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Evaluation of New Extra-Early Maturing Hybrids of Maize (*Zea mays* L.) for Grain Yield and Its Contributing Traits under Humid and Semi-Arid Conditions of Haryana

Rajesh Kumar ARYA[1*] **Mehar Chand KAMBOJ[2]** **Suresh KUMAR[3]**

[1] Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar (Haryana), India
[2] CCS HAU Regional Research Station, Uchani, Karnal (Haryana), India
[3] Department of Agronomy, CCS Haryana Agricultural University, Hisar (Haryana), India

Corresponding author e-mail: rakarayogi@gmail.com

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ABSTRACT

This experiment was conducted under two different agro-climatic conditions of Haryana viz. humid conditions of Karnal and semi-arid conditions of Hisar during *kharif* 2015 to evaluate the performance of newly developed seven extra-early maturing hybrids of maize. The analysis of variance revealed significant differences among the hybrids for different characters. In humid conditions, hybrid Bio9637 (5243.0 kg/ha) was highest yielder followed by hybrid Vivek Hybrid 43 (5047.0 kg/ha), Vivek Hybrid 21 (4631.0 kg/ha), EH2236 (4142.0 kg/ha), Bio9681 (3694.0 kg/ha), Prakash (3644.0 kg/ha) and AH1317 (2972.0 kg/ha). In semi-arid conditions, Prakash (5017.0 kg/ha) was significantly superior and followed by Vivek Hybrid 43 (4977.0 kg/ha), Vivek Hybrid 21 (4294.0 kg/ha), AH1317 (4091.0 kg/ha), EH2236 (3830.0 kg/ha), Bio9637 (2990.0 kg/ha), Bio9681 (2908.0 kg/ha). Likewise, on average basis, Vivek Hybrid 43 with an average yield 5012.0 kg/ha was at the top yielder and followed by Vivek Hybrid 21 (4462.5 kg/ha), Prakash (4330.5 kg/ha), Bio9637 (4116.5 kg/ha), EH2236 (3986.0 kg/ha), AH1317 (3531.5 kg/ha), Bio9681 (3301.0 kg/ha). The grain yield mean performance was high in humid conditions (5243.0 kg/ha) as compared to in semi-arid conditions (5017.0 kg/ha) due to more availability of soil moisture and nutrients.

Keywords: Yield performance, extra-early maturity, maize, hybrids

Introduction

Worldwide, maize (*Zea mays* L.) is considered as an important crop, which is cultivated for food, feed and fodder and also utilized as a raw material for large number of industrial products. In India, it is cultivated as a dual-purpose crop, for grain as well as fodder. Maize being a C_4 plant, it has an excellent potential and able to produce the maximum carbohydrate per day (Dayal *et al*. 2014). The plants of maize are fast growing, succulent, sweet, palatable, high yielding, nutritious and free from toxicants and may be utilized safely to feed animals at any stage of crop growth. The grains of maize are affluent in starch, protein, fat, vitamins and mineral nutrients (Arya *et al*. 2015). In India, maize is cultivated in about 8.55 mha with a production of 21.7 m ton and the average yield is 2.51 t/ha (Singh *et al*. 2014). It is considered as one of the most flexible crops having wide adaptability under varied agro-climatic conditions (Sharma *et al*. 2014). Maize is extremely cross-pollinated cereal plant species. Therefore, open pollinated varieties (OPV), composite/synthetic varieties and hybrids are used for commercial cultivation. Nevertheless, the maximum yield potential invests only in hybrid cultivars. Therefore, more stress is always given on the development and evaluation of maize hybrids rather than the OPVs. Keeping the discussion in view, there is a need to evaluate maize hybrids for their production performance under prevailing Haryana agro-climatic conditions.

