10.18605/2175-7275/cereus.v16n1p35-47

ARTIGO ORIGINAL

<< Recebido em: 04/10/2023 Aceito em: 07/01/2024. >>

REVISTA CEREUS

ISSN: 2175-7275

Intercropping with legumes and detasseling of maize aiming at production of organic baby corn

Consórcio com leguminosas e despendoamento de milho visando produção de minimilho orgânico

Vanessa Pereira de Jesus[1], Fábio Cunha Coelho*[2], Silvio de Jesus Freitas[2]

[1] D.Sc. Produção Vegetal e Escola Técnica Agrícola Estadual Antônio Sarlo - FAETEC. https://orcid.org/0000-0001-5726-1680

[2] D.Sc. Fitotecnia. Universidade Estadual do Norte Fluminense Darcy Ribeiro – UENF. https://orcid.org/0000-0002-7037-8864

E-mail: *fabiocoelhouenf@gmail.com. UENF. Av. Alberto Lamego, 2000, Parque Califórnia, Campos dos Goytacazes, RJ. 28013-602

[3] D.Sc. Produção Vegetal. Universidade Estadual do Norte Fluminense Darcy Ribeiro – UENF. https://orcid.org/0000-0001-5064-9674

RESUMO

O objetivo deste trabalho foi avaliar o consórcio com leguminosas e o despendoamento na produção de minimilho. Dois experimentos de campo foram realizados em Campos dos Goytacazes, RJ. Um experimento foi com milho pipoca e outro com milho doce. Ambos experimentos foram conduzidos com sete manejos: M1: milho com pendão + feijão de porco (*Canavalia ensiformis* L.); M2: milho com pendão + mucuna-preta (*Stizolobium aterrimum*); M3: milho com pendão + crotalária (*Crotalaria juncea*); M4: milho sem pendão e com capina; M5: milho sem pendão e sem capina; M6: milho com pendão e com capina; M7: milho com pendão e sem capina. O milho pipoca apresentou teor de N nas folhas 46% maior que o milho doce. O milho pipoca apresentou 30% mais espigas por planta do que o milho doce. O cultivo consorciado com leguminosas resultou, em média, em queda de 28% na produtividade das espigas comerciais de minimilho. A retirada do pendão resultou em aumento de 55% no número total de espigas no milho pipoca que não foi capinado. Para ambas as cultivares, os maiores pesos comerciais de espiga foram obtidos nos monocultivos do milho despendoado com capina, despendoado sem capina, e no milho com pendão com capina.

Palavras-chave: *Zea mays*, agricultura orgânica, agroecologia

ABSTRACT

The purpose of this study was to evaluate the effects of intercropping with legumes and the detasseling to produce baby corn. Two field experiments were implemented in Campos dos Goytacazes, RJ, Brazil. One experiment was with popcorn kernel and the other with sweet corn. Both experiments were conducted with seven managements: M1: maize with tassel + jack bean (*Canavalia ensiformis* L.); M2: maize with tassel + velvet bean (*Stizolobium aterrimum*); M3: maize with tassel + crotalaria (*Crotalaria juncea*); M4: maize without tassel and with weeding; M5: maize without tassel and without weeding; M6: maize with tassel and with weeding; M7: maize with tassel and without weeding. Popcorn kernel had 46% higher N content in the leaves than sweet corn. Popcorn kernel had 30% more cobs per plant than sweet corn. Intercropping with legumes resulted in a decrease of 28% in the productivity of commercial cobs of baby corn. The removal of the tassel resulted in an increase of 55% in the total number of cobs for popcorn kernel that was not weeded. For both cultivars, the highest commercial cob weights were obtained in maize without tassel and with weeding, without tassel and without weeding, and with tassel and with weeding.

