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Incidence of the mechanized sowing speed in irrigated rice

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Abstract
This paper presents some experimental results to determine the incidence of mechanized sowing speed in the development and growth of rice in El Espinal-Tolima. Using a completely randomized design and a seed density of 104.5 ± 3.3 kg/ha, plots were sown in three replicates at 3.31 ± 0.05 km/h, 5.13 ± 0.18 Km/h, and 6.98 ± 0.24 km/h. Plant population, plant weight, dry matter, moisture content, and yield showed statistically significant differences with respect to sowing speed. This research found that the sowing speed has a proportional relationship with: a) the percentage of plants grouped in their roots, b) the number of non-productive tillers, c) the fuel consumed rate, d) uncovered seed, e) effective field capacity. The sowing speed of 5.13 ± 0.18 km/h was achieved by plants with a higher number of panicles per m^2 and yield: this is optimal.

Keywords: Sowing speed; irrigated rice; rice profitability

Incidencia de la velocidad de siembra mecanizada en el arroz de riego

Resumen
Se determinó la incidencia de la velocidad mecanizada de siembra en el desarrollo y crecimiento del arroz en El Espinal-Tolima. Utilizando un diseño completamente al azar y una densidad de semilla de 104.5 ± 3.3 kg/ha, se sembraron parcelas en tres repeticiones a 3.31 ± 0.05 km/h, 5.13 ± 0.18 Km/h y 6.98 ± 0.24 km/h. La población de las plantas, el peso de la planta, la materia seca, el contenido de humedad y el rendimiento mostraron diferencias estadísticamente significativas con respecto a la velocidad de siembra. Se encontró que la velocidad de siembra tiene una relación proporcional con: a) el porcentaje de plantas agrupadas en sus raíces, b) los tallos no productivos, c) el combustible consumido, d) las semillas descubiertas, e) la capacidad de campo efectiva. La velocidad de siembra de 5.13 ± 0.18 km/h logro plantas con mayor número de panículas por m^2 y rendimiento, lo cual es óptimo.

Palabras claves: Velocidad de siembra; arroz de riego; rentabilidad del arroz.

1. Introduction

The adoption of mechanized practices means a decrease in labor costs for the rice farmers; however, incorrect machining activities limit profitability. It is important to be able to compete in the international market and have access to free trade agreements [1]. In 2030, a free trade agreement will allow the United States to export rice to Colombia without tariffs, which will have an impact on the regional economy (Tolima) and the rural sector in Colombia.

Rice growers need to sow on a specific date and expand the sown area with the same seeder. This leads to an increase in the speed of planting rice without considering its impact. The effective mechanized planting of rice is achieved with certified and treated seed, which is planted at the right date, has a regulated seed density, good water management, and the proper machinery is used. The proper distribution of the seeds by the seeder is important to avoid stress in the rice during its development and growth. The seed that is exposed or placed at an inadequate depth influences uniform emergence, and in turn this means that not all plants develop in the same way in terms of their state and thus the application loses effectiveness.

The optimum speed of mechanized sowing increases the yield for corn [2-9], sunflower [10], soy [11-13], and wheat [14]. In references [4-9,12], yield has been favored with the

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lowest sowing speeds. In terms of rice sowing speed, El-Khateeb and Khodeir [15] evaluated forward speed and performance rice planting machines (mechanical drilling and mechanical transplanting). They found that increasing the forward speed for all rice planting machines tends to increase the effective field capacity, fuel consumption rate, power consumption, energy required, and slip ratio; it also decreases field efficiency. Blanco and Morales [16] recommend not exceeding 6 km/h. SOSBAI [17] recommend that the rice seeder is used at the appropriate speed in order to distribute seeds in a uniform manner in the line, which is varies according to the characteristics of the area.

The purpose of this work was to find out the difference in the effect of the mechanized sowing speed on the development, growth and yield of irrigated rice in El Espinal, Colombia. In this zone, rice irrigation is designed with small-scale land leveling, and rice levees at level curve are compacted with “Taipa” [18]. Rice levee acts like speed bumps (or speed breakers) during rice sowing.

2. Materials and methods

The experiment was established using a completely randomized design at the "La Granja" Agricultural Center, Servicio Nacional de Aprendizaje (SENA), in El Espinal, Tolima, located at 4 ° 9'56.89 "N and 74 ° 55'59.96" W. Nine plots were established based on three sowing speeds with three replicates. Each plot was 50 m long and 8.1 m wide. All plots were site-specific with similar production potential (“Sub-region of a field that expresses a relatively homogeneous combination of yield limiting factors [19]”). Site-specifications were determined according to references [20-22] with normalized difference vegetation index maps, soil characteristics, and the yields from the last two years. The soil was of sandy texture (Table 1, Fig. 1). There was a flat topography, which had a longitudinal and transverse slope of 0.82% and 0.11%, respectively.

