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Evaluation of Maize (*Zea mays* L.) Hybrids under Agro-climatic Conditions of Prayagraj, U.P., India: Experimental Investigation

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted during Kharif season of 2022 at Crop Research Farm (CRF), Department of Agronomy, SHUATS, Prayagraj (UP) to investigate the "Evaluation of Maize (*Zea mays* L.) hybrids under agro-climatic conditions of Prayagraj, U.P". The treatments consists of 18 hybids. The experiment was laid out in Randomized Block Design with ten treatments replicated thrice. The significantly highest plant height (169.75 cm), number of leaves (15. 75), dry weight (138.35 g/plant), CGR (0.0419 g/m2/day), number of cobs/plant (2.41), cob length (19.38 cm), number of Seeds/row (19.17/row), number of rows per cob (17.45), seed yield (5.24 t/ha) stover yield (11.13 t/ha) were recorded in hybrid M-702. Hybrid M-702 fetched maximum gross return (₹ 157200.00 /ha), net return (₹ 104105.00 /ha) and B:C ratio (1.96).

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1. INTRODUCTION

Maize (*Zea mays* L.) is one of the most versatile crops grown throughout the tropical as well as temperate regions of the world. a crop of maize is sown and harvested somewhere in the world in every month of the year" [1]. There is no cereal on the earth which has so immense potentiality and that is why it is also called "Queen of cereals". It is the most important cereal crop, ranking third in the world behind wheat and rice. Globally, India ranks 5th in acreage and 8th in maize production [1].

Maize belongs to poaceae (or), Graminae family. (De candolle 1986) assumed that corn must have originated in origin in new Granada, now Colombia. Reeves [2] postulated that maize had its origin in the lowlands of South America primarily because of historical references to pod corn in that area. Maize is one of the most important cereal crops in the world grown over an area of 132 mha with a production of 57mt. Being a C4 plant, Maize is capable of utilizing solar radiation more efficiently compared to other cereals. It requires a higher amount of nutrients during the crop growing period, although this is attributable to the intensive use of chemical fertilizer to preserve crop health. Organic fertilizer management is required to preserve soil health.

Maize grains contain about 9% protein, 4% oil, 70%starch and 2.7%crude fibre. Maize protein. "Zein" is rich in tryptophan and lysine, the two essential amino acids [1]. Most of cereals have been the staple human diet from prehistoric times because of their wide cultivation, good keeping quality, blend flavour and great variety. Maize is an important staple food in many parts of the world. In addition to staple food for human being and quality feed for animals, maize serves as basic raw material as an ingredient to thousands of industrial products that includes starch, oil, protein, alcoholic beverages, food sweeteners, pharmaceutical, cosmetics, film, textile, gum, package and paper industries etc [1].

Maize is primarily grown as a rainfed crop, and water stress has an impact on both crop productivity and yield stability. Maize productivity is mostly determined by fertilizer management (Kumar et al., 2007). Maize should be seeded in moist soils to ensure optimum germination and inoculation. Maize is extremely vulnerable to drought and water logging (Kumar et al., 2007).

India has produced 30 million tons in an area of 9.9 million hectares in 2020-21. Maize is a largely cultivated crop in north India. Major maize producing states are Andhra Pradesh (20.9%), Karnataka (16.5%), Rajasthan (9.9%), Maharashtra (9.1%), Bihar (8.9%), Uttar Pradesh (6.1%), Madhya Pradesh (5.7%) and Himachal Pradesh (4.4 %). Madya Pradesh ranks first in maize production. In Uttar Pradesh maize accounts for a 0.736-million-hectare area with the production of 1.53 million tons and productivity of 2082 kg/ha (Agricultural statistics at a Glance (2020).

Yield advantage ranged from 12 to 25% across the 2 years, suggesting effective genetic gains in QPM breeding. QPM hybrids CZH132044Q, CZH142238Q and CZH142236Q were stable and high yielding. Promotion of such QPM hybrids may help reduce protein energy malnutrition. After wheat (*Triticum aestivum* L.) and rice (*Oryza sativa* L.), maize is India's third most significant food crop. It has a high output potential (22 tons per acre) (Anonymous, 2013). Rapid climate change necessitates evaluating and developing methods that are suitable for maize-specific varieties, either hybrids or varieties with acceptable sowing dates, in order to prevent the crucial growth stages from the stressors caused by climate conditions.