Materials and Methods

The experiment was conducted under two different agro-climatic conditions of Haryana *viz*. semi-arid conditions of Hisar at RDS Seed Farm, CCS HAU, Hisar and humid conditions of Karnal at CCS HAU Regional Research Station, Uchani, Karnal during *kharif* 2015 with the objective to evaluate the performance of newly developed late maturing maize hybrids under prevailing Haryana agro-climatic conditions. Haryana is the part of Indo-Gangatic alluvial plains, a tectonic basic with covering alluvial deposits brought down during Pleistocene age. The RDS Seed Farm lies at 29°47' N latitude and 75°47' E longitude in the west of Hisar-Barwala road with loamy sand (Type Haplusteptsis) soil. The RRS Uchani, Karnal research area is lies at 29°42' N latitude and 77°02' E longitudes in the east of Karnal-Chandigarh road with mildly alkaline sandy loam (Type Ustrochrept) soil. The experimental material was comprised of seven medium maturing maize hybrids including one check, which was received from IIMR, New Delhi. The experiment was planted on 2 July, 2015 at Karnal and 3 July, 2015 at Hisar in randomized block design with three replications having plot size of 4x3 m^2 with row to row and plant to plant spacing of 75 and 15 cm, respectively. To raise a healthy crop, the N, P, K fertilizers were applied 150, 60, 60 kg/ha, respectively, at both the locations. Six irrigations were applied at different growth stages of the crop. Data were recorded for plant height (cm), grain yield (kg/ha), plant stand at harvest, days to 50% pollen shedding, days to 50% silking, days to 75% husk drying, and ear placement height (cm). The data recorded were analyzed for mean, coefficient of variation, and critical difference by OPSTAT.

Results and Discussion

The analysis of variance results of the present investigation revealed the considerable differences among the different maize hybrids for different characters. This indicated that adequate variability is there among the different hybrids. The mean performance of the different maize hybrids under different parameters is presented below:

Grain yield

The results of grain yield (kg/ha) are presented in Table 1 revealed that in humid conditions at Karnal, Bio9637 (5243.0 kg/ha) was top yielder and significantly superior over the other hybrids, which was followed by Vivek Hybrid 43(5047.0 kg/ha), Vivek Hybrid 21(4631.0 kg/ha), EH2236 (4142.0 kg/ha), Bio9681 (3694.0 kg/ha), Prakash (3644.0 kg/ha) and AH1317 (2972.0 kg/ha). In semi-arid conditions at Hisar, Prakash (5017.0 kg/ha) was significantly superior over the other hybrids, and followed by Vivek Hybrid 43 (4977.0 kg/ha), Vivek Hybrid 21 (4294.0 kg/ha), AH1317 (4091.0 kg/ha), EH2236 (3830.0 kg/ha), Bio9637 (2990.0 kg/ha), Bio9681 (2908.0 kg/ha) Likewise, on the basis average over the locations, Vivek Hybrid 43 with an average yield 5012.0 kg/ha was at the top and followed by Vivek Hybrid 21 (4462.5 kg/ha), Prakash (4330.5 kg/ha), Bio9637 (4116.5 kg/ha), EH2236 (3986.0 kg/ha), AH1317 (3531.5 kg/ha), Bio9681 (3301.0 kg/ha). Above findings were also supported by Dhaka *et al*. (2014), Suthar *et al*. (2014), Arya *et al*. (2015), and Nidhi *et al*. (2019). The grain yield mean performance was high in humid conditions (5243.0 kg/ha) as compared to in semi-arid conditions (5017.0 kg/ha). Higher grain yield in humid condition was observed due to more availability of soil moisture and nutrients. More availability of water and nutrients also resulted in higher grain yield production in pearl millet (Arya *et al.* 2009;2014). Grain yield is a polygenic character which is considerably affected by environmental temperature, soil moisture and nutritional status of field during crop growth and especially at grain filling (Preeti *et al.* 2016). Moreover, different genotypes respond differently under different environments (Yadav *et al*. 2010;2014).

