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Components of Maize Crop as a Function of Doses of Polymerized Urea

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Abstract

The efficiency of nitrogen fertilizer applications such as urea is reduced as a function of volatilization and leaching losses. For this reason, the producers have opted for the use of polymerized urea. Therefore, the objective of this work was to evaluate the production components in maize culture as a function of doses of polymerized urea. The experimental design was a 5 × 3 factorial, totaling fifteen treatments, corresponding to five doses Polyblen® 39% N of polymerized urea (0, 250, 500, 750 and 1000 kg ha^{-1}) and three cultivars of maize (30A37, MG580 and MG600). The variables were analyzed after harvest, being: plant height, ear height commercial, stem diameter, leaf area, plant leaf area, ear diameter without husks, ear diameter with husks, ear length without husks, ear length with husks, number of grains per row, number of grains per ear, grain yield, number of rows per ear, 100-grain weight. Regarding the production components in the corn crop, the presence of Polyblen® polymerized urea influenced all variables analyzed. While varieties 30A37, MG580 and MG600 demonstrated a significant increase in their productivity averages.

Keywords: cerrado Brazilian, fertilizantion nitrogen, protected urea

1. Introduction

In the world ranking, Brazil is the third largest producer with 82 million tons estimated for the 2018/2019 harvest. In Brazil, it is estimated that on the second maize crop 2017 about 61 million tons, with almost 60% of maize production in the country (CONAB, 2017; Fumagalli et al., 2017).

Maize grain yield is associated and influenced by the availability of nitrogen (N) in the soil throughout the plant growth cycle. The N is very important in maize crop productivity, since its lack can limit grain production (Schiavin et al., 2011). The nitrogen balance in the soil-plant-atmosphere system is given by the difference between gains and losses in the system, losses occur through crop removal, erosion, volatilization, biological immobilization and leaching. Due to its transformations in the soil, N is a very dynamic element, which has generated controversies and discussions regarding its source, mode and dose of application in corn. The dynamics of N in the soil-plant system is influenced mainly by the cultivation system (conventional or direct), by the forms of management, by the edaphoclimatic conditions and by the type of fertilizer (Kappes et al., 2013). Urea applied to the soil surface results in high losses of nitrogen (N) by volatilization of NH_3 (Civardi et al., 2011).

Among the many nitrogen sources, urea is the most used in Brazilian agriculture, being the most concentrated (45% N) and, consequently, having a lower impact on the total cost of fertilization. However, in view of the loss of urea, one can opt for the use of polymerized urea. According to a study by Valderrama et al. (2013), one option would be to protect the granule from urea with less hygroscopic products that allow it to be applied to the soil surface, which may delay its release and stimulate the hydrolysis process inside the soil, reducing N losses in the form of ammonia.

According to Caires and Milla (2016), the phytotechnical characteristics of maize vegetative growth, respond positively to nitrogen fertilization, especially in the use of polymer-coated urea compared to uncoated urea, is capable of providing a greater agronomic effect. Thus, the objective of this work was to evaluate the production components in maize culture as a function of doses of polymerized urea.

2. Method

The study was conducted at the Luiz Eduardo de Oliveira Sales Experimental Farm of Center University of Mineiros (UNIFIMES), in the municipality of Mineiros-GO, located between the geographic coordinates of 17°34′10″ South latitude and 52°33′04″ West longitude, with average altitude of 760 m. The average temperature is 22.7 °C, the average annual rainfall is 1.695 mm occurring mainly in spring and summer. The predominant climate is warm, semi-humid and notably seasonal, with rainy summer and dry winter, being classified as “Aw”, according to Köppen classification. The soil is classified as Entisols (Quartzipsamments), with medium texture, smoothly wavy to flat topography and limited drainage (Embrapa, 2013).

The experimental design was a 5 × 3 factorial, totaling fifteen treatments, corresponding to five “Polyblen® 39% N” doses of polymerized urea (0, 250, 500, 750 and 1000 kg ha^{-1}) and 3 cultivars of maize (30A37, MG580 and MG600) in 4 replicates, totaling 60 experimental units, where each unit was composed of 4 lines of 4 meters in length distanced every 0.5 m and density of 3 seeds per linear meter, relating a population of 60,000 plants ha^{-1}.

