Forage Res., **47** (2) : pp. 167-171 (2021) **http://forageresearch.in**

SCREENING OF MEDIUM-LATE MATURING MAIZE HYBRIDS UNDER HUMID AND SEMI-ARID CILMATIC CONDITIONS OF HARYANA

R. K. ARYA*, SURESH KUMAR AND M. C. KAMBOJ[1]

RDS Seed Farm, CCS Haryana Agricultural University, Hisar-125 004 (Haryana), India
[1]CCS HAU Regional Research Station, Uchani, Karnal (Haryana), India
**(e-mail : rajesharya@hau.ernet.in)*

(Received : 08 August 2021; Accepted : 22 September 2021)

SUMMARY

The field experiments were conducted under two different agro-climatic conditions of Haryana *viz*. humid conditions of Karnal and semi-arid conditions of Hisar during *kharif* 2015 to assess the performance of newly developed nine medium-late maturing hybrids of maize. The analysis of variance revealed significant differences among the hybrids for different characters. In humid conditions, X35D601 (14079 kg/ha) followed by Seed tech2324 (13467 kg/ha), PMH-3 (12893 kg/ha) and Bio9637 (12007 kg/ha) were top yielder and significantly superior over the other hybrids. In semi-arid conditions, CP 201 (4813 kg/ha) followed by Bio9681 (4766 kg/ha), PMH-3 (4515 kg/ha) and X35D601 (4073 kg/ha) were significantly superior over the other hybrids. Likewise, on the basis average over the locations, X35D601with an average yield 9076.0 kg/ha was at the top and followed by PMH-3 (8704 .0kg/ha), Seed tech2324 (8159.0 kg/ha) and CP 201 (7955.5 kg/ha). The grain yield mean performance was high in humid conditions (11337.0 kg/ha) as compared to in semi-arid conditions (3634.0 kg/ha). Higher grain yield in humid condition was observed due to more availability of soil moisture and nutrients. Moreover, the genotype Bio 9681 (DSI=0.389) was found drought tolerant and may be utilized in breeding program to develop high yielding drought tolerant genotypes.

Key words : Yield performance, extra-early maturity, maize, hybrids

Maize is one of the most adaptable emerging crop and commonly referred as 'Queen of Cereals' or the miracle crop due to its higher grain yield potential as compared to other cereal crops. It is most important *kharif* and spring/ summer crop which is grown through country (Kumar *et al*., 2021). In addition to this, recent findings suggest that it can also be cultivated as a winter crop, and in winter season it is produces more yield when compared with *kharif* and summer. Therefore, year-round maize production in tropical regions may allow the continuous harvesting of green forage for rumenant livestock.

Throughout the world, maize (*Zea mays* L.) is recognized as an important crop, which is generally cultivated for food, feed and fodder and also utilized as a raw material for the production of a number of industrial products. In India, it is grown as a dual-purpose crop, both for grain and fodder. Maize being a C_4 crop plant, it has an tremendous potential and able to manufacture the maximum carbohydrate per day (Dayal *et al*., 2014). The plants of maize are quick growing, succulent, soft, palatable, sweet, high yielding, nutritious and free from toxicants and may be utilized quite safely to feed our domestic animals at any stage of crop growth. The grains of maize are affluent in carbohydrates, protein, fat, vitamins and other mineral nutrients (Arya *et al*., 2015). In India, maize is cultivated in about 8.55 mha with a production of 21.7 mt and the average yield is 2.51 t/ha (Singh *et al*., 2014).

It is considered as one of the most flexible crop plant having wide adaptability under varied agro-climatic conditions of world (Sharma *et al*., 2014). Maize is extremely cross-pollinated cereal plant species. Therefore, open pollinated varieties (OPV), composite/ synthetic varieties and hybrids are mainly utilized for commercial cultivation by the farmers. Nevertheless, the greatest yield potential invests only in hybrid cultivars of maize. Therefore, more emphasis is generally implied on the improvement and evaluation of maize hybrids rather than the OPVs. Keeping the points in view, there is a need to screen maize hybrids for their production performance under prevailing Haryana agro-climatic conditions.