The most essential cropping system factors are sowing at the correct time and selecting an ideal variety. Its grain is abundant in nutrients, with 66.2% starch, 11.1% protein, 7.12% oil, and 1.5% minerals. Furthermore, per 100 g grains, it includes 90 mg carotene, 1.8 mg niacin, 0.8 mg thiamin, and 0.1 mg riboflavin [3]. In general, local varieties in Uttar Pradesh failed to outperform hybrids in terms of yield. As a result, there is a tremendous need for hybrids of other groupings to replace local varieties. Hybrid maize cultivars had a significant role in increasing maize output and quality, which is utilized for feed, fiber, and aesthetic value.

These not only aided in their direct contribution, but also paved the path for the adoption of other industrial components. These single cross hybrids have advantages such as improved grain yield potential, abiotic and biotic stress tolerance, early maturity, and so on. These benefits enabled farmers to overcome various obstacles in the past [4]. Adoption of modern and diverse maize varieties with increased genetic potential and adaptability to various environmental variations with the goal of increasing maize yield. In India, there is no special coordinated or well-structured system for documenting agricultural varieties and their area coverage. Various efforts have been made to fill such knowledge gaps, such as documenting the major maize varieties and determining the adoption rates of specific genotypes to different agro-climatic zones. Adoption of high-yielding appropriate hybrids not only increases grain production and quality, but also results in increased income per hectare when compared to conventional maize types [5]. When compared to older hybrids, modern maize hybrids have more potential (Russel, 1986).

Since the yield potential of our existing varieties is deteriorating day by day, so the selection of good varieties with high potential and wide range of adoptability is highly essential. Besides tolerance to abiotic and biotic stresses, the likely cause for high yield in modern hybrids has been more ear bearing plants per unit land area without reduction in kernels per ear.

Keeping an eye on the above aspects the present study was carried out at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences. Prayagraj during 2022 Kharif Season.

2. MATERIALS AND METHODS

The experiment was conducted during *Kharif* season of 2022 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The soil of the field constituting a part of central Gangetic alluvium is neutral and deep. The soil of the experimental field was sandy loam in texture, nearly neutral in soil reaction (pH 7.8),low level of organic carbon (0.62%), available N (225 Kg/ha), P (38.2 kg/ha), K (240.7 kg/ha) and zinc (2.32 mg/kg). The treatments consist of 18 hybrids. The experiment was laid out in RBD with 10 treatments each replicated thrice. The 18 hybrids are M-10, M-70, M-100, M-202, M-207, M-210, M-305, M-312, M-400, M-410, M-502, M-512, M-600, M-608, M-612, M-618, M-702, M-710. The growth parameters and yield, production was recorded at harvest from randomly selected plants in each plot. The data was computed and analysed by following statistical method of Gomez and Gomez (1984).

3. RESULT AND DISCUSSION

3.1 Growth Parameters

3.1.1 Plant height (cm)

At 100 days, significantly highest plant height (169.75 cm) was recorded in M-702. However,M-10 (166.72 cm), M-100 (167.62 cm), M-608 (165.57 cm) and M-618 (166.60 cm) were found to be statistically at par with M-702.

The variation in plant height in several hybrids was reported by Ali et al. in 1994. This is because plant height is a genetically controlled factor, and as a result, the height of various types does not remain equal. It is impossible to ignore how environmental conditions affect plant height, however by choosing the right crop cultivar, environmental influence can be controlled.

3.1.2 Number of leaves/plant

At 100 days, significantly the highest number of leaves/plant (No.) was recorded in the hybrid M-502 (14.80). However, the hybrid M-70 (14.04), M-305 (14.79) and M-400 (14.10) were found statistically at par with M-702.

The differences observed in the number of leaves of maize may be attributed to differences in growth characteristics which are being influenced by the genetic makeup of the plants as reported by Gollar et al. [6]. Padilla and Otegue (2005) revealed that the number of leaf whorl expansion varies with hybrid and the rate of development and number was determined primarily by temperature and leaf development rates which were linearly related to accumulated heat units expressed as growing degree days.