Before the installation of the experiment, soil samples were collected and analyzed in the 0-20 cm surface layer, with the following characteristics: hydrogen potential 4.1; phosphorus 3 mg dm^{-3}; potassium 0.6 mg dm^{-3}; calcium 5 cmolc dm^{-3}; magnesium 3 cmolc dm^{-3}; aluminum 4 cmolc dm^{-3}; base sum 8.6 cmolc dm^{-3}; cation exchange capacity 37.6 cmolc dm^{-3} and base saturation 22.94 in cmolc dm^{-3}; clay 80 g kg^{-1}; silt 30 g kg^{-1} and sand 890 in g kg^{-1}. The analyzes were carried out at the UNIFIMES Soil Chemistry and Fertility Laboratory, according to the methodology of (Embrapa, 2009).

Soil preparation was carried out with the use of tractor to the motor traction performing plowing and harrowing. Sowing was performed on February 18, 2017 with manual seed distribution, and fertilization with the NPK mineral fertilizer of the formula 7-20-20 with 300 kg ha^{-1} dose was performed simultaneously in the furrow. Polyblen doses were sprayed 7 days after sowing. Weed control was performed with Zap Qi at the concentration of 1.5 L ha^{-1} in the phenological phase V2, for which a constant pressure 2.0 bar (CO_2) cone-type sprayer was used, applying a volume with a mean temperature of 25 ºC, relative air humidity above 60% and winds below 5 km h^{-1}.

The variables were analyzed after harvesting on June 15, 2017. To that end, the following parameters were determined: plant height (PH), ear height commercial (EHC), stem diameter (SD), leaf area (LA), plant leaf area (PLA), ear diameter without husks (ED-H), ear diameter with husks (ED+H), ear length without husks (EL-H), ear length with husks (EL+H), number of grains per row (NGPR), number of grains per ear (NGPE), grain yield (GY), number of rows per ear (NRPE), 100-grain weight (100GW) (Benincasa, 2004).

The results were submitted to analysis of variance, where the description of the variables was performed as a function of the polymerized urea concentrations. The polynomial regression was performed by testing the linear and quadratic models and choosing the most significant models and presenting the highest correlation value with the means, observing the significance of the test F. Also the maize cultivars were compared with the means of the Tukey test at 5% of probability. All analyzes were carried out with the statistical program System for Analysis of Variance (SISVAR) (Ferreira, 2014).

3. Results

Significant effect for most of the variables analyzed, except for SD and NRPE, with the adjusted quadratic regression model for the cultivares of the maize avaliates. The ED+H fitted to the quadratic model only for the 30A37, and MG580 varieties ($p \geq 0.01$). The MG600 variety was not affected by the application of polymerized urea. The EL+H fitted to the quadratic model ($p \geq 0.01$) for the MG600 variety, and the other varieties showed increasing linear responses ($p \geq 0.01$). The 100GW was not significant for the 30A37, and MG600 varieties; and the MG580 variety presented a quadratic response ($p \geq 0.01$) to 100GW.

The maximum estimated increments in PH were 1.60 m with a rate of 363 kg ha^{-1} ($p \geq 0.01$) of polymerized urea for the 30A37 variety, 1.82 m with a rate of 531.5 kg ha^{-1} ($p \geq 0.05$) for the MG580 variety, and 1.68 m with a rate of 318 kg ha^{-1} ($p \geq 0.01$) for the MG600 variety (Figure 1A). The maximum estimated increments in EHC ($p \geq 0.01$) were 93.53 cm with a rate of 641.29 kg ha^{-1} for the 30A37 variety, 99.98 cm with a rate of 593.9 kg ha^{-1} for the MG580 variety, and 96.50 cm with a rate of 751.52 kg ha^{-1} for the MG600 variety (Figure 1B).