Land preparation was undertaken with two disc harrow passes and a LandPlane pass. Irrigation was designed with small-scale land leveling, and rice levees on a level curve that was compacted with “taipa”. The demarcation of the surrounding levees in the terrain was undertaken with laser level (Laser Leica Rugby 830). Controls were directed to broadleaf (Cucumis melo), cyperaceas (Cyperus rotundus), and Echinochloa colona in post-early, and applications focused on post-tardy.

The FEDEARROZ 2000 variety germination test reached 91 percent germination. According to Guzmán [23], more than 75% of rice growers use a seed density equal to or greater than 120 kg of seed per hectare. According to Pulver [24], and Carmona and Dotto [25], densities between 60 and 100 kg/ha produce stronger plants, achieve a population between 150 and 250 plants/m^2, and there is a possibility of 600 and 800 panicles/m^2 as well as high yields. Therefore, the seeder was calibrated with a seed density of close to 105 kg/ha.

Seeding was undertaken with a SEMEATO PD 17 seeder (17 lines x 17 cm) with a seed density of 104.5 ± 3.3 kg of seed/ha. Eq. 1 defined seeding speeds. The 6145J John Deere tractor engine speed, B1 at 1400 revolutions per minute (rpm),

Table 1.
Soil characteristics

*	SA	C	T	RD	AD	TP	pH	OM
1	58.4	18	FA	2.73	2.3	16.6	6.8	1.12
2	59	12.4	FA	2.91	2.0	30.9	7.2	0.68
3	63	11.6	FA	2.41	2.0	22.5	6.5	0.89
4	49.0	13.0	F	2.2	1.9	18.6	7.3	0.89

* Sampling point. SA= Sand (%). C= Clay (%). T = Texture. RD = Real Density (gr/cm^3). AD = Apparent Density (gr/cm3). TP = Total Porosity (%). OM = Organic matter (%).
Source: The authors

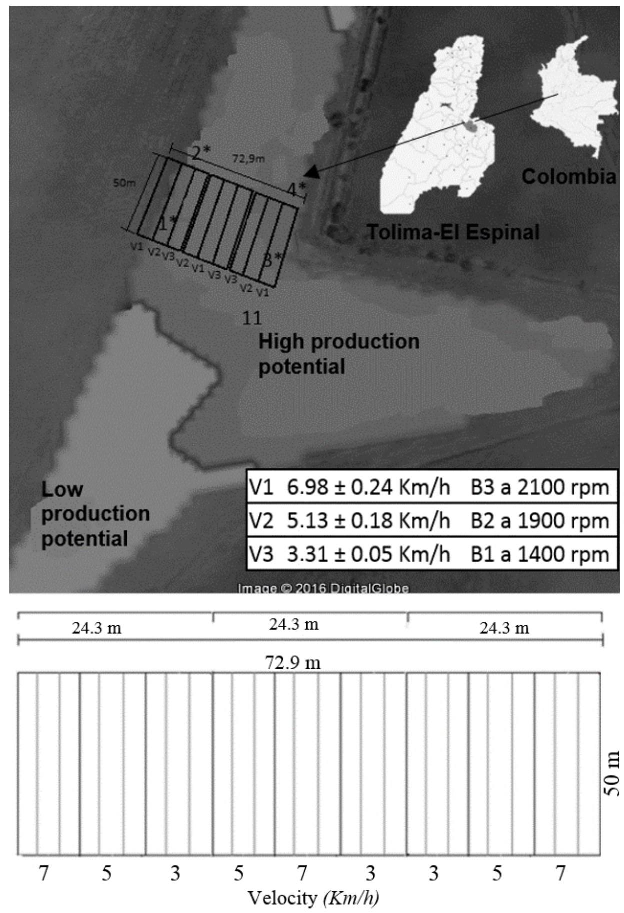

Figure 1. Location and plots characteristics of the Agricultural Center "La Granja".
Source: The authors, Google Earth, and Paint.

