Effect of sowing density on yield and profitability of a hybrid corn under tropical conditions

Efecto de la densidad de siembra en el rendimiento y rentabilidad de un híbrido de maíz en condiciones tropicales

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ABSTRACT

A high sowing density in maize is a widely used management practice for increasing crop yield; this method increases intraspecific competition for solar radiation, nutrients and water, so yield per plant is reduced, but a greater number of plants is harvested. However, different corn hybrids present a differential behavior because some are tolerant and some are susceptible to this condition, as determined by their plasticity in adjusting their morphology and phenology. The aim of this study was to identify the optimum sowing density, in technical and economic terms, of a new hybrid corn named 30K73 YG RRFlex since no information is available for tropical conditions. This study was carried out in the province of Tolima, municipality of Valle de San Juan, Colombia, using a completely randomized block design in divided plots; five sowing densities determined by six spatial arrangements, two distances between rows (0.7 and 0.8 m) and three numbers of plants per linear meter (7, 8 and 9) were assessed. The treatments did not generate a nitrogen deficiency in the plants, and the evaluated hybrid developed morphological adjustments at the leaf level in order to maintain constant solar radiation interception. For yield, there were no significant variations, so the yield was similar for all of the evaluated treatments. The best treatment was 87,500 plants ha^{-1}, with a yield of 9,916.66 ± 1,078 kg ha^{-1} and a profitability of 58%.

Key words: seeding density, nutritional status, crop yield, growth.

RESUMEN

El uso de altas densidades poblacionales en cultivos de maíz se considera una práctica de manejo muy usada para incrementar el rendimiento del cultivo; este método de siembra aumenta la competencia intraespecífica por radiación solar, nutrientes y agua, por lo que el rendimiento por planta se ve reducido, pero se compensa por el mayor número de plantas cosechadas. Sin embargo, los diferentes híbridos de maíz tienen un comportamiento diferencial pues algunos son tolerantes o susceptibles a esta condición. Esto es determinado por la plasticidad del material para ajustar su morfología y fenología. El objetivo de este trabajo fue identificar la densidad poblacional óptima en términos técnicos y económicos, para un nuevo hibrido de maíz 30K73 YG RRFlex, del que no se conocía una recomendación a nivel de trópico. Este trabajo fue realizado en el departamento del Tolima, municipio del Valle de San Juan, Colombia, usando un diseño en bloques completos al azar en parcelas divididas; allí se evaluaron cinco densidades poblacionales determinadas por seis arreglos espaciales dados por dos distancias entre surcos (0.7 m y 0.8 m) y tres números de plantas por metro lineal (7, 8 y 9). Allí se encontró que los tratamientos no generaron deficiencia de nitrógeno en las plantas. Además este hibrido desarrolló un ajuste morfológico a nivel foliar para mantener constante la intercepción de radiación solar. En cuanto a rendimiento se encontró que no se presentaron variaciones significativas, por lo que el rendimiento fue similar para los tratamientos evaluados, de tal forma que el mejor tratamiento fue de 87,500 plantas ha^{-1} con un rendimiento de 9,916.66 ± 1,078 kg ha^{-1} y una rentabilidad del 58%.

Palabras clave: densidades poblacionales, estado nutricional, rendimiento de cultivo, crecimiento.

Introduction

Maize (*Zea mays* L.) cultivation is essential for humanity since it is an important source of carbohydrates, which are necessary for obtaining metabolic energy (Morales-Ruiz *et al.*, 2016). Moreover, considering the increased world population in the future, it is necessary to increase corn yield in order to satisfy carbohydrate demands. In the absence of biotic or abiotic stress, solar radiation capture is the determining factor for plant performance (Cox and Cherney, 2001). However, it increases through agronomical practices such as genetic breeding, sowing dates, fertilization and sowing densities (Duvick, 2005; Morales-Ruiz *et al.*, 2016). The use of high sowing densities has been a

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widely studied practice, with constant evolution over time (Tollenaar, 1992). Thus, the implementation of an adequate sowing density can increase the interception of solar radiation and water and nutrient uptake by crops (Duan, 2005).

