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Article

Corn yield, interdependence and genotype-environment interaction in southeastern Mexico

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Abstract

The Yucatán Peninsula presents high temperatures and soils where corn (*Zea mays* L.) crops have a yield of 2.4 to 3.2 t ha^{-1} under rainfed conditions. One strategy to correct the reduced productivity of corn in the YP is to generate, evaluate, and disseminate the use of hybrids and varieties that adapt to various production environments, identify those that present a superior and predictable grain yield, as well as the possible interdependence of yield with agronomic variables. The experiments were established under rainfed conditions in five locations of the YP to evaluate nine commercial corn genotypes -six hybrids and three varieties- in random complete blocks with three replications. Grain yield, plant and ear height, diameter, length and number of grains per ear were quantified. To identify the most outstanding genotypes and their interaction with the environment (stability and adaptability), the following was performed: combined analysis of variance across localities, test of means, principal component analysis, environment-genotype interaction analysis and path analysis. The H-520 hybrid presented the highest yield in both the favorable (Quetzalcóatl) and unfavorable (Micaela) environments, both in Campeche, and was the most stable; H-391 was the best choice for grain yield in San Felipe II, Yucatán, and YZ-1 in Cafetalito and Chetumal, Quintana Roo. Plant height had a direct effect, and ear length had an indirect effect; both were the variables that had the biggest impact on yield. Thus, the lower the plant height, the higher the yield and the longer the ear.

Keywords:

localities, path analysis, stability, yield.

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Introduction

The Yucatán Peninsula (YP) has a tropical, warm subhumid climate with rainfall in summer and autumn, with a rainfall gradient of 600 to 1 400 mm, classified as Aw (García, 2004). It is in southeastern Mexico and is made up of the states of Campeche, Quintana Roo and Yucatán. In this region, 331 759 ha are planted with rainfed corn and 679 703 t are obtained, which represents 6.8% and 5.2% of the national area and production, respectively; in the cultivation of rainfed corn in the YP, the state of Campeche stands out, which contributed 74% of the total production of the region and ranks ninth nationwide (SIAP, 2024).

In the area, the average yield is 2.88 t ha^{-1}; the highest is obtained in Campeche, with 3.28 t ha^{-1}, whereas in Quintana Roo and Yucatán, it is 3.16 and 2.46 t ha^{-1}, respectively (SIAP, 2024). In this region, 66.1% of the area is planted with hybrid seeds and the rest with native seeds. According to Uzcanga *et al*. (2017), the rainfed corn production systems in YP face temperatures above 30 °C and shallow soils, so they are not considered competitive.

The corn deficit in Mexico, estimated at 18 million tons per year, causes the importation of yellow grain mainly, with a value of 5.4 billion dollars (FIRA, 2024). One strategy to overcome this problem is to strengthen the crop through traditional and subsistence agriculture in order to increase productivity through genetic improvement for the generation of varieties and hybrids for the areas where these types of genotypes are planted (Tadeo *et al*., 2023).

Improved varieties should be evaluated in a large number of environments to represent the environmental conditions in which they will be grown (Yan and Kang, 2003). The differential behavior of genetic materials in various ecological conditions is due to the genotype-environment interaction (GEI), which is of great importance, mainly for the grain yield trait, because the best genotypes in a particular environment are not the best in another; the above makes it difficult to recommend cultivars for an entire agroecological zone (Sánchez-Hernández *et al*., 2019).

One way to take advantage of the GEI, for the recommendation of new cultivars, is to detect genotypes that show adaptability and phenotypic stability; the selection of the best genotypes is an important aspect to increase crop productivity. However, yield is influenced by the environment (Lozano-Ramírez *et al*., 2015).

Correlation analysis has been used to determine the level of linear association between traits. This tool is important for effective selection because the response in selection depends on several factors, including the interdependence of characteristics (Taiwo *et al*., 2020). In this regard, path coefficients estimate the influence of one variable on another, while also quantifying its magnitude and direction; in this way, they classify the variables by their direct or indirect effect and are a valuable tool for effective selection in the improvement of production (Pranay *et al*., 2022).

In this work, the objectives were to quantify the genotype-environment interaction, yield and interdependence between agronomic characteristics in different localities of the YP.

