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Induced Defoliation and Corn Productivity Performance

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Abstract

Due to the change in the environment, diseases and insects can reduce the leaf area of agricultural crops. The objective of this study was to determine the impact of induced defoliation on the vegetative and reproductive phases of corn on its agronomic characteristics. The experiment was carried out in the experimental area of the Mato Grosso Federal Institute of Education, Science and Technology, Campo Novo do Parecis campus, in a second crop system in the 2017/2018 agricultural year, with sowing in March. This study used a randomized complete block design, consisting of 24 treatments and three replications, comprising eight phenological stages. The treatments were performed from the fourth leaf stage (V4) to physiological maturation (R5), with defoliation in the lower, middle and upper thirds of the plant. The characteristics evaluated were: plant height, stem diameter, ears insertion height, ears length, ears diameter, ears weight, number of rows per ears, number of grains per row, weight of grain per ears, prolificity; harvest index, weight of one thousand grains and grain yield. Defoliation between the fourth (V4) and twelfth leaves (V12) does not interfere in the evaluated characteristics. Grain and ear weight are interfered when defoliation occurs in the middle and upper third of plants in V12. Defoliation between flowering (R1) and beginning of grain filling (R2) negatively affects the weight of one thousand grains, grain and ear weight, and may reduce grain yield by up to 30%. Defoliation in the upper third of the plant significantly reduces the diameter and length of ears, grain and corn ear of the corn crop.

Keywords: leaf area removal, photosynthesis, production components, *Zea mays* L.

1. Introduction

Corn (*Zea mays* L.) is an important commodity in global nutrition and its yield is dependent on the how a plant allocates the accumulated biomass between the corn grains and other plant parts. The plant's growth, represented by the accumulation of the dry matter depends on photosynthesis, is the process in which photosynthetically active radiation (light) is transformed into chemical energy (Karam et al., 2010).

Corn productive components are defined in the vegetative period, from V4 and V5 (fourth and fifth leaves developed, respectively), where the tassel and ears beginnings to be formed with the differentiation of all the leaves. At V5, the apical meristem develops below ground, which explains that at that stage, the plant can undergo some injury on the aerial part and recover with no significant damage to its production performance, since the number of grain rows per ears is defined at V8 (eighth developed leaf), while the number of grains per row until the V17 stage (Ritchie et al., 1993; Magalhães & Durães, 2006; Alvim et al., 2010). The real impact on yield caused by stress, whether water or caused by leaf area removal, affects the period from pre-flowering (VT) to grain filling (R2), according to the phenological scale of Ritchie et al. (1993) and Brito et al. (2011).

In corn production, management techniques aligned with the correct use of cultivation tools such as sowing planning, genetic improvement, biotechnology, tillage, plant nutrition, phytosanitary control and planned harvesting, are indispensable to the amount of solar radiation intercepted by the leaves. Without solar radiation, the production would be reduced, because corn is the species of agricultural importance that most expresses its productive potential due to the use of solar radiation (Strieder et al., 2007).

Altering the redistribution of photoassimilates in the plant results in the deficit in the source:sink ratios. These changes are caused by stresses and leaf injuries that result in the imbalance in leaf arrangement, microclimate, plant density and, mainly, leaf area. These losses are denominated defoliation, originated by biotic and abiotic factors. In this context, it is essential to detect tolerable defoliation levels in corn as it is a plant that has low compensation index, low prolificity and small leaf plasticity (Pereira et al., 2012).

Biotic defoliation in corn can be caused by pests, while abiotic defoliation can be due to the climate, such as excessive or severe rainfall, winds, frost and hail. Both factors strictly reduce the photosynthetically active leaf area (Torres et al., 2013), which can represent a serious crop damage, depending on which phase the corn plant is.

In the early growth stages, defoliation causes little or no reduction in crop yield (Ritchie et al., 1993; Magalhães & Durães, 2006); however, as the plant develops, there is a tendency to increase the severity over the mentioned productivity. Therefore, the simulation of damage caused on the leaf area is important to know the source:sink ratios studies, as well as the knowledge of the photoassimilates distribution in the corn plant (Alvim et al., 2010). In addition, studies with corn defoliation are observed at specific phenological stages, predominantly in the vegetative phases, V2 to V20 (Karam et al., 2010; Sangoi et at., 2014; Rezende et al., 2015; Santos et al., 2017), or reproductive stages, R1 to R3 (Alvim et al., 2010; 2011; Pereira et al., 2012; Uitzil et al., 2016; Trogello et al., 2017). The objective of this study was to determine the impact of induced defoliation on the vegetative and reproductive phases of corn on its agronomic characteristics evaluated.