Keywords: *Zea mays*, organic agriculture, agroecology

1. INTRODUÇÃO

Baby corn is the name given to the female inflorescence of maize (Zea mays L.), before pollination. To put it more simply, it is the developing maize cob. Thus, baby corn comes from the cultivation of maize with a high plant population. This is harvested two to three days after the issue of the styles-stigmas. It can be considered a vegetable, due to the time spent from sowing to harvesting (COSTA et al., 2020). In the summer months, it is harvested with up to 45 days, which is achieved depending on the precocity of the cultivar used. In winter, even with early cultivars, the interval between sowing and harvesting is prolonged, reaching up to 70 days (PEREIRA FILHO; CRUZ, 2001). Thus, the baby corn culture allows several cultivation cycles per year, provided that there is irrigation in times of water deficiency. Its organic cultivation is quite interesting, mainly because it is a consumed product in nature with a short period between harvest and consumption (SILVA et al., 2020).

This culture has been increasing in importance among small producers, especially those who use family labor. In addition to allowing the commercialization of baby corn, the straws, the leaves, and the styles-stigmas for animal feed can also be used because they are rich in nutrients, especially protein (ARAÚJO et al., 2010; PEREIRA FILHO; QUEIROZ, 2008).

Several cultivars of maize for the production of baby corn have been evaluated in order to identify those most adapted to tropical conditions. Selected cultivars of sweet corn and popcorn kernel germplasm and prolific cultivars of normal maize have been used for the production of baby corn. In addition, research has been done on the effect of detasseling on the type of cultivar used in the production of baby corn since there are different responses among these (PEREIRA FILHO et al., 1998; SANTOS et al., 2020).

One of the agricultural practices aimed at increasing the productivity of cobs is detasseling, that is, removing the tassel or male inflorescence to stimulate the faster development of cobs. This is due to the breakdown of apical dominance, where the male inflorescence is located, which is a large energy consumer. Removing the tassel stimulates shoots of lateral buds, giving rise to new female inflorescence, which can be harvested as baby corn (AEKATASANAWAN; HALLAUER, 2001).

The intercropping of maize with fabaceous considered green fertilizers can decrease the incidence of spontaneous plants due to the high production of phytomass and the allelopathic effect both during vegetative growth and during the decomposition process by interspecific inhibition on other species (ARAÚJO et al., 2007). Thus, the greater the amount of vegetable mass available, the longer the time in which the crop will remain without interference, and it can, perhaps, delay the control of spontaneous plants or even, depending on the amount of vegetable mass, suppress them. However, the interactions that occur in the agricultural ecosystem are very specific and dynamic, depending on the quantity and quality of the plant mass, mainly the weed species that may be favored or not by the vegetation cover (SILVA et al., 2008).

Weeding is laborious and expensive; however, although efficient in the control of spontaneous plants, the application of herbicides can cause environmental damage and contribute to the selection of weed biotypes resistant to them. In this context, intercropping can provide better use of production resources and reduce management for maize weed control (ARAÚJO et al., 2012).

The hypothesis of this study was that intercropping with legumes does not decrease the productivity of baby corn and that weeding and detasseling result in gains in the productivity of baby corn. This study aimed to evaluate the effects of intercropping with legumes, weeding, and the detasseling of maize plants on the productivity of cobs harvested as baby corn, produced from popcorn kernel and sweet corn under organic cultivation.

2. MATERIAL AND METHODS

Two experiments were implemented with the cultivation of maize, aiming at the production of baby corn under organic management, in the municipality of Campos dos Goytacazes, RJ, Brazil (21º19'S, 41°19'W). The soil of the experimental area was classified as Fluvic Neosol with a pH in water of 6.1; 63 mg dm^{-3} of P; 158; 4,3; 1,9; 0,0; 2,6; and 0,06 cmolc dm^{-3} of K, Ca, Mg, Al, H+Al and Na, respectively; 1.37% of C; and 23.6 g dm^{-3} of organic matter in the layer from 0 to 20 cm deep. The soil in the experimental area had been in an organic production system for 20 years. The experimental area contained in its vegetation the predominance of the following species: *Alternanthera tenella* Glue, *Bidens pilosa* L., *Cyperus rotundus* L., *Boerhavia diffused* L., *Sorghum arundinaceum* Desv. Stapf., and *Portulaca oleracea* L.