Materials and methods

Setup and management

The location, altitude, and planting dates evaluated in 2022 are presented in Table 1. Fertilization in all cases was carried out with the 110-46-00 (N-P-K) formula; half of the nitrogen and all the phosphorus were applied at the time of sowing, and the rest of the nitrogen at the second weeding. For weed control, 1.5 kg ha^{-1} of the active ingredients Picloram plus Nicosulfuron was used at 20 days after sowing (DAS), and manual weeding was performed at 50 DAS.

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Table 1. Location, altitude, and planting date of the study localities.

Locality, Municipality, State	Geographic location	Altitude (m)	Planting date
Ejido Quetzalcóatl, Champotón, Campeche	19° 13’ 09.16” N 90° 12’ 41.85’’ W	10	July 10
Villa Micaela, Hecelchakán, Campeche	20° 10’ 52.34’’ N 90° 05’ 49.42’’ W	14	July 12
Ejido San Felipe II, Tekax, Yucatán	19° 48’ 38’’ N 89° 28’ 05’’ W	21	July 31
Cafetalito, José María Morelos, Quintana Roo	19° 43’ 42.30’’ N 88° 47’ 57.90’’ W	21	June 24
Chetumal, Othón P. Blanco, Quintana Roo	18° 31’ 45’’ N 88° 27’ 56.89’’ W	2	July 6

The active ingredient chlorantraniliprole (50 ml ha^{-1}) was applied to combat fall armyworm (*Spodoptera frugiperda*) and dimethoxyphosphinothioylthio (1 L ha^{-1}) with imidacloprid (25 ml ha^{-1}) was used for corn aphid (*Rhopalosiphum maidis*).

Genotypes evaluated

The materials evaluated were the three-way hybrids H-520, H-391, H-392, H-565, H-567 and YZ-1 and the open-pollinated varieties Sac Béh, V-569A (Ocotito) and Chichén Itzá (Nucuch Nah); the latter two served as yellow-grained controls. All genotypes were generated by the National Institute of Forestry, Agricultural and Livestock Research (INIFAP, for its acronym in Spanish), except for the YZ-1 hybrid, which was formed by a cooperative society in Campeche.

Variables evaluated

Plant height (PH) and ear height (EH), evaluated in cm, from ground level and up to the insertion node of the tassel and ear, respectively; ear diameter (ED), evaluated in cm, in the central part of the ear; ear length (EL), evaluated in cm, from the base to the apex; number of rows per ear (NRE), counted in the central part of the ear; and grain yield (GY), evaluated in t ha^{-1}, with grain weight adjusted to 14% moisture (Sánchez-Hernández *et al*., 2019).

Experimental design

By locality, it was a randomized complete block design with three replications. Each experimental plot consisted of four rows measuring 10 m in length and 0.8 m apart, and the useful plot was the two central rows, with a planting density of 70 000 plants ha^{-1} (Medina-Méndez *et al*., 2019).

Statistical analysis

Combined analyses of variance were performed from an experimental design of randomized complete blocks across environments, using the least significant difference (LSD) test of means. A path analysis by covariance was carried out to identify the relationship between evaluated variables and detect their direct and indirect effects on yield; these were performed with the statistical analysis system (SAS, 2011). To identify the interaction of genotypes and their stability in GY (Yan and Kang 2003; Pacheco-Gil *et al*., 2015), the site regression model (SREG) was used.

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Results and discussion

Combined analysis of variance

In the analysis of variance, there were statistical differences between the evaluation sites in the expression of all the variables evaluated, except for NRE (Table 2), between the genotypes evaluated for all variables, and for the genotype-environment interaction in GY, PH, EH and EL. Among the study factors, the most important, due to the variation generated, were the localities, which gave rise to differences in GY, based on EL (Medina-Méndez *et al*., 2019).

Table 2. Analysis of variance for the traits evaluated in corn, in five localities of the Yucatán Peninsula.

