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GRAINS YIELD IN SOME CORN HYBRIDS: COMPARATIVE ANALYSIS

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Abstract

The present research tested, in comparative crops, 15 corn hybrids (F8021 to F8025), created within NIARD Fundulea. The field experiments were conducted under the conditions of ARDS Lovrin during the agricultural year 2023-2024. The comparative corn crop was grown in an unfertilized and unirrigated system, to test the genetic potential of the hybrids. The yield recorded values Y = 3387.80±174.57 kg ha^{-1} (hybrid F8035) and Y = 5994.47±174.57 kg ha^{-1} (hybrid F8021). Compared to the mean calculated at the experiment level (Y_m = 4804.61±174.57 kg ha^{-1}), nine hybrids recorded yield above the mean value, with statistical safety the hybrids F8021 and F8023 at the p<0.001 level (***), hybrid F8030 at the p<0.05 level (**) and hybrid F8025 at the p<0.05 level (*).Yield values below the experimental mean were recorded for hybrids F8031 and F8035 at the p<0.001 level (ooo), and for hybrid F8027 at the p<0.01 level (oo). In the case of the other hybrids, the differences did not present statistical certainty. The positive yield increase (ΔY) was between ΔY = 125.71 kg ha^{-1} (hybrid F8033) and ΔY = 1189.86 kg ha^{-1} (hybrid F8021).

***Key words**: comparative analysis, genetic potential, maize, positive yield increase, unfertilized comparative crops, yield.*

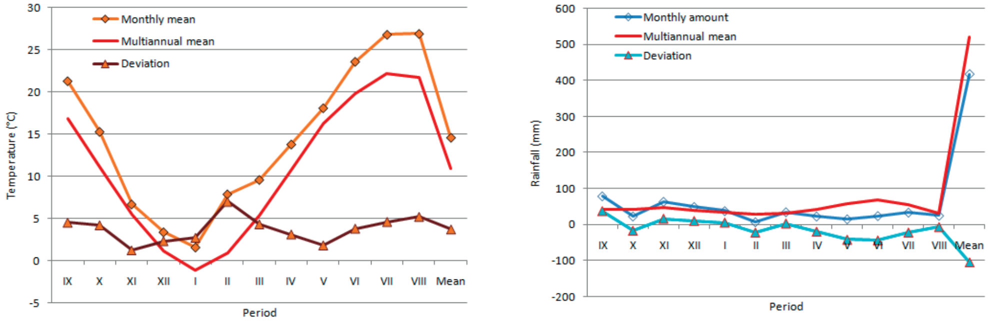
INTRODUCTION

Evaluating corn hybrids based on yield and main quality indices is an important objective in the breeding process, but also for farmers and agricultural practice (Mircea et al., 2023; Vana et al., 2023; Li et al., 2025).
The selection and cultivation of appropriate corn hybrids plays an important role in increasing productivity and yield (Bougma et al., 2024).
The analysis of the influence of genotype, environment, management practices, as well as the interactions of these elements on corn crop yield, has shown interest for agricultural production (farmers) as well as for research directions in breeding programs (Assefa et al., 2017).
Testing corn hybrids in different locations to evaluate yields is important for selecting hybrids with adaptability to certain environmental conditions (Wicaksana et al., 2022). Based on the results recorded, the study authors identified hybrids with high yield and stability, which showed interest for sustainable corn development programs.
The selection of corn hybrids, in relation to stability and yield levels associated with different environmental conditions, requires specific methods, and the "multienvironment" evaluation is an appropriate method (Ruswandi et al., 2022a).
The level of hybrids adaptation to regional (or local) environmental conditions, and the genetic potential for production, are important elements for the choice of hybrids, as they influence crop technologies and yields (Lingua et al., 2023).
The selection of corn genotypes, adapted to the environmental conditions of the area, and correlated with the agricultural system practiced, represents an important decision in the management of the farm and the farmers (Lingua et al., 2023; Bhat et al., 2024).
Climate change requires effective strategies to adopt new genotypes with high adaptability and economic yields (Zhao et al., 2023). Testing corn hybrids in various locations represents a step in future strategies for selecting genotypes with high adaptability (Zhao et al., 2023).
Climate change has significantly reduced corn crop yields, and the selection of hybrids

