Strategy in the selection of corn genotypes for their efficiency and response to nitrogen

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Abstract**—***Corn is of great importance in the national economy, being one of the most produced and exported cereals in Brazil. With the growing concern of producing food for the population, the search for new corn genotypes is increasingly intensified in order to obtain efficient seeds with an adequate response to the particularities of each planting region. In this sense, the present work aims to identify genotypes of corn efficient and responsive to the use of nitrogen for grain production in the Cerrado biome. The studies were carried out in two maize trials at the Federal University of Tocantins Agricultural Center (UFT), Campus de Palmas - Brazil, with planting in the 2017/18 crop, with nitrogen (BN) (0 kg ha^{-1}) and another in high nitrogen (AN) (150 kg ha^{-1}). The experimental design was a randomized block with three replicates and 20 treatments with an analysis of the response of these effects on grain yield. The methodology of Fageria & Kluthcouski (1980) was used to identify efficient and responsive genotypes. The genotype UFT-M12 was classified as efficient and responsive regarding the use of N for grain yield.*

Keywords**—*****fertilization, productivity, Zea mays.***

I. INTRODUCTION

Brazil is the third-largest producer of corn, with a production of 79,877,714 tons in 2014, behind only the United States and China. Being one of the three most produced crops in Brazil, thus assuming prominence in the national economy (FAO, 2014).

Corn has multiple uses, highlighting human consumption because it is an important source of carbohydrates, it is used in the food industry to transform various products. It is also important for animal production, as it is an important energy source in the diets. And since the world population has grown significantly and for food production livestock herds have also increased, the demand for this cereal grows proportionally (GARCIA et al., 2006).

In the Tocantins state, the maize crop obtained an average yield of 5,360 kg ha^{-1} in the harvest 2018/19 (crop), which was lower than the national average of 5,355 kg ha^{-1} in the harvest 2018/19 (Conab). This is due to climatic conditions, the scarcity of regional maize breeding programs, the lack of selection of genotypes for the technological level of the properties and for the efficient use of nutrients (COUTO et al., 2017) (SANTOS et al., 2016).

Currently with the concern to increase production to feed the growing population, reduce its costs and at the same time build a system of sustainable agriculture, obtaining genotypes with greater efficiency to the use of nitrogen (EUN) has been a goal pursued by researchers and producers (SANTOS et al., 2016) (SIMIONI et al., 2017).

In order to obtain more efficient genotypes, several studies have been conducted. However, it is necessary to further deepen these studies mainly for maize crops in the Cerrado conditions. In this sense, the study was carried out with the objective of identifying efficient and responsive corn genotypes for the use of nitrogen for grain production in the Cerrado biome.

II. MATERIALS AND METHODS

The experiments were conducted at the Agrotechnological center of the Universidad Federal of Tocantins – UFT, municipality of Palmas – TO - Brazil, in a dystrophic yellow-red Latosol type soil, in the geographic coordinates 10^{o} 45’ S e 47^{o} 14’ O, at an altitude of 220m. Being a representative area of the Cerrado biome. In soil preparation, the operations of burning, grading, and furrow were performed. Seed planting and fertilization in the sowing furrow were performed manually. Pre-planting fertilization was performed using 300 kg ha^{-1} of NPK and Zn for all assays.

The nitrogen fertilization used in coverage was 0 and 150 kg ha^{-1} of N, providing a total of 15 and 165 kg ha^{-1} of N, for the environments of BN and in, respectively.

The evaluations of the genotypes were performed in two contracting levels of nitrogen availability, being one installed in high N (AN) (150 kg Ha^{-1}) and another under low N (BN) (0 kg ha^{-1}), in the Harvest 2017/18. The experimental design used was randomized blocks in both assays with 20 treatments and three replications. The experimental plot consisted of four lines of 5.0 m long, spaced by 0.90 m between the rows. The spacing between plants was 0.20 m, which after thinning, totaled a booth of 55,555 plants ha^{-1}. For the evaluation, only the cobs of the central lines of each plot were harvested, discarding 0.50 m of the extremities.

The 20 genotypes were called: UFT-3, UFT-8, UFT-9, UFT-11, UFT-12, UFT-13, UFT-14, UFT-16, UFT-18, UFT-19, UFT-2B, UFT-EA, UFT-ED, UFT-3E, UFT-M1, UFT-M10, UFT-M12, UFT-M18, UFT-M5, UFT-M9. From genetic breeding programs at Universidad Federal of Tocantins.