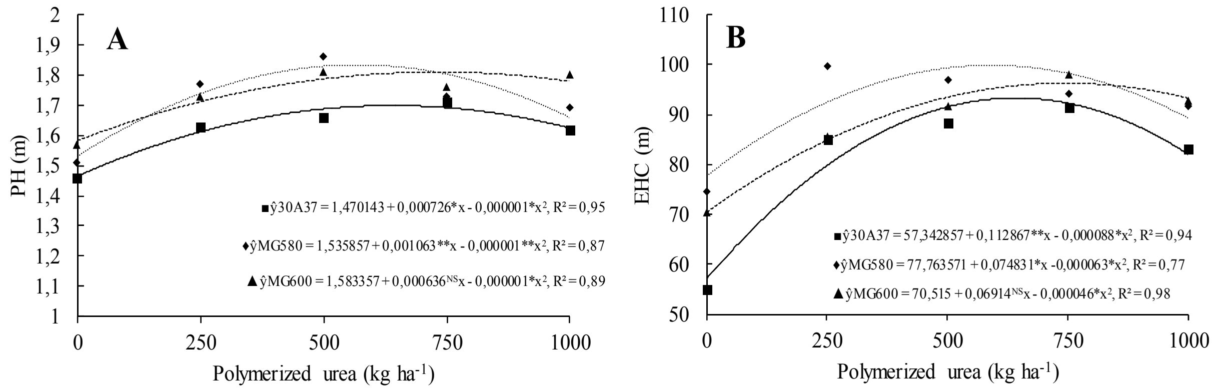

Figure 1. Plant height (A) and ear height commercial (B) of three varieties of maize in function of polymerized urea

The maximum estimated increments in LA ($p \geq 0.01$) were 734.12 cm^2 with a rate of 731.40 kg ha^{-1} for the 30A37 variety, 770.31 cm^2 with a rate of 710.39 kg ha^{-1} for the MG580 variety, and 761.13 m^2 with a rate of 835.79 kg ha^{-1} for the MG600 variety (Figure 2A). The maximum estimated increments in PLA ($p \geq 0.01$) were 12,481.18 cm^2 with a rate of 731.58 kg ha^{-1} for the 30A37 variety, 13,093.84 cm^2 with a rate of 710.20 kg ha^{-1} for the MG580 variety, and 12,939,25 cm^2 with a rate of 835.79 kg ha^{-1} for the MG600 variety (Figure 2B).

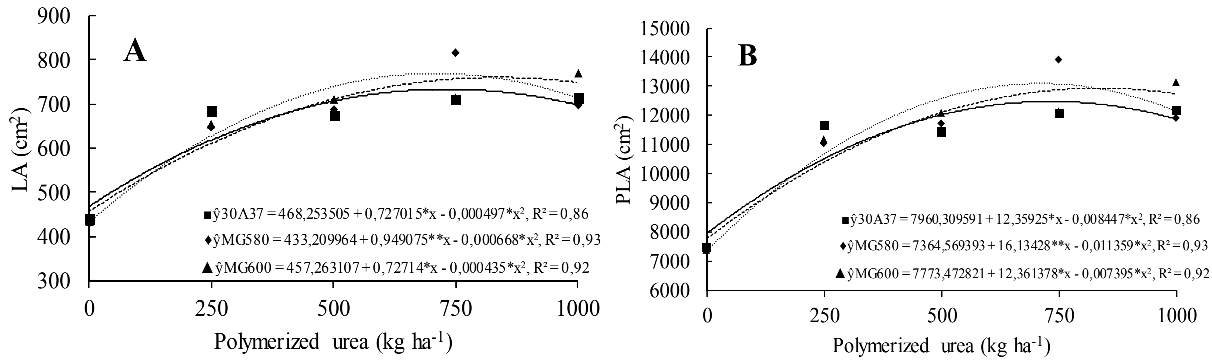

Figure 2. Leaf area (A) and plant leaf area (B) of three varieties of maize in function of polymerized urea