Kernel shelling (%)

It is evident from Table 1 that in humid conditions, maximum kernel shelling (%) was found in hybrid, EH2236 (82.30%) which was followed by Prakash (81.30%), Vivek Hybrid 21 (81.30%), Vivek Hybrid 43 (80.60%), Bio9637 (80.00%), AH1317 (79.70%) and Bio9681 (79.70%). In semi-arid conditions, maximum grain shelling (%) was in Prakash (85.70%) and followed by Vivek Hybrid 21 (85.10%), Vivek Hybrid 43 (85.10%), EH2236 (84.90%), Bio9681 (84.60%), Bio9637 (83.50%) and AH1317 (81.30%). But, on mean basis, maximum kernel shelling (%) was in EH2236 (83.60%) and followed by Prakash (83.50%), Vivek Hybrid 21 (83.20%), Vivek Hybrid 43 (82.85%), Bio9681 (82.15%), Bio9637 (81.75%) and AH1317 (80.50%). The kernel shelling (%) was high in semi-arid conditions (85.70%) as compared to in humid conditions (82.30%). Similar finding were also reported in maize by Arya *et al*. (2015) and Arya *et al*. (2016). The higher kernel shelling (%) in semi-arid conditions may be due to more photosynthetic accumulation in kernels.

Plant stand

In humid conditions, plant stand was maximum for AH1317 (63.90) and followed by Vivek Hybrid 43 (63.30), EH2236 (63.30), Prakash (63.10), Bio9637 (62.20), Bio9681 (62.20). Lowest plant stand was found

in Vivek Hybrid 21 (61.90). In semi-arid conditions, plant stand (000/ha) was maximum for AH1317 (61.40) and Bio9681 (61.40) and followed by EH2236 (61.10), Bio9637 (60.80), Prakash (60.80), Vivek Hybrid 21 (60.80) however, it was lowest was in Vivek Hybrid 43 (60.30). Likewise, on average basis, plant stand was maximum for AH1317 (62.65) and followed by EH2236 (62.20), Prakash (61.95), Bio9681 (61.80), Vivek Hybrid 43 (61.80), Bio9637 (61.50). While, the lowest plant stand was found in Vivek Hybrid 21 (61.35). The plant stand was high in humid conditions (63.90) as compared to in semi-arid conditions (61.40). Similar results were also reported in maize by Arya *et al*. (2015) and Arya *et al*. (2016).

Days to 50% pollen shedding

In humid conditions, Bio9637 (52.3 days) was earliest in pollen shedding and followed by Vivek Hybrid 43 (46.0 days) Prakash (46.0 days), AH1317 (46.3 days), and EH2236 (47.0 days). However, Vivek Hybrid 21 (48.3 days) and Bio9681 (49.0 days) were late in pollen shedding. Likewise, in semi-arid conditions, Vivek Hybrid 43 (38.3 days), Prakash (38.7 days), Vivek Hybrid 21 (39.0 days) were early in pollen shedding. However, Bio9637 (47.7 days), Bio9681 (45.0 days), AH1317 (44.0 days), EH2236 (44.0 days) were late in pollen shedding. On mean basis, Vivek Hybrid 43 (42.15 days), Prakash (42.35 days) and Vivek Hybrid 21 (43.65 days) were early in pollen shedding. However, Bio9637 (50.0 days), Bio9681 (47.0 days), EH2236 (45.5 days), AH1317 (45.15 days) were late in pollen shedding. Similar finding were also reported in maize by Dhaka *et al*. (2014) and Arya *et al*. (2016). The days to 50% pollen shedding was early in humid conditions (52.2 days) as compared to in semi-arid conditions (53.8 days).

Days to 50% silking

It is revealed from the Table 1 that in semi-arid conditions, Vivek Hybrid 43 (39.7 days), Vivek Hybrid 21 (40.0 days) and Prakash (40.0 days) were early in silking. However, Bio9637 (48.7 days), Bio9681 (46.0 days), AH1317 (45.3 days), EH2236 (45.3 days) were late in silking. In humid conditions, the hybrids viz. AH1317 (48.3 days), Vivek Hybrid 43 (48.7 days), Prakash (49.3 days), EH2236 (49.3 days) were early in silking. However, Bio9637 (54.7 days), Bio9681 (51.0 days), Vivek Hybrid 21 (50.3 days) were late in silking. Similarly, on the average basis over the locations, Vivek Hybrid 43 (44.2 days), Prakash (44.65 days), Vivek Hybrid 21 (45.15 days) were early in silking. Opposite to this, on the average basis over the locations, Bio9637 (51.7 days), Bio9681 (48.5 days), EH2236 (47.3 days), AH1317 (46.8 days) were late in silking. The days to 50% silking was early in humid conditions (43.6 days) as compared to in semi-arid conditions (50.2 days). The above findings were also supported by Dhaka *et al*. (2014) and Arya *et al*. (2016) in maize.