3.1.3 Plant dry weight (g)

At 100 days,, significantly higher plant dry weight (138.35 g/plant) was recorded in M-702. The hybrids M-100 (136.38 g/plant), M-305 (137.55 g/plant) and M-612 (135.64 g/plant) recorded statistical parity with M-702.

The differential growth concerning plant dry weight among the hybrids may be attributed to differences in genetic characterization of the individual varieties, including rapid growth rates, tallness, or shortness of species. The result confirmed with Pal and Bhatnagar [7]. The variation in dry matter of different hybrids at different growth stages was attributed to variation in plant height and speed of growth at that time which was in conformity with Sangai and Salvador [8].

3.1.4 Crop growth rate (g/m^2/day)

At 80-at harvest significantly highest crop growth rate (11.71 g/m2/day) was recorded in M- 702. However, the hybrid M-502 (10.81 g/m2/day), M-608 (10.84 g/m2/day) and M-612 (10.65 g/m2/day) were found statistically at par with M-702.

Sabir et al. (2000) reported the similar results in maize that increase in CGR values in early stages due to the less vegetation and low per cent of light absorption, but rapid increase in the rate of plant growth that occurs because the level of developed leaves and thus absorption of solar radiation increases. The distribution and remobilization of assimilate partitioning and also duration of the crop influences the biomass accumulation and CGR of the crop.

3.1.5 Relative growth rate (g/g/day)

For the duration of 80-at harvest significantly highest relative growth rate obtained in M-702 having 0.0305 g/g/day. However, hybrids M-305 (0.0197 g/g/day), M-312 (0.0198 g/g/day), M- 600 (0.0212 g/g/day) and M-612 (0.0205 g/g/day) were statistically at par with M-702.

The variation in RGR at different growth stages was due to the higher accumulation of dry matter at those stages. Similar results have also been reported by Dahmardeh et al. (2010).

3.1.6 Days to 50% tasseling

Days taken to 50 percent tasseling as influenced in hybrids and presented in Table 1. The days to 50% tasseling was recorded significantly minimum in the hybrid M-600 (43.33 DAS). However, hybrids M-512 (44.33 DAS), M-612 (44.33 DAS), M-210 (44.33 DAS), M-100 (45.33 DAS) and M-400 (45.33 DAS) were found statistically at par with M-600. The maximum (49.33 DAS) days to 50% tasseling was taken in M-10.

3.1.7 Days to 50% Silking

Days took to 50 per cent silking as influenced in hybrids and presented in Table 1.

The days taken to 50% silking was found significantly minimum M-305 (51.33 DAS). However, M-207 (52.33 DAS), M-312 (52.33 DAS), M-512 (53.00 DAS) and M-612 (53.66 DAS) were statistically at par with M-305. The maximum days to 50% silking was recorded in M-702 (59.66 DAS).

3.1.8 Days to maturity

Observed data has recorded and presented in Table 1.

The days to maturity was found significant. The hybrid M-512 had recorded days to maturity (80.33 DAS) which was considered as significant and better performing as it took less days to mature. However, hybrids M-70 (84.33 DAS), M-600 (83.66 DAS), M-618 (84.66 DAS), M-710 (84.66 DAS) and M-502 (85.33 DAS) were statistically at par with M-512. The maximum days to maturity was recorded in M-210 (98.33 DAS).

3.2 Yield Parameters

3.2.1 Number of cobs/plants (No.)

At harvest, the number of cobs/plant (2.41) was recorded highest in the hybrid M-702. However, M-600 (2.26), M-70 (2.27), M-100 (2.34) and M-710 (2.31) were statistically at par with M-702.

Number of cobs per plant depends upon genetic character of the hybrid and is a vital yield contributing parameter, which is affected by environmental conditions. Similar results have also been reported by Asghar and Mehdi [9].

3.2.2 Cob length (cm)

The cob length was affected by the selection of hybrids and different agro-climatic conditions, the recorded data was presented in Table 2.

At harvest, significantly highest cob length (19.38 cm) was recorded in M-702. However, M-100 (18.17 cm), M-400 (18.38 cm), M-710 (18.82 cm) and M-512 (18.43 cm) were found statistically at par with M-400. The probable reason for longer cob length could be due to optimum utilization of solar light, higher assimilated production and its conversion to starches resulted in higher ear length as reported by Derbay et al. (2004).