B2 at 1900 rpm, and B3 at 2100 rpm corresponded to speeds of 3.31 ± 0.05 km/h, 5.13 ± 0.18 km/h and 6.98 ± 0.24 km/h, respectively. The document will discuss 3, 5, and 7 km/h. The theoretical field capacity (TC) is the result of multiplying the average speed (km/h) when working width of the seeder (m) by a conversion factor equal to 0.1.

$$V = \left(\frac{L}{\bar{t}} \pm \sqrt{\sum_{i=1}^{N} \left(\frac{L}{t_i} - \frac{L}{\bar{t}} \right)^2 / (N-1)} \right) x3,6 \qquad (1)$$

Where "V" is the seeder speed (Km/h), L is the length of the plot (50m), "t" is the time spent to traverse the plot (s), "n" is time taken by each sowing speed (treatment), and $\bar{t}$ is the mean time.

Rice had intermittent irrigation in the dry season from May to October 2016, where the maximum solar radiation coincided with the reproductive and maturation rice phases. According to CORPOICA-NATAIMA weather station, which is to 6.7 km from the plots, in these phases the average solar radiation was 427.47 ± 84.79 Cal/cm^2-day. The irrigation sheet applied was 921 mm, and the total precipitation was 350 mm. The distribution of the monthly precipitation is bimodal, and there are abundant rains from March to May and from October to November. Ambient temperature in the vegetative phase oscillates between 21 and 36 °C, and between 20 and 38°C in the reproductive phase. FEDEARROZ-2000 tolerates daytime temperatures of between 29 to 37 °C, and does not tolerate night temperatures outside the range of between 21 to 25 °C [26]. Over a short period (10 days) in the reproductive stage, plots had a limited availability of water, which caused stress in the rice and has the ability to reduce yield [27].

Pyricularia control were undertaken with three applications of fungicide during the reproductive phase. FEDEARROZ 2000 has high susceptibility to diseases in relative humidity greater than 80%. The maximum relative humidity during rice development was 83%. Insecticide was not applied. Considering the chemical analysis of the soil, the nutritional requirements of FEDEARROZ 2000 [28], and the result of the FEDEARROZ Rice Fertilization System (SIFA; [29]), soil fertilizations were fractions with 160 kg-N/ha, 33 P_2O_5-kg/ha and 119 K_2O-kg/ha. When the average of the field readings with the chlorophyllometer SPAD 502 were between 34 ± 1 SPAD, nitrogen (NH_4) was applied. Field monitoring with Chlorophyllometer was undertaken according to Garcés and Castilla [30]. During floral primordium, the third fertilization was applied.

Variables measured in the vegetative, reproductive and maturation phases allowed the researchers to evaluate the incidence of mechanized sowing speed on rice development and growth. In the vegetative phase, eighteen days after sowing, and nine days after rice emergence (d. a. r. e), seed depth (SD) in thirty seedlings per plot were randomly selected and measured. Plant population per m^2 (P/m^2) was measured ten d. a. r. e with three replications per plot. Frame (1 m^2) was located at random.

The spacing between plants was determined ten d. a. r. e., and the distance between plants (Xi) was then measured within a frame (1 m^2) three replicates in each plot. The spaces between the plants were analyzed by the classification proposed by ISO 7256/1 *[31]*, which determines the percentage of spacing corresponding to normal, multiples, and fault classes.

For a seed density of 104 kg/ha, there are 62 seeds per linear meter; i.e. reference spacing (X_{ref}) of 1.6 cm. Normal class (NC) had X_i between 0.8 and 2.4 cm (0.5 X_{ref} <X_i <1.5 X_{ref}), multiple class (MC) had X_i less than 0.8 cm (X_i <0.5 m. X_{ref}), and fail class (FCS) had X_i greater than 2.4 cm. For the analysis were calculated the coefficient of variation (CV) and the precision index (PI) plant distribution (eq. 2 - 3).

$$CV = \frac{\sigma}{X}.100 \tag{2}$$

$$PI = \frac{\sigma}{X_{ref}}.100 \tag{3}$$

Where σ is the standard deviation of spacing between seedlings (cm), and X is the mean of all plant spacing (cm).

