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ANALYSIS OF THE AGRONOMIC TRAITS OF 15 MAIZE HYBRIDS CULTIVATED IN THE WESTERN PART OF ROMANIA

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Abstract

This paper presents the analysis of 15 cultivated maize hybrids for further selection of the hybrids that present a high yield potential and favourable agronomical traits, in the context of actual climate change. The analysis and interpretation of the obtained results was performed with the help of the IBM Spss statistical software. Descriptive characteristics were calculated: average, median, standard deviation, minimum values and maximum values. In order to analyse the significant differences, the ANOVA and Duncan statistical test was applied, respectively Kruskal Wallis and Mann-Whitney. For the study of the links between the variables, the Pearson correlation coefficients and the regression lines were determined. The results are indicating the existence of significant differences between the analysed parameters Also, the results are corelated to the meteorological data, registered during the corresponding development phase of the plants.

Key words*: maize hybrids, agronomic characteristics, climate change.*

INTRODUCTION

The climate changes of recent years require seed producers to change their strategies to ensure that their maize hybrids can withstand a changing environment (Haș, 2000; Sarca, 2004; Șuteu et al., 2013 In this regard, genetic selection plays a very important role. Seed producers use genetic selection to develop hybrids that are more tolerant to high temperatures, droughts, floods, or diseases. (Duvick, 1984; Nagy, 2004) In this way, more resistant hybrids to climate change are obtained. Another approach is the development of specially adapted hybrids (Grecu and Has, 2001). Seed producers develop hybrids specifically adapted to certain geographic regions or climatic conditions to achieve better yields (Has et al., 1999; Nagy, 2004; Musteață, 2005). Increasing genetic diversity in the maize breeding process can help reduce the risks associated with climate change, such as drought or the emergence of new diseases (Tătaru, 1974; Tătaru, 1978).

Additionally, advanced agronomic technologies, including irrigation and soil fertility systems, can help increase the productivity of maize hybrids in drier or less rainy environments (Roman et al., 1973; Troyer 1999; Troyer et al., 2000). Adopting better agronomic practices can also help conserve soil and reduce nutrient loss. The use of early detection technologies, such as satellites and sensors mounted on drones, can detect temperature and humidity changes more quickly, allowing producers to make faster decisions and adjust their agronomic practices. In general, efforts to adapt maize hybrids to the current climate context are ongoing and aim to obtain more resistant and adaptable hybrids to climate change to ensure food security and the continuity of agricultural production in the future

MATERIALS AND METHODS

The biological material subjected to research consisted of 15 maize hybrids grown in the western region of Romania. Testing was carried out at Lovrin Agricultural Research and Development Station, on a cambic chernozem soil, with a shallow water table, moist, with weak salinization below 100 cm, moderate alkalinization, slightly decarbonated, on sandy loam with a parent rock composed of sand and with the water table at a depth of 2-5 m. The experience was a comparative culture type, and production results were interpreted relative to the field average. Statistical analysis of the data was performed using the IBM Spss statistical software. Descriptive characteristics such as mean, median, standard deviation, minimum and maximum values were calculated. For the analysis of significant differences, the ANOVA and Duncan test, as well as the Kruskal-Wallis and Mann-Whitney tests were applied. Pearson correlation coefficients and regression lines were determined to study the relationships between variables.

RESULTS AND DISCUSSIONS

The observation of the different hybrid traits was made in the filed and in the laboratory, post-harvest. Leaf colour, position and total number, anthers and stigma colour, cob position and plant height variation were the characteristics that were taken under observations

Leaf colour - The colour of the leaves is light green for 5 (33.3%) hybrids: Lv101, Lv102, Lv103, Lv104, Lv106, Lv107 and dark green for the remaining 10 hybrids (66.67%).

Leaf position - The insertion angle (leaf position) is erect for 8 (53.33%) of the hybrids and semi-erect for 7 (46.67%) of the hybrids (Lv101, Lv102, Lv103, Lv104, Lv106, Kerala, Replik).

