






Productive response of corn (*Zea mays* L.) under irrigation

Pérez-Armas, Reinaldo¹ ; Duarte-Díaz, Carmen E.² ; Guevara-Hernández, Francisco³ ; Cadena-Iñiguez, Pedro^{4*} ; Gómez-Padilla, Ernesto J.³ 

¹ Universidad de Cienfuegos, Facultad de Ciencias Agraria, Carretera a Rodas, km 3 1/2, Cuatro Caminos, Cienfuegos, Cuba. perez661130reinaldo@gmail.com

² Instituto de Ingeniería Agrícola, Carretera Fontanar, Hm 21/2, Reparto Abel Santamaría, Rancho Boyeros. La Habana. Cuba. carmenenriquetaduarte56@gmail.com

³ Universidad Autónoma de Chiapas, Facultad de Ciencias Agronómicas Campus V, carretera Ocozocoautla– Villaflores km 84.5, Apartado Postal 78, Villaflores, Chiapas, México, C.P. 30470. francisco.guevara@unach.mx

⁴ Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (INIFAP). cadena.pedro@inifap.gob.mx

⁵ Estudiante de Doctorado del programa en Ciencias Agropecuarias y Sustentabilidad. Universidad Autónoma de Chiapas. Boulevard Laguitos # 338, Colonia Los Laguitos, C.P. 29020, Tuxtla Gutiérrez, Chiapas. ernesto.gomez54@unach.mx

* Correspondence: cadena.pedro@gmail.com

ABSTRACT

Objective: To evaluate the productive response of the maize variety H-Ame 15 in the soil and climatic conditions of the Horquita Agricultural Company.

Design/Methodology/Approach: an experimental investigation was carried out at the “La Prosperidad” farm during the cold and spring sowing seasons from January 2022 to June 2024. A simple randomized experimental design with five replications was conducted, and analysis of variance (ANOVA) simple classification was applied. The statistical software IBM SPSS[®] Statistics version 21.0 was utilized in all instances. Plots measuring 60 m² were established for the evaluation of crop growth, development and yield variables. The study area was characterized in its main components: soil, climate, crop and irrigation system. The irrigation regime was applied to reduce the number of irrigations in both seasons, taking advantage of rainfall and applying irrigation at the right time based on soil moisture monitoring. The morphoagronomic behaviors was evaluated and the crop yield was determined for each plot in both sowing seasons. The maize variety used was H-Ame 15, which was sown with a 0.90×0.25 m spacing. The area is serviced by the electric center pivot machine No. 2, Western model, with 5 towers, irrigating an area of 30.7 ha. For the study, 5 plots of 60 m² (10 m long by 6 m wide) were established to evaluate growth, development, and yield variables of the crop, arranged in a completely randomized design. For each plot, 40 plants (8 per row) were taken as the experimental unit.

Results: The study’s primary findings indicated that the soil, climate, and irrigation system characteristics of the region are conducive to successful maize cultivation.

Findings/Conclusions: The morphoagronomic behavior exhibited by the maize variety H-Ame 15 demonstrated a high degree of adaptability to the soil and climatic conditions of the La Prosperidad farm, with yields exceeding 9 t ha⁻¹ during the winter season.

Keywords: Planting time, morphoagronomic, irrigation regime, yield.

Citation: Pérez-Armas, R., Duarte-Díaz, C. E., Guevara-Hernández, F., Cadena-Iñiguez, P., & Gómez-Padilla, E. J. (2025). Productive response of corn (*Zea mays* L.) under irrigation. *Agro Productividad*. <https://doi.org/10.32854/8a0f1r84>

Academic Editor: Jorge Cadena Iñiguez

Associate Editor: Dra. Lucero del Mar Ruiz Posadas

Guest Editor: Daniel Alejandro Cadena Zamudio

Received: January 26, 2025.

Accepted: April 28, 2025.

Published on-line: June XX, 2025.

Agro Productividad, 18(5). May. 2025. pp: 249-263.

This work is licensed under a Creative Commons Attribution-Non-Commercial 4.0 International license.



INTRODUCTION

Maize (*Zea mays* L.) is the domesticated form of the Mexican wild grass known as teocintle (*Zea mexicana* L.), and it has the greatest potential for genetic yield improvement

among cereal crops. This cereal meets the food needs of humans and animals, making it a key strategic crop worldwide. It is widely grown across various tropical, subtropical, and temperate regions of Asia, Africa, Europe, and the Americas (El-Sayed *et al.*, 2021; Sahoo *et al.*, 2021).

Globally, maize is one of the oldest and most widely produced crops, with a production of 1,194.8 million tons, surpassing wheat and rice. Although it ranks second in planted area, with approximately 140 million hectares across 135 countries, its international trade exceeds 90 million tons annually, with the United States, Brazil, Argentina, and Ukraine being the main exporters (González *et al.*, 2020; USDA, 2021). The increasing global demand for this crop shows no signs of slowing down in the coming years.