3.2.3 Number of rows/cob (No.)

The number of rows per cob was found significant. The data recorded was presented in the Table 3.

At harvest, significantly highest number of rows per cob was recorded in M-702 (17.45). However, the hybrids M-202 (15.87), M-305 (17.13), M-312 (15.60) and M-710 (16.59) were found statistically at par with M-702.

3.2.4 Number of seeds/row (No.)

The number of seeds per row was found significant. The data recorded was presented in Table 3.

Significantly higher number of grains/row (19.17) was recorded in M-702. However, the hybrids M-70 (18.75), M-305 (19.24), M-210 (18.86), M-312 (19.00) and M-710 (18.47) were found statistically at par with M-702. Zhang et al. (2014) reported that the number of grains/rows of corn had significantly affected by maize hybrids. Seyed and Taghizadeh observed the importance of the number of kernels/ears in grain yield.

3.2.5 Seed yield (t/ha)

The seed yield was found significant. The recorded data were presented in Table 4.

At harvest, significantly the highest seed yield (5.24 t/ha) was recorded in M-702. However, the hybrid M-70 (4.87 t/ha), M-312 (5.12 t/ha), M-600 (4.94 t/ha) and M-710 (4.95 t/ha) exhibited statistical parity with M-702.

The significant difference in grain yield and other agronomic traits among various hybrids were probably due to the diverse background from which the hybrids were developed. The higher grain yield of the above genotypes could be correlated to the higher number of grains per row and cob weight. Similar results have also been reported by Manjunatha et al. [10]. Kumar and Kumar (1997) reported that plant height was positively correlated with grain yield.

3.2.6 Stover yield (t//ha)

The Stover yield was also found significant. The data recorded was presented in the Table 4. At harvest, significantly higher stover yield (11.13 t/ha) was recorded in M-702. However, M-10 (10.71 t/ha), M-100 (10.86 t/ha), M-202 (10.99 t/ha) and M-618 (10.45 t/ha) were found statistically at par with M-702. The increase in biological growth reflects the better growth and development of the plants due to steady and more availability of nutrients throughout the growing period. These results are in consonance with of Ibeawuchi et al. [11].

Economics:

The result showed that maximum gross return (157200.00 /ha INR/ha), higher net return (104105.00 INR/ha) and highest benefit cost ratio (1.96) was recorded in hybrid M-702 [12-18].

Table 1. Evaluation of Growth attributes of Maize hybrids under agro-climatic conditions of Prayagraj, U.P

Treatments	Plant height (cm)	Number of leaves/ plant	Plant dry weight (g)	80-100 days	
				Crop growth rate ($g/m^2/day$)	Relative growth rate (g/g/day)
M-10	166.72	13.23	134.03	9.63	0.0174
M-70	165.40	14.04	134.28	10.40	0.0037
M-100	167.62	12.89	136.38	10.81	0.0176
M-202	163.45	13.65	134.44	10.27	0.0123
M-207	165.35	13.74	133.27	9.6	0.0162
M-210	162.71	13.83	134.94	10.84	0.0112
M-305	163.57	14.79	137.55	9.02	0.0197
M-312	164.64	13.22	133.18	10.51	0.0198
M-400	166.22	14.1	131.38	9.68	0.008
M-410	163.92	12.9	130.09	9.6	0.0153
M-502	164.7	12.92	134.79	9.94	0.0093
M-512	163.67	13.36	134.92	10.25	0.0103
M-600	165.41	12.9	130.11	10.35	0.0212
M-608	165.57	12.69	132.04	10.15	0.0145
M-612	154.90	12.36	135.64	10.65	0.0205
M-618	166.6	12.78	132.37	9.65	0.0143
M-702	169.75	15.75	138.35	11.71	0.0305

Treatments	Plant height (cm)	Number of leaves/ plant	Plant dry weight (g)	80-100 days	
				Crop growth rate ($g/m^2/day$)	Relative growth rate (g/g/day)
M-710	164.74	12.89	131.14	10.07	0.0215
F-test	S	S	S	S	S
SEm±	1.44	0.58	1.11	0.35	0.004
CD (P = 0.05)	4.33	1.75	3.35	1.06	0.012