Anthers colour (tassel) - The colour of the anthers is white-yellowish for 7 (46.67%) hybrids (Lv101, Lv102, Lv104, Lv107, HSLvOana, LG 31377, 3520R) rose for 7 (46.67%) hybrids (Lv103, Lv105, Lv106, Multipel, CERA 320, Kerala, Replik) respectively yellow-rose for 1 hybrid, namely P0217.

Stigma colour (silk) - The colour of the stigmas is yellow for 7 (46.67%) hybrids (Lv101, Lv102, HSLvOana, LG 31377, 3520R), rose for 4 (26.67%) hybrids (Lv103, Lv104, Lv105, Lv106) and yellow-rose for the remaining 4 (26.67%) hybrids.

Cob position (degrees) - The position of the cob was at angles of 25 (2.22%), 30 (6.67%), 35 (37.78%), 40 (2.22%) and 45 (51.11%) degrees, the minim angle being registered in the measuring of the hybrid Lv 107

Total number of leaves, Number of leaves up to the main cob - The total number of leaves varies between 9 and 15 leaves per cob, with a mean value of 13.4 leaves, respectively the number of leaves to the main cob varies between 6 and 9 leaves, with a mean value of 7.55 leaves.

Between the number of leaves to the main cob and the total number of leaves one can observe a significant direct correlation ($R=0.6$, $p=0.000$).

Plant height (m) - Regarding the total plant height, this varied between 1.60 m for the hybrid Lv102 and a maximum of 2.5 m for the hybrid Lv103, and the mean height was 1.986 m (Figure 1).

Applying ANOVA, one observes that there are significant differences between the studied hybrids regarding the total plant height ($F=68.092$, $p=0.000$). The hybrids Lv103, LG 31377, Multipel, Kerala and Po217 are those which presented significant differences in positive sense with respect to the mean of the field (Table 1).

The data regarding the insertion height of the cob show that this has varied between0.50m for the hybrids Lv101, Lv102, Lv104, lv106, Lv107 and 1.10 m for the hybrids HSLvOana and LG 31377 with a mean of the field of 0.7709 m (Figure 2).

The hybrids differ significantly from the point of view of the variable Main cob insertion height ($F=35.570$, $p=0.000$). One observes that the hybrids Lv103, HSLvOana, LG 31377 and 3520R, Multipel, are those which have presented significant differences in positive sense with respect to the mean of the field (Table 2).

Table 1. Numerical data associated to plant height

	Mean	Std. Deviation	95% Confidence Interval for Mean		Min	Max	The difference between the averages and the average of the field	P	Semnif.
			Lower Bound	Upper Bound					
Media campului	1.9860	0.16882	1.9706	2.0013	1.60	2.50	-	-	-
Lv101	1.8160	0.12770	1.7683	1.8637	1.62	2.10	-0.17000	0.000	000
Lv102	1.8000	0.08280	1.7691	1.8309	1.60	2.00	-0.18600	0.000	000
Lv103	2.1203	0.16420	2.0590	2.1816	1.80	2.50	0.13433	0.000	***
Lv104	1.8200	0.08741	1.7874	1.8526	1.68	2.00	-0.16600	0.000	000
Lv105	1.9817	0.10554	1.9423	2.0211	1.80	2.20	-0.00433	0.883	Ns
Lv106	1.9173	0.11588	1.8741	1.9606	1.70	2.10	-0.06867	0.020	0
Lv107	1.9470	0.10103	1.9093	1.9847	1.70	2.12	-0.03900	0.185	Ns
HSLvOana	1.9867	0.08563	1.9547	2.0186	1.83	2.19	0.00067	0.982	Ns
LG 31377	2.3217	0.06259	2.2983	2.3450	2.20	2.45	0.33567	0.000	***
3520R	1.9690	0.05671	1.9478	1.9902	1.85	2.09	-0.01700	0.563	Ns
Multipel	2.1353	0.07664	2.1067	2.1640	2.02	2.30	0.14933	0.000	***
CERA 320	1.8083	0.07456	1.7805	1.8362	1.69	1.98	-0.17767	0.000	000
Kerala	2.0697	0.06881	2.0440	2.0954	1.92	2.20	0.08367	0.005	**
Replik	1.9780	0.07014	1.9518	2.0042	1.84	2.12	-0.00800	0.785	Ns
Po217	2.1187	0.10699	2.0787	2.1586	1.96	2.34	0.13267	0.000	***

