means followed by same uppercase letter in rows and lowercase letter in columns do not differ statistically by tukey at 5%.

The percentage of dead matter from Piata grass (Table 10) differed for sowing rates, and broadcast sowing had the highest percentage of dead material followed by two rows (900 points CV) and one row (600 points VC). Cunha Neto et al. (2009) reported that the percentage of dead matter from Piata grass was the lowest compared with other cultivars *Brachiaria brizantha*, but their results show lower values of dead material compared to this work (close to 7.5%).

Regarding mass of leaves and dead material (Table 11), it is observed that broadcast sowing (750 points VC) resulted in higher values compared to one and two rows of Piata grass (600 points VC). This data suggests that the uneven sowing of solid seeding favored a plant distribution that reduced competition, thus increasing production of leaves and dead material. It is interesting to note that the treatment that produces the highest percentage of leaves will not always produce the highest total mass of leaves.

The stem mass (Table 11) was similar for two rows of grass Piata (900 points VC) and solid seeding (750 points VC) and their stem masses were higher than the treatment with one row (600 points VC), thus making it clear that the proposed methodology is correct, since the 900 points VC of Piata grass intensifies shading and yields more stems.

The LAI of Piata grass (Table 12) did not differ among different densities, which indicated that sowing intensities did not influence grass LAI. According to GIACOMINI (2007), LAI determines the intensity of competition for light among individual plants, and tillering is regulated by it. However, in the present study, although different seeding rates resulted in different tillering and leaf percentage, these changes did not affect LAI.

CONCLUSION

The yield of corn ears does not change when corn is planted in consortium with Piata grass at different sowing densities. The increased competition among plants changed the number of tillers and consequently increased total forage mass and the percentage of Piata grass leaves. Thus, the sowing density of Piata grass in two rows planted between rows of corn may be indicated since it resulted in best pasture formation and maintained corn productivity. The pasture was established successfully at the end of the experiment, thus ensuring the principles of integrated crop livestock.

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