MATERIALS AND METHODS

The field experiments were carried out 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 RRS Uchani, Karnal during *kharif* 2015 with the objective to assess the performance of newly developed nine medium-late maturing maize hybrids under prevailing Haryana agro-climatic conditions. Haryana state is the part of Indo-Gangatic alluvial plain region, a tectonic basic with covering alluvial deposits brought down during Pleistocene age. The Ram Dhan Singh Seed Farm is located at 29º47' N latitude and 75 º 47' E longitudes in the west of Hisar-Barwala road and its soil is loamy sand (Type Haplusteptsis). The Regional Research Station, Uchani, Karnal (Haryana) research area is located at 29º42' N latitude and 77º02' E longitude in the east of Karnal-Chandigarh road and its soil is mildly alkaline sandy loam (Type Ustrochrept). The experimental material was comprised of nine medium-late maturing maize newly developed hybrids including check, which was made available by IIMR, New Delhi. The experiments were planted on 2 July, 2015 at Karnal and 3 July, 2015 at Hisar in RBD with three replications having plot size of 4 x 3 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 to the crop at different growth and development stages. Observatios 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 on above traits were subjected to statistical analysis by using OPSTAT on line statistical software for estimation of mean, coefficient of variation, and critical difference.

Drought susceptibility index (DSI) was calculated for grain yield and other quantitative traits over drought stress (semi-arid condition) and non-stress environment (humid condition) by using the formula as suggested by Fisher and Maurer (1978). HSI = [l-YD/YP]/D Where, YD = mean of the genotypes in stress environment. YP = mean of the genotypes under non stress environment. D = 1-[mean YD of all genotypes/mean YP of all genotypes].

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, X35D601 (14079 kg/ha) followed by Seed tech2324 (13467 kg/ha), PMH-3 (12893 kg/ha) and Bio9637 (12007 kg/ha) were top yielder and significantly superior over the other hybrids. In semi-arid conditions at Hisar, CP 201 (4813 kg/ha) followed by Bio9681 (4766 kg/ha), PMH-3 (4515 kg/ha) and X35D601 (4073 kg/ha) were significantly superior over the other hybrids. Likewise, on the basis average over the locations, X35D601with an average yield 9076.0 kg/ha was at the top and followed by PMH-3 (8704 .0kg/ha), Seed tech2324 (8159.0 kg/ha) and CP 201 (7955.5 kg/ha). Above findings were also supported by Suthar *et al*. (2014), Arya *et al*. (2015) and Arya *et al*. (2020). The grain yield mean performance was high in humid conditions (11337.0 kg/ha) as compared to in semi-arid conditions (3634.0 kg/ha). Higher grain yield in humid condition was observed due to more availability of soil moisture and nutrients.

Kernel Shelling (%)

It is evident from Table 1 that in humid conditions, maximum kernel shelling (%) was found in hybrid, HM-9 (82.6%)which was followed by PMH-4 (81.9%), CP 201 (80.9%) and Bio9637 (80.7%). In semi-arid conditions, maximum grain shelling (%) was in X35D601 (85.8%) followed by PMH-3 (85.3%), CP 201 (85.1%) and PMH-4 (82.7%). But, on mean basis, maximum kernel shelling (%) was in CP 201 (83.0%) and followed by PMH-3 (82.7%), PMH-4 (82.3%) and X35D601 (82.1%). The kernel shelling (%) was high in semi-arid conditions (80.3%) as compared to in humid conditions (81.8%). 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 HM-9 (63.3) followed by Bio9637 (63.3) and CP 201 (63.1). Lowest plant stand was found in X35D601 (61.70). In semi-arid conditions, plant stand

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
CP 201	11098	4813	7955.5	80.9	85.1	83.00	63.1	61.7	62.40	55.3	45.7	50.50
X35D601	14079	4073	9076.0	78.4	85.8	82.10	61.7	61.1	61.40	56.0	50.0	53.00
PMH-1	9988	2971	6479.5	79.7	80.5	80.10	62.8	61.1	61.95	51.3	50.0	50.65
PMH-3	12893	4515	8704.0	80.1	85.3	82.70	62.8	61.9	62.35	52.7	46.0	49.35
Seed tech2324	13467	2851	8159.0	78.6	79.1	78.85	62.8	61.1	61.95	56.7	43.0	49.85
Bio9681	6477	4766	5621.5	79.5	81.7	80.60	62.2	61.4	61.80	54.0	44.0	49.00
HM-9	11665	2707	7186.0	82.6	75.2	78.90	63.3	60.8	62.05	56.0	46.0	51.00
Bio9637	12007	2405	7206.0	80.7	80.4	80.55	63.3	61.1	62.20	52.7	45.0	48.85
PMH-4	9758	3605	6681.5	81.9	82.7	82.30	62.5	60.3	61.40	57.0	45.7	51.35
Mean	**11337**	**3634**	7485.5	**80.3**	**81.8**	81.05	**62.7**	**61.2**	61.95	**54.6**	**46.1**	50.35
CD (5%)	648	261	-	0.23	5.15	-	2.13	1.63	-	1.05	2.58	
CV(%)	3.28	4.13	-	0.20	3.64	-	1.97	1.54	-	1.11	3.23	