In contrast, Cuba faces significant challenges in its domestic maize production. Maize is of vital importance for import substitution, as it is used for human and animal consumption and as an associated crop in agricultural systems (Ferro-Valdes *et al.*, 2023). However, despite its relevance, domestic production has shown a downward trend in recent years due to factors such as limited access to modern agricultural technologies, low-quality seeds, and insufficient irrigation infrastructure. According to the National Office of Statistics and Information (ONEI, 2023), only 167,000 tons of maize were produced in 2022, with an average yield of 1.76 t ha^{-1} , far below the national demand of 700,000 tons per year.

Maize exhibits considerable genetic diversity, a result of millennia of selection by farmers to adapt it to diverse environmental conditions and cultural needs. The exchange of seeds among farmers and their continuous adaptation have generated local biotypes and cultivars that meet specific needs. This selection process has led to the creation of materials adapted to both new demands and producer preferences (Guevara & Mariaca, 2023).

In Cuba, the morphoagronomic variability of maize has been extensively studied (Fernández, 2009). However, due to the allogamous nature of maize, natural hybridizations frequently occur, generating new genetic variations adapted to specific conditions. This underlines the need for periodic surveys and evaluations of this variability.

Agronomic and morphological descriptions of crops are essential for farmers to develop efficient production systems, determine optimal planting times, and establish appropriate plant density and agronomic management practices, thereby ensuring maximum yield and economic efficiency according to soil and climatic conditions.

One of the main strategies to increase maize yields has been the use of simple hybrids. In Cuba, national production is largely based on conventional varieties, well adapted to tropical conditions and characterized by their tolerance to pests and diseases (Téllez *et al.*, 2021).

Given the ongoing challenges in maize production, the development of transgenic hybrids, such as H-Ame 15, which resist fall armyworm (*Spodoptera frugiperda*) and herbicides, provides a promising solution to increase maize yields in the country. Therefore, the general objective of this study is to evaluate the morphoagronomic behavior and yield of the H-Ame 15 variety under the edaphoclimatic conditions of the Horquita Agricultural Enterprise with an irrigation regime.

MATERIALS AND METHODS

This experimental research was conducted at the 'La Prosperidad' farm of the Horquita Agricultural Enterprise, located at 22.16796° N and 80.72754° W, near the town of Mijalito in the municipality of Abreu, Cienfuegos Province (see Figure 1). The study spanned from January 2022 to June 2024. The maize variety used was H-Ame 15, which was sown with a 0.90×0.25 m spacing. The area is serviced by the electric center pivot machine No. 2, Western model, with 5 towers, irrigating an area of 30.7 ha. For the study, 5 plots of 60 m² (10 m long by 6 m wide) were established to evaluate growth, development, and yield variables of the crop, arranged in a completely randomized design. For each plot, 40 plants (8 per row) were taken as the experimental unit. The results were tested for normality and homogeneity of variance using the Kolmogorov-Smirnov and Levene tests, respectively.

The study area was characterized by considering the behavior of climate, soil, crop, and irrigation system variables, all of which impact the growth, development, and yield of the crop. Climate data were obtained from the automatic weather station and rain gauge installed in the study area, both used to monitor climatic variables (Figure 2 a, b).



Figure 1. Satellite image of the study area. Source. Google Earth (2023).



Figure 2. Illustrate the installation of automatic station (a) and rain gauges (b) for the purpose of monitoring climatic variables. Source. Photograph taken by the first author.

The soil of the farm falls within Group IIA, typified by Red Ferrallitic characteristics, thereby offering optimal conditions for the cultivation of maize (Hernández *et al.*, 2019). The soil's texture is clayey, with an effective depth of 1.20 m, exhibiting a flat relief and adequate internal drainage.

The soil was prepared in accordance with the recommended practices, involving plowing, harrowing, crossing, a second pass of the harrow, hoeing, and furrowing. The entire process, including the preparation and planting stages, was mechanized. At the time of planting, the soil was found to be in optimal condition. The seeder employed was the JUMIL JM2570 PD SH, which was meticulously calibrated to dispense four seeds per linear metre, a strategy that was predicated on the assumption that the germination rate would exceed 80%. To further characterize the soil, samples were taken to the testing laboratory at the Cienfuegos Environmental Studies Center.

In order to characterize the irrigation system, the machine, its nozzle distribution and the pluviometric evaluation and irrigation uniformity according to Cuban standard ISO 11545 were observed. The operational characteristics of the irrigation system are delineated in Table 1.