Field sampling was undertaken at maximum tillering (30 d. a. r. e.), flowering (99 d. a. r. e.), and maturation (127 d. a. r. e.). Each plot was divided into three parts, and in each of the parts a W path was taken, extracting two or more plants per point from the root. At a sampling point, roots grouped some plants. The percentage of plants grouped by their roots in each plot was determined (Plants grouped number/total number of plants * 100). In thirty rice plants selected per plot (70 plants in total) in the laboratory, plant length (PL), root length (RL), tillers length (TL), plant weight (PW), root weight (RW), and tillers weight (TW) were measured. Then, dry plant weight (DW), the percentage of dry matter (DM; eq. 4), and plant moisture (%P; eq. 5) were obtained. Drying was carried out at 60 ° C in a Memmert oven.

$$DM(\%) = \frac{DW}{PW} * 100 \tag{4}$$

$$PM\ (\%) = 100 - \ \%DM \tag{5}$$

In the reproduction (99 d. a. r. e.) and maturation phases (127 d. a. r. e.), three frames of 0.25 m^2 were randomly located in each plot. During flowering and maturation, the number of tillers (T/m^2) and panicles per m^2 (PA/m^2) were calculated. During maturation, 25 panicles were randomly collected within each plot. Filled grain per panicle (#G/PA: Number of filled spikelets panicle^{-1}), 1000 grain weight (1000GW), percentage of sterile spikelet (% SS), length of the panicle (PAL), and panicles weight per plant (PAW/P) were then characterized.

Variance analysis of the information collected in the statistical software "InfoStat" was performed, using the Duncan test with a 5% significance to compare means.

Fuel, seed, and yield with respect to mechanized sowing speed were then determined. The work team then estimated fuel consumed with volumetric containers, recharge of the tank after sowing the plot, and sowing area. The average fuel consumption rate (FC (Gallons/ha)) was then obtained by sowing speed. With six replications per plot, the percentage of uncovered seed (% US) per unit area was calculated as the average of the ratio between the number of seeds exposed in 1 m^2 and the seeds deposited in a 1 m^2 area by the seeder. In three samples of 0.25 m^2 per plot, the paddy yield using a manual grain harvest with 20.6% moisture was estimated.

3. Results and discussion

Table 2 presents the results from the variables measured in the three rice phases based on sowing speed. Sowing plots at 7 km/h allowed half the time required for planting with 3 km/h, and demanded 2.2 times more fuel than at a speed of 3 km/h.

The sowing speed of 5 km/h approached a seed depth for which the seeder was calibrated (3 cm) although there are no significant differences with the other speeds. Uncovered seed was less than 1% at all speeds used. The sowing speed of 7 km/h obtained the highest percentage of uncovered seed. Sowing speed was proportional to the quantity of uncovered seed, which is in agreement with Mahl et al. [7] for corn. The plant population obtained in the plots was superior to the 150 plants/m^2 recommended by Pulver [24] in order to obtain good yields. According to FEDEARROZ [32], the plots sown at 5 and 7 km/h were in the range of 300 to 350 plants/m.

There were significant differences in spacing in terms of multiples and faults classes. Seedlings in the plots sown at 7 km/h were closer to each other and had the highest percentage of multiple and normal spacing (Table 2). Plants were quite far apart (more than 2.4 cm) in the plots that were sown at 5 km/h. There were no differences in the normal spacing percentages. The authors observed that the multiple class had the lowest percentage spacing with a sowing speed of 3 km/h. The variability in seed distribution, expressed by the coefficient of variation (CV), was high for all three speeds.

In terms of the seed's longitudinal distribution, the optimum result would be a percentage of normal spacing that is close to 100%. However, both soil and machinery factors influence the distribution of irregular plants [25]. The seeder delivers seeds in a continuous flow.

In the three phases, the plots sown at 7 km/h had a higher percentage of plants grouped by root (Figs. 2-3). Sowing at high speeds does not evenly distribute the seed [2], which favors nutrient, light, and water competition in nearby plants and consequently affects production [33].

The weight of the plant presented statistically significant differences in the vegetative and maturation phases; the higher weight were sowing speed of 5 km/h. Therefore, the percentage of dry matter and moisture content varies throughout the different phases. The plots sown at 7 km/h had the lowest percentage of moisture (Fig. 4). Water stress and temperatures below 35 °C influence moisture content in the reproductive phase. During this phase, plots sown at 3 km/h had a higher moisture content (plots with lower plants population). Temperatures may affect pollen formation, grain fertility [34], and decrease potential yields by up to 50% [35].