Sources of variation	DF	Mean squares					
		Yield	Altura planta	Altura mazorca	Yield	Longitud mazorca	Núm. hileras
Localities	4	74.27 **	8 543.5 **	3 739.7 **	2.12	20.4 **	0.77
Blocks/Loc	10	0.24	368.5	398.1	0.64	2.5	0.78
Genotypes	8	4.67 **	6 287.9 **	5 662.5 **	0.3 **	5.6 **	24.44 **
Gen*Loc	32	0.94 **	295.6 **	278.6 **	0.07	1.8 **	0.44
Residual error	79	0.13	124.9	129.3	0.06	0.6	0.52
CVLoc (%)		8.9	8.9	17.7	16.7	10	6.2
CVGen (%)		6.7	5.2	10.1	5.1	5.2	5.1

DF= degrees of freedom; Loc= localities; Gen= genotypes; **= $p \leq 0.01$; CV= coefficient of variation.

The genetics of the cultivars showed variation in all variables, where the one generated by EL was higher than that of ED, both with the same units of measurement (cm); likewise, between EH and PH, the latter was more important. The genotype-by-locality interaction ranked third in generated variation, where those of GY, PH, EH and EL were statistically significant. Coefficients of variation are acceptable as an indicator of experimental error (Lozano-Ramírez *et al*., 2015).

The locality of Quetzalcóatl showed the highest values of PH, EH and EL (Table 3), followed by the locality of Cafetalito; nevertheless, the latter presented the highest GY, higher by 2.2 t ha^{-1} than that obtained in Quetzalcóatl, probably associated with temperature; in Chetumal, the average temperature fluctuated from 33 to 35 °C for four months, that is, from leaf development to flowering, and in Cafetalito, it did not exceed 29 °C (Figure 1), and it was the only locality where rainfall remained from flowering to grain filling, at 116 mm (August to November).

Table 3. Comparison of means between localities, for the traits studied in corn, in the Yucatán Peninsula.

Locality	Yield (t ha^{-1})	Plant height (cm)	Ear height (cm)	Ear diameter (cm)	Ear length (cm)	Num. rows
El Cafetalito, Q. Roo	7.4a	231ab	117b	4.8	16.1ab	13.9
Chetumal, Q. Roo	6.6b	214bc	105bc	4.8	16.2ab	13.7
Quetzalcóatl, Campeche	5.2c	232a	130a	4.8	16.6a	14.2
V. Micaela, Campeche	4.6d	197cd	106bc	4.7	15.5b	14.2
San Felipe II, Yucatán	3.2e	195d	101c	4.3	14.3c	13.9
LSD ($p \leq 0.05$)	0.3	11.6	12.1		0.9	

Different letters in the same column indicate significant differences (LSD, $p \leq 0.05$).

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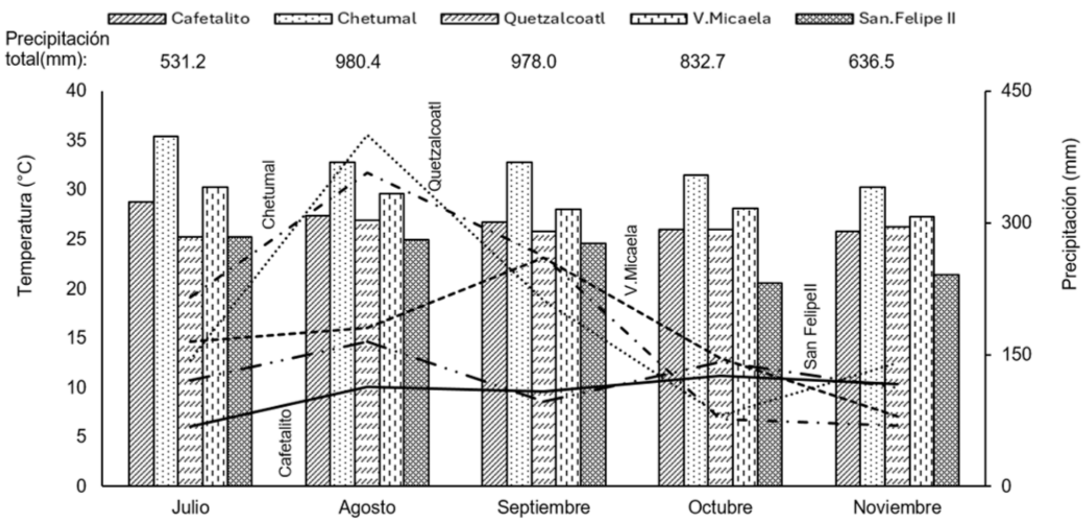
Figure 1. Temperature and precipitation in the evaluation localities of nine corn genotypes in the Yucatán Peninsula (CNA, 2024).