The fertilizer rates used had no effect on the ED+H of the MG600 variety, presenting a mean of 5.69 cm. The maximum estimated increments in ED+H were 5.93 cm with a rate of 785 kg ha^{-1} ($p \geq 0.01$) for the 30A37 variety, and 5.95 cm with a rate of 595 kg ha^{-1} ($p \geq 0.01$) for the MG580 variety (Figure 3A). The maximum estimated increments in ED-H were 5.50 cm with rate of 608.50 kg ha^{-1} ($p \geq 0.01$) for the MG600 variety, 5.48 cm with a rate of 563.75 kg ha^{-1} ($p \geq 0.01$) for the MG580 variety, and 5.21 cm with a rate of 542 kg ha^{-1} ($p \geq 0.01$) for the 30A37 variety (Figure 3B).

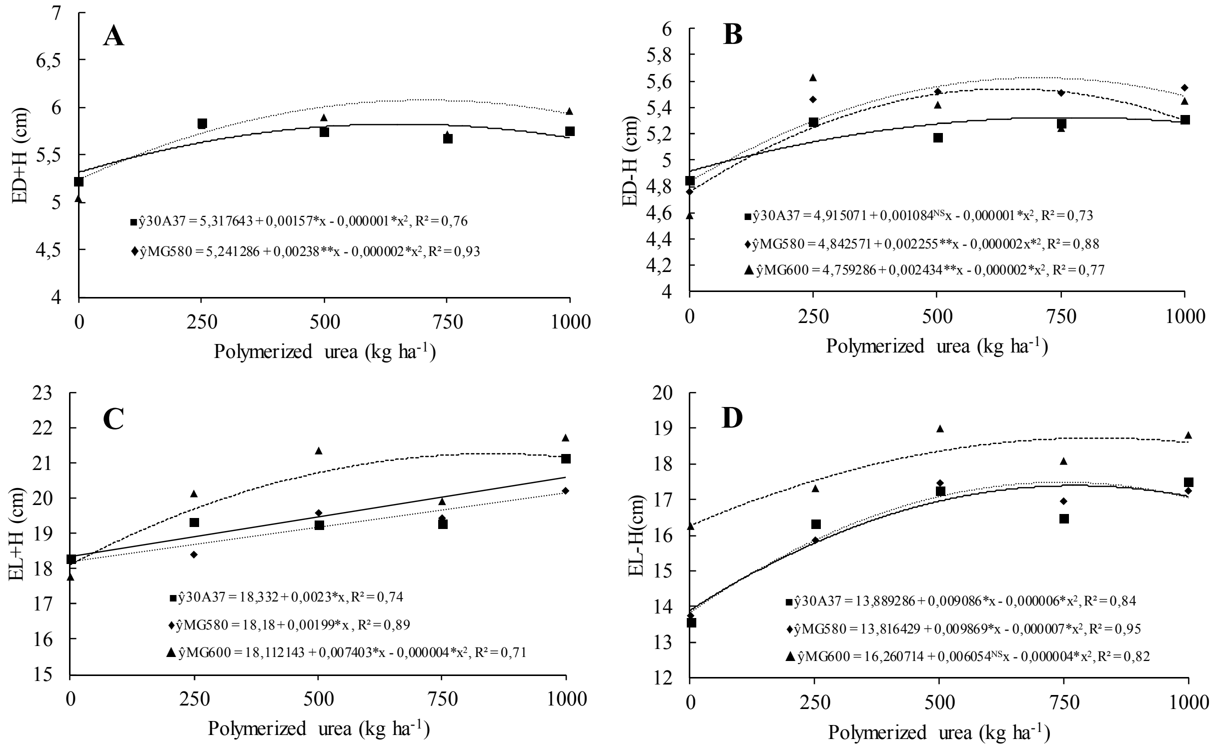

Figure 3. Ear diameter without husks (A), ear diameter with husks (B), ear length without husks (C) and ear length with husks (D) of three varieties of maize in function of polymerized urea

The maximum incrementin EL+H were 20.63 cm for the MG580 variety, and 18.18 for the 30A37 variety, with the rate of 1000 kg ha^{-1}, presenting a linear effect ($p \geq 0.01$). The maximum estimated incrementin EL+H was 21.54 cm with a rate of 925.37 kg ha^{-1} for the MG600 variety, ($p \geq 0.01$) (Figure 3C). The maximum estimated incrementin EL-H were 18.56 cm with a rate of 758 g ha^{-1} for the MG600 variety, 17.29 cm with a rate of 705 kg ha^{-1} for the MG580 variety, and 16.33 cm with a rate of 757 kg ha^{-1} for the 30A37 variety (Figure 3D).