To evaluate the morphoagronomic behavior of the maize crop (variety H-Ame 15) in the study area during two seasons (spring and cool), the following variables were measured: germination percentage, determined through preplanting trials; plant density per linear meter; and root depth, assessed through the meticulous collection of plant samples at various temporal points. The appearance of the first male flowers was recorded on the 15th day after planting for analysis purposes. Days to the onset of female flowering were recorded on the day when the first female flowers were observed. Days to the completion of male flowering were noted when 100% of the plants had emitted their male flowers, and the same methodology was applied for days to the completion of female flowering.

Additional measurements included stem diameter, measured with a caliper, and ear height, measured from the soil surface to the base of the ear using a tape measure. Plant

Table 1. Technical specifications of the machine.

Parameters	Descripción
Type of irrigation machine	Center pivot
Model	Western
Number of towers (u)	5
Machine radius (m)	312.6
Irrigating area (ha)	30.7
Supply source	Water table
Maximum speed of the last tower ($\text{m}\cdot\text{min}^{-1}$)	3.26
Flow rate delivered ($\text{L}\cdot\text{s}^{-1}$)	39.47
Minimum time to make a turn (at 100%) (h)	9.21
Maximum time to make one turn (at 3%) (h)	306.99
Minimum irrigation rate (mm) (at 100%)	4.26
Maximum watering rate (mm) (at 3%)	142.08

Source. Own elaboration with data from the irrigation machine catalog.

height was recorded at 7, 30, 45, and 60 days after planting, measuring from the soil surface to the insertion of the last leaf. Finally, the harvest date was documented.

The productive response of the maize crop (H-Ame 15 variety) was evaluated according to the methodology of the International Maize and Wheat Improvement Center (CIMMYT, 2012), using the following variables: number of ears per plant, determined by counting the ears on each plant; length of the fresh ear, measured at harvest using a tape measure to determine the length of selected ears; number of grains per ear, calculated by counting the number of grains per row and summing the totals; average ear weight, obtained by individually weighing each ear from each plant at the time of harvest; and grain weight, determined by taking three samples of 100 grains per ear and weighing them. A descriptive statistical analysis and one-way analysis of variance (ANOVA) were performed on the morphoagronomic and yield variables using the SPSS processor, version 21.0.

The climate during the study period provided optimal conditions for maize cultivation throughout both seasons, as shown in Table 2. However, wind speed negatively impacted irrigation uniformity, with average values exceeding 2 m.s^{-1} , which is the maximum permissible limit for uniform sprinkler irrigation application. All stages of crop development occurred within the optimal range for each variable affecting growth, as outlined by López and Gil (2011).

Soil characteristics

The key findings of the laboratory analysis of the soil samples taken at the farm are outlined in Table 3. The analysis revealed that the organic matter content ranged from 2.9 to 3.9%, indicating that this soil property is not a limiting factor for maize cultivation. Additionally, the pH levels were found to be slightly alkaline in all samples, suggesting that this is not a limiting factor for maize cultivation. Phosphorus content is high, while potassium content is low. Although potassium is essential for the optimal development of maize, its demand is not as high as that of other nutrients such as phosphorus and nitrogen. However, ensuring an adequate presence of potassium in the soil remains crucial for sustaining healthy plant growth and attaining optimal crop yields (Gavilanez, 2022).

According to the criteria established by López and Gil (2011), maize requires well-drained, deep, medium-textured soils, with optimal calcium levels and a pH range of 6 to 7. The ideal soil moisture content should be maintained between 70 and 75% of field capacity.

Table 2. Behavior of the climate variables in the study periods.

Cold Sowing					Spring Sowing				
Month	Min	Max	Relative Humidity (%)	Wind (m.s^{-1})	Month	Min	Max	Relative Humidity (%)	Wind (m.s^{-1})
	Temp ($^{\circ}\text{C}$)					Temp ($^{\circ}\text{C}$)			
January	19.2	28.4	84.0	1.7	July	22.2	33.4	79.0	5.8
February	17.3	28.8	88.0	1.8	August	22.3	33.3	81.0	5.1
March	19.0	30.2	77.0	3.0	September	22.1	32.5	83.0	4.9
April	21.5	31.3	67.0	5.1	October	20.8	31.6	83.0	6.5

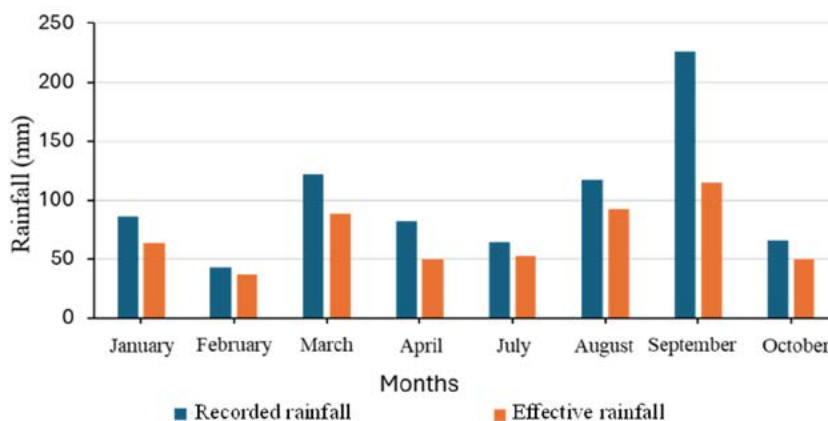
Table 3. Some chemical characteristics of soil.