2. Materials and Methods

The experiment was conducted in 2018 following a soybean (*Glycine max* L.) crop, in the experimental area at Mato Grosso Federal Institute of Education, Science and Technology, Campo Novo do Parecis Campus, on a dystrophic Red Latosol, according to the Brazilian Soil Classification System (Empresa Brasileira de Pesquisa Agropecuária [EMBRAPA], 2018). The area was located at the geographic coordinates 13°40′37″ South latitude and 57°47′30″ West longitude and at 574 m above sea level. The local climate, according to the Köppen classification, is Aw type, tropical climate with well-defined dry season, between May and September (Dallacort et al., 2011). The average maximum, mean and minimum temperatures over the experimental period were 29.4; 22.1 and 17.5 °C, respectively, as well as 416.8 mm rainfall (Figure 1), which partially met the water demand of the crop, which is between 450 and 800 mm, regularly distributed throughout its growth cycle (Bergamaschi & Matzenauer, 2014).

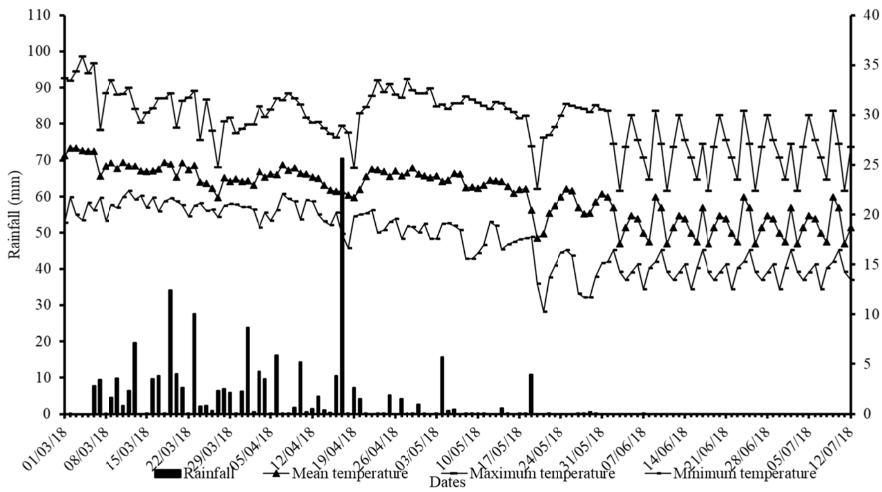

Figure 1. Rainfall and average temperatures over the experimental period, 2018

The experiment used a randomized complete block design with 24 treatments (Table 1) and three replicates based on the phenological scale of Ritchie et al. (1993).

Table 1. Description of the treatments based on phenological scale of Ritchie et al. (1993)

Control	T1	No defoliation
V4	T2	Defoliation of the two lower leaves
	T3	Defoliation of the two upper leaves
V8	T4	Defoliation of three leaves of the lower third
	T5	Defoliation of three leaves of the middle third
	T6	Defoliation of three leaves of the upper third
V12	T7	Defoliation of four leaves of the lower third
	T8	Defoliation of four leaves of the middle third
	T9	Defoliation of four leaves of the upper third
R1	T10	Defoliation of five leaves of the lower third
	T11	Defoliation of the five leaves of the middle third
	T12	Defoliation of the five leaves of the upper third
R2	T13	Defoliation of 1/3 of the leaves of the lower third
	T14	Defoliation of 1/3 of the leaves of the middle third
	T15	Defoliation of 1/3 of the leaves on upper third
R3	T16	Defoliation of 1/3 of the leaves of the lower third
	T17	Defoliation of 1/3 of the leaves of the middle third
	T18	Defoliation of 1/3 of the leaves of the upper third
R4	T19	Defoliation of 1/3 of the leaves of the lower third
	T20	Defoliation of 1/3 of the leaves of the middle third
	T21	Defoliation of 1/3 of the leaves of the upper third
R5	T22	Defoliation of 1/3 of the leaves on the lower third
	T23	Defoliation of 1/3 of the leaves on the middle third
	T24	Defoliation of 1/3 of the leaves of the upper third

Only photosynthetically active leaves were considered, discarding senescent leaves. The experimental plot consisted of seven rows 7 m long, 0.45 meters between rows. The sample area of the plot consisted of four rows (third to sixth row) for center 5 ms, eliminating one meter at each end of the research plot.