adaptable to new climatic conditions is of high interest (Kunwar et al., 2024).
The decrease in production and yield in corn has been analyzed and studied in relation to environmental factors that generate "multiple stress" (Konate et al., 2023). Cultivation of tolerant genotypes is important, but the authors considered it difficult to select stable and high-yielding hybrids, precisely as a result of the "genotype x environment" interaction. Therefore, testing a wide range of hybrids under specific cultivation conditions is a necessary and important step for identifying adapted genotypes.
The selection of genotypes suitable for divergent categories of farmer preferences (for corn cultivation) is of interest (Dermail et al., 2022). For this, simultaneous selection methods, in relation to the categories of interest, are necessary to identify appropriate hybrids (Dermail et al., 2022).
Yield potential has been studied in different plants and significant variability has been recorded in relation to cultivation locations (Ostberg et al., 2018; Pobkhunthod et al., 2022; Sjulgård et al., 2023).
Corn yield was analyzed in relation to agronomic traits through multivariate analysis on a collection of hybrids (59 hybrids) in order to describe the contribution of the traits considered to yield formation (Long et al., 2024). Corn yield was analyzed comparatively in relation to different categories of hybrids and agricultural systems (Reisig and Heiniger, 2024). Based on the results, the study authors concluded the need to improve yield in the studied genotypes.
Comparative analysis and selection of corn hybrids based on yield is important and requires appropriate mathematical and statistical analysis methods (Ruswandi et al., 2022a). Hierarchical modeling, within the synthesis analyses in comparisons of corn hybrids, was used to rank different hybrids based on yield (Assefa et al., 2017). Multivariate, non-parametric and parametric analyses were used to evaluate orumb hybrids grown in pure culture (single plant in the crop) and in intercropping (Ruswandi et al., 2022b). The authors selected different hybrids, suitable for the tested cropping systems, with the aim of promoting them in agricultural practice. In other studies, two clusters of corn hybrids and four groups of traits in relation to hybrid performance were identified through multivariate analysis (Long et al., 2024).
This study comparatively evaluated the yield of a collection of fifteen maize hybrids created within NIARD Fundulea, hybrids that were cultivated in comparative crops within ARDS Lovrin, under the pedoclimatic conditions specific to the Western Plain of Romania.

MATERIALS AND METHODS

In accordance with the research and testing protocols of plant genotypes for breeding programs and promotion in agricultural practice for farmers, a collection of fifteen corn hybrids, created at NIARD Fundulea, were tested under the conditions of the Western Plain of Romania. The field research and study were conducted under the specific conditions of ARDS Lovrin. The study period was in the agricultural year 2023-2024. The field experiment was located on an experimental plot with chernozem soil, and in a non-irrigated system. Climatic conditions, in the form of mean monthly temperatures (°C) and rainfall (mm) during the study period are presented in Figure 1.
The biological material was represented by fifteen hybrids, with experimental names F8021 to F8035.
The experiment was organized in comparative crops, and each hybrid was cultivated in repetitions. The crop technology was uniform and consisted of land preparation (plowing, followed by soil harrowing and work with the combiner), and weed control (pre-emergence herbicides, mechanical weeding in vegetation, supplemented with manual work). No fertilization was applied. The sowing was done in the first decade of April 2024. At harvest maturity (Meier, 2001), samples were collected from each variant (hybrid) and repetition to determine yield.
The authors generated a flow chart, which included the phases and work stages, in relation to the purpose of the study (Figure 2).
The recorded experimental data were analyzed in relation to the purpose of the study, to compare the tested hybrids and identify hybrids with generic advantage for yield under the experimental study conditions.



(a) (b)

Figure 1. Climatic conditions during the study period; (a) temperature values, (b) precipitation values