Plots	OM (%)	pH	P (mg.kg ⁻¹)	K (mg.kg ⁻¹)
T1	3.4	7.41	510.0	0.210
T2	3.6	7.53	560.0	0.220
T3	2.9	7.57	420.0	0.210
T4	3.8	7.20	450.0	0.210
T5	3.9	7.76	540.0	0.220

Note: OM (%) - Organic matter percentage; pH - Hydrogen potential; P (mg.kg⁻¹) - Phosphorus in milligrams per kilogram; K (mg.kg⁻¹) - Potassium in milligrams per kilogram. Source. Environmental Testing Laboratory (CEAC).

Irrigation plays a fundamental role in maintaining soil moisture levels, as rainfall is not sufficient to meet the plant's water requirements, potentially leading to significant production losses. The volume of effective rainfall (238.8 mm in the cold planting campaign and 309.7 mm in the spring planting campaign), as shown in Figure 3, falls short of meeting the water demands. According to Duarte *et al.* (2015), the demand for dry grain is 580 mm. This study provides a case in point, highlighting the importance of irrigation in Cuban agriculture. Given the irregular spatial and temporal distribution of rainfall in Cuba, which on average does not exceed 1350 mm per year, it is impossible to achieve maize production without irrigation.

The irrigation system has been shown to maintain its technical characteristics (see Table 1) of design, as evidenced by observations of its operation and subsequent evaluations. The pluviometric evaluation demonstrated that it maintains its uniformity and distribution parameters of design, which are regarded as excellent according to the criteria of Montero (2005), as cited by Pérez *et al.* (2020) (Figure 4). These criteria establish that a CU of 85% is considered excellent. Furthermore, it irrigates with good quality level parameters, such as distribution uniformity and the coefficient of variation of the delivered sheet. These parameters are higher than those reported by Pérez *et al.* (2020) in the Western 4 and 9 machines of the Horquita Company itself, which reached values of 77.0%, 5.0% and 82.4% of CU, respectively. In contrast, López *et al.* (2019) reported values ranging from 77.30%

**Figure 3.** Recorded and effective rainfall in both sowing periods.

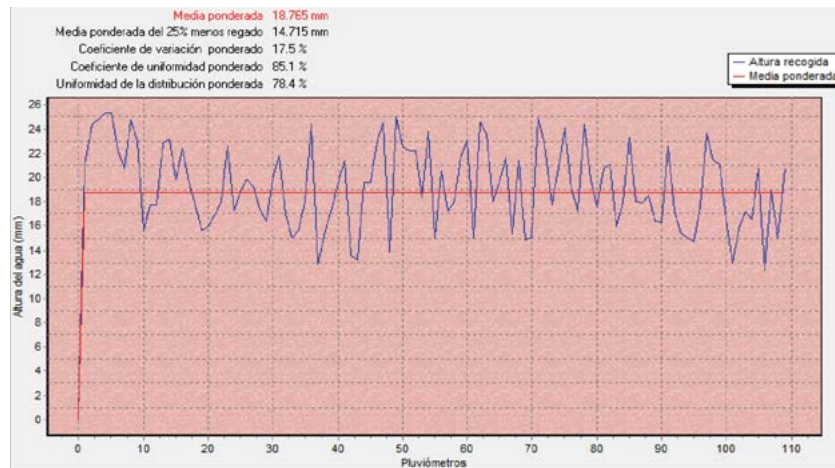


Figure 4. Rainfall Assessment of the Irrigation Machine. Source: Pluviopivot Program.

to 82.8% in a study conducted on six centre pivot machines operated by the Cuba Soy and La Cuba de Ciego de Ávila Companies.

Irrigation Regime Applied

For the crop to reach its productive potential, soil moisture must be maintained within optimum limits. Rainfall alone is insufficient, and irrigation ensures the necessary supplement of moisture that does not naturally reach the soil. It is crucial to apply irrigation at the precise moment and in the required dose based on soil moisture dynamics. This was achieved by applying the farm’s irrigation regime.

During the spring planting season, the total water consumption of the crop reached 565.6 mm, of which 45.2% (255.9 mm) was provided by irrigation to supplement the rainfall, necessitating the application of 19 irrigations throughout the entire crop cycle, as shown in Figure 5. The reported rainfall utilization rate is higher than that reported by Gallardo *et al.* (2018) in Ciego de Avila province, in a study on the impacts of agricultural drought on maize and bean crops in the agricultural areas of the Venezuela municipality.