In one of the experiments, the popcorn kernel type was used, and in the other, the sweet type. The variety of popcorn kernel 'UENF 14' and the simple hybrid 'Super Sweet corn' (Hawaii type) were used as cultivars. The two experiments were conducted in the field, containing seven managements: M1: maize with tassel + jack bean (*Canavalia ensiformis* L.); M2: maize with tassel + velvet bean (*Stizolobium aterrimum*); M3: maize with tassel + crotalaria (*Crotalaria juncea*); M4: maize without tassel and with weeding; M5: maize without tassel and without weeding; M6: maize with tassel and with weeding; M7: maize with tassel and without weeding. The design used was entirely randomized, with four repetitions. This design was used because the experimental area was very homogeneous.

Each experimental unit (E.U.) consisted of four rows of maize 6 m long, spaced 0.80 m apart. Thus, the area of each E.U. was 19.2 m^2. The useful area of each U.E. corresponded to the two central lines, discarding 0.50 m from their ends.

In the sowing of maize, twenty seeds per linear meter were used. In the intercropping, the fabaceous were sown among the rows of maize in rows arranged in the center of each row. For velvet bean and jack beans, six seeds per linear meter were used, while for crotalaria 20 seeds per linear meter were used. The seeds were deposited in the grooves and covered with soil, remaining at a depth of approximately 5.0 cm. The maize and fabaceous were sown on the same day. The emergence of maize plants occurred seven and 15 days after sowing for popcorn kernel and sweet corn, respectively. Before sowing, one plow and two gradations were carried out.

Immediately after the first harvest, the tassel was removed from the management that contained its treatment. The weeding was performed manually with a hoe at 35 days after emergence (DAE) only in the E.U. with weeding treatments.

Fertilizing was carried out on the maize lines two days before sowing, using approximately 1.2 L of bovine manure per meter of groove. Cover fertilization was also performed with the same amount of manure when the maize plants presented eight completely expanded leaves.

For *Spodoptera frugiperda* management, sprays were performed with nim extract (*Azadirachta indica*).

The first harvest of the baby corn was carried out at 60 and 83 days after emergency for popcorn kernel and sweet corn, respectively, three days after the issue of the style-stigmas. Two weekly harvests were carried out, approximately every three or four days, for a period of five weeks, totaling nine baby corn harvests. After each harvest, the cobs were placed in a cold chamber at temperatures ranging from 5 to 12 °C until the time of the determinations.

The organic N content (NIT) in the maize leaves, the number of total cobs (NET), the number of commercial cobs (NEC), the weight of total cobs (PET), the weight of commercial cobs (PEC), the final stand (EST) and the number of cobs per plant (NEP) were performed in all experimental units of the two cultivars.

For the determination of N-organic levels, the opposite leaf and below the first emitted cob (60 and 83 DAE of popcorn kernel and sweet corn, respectively) was taken from 10 plants randomly sampled in the useful area of each E.U. The material was subjected to drying in a greenhouse with forced air circulation at a temperature of 75°C for 72 hours, then to milling in a Willey type of mill and to homogenization. The dry matter was heavy, and a 100 mg sample of the leaves was used for determination. Sulfuric digestion was performed (LINDER, 1944), followed by colorimetric evaluation using the Nessler reagent for the determination of N-organic (JACKSON, 1965).

All the cobs in each useful area were peeled, counted (NET), and weighed (PET). Those that fit the commercial pattern: diameter between 1.0 and 1.8 cm and length between 4.0 and 12 cm (PEREIRA FILHO; CRUZ, 2001), were selected, counted (NEC), and weighted (PEC). At the time of the first harvest, the plants in each useful area were counted, obtaining the final stand (EST). To obtain the number of cobs per plant (NEP), the NET was divided by the EST.