Following the soybean harvest (March 3, 2018), the area was sprayed with glyphosate (648 g L^{-1}) at a dose of 1.5 L ha^{-1} (commercial product—c.p.) to kill the existing vegetation. The area was than planted with the corn hybrid DKB 290 VT PRO3® at a rate of 2.8 seeds per meter (60,000 plants ha^{-1}) on March, 2018. The corn seed was planted with a seven-row planter.

Fertilization at planting was performed according to soil fertility analysis and crop requirements, 15, 60 and 40 kg ha^{-1} of N, P_2O_5 and K_2O, respectively. In the first topdressing fertilization (V4), 300 kg ha^{-1} of 20-00-20 ($N-P_2O_5-K_2O$) was applied, followed by 100 kg ha^{-1} application (20-00-20) for the second topdressing fertilization (V8) for a projected grain yield of 8 t ha^{-1} (Souza & Lobato, 2004).

After corn emergence, insect monitoring was performed and a moderate infestation of stink bug (*Nezara viridula*) was found, and was controlled with tiametoxan (250 g kg^{-1}) at a dose of 250 mL ha^{-1}. At the V4 stage, with the objective of controlling *Nezara viridula* and *Diabrotica speciosa*, the insecticides bifenthrin (50 g L^{-1}) and carbosulfan (150 g L^{-1}) was applied at the dose of 0.5 L^{-1}, and thiametoxan (250 g kg^{-1}) was applied at a dose of 250 mL ha^{-1}. At V10, triflumuron (480 g kg^{-1}) at a dose of 100 mL ha^{-1} was applied to control *Spodoptera frugiperda*.To control the diseases *Helminthosporium turcicum* and *Cercospora zeae-maydis*, epoxiconazole (50 g L^{-1}) and piraclostrobin (133 g L^{-1}) at 0.5 L^{-1} were applied at V8, and metconazole (80 g kg^{-1}) at the dose of 650 mL ha^{-1} was applied at V10. For weed control, glyphosate (648 g L^{-1}) was applied (of product per ha) at V2 at a dose of 1.5 L ha^{-1} and atrazine (500 g L^{-1}) at a dose of 0.5 L ha^{-1} in V4, with application volume (water + product) of 80 L ha^{-1}, with 60 lbs of pressure.

The vegetative characteristics evaluated in R2 included plant height (PLH, m), which was the distance from the ground level to the top of the tassel and the stem diameter (SD, mm), measured with a digital caliper at 5 cm from the ground level. These measurements were collected from ten plants from the research plot.

The production characteristics were measured on five plants/ears at physiological maturity (R6) were ears insertion height (EIH, m), which is the distance between soil level and first ears node insertion; ears length (EL, cm); ears diameter (ED, mm), obtained with digital caliper in its middle third; ears weight (EW, g), with the aid of a digital scale; number of rows per ears (NRE); number of grains per row (NGR); weight of grain per ears (WGE, g); prolificity in 10 plants per plot (PRL); harvest index (HI), obtained by the ratio of the threshed and non- threshed ears weight; weight of one thousand grains (WTG, g), with moisture correction to 13% (wet basis), as well as to estimate grain yield (GY, kg ha^{-1}) based on the entire plot useful area. The manual harvest was performed on December 7, 2018, where all the ears contained in the useful area of the plot were collected.

Once the assumptions of homogeneity and constant variance of the residues are met by the Levene test, data were submitted to analysis of variance and, when significant F ($p < 0.05$), it was submitted to the Scott-Knott mean test for comparison of treatments through statistical software SISVAR (Ferreira, 2011).