Table 2.
Relationship of sowing speed with different variables

Sowing				**Vegetative phase - seedling**						
V (Km/h)	**TC (Ha/h)**	**FC (G/ha)**	**% US**	**SD (cm)**	**P/m^2**	**FCS (%)**	**NC (%)**	**MC (%)**	**CV (%)**	**PI**
3	0.96	2.55	0.86	3.14a	189b	25.63b	37.61a	36.76a	123.59	30
5	1.48	3.75	0.4	3.06a	331a	29.38a	34.90a	35.72b	120.83	29.4
7	2.02	5.62	0.17	3.17a	355a	12.11b	45.62a	42.27b	87.5	28.1

Vegetative phase - tillering					**Reproductive phase - flowering**						
V (Km/h)	**PL (cm)**	**PW (g)**	**DM (%)**	**PM (%)**	**PL(cm)**	**PW (g)**	**%DM**	**%PM**	**RL (cm)**	**T/m^2**	**PA/m^2**
3	27.30a	2.29b	19.37b	80.63a	91.77a	132.33a	27.14b	72.86a	20.78b	544a	299a
5	28.11a	3.09a	17.53b	82.47a	90.25a	133.00a	32.82a	67.18b	20.51b	637a	370a
7	27.83a	2.68ab	22.37a	77.63b	92.04a	112.44a	31.28a	68.72b	22.58a	736a	385a
F value	0.78	6	7.58	7.58	1.23	2.26	13.98	13.98	4.3	0.95	0.84
P value	0.458	0.0028	0.0006	0.0006	0.2936	0.1065	<0.0001	<0.0001	0.0147	0.4097	0.4509
CV	15.86	57.26	42.58	10.48	8.7	58.02	23.27	10.24	23.72	37.35	35.91

Maturation phase					**Yield components**						
V (Km/h)	**LP (cm)**	**PW (g)**	**DM (%)**	**PM (%)**	**1000GW (g)**	**PAL (cm)**	**PAW/P (g)**	**#G/PA**	**PA/m^2**	**%SS**	**Y (Ton/ha)**
3	88.01a	70.09c	27.81c	72.19a	23.73a	19.72b	7.60b	93a	451a	22.40a	5.83a
5	88.10a	107.11a	29.81b	70.19b	23.77a	19.78b	10.49a	82a	497a	19.70a	5.93a
7	89.59a	91.03b	31.97a	68.03c	23.47a	21.15a	11.66a	93a	405a	22.03a	4.37b
F value	1.39	10.55	10.97	10.97	0.01	13.1	8.4	0.86	2.14	0.08	8.76
P value	0.251	<0.0001	<0.0001	<0.0001	0.9964	<0.0001	0.0003	0.4677	0.1468	0.9281	0.0166
CV	7.67	51.71	19.16	8.18	20.04	10	67.22	13.06	20.92	43.16	9.54

Means with the same letter are not significantly different from each other. Duncan (p<0.05). P value is the significance level

Source: The authors

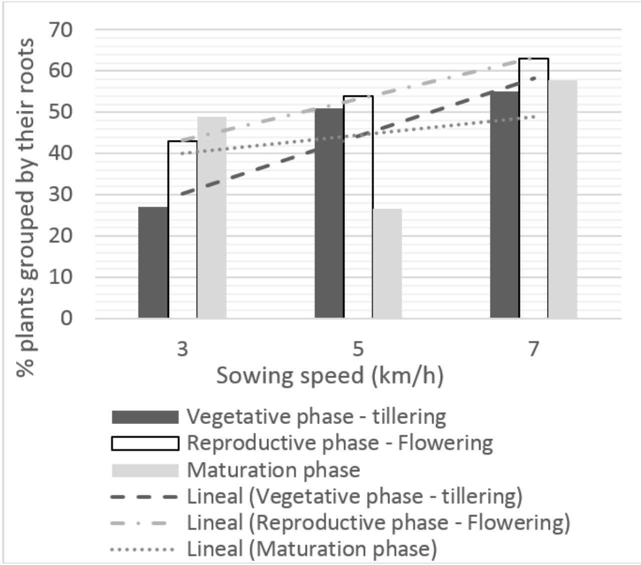

Figure 2. Percentage of grouping with respect to sowing speed and rice phase.
Source: The authors

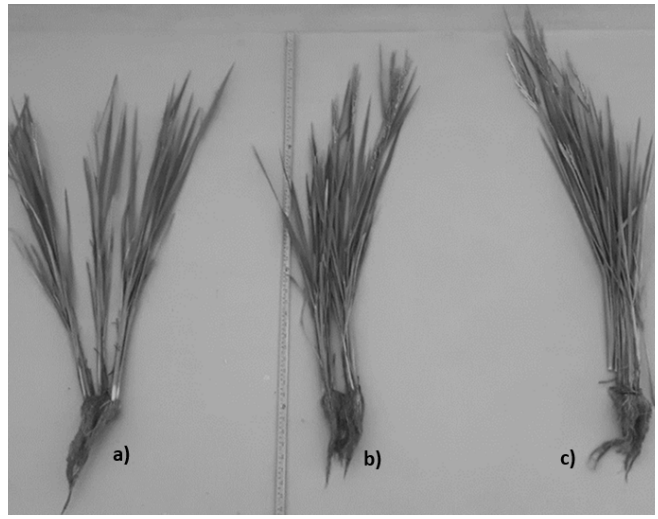

Figure 3. Plants grouped in the root. a-b) Three and two plants in competition; c) Plant with good development.
Source: The authors

