BIOMASS YIELD FOR SILAGE AND GRAIN YIELD OF MAIZE INTERCROPPED WITH SOYBEAN

Abstract -Maize is one of the main cereals produced worldwide and, in association with soybean crop, can result in benefits to the production system. The objective of this study was to evaluate the biomass yield for silage and grain yield in maize crop, in the maize-soybean intercropping system. The study was conducted in the municipality of Dois Vizinhos - PR, Brazil, using a randomized block design, with nine treatments and four replicates. The treatments were composed of three maize hybrids grown in monoculture and in intercropping with two soybean cultivars (P1630+TMG7062, P1630+P95R51, P1630, LG6030+TMG7062, LG6030+P95R51, LG6030, P30F53+TMG7062, P30F53+P95R51 and P30F53). The data were subjected to analysis of variance and, when there was significance, Scott-Knott test was applied. Maize biomass yield for silage was approximately 4,000 kg ha^{-1} higher when the hybrids LG6030 and/or P30F53 were used. The cultivar TMG7062 stands out from P95R51 in terms of dry biomass yield for silage. The higher the percentage of soybean biomass added to the silage, the higher its crude protein content. However, crude protein yield per area was similar for the evaluated treatments. Some yield components (number of grains per row and thousand-grain weight) and grain yield of maize differ according to the hybrid used, but similarity is observed between intercropping and monoculture. There is evidence that the soybean cultivar TMG7062, intercropped with P1630, has the potential to reduce the grain yield of the cereal.

Keywords: Forage, crude protein, yield, *Zea mays*, *Glycine max.*

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PRODUTIVIDADE DE BIOMASSA PARA SILAGEM E GRÃOS DE MILHO NO CULTIVADO EM CONSÓRCIO COM SOJA

Resumo - O milho é um dos principais cereais produzidos mundialmente e em associação com a cultura da soja, pode resultar em benefícios ao sistema produtivo. O objetivo do estudo foi avaliar a produtividade de biomassa para ensilagem e de grãos na cultura do milho, no sistema de cultivo consorciado milho e soja. O estudo foi conduzido no município de Dois Vizinhos – PR, utilizado delineamento de blocos ao acaso, com nove tratamentos e quatro repetições. Os tratamentos foram compostos por três híbridos de milho cultivados em monocultura e em consórcio com duas cultivares de soja (P1630+TMG7062, P1630+P95R51, P1630, LG6030+TMG7062, LG6030+P95R51, LG6030, P30F53+TMG7062, P30F53+P95R51 e P30F53). Os dados foram submetidos a análise de variância e havendo significância, aplicou-se teste de Scott-Knott. A produtividade de biomassa para ensilagem da cultura do milho foi de aproximadamente 4.000 Kg ha^{-1} superior quando utilizado os híbridos LG6030 e/ou P30F53. A cultivar TMG7062 destaca-se da P95R51 na produtividade de biomassa seca para ensilagem. Quanto maior a porcentagem de biomassa de soja adicionado na silagem, maior o teor de proteína bruta da silagem. Entretanto a produtividade de proteína bruta por área, é similar para os tratamentos avaliados. Alguns componentes de rendimento (número de grãos por fileira e massa de mil grãos) e a produtividade de grãos do milho apresentam diferença em função do híbrido utilizado, mas observa-se similaridade entre o cultivo consorciado e em monocultura. Existem evidencias que a soja TMG7062, em consórcio com o milho P1630, apresente potencial para reduzir a produtividade de grãos do cereal.

Palavras-chave: Forragem, proteína bruta, rendimento produtivo, *Zea mays*, *Glycine max.*

Maize (*Zea mays*) is one of the most produced and consumed cereals in the world, being classified as the second most traded commodity in the world, second only to the soybean crop. Among the maize-producing countries, Brazil is in third place as one of the largest producers in the world due to the volume produced, only behind the United States and China (Acompanhamento da Safra Brasileira [de] Grãos, 2018).