A high sowing density leads to increased intraspecific competition for light, generating stress as a result of low radiation and limiting photosynthesis; in addition, plant growth is altered by avoiding a response to the shading produced by stalk elongation and petiole and apical dominance. Nevertheless, corn plants respond by adjusting leaf morphology, with narrower and smaller leaves with a more acute insertion angle (Gou *et al.*, 2017), resulting in changes in the leaf area index (LAI).

Solar radiation captured by canopies and efficiency in carbohydrate conversion determine dry matter accumulation (Boomsma *et al.*, 2009). The solar radiation captured by canopies depends on the fraction of the solar radiation intercepted per day, and this is defined by the LAI and the light extinction coefficient (*k*) (Shi *et al.*, 2016). Therefore, reaching an optimum LAI in the shortest possible time is important for increasing dry matter production (Morales *et al.*, 2016). A reduction of 20% in stalk thickness has been reported with the use of high sowing densities, so plants become more susceptible to lodging. In addition, plants change the yield components and morphological characteristics of the cob (Testa *et al.*, 2016). Under this condition, yield per plant is reduced, but a higher number of harvested plants compensates for this reduction (Hashemi *et al.*, 2005). Furthermore, maximum yield per unit area can be obtained with a density of 100,000 plants ha^{-1} (Huseyin *et al.*, 2003).

Nitrogen is an essential macroelement that limits plant performance (Marschner, 2012). It is closely related to photosynthesis since it is an essential part of the Rubisco enzyme and chlorophyll (Imai *et al.*, 2008; Lee *et al.*, 2011). Nitrogen availability is a yield limiting factor when high sowing densities are used since crops, because of competition, present stress to low contents of this element (Al-Naggar *et al.*, 2015). Therefore, it is necessary to increase nitrogen fertilization; however, corn producers cannot perform this practice because of resource limitations, so methodologies that do not generate a nitrogen deficiency stress should be identified (Bänziger *et al.*, 1999).

Considering the plant genetic materials of this species, there are hybrids that do not tolerate high sowing densities because of significant yield reductions per unit area. On the other hand, there are hybrids that tolerate this condition because they develop morphological and phenological adjustments (Duvick *et al.*, 2004). Therefore, it is important to establish a sowing density for hybrids and for varieties in each agroecological zone in order to reach maximum yield and, therefore, greater profitability. Currently, in Colombia, the genotype that shows this type of behavior is the Impacto® hybrid, which reaches maximum yield with a sowing density of 112,500 plants ha^{-1} (Quevedo *et al.*, 2015).

Bearing in mind that the behavior of hybrid 30K73 YG RRFlex under different sowing densities is not known, the aim of this study was to evaluate the effect of different sowing densities on the yield and the profitability of this hybrid and to identify its optimal sowing density.

Materials and methods

This research was carried out between the months of October and March, 2013 in the municipality of Valle de San Juan, province of Tolima, Colombia. The average temperature was 26°C, with 80% relative humidity and average precipitation of 1,552 mm per year. This study site was selected because about 22% of the genetically modified corn is planted in this region (Agronet, 2018). The location coordinates were 4°12’42.8” N and 75°9’38.1” W, at an altitude of 650 m a.s.l. The soil where the experiment was established had a fluvial-volcanic origin and sandy clay loam texture.

The experiment was established in a randomized complete block design in divided plots with four replicates. The main plots had distances between the rows of 0.7 m and 0.8 m, and the subplots were number of plants established per linear meter (7, 8 and 9). This combination generated six treatments that corresponded to the sowing densities that are shown in Table 1.

TABLE 1. Treatments as a function of sowing densities.