In other words, the environmental conditions were the best in terms of temperature and precipitation. In Quetzalcóatl, although temperatures remained in the optimal range of development, the lowest rainfall was recorded during flowering and grain filling. In Villa Micaela, the biggest reduction occurred in the same period, whereas San Felipe II experienced the lowest temperatures, 25 and 20.6 °C (Vatca *et al*., 2021).

The trials established in Quintana Roo in June presented the highest GYs, while the lowest were obtained in the trial of the state of Yucatán; in this regard, Uzcanga *et al*. (2015) point out that, in the YP, the optimal period for corn planting is when the rainy season begins (June 15-July 15); Medina-Méndez *et al*. (2019) observed that the highest corn yields in Campeche were obtained from plantings carried out in July and that there was a decrease when the crop was established in August (Table 3).

During the crop cycle, the locality of San Felipe II experienced low temperatures in the last 90 days of the crop cycle (20.6 to 24.6 °C). The locality of Chetumal surpassed Quetzalcóatl in yield by 1.4 t ha^{-1}; however, in the latter, there was a higher EL, probably associated with a higher temperature, within the optimal range of development for the crop.

Among the five localities, San Felipe II presented the most unfavorable environmental conditions, which resulted in the lowest GY among the genotypes evaluated, probably due to the lowest records of EL, PH and EH (LSD, *p* # 0.05). The locality of V. Micaela surpassed San Felipe II by 1.4 t ha^{-1} in grain and by 1.2 cm in EL.

The H-520 hybrid was the one with the highest average grain yield (*p* # 0.05), so it surpassed the H-391 and H-392 hybrids by 400 and 600 kg ha^{-1}, respectively (Table 4); in the tropics, Sierra-Macias *et al*. (2016) reported higher (8 to 9%) H-520 yields compared to the control, whereas Medina-Méndez *et al*. (2019) reported yields of 4.7 and 4.8 t ha^{-1} for H-520 and H-565, respectively, in different environments of Campeche and they were classified as intermediate-yielding materials.

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Table 4. Comparison of means of corn genotypes for the variables evaluated in the Yucatán Peninsula.

Genotype	Yield (t ha^{-1})	Plant height (cm)	Ear height (cm)	Ear diameter (cm)	Ear length (cm)	Num. rows
H-520	6.3 a	199 d	97 e	5.4 ab	15.5 cd	13.5 de
H-391	5.9 b	198 de	107 cd	5.4 ab	15.1 de	14.1 c
H-392	5.7 bc	205 cd	99 de	5.5 a	16.8 a	13.9 cd
YZ-1	5.6 cd	209 bc	106 cd	5.6 a	15 e	16.3 a
H-565	5.5 de	201 cde	100 de	5.5 a	15.8 c	15 b
Ocotito	5.3 e	197 e	97 e	5.5 ab	15.2 de	14.9 b
H-567	5.3 e	217 b	111 c	5.5 ab	15.7 cd	13.2 e
Sac Béh	4.7 f	245 a	137 b	5.3 bc	16.5 ab	12.3 f
Chichén-Itzá	4.6 f	251 a	152 a	5.2 c	16 bc	12.6 f
LSD ($p\leq0.05$)	0.2	8.1	8.2	0.19	0.6	0.5

Averages with the same letter in the same column are not statistically different.

The best response of H-391 has been obtained in regions with altitudes from 900 to 1 859 m; nonetheless, in tropical regions of Nayarit and Guerrero, it presented yields close to 6 t ha^{-1} (Ramírez-Díaz *et al*., 2023). The best yields of H-392 have been reported between 1 500 and 2 000 m altitude, although in the tropics, it has presented a yield of 5.9 t ha^{-1} (Ramírez-Díaz *et al*., 2022).