Table 2. Evaluation of Days 50% tasseling, silking and days to maturity of Maize hybrid under agro-climatic conditions of Prayagraj, U.P

Treatments	Days to 50% tasseling	Days to 50% silking	Days to maturity
M-10	49.33	55.33	88.33
M-70	48.00	54.33	84.33
M-100	45.33	56.33	92.33
M-202	46.33	59.33	88.33
M-207	42.00	52.33	86.00
M-210	44.33	56.33	98.33
M-305	46.33	51.33	86.33
M-312	42.00	52.33	86.00
M-400	45.33	56.33	92.33
M-410	46.33	54.33	88.33
M-502	49.00	58.33	85.33
M-512	44.33	53.00	80.33
M-600	43.33	54.00	83.66
M-608	47.33	56.33	94.66
M-612	44.33	53.66	90.33
M-618	46.00	57.00	84.66
M-702	46.33	59.66	88.33
M-710	48.00	54.33	84.66
F-test	S	S	S
SEm±	0.82	0.85	1.72
CD (P = 0.05)	2.47	2.56	5.16

Table 3. Evaluation of Yield attributes and Yield of Maize hybrids under agro-climatic conditions of Prayagraj, U.P

Treatments	Cob length (cm)	No of cob/plant	No. of seeds/row	No. of rows / cob	Seed yield(t/ha)	Stover yield(t/ha)
M-10	16.60	2.14	17.42	15.03	4.11	10.71
M-70	17.89	2.27	18.75	14.73	4.87	9.76
M-100	18.17	2.34	17.16	14.57	4.73	10.86
M-202	14.38	2.14	18.25	15.87	4.77	10.99
M-207	18.55	1.57	18.13	13.07	4.73	8.42
M-210	15.60	1.97	18.86	14.00	4.7	8.71
M-305	14.07	1.49	19.24	17.13	4.76	9.18
M-312	16.62	1.45	19.00	15.60	5.12	10.14
M-400	18.38	1.94	16.24	13.07	4.43	9
M-410	14.15	1.02	15.40	12.40	4.4	10.38
M-502	14.38	1.57	15.65	13.25	4.56	10.13
M-512	18.43	1.86	14.65	12.25	4.68	9.45
M-600	17.19	2.26	17.65	13.05	4.94	9.47
M-608	15.60	1.45	16.54	13.60	5.12	8.98
M-612	14.07	1.98	15.14	14.60	4.23	9.47
M-618	16.62	1.85	16.54	12.54	4.74	10.45

Treatments	Cob length (cm)	No of cob/plant	No. of seeds/row	No. of rows / cob	Seed yield(t/ha)	Stover yield(t/ha)
M-702	19.38	2.41	19.17	17.45	5.24	11.13
M-710	18.82	2.31	18.47	16.59	4.95	9.39
F-test	S	S	S	S	S	S
SEm±	0.44	0.08	0.23	0.62	0.11	0.24
CD (P = 0.05)	1.32	0.26	0.71	1.87	0.37	0.73

Table 4. Evaluation of Economics of Maize hybrids under agro-climatic conditions of Prayagraj, U.P

Treatments	Total cost of Cultivation	Gross Returns	Net Returns	B:C ratio
M-10	53095	153300	100205	1.89
M-70	53095	149100	96005	1.81
M-100	53095	141900	88805	1.67
M-202	53095	143100	90005	1.70
M-207	53095	141900	88805	1.67
M-210	53095	141000	87905	1.66
M-305	53095	142800	89705	1.69
M-312	53095	139500	86405	1.63
M-400	53095	132900	79805	1.50
M-410	53095	132000	78905	1.49
M-502	53095	136800	83705	1.58
M-512	53095	140400	87305	1.64
M-600	53095	148200	95105	1.79
M-608	53095	153600	100505	1.89
M-612	53095	148200	95105	1.79
M-618	53095	142200	89105	1.68
M-702	53095	157200	104105	1.96
M-710	53095	153300	100205	1.89

4. CONCLUSION

The Study concluded that among all hybrids, M-702 was found to be more productive, in terms of growth, yield and economics when compared to others hybrids under agroclimatic conditions of Prayagraj. UP. Since the findings are based on the research done in one season and region it may be subjected to changes in future.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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