During the winter season, which corresponds to the period of least rainfall in Cuba, there were nine rainfall events, each with variable volumes and spaced at regular intervals. These

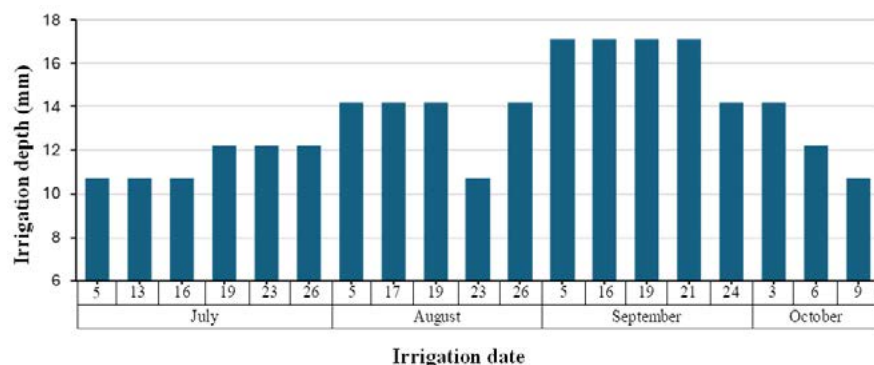


Figure 5. Irrigation regime applied in the spring planting season.

events contributed a total of 359.6 mm, with 66.4% of this volume classified as effective. In addition to these rains, 17 irrigations were applied to meet the water requirements of the crop, as illustrated in Figure 6, resulting in a total rainfall of 264 mm.

Good irrigation management based on the moisture balance and the implementation of the farm irrigation regime ensured that the crop did not see its productive potential limited by maintaining soil moisture within the limits of optimum humidity.

Morphoagronomic behavior of the maize variety H-Ame 15

The principal variables used to describe the crop's morphology demonstrated satisfactory performance across both planting seasons. For plant height, stem diameter, and ear height, higher values were observed during the cold season. In contrast, variables related to the onset and cessation of flowering indicated an earlier initiation and completion of both male and female flowering during the spring season.

In terms of resistance to lodging, 40% of the plants exhibited lodging during the spring season, likely due to a meteorological event characterized by heavy rainfall and strong winds, which is typical of spring in Cuba. No lodging was observed during the cold season.

Additionally, during the spring season, both male and female flowering phases began and ended earlier. The statistical analysis of the morphoagronomic variables, as shown in Table 4, reveals no significant variability between the plot means across the two planting seasons.

The sampling process failed to detect the presence of the main crop pest, the codling moth (*Spodoptera frugiperda* Smith), as well as other noctuid lepidoptera. This finding aligns with the conclusions of Téllez *et al.* (2021), who emphasised that Among the properties of the single hybrid H-Ame 15 are resistance to the codling moth and tolerance to herbicides through the expression of toxins from the vip3Aa20 and cry1Fa genes originating from *Bacillus thuringiensis* (Bt). The tolerance to glufosinate-ammonium herbicides is attributable to the expression of the enzyme Phosphinothricin N-acetyltransferase, which is encoded by the pat gene originating from *Streptomyces viridochromogenes*.

The phytosanitary and nutritional status of the crop, as illustrated in Figure 7, is the result of the care provided and its adaptability response.

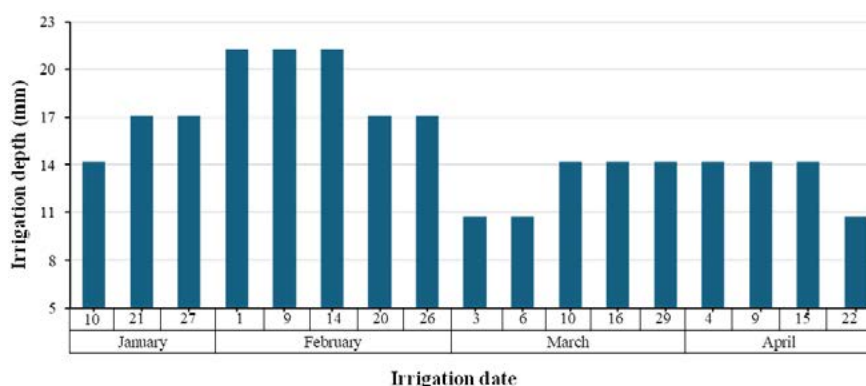


Figure 6. Irrigation regime applied in the cold planting season.

Table 4. Descriptive statistics for morphoagronomic characteristics of H-Ame 15 in two sowing seasons.