The YZ-1 and H-565 hybrids presented statistically equal yields and were surpassed by H-520 by 700 and 800 kg ha^{-1}, respectively. Ocotito, H-565 and H-567 presented similar yields, which exceeded the Sac-Béh and Chichén-Itzá varieties by 720 kg ha^{-1}; the best GY for Ocotito (V-569) was reported at altitudes below 1 500 m (Gómez-Montiel *et al*., 2023). On average, the H-520 and H-391 hybrids outperformed the Ocotito, Sac-Beh, and Chichen-Itzá varieties by 0.8 to 1.5 t ha^{-1}. H-565 and H-567 presented yields similar to those of Ocotito but surpassed the Sac-Béh and Chichén-Itzá varieties by 0.6 to 0.9 t ha^{-1}. The latter varieties were the ones with the highest PH and EL, but with the lowest NH.

Genotype-by-environment interaction and stability

In GY, the H-520 hybrid surpassed the other genotypes in the localities of Campeche (Micaela and Quetzalcóatl), followed by H-391 and H-392 (Figure 2); below the average of both localities were H-565, H-567, and the YZ-1 control hybrid; finally, the lowest yields corresponded to the Ocotito, Chichén-Itzá, and Sac-Béh varieties. That is, H-520 performed well in the favorable (Quetzalcóatl) and unfavorable (Micaela) environments; the favorable response in GY of this hybrid across different environments of the humid tropics of Mexico is also reported by Sánchez-Hernández *et al*. (2019).

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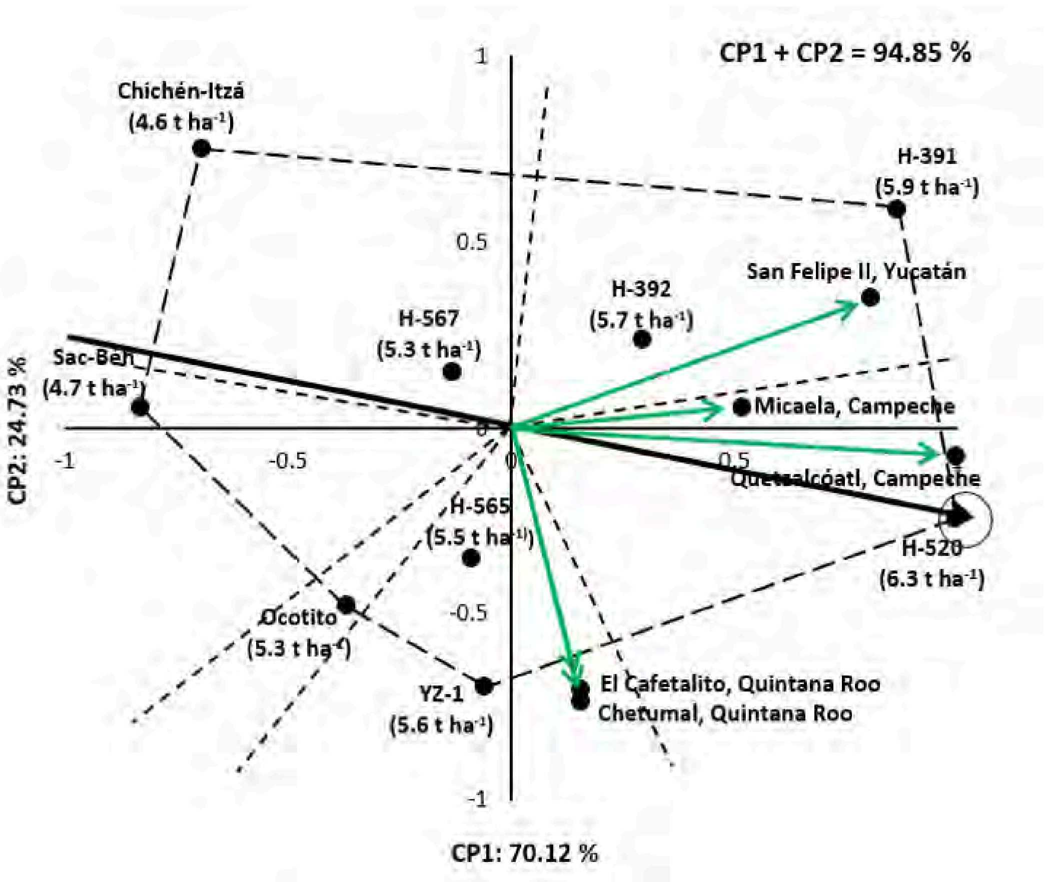
Figure 2. Dispersion of nine genotypes across five environments and yield stability, with the SREG model in the Yucatán Peninsula.



