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Corn (*Zea mays* L.) green matter production in different sowing densities

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ABSTRACT

Objective: To evaluate the corn green matter production at different sowing densities, in Valle del Mezquital, Hidalgo, Mexico.

Design/Methodology/Approach: The DK-4018 hybrid corn was sown in the spring-summer 2021 cycle. The treatments (T) were different sowing densities: (T1) 112,500, (T2) 120,000, and (T3) 136,000 plants per hectare. The experimental design was completely randomized. The evaluated variables were: plant height at 30, 60, and 76 days after sowing (cm); final stem diameter at ground level (cm); fresh weight (g); and green matter yield (ton ha^{-1}). The results were analyzed with the SAS program (2001) and the means were compared with the Tukey test ($p \leq 0.05$).

Results: The highest green matter production of the DK-4018 hybrid corn was obtained with a sowing density of 136,000 plants per hectare, with an estimated yield of 114.6 ton.

Study limitations/implications: No scientific publications about the DK-4018 hybrid corn green matter production were found.

Findings/Conclusions: With a population density of 136,000 corn plants per hectare, 114.6 ton of DK-4018 corn green matter yield is estimated.

Keywords: production, fresh weight, plant height, Valle del Mezquital.

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INTRODUCTION

Corn (*Zea mays* L.) a plant native to Mexico and Central America— is, after wheat and rice, the most important crop in various parts of the world and has adapted to different climatic and soil conditions. It is mainly used for human consumption and as animal feed (grain or fresh forage), as a result of its high aerial biomass content (35 to

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95 tons per hectare) (Sánchez *et al.*, 2013). In the dairy basins of Mexico, corn forage is mainly used to feed dairy cattle (Zaragoza *et al.*, 2019). It is one of the major crops in the world in terms of sown area each year: 8.5 million hectares for grain on average, 25% of them sown with improved seed, and 75% with native seeds (Tadeo *et al.*, 2016). In industrialized countries, it is mainly used to produce processed foods and, recently, ethanol. Its yield and quality depend on soil fertility, crop management, and its genetics. It is considered an excellent ruminant feed, due to its high energy and protein content (Santiago *et al.*, 2018). Currently this grass is the crop with the greatest diversity of uses, applications, forms, and production conditions. Producers consider the corn plant to be excellent fresh or dry forage. A higher crop density is needed for forage production than for grain production. Consequently, 30,000-90,000 plants ha^{-1} sowing densities have been recommended, depending on the region, irrigation, genotype, and fertilization level, although a greater amount of biomass has been obtained in other trials, using 73,000 to 80,000 plants ha^{-1} (Vázquez *et al.*, 2013; Sánchez *et al.*, 2019). The objective of this research was to evaluate the corn green matter production at different sowing densities, in Valle del Mezquital, Hidalgo, Mexico.

MATERIALS AND METHODS

This research was established in the spring-summer 2021 cycle at the experimental platform of the Universidad Politécnica Francisco I. Madero, located in the Francisco I. Madero municipality, in the state of Hidalgo, Mexico. The town is located at 1,995 masl, 20° 15' 20" N and 99° 00' 10" W. It has a cold temperate climate, a 17 °C average annual temperature, and a 540 mL annual rainfall (Rodríguez-Ortega *et al.*, 2013).

The DK-4018 (Dekalb Genetics Corporation) hybrid corn was sowed in a plot that had been previously prepared using traditional cultural practices. The treatments were different sowing densities (DDS): T1=112,500, T2=120,000, and T3=136,000 plants per hectare, on a surface with homogeneous climatic and edaphic conditions. The experimental design was completely randomized with five repetitions of 4 m^2 per experimental unit, using a five diagonal point sampling method. Several agronomic activities —including fallowing, soaking, and harrowing— were carried out before sowing to obtain optimal crop development. The corn seed was placed in the hoppers of the following planters: a 1035 John Deere model for T1 and a Magnus Dobladense model for T2 and T3. A granulated fertilizer mixture with a 22N-08P-12K formula was added and micronutrients were applied 32 days after sowing. Two gravity irrigations were carried out at 30 and 50 days, until the first rainfalls took place. To avoid weed competition, a selective post-emergence herbicide was applied. The variables measured in the development of the crop were plant height at 30, 60, and 76 days after sowing; final stem diameter at ground level (cm), fresh weight (g), and estimated yield of green matter (ton ha^{-1}) were also measured at 76 days. The results were analyzed with the SAS program (2001) and the means were compared with the Tukey test ($p \leq 0.05$).