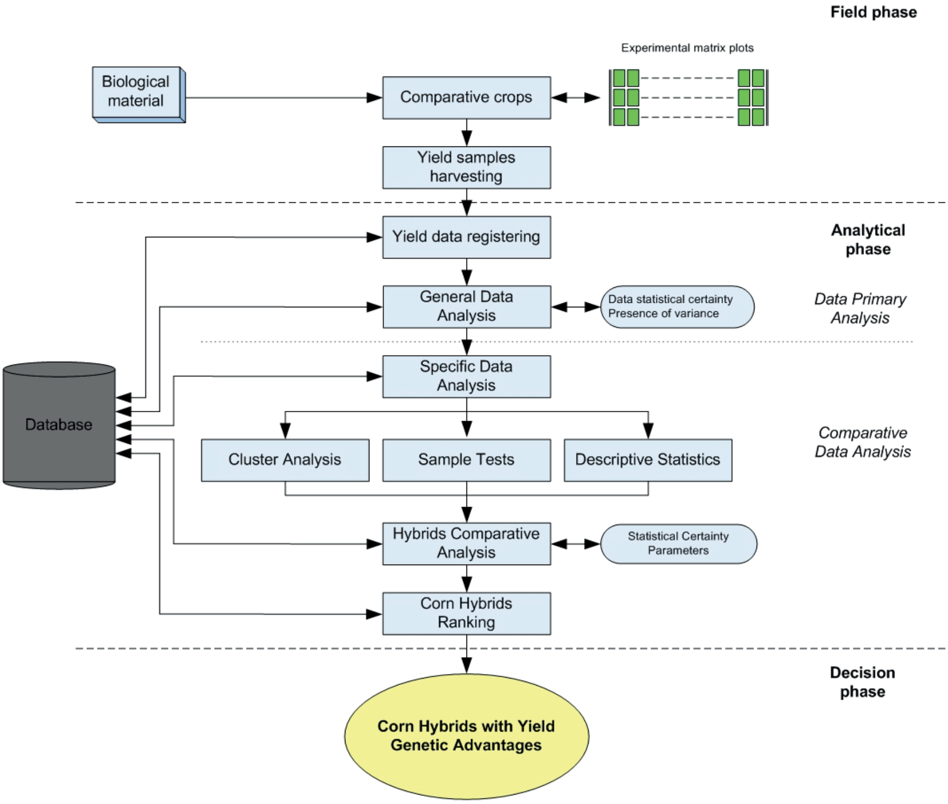


Figure 2. Workflow for identifying valuable corn genotypes

Different methods were applied, Anova Test (data reliability and presence of variance), t Test (comparative analysis), descriptive statistical analysis (definition of quartile thresholds), cluster analysis, ranking analysis. The calculations and statistical processing of the data were done in EXCEL and with the PAST software, which also resulted in graphical models (Hammer et al., 2001).

RESULTS AND DISCUSSIONS

Corn crop yield is the expression of the genetic potential of the cultivated genotypes, in relation to environmental and technological conditions, as an interaction between them.

The present study focused on the genetic potential of the tested corn hybrids. A cultivation technology was applied to ensure uniform conditions for the comparative corn crop, but without fertilization and irrigation, so that the corn hybrids expressed their genetic potential in relation to yield.

Yield values were recorded from Y = 3387.80±174.57 kg ha^{-1} (hybrid F8035), to Y = 5994.47±174.57 kg ha^{-1} (hybrid F8021). The Anova test (Alpha = 0.05) validated the experimental data reliability, and the existence of variance, in the data set (Table 1).

Table 1. Anova Test

Source of variation	SS	df	MS	F	P-value	F crit
Between Groups	25600002	14	1828572	2.3817	0.0141	1.9182
Within Groups	34549596	45	767768.8			
Total	60149598	59				

The calculated mean yield value (Y_m) at the experiment level was Y_m = 4804.61±174.57 kg ha^{-1}. Compared to the calculated mean (Y_m), nine hybrids recorded yield values above the mean value, and six hybrids recorded yield values below the mean at the experiment level (Table 2).

Table 2. Statistical values resulting from the comparative analysis of corn hybrids

Corn hybrid	Given mean	Difference	Statistical parameters			
			95% conf. interval	t	p (same mean)	Significance
F8021	5994.47	1189.90	(815.43 1564.3)	-6.8158	8.38E-06	***
F8022	4476.24	-328.37	(-46.052 702.8)	1.8810	0.0809	ns
F8023	5556.68	752.07	(377.64 1126.5)	-4.3080	0.0007	***
F8024	4441.40	-363.21	(-11.212 737.64)	2.0806	0.0563	ns
F8025	5321.82	517.21	(142.78 891.63)	-2.9627	0.0103	*
F8026	5032.14	227.53	(-146.9 601.95)	-1.3033	0.2135	ns
F8027	4167.51	-637.10	(262.68 1011.5)	3.6495	0.0026	oo
F8028	4954.47	149.86	(-224.57 524.28)	-0.8584	0.4051	ns
F8029	4986.21	181.60	(-192.83 556.02)	-1.0402	0.3159	ns
F8030	5325.20	520.59	(146.16 895.01)	-2.9820	0.0099	**
F8031	3765.40	-1039.20	(664.79 1413.6)	5.9528	3.53E-05	ooo
F8032	4772.83	-31.78	(-342.64 406.21)	0.1821	0.8582	ns
F8033	4930.32	125.71	(-248.72 500.13)	-0.7201	0.4833	ns
F8034	4956.70	152.09	(-222.34 526.51)	-0.8712	0.3983	ns
F8035	3387.80	-1416.80	(1042.4 1791.2)	8.1158	1.16E-06	ooo

In the case of hybrids with values above the mean, in four hybrids the differences from the mean presented statistical certainty, respectively hybrids F8021 and F8023 at the $p<0.001$ level (***), hybrid F8030 at the $p<0.05$ level (**), and hybrid F8025 at the $p<0.05$ level (*).