3. Results and Discussion

Only the characteristics plant height, weight of one thousand grains, number of grains per ears, ears length, weight of grain per ears, ears weight and harvest index were statistically significant by the F test ($p < 0.05$) (Table 2). The coefficients of variation ranged from 2.5 to 12.4% (Table 2), remaining between low (up to 10%) and medium (10-20%), according to classification of Pimentel and Garcia (2002). The variability of the coefficient of variation is linked to the environment and the agronomic characteristics of corn (Hiolanda et al., 2018).

Table 2. Summary of analysis of variance for vegetative and productive characteristics of corn in second crop (Campo Novo do Parecis, MT, 2018)

Characteristics[1]	F[2]	CV (%)[3]	OM[4]
PLH (m)	2.3**	2.5	2.61
SD (cm)	0.9	5.8	2.22
EIH (m)	0.9	5.4	1.34
WTG (g)	2.1*	8.4	331.7
PRL	0.7	7.5	1.1
NRE	0.6	3.5	17.2
NGE	1.9	6.5	549.4
NGR	1.7	6.6	31.9
ED (cm)	1.5	3.6	5.12
EL (cm)	3.0**	4.6	14.71
WGE (g)	2.9**	9.4	149.1
EW (g)	3.7**	9.5	191.4
HI	2.7**	3.0	0.70
GY (kg ha^{-1})	1.3	12.4	8163

Note. [1] PLH = plant height, SD = stem diameter, EIH = ears insertion height, WTG = weight of one thousand grains, PRL = prolificity, NRE = number of rows per ears, NGE = number of grains per ears, NGR = number of grains per row, ED = ears diameter, EL = ears length, WGE = weight of the grains per ears, EW = ears weight, HI = harvest index, GY = grain yield; [2] ** and * significant at 1 and 5%, respectively; [3] CV = coefficient of variation; [4] OM = overall mean.

The treatments in which defoliation was performed in the first (V4) and last stages (starting at R1), together with the control, were those that prusuced the larger plants (over 2.6 m). These results show that leaf damage at the beginning of corn plant development does not produce a decrease plant growth. This indicates that the plant has the ability to recover by the end of the cycle when the plant naturally ceases its growth as the channeling of its energies at this stage is towards the reproductive structures (Table 3). In contrast, when defoliation occurred between V4 and R1, plant plant height was reduced to 2.5 m or less. Therefore, when the plants are in full structural growth and environmental stress, defoliation can impair the growth process. This trend is consistent with research by Souza et al. (2015), where defoliation between V5 and V8 did not affect plant height, but did adversely affect plant height when the defoliation occurred from VT to R3.

As the plants evolved in the vegetative phases of development, it was found that the defoliation of the lower third did not influence their height, a fact caused by the lower uptake of sunlight by these leaves in relation to the leaves of the pointer (Table 3). For the reproductive phase, the same behavior was verified, however, it was attributed to the natural senescence of the leaves in this phase of the plant development as well as to the occurrence of leaf diseases (*Helminthosporium turcicum* and *Cercospora zeae-maydis*), clearly culminating, in reduction of photosynthetic capacity. Such findings were also reported by Gaias et al. (2017), where the highest plant height was shown in the control, then it decreased from V4 or when the leaf removal occurred in the middle and upper third. Additionally, Rezende et al. (2015) found that the greater the leaf removal, the smaller the plant height and, consequently, the ears insertion height.

For stem diameter, whose average values ranged from 2.1 to 2.4 cm, no significant difference was found between treatments (Tables 2 and 3) as it was also found by Vaz et al. (2016) and Gaias et al. (2017). According to Sangoi et al. (2012), the stem has a vital function in plant support when subjected to stresses on the leaf area, caused by pests, physiological disturbances, climate, hail and wind, being a source of carbohydrate supply to compensate the plant balance.

Ears insertion height, with averages between 1.2 and 1.4 m, showed no effect of defoliation levels (Tables 2 and 3); however, the behavior trend was similar to that of plant height. The lack of significant results for this characteristic in relation to defoliation levels may be justified by the fact that the new cultivars are formed through breeding programs that target more compact plants, thereby increasing the balance, reducing the lodging and enhancing the efficiency of mechanized harvest (Souza et al., 2015).

Regarding prolificity, no significant difference was observed between treatments (Tables 2 and 3), corroborating Alvim et al. (2010) and Trogello et al. (2017) who found that prolificity is negatively affected only when a complete leaf removal is performed. Tinca et al. (2015) pointed out that prolificity is intrinsically related to genotypic factors previously determined in their genetic improvement, however, adequate management and edaphoclimatic conditions may indirectly interfere with this trait.