The YZ-1 hybrid stood out for its yield in the localities of Quintana Roo (Cafetalito and Chetumal), whose conditions for the expression of the yield were similar; it was followed in importance by H-520, Ocotito, H-565, H-392, H-391, and H-567; finally, the lowest yields were for the control varieties Sac-Béh and Chichén-Itzá. H-391 adapted to the locality of San Felipe, Yucatán, surpassing the rest of the genotypes, and was followed by H-520 and H-392.

The variance explained by this analysis was 94.8%. The locality of Quetzalcóatl was the most favorable environment for the yield of genotypes, and the least favorable was Micaela; that is, without error effects contained in the averages (Yan and Kang, 2004). The H-520 hybrid was ranked as the most desirable for presenting the highest yield and being predictable or stable; that is, its deviations from the regression line were the smallest. Between H-391 and H-392, the former had the highest yield but was the most unstable. In contrast, these last two hybrids were classified as stable in GY in subtropical environments of Mexico (Ramírez-Díaz *et al*., 2022; Ramírez-Díaz *et al*., 2023). The Ocotito, Sac-Béh, and Chichén-Itzá varieties were the ones with the lowest yield. Between Ocotito and Chichén-Itzá, both presented below-average yields and were classified as unstable, that is, they were the least desirable.

Path analysis

This analysis explained 96.2% of the total variance (Figure 3). The most important path coefficient (PC) due to its indirect and positive effect was between plant height and ear length (PC= 4.06); in this way, the higher the plant height, the greater the ear length; it was followed by the direct and negative effect between plant height and grain yield (PC= -3.82).

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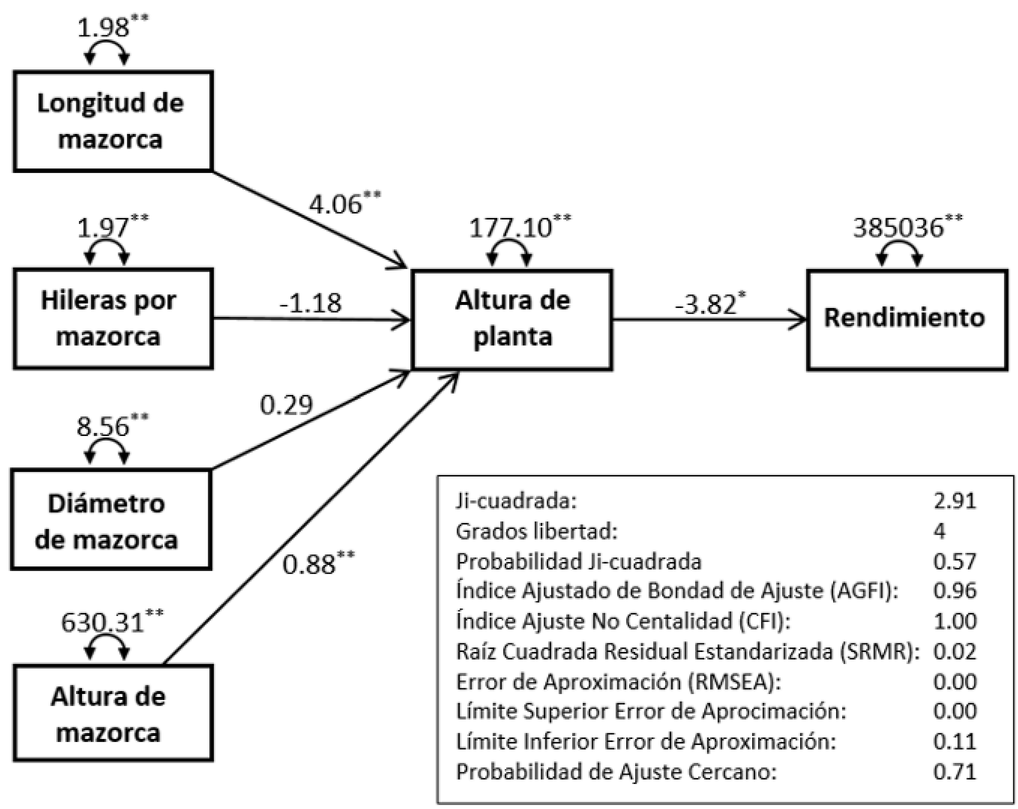
Figure 3. Path analysis in nine corn genotypes, evaluated in five environments of the Yucatán Peninsula.