The cultivation system used urea as a nitrogen source in two applications. The first in the phenological stage of four leaves (V4) and the second in the Eight (V8). The doses used for both environments correspond to the smallest and highest grain yield expected by the maize crop. The cultural tracts were carried out whenever necessary, according to the technical recommendations of Francelli and Dourado Neto (2004) for the maize crop.

In the two central rows of each experimental plot, all the ears were harvested when the plants reached the physiological maturation stage (R6). Next, they were tracked, and the grains were packed and identified, each genotype, in a single paper bag, where the grain mass of each plot corrected to 13% of moisture was calculated and transformed into kg ha^{-1} to obtain the grain yield.

For the differentiation of the genotypes, the methodology proposed by Fageria and Kluthcouski (1980), that suggest the classification of the genotypes regarding the efficiency in the use and response to the application of N. Where the nutrient utilization is defined by the average grain yield at low level. The response to nutrient utilization is obtained by the difference between grain yield in the two levels divided by the difference between the doses using the following formula: An = (PNN-PBN)/(DEN), where: αn = response index; PNN = Production with optimum nutrient level; PBN = Production with low nutrient level; DEN = difference between the doses applied (kg ha^{-1}).

A graphic representation was used in the cartesian plane to classify the genotypes. In the abscissae axis (x), there is the efficiency in the use of N and the axis of the Ordinates (y), the response to its use. The point of origin of the axes is the average efficiency and the average response of the genotypes. In the first quadrant are represented the efficient and responsive genotypes; In the second, the non-efficient and responsive; In the third, the non-efficient and non-responsive and in-room, the efficient and non-responsive.

The data obtained for grain yield were submitted to normality test and ANOVA for each test with joint analysis following the criterion of homogeneity of the residual mean squares of the assays. The efficiency and response indices of the genotypes were also submitted to normality and analysis of variance for each of these.

The means of the genotypes, environments, and indices of efficiency and response were compared by the Scott and Knott Group test (1974), to 5% significance, using the SISVAR program.

III. RESULTS AND DISCUSSION

Analysis of variance (Table 1) had a significant effect ($p<0,05$) for assays, genotypes and interaction in grain yield. The latter indicates a differential behavior of the genotypes at different levels of fertilization. The coefficient of variation (CV) was from 7,5%, less than those found by Godoy et al. (2013), and Cancellier et al. (2011). This CV indicates good accuracy in the conduction of the experiments, is considered low because it is less than 10% according to the classification proposed by Pimentel-Gomes (2009).

Table 1. Summary of the joint variance analysis for grain yield of 20 corn genotypes cultivated in two assays (different nitrogen levels).

Source of variation	Degree of freedom	Square Middle
Tests	1	89268750,00*
Genotypes	19	2455998,45*
Interaction	19	977031,23*
Blocks (essays)	4	274342,92
Error	76	93262,44
General mean		4070,58
CV%		7,50

*, ns = Significant and not significant, respectively, by the F test to 5%.

Grain yields (Table 2), Ranged from 1835 kg ha^{-1} (BN) a 6246 kg ha^{-1} (AN). In the group with the highest mean, the genotypes are UFT-13 (6034 kg ha^{-1}), UFT-19 (6246 kg ha^{-1}), UFT-M10 (5739 kg ha^{-1}) and UFT-M12 (5963 kg ha^{-1}) in AN. And in the group with lower mean are the genotypes UFT-13 (1835 kg ha^{-1}), UFT-18 (1984 kg ha^{-1}), UFT-EA (2274 kg ha^{-1}) and UFT-3E (2107 kg ha^{-1}) in BN.

Grain yield (Table 2), was significantly higher in the assay of AN Comparing to that of BN, with mean 4933 kg ha^{-1} and 3208 kg ha^{-1}, respectively, being 35% lower in the low-test N. What shows a general increment of RG as a function of nitrogen fertilization. Cancellier et al. (2011) and Souza et al. (2008) evaluating tropical populations of corn have found an increase in 23% and 30 % productivity in high-performance assay N, respectively. Only the UFT-M5 showed a statistically equal mean grain yield in both environments.

Table 2. Mean grain yield (kg ha-1) of 20 maize genotypes cultivated under two levels of N.