Currently, more sustainable forms and managements of cultivation have been sought, and the technique of associating crops (intercropping) is an alternative. According to Alvarenga and Gontijo Neto (2009), there are numerous examples of the benefit of using some intercropped species, such as a cover plant with maize, a system that improves the production environment, keeps the soil covered and assists in nutrient cycling for the next crop.

As for the maize-soybean intercropping, there is a lack of studies on the subject and no recent studies are found in the national literature. However, Alvarenga et al. (1998) reported that maize grain yield is not influenced by the sowing system intercropped with soybean. Vieira and Ben (1984) highlight that the intercropping treatments were more efficient in terms of grain production than the monoculture of each crop.

However, the international literature has numerous recent studies evaluating the maize-soybean intercropping system. According to Song et al. (2017), soybean can improve soil fertility through biological nitrogen fixation. According to Kamara et al. (2017), the yield of maize cropping systems can be improved by intercropping with soybean. According to the researchers cited, in the intercropped system there is greater exploitation of environmental resources, resulting in yield and economic advantages for the producer, compared to monoculture systems.

In addition, studies show that soybean has the ability to improve the quality of maize silage, increasing its crude protein contents (Batista et al., 2019; Tsujimoto et al., 2015; Sánchez et al., 2010; Lempp et al., 2000), further justifying the need for studies evaluating the maize-soybean intercropping. Based on this context, the objective of the study was to evaluate the components of dry mass yield for silage and to measure the yield components and grain yield of maize crop in maize-soybean intercropping.

Material and Methods

The study was conducted from August 2016 to February 2017, at the Experimental Station of the Federal University of Technology - Paraná (UTFPR), campus of Dois Vizinhos, Paraná, Brazil (25º 42' 52" S latitude and 53º 03' 94" W longitude). The region has an average altitude of 510 meters, Cfa climate (Alvares et al., 2013), soil classified as *Nitossolo Vermelho Distroférrico* (Ultisol) (Santos et al., 2013) and average annual precipitation of 2,044 mm (Possenti et al., 2007). Table 1 presents some soil components of the experimental area at the time of experiment installation.

Table 1. Chemical analysis of the soil of the experimental area. UTFPR, Dois Vizinhos-PR, Brazil (2019)

|	pH	OM	P	Al^{+3}	H+Al	Ca	Mg	SB	V
	CaCl$_2$	g dm^{-3}	mg dm^{-3}			cmol$_c$ dm^{-3}			%
0 -10 cm	5.40	44.23	36.65	0.00	2.95	4.40	1.50	6.18	67.69
10 - 20 cm	5.30	29.48	29.19	0.00	3.18	3.80	1.60	5.50	63.36

OM=organic matter; SB=sum of bases; V=base saturation;

The experimental design was randomized blocks with four replicates, and the treatments were composed of three maize hybrids (P1630, LG6030 and P30F53) cultivated in monoculture and intercropped with two soybean cultivars (TMG7062 and P95R51), resulting in nine treatments (P1630+TMG7062, P1630+P95R51, P1630, LG6030+TMG7062, LG6030+P95R51, LG6030, P30F53+TMG7062, P30F53+P95R51 and P30F53), and 36 plots of 72 m² (3.6 x 20 m). These plots were subdivided into two usable areas with 36 m² (3.6 x 10 m), one for evaluation of silage yield components and the other for evaluation of grain yield components. The observation units (OU) consisted of the two central rows of maize and soybean with length of seven meters (1.2 x 7.0 m) (8.4 m²).

The maize hybrids and soybean cultivars used in the study have distinct cycles: P1630 (super-early cycle), LG6030 (intermediate cycle), P30F53 (early cycle), TMG7062 (maturation group 6.2 and semi-determinate growth habit) and P95R51 (maturation cycle 5.1 and indeterminate growth habit).