Row distance (m)	Number of plants	Sowing density (plants ha^{-1})
0.7	7	100,000
0.7	8	114,286
0.7	9	128,571
0.8	7	87,500
0.8	8	100,000
0.8	9	112,500

Each subplot was comprised of six rows that were 10 m in length, where two plants per site were manually sown. When the plants reached the V3 stage, thinning was carried out, leaving one plant per site. Agronomic management was carried out according to local production practices, and all of the experiment units were subjected to the same agronomic and edaphoclimatic management conditions, so the observed variations were attributed to the population density treatments. The fertilization of the crop was carried out based on soil analysis and crop extraction, which was 120 kg of N ha^{-1}, 80 kg of P_2O_5 ha^{-1} and 120 kg of K_2O ha^{-1}.

To achieve the aim of this study, the following variables were evaluated within the four central rows:

Relative chlorophyll content

The relative chlorophyll content (RCC) in the SPAD units was estimated in the fifth youngest leaf during the vegetative phase (V8) and the beginning of the reproductive phase (VT); The RCC was evaluated in the basal, middle and distal zone of each leaf in four plants per subplot using a portable chlorophyll meter (SPAD 502, Konica-Minolta, Japan).

Plant and cob height and stalk diameter

These variables were evaluated in all plants that were in their R1 stage and throughout four linear meters. The plant height was registered as the length in meters from the base of the stalks to the apex of the cobs. Moreover, the cob height was measured from the base of the stalks to the insertion of the lowest cobs. The stalk diameter was calculated in node one with a digital calibrator and, with this measurement, the stalk area was calculated (Eq. 1) following the methodology described by Testa *et al.* (2016).

$$Stalk\ area = \left(\frac{\left(\frac{D}{2} \times \frac{d}{2} \right)}{100} \right) \times \pi \tag{1}$$

where D refers to the maximum diameter and d to the minimum diameter.

Solar radiation intercepted per day and light extinction coefficient

Four measurements were taken per subplot when the plants were in the VT stage. The solar radiation intercepted (RI) measurement was carried out in the hours of maximum solar radiation (11:00 to 13:00 h) using a linear ceptometer (AccuPAR Linear Ceptometer, Decagon Devices, Pullman, WA, USA) where the incident radiation in the upper part (IRUP) and in the lower part (IRLP) of the canopy was assessed (Williams, 2012). With this data, the RI was calculated using the formula described in Equation 2 (Shi *et al.*, 2016). Moreover, with these measurements, the light extinction coefficient (k) was also estimated using Equation 3 (Flénet *et al.*, 1996).

$$RI = 1 - \left(\frac{IRLP}{IRUP} \right) \tag{2}$$

$$k = \frac{-\ln\left(\frac{IRLP}{IRUP} \right)}{LAI} \tag{3}$$

Performance components and morphological characteristics of the cob

To estimate the prolificacy or the number of cobs per plant, four lineal meters were assessed in each subplot, and the number of cobs was counted. For the other obtained data, the harvest of the two central rows was carried out when the plants reached physiological maturity (R6). From the harvested cobs, 20 were randomly selected, and the number of rows per cob, number of grains per row, seed index, cob height and diameter, percentage of grains and number of grains per cob were established. Subsequently, all of the harvested cobs were manually shelled, and the result of this process was weighed and adjusted to 12% grain moisture.

Profitability

To calculate profitability (Pr), Equation 4, as published by Quevedo *et al.* (2015), was used. For this, a production cost (PC) structure was made for each treatment, where the only variation source was seed cost. In addition, the grain sale price (SP) was calculated according to the price stated by the national agricultural exchange market of Colombia. Letter Y represents yield.

$$Pr = \left(\frac{(Y \times SP) - PC}{Y \times SP} \right) \times 1 \tag{4}$$

Statistical analysis

A univariate analysis of variance with mean comparison Tukey test ($\alpha = 0.05$) and multivariate analysis of variance with mean comparison Hotelling test ($\alpha = 0.05$) were performed. For these analyses, a preliminary analysis of the assumptions was carried out. The software used for the statistical analyses was R version 3.4.1 (R Core Team, 2017) through RStudio version 1.0.136 (RStudio, USA).