Ns= Not significant. * The mean difference positive and is significant at the 0.05 level. ** The mean difference positive and is significant at the 0.01 level. *** The mean difference positive and is significant at the 0.001 level. 0 The mean difference negative and is significant at the 0.05 level. 00 The mean difference negative and is significant at the 0.01 level. 000 The mean difference negative and is significant at the 0.001 level.

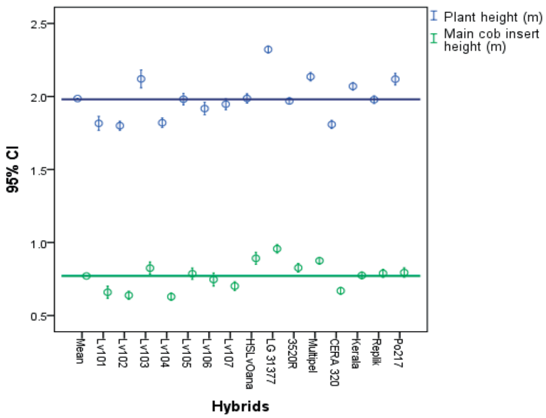

Figure 1. Means and confidence intervals for the means of the variables Total plant height, Main Cob insertion height vs mean of the field

Table 2. Numerical data associated to cob insertion height

	Mean	Std. Deviation	95% Confidence Interval for Mean		Min	Max	The difference between the averages and the average of the field	p	Semnif
			Lower Bound	Upper Bound					
The average of the field	0.7709	0.12575	0.7595	0.7824	0.5	1.1			
Lv101	0.6593	0.11117	0.6178	0.7008	0.5	0.92	-0.1116	0.000	000
Lv102	0.6383	0.07502	0.6103	0.6663	0.5	0.8	-0.1326	0.000	000
Lv103	0.8247	0.11082	0.7833	0.866	0.6	1.05	0.0538	0.045	*
Lv104	0.629	0.0664	0.6042	0.6538	0.5	0.79	-0.1419	0.000	000
Lv105	0.7863	0.1045	0.7473	0.8254	0.6	1.05	0.0154	0.564	Ns
Lv106	0.7467	0.12027	0.7018	0.7916	0.5	1	-0.0242	0.365	Ns
Lv107	0.7017	0.0797	0.6719	0.7314	0.5	0.9	-0.0692	0.010	0
HSLvOana	0.8917	0.11008	0.8506	0.9328	0.6	1.1	0.1208	0.000	***
LG 31377	0.957	0.07702	0.9282	0.9858	0.8	1.1	0.1861	0.000	***
3520R	0.8267	0.0804	0.7966	0.8567	0.6	0.94	0.0558	0.038	**
Multipel	0.8753	0.06163	0.8523	0.8983	0.75	1	0.1044	0.000	***
CERA 320	0.6693	0.06258	0.646	0.6927	0.55	0.8	-0.1016	0.000	0
Kerala	0.7747	0.06437	0.7506	0.7987	0.7	0.9	0.0038	0.888	Ns
Replik	0.7887	0.07328	0.7613	0.816	0.6	0.9	0.0178	0.507	Ns
Po217	0.7943	0.0878	0.7615	0.8271	0.6	1	0.0234	0.381	Ns

Ns= Not significant. * The mean difference positive and is significant at the 0.05 level. ** The mean difference positive and is significant at the 0.01 level. *** The mean difference positive and is significant at the 0.001 level. 0 The mean difference negative and is significant at the 0.05 level. 00 The mean difference negative and is significant at the 0.01 level. 000 The mean difference negative and is significant at the 0.001 level.