That is, as plant height decreased, yield increased, both probably due to the selection by the plant breeders, who sought to reduce the plant size to reduce lodging and increase the ear size while simultaneously increasing the grain yield in improved genotypes. The direct and negative effects exhibited by PH and GY were also reported by Pranay *et al*. (2022).

Conclusions

The H-520 hybrid presented the highest yield, stability, and adaptability in the Yucatán Peninsula, in addition to surpassing the rest of the genotypes in the localities of Campeche. YZ-1 was the best option in the localities of Quintana Roo and H-391 excelled only in the locality of San Felipe II, Yucatán.

The best yields were observed in the localities that presented the highest rainfall during vegetative development (August) and temperatures within the optimal development range, during grain filling (October to November). The breeders' selection criteria allowed for a higher grain yield, associated with shorter plants and longer ears, variables that presented the greatest interdependence.

Bibliography

1 CNA. 2024. Comisión Nacional del Agua. Observaciones diarias de temperatura, lluvia y evaporación. Organismo de cuenca Península de Yucatán https://www.gob.mx/conagua/es/#960.

Revista Mexicana de Ciencias Agrícolas

DOI: https://doi.org/10.29312/remexca.v16i8.3778

2 FIRA. 2024. Fideicomisos Instituidos en Relación con la Agricultura. Panorama agroalimentario maíz. México. 28 p.

3 García, E. 2004. Modificaciones al sistema de clasificación climática de Köppen. Instituto de Geografía-Universidad Nacional Autónoma de México (UNAM). 97 p.

4 Gómez-Montiel, N. O.; Hernández-Galeno, C. Á.; Anzures-Olvera, F.; Toledo-Aguilar, R.; Ramírez-Díaz, J. L.; Espinosa-Calderón, A.; Tadeo-Robledo, M.; Santos-Echeverría, R. y Antúnez-Ocampo, O. M. 2023. Variedad mejorada de maíz de grano amarillo para pequeños ganaderos del trópico seco. Agro-Divulgación. 3(3):45-47. https://doi.org/10.54767/ad.v3i3.186.

5 Lozano-Ramírez, Á.; Santacruz-Varela, A.; Vicente-García, F.; Crossa, J.; Burgueño, J. y Molina-Galán, J. D. 2015. Modelación de la interacción genotipo x ambiente en rendimiento de híbridos de maíz blanco en ambientes múltiples. Revista Fitotecnia Mexicana. 38(4):337-347.

6 Medina-Méndez, J.; Soto-Rocha, J. M.; Villalobos-González, A.; Volke-Haller, V. H. and Gómez-Tejero J. 2019. Productivity of white and yellow grain corns in Campeche, México. Agricultural Sciences. 10(9):1255-1269. https://doi.org/10.4236/as.2019.109093.

7 Pacheco-Gil, R. A.; Vargas, M.; Alvarado, G.; Rodríguez, F.; López, M.; Crossa, J. and Burgueño, J. 2015. GEA-R (genotype × environment analysis with R for Windows) version 4.1. https://data.cimmyt.org/dataset.xhtml?persistentId=hdl:11529/10203 . CIMMYT Research Data & Software Repository Network.

8 Pranay, G.; Shashibhushan, D.; Rani, K. J.; Bhadru, D. and Kumar, C. V. S. 2022. Correlation and path analysis in elite maize (*Zea mays* L.) lines. International Journal of Plant & Soil Science. 34(24):414-422. Doi: 10.9734/IJPSS/2022/v34i242657.

9 Ramírez-Díaz, J. L.; Alemán-Torre, I.; Ledesma-Miramontes, A.; Vidal-Martínez, V. A.; Salinas-Moreno, Y.; Briones-Reyes, D.; Gómez-Montiel, N. O.; Peña Ramos, A. y Reyes-Méndez, C. A. 2023. H-391: Híbrido trilineal de maíz de grano blanco para regiones del subtrópico de México. Revista Fitotecnia Mexicana. 46(3):327-329.