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
CP 201	58.0	46.7	52.35	89.3	80.7	85.00	180.0	203.7	191.85	95.0	90.4	92.70
X35D601	58.0	52.0	55.00	89.7	87.0	88.35	205.0	215.0	210.00	118.3	103.9	111.10
PMH-1	53.3	51.7	52.50	88.0	86.7	87.35	190.0	211.3	200.65	98.3	96.0	97.15
PMH-3	55.3	47.7	51.50	84.3	88.0	86.15	195.0	242.7	218.85	110.0	114.9	112.45
Seed tech2324	60.0	47.3	53.65	91.7	80.3	86.00	180.0	182.5	181.25	111.7	83.6	97.65
Bio9681	56.7	45.0	50.85	86.0	81.0	83.50	181.7	231.5	206.60	90.0	94.8	92.40
HM-9	58.0	47.7	52.85	84.3	77.7	81.00	170.0	174.5	172.25	90.0	72.5	81.25
Bio9637	55.3	46.3	50.80	89.7	80.0	84.85	166.7	167.4	167.05	93.3	77.5	85.40
PMH-4	60.7	47.3	54.00	87.7	79.0	83.35	153.3	185.3	169.30	85.0	78.7	81.85
Mean	**57.3**	**48.0**	52.65	**87.9**	**82.3**	85.10	**180.2**	**201.6**	190.90	**99.1**	**90.2**	94.65
CD (5%)	0.88	1.96	-	1.03	1.94	-	8.99	35.63	-	5.36	18.20	-
CV(%)	0.99	2.37	-	0.68	1.36	-	2.88	10.21	-	3.13	11.65	-

(000/ha) was maximum for PMH-3 (61.9) followed by CP 201 (61.7) and Bio9681 (61.4) however, it was lowest was in PMH-4 (60.30). Likewise, on average basis, plant stand was maximum for CP 201 (62.40) followed by PMH-3 (61.4) and X35D601 (61.4).While, the lowest plant stand was found in PMH-4 (61.35). The plant stand was high in humid conditions (62.7) as compared to in semi-arid conditions (61.2). Similar results were also reported in maize by Arya *et al*. (2015) and and Arya *et al*. (2020).

Days to 50% pollen shedding

In humid conditions, PMH-1 (51.3 days) was earliest in pollen shedding and followed by Bio9637 (52.7 days) PMH-3 (52.7 days), Bio9681 (54.0 days), CP 201 (55.3 days). However, PMH-4 (57.0 days) and Seed tech2324 (56.7%) were late in pollen shedding. Likewise, in semi-arid conditions, Seed tech2324 (43.0 days), Bio9681 (44.00 days), Bio9637 (45.0 days), PMH-4(45.7 days) and CP 201 (45.7 days) were early in pollen shedding. However, X35D601 (50.0%) PMH-1 (50.0%), PMH-3 (46.0%) and HM-9 (46.0%) were late in pollen shedding. On mean basis, Bio9637 (48.85 days), Bio9681 (49.00 days), PMH-3(49.35 days) Seed tech 2324 (49.85 days) were early in pollen shedding. However, X35D601 (53.00%) PMH-4 (51.35%), HM-9 (51.00%) and PMH-1 (50.65%) were late in pollen shedding. Similar finding were also reported in maize by Arya *et al*. (2016) and Arya *et al*. (2020). The days to 50% pollen shedding was early in humid conditions (54.6 days) as compared to in semi-arid conditions (46.1 days).

Days to 50% silking

It is revealed from the Table 1 that in humid

conditions, PMH-1 (53.3 days), Bio9637 (55.3 days), PMH-3 (55.3 days) were early in silking. However, PMH-4 (60.7 days), Seed tech2324 (60.0 days), CP 201 (58.0 days), X35D601 (58.0 days) and HM-9 (58.0 days) were late in silking. In semi-arid conditions, the hybrids viz. Bio9681 (45.0 days), Bio9637 (46.3 days), CP 201 (46.7 days), PMH-4 (47.3 days) and Seed tech2324 (47.3 days) were early in silking. However, X35D601 (52.0 days), PMH-1 (51.7 days) were late in silking. Similarly, on the average basis over the locations, Bio9637 (50.8 days), Bio9681 (50.85 days), PMH-3 (51.5 days) were early in silking. Opposite to this, on the average basis over the locations, X35D601 (55.0 days), PMH-4 (54.0 days), Seed tech2324 (53.65 days), HM-9 (52.85 days) were late in silking. The days to 50% silking was early in humid conditions (57.3 days) as compared to in semi-arid conditions (48.0 days). The above findings were also supported by Arya *et al*. (2016) and Arya *et al*. (2020) in maize.