The leaf length of the main cob has registered values between 50 cm for the hybrid Lv107and 86 cm for the hybrid LG 31377, the maxim of the means of the lengths of the leaves being attained for LG 31377 (Figure 2).
The analysis of the length of the leaf of the main cob shows that there are significant differences regarding the analysed hybrids (F=23.530, p=0.000) and the mean of the field, the hybrids LG 31377, Multipel, Replik, Po217 being those which differ significantly in positive sense with respect to the mean of the field (Table 3).

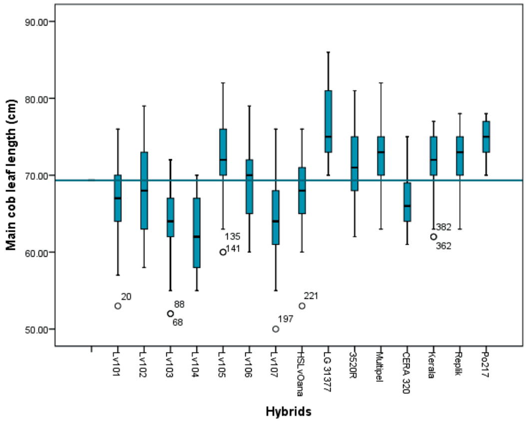

Figure 2. Box-plot diagram associated with the characteristic length of leaf of the main cob vs. mean of the field

Table 3. Numerical data associated to cob insertion height

	Mean	Std. Deviation	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Min	Max	The difference between the averages and the average of the field	p	Semnif.
The average of the field	69.3333	6.08789	68.7791	69.8875	50.00	86.00			
Lv101	66.6667	5.68321	64.5445	68.7888	53.00	76.00	-2.6666	0.064	Ns
Lv102	68.5000	5.64923	66.3905	70.6095	58.00	79.00	-0.8333	0.561	Ns
Lv103	63.7667	4.93183	61.9251	65.6082	52.00	72.00	-5.5666	0.000	000
Lv104	61.9000	4.56637	60.1949	63.6051	55.00	70.00	-7.4333	0.000	000
Lv105	72.0000	5.90149	69.7963	74.2037	60.00	82.00	2.6667	0.063	Ns
Lv106	68.9333	5.17909	66.9994	70.8672	60.00	79.00	-0.3999	0.780	Ns
Lv107	64.0667	5.56425	61.9889	66.1444	50.00	76.00	-5.2666	0.000	000
HSLvOana	67.7333	4.54808	66.0351	69.4316	53.00	76.00	-1.5999	0.265	Ns
LG 31377	76.5667	4.24819	74.9804	78.1530	70.00	86.00	7.2333	0.000	***
3520R	71.6333	4.95833	69.7819	73.4848	62.00	81.00	2.300	0.109	Ns
Multipel	72.7000	3.87877	71.2516	74.1484	63.00	82.00	3.3667	0.019	**
CERA 320	66.6667	3.19842	65.4724	67.8610	61.00	75.00	-2.6666	0.064	Ns
Kerala	71.7333	4.44067	70.0752	73.3915	62.00	77.00	2.4000	0.095	Ns
Replik	72.2333	4.04017	70.7247	73.7420	63.00	78.00	2.9000	0.044	*
Po217	74.9000	2.46842	73.9783	75.8217	70.00	78.00	5.5667	0.000	***

Ns= Not significant. * The mean difference positive and is significant at the 0.05 level. ** The mean difference positive and is significant at the 0.01 level. *** The mean difference positive and is significant at the 0.001 level. 0 The mean difference negative and is significant at the 0.05 level. 00 The mean difference negative and is significant at the 0.01 level. 000 The mean difference negative and is significant at the 0.001 level.

The main width of the cob leaf varies between 5 cm and 11 cm and shows significant differences compared to both the field average and the hybrids considered in the study (F=34.323, p=0.000). Hybrids 3520R, Multipel, and Po217 differ significantly positively compared to the field average (Table 3, Figure 3).