Days to 75% husk drying

In humid conditions, Vivek Hybrid 43 (73.0 days), Vivek Hybrid 21 (74.0 days), Prakash (77.7 days) were early in days to 75% husk drying. However, Bio9637 (96.7 days), AH1317 (83.0 days), EH2236 (81.7 days), Bio9681 (80.7 days) were late in 75% husk drying. In semi-arid conditions, Vivek Hybrid 43 (80.3 days), Vivek Hybrid 21 (83.7 days), Bio9637 (83.7 days) were early in days to 75% husk drying. However, EH2236 (87.3 days), AH1317 (85.0 days), Prakash (84.3 days), Bio9681 (84.0 days) were late in 75% husk drying. Likewise, on average basis, the hybrid, Vivek Hybrid 43 (76.65 days) was earliest in 75% husk drying and followed by Vivek Hybrid 21 (78.85 days), Prakash (81.0 days), Bio9681 (82.35 days). However, Bio9637 (90.2 days), AH1317 (84.0 days), EH2236 (84.5 days) were late in 75% husk drying. The days to 75% husk drying were early in humid conditions (83.6 days) as compared to in semi-arid conditions (96.9 days). Above results were also supported by Arya *et al*. (2015) and Arya *et al*. (2016) in maize.

Plant height

The mean performance (Table 1) indicated that in semi-arid conditions, Bio9681 (236.5 cm) was tallest and significantly superior over the check and other hybrids, which was followed Prakash (223.9cm), EH2236 (215.5 cm), Bio9637 (205.0 cm) AH1317 (201.4 cm). However, Vivek Hybrid 43 (182.4cm), Vivek Hybrid 21 (189.6 cm) were short in stature. Likewise, in humid conditions, Bio9637 (210.0 cm), Bio9681 (170.0 cm), Prakash (170.0 cm) were tall in plant height. However, AH1317 (130.0 cm), Vivek Hybrid 43 (143.3 cm), Vivek Hybrid 21 (156.7 cm), EH2236 (161.7 cm) were short in stature. But, on average basis, Bio9637 (207.5 cm), Bio9681 (203.25 cm), Prakash (196.95 cm), EH2236 (188.6 cm) were tall in plant height. However, Vivek Hybrid 43 (162.85 cm), AH1317 (165.7 cm), Vivek Hybrid 21 (173.15 cm) were short in stature. Similar findings were also reported in maize by Dhaka *et al.* (2014), Suthar *et al.* (2012 and 2014) and Arya *et al*. (2016). The plant height was more in humid conditions (203.4 cm) as compared to in semi-arid conditions (194.5 cm). Favourable environmental and soil conditions are responsible for better growth of plant under humid conditions.

Ear placement height

The perusal of results on mean performance revealed that in semi-arid conditions, ear placement

height was high for Prakash (103.9 cm), and followed by Bio9637 (99.0 cm), Bio9681 (93.9 cm), EH2236 (93.6 cm), AH1317 (90.3 cm) Vivek Hybrid 43 (75.7 cm), Vivek Hybrid 21 (74.0 cm). Likewise, in humid conditions, ear placement height was high for Bio9637 (121.7 cm), and followed by Prakash (93.3 cm), EH2236 (81.7 cm), Bio9681 (80.0 cm), AH1317 (65.0 cm), Vivek Hybrid 21 (51.7 cm), Vivek Hybrid 43 (66.7 cm). Moreover, on pooled basis, ear placement height was highest for Bio9637 (110.35 cm), and followed by Prakash (98.6 cm), EH2236 (87.65 cm), Bio9681 (86.95 cm), AH1317 (77.65 cm) Vivek Hybrid 43 (71.2 cm), Vivek Hybrid 21 (62.85 cm). The ear placement height was more in humid conditions (104.8 cm) as compared to semi-arid conditions (88.1 cm). Similar findings were also reported in maize by Arya *et al*. (2015). In humid conditions, higher ear placement height may be due to fast growth rate of plants in response to more availability of soil moisture and nutrients accompanying favourable environment conditions.