In the case of negative differences, statistical certainty was recorded in the case of hybrids F8031 and F8035 at the $p<0.001$ (ooo), in the case of hybrid F8027 at the $p<0.01$ (oo).

In the case of the other hybrids, the differences from the mean at the experimental level (positive or negative) did not present statistical certainty.

The positive yield increase (ΔY) was between ΔY = 125.71 kg ha^{-1} (hybrid F8033) and ΔY = 1189.86 kg ha^{-1} (hybrid F8021). The negative yield increase was between ΔY = -328.37 kg ha^{-1} (hybrid F8022) and ΔY = -1416.81 kg ha^{-1} (hybrid F8035).

Genetic advantage for yield, under the study conditions, was shown by the hybrids F8021, F8023 (***), F8030 (**) and F8025 (*). The graphic representation of the yield differences for the studied hybrids, in relation to the mean value of the experiment, is presented in Figure 3.

Descriptive statistical analysis facilitated the determination of threshold values for the delimitation of quartiles.

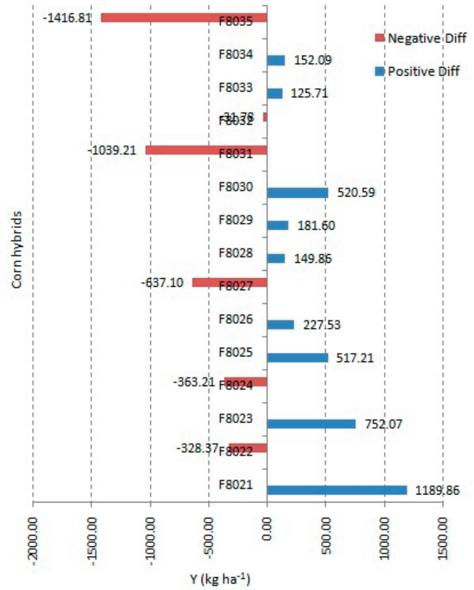


Figure 3. Distribution of yield differences compared to the mean value for the studied corn hybrids

The lower quartile included values lower than 4441.40, the middle quartile included values between the two thresholds (4441.40 > Mean Quartile < 5321.82), and the upper quartile included values higher than 5321.82.

Based on the yield values generated under the experimental conditions, the corn hybrids were classified into quartiles according to the scheme in Figure 4.

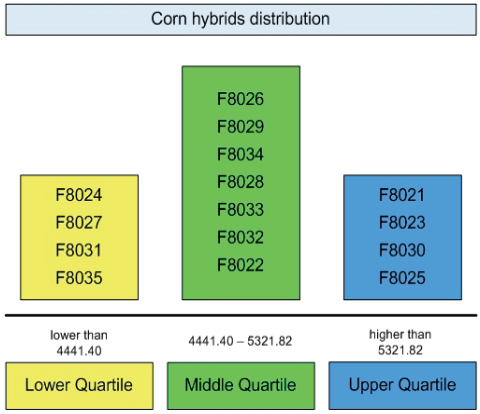


Figure 4. Distribution of corn hybrids by quartiles, in relation to yield

Four hybrids were classified in the lower quartile, F8024, F8027, F8031 and F8035. Seven hybrids were classified in the middle quartile, respectively F8026, F8029, F8034, F8028, F8033, F8032, and F8022. Four hybrids were classified in the upper quartile, respectively F8021, F8023, F8030, and F8025.

Cluster analysis grouped corn hybrids based on yield (Coph. corr. = 0.825) (Figure 5). Two distinct clusters resulted, with SDI values in Table 3.

One cluster (C1) included two hybrids with lower yield values (F8031 and F8035).