Variables	N	Minimum	Maximum	Mean	CV (%)
GP	10	88.0	94.0	90.5	2.2
PA	10	2.6	2.9	2.7	3.6
SD	10	36.1	43.6	40.5	6.1
DMF	10	53.0	59.0	55.5	3.4
DFF	10	55.0	65.0	59.5	6.5
FFM	10	61.0	70.0	66.0	5.2
FFF	10	66.0	78.0	71.5	5.6
FEH	10	1.1	1.5	1.3	10.5

Note. GP: germination percentage; PA: plant height; SD: stem diameter; DMF: days to the onset of male flowering; DFF: days to the onset of female flowering; FFM: days to the end of male flowering; FFF: days to the end of female flowering; FEH: first ear height; CV, coefficient of variation.

**Figure 7.** Maize plants from the experiment. Source. Taken by the autor.

Productive response of maize variety H-Ame 15 under soil and climatic conditions of La Prosperidad farm.

Number of ears per plant. The number of ears per plant varied, with a random sample of 10 plants per plot in two seasons demonstrating the variety's capacity to produce more than one ear of commercial value per plant (Télez *et al.*, 2021). This finding suggests potential for further study, as in several plants, up to a fifth cob was observed, although few developed due to the necessity of suspending irrigation during fruit development for reasons of crop timing. Télez *et al.* (2021) state that this variety can present between one and two ears per plant. In three of the five plots, the cold season showed a greater number of cobs per plant (Table 5), supporting the hypothesis that this season yields the best results for this crop.

Table 5. Number of cobs per plant in cold and spring campaigns.

Season	Plots					Media
	1	2	3	4	5	
Cold	2.0	2.10	1.90	1.85	1.90	1.96
Spring	1.8	1.90	1.75	1.85	2.00	1.87

Tender ear length. Apart from plot 1, the remaining plots demonstrated greater ear length during the cold planting season, thereby confirming that this is the season in which the maize crop best expresses its morphological potential.

The average number of grains per ear was found to be higher in the spring planting season, with an average of 529.18 grains per plant, as opposed to 518.8 grains per plant in the cold planting season. These values exceed 480 grains per ear, which is the average expected for the variety, according to Téllez *et al.* (2021), with the potential to yield 12 t.ha⁻¹.

Concerning the variables of ear weight and diameter, the cold planting season exhibited superior performance in the former, while the spring season demonstrated the highest mean values for the latter in two out of five plots.

Grain weight. Among the planting seasons, it was observed that the cold planting season showed the highest values for this variable in the five plots, with an average of 29.002 g, slightly higher than that found in the spring planting season.

As Sangoi (2001), cited by Becerra *et al.* (2023), observed, the relationship between grain yield and population density is complex, as the best response in grain yield varies according to soil condition, climate, cultural practices, and genotype.

The mean yield obtained at harvest, with a moisture content below 12%, exhibited values in both campaigns exceeding the national average obtained in Cuba. In recent years, the national average has not surpassed 2 t ha⁻¹, demonstrating a decreasing trend since 2017, when 2.37 t ha⁻¹ was recorded, reaching 1.76 t ha⁻¹ in 2022, according to figures from the National Office of Statistics and Informatics (ONEI, 2023).

The findings of this study indicate that the cold season yielded the highest results, with values ranging from 9.24 to 10.89 t.ha⁻¹ at the plot level. In contrast, the spring season yielded an average of 9.30 t ha⁻¹. Although these results surpass the national yield, they do not reach the estimates by Téllez *et al.* (2021), who consider that this variety can achieve yields of 12 t.ha⁻¹.

However, the author suggests that with agro-technologies better tailored to the crop's demands, careful monitoring of irrigation timing and dosage, optimal use of rainfall, and fertilization based on the soil's actual requirements, it may be possible to achieve this potential yield.

Table 6 presents the descriptive statistical analysis for the yield variables from the mean values of the plots, where low variability across the different variables is observed. The results are consistent with the assumptions of normality and homogeneity of variance, as evidenced by the Kolmogorov-Smirnov and Levene tests.

Table 6. Average values and coefficient of variation of performance variables.

Variables	N	Minimum	Maximum	Mean	CV (%)
EL (cm)	10	17.1	22.9	19.1	9.4
ED (mm)	10	53.5	65.7	55.7	6.5
GPE (U)	10	485.0	585.0	523.7	6.4
GPE (g)	10	246.5	329.0	289.8	11.9
W100 G (g)	10	26.1	30.2	28.2	4.4
GY (t.ha ⁻¹)	10	8.7	11.0	9.6	6.9

Note. EL, ear length; ED, ear diameter; GPE, grains per ear; W100 G, weight of 100 grains; GY, general yield.

The simple analysis of variance (ANOVA) applied to the morphoagronomic and yield variables between the two planting campaigns studied revealed no significant differences for stem diameter, the height of the first ear, ear length, ear diameter and yield (see Table 7). These variables are expressed as mean \pm standard error for a probability of error of less than 5% ($P \leq 0.05$). Therefore, it can be concluded that neither the planting season nor the irrigation management had a negative influence. As long as they are properly managed, the response of these variables will be as desired.