Table 3. Mean values for plant height (PLH), stem diameter (SD), ear insertion height (EIH) and prolificity (PRL) of corn grown in the second harvest (Campo Novo do Parecis, MT, 2018)

Phenological stage	Treatments	PLH (m)	SD (cm)	EIH (m)	PRL
	T1	2.60 b	2.20	1.35	1.1
V4	T2	2.61 a	2.26	1.36	1.2
	T3	2.52 b	2.26	1.33	1.2
V8	T4	2.65 a	2.27	1.38	1.2
	T5	2.57 b	2.12	1.29	1.1
	T6	2.57 b	2.18	1.25	1.1
V12	T7	2.62 a	2.23	1.33	1.1
	T8	2.57 b	2.14	1.32	1.1
	T9	2.47 b	2.40	1.29	1.2
R1	T10	2.57 b	2.22	1.34	1.1
	T11	2.66 a	2.26	1.40	1.2
	T12	2.63 a	2.36	1.34	1.2
R2	T13	2.60 b	2.33	1.32	1.1
	T14	2.58 b	2.11	1.33	1.1
	T15	2.63 a	2.14	1.35	1,1
R3	T16	2.63 a	2.33	1.37	1.1
	T17	2.70 a	2.34	1.38	1.2
	T18	2.68 a	2.20	1.36	1.2
R4	T19	2.52 b	2.22	1.33	1.1
	T20	2.63 a	2.23	1.34	1.1
	T21	2.69 a	2.26	1.42	1.1
R5	T22	2.70 a	2.26	1.39	1.1
	T23	2.57 b	2.27	1.28	1.1
	T24	2.70 a	2.24	1.41	1.1

Note. Distinct letters are different from each other by the test of Scott-Knott, at 5% probability; T1 = control.

The weight of one thousand grains achieved the greatest values (332.1 to 369.7 g) when defoliation was performed at V4, V8, V12, R4 and R5 (Table 4), while the minors grains (297.1 to 325.9 g), which showed the greatest effects of defoliation, were plants whose leaves removed between R1 and R3. Consequently, this behavior reflected directly on the weight grain per ear and ears weight (Table 5). So, a critical period (R1 to R3) was observed in corn crop in relation to loss of leaf area and its effects on plant reproductive characteristics, which was also evidenced by Trogello et al. (2017), when they observed that in stage R1, as defoliation intensity increased, there was a reduction in the weight of one thousand grains, grain weight per ear and ear weight. Additionally, Alvim et al. (2010) reported that the weight of one thousand grains is intrinsically related to the source and drainage capacity of the plant, where defoliation from R3 no longer influences this characteristic, since the grains have their photoassimilates guaranteed for their complete formation and filling.

Regarding the number of rows per ears, number of grains per ear and number of grains per row, no significant differences were detected between treatments (Tables 2 and 4). Souza et al. (2015) evaluated nine defoliation levels in three different hybrids in the 2010/2011 crop and did not obtain any statistical significance for the number of rows per ears and number of grains per row. Alvim et al. (2010) found that defoliation at R2 did not negatively affect the number of grains per row and the number of grains per ear as at this stage, these production components are already defined. Both studies ratify the data of this study.

Table 4. Mean values for weight of one thousand grains (WTG), number of rows per ear (NRE), number of grains per ear (NGE), number of grains per row (NGR) and ear diameter (ED) of corn grown in second crop (Campo Novo do Parecis, MT, 2018)

Phenological stage	Treatments	WTG (g)	NRE	NGE	NGR	ED (cm)
	T1	300.2 b	17	571	33	5.19
V4	T2	356.8 a	17	564	32	5.32
	T3	319.8 b	17	591	34	5.15
V8	T4	369.7 a	17	523	32	5.14
	T5	305.0 b	17	545	32	5.09
	T6	366.0 a	17	531	31	5.19
V12	T7	304.7 b	17	564	33	5.16
	T8	343.3 a	17	512	30	5.08
	T9	339.3 a	17	519	30	5.08
R1	T10	301.5 b	17	553	32	4.77
	T11	311.5 b	17	559	32	5.16
	T12	311.8 b	18	534	30	4.94
R2	T13	325.9 b	17	605	35	5.17
	T14	313.2 b	17	556	33	5.05
	T15	314.1 b	17	467	28	4.83
R3	T16	350.4 a	17	551	33	5.20
	T17	297.1 b	17	558	32	5.14
	T18	344.6 a	17	532	31	4.98
R4	T19	365.3 a	18	591	34	5.33
	T20	334.2 a	17	549	31	5.21
	T21	338.8 a	17	546	32	5.16
R5	T22	366.4 a	17	541	31	5.11
	T23	332.1 a	17	577	34	5.24
	T24	349.3 a	17	548	32	5.16