The crops were sown simultaneously, in a no-tillage system, on September 2, 2016, after the desiccation of the area with 1,100 g a.i. of glyphosate. The crops were planted with a distance of 30 cm between rows, alternating one row of each crop (Figure 1). The sowing density of the crops involved was 70,000 plants per hectare for maize and 225,000 plants per hectare
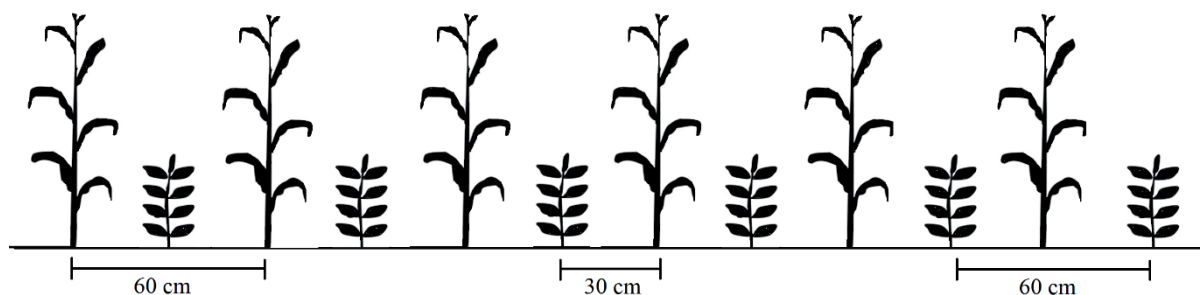
Figure 1. Row arrangements in the intercropping of maize and soybean, Dois Vizinhos – Brazil (2019) Source: Authors

for soybean.

Fertilization consisted of 366 kg ha^{-1} of the formulation 03-22-00 / N-P$_2$O$_5$-K$_2$O applied in the maize furrow, plus 185 kg ha^{-1} of potassium chloride with 60% K$_2$O, applied broadcast on the sowing date. Nitrogen fertilization was carried out as top-dressing with 180 kg ha^{-1} of nitrogen in the form of urea (45% N), applied on two dates, September 19 and October 14.

Weed control was performed with glyphosate application on September 23 and October 8, with doses of 1,400 and 1,200 g a.i. ha^{-1}, respectively. In the VT stage of maize (pre-silage), systemic fungicide containing Prothioconazole (175 g L^{-1}) + Trifloxystrobin (150 g L^{-1}) was applied at a dose of 72 + 61 g a.i. ha^{-1}. Together with fungicides, vegetable oil (0.5 L ha^{-1}) was added, in a mixture volume of 150 L ha^{-1}. The products were applied with a self-propelled sprayer.

Silage yield components were evaluated considering the maturity stage of maize, by observing the milk line in the grain with 2/3 already filled with starch, that is, milk stage changing to dough stage. Silage point was 115 days after sowing (12/26/2016) for the maize hybrid P1630 and 122 days after sowing (01/02/2017) for the hybrids P30F53 and LG6030.

Plants located in the OU were cut 30 cm above ground level, weighed and crushed. One forage sample (300 g) was collected from this biomass, placed in paper bags and dried for 72 hours in a forced ventilation oven at 55 °C to determine the percentage of dry mass (DM). The dry mass values were related to the respective weights of the field samples and extrapolated to hectares, to determine the soybean biomass yield for silage (SYS) and maize biomass yield for silage (MYS) (kg ha^{-1}). SYS and PSM values were then summed to obtain the total yield of silage (TYS).

The percentage of soybean mass in the silage (PSMS) (%) was obtained by the formula: SMS=SYS*100/TYS. The percentage of crude protein in the silage (PCPS) (%) was determined by the equation obtained by Stella et al. (2016) (CPS=20.55-0.13x), where x refers to the percentage of maize dry mass in the silage, and the crude protein yield per area (CPYA) (kg ha^{-1}) was determined by the equation: CPYA= TYS* PCPS.