Results and discussion

Relative chlorophyll content

Table 2 shows that the factors of the experiment and their interaction did not generate statistically significant variations for the RCC.

TABLE 2. Summary of the analysis of variance for the RCC evaluated in V8 and VT plants under different sowing density treatments.

Factor	RCC in V8	RCC in VT
Row distance (RD)	ns	ns
Number of plants (NP)	ns	ns
RD x NP	ns	ns

ns: non-statistical significant differences.

Despite not showing statistical differences, Figure 1 shows that the plants in V8 decreased their RCC as the sowing density increased; however, in VT, this trend was not clear despite the finding that the SPAD value was the highest (50) with the lowest sowing density (87,500 plants ha^{-1}).

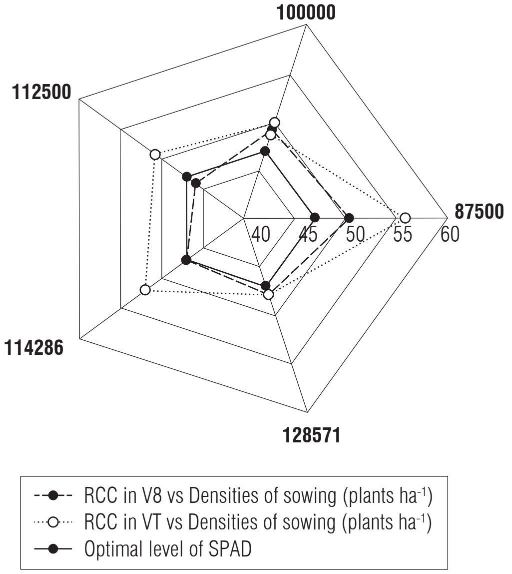

FIGURE 1. RCC in two phenological stages as a function of the effect of six sowing density treatments in corn.

Plant and cob height and stalk diameter

Table 3 shows the effect of each factor on these variables. The interaction of row distance x number of plants was observed. The sowing density did not affect any of the evaluated growth parameters at the statistical level; however, significant effects of individual factors were found. Figure 2 shows that the number of plants generated significant differences in the stalk diameter with an inverse relationship (i.e. increasing the number of plants generated a reduction in stalk diameter). For plant and cob height, the distance between the rows significantly affected this variable. In Figures 3A and 3B, it was observed that the plants and cobs developed a higher height when they were established with a distance between rows of 0.8 m. Nonetheless, Figure 3C shows the ratio observed between the plant and cob height, which established the relative position of the cobs inside the canopy. Additionally, it was observed that the cobs were located in a similar position with both row distances.

TABLE 3. Summary of the analysis of variance for stalk area, plant height and cob height.

Factor	Stalk area	Plant height	Cob height
Row distance (RD)	ns	**	*
Number of plants (NP)	*	ns	ns
RD x NP	ns	ns	ns

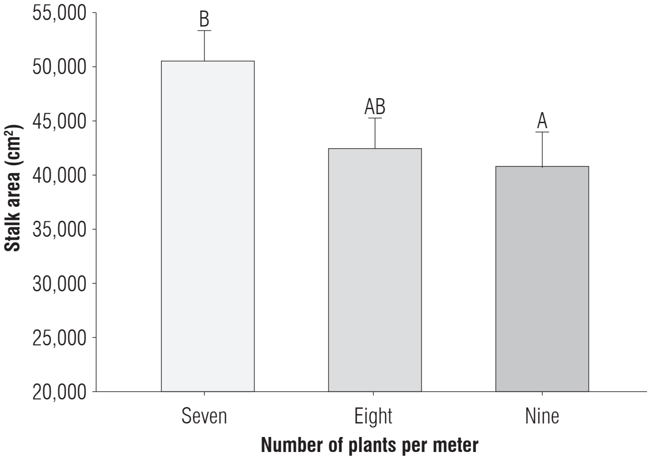

FIGURE 2. Corn stalk area obtained with three different numbers of plants per linear meter. Lines indicate the standard error, and treatments with different letter are significantly different ($P<0.05$).