Days to 75% husk drying

In humid conditions, HM-9 (84.3 days), PMH-3 (84.3 days), Bio9681 (86.0 days) and PMH-4 (87.7 days) were early in days to 75% husk drying. However, Seed tech2324 (91.7 days), X35D601 (89.7 days), Bio9637 (89.7 days), CP 201 (89.3 days) and PMH-1 (88.0 days) were late in 75% husk drying. In semi-arid conditions, HM-9 (77.7 days), PMH-4 (79.0 days), Bio9637 (80.0 days), Seed tech2324 (80.3 days) and CP 201 (80.7 days) were early in days to 75% husk drying. However PMH-3 (88.0 days) X35D601 (87.0 days), PMH-1 (86.7 days) and Bio9681 (81.0 days) were late in 75% husk drying. Likewise, on average basis, the hybrid, HM-9 (81.00 days) was earliest in 75% husk drying and followed by PMH-4 (83.35 days), Bio9681 (83.50 days), Bio9637 (84.85 days) and CP 201 (85.00 days). However, X35D601 (88.35 days), PMH-1 (87.35 days), PMH-3 (86.15 days) and Seed tech2324 (86.00 days)were late in 75% husk drying. The days to 75% husk drying were early in humid conditions (87.9 days) as compared to in semi-arid conditions (82.3 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, X35D601 (205.0 cm), PMH-3 (195.0 cm), PMH-1 (190.0 cm) and Bio9681 (181.7 cm) were tallest and significantly superior over the check and other hybrids. However, PMH-4 (153.3 cm), Bio9637 (166.7 cm), HM-9 (170.0 cm), CP 201 were short in stature. Likewise, in humid conditions, PMH-3 (242.7 cm), Bio9681 (231.5 cm), X35D601 (215.0 cm), PMH-1 (211.3 cm) and CP 201 (203.7 cm) were tall in plant height. However, Bio9637 (167.4 cm), HM-9 (174.5 cm), Seed tech2324 (182.5 cm) andPMH-4 (185.3 cm) were short in stature. But, on average basis, PMH-3 (218.85 cm), X35D601 (210.00 cm), Bio9681 (206.60 cm), PMH-1 (200.65 cm) and CP 201 (191.85 cm) were tall in plant height. However, Bio9637 (167.05 cm), PMH-4 (169.30 cm), HM-9 (172.25 cm) and Seed tech2324 (181.25 cm) were short in stature. Similar finding were also reported in maize by Suthar *et al.* (2012 & 2014) and Arya *et al*. (2016). The plant height was more in humid conditions (180.2cm) as compared to in semi-arid conditions (201.6cm). 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 X35D601 (118.3 cm), and followed by Seed tech2324 (111.7 cm), PMH-3 (110.0 cm) and PMH-1 (98.3 cm). Likewise, in humid conditions, ear placement height was high for PMH-3 (114.9 cm), and followed by X35D601 (103.9 cm), PMH-1 (96.0 cm), and Bio9681 (94.8 cm). Moreover, on pooled basis, ear placement height was highest for PMH-3 (112.45 cm), and followed by X35D601 (111.10 cm), Seed tech2324 (97.65 cm), PMH-1 (97.15 cm). The ear placement height was more in humid conditions (99.1cm) as compared to semi-arid conditions (90.2cm). Similar finding were also reported in maize by Arya *et al*. (2015) and Arya *et al*. (2020). 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.

Drought susceptibility index

Drought susceptibility index (DSI) is also an important tool to identify the drought tolerant genotypes. In the present investigation, minimum DSI was recorded in Bio 9681 (0.389) and followed by CP

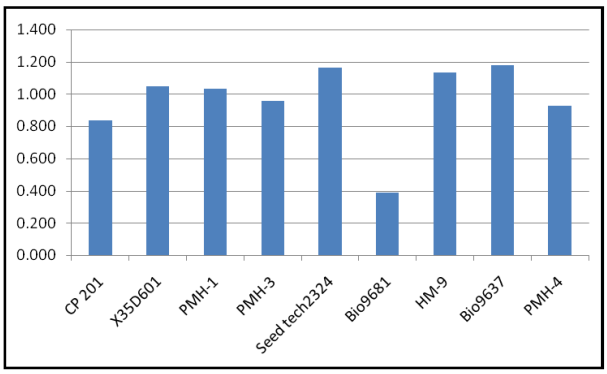

Fig. 1. Drought susceptibility index in maize.