No significant differences were found for plant length. However, after maximum tillers elongation, plants sown at 7 km/h were the largest, both in the aerial part and in the root. There are significant differences in terms of root length. The plots sown at 5 km/h had the shortest root length. As mentioned by Yoshida et al. [36], plants with the highest tillering ability tend to have a shorter root system due to competition for the assimilation of supplements, which is activated by the tillering process. Genetic factors, climatic conditions and agronomic management determined plant length [37]. Competing plants seek to grow by using light and water. Therefore, the competition between plants for light and water identified in plots sown at 7 km/h may explain the additional growth. The plant resources that are invested in the further elongation of the internode (sink and future source) affect the growth of the panicle (sink). In the reproductive-flowering phase, the number of tillers that did not produce panicle was higher as the sowing speed increased (Fig. 5).

There were no significant differences in the number of panicles per m^2, filled grain per panicle, 1000-grain weight, and percentage of sterile spikelet with respect to the sowing speed. Fig. 6 shows a principal component analysis. The number of panicles per m^2, 1000-grain weight, and yield were higher for the 5 km/h sowing speed, followed by 3 km/h (Figs. 7-8). The weight and length of the panicles per plant was higher in the 7 km/h plots planted.

The results of the components yield were compared with the work by Petro et al. ([38]; Zone benchmark, Figs. 7-8), where R1 and R2 represent the FEDEARROZ 2000 sowing campaigns in April and December 2013, respectively in Saldaña Tolima. Between Saldaña and El Espinal, there is a distance of 29.8 Km. The minimum temperature (Tmin) varied less than 1°C in the experiment (22.07 ±1.14 °C) and R1, as well as for R1 (23.05+1.10 °C) and R2 (23.07+0.89 °C: Fig. 9). The solar radiation in R1 (446.09 ±94.33 cal.cm-2.dia-1) and R2 (448.86 ±102.78 cal.cm-2.dia-1) were greater than the solar radiation

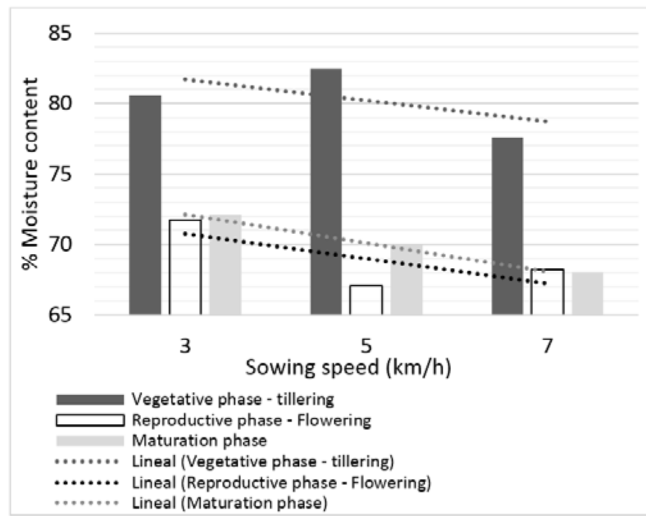

Figure 4. Percentage of moisture in the rice plant for the three phases.
Source: The authors