Grain yield components were evaluated when the grains had approximately 22% moisture. Final maize population (FMP) (plants ha^{-1}) was evaluated by counting the final stand of plants in the OU and extrapolating it to hectares. Ten random ears per OU were collected and evaluated for the number of grains per row (NGR), by counting the number of grains present in one of the rows, and the number of grain rows per ear (NGRE), obtained by counting the number of grain rows present in each ear. The arithmetic mean of the observed values was calculated, and the result was used for data analysis.

To obtain the grain yield (GY) (kg ha^{-1}), all ears from each OU were harvested and threshed with a cereal thresher, the grain sample was weighed, grain moisture was measured, and

the OU yield with standard moisture of 13% was calculated and extrapolated to hectare. Thousand-grain weight (TGW) (g) was also determined by weighing four samples of 200 grains, calculating the mean of the data and multiplying the result by the correction factor 10.

The obtained data of each variable were subjected to analysis variance (ANOVA) and, in case of significance (p≤0.05), Scott-Knott test was applied at 5% probability level, using the program Sisvar 5.6 (Ferreira, 2008).

Results and Discussion

The data of minimum and maximum temperatures and precipitation recorded during the experimental period are shown in Figure 2. Temperatures ranged from 8.2 °C (minimum) to 34.9 °C (maximum), with total precipitation of 670.9 mm, distributed throughout the study period.

According to Albuquerque and Resende (2002), maize needs 400 to 700 mm of water during its cycle to meet the needs for grain production. Thus, it is assumed that maize had favorable conditions of temperature and sufficient amount of water for its establishment, development and production along the study period.

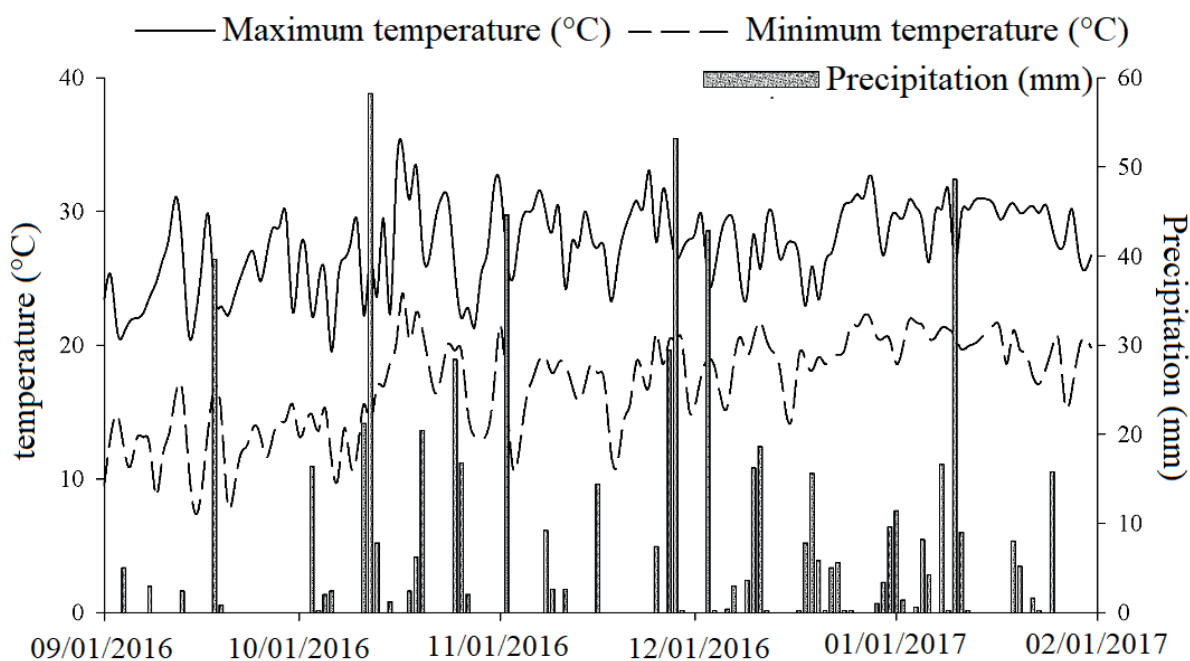The silage yield components for the

Figure 2. Maximum and minimum temperatures (°C) and precipitation (mm) recorded during the experimental period. UTFPR, Dois Vizinhos-PR, Brazil (2019)