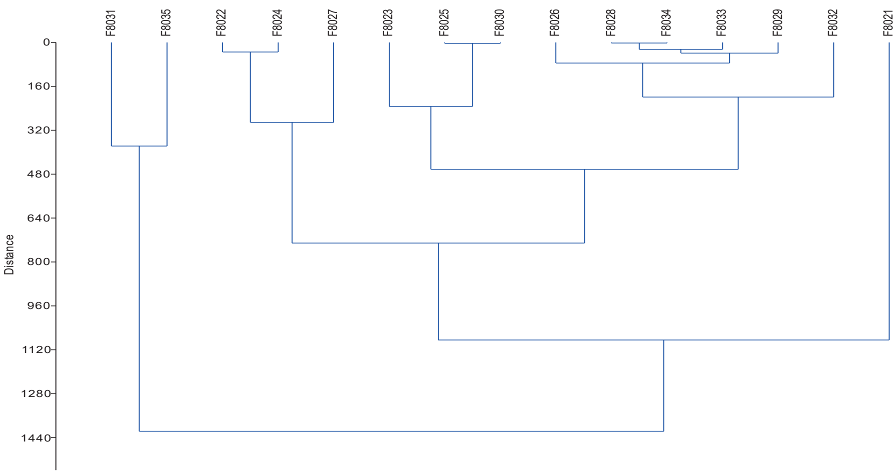


Figure 5. Cluster dendrogram of corn hybrids grouping based on Euclidean distances, in relation to yield values

Table 3. SDI values that describe the level of similarity between corn hybrids based on yield

	F8021	F8022	F8023	F8024	F8025	F8026	F8027	F8028	F8029	F8030	F8031	F8032	F8033	F8034	F8035
F8021		1518.20	437.79	1553.10	672.65	962.33	1827.00	1040.00	1008.30	669.27	2229.10	1221.60	1064.20	1037.80	2606.70
F8022	1518.20		1080.40	34.84	845.58	555.90	308.73	478.23	509.97	848.96	710.84	296.59	454.08	480.46	1088.40
F8023	437.79	1080.40		1115.30	234.86	524.54	1389.20	602.21	570.47	231.48	1791.30	783.85	626.36	599.98	2168.90
F8024	1553.10	34.84	1115.30		880.42	590.74	273.89	513.07	544.81	883.80	676.00	331.43	488.92	515.30	1053.60
F8025	672.65	845.58	234.86	880.42		289.68	1154.30	367.35	335.61	3.38	1556.40	548.99	391.50	365.12	1934.00
F8026	962.33	555.90	524.54	590.74	289.68		864.63	77.67	45.93	293.06	1266.70	259.31	101.82	75.44	1644.30
F8027	1827.00	308.73	1389.20	273.89	1154.30	864.63		786.96	818.70	1157.70	402.11	605.32	762.81	789.19	779.71
F8028	1040.00	478.23	602.21	513.07	367.35	77.67	786.96		31.74	370.73	1189.10	181.64	24.15	2.23	1566.70
F8029	1008.30	509.97	570.47	544.81	335.61	45.93	818.70	31.74		338.99	1220.80	213.38	55.89	29.51	1598.40
F8030	669.27	848.96	231.48	883.80	3.38	293.06	1157.70	370.73	338.99		1559.80	552.37	394.88	368.50	1937.40
F8031	2229.10	710.84	1791.30	676.00	1556.40	1266.70	402.11	1189.10	1220.80	1559.80		1007.40	1164.90	1191.30	377.60
F8032	1221.60	296.59	783.85	331.43	548.99	259.31	605.32	181.64	213.38	552.37	1007.40		157.49	183.87	1385.00
F8033	1064.20	454.08	626.36	488.92	391.50	101.82	762.81	24.15	55.89	394.88	1164.90	157.49		26.38	1542.50
F8034	1037.80	480.46	599.98	515.30	365.12	75.44	789.19	2.23	29.51	368.50	1191.30	183.87	26.38		1568.90
F8035	2606.70	1088.40	2168.90	1053.60	1934.00	1644.30	779.71	1566.70	1598.40	1937.40	377.60	1385.00	1542.50	1568.90	

In cluster C2, the other hybrids were grouped into different subclusters based on similarity. The hybrid F8021 with the highest yield had an independent position. The other hybrids were grouped into three subclusters.

Based on the yield values, a ranking of the corn hybrids was made. The result is the hierarchy in Figure 6, which shows the order of the hybrids, and the interevent distance values.