Note. Distinct letters differ from each other by the test of Scott-Knott, at 5% probability; T1 = control.

Regarding ears diameter, there was no significant difference between treatments (Table 4) although Alvim et al. (2010) found that when the leaves are removed in the upper third of the plants in reproductive stages, the photosynthetic activity is dramatically reduced, leading to a decline in carbohydrate accumulation, which may interfere with production components, grain yield and ears diameter.

For ears length, no significant difference was found between defoliation levels and control (Tables 2 and 5). However, when defoliation occurs in the upper third of the plant in R1 (13.8 cm) and R2 (12.6 cm), the observed responses were similar to the lowest averages showed by Pereira et al. (2012), when the 80% reduction in leaf area occurred in tasseling. Souza et al. (2015) explained this fact as a reflection of leaf stress affecting the source and drain relationship, where the photoassimilates are transported to larger structures, the ears. Therefore, the definition of its size is influenced from flowering.

Regarding the grain weight per ears, two distinct groupings of means were formed. The group with the highest mean values ranged from 149.8 to 177.8 g (Table 5), with an overall mean of 158.3 g. The composition of the lowest mean values ranged from 115.0 to 145.1 g (136.4 g average). Thus, it was found that there was an average reduction of 14% in weight grain per ears for the group with the lowest means. The highest value (177.8 g) was found when defoliation occurred in the upper third of plants in R3 and the lowest average (115.0 g) in R2, with defoliation performed in the upper third.

The group with the highest means for the weight grain per ears was formed by the control, for the defoliation at V4, V8, V12, R4 and R5, regardless of the defoliation location in the plant, while the second group, composed by the lowest averages, contemplated the treatments with defoliation from R1 to R3. Thus, it is found that defoliation in flowering and grain filling can drastically affect weight grain, regardless of the defoliation site (Table 5). Souza et al. (2015) found that vegetative and reproductive defoliation reduced weight grain per ears by up to 50% and that environmental conditions and genotype characteristics can determine yield levels for weight grain per ears.

The effect of defoliation on ear weight can be evidenced in two value classes (Table 5). In the first, with the highest means, the values ranged from 191.0 to 230.1 g (average of 204.4 g), which was formed by defoliation at the beginning of the vegetative period (V4 to V8), besides the control, and in the end of the crop cycle (R3 to R5), in the middle and lower third of the plant, since this region presents leaves with low or no photosynthetic activity, due to self-shading. The second group, with the lowest averages, presented values between 158.8 and 176.3 g and an average of 169.9 g, when defoliation occurred in V12 (middle and upper third), R1, R2 (middle and upper third) and in R3, with defoliation in the upper third. This group presented a reduction by 17% in ears weight when compared to the mean of the group with the highest values. Brito et al. (2011) found that the total defoliation of the plant in R2 reduces the ear weight by 56% and that a significant difference was found at that time with the control when defoliation was performed in any part of the plant.

Table 5. Average values for ear length (EL), weight of grain per ear (WGE), ear weight (EW), harvest index (HI) and grain yield (GY) of corn grown in the second crop (Campo Novo do Parecis, MT, 2018)