Genotypes	High N	Low N/efficiency	Answer
UFT-3	4220 Ac	2784 Bd	10
UFT-8	4944 Ab	4168 Bb	5
UFT-9	5027 Ab	3373 Bc	11
UFT-11	4904 Ab	3679 Bc	8
UFT-12	4138 Ac	3052 Bd	7
UFT-13	6034 Aa	1835 Be	28
UFT-14	4828 Ab	3636 Bc	8
UFT-16	5113 Ab	3851 Bd	8
UFT-18	4511 Ac	1984 Be	17
UFT-19	6246 Aa	5060 Ba	8
UFT-2B	5041 Ab	3372 Bc	11
UFT-EA	3903 Ac	2274 Be	11
UFT-ED	4212 Ac	2573 Bd	11

UFT-3E	4589 Ac	2107 Be	17
UFT-M1	5227 Ab	3633 Bc	11
UFT-M10	5739 Aa	3996 Bb	12
UFT-M12	5963 Aa	3544 Bc	16
UFT-M18	4489 Ac	2543 Bd	13
UFT-M5	4405 Ac	3948 Ab	3
UFT-M9	5132 Ab	2753Bd	16
Mean	4933A	3208B	12

Mean followed by the same lowercase letter in the column and capitalized in the row, belong to the same group, by the grouping criterion of Scott and Knott (1974), the 5% of significance.

The tests in AN showed three groups of mean (Table 2), varying from 3903 kg ha^{-1} a 6246 kg ha^{-1}, in the group with the highest mean are the UFT-13 (6034 kg ha^{-1}), UFT-19 (6246 kg ha^{-1}), UFT-M10 (5739 kg ha^{-1}) and UFT-M12 (5963 kg ha^{-1}), in the group with the lowest mean are the genotypes UFT-3 (4220 kg ha^{-1}), UFT-12 (4138 kg ha^{-1}), UFT-18 (4511 kg ha^{-1}), UFT-EA (3903 kg ha^{-1}), UFT-ED (4212 kg ha^{-1}), UFT-3E (4589 kg ha^{-1}), UFT-M18 (4489 kg ha^{-1}), and UFT-M5 (4405 kg ha^{-1}).

The BN assays showed five groups of mean (Table 2), with RG ranging from 1835 kg ha^{-1} a 5060 kg ha^{-1}, in the group with the highest mean is the genotype UFT-19 (5060 kg ha^{-1}), in the group with the smallest medias are the genotypes UFT-13 (1835 kg ha^{-1}), UFT-18 (1984 kg ha^{-1}) and UFT-3E (2107 kg ha^{-1}). Only the genotypes UFT-18, UFT-EA and UFT-3E showed lower averages for both BN and AN. The genotype UFT-19 was the only one that presented the highest mean for the two levels of N.

According to the methodology of Fageria and Kluthcouski (1980) (Figure I), the genotypes were identified UFT-M12, UFT-M10, UFT-2B, UFT-M1, UFT-16, UFT-11, UFT-14, UFT-19, UFT-8, and UFT-M5 as being efficient to N. Thus, they were considered for obtaining grain yield in BN higher than the mean of the genotypes of 3208 kg ha^{-1}, these genotypes are found in quadrants I and IV.