Morphological cob characteristics

To determine whether the sowing density treatments affected parameters such as number of rows per cob, number of grains per row, seed index, grain percentage, cob height and diameter, a multivariate analysis of variance was carried out (data not shown). This analysis showed that the treatments did not statistically affect the evaluated variables. However, Table 4 shows that the seed index, number of grains per cob and grain percentage showed high variability among the row distances. Therefore, a multivariate analysis of variance was carried out only for these variables. According to the analysis observed in Table 5, there were statistical differences between the two row distances, with evidence that the plants established with a distance of 0.8 m between rows had a greater number of grains per cob as a result of higher grain filling. This was corroborated by a greater grain percentage, plus the fact that grains were heavier.

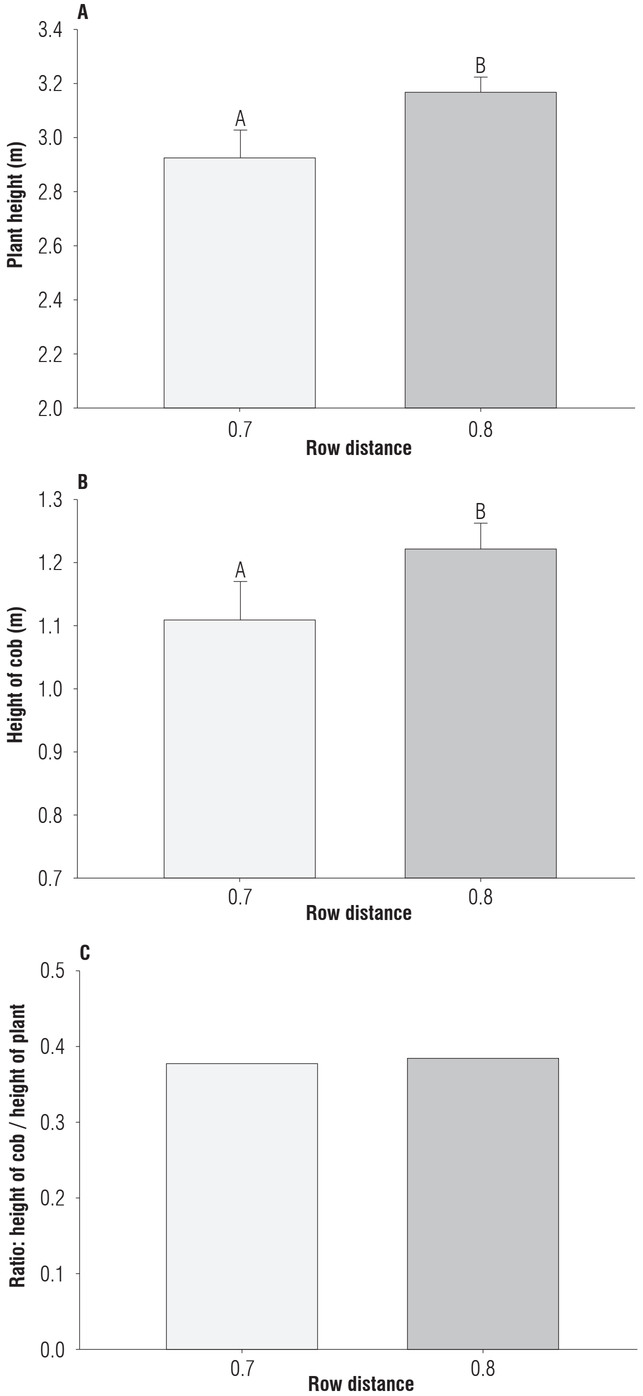

FIGURE 3. Influence of distance between rows on A) Plant height, B) Cob height, C) Cob height/plant height ratio. Lines indicate the standard error, treatments with different letter are significantly different ($P<0.05$).