Phenological stage	Treatments	EL (cm)	WGE (g)	EW (g)	HI	GY (kg ha^{-1})
	T1	14.76	152.8 a	194.0 a	0.79 a	8,472.6
V4	T2	15.09	166.3 a	209.4 a	0.79 a	8,966.0
	T3	15.11	157.3 a	203.4 a	0.77 b	8,775.2
V8	T4	15.90	157.8 a	207.2 a	0.76 b	7,954.0
	T5	14.46	133.2 b	176.3 b	0.76 b	7,389.0
	T6	14.54	153.0 a	199.5 a	0.77 b	9,621.0
V12	T7	14.87	151.0 a	191.0 a	0.80 a	8,338.4
	T8	14.13	140.1 b	166.5 b	0.84 a	7,516.7
	T9	14.10	140.7 b	172.4 b	0.82 a	7,669.0
R1	T10	14.51	144.3 b	184.0 b	0.79 a	8,214.3
	T11	14.64	145.1 b	182.0 b	0.80 a	7,832.4
	T12	13.76	129.0 b	158.8 b	0.81 a	6,947.3
R2	T13	15.50	161.6 a	210.0 a	0.77 b	7,540.3
	T14	14.50	137.0 b	174.0 b	0.79 a	8,012.6
	T15	12.64	115.0 b	144.0 b	0.80 a	6,804.8
R3	T16	15.20	164.4 a	216.0 a	0.76 b	8,842.0
	T17	14.62	142.3 b	189.3 a	0.75 b	7,933.2
	T18	14.47	137.2 b	171.5 b	0.80 a	7,612.7
R4	T19	16.02	177.8 a	230.1 a	0.77 b	8,851.5
	T20	14.33	149.8 a	195.6 a	0.77 b	7,982.0
	T21	15.00	155.8 a	201.0 a	0.77 b	8,660.2
R5	T22	15.05	158.8 a	209.4 a	0.76 b	8,499,6
	T23	15.28	163.8 a	214.1 a	0.77 b	8,696.1
	T24	14.70	146.2 a	197.0 a	0.75 b	8,782.7

Note. Distinct letter differ from each other by the test of Scott-Knott, at 5% probability; T1 = control.

Regarding the harvest index (HI), it was also possible to highlight two distinct groups, one with a value greater than 0.79 (mean of 0.80) and another with values less than 0.77 (mean of 0.75), according to Table 5. Overall, the absence of defoliation (control), or defoliation up to R2 had lower, albeit significant, effects on this characteristic, whereas defoliation from R3 reflected in lower harvest index. Karam et al. (2010) also observed that there was no statistical difference for defoliation performed between V2 and V4. According to Sangoi (2001), the variations in the harvest index that occur in corn are designated by the characteristics of each genotype, related to the photoassimilates translocation from the leaves to the grain. Besides, this characteristic is strictly linked to the photosynthetic capacity of the leaves, leaf longevity, the source-drain relationship, especially stem-to-grain translocation, the need for other structures of the plant in the reproductive phase and the size and ear formation as a drain.

Grain yield (GY) showed no significant difference between the treatments under study (Tables 2 and 5). Nevertheless, it was observed that when defoliation occurred in the upper third of the plant at R2 (T15), a reduction by 30% was observed in grain yield compared to the treatment with the highest grain yield, 9621.0 kg ha^{-1} (T6). Such phase (R2) was also reported to be the most sensitive to defoliation (with major negative effects on grain yield) by Brito et al. (2011) and Vaz et al. (2016). On the other hand, Gaias et al. (2017) also found that defoliation in the vegetative period, especially in V4, is not different from the control (absence of defoliation).

Even when subjected to adverse conditions that damage the leaf tissue, the corn agronomic characteristics may have different behaviors, depending on the hybrid performance, climatic conditions, nutritional status and plant phenological stage (Pereira et al., 2012; Sangoi et al., 2014). Souza et al. (2015) found in an experiment conducted for two years, that the influence of the environment is relevant to the performance of the defoliated hybrids, since in the first year there was a reduction of approximately 56% in grain yield, while in the second year the reduction was 80%.

The results obtained in this research show the importance of adopting a productive management for high technological corn, where the genotypic characteristics of the crop can play their potential, offsetting the adversities that may damage its leaf area.

4. Conclusions

Defoliation between the fourth (V4) and twelfth leaves (V12) does not interfere in the evaluated characteristics, except for grain and ears weight when defoliation occurs in the middle and upper third of plants in V12. Defoliation between flowering (R1) and beginning of grain filling (R2) negatively affects the weight of one thousand grains, grain and ear weight, and can reduce grain yield by up to 30%. Defoliation in the upper third of the plant significantly reduces the ear diameters and lengths, and the grain and ear weight of the corn crop.

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