evaluated treatments are presented in Table 2. Treatments composed of the hybrid P1630 had lower values of MYS and TYS than treatments using the materials LG6030 and P30F53. For soybean, wide variation of SYS among the treatments, as evidenced by Table 2. Higher values of SYS were found in the association of P1630+TMG7062 (1.886 kg ha^{-1}), followed by the treatment P1630+P95R51 (1.438 kg ha^{-1}) (Table 2). Next, SYS of 748 and 845 kg ha^{-1} were found in the treatments LG6030+TMG7602 and P30F53+TMG7062, respectively, followed by LG6030+P95R51 and P30F53+P95R51 with SYS of 453 and 425 kg ha^{-1}.

The statistical results observed for SYS

were similar to those of PSMS and PCPS (Table 2). The treatment P1630+TMG7062 stands out with higher values of PSMS (10.42) and PCPS (8.90), followed by P1630+P95R51 with PSMS of 7.90% and PCPS of 8.58%. These were followed by the combinations LG6030+TMG7602 and P30F53+TMG7062, but they did not differ from each other. The combinations LG6030+P95R51 and P30F53+P95R51 were the ones that had the lowest values of PSMS and PCPS, but were similar to each other. The results showed that maize cultivation in monoculture led to the lowest values of PSMS and PCPS (Table 2).

With values from 1,550 kg ha^{-1} (P1630+P95R51) to 1,692 kg ha^{-1}

Table 2. Silage yield components in maize-soybean intercropping. UTFPR, Dois Vizinhos-PR, Brazil (2019)

Treatments	MYS	SYS	TYS	PSMS	PCPS	CPYA
P1630+TMG7062	16,353.75 b	1,886.00 a	18,239.75 b	10.42 a	8.90 a	1,622.28 a
P1630+P95R51	16,526.25 b	1,438.00 b	18,064.25 b	7.90 b	8.58 b	1,550.79 a
P1630	16,650.00 b	0.00 e	16,650.00 b	0.00 e	7.55 e	1,257.08 b
LG6030+TMG7602	19,119.75 a	748.50 c	19,868.25 a	3.79 c	8.04 c	1,597.36 a
LG6030+P95R51	20,277.25 a	453.25 d	20,730.50 a	2.20 d	7.84 d	1,624.08 a
LG6030	20,783.25 a	0.00 e	20,783.25 a	0.00 e	7.55 e	1,569.14 a
P30F53+TMG7062	19,899.25 a	845.00 c	20,745.25 a	4.07 c	8.08 c	1,676.12 a
P30F53+P95R51	21,262.00 a	425.75 d	21,688.50 a	1.95 d	7.80 d	1,692.83 a
P30F53	22,196.50 a	0.00 e	22,196.50 a	0.00 e	7.55 e	1,675.84 a
Mean	19,229.78	644.06	19,885.14	3.37	7.99	1,585.06
P	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
CV (%)	6.81	19.70	6.43	21.49	1.67	6.52

$p \leq 0.05$ - significant at 5% probability level. Means followed by different letters in the column differ statistically by the Scott-Knott test at 5% probability level. SYS=soybean yield for silage (kg ha^{-1}), MYS=maize yield for silage (kg ha^{-1}), TYS=total yield of silage (kg ha^{-1}), PSMS=percentage of soybean mass in the silage (%), PCPS=percentage of crude protein in the silage (%), CPYA=crude protein yield per area (kg ha^{-1}).

(P30F53+P95R51) of CPYA, all combinations were similar to one another for CPYA, except the treatment involving the hybrid P1630 in monoculture, which had CPYA of 1,257 kg ha^{-1}, being statistically lower than the other treatments (Table 2).