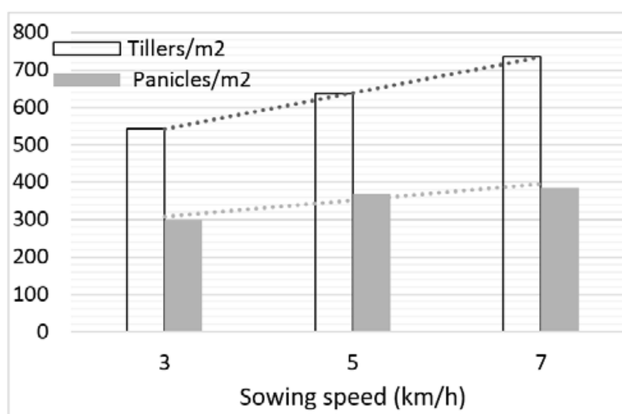

Figure 5. Tillers/m^2 vs. Panicles/m^2 for flowering rice.
Source: The authors

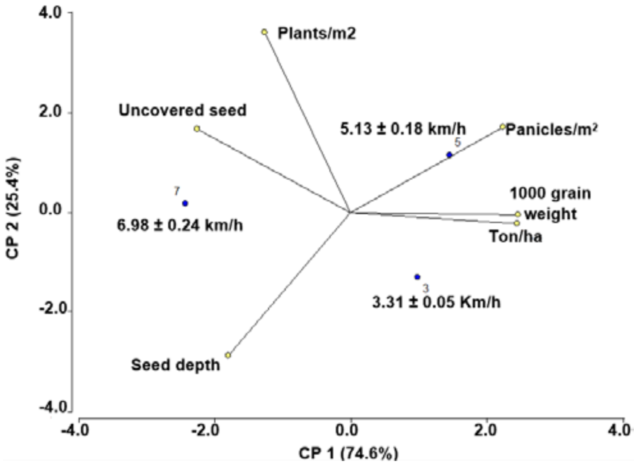

Figure 6. Principal component analysis.
Source: The authors

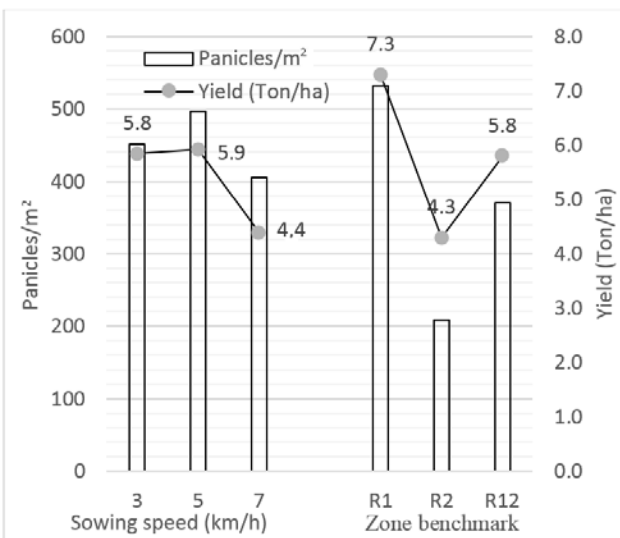

Figure 7. Panicles/m^2 vs. yield (Ton/ha) in experimental and reference plots
Source: The authors

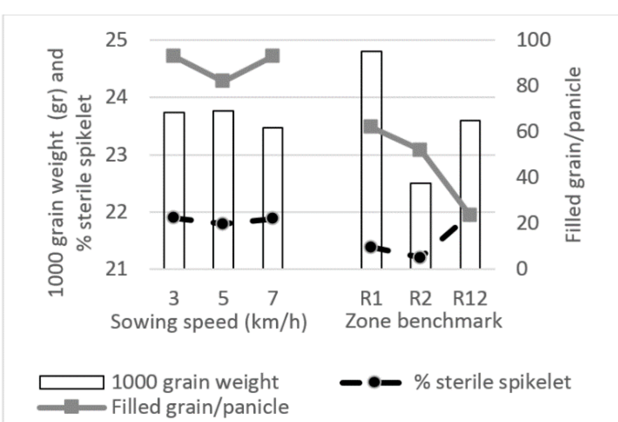

Figure 8. 1000-grain weight in experimental and reference plots
Source: The authors

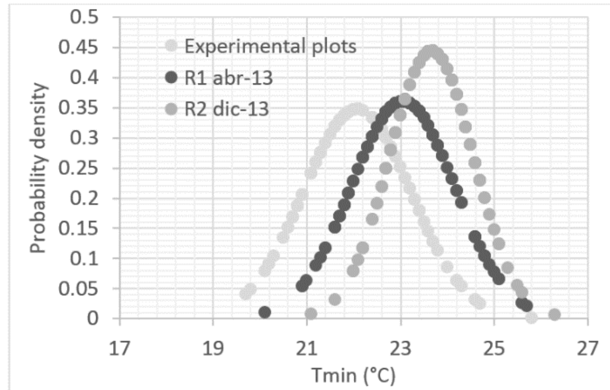

Figure 9. Distribution of the minimum temperature during rice growth in experimental and reference plots.
Source: The authors

in the experiment (424.5 ± 83.66 Cal/cm^2-day). The results from plots sowing at 5 km/h are higher than the results of R2, the average of R1 and R2 (R12: Fig. 7). Therefore, the yield falls within the range of the yields in the area.