Table 4. Numerical data associated to main cob leaf width

	Mean	Std. Deviation	95% Confidence Interval for Mean		Min	Max	The difference between the averages and the average of the field	p	seminif
			Lower Bound	Upper Bound					
The average of the field	7.4000	1.10327	7.2996	7.5004	5.00	11.00			
Lv101	6.6000	0.81368	6.2962	6.9038	6.00	8.00	-0.80000	0.001	000
Lv102	6.9000	0.99481	6.5285	7.2715	5.00	8.00	-0.50000	0.035	00
Lv103	6.4000	0.62146	6.1679	6.6321	5.00	7.00	-1.00000	0.000	000
Lv104	6.1333	0.50742	5.9439	6.3228	5.00	7.00	-1.26667	0.000	000
Lv105	7.3000	0.91539	6.9582	7.6418	6.00	8.00	-0.1000	0.673	Ns
Lv106	6.6000	0.62146	6.3679	6.8321	5.00	8.00	-.80000	0.001	000
Lv107	7.6000	0.81368	7.2962	7.9038	6.00	9.00	0.2000	0.399	Ns
HSLvOana	7.8333	0.94989	7.4786	8.1880	6.00	9.00	0.4333	0.068	Ns
LG 31377	7.6000	0.72397	7.3297	7.8703	6.00	8.00	0.2000	0.399	Ns
3520R	9.0667	0.98027	8.7006	9.4327	8.00	11.00	1.66667	0.000	***
Multipel	8.8333	0.46113	8.6611	9.0055	7.00	9.00	1.43333	0.000	***
CERA 320	7.0667	0.78492	6.7736	7.3598	6.00	8.00	-0.3333	0.160	Ns
Kerala	7.5333	0.77608	7.2435	7.8231	6.00	8.00	0.1333	0.574	Ns
Replik	7.3000	0.74971	7.0201	7.5799	5.00	8.00	-0.1000	0.673	Ns
Po217	8.2333	0.72793	7.9615	8.5051	6.00	9.00	0.83333	0.000	***

ns= Not significant. * The mean difference positive and is significant at the 0.05 level. ** The mean difference positive and is significant at the 0.01 level. *** The mean difference positive and is significant at the 0.001 level. 0 The mean difference negative and is significant at the 0.05 level. 00 The mean difference negative and is significant at the 0.01 level. 000 The mean difference negative and is significant at the 0.001 level.

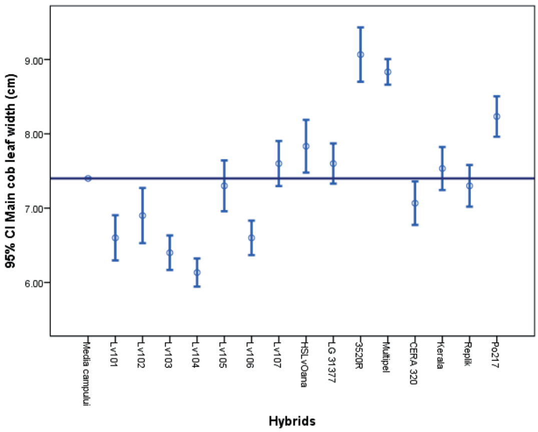

Figure 3. Means and confidence intervals of the mean for main cob leaf width (cm)

The average number of days to germination is 8.82 days with a standard deviation of 0.94 days. The hybrids Po217, Kerala, and Lv107 germinated after a minimum of 8 days, while the last hybrid to germinate was HSLvOana after a maximum of 12 days (Figure 4, Table 5). The median number of days to flowering is Me=69.67 days.

Table 5. Numerical data associated to main cob leaf width

	Mean	SD	Min	Max	Percentiles		Median
					25(Q_1)	75(Q_3)	
Days to plant emergence	8.82	0.94	7.67	11.33	8.33	9.33	8.33
Days to flowering	70.00	1.40	69.00	74.00	69.00	70.50	69.67
Days to silk	73.38	1.48	72.00	76.67	72.33	73.83	73.00