201 (0.834) against national check, HM-9 (1.131) Bio 9637 (1.178), and PMH-4 (0.929) therefore, the genotype Bio 9681 (0.389) considered drought tolerant genotypes and may be utilized crop improvement programme for the development of drought stress tolerant cultivars. Research on drought tolerance or susceptibility and its association with seed yield and other related traits would help in the development of drought tolerant genotypes (Barnabás *et al*., 2008; Arya *et al*., 2014).

CONCLUSIONS

From the present study It was concluded that the hybrid, grain yield higher in humid condition was observed due to more availability of soil moisture and nutrients. In humid conditions, X35D601 (14079 kg/ha) followed by Seed tech2324 (13467 kg/ha), PMH-3 (12893 kg/ha) and Bio9637 (12007 kg/ha) were top yielder and significantly superior over the other hybrids. In semi-arid conditions, CP 201 (4813 kg/ha) followed by Bio9681 (4766 kg/ha), PMH-3 (4515 kg/ha) and X35D601 (4073 kg/ha) were significantly superior over the other hybrids. However, Bio 9681 (DSI=0.389) was found drought tolerant genotypes and may be utilized in breeding program to develop high yielding drought tolerant genotypes.

ACKNOWLEDGEMENTS

The authors are thankful to Director, IIMR for providing opportunity to conduct maize trial and financial assistance and also thankful to Regional Director, RRS Karnal and Director, RDS Seed Farm, CCS HAU, Hisar for field trial facilities for the investigation.

REFERENCES

Arya, R. K., Kamboj, M. C. and Kumar, S. 2015 : Performance of medium maturing maize hybrids under Haryana agro-climatic conditions. *Forage Res*. **41**: 130-34.

Arya, R. K., M. C. Kamboj and Suresh Kumar 2016 : Evaluation of late maturing maize hybrids under semi-arid and humid conditions of Haryana. *Haryana J. Agron*., **32**: (in press).

Arya, R. K., Kamboj M. C., Kumar S., 2020 : 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. Ekin J. **6**(2):23-27.

Arya, R. K., M. K. Singh, A. K. Yadav, A. Kumar and S. Kumar, 2014 : Advances in pearl millet to mitigate adverse environment conditions emerged due to global warming. *Forage Res*., **40** (2): 57-70.

Barnabás, B., K. Jäger, and A. Fehér, 2008 : The effect of drought and heat stress on reproductive processes in cereals. *Plant Cell Environ*., **31**: 11-38. doi: 10.1111/j. 1365-3040.2007.01727.x

Dayal, A., Rangare, N. R., Kumar, A. and Kumari, M. 2014 : Effect of physiological maturity of seed quality of maize (*Zea mays* L.) *Forage Res*., **40**: 1-6.

Fisher, R. A. and Maurer, R., 1978 : Drought resistance in spring wheat cultivars I. Grain yield responses. *Aust. J. Agric. Res*., **29** (5): 897-912.

Kumar, S. R. K. Arya, N. Singh and Satpal, 2021 : Response of zero-till rainfed maize to super absorbent polymer and mulching in maize-wheat cropping system under semi-arid conditions of Haryana. *Forage Res.,* **47** : 125-129.

Sharma, M., Gupta, M., Kour, S., Bharat, R. and Singh, S. P. 2014 : Effect of sowing dates and varieties on productivity and economics of baby corn (*Zea mays*). *Har. J. Agron*., **30** : 89-93.

Singh, M. V., Prakash, V., Singh, B. and Shahi, H. N. 2014 : Response of maize hybrids to integrated nutrient management. *Har. J. Agron*., **30** : 65-69.

Suthar, M., Singh, D. and Nepalia, V. 2012 : Green fodder and cob yield of sweet corn (*Zea mays* L. spp. Saccharata) varieties at varying fertility levels. *Forage Res*., **38**: 115-118.

Suthar, M., Singh, D., Nepalia, V. and Singh, A. K. 2014 : Performance of sweet corn (*Zea mays* L.) varieties at varying fertility levels. *Indian J. Agron*., **59**: 168-170.