The mechanized sowing speed showed incidence in the development, growth, and yield of irrigated rice. The results manifested that the 7 km/h sowing speed is closely associated with the percentage of uncovered seed and plant competition (Figs. 2-7). If seeds have distribution problems when they are sown, plants develop and grow in direct competition, which limits their yield potential. This occurred in plots sown at 7 km/h, for which the yield decreased by 25 percent compared to other plots (Fig. 8).

Rice yield was affected by competition between plants as they formed during the three rice phases [39-40]. Plant competition affected carbohydrate, nitrogen, and water reserves in plants. In the vegetative phase, leaves and tillers are the source of assimilates that are to be used for the growth of the panicles and for the filling of the grain. Rice plants save 68 percent of the carbohydrates until flowering, and 26 percent invest in the grain filling. Thus, flowering reserves can increase yields from one to two ton/ha [41]. The grain weight is determined in the maturation phase, in which the carbon and nitrogen balance of the entire plant are very important [40]. Furthermore, the rice plant is very sensitive to drought from the initiation stage of the panicle to the spike; this can reduce yield and increase the sterility of the spikelet [27].

Frizzell et al. [42] found that reducing seed density to an optimal point is favorable for the yield. Reducing planting density involves fewer seeds per linear meter in each line. If the seeds are well calibrated and the seeder has an optimum sowing speed, it is possible to increase the normal spaces between plants and reduce direct competition. A high plant population and distribution have an effect on the tillering. In rice transplants (20cm by 20cm), one plant reaches 30 tillers (750 tillers/m^2), while at densities of 80-100kg/ha in mechanized sowing, 2 or 3 tillers per plant are obtained (1000 tillers/m^2: [40]). Frizzell et al. [42] also found that the change in spacing between 6 in (15.2) and 10 in (25.4 cm) sowing lines was not favorable for the yield. Therefore, optimum distribution of the seed should be sought in each specific site with similar production potential in order to obtain the highest yield. In “El Espinal”, Tolima, the 5.13 ± 0.18 km/h sowing speed achieved a greater yield, and it used resources appropriate that were favorable for the profitability of the crop. The previously mentioned sowing speed is close to the 5.1 km/h sowing speed that favored the wheat yield [14].

Furthermore, based on secondary information, it can be affirmed that the wear rate of the tool increases with sowing speed, which in turn affects costs. Operational factors that affect the wear of tillage tools are the working speed, depth, and type of soil [43]. In the experiment, work team qualitatively identified that the tractor-seeder assembly supports greater stresses in direct relation to the sowing speed since rice levee act like speed bumps (or speed breakers) during rice sowing. An increase in sowing speed affects bearings, hoses, and discs (discs open slots for fertilizer and seed placement). Archard and Hirst [44] developed a relationship for sliding wear, where wear rate (W) is proportional to applied normal load (F) and relative velocity (v). A 0.5 m/s increase in working speed increases draft by about one Newton for sandy soil [43]. This relationship was modified to Graff, L. [44], equation 6, when the constant of proportionality (k) and weighting constants (b and c) were added.

$$W = kF^b v^c \tag{6}$$

Experimentally, the researchers have demonstrated the wear that tillage implements have on function of speed. For a chisel plow, tools was founded that the increase in working speed affects weight loss of the tool on equal soils (clay loam and silty loam) [46]. The wear rate of rotary plow blades was tested with 141, 177, and 251 rpm, which led to an average mass losses of 0.67 g, 1.35 g, and 2.33 g, respectively [47]. Therefore, the discs wear rate increases with sowing speed, which in turn affects costs.

4. Conclusions

This research provides an antecedent to the effects of the increase in the mechanized sowing speed of rice.

The number of plants, plant weight in the three rice phases, dry matter, moisture, and yield presented statistically significant differences with respect to the sowing speed. There is a proportional relationship between the sowing speed and percentage of plants that are grouped in their roots (direct competition between plants for nutrients, water, and light), and number of non-productive tillers. The rate of fuel consumed, the uncovered seed, and the work field capacity all have a proportional relation to the sowing speed. The optimal sowing speed for the proper development and growth of the rice was 5 km/h, which better locates and distributes the seed and leads to plants with a greater number of panicles/m^2 and a better yield. In addition, a 5 km/h sowing speed had an acceptable field capacity and consumption of inputs.

The yield is the result of the interaction between various factors relating to physiology, genetics, climate, and management. A difference of 25 percent was found between yields and sowing supplies; therefore, the way of sowing seeds has an influence on the profitability of rice.

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