Conclusions

It was concluded from the present study that the hybrid Vivek Hybrid 43 with an average yield 5012.0 kg/ha was the highest in grain yield production, shortest in plant height with an average 162.85 cm as well as very low in ear placement height (71.2 cm). Moreover, it was also goo d in crop plant stand as well as in grain shelling (%). In addition to this, Vivek Hybrid 43 was also earliest in silking (44.2 days), pollen shedding (42.15 days) and 75% husk drying (76.65 days). All the maize hybrids produced more grain yield in humid conditions, as it has more fertile soil and favourable environmental conditions.

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Table 1. Mean Performance of extra-early maturing hybrids of maize under different agro-climatic conditions of Haryana.

Hybrids	Grain yield (kg/ha)			Grain shelling (%)			Plant stand (000/ha)			Days to 50% pollen shedding		
	Karnal	Hisar	Mean	Karnal	Hisar	Mean	Karnal	Hisar	Mean	Karnal	Hisar	Mean
AH1317	2972	4091	3531.5	79.7	81.3	80.50	63.9	61.4	62.65	46.3	44.0	45.15
EH2236	4142	3830	3986.0	82.3	84.9	83.60	63.3	61.1	62.20	47.0	44.0	45.50
Bio9637	5243	2990	4116.5	80.0	83.5	81.75	62.2	60.8	61.50	52.3	47.7	50.00
Bio9681	3694	2908	3301.0	79.7	84.6	82.15	62.2	61.4	61.80	49.0	45.0	47.00
Prakash	3644	5017	4330.5	81.3	85.7	83.50	63.1	60.8	61.95	46.0	38.7	42.35
Vivek Hybrid 21	4631	4294	4462.5	81.3	85.1	83.20	61.9	60.8	61.35	48.3	39.0	43.65
Vivek Hybrid 43	5047	4977	5012.0	80.6	85.1	82.85	63.3	60.3	61.80	46.0	38.3	42.15
Mean	**4196**	**4015**	**4105.5**	**80.7**	**84.3**	**82.50**	**62.9**	**61.0**	**61.89**	**47.8**	**42.4**	**45.10**
CD (5%)	197	481		0.43	2.1		1.44	1.69		1.13	2.84	
CV(%)	2.61	6.66		0.3	1.4		1.29	1.56		1.33	3.76	

Hybrids	Days to 50% silking			Days to 75% dry husk			Plant height (cm)			Ear placement height (cm)		
	Karnal	Hisar	Mean	Karnal	Hisar	Mean	Karnal	Hisar	Mean	Karnal	Hisar	Mean
AH1317	48.3	45.3	46.80	83.0	85.0	84.00	130.0	201.4	165.70	65.0	90.3	77.65
EH2236	49.3	45.3	47.30	81.7	87.3	84.50	161.7	215.5	188.60	81.7	93.6	87.65
Bio9637	54.7	48.7	51.70	96.7	83.7	90.20	210.0	205.0	207.50	121.7	99.0	110.35
Bio9681	51.0	46.0	48.50	80.7	84.0	82.35	170.0	236.5	203.25	80.0	93.9	86.95
Prakash	49.3	40.0	44.65	77.7	84.3	81.00	170.0	223.9	196.95	93.3	103.9	98.60
Vivek Hybrid 21	50.3	40.0	45.15	74.0	83.7	78.85	156.7	189.6	173.15	51.7	74.0	62.85
Vivek Hybrid 43	48.7	39.7	44.20	73.0	80.3	76.65	143.3	182.4	162.85	66.7	75.7	71.20
Mean	**50.2**	**43.6**	**46.90**	**79.5**	**84.0**	**81.75**	**163.1**	**207.7**	**185.40**	**80.0**	**90.0**	**85.00**
CD (5%)	0.76	2.86		1.65	3.3		6.95	7.65		4.48	9.06	
CV(%)	0.85	3.69		1.16	2.21		2.4	2.07		3.15	5.66	