Leaf area index, light extinction coefficient and intercepted radiation fraction

The results were analyzed with a multivariate analysis of variance, showing that the LAI, *k* and RI were equal at the significant level considered for the effect of the row distance, number of plants and their interaction. Table 6 shows the values of each of these parameters; moreover, it was observed that the LAI did not have a defined trend, ranging between 5-6, as seen with the *k* and RI, which were between 0.15-0.2 and 0.59-0.63, respectively. This suggested that the light distribution inside the canopy was very good; however, the LAI developed by the plants did not capture large amounts of solar radiation.

TABLE 5. Yield components of corn plants established with two different distances between rows.

Row distance (m)	Seed index (g)	No. of grains per cob	Grain percentage (%)	Hotelling grouping
0.7	22.05	390.12	80.65	A
0.8	26.24	398.7	83.2	B

Treatments with different letter are significantly different ($P<0.05$).

TABLE 6. Characteristics of solar radiation interception by corn plants in the VT stage established with different sowing densities.

Row distance (m)	No. plants	Sowing density (plants ha^{-1})	LAI	*k*	RI	Hotelling grouping
0.8	7	87,500	5.78	0.16	0.6	A
0.8	8	100,000	5.65	0.17	0.6	A
0.8	9	112,500	6.17	0.15	0.59	A
0.7	7	100,000	5.25	0.19	0.62	A
0.7	8	114,286	5.8	0.17	0.63	A
0.7	9	128,571	4.97	0.21	0.63	A

Treatments with different letter are significantly different ($P<0.05$).

Yield

Yield is the final expression of plant growth and development regarding yield components. The row distance x number of plants interaction was significant for yield. Table 7 shows that the highest yield was 10,469 ± 765 kg ha^{-1}, obtained with 128,571 plants ha^{-1}; however, this was only

TABLE 4. Morphological characteristics of cobs found in plants sown with two distances between rows.

Row distance (m)	Seed index (g)	Cob diameter (mm)	Cob height	Number of rows	No. of grains per row	No. of grains per cob	Grain percentage (%)	Hotelling grouping
0.7	22.05	36.17	138.4	12.46	31.29	390.12	80.65	A
0.8	26.24	34.94	147.2	12.5	31.9	398.7	83.2	A

Treatments with different letter are significantly different ($P<0.05$).

TABLE 7. Crop yield per plant obtained with different corn sowing densities.

Row distance (m)	Number of plants	Sowing density (plants ha^{-1})	Prolificacy	Yield (kg ha^{-1})	Yield per plant (g)
0.8	7	87,500	1.18 ± 0.1 A	9,914.66 ± 1078 AB	113.31 ± 12.33 B
0.7	7	100,000	1 ± 0 A	7,548.43 ± 567 A	75.48 ± 5.67 A
0.8	8	100,000	1 ± 0 A	8,285.38 ± 230 AB	82.85 ± 2.31 A
0.8	9	112,500	1 ± 0 A	10,082.91 ± 725 AB	89.63 ± 5.96 AB
0.7	8	114,286	1 ± 0 A	10,754.68 ± 342 B	94.1 ± 3.83 AB
0.7	9	128,571	1 ± 0 A	10,469 ± 765 B	81.43 ± 6.45 AB

Treatments with different letter are significantly different ($P<0.05$); the numbers are means ± standard error.

different at the considered significant level from the density of 100,000 plants ha^{-1}, established in an arrangement with a 0.7 m sowing density and a number of plants of 7, which obtained the lowest yield (7,548.43 ± 567 kg ha^{-1}).

For yield per plant, it was observed that the row distance x number of plants interaction was significant, with evidence that the yield per plant was much higher under 87,500 plants ha^{-1} (lowest evaluated density) than at the other densities. The yield per plant did not exceed 95 g; the high yield per plant in this treatment can be explained by the prolificacy of 1.18, about 18% higher than other densities.

The efficiency evaluation of this practice, in economic terms, is presented in Figure 4 and was elaborated with a purely descriptive analysis. In this figure, it can be observed that, for all of the treatments, the profitability exceeded 30%, and the treatment with 87,500 plants ha^{-1} stood out as the most profitable. For cost per plant, it was observed that, as the sowing density increased, the cost decreased, with $0.127 USD for the treatment with 128,572 plants ha^{-1}.