The results of each experiment were submitted to the analysis of variance by the F test and subsequently to the joint analysis of experiments. In the case of significant results ($p \leq 0.05$), the data were submitted to the Tukey test at 5% probability. Statistical analyses were performed with the help of the SAEG computational application (system for statistical and genetic analysis) (GOMES et al., 1990).

3. RESULTS AND DISCUSSION

Organic nitrogen levels in maize leaves in all managements were below the critical level of 30 g kg^{-1} (MALAVOLTA, 1997). However, the M6 (maize with tassel and weeding) was the one that presented foliar N content closer to the critical level, while the other managements presented N content of approximately 50% of the recommended level as critical for the culture (Figure 1).

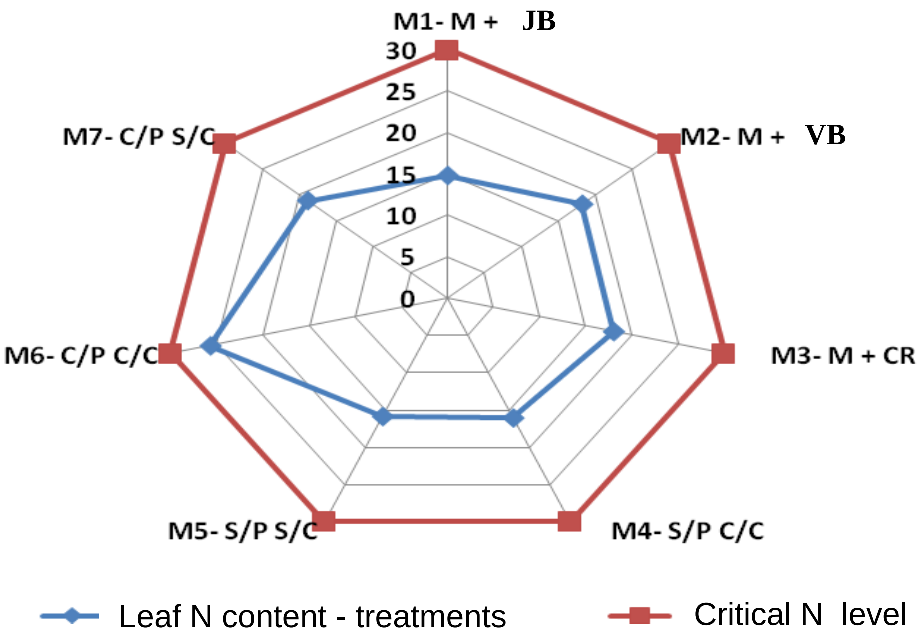

Figure 1. Average N content (g kg^{-1}) in maize leaves, of popcorn kernel and sweet corn cultivars, grown under different managements. M1: maize + jack bean; M2: maize + velvet bean; M3: maize + crotalaria; M4: maize without tassel and with weeding; M5: maize without tassel and without weeding; M6: maize with tassel and with weeding; M7: maize with tassel and without weeding.

Certainly, the intercropped legumes did not provide N for the nutrition of maize plants. This is possibly due to the fact that the cycle of maize for the production of small grains is shorter than that of maize for grain. In addition, this result was expected since, generally, simultaneous cultivation of maize for the production of baby corn with legumes for green fertilization does not result in gains in the contribution of N in the first year of cultivation. However, the new data presented in this study shows that intercropping with the legumes: jack beans, crotalaria, and velvet bean, when intercropped for the production of baby corn, does not result in competition for N. The competition for N was expected; therefore, the intraspecific competition in maize for the production of small grain tends to be greater since the population of plants in the production of small grain is four times greater than the populations used in the production of grain. Since there was no reduction in the N content in maize leaves due to the intercropping with legumes (Figure 1), it is indicative that these intercrops can be used as a facilitating element for the insertion of legumes from green fertilizers in production systems, as also observed by Cordeiro et al. (2016).