The maximum estimated increments in NGPR ($p \geq 0.01$) were 40.34 with a rate of 667.92 kg ha^{-1} for the MG600 variety, 37.31 with a rate of 631.75 kg ha^{-1} for the MG580 variety, and 38.08 with a rate of 686.40 kg ha^{-1} (Figure 4A) for the 30A37 variety.

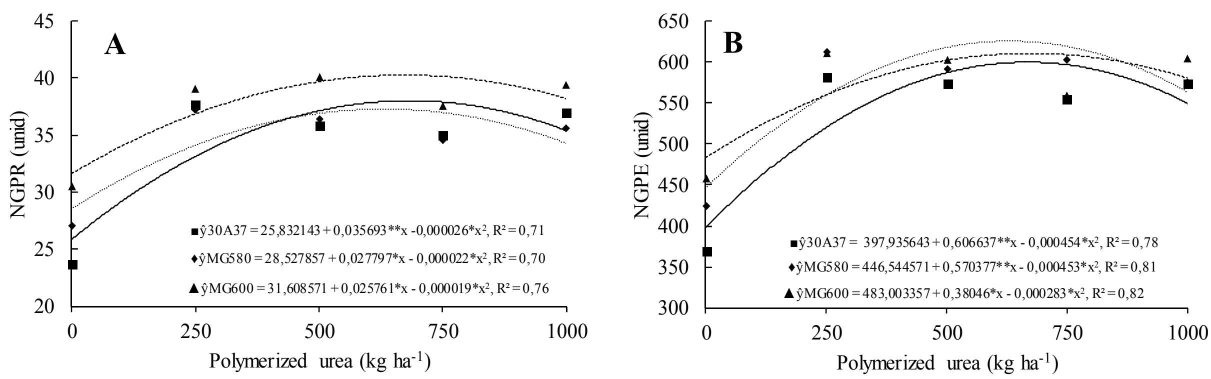

Figure 4. Number of grains per row (A) and number of grains per ear (B) of three varieties of maize in function of polymerized urea

The maximum estimated increments in GY ($p \geq 0.01$) were 11799.48 kg ha^{-1} with a rate of 664.55 kg ha^{-1} for the MG580 variety, 11275.73 kg ha^{-1} with a rate of 714.19 kg ha^{-1} for the MG600 variety, and 10720.20 kg ha^{-1} with a rate of 696.54 kg ha^{-1} for the 30A37 variety (Figure 5A).

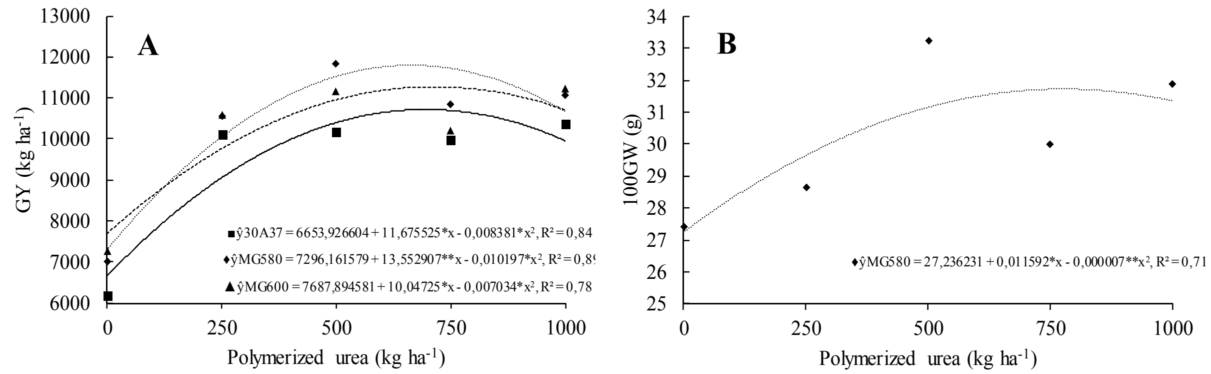

Figure 5. Grain yield (A) and 100-grain weight (B) of three varieties of maize in function of polymerized urea