As shown in Table 8, significant differences ($P \leq 0.05$) were observed between the two planting seasons for germination percentage, plant height, ear weight, grain weight, and the onset and cessation of both male and female flowering. Except for germination percentage, these variables showed higher values during the cold season.

Table 7. Simple ANOVA results ($P \leq 0.05$) for yield variables in the two campaigns.

Sowing campaign	SD	FEH	EL	ED	GPE	OY
Spring	39.5 (± 1.3)	1.3 (± 0.1)	18.5 (± 1.1)	56.3 (± 2.3)	529.2 (± 19.5)	9.3 (± 0.3)
Cold	41.5 (± 0.8)	1.3 (± 0.1)	19.8 (± 0.2)	55.1 (± 0.5)	518.2 (± 10.4)	9.9 (± 0.3)
P-value (Levene test)	0.22	0.62	0.30	0.63	0.63	0.15

Note. SD, stem diameter; FEH, first ear height; EL, ear length; ED, ear diameter; GPE, grains per ear; OY, Overall Yield. Numbers in parentheses represent the standard deviation of the mean.

Table 8. Results of simple ANOVA applied to morphoagronomic and performance variables.

Sowing campaign	GW	PH	EW	100GW	DMFI	DFFI	DMFC	DFFC
Spring	91.8 (± 0.7)	2.7 (± 0.01)	268.4 (± 13.8)	27.4 (± 0.5)	54.0 (± 0.4)	56.0 (± 0.3)	63.0 (± 0.7)	68.0 (± 0.5)
Cold	89.2 (± 0.6)	2.8 (± 0.01)	311.3 (± 10.6)	29.0 (± 0.3)	57.0 (± 0.5)	63.0 (± 0.7)	69.0 (± 0.6)	75.0 (± 0.8)
P-value (Levene test)	0.02	0.01	0.04	0.03	0.001	0.001	0.001	0.001

Note. GW, grain weight; PH, plant height; EW, ear weight; 100GW, 100-grain weight; DMFI, days to male flowering initiation; DFFI, days to female flowering initiation; DMFC, days to male flowering completion; DFFC, days to female flowering completion. Numbers in parentheses represent the standard deviation of the mean.

CONCLUSIONS

The morphoagronomic behavior of the maize variety H-Ame 15 showed a total adaptability to the soil, climate and irrigation management conditions of the La Prosperidad farm. The H-Ame 15 maize variety achieved yield indicators higher than 9 t.ha⁻¹ with the best performance in the cold season without significant difference with the spring planting season.

ACKNOWLEDGMENTS

Authors are very grateful to Erislandy José Becerra-Fonseca, Yaima Dita-Jiménez, Adis Ramona Hernández-Jiménez, Lisset Ponce-Rancel for their assistance along the conduction of this investigation and to all the farmers involved in the field research.