Jesus (2009), in an experiment carried out to evaluate the production of baby corn, verified an average leaf content of 15.8 g kg-1 of N in maize leaves intercropped with fabaceous, with no significant differences occurring between them. On the other hand, Dias and Souto (2005), in an experiment in which they evaluated the effects on the productivity of maize grain, found that the phytomass of maize plants intercropped with crotalaria and velvet bean presented a higher N content than that of maize in monoculture, demonstrating a strong contribution of biological N fixation in fabaceous. In this last report, sampling was performed 105 days after sowing, and the population density of maize was six plants per meter of the sowing line. Thus, in Dias and Souto (2005), maize plants were intercropped with legumes for a longer period, and there was a smaller population of maize plants compared to the experiments for the production of baby corn carried out in this work.

There was a significant difference only among cultivars ($p > 0.05$) for the number of cobs per plant (NEP) and for the final stand (EST), with no significant effect ($p < 0.05$) of the different managements (Table 1).

Table 1. Final stand (EST) and number of spikes of baby corn per plant (NEP) for popcorn kernel and sweet corn considering different management

Management*	**Final stand (EST) (x 1,000 ha^{-1})**			**Cobs per plant (NEP)**		
	Popcorn kernel	**Sweet corn**	**Average**	**Popcorn kernel**	**Sweet corn**	**Average**
M1- M + JB	119.68	120.93	120.31 **A**	1.5	0.8	1.1 **A**
M2- M + VB	195.00	130.62	162.81 **A**	0.6	0.9	0.7 **A**
M3- M + CR	160.00	110.93	135.46 **A**	0.8	0.8	0.8 **A**
M4- S/P C/C	138.75	115.00	126.87 **A**	1.4	1.1	1.2 **A**
M5- S/P S/C	134.06	101.56	117.81 **A**	1.8	1.1	1.5 **A**
M6- C/P C/C	151.25	105.31	128.28 **A**	1.4	1.1	1.2 **A**
M7- C/P S/C	132.81	130.62	131.71 **A**	1.4	1.0	1.2 **A**
Average	147.36 **a**	116.42 **b**		1.3 **a**	1.0 **b**	
C.V %	37.2			50.2		

The averages followed by the same uppercase letters in the column and lowercase letters in the row do not differ from each other by the Tukey test or F at 5% probability, respectively. * M1: maize + jack bean; M2: maize + velvet bean; M3: maize + crotalaria; M4: maize without tassel and with weeding; M5: maize without tassel and without weeding; M6: maize with tassel and with weeding; M7: maize with tassel and without weeding

Popcorn kernel had 30% and 26.2% more cobs per plant and final stand than sweet corn, respectively (Table 1). The management methods did not affect the number of cobs per plant, and neither did the stand, which indicates that weeding, detasseling and intercropping had no significant effect on these variables. Bastiani et al. (2012) found that differences between management methods only occur for these variables when high doses of N are added to fertilization. Thus, in general, there was no increase in the foliar content of N due to management (Figure 1), and there was also no response on the NEP or EST (Table 1). Jesus (2009) also found no effect of weeding, intercropping with legumes, or detasseling on the NEP; however, they found higher EST for the managements without weeding.

Regarding the number of total cobs (NET), there was a significant effect ($p > 0.05$) on the interaction of the management with the cultivars (Table 2). For popcorn kernel, the managements M4 (without tassel and with weeding), M5 (without tassel and without weeding), and M6 (with tassel and with weeding) had the highest averages. Only the M5 differed from the others, indicating that the withdrawal of the tassel is highly favorable to increasing the NET in popcorn kernels (UENF 14). When comparing the maize without weeding (M5 and M7), it is verified that the removal of the tassel resulted in an increase of 55% in the NET for popcorn kernel (Table 2).