RESULTS AND DISCUSSION

Sanchez *et al.* (2013) mention that corn sowing densities vary according to the production objective (grain, forage, or both); they recommend an optimum population density of 39,520 to 98,800 plants per hectare for forage corn, because in theory the total forage biomass increases proportionally to plant density. It is also known that the optimal density of corn plants for grain and forage yield depends on the type of hybrid, soil fertility, and agronomic management of the crop. Therefore, when forage corn was evaluated at a density of 104,000 plants per hectare under irrigation conditions, forage yields between 27.8 and 70.2 t ha^{-1} were obtained. Hybrids such as H-376 —which are used to produce grain and forage— should be sown under irrigation, with an 80,000 plants ha^{-1} density, in order to obtain an estimated green matter yields of 78.1 to 90.8 t ha^{-1}. Forage corn yields of 52.5 to 85.6 t ha^{-1} were obtained with Aspros-721, H-31, VS-2000, and cacahuacintle at 85,000 plants ha^{-1}.

Plant height. Table 1 shows the average plant height results at 30, 60, and 76 days after sowing. There is no statistical difference ($p>0.05$) at 30 days between the three treatments (Figure 1). The value obtained 60 days after sowing did show significance; the best averages were obtained with T2 and T3 (169.9 cm). At 76 days after sowing, plant height was also significant ($p \leq 0.05$); T2 produced the tallest plants (277.5 cm).

Table 1. Plant height at 30, 60, and 76 days after sowing, stem diameter, fresh weight and green matter yield of DK-4018 sown at different sowing densities, in the cycle spring-summer in Tepatepec, Francisco I. Madero, Hidalgo, Mexico.

Variables	Tratamientos (DDS=plantas ha^{-1})		
	T1: 112,500	T2: 120,000	T3: 136,000
Altura a los 30 días (cm)	25.300 a	26.300 a	28.200 a
Altura a los 60 días (cm)	144.900 b	169.900 a	169.900 a
Altura a los 76 días (cm)	247.700 b	277.500 a	271.200 a
Diámetro de tallo (cm)	2.500 b	2.600 a	2.600 a
Materia verde (g $planta^{-1}$)	689.320 b	880.200 a	842.800 a

Values with different letters in each row are statistically different (Tukey, $p \leq 0.05$). DDS=sowing density.

Figure 1. Corn crop evaluated at different sowing densities. T1=112,500, T2=120,000, and T3=136,000 plants per hectare.

Marcos *et al.* (2016) report similar stem heights in native corn (average value: 270 cm).

Plant height recorded 30 days after sowing was not significant ($p>0.05$) between treatments (Table 1). These results are like those obtained by Quispe *et al.* (2011), who recorded average 28.19 cm heights in Testigo Joya and Testigo Canta corn. In this study, the results showed that, 30 days after sowing, the corn plants did not compete for space, water, light, and nutrients in the three densities of the experiment, because the preexistent soil conditions cover those needs. At 60 days after sowing, a statistical difference was found in treatments T2 and T3, with higher values (Table 1).

Significant differences in corn plant height were observed ($p\leq0.05$) at 76 days after sowing (Table 1). Rodríguez and Rabery (2003) evaluated the distance between furrows in two sowing times to obtain higher grain yield and reported similar results, concluding that corn plant height is determined by both genes and environmental conditions. Cervantes *et al.* (2014) analyzed the effect of population density and corn genotypes, observing that the increase in population density generally results in larger plants, which is consistent with the results of this research. Other studies about the same subject also evaluated the effect of three sowing densities in four purple corn genotypes yields and concluded that they did not affect plant size. Meanwhile, Antuna *et al.* (2003) evaluated the agronomic behavior of six corn lines and their hybrid combinations and highly recommend using short-statured materials that tolerate high densities and have resistance to stalk lodging, without neglecting the positive relationship between plant height and grain yield potential.