10 Ramírez-Díaz, J. L.; Peña-Ramos, A.; Ledesma-Miramontes, A.; Alemán-Torre, I.; Vidal-Martínez, V. A.; Briones-Reyes, D.; Salinas-Moreno, Y.; Gómez-Montiel, N. O.; Reyes-Méndez, C. A. y Bautista-Ramírez, E. 2022. H-392: Híbrido de maíz de grano blanco para regiones agrícolas del subtrópico y transición de México. Revista Fitotecnia Mexicana. 45(4):523-525.

11 Sánchez-Hernández, M. A.; Jiménez-Maya, J. B.; Morales-Terán, G.; Acevedo-Gómez, R.; Antonio-Estrada, C. y Villanueva-Verduzco, C. 2019. Rendimiento de grano en maíces adaptados a condiciones de la baja cuenca del Papaloapan. Tropical and Subtropical Agroecosystems. 22(2):519-529.

12 SAS. 2011. Institute, Statistical Analysis System. User's guide. Software Release V 9.3. SAS Institute Inc. Cary, N. C. USA.

13 SIAP. 2024. Servicio de Información Agroalimentaria y Pesquera. Anuario estadístico de la producción agrícola. Secretaría de Agricultura y Desarrollo Rural (SADER). Ciudad de México, México. https://nube.siap. gob.mx/cierreagricola/.

14 Sierra-Macías, M.; Rodríguez-Montalvo, F. A.; Palafox-Caballero, A.; Espinosa-Calderón, A.; Andrés-Meza, P.; Gómez-Montiel, N. O. y Valdivia-Bernal, R. 2016. Productividad de semilla y adopción del híbrido de maíz H-520, en el trópico de México. Agricultura, Sociedad y Desarrollo. 13(1):19-32.

15 Tadeo, R. M.; Espinosa, C. A.; Canales, I. E. I.; Monter, S. A.; Turrent, F. A.; Arteaga, E. I.; López, L. C.; Virgen, V. J.; Gómez, M. N.; Sierra, M. M.; Zaragoza, E. J.; Macedo, G. J. J.; Valdivia, B. R.; Zamudio, G. B.; Andrés, M. P. y Aguilar, V. K. E. 2023. Mistli UNAM:

Revista Mexicana de Ciencias Agrícolas
REMEXCA
DOI: https://doi.org/10.29312/remexca.v16i8.3778

Híbrido varietal de maíz precoz de grano amarillo para Valles Altos de México. Revista Fitotecnia Mexicana. 46(3):331-333.

16 Taiwo O. P.; Nwonuala, A. I.; Isaiah, B. F.; Olawamide, D. O. and Agbugba, I. K. 2020. Correlation and path coefficient analysis studies on grain yield and its contributing characters in maize (*Zea mays* L.). International Journal of Plant & Soil Science. 32(7):7-13. Doi: 10.9734/IJPSS/2020/v32i730300.

17 Uzcanga, P. N. G.; Cano, A. J. G.; Ramírez, J. H. S. y Tun, C. D. 2015. Características socioeconómicas y rentabilidad de los sistemas de producción de maíz bajo condiciones de temporal de la Península de Yucatán, México. Revista Mexicana de Agronegocios. 37:173-183.

18 Uzcanga, P. N. G.; Larqué, S. A. L.; Ángel, P. M. A.; Rangel, F. A. y Cano, J. G. 2017. Preferencias de los agricultores por semillas mejoradas y nativas de maíz en la Península de Yucatán, México. Revista Mexicana de Ciencias Agrícolas. 8(5):1021-1033.

19 Vatca, S. D.; Stoian, V. A.; Man, T. C.; Horvath, C.; Vidican, R.; Gadea, S.; Vatca, A.; Rotaru, A.; Varban, R.; Cristina, M. and Stoian, V. 2021. Agrometeorological requirements of maize crop phenology for sustainable cropping A historical review for Romania. Sustainability. 13(14):7719. https://doi.org/10.3390/su13147719. 14 p.

20 Yan, W. and Kang, M. S. 2003. GGE biplot analysis: a graphical tool for breeders, geneticists and agronomists. CRC press: Boca Raton, Fl. 271 p.

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