Although the hybrids LG6030 and P30F53 had different cycles, being intermediate and early, respectively, these materials showed similar behaviors in the field, with silage point occurring simultaneously for both.

Soybean did not influence the development and yield components for silage of maize plants, as there were similar values of MYS among the treatments composed of the same maize hybrid, corroborating the results found by Sánchez et al. (2010) and Lempp et al. (2000), who also observed similar dry mass accumulation for silage between the maize-soybean intercropping and the cultivation of maize in monoculture.

It was observed that the hybrid P1630 produced a lower amount of MYS compared to the other materials, corroborating the results obtained by Paziani et al. (2009), who report differences in the biomass accumulation of different maize materials in different locations. This result may be related to the cycles of the evaluated hybrids, so that P1630, with the fastest cycle (super-early), remained for a shorter time in the field, hence having a shorter time for development, which resulted in less dry mass accumulation.

For SYS, it can be observed that the cultivar TMG7062 has higher values when compared to P95R51 among the treatments with the same maize material, and that this SYS, despite being reduced in some treatments, is sufficient to differentiate statistically from the treatments of monoculture maize. Lempp et al. (2000), evaluating the intercropping of maize and soybean for silage, also observed that there are differences in the dry mass accumulation between different cultivars.

In addition, there were large differences between the SYS values of the treatments with the hybrid P1630 and the SYS values of the treatments with LG6030 and P30F53. It is worth pointing out that, in the field, there was strong interference of end-of-cycle diseases on soybean, mainly *Phakopsora pachyrhizi*, which caused major defoliation in soybean materials at the end of the cycle in the treatments with the hybrids LG6030 and P30F53. In this context, it cannot be concluded whether the lower SYS found in treatments with LG6030 and P30F53 resulted from the higher MYS observed in these materials or from the occurrence of end-of-cycle diseases in these treatments, or also from the joint action of these two factors.

Soybean is the main crop hampered by competition in intercropped systems with maize (Tsujimoto et al., 2015). Zhang et al. (2015) found in their studies that the row arrangement used in the maize-soybean intercropping system interferes with the development of these crops. According to Liu et al. (2017), there is a reduction in the photosynthetic radiation intercepted by soybean crop in the intercropping system

with maize, which contributes to a significant reduction in soybean dry mass. These researchers evaluated different row arrangements in maize-soybean intercropping and observed that, when the row spacing is smaller than 100 cm, there is a reduction in soybean dry mass accumulation. In this context, it is assumed that soybean was hampered by the competition with maize crop in the present study, because the row arrangement used was smaller than the arrangements evaluated by Liu et al. (2017).

Tsujimoto et al. (2015) highlight that, in order to obtain positive results in the intercropping of maize and soybean for silage, it is necessary to combine the dry mass accumulation with the nitrogen contents present in the organs of the plants. Soybean harvesting for silage should be performed between the stages R5 and R7, because the greatest increase in crude protein of the silage is observed in this period (Keplin, 2004). On this subject, it is worth mentioning that at the time of maize ensilage, soybean cultivars were in the stage R5.3 to R7, which is positive in terms of silage quality.

For TYS, it can be observed that its values changed between treatments as a function of maize hybrid and, although there were variations in SYS amounts among the cultivars evaluated, these values did not have potential to statistically change the values of TYS. Thus, it is possible to assume that the maize-soybean intercropping does not increase or reduce the dry mass yield for silage of a plantation. Similar results were observed in other studies involving the intercropping of maize and soybean (Martin et al., 1998; Sánchez et al., 2010) and soybean and sorghum (Rezende et al., 2001).

As for silage composition, it was possible to observe a relationship between SYS and PSMS values, and the treatments with higher values of SYS resulted in higher PSMS. According to Stella et al. (2016), it is important to know the percentage of soybean mass to be used in the ensilage, as it increases crude protein content. This was also observed in the present study, as higher amounts of CPS were found in treatments that received higher SYS, corroborating other scientific investigations that indicated an increase in crude protein contents of the silage with the addition of soybean plants (Tsujimoto et al., 2015; Sánchez et al., 2010; Lempp et al., 2000).