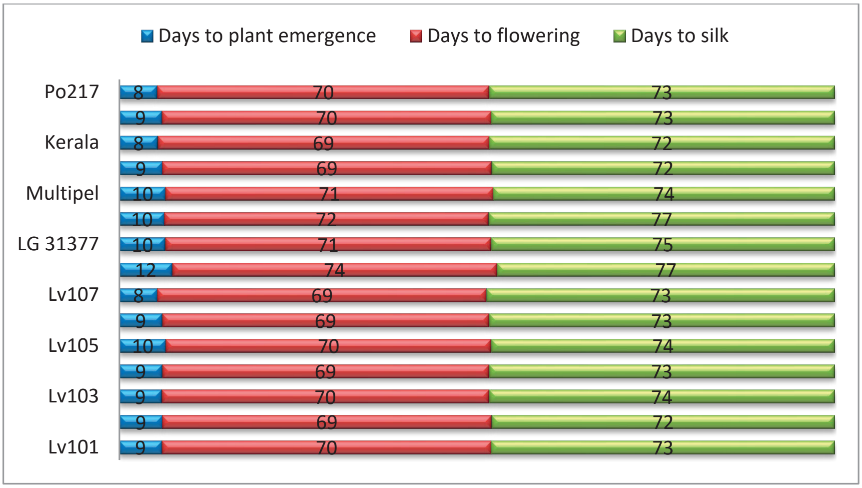

Figure 4. The number of days until emergence/flowering/silking for the hybrids considered in the study

The average of the accumulated growing degree days until flowering was 16238.20 (°C)/hour degrees, with a standard deviation of 464.40 (°C) (Table 6)

Table 6. Numerical descriptive characteristics associated with the variables of cumulative thermal degree sum until flowering (°C)/Degree hours, cumulative thermal degree sum until flowering (°C)/Degree days, cumulative thermal degree sum until tasselling (°C)/Degree hours, and cumulative thermal degree sum until tasselling (°C)/Degree days

	Mean	SD	Min	Max	Percentiles		Median
					25 (Q_1)	75 (Q_3)	
The sum of thermal degrees until flowering day(C) / Degrees hours	16238.20	464.40	15865.67	17487.00	15869.67	16471.50	16055.00
The sum of thermal degrees until flowering day(C) / Degrees days	674.78	19.35	659.00	726.67	659.33	684.50	667.33
The sum of thermal degrees to silky day (C) / Degrees hours	17608.29	396.56	17177.00	18490.00	17326.67	17707.00	17575.33
The sum of thermal degrees to silky day (C) / Degrees days	731.82	16.47	714.00	768.67	720.00	735.67	730.33

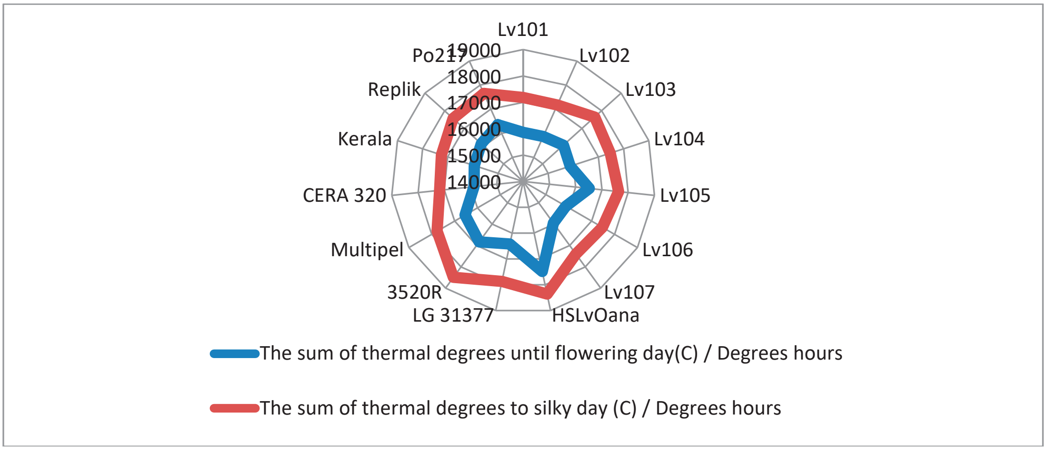

Figure 5. The cumulative thermal degree sum until flowering (°C) / degree hours and the cumulative thermal degree sum until tasseling (°C) / degree hours according to hybrids