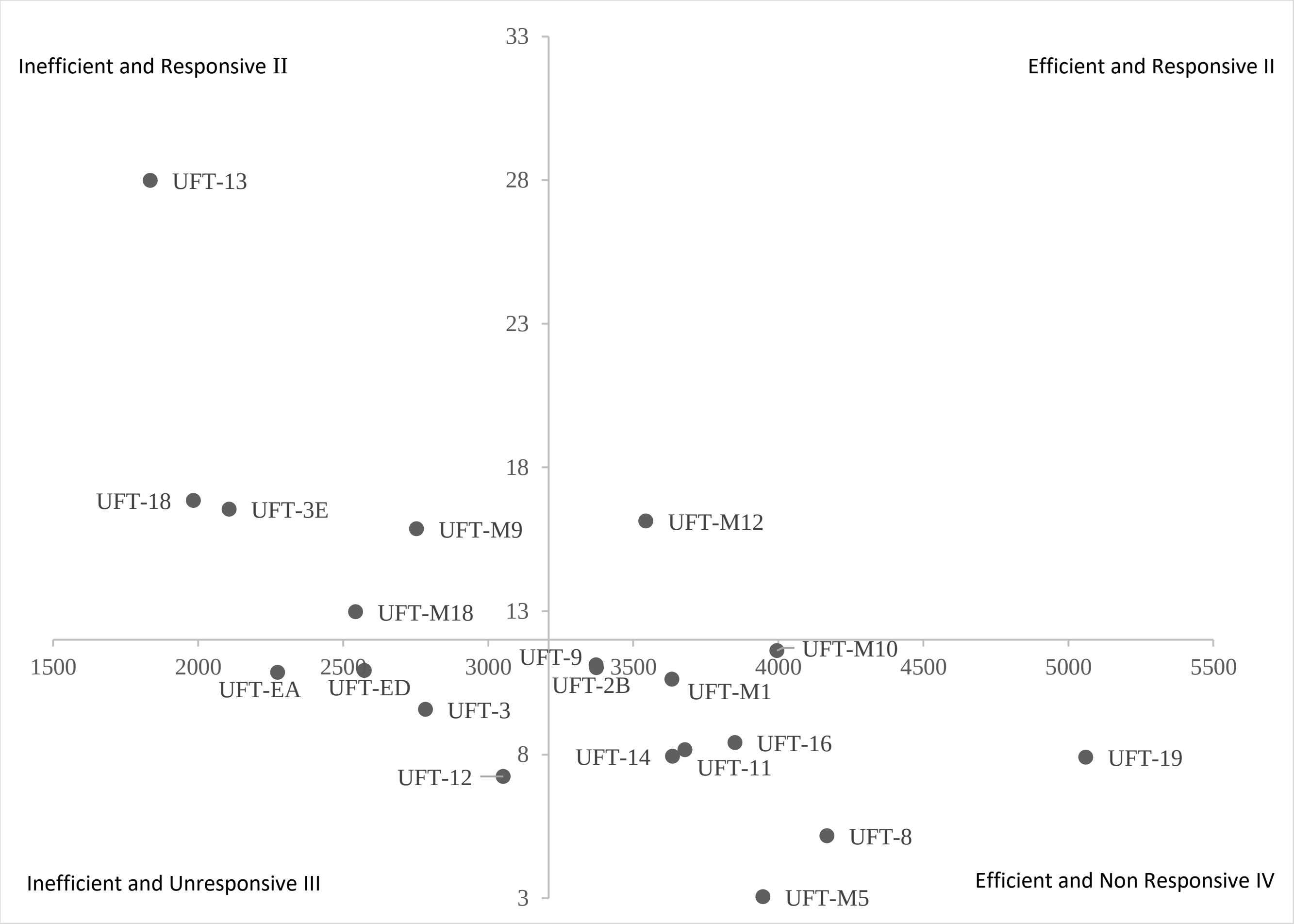

Fig.1. Efficiency in the use and response to nitrogen application in maize genotypes, by the methodology of Fageria and Kluthcouski (1980).

The genotypes UFT-M12, UFT-13, UFT-18, UFT-3E, UFT-M9, and UFT-M18 were considered as responsive to N, values found in quadrants I and II (Figure 1). They were classified to obtain a higher response than the mean of the genotypes, which was 12.

It is noteworthy that the genotype UFT-M12 in addition to efficient was also considered as responsive (Quadrant I). The genotype UFT-M12 and the most indicated, for cultivation using high or low fertilization, providing greater economic return. Second Passos et al. (2015) efficient and responsive genotypes, ie, responsive, because nitrogen fertilization, significantly increased their productivity, efficient because they achieved good yields in the absence of fertilization.

The genotypes UFT-13, UFT-19, UFT-3E, UFT-M9, and UFT-M18 are responsive, by presenting low RG down are considered non-efficient (Quadrant II). These genotypes are recommended for producers of high technological level because they are not efficient in conditions of low nitrogen fertilization, respond well to this fertilization with gains in productivity (PASSOS et al., 2015).

The genotypes UFT-EA, UFT-ED, UFT-3, and UFT-12 are considered as non-efficient and non-responsive (Quadrant III), not being indicated for planting for economic purposes (SANTOS et al., 2017). For having presented low grain yield in an environment with N deficiency (lower to the mean of the genotypes, ie, 4070 kg ha^{-1}) and for having presented low rates of response to the application of N (below 12).

In quadrant IV are the genotypes UFT-M10, UFT-2B, UFT-M1, UFT-16, UFT-11, UFT-14, UFT-19, UFT-8 and UFT-M5 that are regarded as efficient, however, because they have a low response to N (below 12) are classified as non-responsive. Genotypes of this quadrant are indicated for producers of low technological level (SANTOS et al., 2017).

IV. CONCLUSION

For the grain yield characteristic, the methodology of Fageria and Kluthcouski (1980), proved to be effective in classifying efficient and responsive maize genotypes.

The UFT-M12 genotype was classified as efficient and responsive for the use of N for grain yield, indicated, for cultivation at high or low technological level.

The genotypes UFT-EA, UFT-ED, UFT-3, and UFT-12 are considered as non-efficient and non-responsive, are not indicated for planting for economic purposes.

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