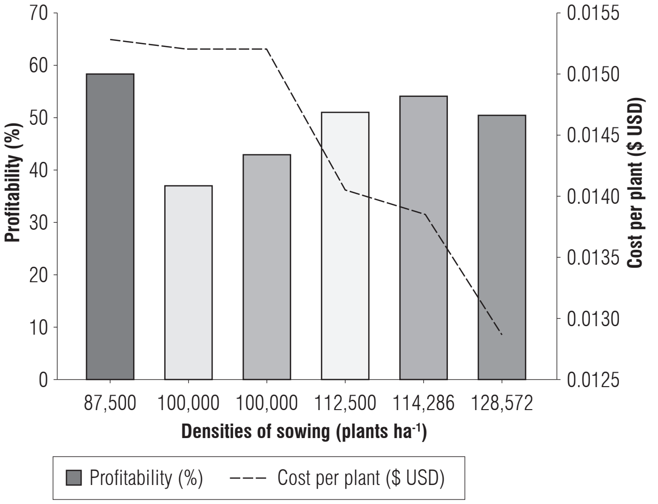

FIGURE 4. Profitability and cost per plant obtained with different treatments as a function of sowing density.

The RCC in monocotyledonous plants has a strong relationship ($r^2 = 0.8$) with foliar nitrogen contents (Xiong *et al.*, 2015). In corn, the chlorophyllometer is a widely used tool for nitrogen assessment (Yu *et al.*, 2010). In this study, it was observed that, for the hybrid 30K73, the RCC was not significantly affected by the treatments in either of the two evaluated phenological stages. Nonetheless, Figure 1 shows that, in plant stage V8, the treatments with 87,500 plants ha^{-1} and 100,000 plants ha^{-1} exceeded the optimum RCC level (47 SPAD) established for corn (Sainz and Echeverría, 1998); on the other hand, with a higher sowing density, the RCC was very close to this level. Moreover, in the VT stage, the plants in all of the treatments, with the exception of the sowing density 128,571 plants ha^{-1}, exceeded the optimum level, with the sowing density 87,500 plants ha^{-1} obtaining the highest RCC with 55 SPAD. It is noteworthy that, according to these results, the treatments did not produce nitrogen deficiency since none reached 35.3 SPAD (Novoa and Villagrán, 2002). It has been reported that a high sowing density causes stress as a result of a low nitrogen content (Al-Naggar *et al.*, 2015). However, intra-specific competition as caused by high sowing densities did not limit nitrogen availability for the hybrid 30K73 plants. This means that the hybrid can be tolerant to high sowing densities, which agrees with Al-Naggar *et al.* (2015), who stated that there are hybrids that need high amounts of nitrogen when they are established with a sowing density close to 95,200 plants ha^{-1}.

The foliar nitrogen content has a strong relationship with RI and solar radiation conversion to dry matter, i.e. with efficient radiation use, since this element is related to greater foliar expansion and chlorophyll and Rubisco contents (Uhart and Andrade, 1995; Imai *et al.*, 2008; Lee *et al.*, 2011). With the use of high sowing densities, plants can adjust their leaf morphology and adapt to solar radiation competition (Duvick *et al.*, 2004).

The LAI is a variable that is altered with changes in population density; it increases with the sowing density in order to expose more area and increase RI (Morales-Ruiz *et al.*, 2016); however, the development of a higher LAI depends on nitrogen availability (Chen *et al.*, 2017). In the case of the 30K37 hybrid, it was found that it adjusted its leaf morphology and maintained a LAI that did not vary significantly in the various treatments. Likewise, the *k* in this hybrid was very low (0.21-0.15), which means that the light was evenly distributed in the canopy, allowing a large amount of radiation to reach the lower third part of the plants. Therefore, this variable was not affected by the treatments, which contrasts with other studies, where the *k* increased when the sowing density increased (Flénet *et al.*, 1996; Morales-Ruiz *et al.*, 2016). Despite reaching a low *k*, the RI was very low in all of the treatments within a range of 0.59-0.63 and, therefore, there were no statistical differences between the treatments. This could have been because changes in the LAI were not significant, which contrasts with the RI obtained by Morales-Ruiz *et al.* (2016).