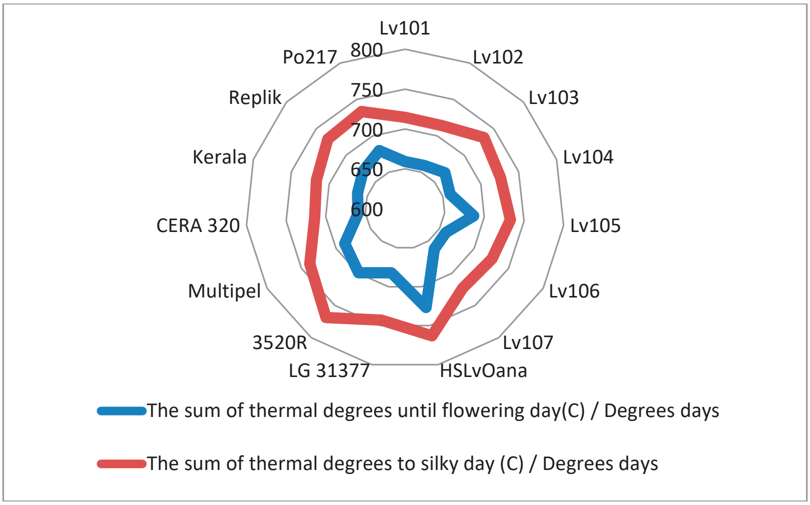

Figure 6. The cumulative thermal degree sum until flowering (°C)/degree days and the cumulative thermal degree sum until tasselling (°C)/degree days according to hybrids

Table 7 and Figures 7-8 present the production results for 15 hybrids evaluated in the experiment. Three hybrids (3520R, Multipel, and Po217) produced yields exceeding the field mean of 8064 kg/ha, with the hybrid P0217 producing the highest mean yield of 11807 kg/ha, followed by Multipel with 11322 kg/ha and 3520R with 10260 kg/ha. The differences in production among these hybrids were statistically significant. The hybrids Replik (9418 kg/ha) and LG31377 (9779 kg/ha) also produced yields above 9000 kg/ha, with differences from the field mean being statistically significant. The production of four hybrids, HSLvOana, CERA 320, Kerala, and Lv101, were close to the field mean, with no statistically significant differences. Three hybrids, Lv106, Lv104, and LV102, produced yields below the field mean by 2000-3000 kg/ha, with statistically significant differences in a negative sense. The hybrids Lv103, Lv105, and Lv107 produced yields lower than the field mean by 1300-1800 kg/ha.

Table 7. Kernel yield (kg/ha; u=14%)

	Mean	Std. Deviation	95% Confidence Interval for Mean		Minimum	Maximum	Diferenta mediilor fata de media campului	semnif	Tukey HSD
			Lower Bound	Upper Bound					
Lv106	4954	318.11	4835.21	5072.79	4394	5391	-3110.14	000	A
Lv104	5080.67	262.84	4982.52	5178.81	4620	5612	-2983.47	000	A
Lv102	5962.33	440.56	5797.82	6126.84	5130	6620	-2101.81	000	B
Lv103	6188.47	546.95	5984.23	6392.7	5448	6989	-1875.67	00	B, C
Lv107	6582.93	496.96	6397.36	6768.5	6002	7399	-1481.21	0	C
Lv105	6755.9	284.73	6649.58	6862.22	6380	7228	-1308.24	0	C, D
Lv101	7228.67	714.13	6962.01	7495.33	6264	8308	-835.47	Ns	D
Media campului	8064.14	2219.85	7397.22	8731.05	4549.10	13575.10	-	-	-
Kerala	8424.53	972.23	8061.5	8787.57	7081	9754	360.39	Ns	E
CERA 320	8488.3	467.56	8313.71	8662.89	7846	9386	424.16	Ns	E
HSLvOana	8707.97	457.53	8537.12	8878.81	8171	9503	643.83	Ns	E
Replik	9418.5	846.18	9102.53	9734.47	8224	10601	1354.36	**	F
LG 31377	9779.77	433.57	9617.87	9941.66	9319	10503	1715.63	**	F,G
3520R	10260.1	561.97	10050.26	10469.94	9250	11027	2195.96	***	G
Multipel	11322.5	869.66	10997.76	11647.24	10088	12482	3258.36	***	H
Po217	11807.47	1338.44	11307.69	12307.25	10222	13760	3743.33	***	H