Stem diameter. Stem diameter at 76 days after sowing was different between sowing densities ($p\leq0.05$): the lowest sowing density (T1=112,500 plants per hectare) resulted in smaller diameter stems. This probably helps to avoid stalk lodging problems (Table 1). These results are similar to the findings of Sánchez *et al.* (2013), who obtained an average stem diameter of 2.33 cm when evaluating 24 commercial hybrid corns, under adequate soil, temperature, and precipitation conditions.

Intriago and Torres (2018) analyzed the effect of sowing density and crop arrangement on the growth and development of the HAZ1 corn hybrid; they report that there were no significant differences, neither as a result of the effects of the sowing arrangement and population density, nor of the interaction of the arrangement and density regarding plant height, stem diameter, and root weight. They also mention that an increase in population density significantly affects plant height, while stem diameter decreases due to competition for light. Additionally, Cruz (2017) evaluated the effect of four sowing densities and four fertilizer doses in the development and yield of corn and determined that the diameter and height of the plant have significant differences in the density factor. Likewise, she reports that, as the density increases from 50,000 to 126,000 plants per hectare, the corn plant stem diameter decreases, and that stem diameter can be affected by high sowing densities and competition for light, causing stalk elongation and consequently diameter reduction. She also reports that plants at low densities per hectare (50,000 plants ha^{-1}) reached the same height as plants at medium densities (76,000 plants ha^{-1}); on the contrary, high densities (101,000 plants ha^{-1}) presented greater height than plants at low densities. Therefore, she concluded that at high densities the diameter is reduced, and the plants elongate.

Green matter weight. There were statistical differences in the production of green matter per plant (Tukey, p≤0.05; Table 1). T2 (120,000 plants ha^{-1}) has the greatest weight with an average of 880.20 grams plant^{-1}, exceeding the green matter recorded in T1 (112,500 plants ha^{-1}) by 22.3%. Similarly, Vásquez (2019) reported that sowing density determines the differences in fresh weight of corn plants. Cusicanqui and Lauer (1999) determined that the dry matter yield increased at a density of 97,300 and 102,200 plants per hectare. In contrast, Santiago *et al.* (2018) report low yields of green matter per hectare of corn and point out that soil fertility, crop management, and genetics are important factors to obtain good yields. For their part, Wiersma *et al.* (1993) and Guyader *et al.* (2018) report that climatic conditions (*e.g.*, precipitation and drought) are major factors that determine the good development and yield of the crop.

Yield. The green matter yield per hectare of DK-4018 corn was statistically different between sowing densities (p≤0.05) at 76 days after sowing. The best results were obtained with the two highest densities (Figure 2); under the experimental conditions of this study, the sowing density and fresh weight yield per treatment have a directly proportional relationship.

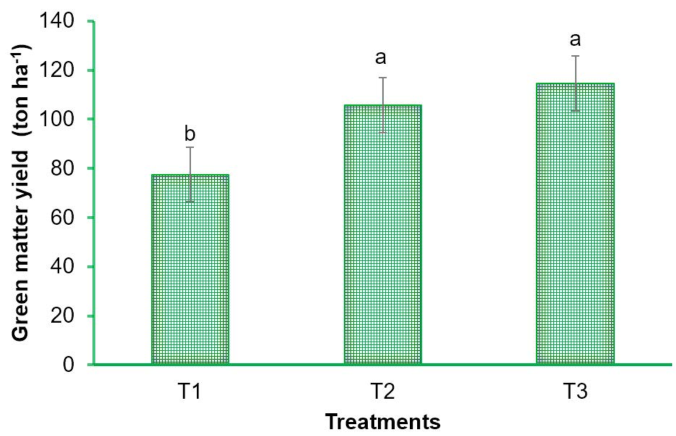

Figure 2. Green matter yield of DK-4018 corn with three sowing densities. Bars ± DE with different letters are statistically different (Tukey, p≤0.05). DDS=sowing density. T1=112,500, T2=120,000, and T3=136,000 plants per hectare.

CONCLUSION

For green matter production, the best sowing density of the DK-4018 corn hybrid is 136,000 plants per hectare, with an estimated fresh weight yield of 114.6 tons, under the edaphic and climatic conditions of Valle del Mezquital, Hidalgo, Mexico.

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