The results for 100GW did not fitted to any statistical model applied, presenting 29.25 g for the 30A37 variety, and 30.38 g for the MG600W variety. The maximum estimated increment in 100GW were 32.04 g with a rate of 828 kg ha^{-1} for the MG580 maize ($p \geq 0.05$) (Figure 5B).

The varieties showed significant differences ($p \geq 0.05$) for PH, EL-H, and NRPE, and no significant statistical difference ($p \geq 0.05$) for EH, SD, LA, PLA, ED+H, EL+H, ED-H, NGPR, NGPE, GY, and 100GW (Table 1). All variables analyzed showed viable coefficient of variation for the test performed.

Table 1. Means of plant height (PH), ear height commercial (EHC), stem diameter (SD), leaf area (LA), plant leaf area (PLA),ear diameter with husks (ED+H),ear diameter without husks (ED-H), ear length with husks (EL+H), ear length without husks (EL-H), number of rows per ear (NRPE), number of grains per row (NGPR),number of grains per ear (NGPE), grain yield (GY), 100-grain weight (100GW)of three varieties of maize in function of polymerized urea

Variety	PH	EHC	SD	LA	PLA
	--------------------------- cm ---------------------------			--------- cm^2 --------	
30A37PW	1.62 b	80.68 a	2.01 a	645 a	10.972 a
MG580PW	1,71 ab	91.41 a	2.07 a	657 a	11.172 a
MG600PW	1.73 a	87.68 a	2.15 a	657 a	11.181 a
CV (%)	7.9	16.63	10.07	22.39	22.39
Variety	ED+H	ED-H	EL+H	EL-H	
	--- cm ---				
30A37	5,65 a	5.19 a	19.46 a	16.22 b	
MG580	5,79 a	5.36 a	19.17 a	16.26 b	
MG600	5,69 a	5.26 a	20.18 a	17.89 a	
CV (%)	5.79	8.4	6.35	9.14	
Variety	NRPE	NGPR	NGPE	GY	100GW
	--------------------------- unid ---------------------------			kg ha^{-1}	g
30A37	15.67 b	33.87 a	530 a	934.8 a	29.25 a
MG580	16.43 a	34.15 a	561 a	1.024.8 a	30.23 a
MG600	15.19 a	37.30 a	567 a	1.007.8 a	29.49 a
CV (%)	4.06	13.44	14.35	18.41	7.91

Note. *Means followed by the same uppercase letter in the column do not differ according to the Tukey test at 5% probability.

4. Discussion

Caires and Milla (2016), and Biscaro et al. (2013) reported that applications of N promote increments in PH and EHC of maize; however, the higher height of the plants may favor their lodging. Nutrition of plants must meet the demand, or even the morphophysiological requirements of each variety. Very high plants may present low resistance to physical factors such as wind, and very low resistance to phytopathogens. Therefore, an intermediate ear insertion height is important for the transport of photoassimilates for grain filling, and plant physical balance.

The rates of polymerized urea had no effect on the maize SD, which presented means of 2.02 cm for the 30A37 variety, 2.09 cm for the MG580 variety, and 2.16 cm for the MG600 variety. Aratani et al. (2006) found similar results with nitrogen fertilization in maize crops, with the greatest increment in SD of 2.28 cm. Contrastingly, Oliveira et al. (2009) found that rates of N promoted linear increments in SD. However, some characteristics have low variations, which are often intrinsic to the genotype of each variety.