DL 5%=1167.329; DL 1% =1571.623; DL 0.1%=2089.803

ns= Not significant. * The mean difference positive and is significant at the 0.05 level. ** The mean difference positive and is significant at the 0.01 level. *** The mean difference positive and is significant at the 0.001 level. 0 The mean difference negative and is significant at the 0.05 level. 00 The mean difference negative and is significant at the 0.01 level. 000 The mean difference negative and is significant at the 0.001 level. Homogeneous subsets for alpha = 0.05 are displayed.

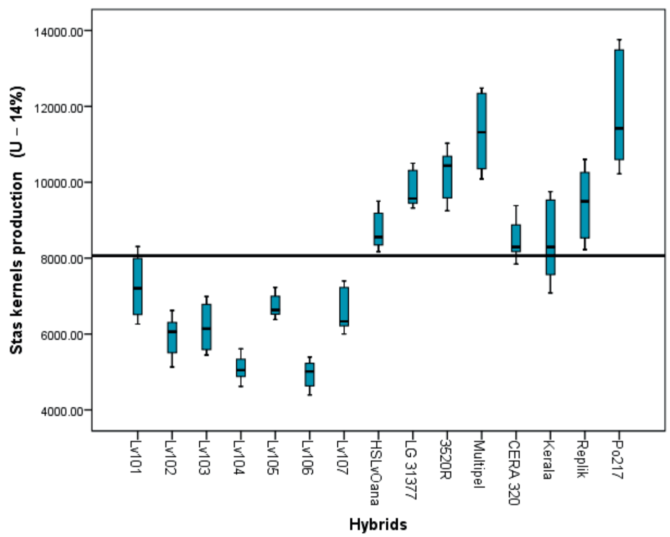

Figure 7. Box plot diagram associated to yield of each hybrid compared to the field mean

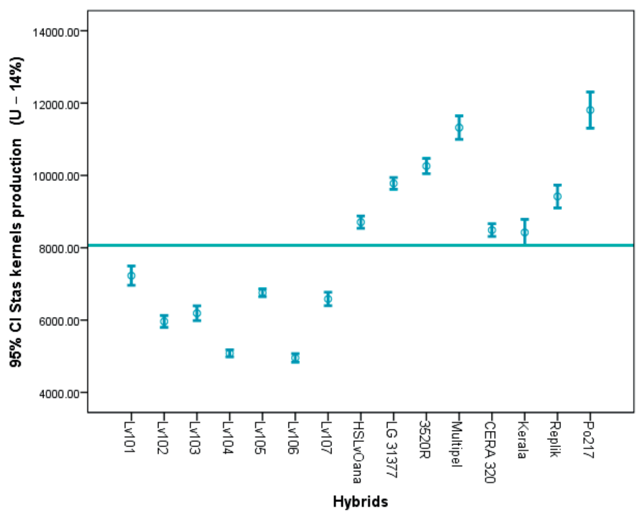

Figure 8. The means and confidence intervals for the means associated with the yields of the hybrids considered in the study compared to the field mean

CONCLUSIONS

The results regarding the behavior of 15 maize hybrids in the climatic conditions of the Agricultural Research and Development Station Lovrin area highlight different behaviors depending on their vegetation period, information that can be very useful for farmers in choosing the hybrid variety. In terms of production capacity, compared to the field average of 8064 kg/ha, the highest bean production was obtained for the Po217 hybrid - 11807 kg/ha, followed by the production of the Multipel hybrid - 11322 kg/ha and 3520R - 10260 kg/ha. Productions of over 9000 kg/ha were obtained for the Replik and LG31377 hybrids, 9418 kg/ha and 9779 kg/ha, respectively, indicating that these hybrids have a strong production capacity and resistance to water stress.

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