The positive effects of soybean addition on maize silage are confirmed with CPYA values found in the present study. It was observed that the treatments P1630+TMG7062 and P1630+P95R51, which had produced a lower amount of MYS, but with higher amounts of SYS, showed similar CPYA values to those of the other treatments evaluated. The increase in crude protein promoted by soybean is evident when comparing the treatment P1630+TMG7062, which led to MYS of 16,353 kg ha^{-1} and SYS of 1,886 kg ha^{-1}, resulting in TYS of 18,239 kg ha^{-1}, with the treatment P30F53, which had MYS and PMT of 22,196 kg ha^{-1}, but these treatments showed similar values of CPYA, 1,622 kg ha^{-1} (P1630+TMG7062) and 1,675 kg ha^{-1} (P30F53). In other words, the addition of 1,886

kg ha^{-1} of soybean dry mass supplied the 5,843 kg ha^{-1} of dry mass produced less in the treatment P1630+TMG7062 compared to the treatment P30F53.

However, no statistical effect of soybean addition was observed in treatments composed of the hybrids LG6030 and P30F53 compared to the monoculture cultivation of these materials. This fact may be related to the lower values of SYS and higher values of MYS observed in these treatments, which resulted in low PSMS and consequently similar CPYA values.

The results found in the literature associated with the data of the present study show the potential that the maize-soybean intercropping system can represent for the yield of silage with higher crude protein contents. Despite these pieces of evidence, new field investigations evaluating arrangements of plants, cultivars and hybrids, and cycles of the materials, need to be conducted in order to understand the system and enable the cultivation technique, so that it can be carried out by rural producers.

As for the grain yield components of the maize crop, it was observed that FMP was similar between the treatments evaluated, averaging 60,614 plants ha^{-1} (Table 3). NGR was statistically different between the treatments evaluated, and those composed of the hybrid P1630 had higher values of NGR compared to the other materials, but there are no differences between treatments for NGRE. Data analysis

Table 3. Grain yield components of maize intercropped with soybean. UTFPR, Dois Vizinhos-PR, Brasil (2019)

Treatment	FMP	NGRE	NGR	TGW	GY
P1630+TMG7062	59,428.57 a	18.90 a	39.00 a	303.43 c	13,477.90 b
P1630+P95R51	61,074.16 a	19.30 a	39.10 a	304.08 c	14,366.65 a
P1630	59,821.42 a	18.85 a	40.05 a	312.80 c	14,232.23 a
LG6030+TMG7062	61,500.00 a	15.40 b	41.40 a	337.07 b	13,078.71 b
LG6030+P95R51	59,226.19 a	15.40 b	41.60 a	336.16 b	12,866.02 b
LG6030	60,785.71 a	15.60 b	42.15 a	333.16 b	13,305.73 b
P30F53+TMG7062	61,583.33 a	15.70 b	39.05 a	371.27 a	15,085.15 a
P30F53+P95R51	60,714.28 a	15.50 b	39.95 a	367.35 a	14,687.32 a
P30F53	61,392.85 a	16.00 b	40.65 a	356.95 a	14,511.30 a
Mean	60,614.06	16.74	40.33	335.81	13,956.78
P	0.1765	0.0000	0.1996	0.0000	0.0001
CV (%)	5.37	2.53	4.80	2.89	4.54

p≤0.05 - significant at 5% probability level. Means followed by different letters in the column differ statistically by the Scott-Knott test at 5% probability level. FMP=final maize population (plants ha^{-1}), NGR=number of grains per row, NGRE=number of grain rows per ear, TGW= thousand-grain weight (g), GY=grain yield (kg ha^{-1}).

divided the treatments evaluated into three groups for TGW, formed as a function of the maize hybrid used, with the highest values for the hybrid P30F53, followed by LG6030 and P1630, respectively. Maize GY was different between the treatments studied. It was observed that the use of hybrids P30F53 and P1630 resulted in higher GY, except when using P1630+TMG7062, which had GY of 13,477 kg ha^{-1} and was part of the group composed of the treatments with the hybrid LG6030, with lower GY values (Table 3).