According to Menezes (2016), leaf area and leaf dry matter content are affected by N availability. Moreover, according to Picoli Júnior (2011), increasing rates of N in maize crops promoted a recovering of leaf area at flowering, when the maize was defoliated at the V8 stage, increasing the PLA.

Menezes (2016) evaluated N fertilization applied as topdressing on maize crops and found a positive effect on the productive performance of the crop in no-tillage system, when applied at the stage 3 (ten completely expanded leaves), providing a larger ear diameter.

Civardi et al. (2011) found an increment in maize ear length with application of polymerized urea, presenting a mean of 13.81 cm, confirming that the use of high rates and the application method of polymerized urea affect the ear length. Moreover, Müller (2013) reported that production components such as ear length are determined at the stage when the plants have four to six leaves, thus, an adequate supply of Nin this period is required. N deficiency at this stage reduces the number of ovules in the ear primordia and, consequently, the ear size. This shows the importance of the N fertilization in amounts that makes it available during the plant development cycle.

The results for NRPE did not fitted to any statistical model applied, presenting a mean of 15.67 for the 30A37 variety, 16.43 for the MG580 variety, and 15.19 for the MG600 variety. Vanin et al. (2011) found similar results, with the treatment with polymerized N not differing statistically from the control; however, Civardi et al. (2011) found different results, with the use of polymerized urea being able to increase the NRPE, reaching 13.12 rows per ear.

Souza et al. (2011) conducted an experiment with irrigated maize in Selvíria, MS, Brazil, in a dystroferric Red Latosol (Oxisol) and found an increase in leaf N content, NGPR, NGPE, and GY with increasing rates of N. The maximum estimated increments in NGPE ($p \geq 0.01$) were 626.09 with a rate of 629.55 kg ha^{-1} for the MG580 variety, 610.87 with a rate of 672.19 kg ha^{-1} for the MG600 variety, and 600.58 with a rate of 668.10 kg ha^{-1} for the 30A37 variety (Figure 4B).

The potential NGPE is defined at the V12 stage, thus, the beginning of the most critical period for the maize production is in this stage (Magalhães et al., 2006; VANIN et al., 2011) and extends up to the pollination, when the NRPE was already determined. However, the final NGPR is determined from one week before flowering, approximately at the V17 stage (Magalhães et al. 2006). The NRPE and NGPR combined determine the final GY (Vanin et al., 2011).

Scopel and Borsoi (2017) evaluated fertilizations with N at planting and coated urea as topdressing and found a GY of 10560 kg ha^{-1}. According to Raposo et al. (2013), the use of polymer-coated urea resulted in a potential yield of 6720 kg ha^{-1} when compared to conventional urea (4080 kg ha^{-1}), showing that the polymers can enable the control of release of N, synchronizingit with the nutritional requirements of the plants considering their production cycle. According to Schiavinatti et al. (2011), maize grain yield is affected by N availability in the soil throughout the plant development cycle. N is important to the productivity of the maize crops because soils with low N content can limit grain production due to the function of this element on the metabolism of plants.

According to Besen (2015), 100GW of maize is highly dependent on the N uptake by the plants, which peaksat flowering and beginning of grain formation. Thus, N availability in the soil at these stages of greater demand is essential; N assimilation is more efficient in these periods; and insufficient rates of N decreases the density of grains.

The results of N fertilization are better in grass crops, such as maize; however, the response of the crop to N fertilization is affected by several factors, including the supply of other nutrients, depth of the soil profile with effective presence of roots, soil history, soil preparation system, crop rotation, rainfall intensity, solar radiation level, and soil organic matter content (Souza et al., 2011).

5. Conclusions

The production components in the maize crop were influenced by the presence of polymerized urea Polyblen®, since varieties 30A37, MG580 and MG600 demonstrated a significant increase in their productivity averages.

The highest increment was obtained in variety MG580 (11.799 kg ha^{-1}) followed by MG600 (11.275 kg ha^{-1}) and 30A37 (10.720 kg ha^{-1}).

For the study conditions it is recommended to apply Polyblen® polymerized urea in the proportion of 690 kg ha^{-1} to obtain high yields.

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