REFERENCES

- Becerra-Fonseca, E. J., García-Quiñones, E., García Vega, J., & Pérez Armas, R. (2023). Producción de semilla de maíz (*Zea mays* L) H-Ame15 en la Empresa Agropecuaria de Horquita, Abreu-Cienfuegos. *Universidad y Sociedad*, 15(S2), 59-69. <https://rus.ucf.edu.cu/index.php/rus/article/view/3864>
- Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT). (2012). Manual de determinación de rendimiento. CIMMYT. <https://idp.cimmyt.org/publicacion/manual-del-determinacion-de-rendimiento/>
- Duarte, D.C.; Herrera, P.J.; López, S.T.; González, R.F. & Zamora, H.E.: “Nuevas normas netas de riego para los cultivos agrícolas en Cuba”, *Revista Ingeniería Agrícola*, 5(4): 46-51, ISSN: 2306-1545, 2227-8761. <https://www.redalyc.org/articulo.oa?id=586261427009>
- Fernández, L. (2009): Identificación de razas de maíz (*Zea mays* L.) presentes en el germoplasma cubano. *Cultivos Tropicales*. 30(4). 62-70. <https://ediciones.inca.edu.cu/index.php/ediciones/article/view/784>
- Ferro Valdés, E. M., Geada López, G., Morejón García, M., Gigato Toledo, A., & Martínez Maqueira, Y. (2023). Incongruencia entre actores del sistema de semillas de maíz: un riesgo para el desarrollo local. *Cooperativismo y Desarrollo*, 11(1). http://scielo.sld.cu/scielo.php?pid=S2310-340X2023000100005&script=sci_arttext
- Gallardo Y, Brown O. (2018): Análisis de los impactos provocados por la sequía agrícola en los cultivos de maíz y frijol en áreas agrícolas del municipio Venezuela, Ciego de Ávila, Cuba. *Sociedad y Naturaleza*. 30(2):96-115. <https://doi.org/10.14393/SN-v30n2-2018-5> [Links]
- Gavilánez-Luna, F. C., & Gómez-Vargas M. J. (2022). Definición de dosis de nitrógeno, fósforo y potasio para una máxima producción del maíz híbrido Advanta 9313 mediante el diseño central compuesto. *Ciencia y Tecnología Agropecuaria*, 23(1). <https://doi.org/10.21930/rcta.vol>
- Gavilánez Luna, F. C. (2022). Definición de dosis de nitrógeno, fósforo y potasio para una máxima producción del maíz híbrido Advanta 9313 mediante el diseño central compuesto. *Ciencia y Tecnología Agropecuaria*, 23(2). DOI: https://doi.org/10.21930/rcta.vol23_num1_art:2225
- Google earth (s.f.):[Finca La Prosperidad, Mijalito, Abreus] obtenida el 20 de julio 2023 de <https://www.google.es/earth/>
- Guevara-Hernández, F., Mariaca-Méndez, R. (2023). Importancia actual de los maíces locales (*Zea mays* L.): aportes y reflexiones etnobotánicas desde Chiapas, México. *Universidad y Sociedad* 15(6),438-445. <https://rus.ucf.edu.cu/index.php/rus/article/view/4162>
- Hernández A., Pérez J., Bosch D. & Castro N. (2019): La clasificación de suelos de Cuba: énfasis en la versión de 2015. *Cultivos Tropicales*, 2019, 40(1 ISSN impreso: 0258-5936. ISSN digital: 1819-4087) <http://www.ediciones.inca.edu.cu>.
- López R. & Gil V. (2011): Generalidades del Cultivo del Maíz. Editorial Fejoo. Universidad Central «Marta Abreu» de Las Villas. ISBN 978-959-250-768-5
- López, M., Carmenate, D., Mujica, A., & Paneque P. (2019). Criterios de eficiencia para la evaluación del riego por aspersión. *Revista Ciencias Técnicas Agropecuarias*, 28(3). <https://revistas.unah.edu.cu/index.php/rcta/article/view/1130>
- Oficina Nacional de Estadísticas (ONEI) (2023). Anuario Estadístico de Cuba. Edición 2023. <https://www.onei.gob.cu/anuario-estadistico-de-cuba-2023>

- Pérez R., Fernández R., Hernández H. & Ponce, L. (2020). Uniformidad del riego de las Máquinas de Pivote 4 y 9 de la Empresa Agropecuaria Horquita. *Revista Científica Agroecosistemas*, 8(3), 70-76. <https://aes.ucf.edu.cu/index.php/aes/article/view/429>
- Téllez-Rodríguez, Pilar; Morán-Bertot, Ivis; Riverón-Hernández, Albis; Espinoza-Delgado, Davel; Hernández-Hernández, Daily; Martínez- Ramírez, Alberto; Ayra-Pardo, Camilo & Isidró-Pérez, Miriam. (2021) H-Ame15: Nuevo híbrido simple de maíz transgénico, resistente a la palomilla y tolerante a herbicidas. *Cultivos Tropicales*, 42(4), Ediciones INCA. <https://doi.org/10.7440/res64.2018.03>
- El-Sayed E. A., El-Sobky & Ahmed I. Abdo (2021). Efficacy of using biochar, phosphorus and nitrogen fertilizers for improving maize yield and nitrogen use efficiencies under alkali clay soil. *Journal of Plant Nutrition*, 1-19. <https://doi.org/10.1080/01904167.2020.1845369>
- Chirino E.; Vento R; Ferro E; González M. A.; Martínez Y; León D & Rosado A. (2020). Prácticas de Agricultura de Conservación para la producción de maíz (*Zea mays* Lin.) ecológico. *Revista ECOVIDA*, 10(2), 134-147. <https://revistaecovida.upr.edu.cu/index.php/ecovida/article/view/200/html>
- Del Toro, Tablada R.N. & Caraballo LC (2019): Tecnología mecanizada para la producción de maíz en las condiciones edafoclimáticas de Guantánamo, Cuba. 9na Edición de la Conferencia Científica Internacional de la Universidad de Holguín.
- USDA. (2021). World Agricultural Production. Recuperado el 21 de diciembre del 2021, desde <https://downloads.usda.library.cornell.edu/usdaemis/files/5q47rn72z/z603rw92p/x633fz20k/production.pdf>
- Sahoo S, Adhikari S, Joshi A & Kumar N., (2021). Use of Wild Progenitor Teosinte in Maize (*Zea mays* subsp. *mays*) Improvement: Present Status and Future Prospects. *Tropical Plant Biology*, 14(2), 156-179. <https://doi.org/10.1007/s12042-021-09288-1>