The final plant stand is one of the main components of maize yield and, according to Vian et al. (2016), the obtaining of high grain yield in maize plantations is directly conditioned on the final plant population. The non-statistical differentiation for FMP, associated with the low coefficient of variation (CV) of this variable (5.37%), suggests that the OUs showed homogeneity among themselves in a comparison of treatments in intercropping with the treatment in maize monoculture. These results indicate that there was no competition between the crops in the intercropped treatments, to the point of interfering in the population of maize plants.

There are no recent studies on maize grain yield in maize-soybean intercropping system, but Alvarenga et al. (1998) report similar maize grain yields in the intercropping system with soybean and in monoculture. Paz et al. (2017) evaluated the cultivation maize as sole crop and intercropped with other legumes (*Canavalia ensiformis* L., *Crotalaria juncea* L., *Stylozobium aterrimum* L., *Cajanus cajan* L. and *Vigna unguiculata* L.) and

concluded that the intercropping system did not affect the production performance of maize.

Similar results were observed in the present study, as identical values were found for NGR, NGRE and TGW between intercropped treatments and maize monoculture for the respective hybrids. The statistical difference between the NGR and TGW of maize is related to the hybrid used and not to the cropping system, corroborating studies that indicate differences in the number of grains per row (Batista et al., 2018; Araújo et al., 2017) and 1000-grain weight (Araújo et al., 2017; Vilela et al., 2012) between different maize materials.

In addition, Araújo et al. (2017), Vilela et al. (2012) and Batista et al. (2018) concluded that maize grain yield varies according to the material planted, agreeing with the results of the present study, in which the division of treatments was basically performed as a function of the maize hybrid and not the cropping system (monoculture or intercropping).

However, it was observed that the treatment P1630+TMG7062 had lower GY (approximately 820 kg ha^{-1}) compared to the other treatments composed of the hybrid P1630. This result may be related to the higher dry mass accumulation of soybean observed in this treatment. Thus, it is assumed that the superior development of the legume crop results in competition with maize and, consequently, in reduced yield in this cereal. In this context, it can be inferred that, depending on the hybrid and on the cultivar used in the maize-soybean intercropping, there may be a

negative interference on the yield of the cereal, but further investigations are needed to confirm or reject this hypothesis.

It is worth pointing out that in the treatment P1630+TMG7062, there was production of 1,886 kg ha^{-1} of soybean dry mass, biomass that will serve as cover for the soil, which can contribute with the increase in organic matter content, improve chemical and physical components, and also result in benefit due to the potential for biological nitrogen fixation. Zhang et al. (2015) described in their studies that, in the comparison of the conventional maize cropping system (monoculture) with the maize-soybean intercropping system, the latter had significant advantages in yield performance, economic performance, land utilization ratio, besides reducing nitrate accumulation in the soil and improving the residual effect for the subsequent wheat crop. However, it is necessary to conduct further studies evaluating the potential use of soybean as a cover plant in agricultural production systems.

Conclusions

For the conditions under which the present study was conducted, it was possible to conclude that:

The use of the hybrids LG6030 and/or P30F53 results in higher accumulation of dry mass for silage, and cultivar TMG7062 stands out for being superior to cultivar P95R51 in terms of dry biomass yield.

Some yield components (number of grains per row and thousand-grain weight) and grain yield of maize differ according to the hybrid used, but there is similarity between intercropping and monoculture cultivation.

There is evidence that the soybean cultivar TMG7062 intercropped with maize (P1630) has the potential to reduce the grain yield of this cereal.

Acknowledgments

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