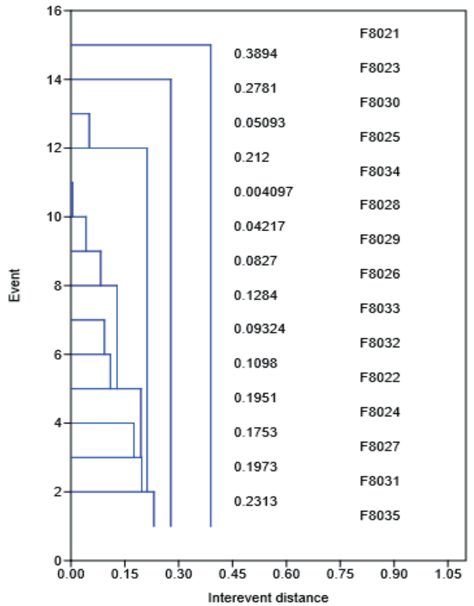


Figure 6. Ranking scaling dendrogram of corn hybrids based on yield values

Hybrids positioning in scattergram format is presented in Figure 7, with the confidence interval.

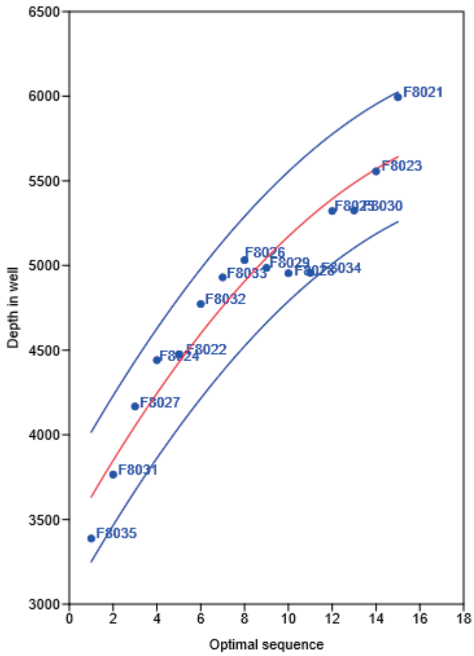


Figure 7. Distribution of corn hybrids in scattergram format, with confidence interval (95%)

Evaluating the degree of adaptation and productivity of corn hybrids through "multi-zonal" comparative testing in field conditions and technology is important, necessary and promoted by various studies and research (Lingua et al., 2023; Bougma et al., 2024).

The variation in yield of the tested corn hybrids was recorded in relation to the potential of the genotype, but also to environmental conditions (Bhat et al., 2024; Bougma et al., 2024).

Alam et al. (2022) identified maize genotypes that expressed differential genetic potential in relation to certain climate and soil conditions, and the authors formulated in the selection of the tested genotypes "hybrids with potential centered on the geographical region". Similar results have been reported in other studies, regarding the evaluation of morphological, phenotypic parameters, productivity and yield elements in corn, which confirms the high importance of these approaches (Perkins et al., 2024; Tashikalma and Giroh, 2024).

In the context of the present study, uniform cultivation conditions facilitated the expression of the genetic potential for yield of the 15 tested hybrids. Through adequate analysis of the results, four hybrids positioned in the upper quartiles, with high yield values, were identified. The yield increase generated by these hybrids ranged between $\Delta Y = 517.21$ kg ha^{-1} (F8025), and $\Delta Y = 1189.86$ kg ha^{-1} (F8021).

The comparative analysis of the hybrids differentiated the hybrids with a genetic advantage with statistical certainty compared to the mean of the experiment. The cluster analysis and the ranking analysis clearly detected the hybrids based on similarity and ranked the hybrids based on yield performance.

CONCLUSIONS

Corn hybrids created within NIARD Fundulea, and comparatively tested in the pedoclimatic conditions specific to the Western Plain of Romania, expressed differentiated genetic yield potential.

Nine hybrids showed positive differences compared to the experimental mean. Of these hybrids, four hybrids (F8021, F8023, F8030 and F8025) were placed in the upper quartiles, with yield values higher than 5321.82 kg ha^{-1}, which was the threshold of this quartile. The F8021 and F8023 hybrids showed differences at the $p<0.001$ level compared to the experimental mean, the F8030 hybrid showed differences at the $p<0.01$ level, and the F8025 hybrid showed differences at the $p<0.05$ level.

Cluster analysis based on hybrid similarity, and ranking of hybrids through ranking analysis based on yield performance, facilitated the analysis and selection of hybrids with a high level of confidence for the breeding program, as well as for crop recommendations.

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