The evaluated hybrid was tolerant to a high sowing density since it adjusted its leaf morphology to maintain a constant RI to allow it to grow and develop.

Furthermore, variables, such as plant and cob height and stalk diameter, were related to plant lodging (Tollenaar, 1992; Wang *et al.*, 2016). Studies have reported that the sowing density affects these characteristics (Testa *et al.*, 2016; Gou *et al.*, 2017). The plant height was affected by the row distance; the plants reached their highest height with a row distance of 0.8 m. Usually, the opposite happens with a narrower row distance because the light quality is altered, with a greater amount of far-red light (Rajcan and Swanton, 2001), generating an avoidance response to shading and increasing stalk elongation and, therefore, plant elongation (Gou *et al.*, 2017).

The cob height had a similar behavior to that of the plant height, with the cobs located at a greater height with a row distance of 0.8 m. However, Figure 3C shows that cobs in both treatments were inserted below the center of gravity (0.5) and exactly in the same position (0.39), regardless of height. This indicates that cob insertion in this hybrid is a characteristic that is not affected by sowing density, thereby reducing the possibility of lodging.

The number of plants affected the stalk area in this study; the stalks became thinner as the number of plants increased. This agrees with the findings published by Testa *et al.* (2016), who found that stalk area was reduced by 20% as a result of a high sowing density, meaning this behavior is undesirable since lodging susceptibility increases.

An increase in sowing density is considered a stress factor for plants since it affects yield, which is reduced per plant. However, crop yield can be compensated for with a higher number of harvested plants (Li *et al.*, 2015). In this research, it was found that the seed index and number of grains per cob were reduced by planting this hybrid with a row distance of 0.7 m as a result of an increase in intraspecific competition for carbon, nutrients and water (Liu *et al.*, 2015; Testa *et al.*, 2016). Furthermore, this behavior explains the low yield per plant (<100 g) in all of the treatments, except for the one with 87,500 plants ha^{-1}, which had the lowest sowing density. However, different authors have reported that this is a normal behavior (i.e. compensation resulting from a higher number of harvested plants). This means that hybrid 30K73 YG RRFlex, used in this study, has plasticity because it adjusts its yield components according to the sowing density to maintain a similar crop yield, which would allow each plant to ensure seed availability to establish future generations.

The sowing density for every hybrid and variety that will be planted in any agroecological zone should be adjusted (Sangoi *et al.*, 2002). In a previous research on the same agroecological zones and treatments, the Impacto hybrid increased its yield in response to an increase in sowing density, with 112,500 plants ha^{-1} as the point of inflection for yield. For this reason, this hybrid has been considered as tolerant to high sowing densities (Quevedo *et al.*, 2015) taking into account the previously discussed results, in which it is evident that hybrid 30k73 has an opposite behavior. Furthermore, it is important that each genetic material that is released to the market is accompanied by specific management recommendations so that the best genetic potential of the cultivar can be achieved.

In addition, the management practices of a crop must be considered from a technical and economic viability point of view (Khush, 2015). From an agronomic point of view, for grain production, it is recommended that this hybrid be established with a sowing density of 87,500 plants ha^{-1} in a spatial arrangement with a row distance of 0.8 m and seven (7) plants, which will achieve better stalk development that avoids plant lodging and generates a profitability of 58%, higher than the other treatments. On the other hand, if this hybrid is used for forage production, it is advisable that it be established with a density of 128,571 plants ha^{-1}, a row distance arrangement of 0.8 m and nine (9) plants since the LAI and grain yield remain constant. This would produce a higher amount of forage per area; however, this hypothesis should be evaluated in another experiment.

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