Table 2. Number of total cobs (NET) and number of small commercial cobs (NEC) per hectare of popcorn kernel and sweet corn, considering different management

Management*	NET (x 1,000 ha^{-1})			NEC (x 1,000 ha^{-1})		
	Popcorn kernel	Sweet corn	Average	Popcorn kernel	Sweet corn	Average
M1- M + JB	140.62 **B**	93.12 **A**	116.87	65.00 **B**	57.50 **A**	61.25
M2- M + VB	114.68 **B**	110.00 **A**	112.34	66.87 **B**	51.87 **A**	59.37
M3- M + CR	123.12 **B**	73.75 **A**	98.75	70.00 **B**	45.93 **A**	57.96
M4- S/P C/C	160.93 **AB**	121.56 **A**	141.25	97.50 **AB**	72.50 **A**	85.00
M5- S/P S/C	212.18 **A**	105.31 **A**	158.75	126.87 **A**	57.18 **A**	92.03
M6- C/P C/C	157.18 **AB**	107.81 **A**	132.50	88.12 **B**	63.43 **A**	75.78
M7- C/P S/C	136.87 **B**	116.87 **A**	126.87	72.81 **B**	69.06 **A**	70.93
Average	149.37	104.15		88.3	59.6	
C.V %	20.1			20.7		

The averages followed by the same uppercase letters in the same column do not differ from each other by the Tukey test or F at 5% probability, respectively. ***** M1: maize + jack bean; M2: maize + velvet bean; M3: maize + crotalaria; M4: maize without tassel and with weeding; M5: maize without tassel and without weeding; M6: maize with tassel and with weeding; M7: maize with tassel and without weeding.

Aekatasanawan and Halauer (2001) found that with the removal of the tassel, there is stimulation of shoots of lateral buds, giving rise to new female inflorescence, which can be harvested as baby corn. Jesus (2009) also obtained similar results in relation to the NET, with emphasis on the treatment without tassel and without weeding, concluding that the removal of the tassel can be efficient in increasing the total number of cobs of baby corn. On the other hand, the same was not verified for sweet corn (Table 2), because for this cultivar there was no effect of the management on the NET.

Popcorn kernel presented the best net averages in the M1, M3, M4, M5, and M6 management (Table 2). Carvalho et al. (2003) also observed a significant effect of the interaction of maize detasseling x cultivars. The authors found that of the eight cultivars evaluated, only three obtained an increase in the number of cobs after detasseling.

In relation to NEC, there was a significant effect ($p < 0.05$) of cultivar and management interaction (Table 2). For popcorn kernel, the treatment M5 (without tassel and without weeding) was highlighted, followed by M4 (without tassel and with weeding). When comparing the managements M5 and M7 (Table 3), it is verified that the withdrawal of the tassel in the popcorn kernel not weeding resulted in an increase of 74% in the number of commercial cobs. The increase in the number of commercial cobs in the popcorn kernel is of great importance, as it is one of the most important variables to consider for the canned trade.

For sweet corn, there was no significant effect of the withdrawal of the tassel, indicating that cultivating super sweet corn (Hawaii type) does not respond with increased NEC when removing the tassel (Table 3). On the other hand, popcorn kernels presented a higher NEC than sweet corn in M3, M4, M5, and M6 (Table 2).

Pereira Filho et al. (2009), evaluating cultivars in the presence or absence of the tassel for the production of baby corn, verified that the range of responses in relation to productivity is related to cultivar, with some responses having a higher percentage yield due to the removal of the tassel, while for others there is no influence and may only burden the cost of crop production.

The weight of total cobs (PET) did not have a significant effect ($p < 0.05$) on maize managements or cultivars, resulting in an average of 966.0 kg ha-1 (Table 3). While the weight of commercial spikes (PEC), on average, presented a significant difference in each of the managements ($p > 0.05$) (Table 3). The highest averages of the two cultivars were M4, M5, and M6, respectively, maize without tassel and with weeding (S/P C/C); without tassel and without weeding (S/P S/C); and with tassel and with weeding (C/P C/C). Then, the M7 (with tassel and without weeding) was similar to both the other maize monocultures and the intercropping with jack bean. The management methods that presented lower values were intercropping with velvet beans and crotalaria (Table 3).

On the basis that the usual management is the M6-C/P C/C and that this management resulted in a PEC similar to the M4-S/P S/C, it is advised to remove the tassel and not carry out the weeding, since the removal of the tassel requires less labor than weeding. On the other hand, the management with tassels and without weeding (M7-C/P

S/C), although it did not differ significantly ($p < 0.05$) from the other monoculture management, was the one that presented the lowest absolute value in this group, reaching no significant difference ($p < 0.05$) from the intercrop management, which decreased the PEC in relation to the maize monoculture. Thus, not weeding the maize and leaving the tassel can result in a decrease in the PEC.

Table 3. Weight of total cobs (PET) and weight of commercial cobs (PEC) per hectare for popcorn kernel and sweet corn, considering different management

Management*	PET (kg ha^{-1})			PEC (kg ha^{-1})		
	Popcorn kernel	**Sweet corn**	**Average**	**Popcorn kernel**	**Sweet corn**	**Average**
M1- M + JB	1050.3	864.0	957.2 **A**	387.5	334.3	360.9 **BC**
M2- M+ VB	670.0	1173.6	921.8 **A**	365.5	321.9	343.7 **C**
M3- M + CR	723.7	607.3	665.5 **A**	400.0	252.3	326.1 **C**
M4- S/P C/C	937.1	1182.6	1059.8 **A**	553.1	402.8	478.0 **A**
M5- S/P S/C	1254.3	962.6	1108.5 **A**	641.9	321.4	481.6 **A**
M6- C/P C/C	1175.2	938.9	1057.1 **A**	576.1	381.5	478.8 **A**
M7- C/P S/C	994.0	989.8	991.9 **A**	449.9	381.2	415.6 **AB**
Average	972.1 **a**	959.8 **a**		482.0 **a**	342.2 **a**	
C.V %	24.9			31.5		

The averages followed by the same uppercase letters in the column and lowercase letters in the row do not differ from each other by the Tukey test or F at 5% probability, respectively. ***** M1: maize + jack bean; M2: maize + velvet bean; M3: maize + crotalaria;M4: maize without tassel and with weeding; M5: maize without tassel and without weeding; M6: maize with tassel and with weeding; M7: maize with tassel and without weeding.

Intercropping with legumes resulted, on average, in a decrease of 28% in the productivity of commercial cobs of baby corn when compared to maize monoculture (Table 3). The results indicate that detasseling positively affects the productivity of commercial cobs of the cultivars of both popcorn kernel and sweet corn evaluated, while intercropping with legumes is harmful.

Although there was no significant difference in PEC between maize with tassel and without weeding (M7) and the other monocultures (Table 3), this treatment was similar to the intercropping with jack bean, which differed significantly from M4, M5, and M7. Thus, it is inferred that the removal of the maize tassel, by providing the plant with less expenditure on photo assimilate for the maintenance of the tassel, provides the maize plant with greater competitive capacity in relation to weeds and weeding may not be carried out under these conditions. On the other hand, the intercrop of tassel maize with legumes, aimed at the production of baby corn, results in a low PEC. This is possibly due to interspecific competition among plants. It should be considered that the effect of these intercrops with tassel-free maize plants should be investigated.

These results differ from those of Jesus (2009), who, when analyzing the PEC in management with intercrops and without the tassel, verified that there was no difference between the management methods; however, in relation to the PET, the results were similar. Bastiani et al. (2012) also found that weeding did not affect the PEC, as did Eklund (2010), who evaluated the productivity of the baby corn on the legume straw in direct planting and verified that the total number of cobs showed the effect of the management, while the weight, diameter, and length of the cobs were not significantly affected.

5. CONCLUSIONS

Intercropping with legumes resulted, on average, in a decrease of 28% in the productivity of commercial cobs of baby corn when compared to maize monoculture.

The removal of the tassel resulted in an increase of 55% in the number of total cobs for popcorn kernel that was not weeded.

For both cultivars, the highest commercial cob weights were obtained in maize without tassel and with weeding, without tassel and without weeding, and with tassel and with weeding.

The detasseling positively affected the baby corn productivity of commercial cobs of popcorn kernel and sweet corn cultivars evaluated.

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