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Short Communication

Effect of Planting Season on Seed Quality in Hybrid Maize Seeds

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Maize (*Zea mays* L.) is one of the most important multipurpose food grains of the world, having wider adaptability under varied agro-climatic conditions. Globally, maize is known as queen of cereals because of its highest genetic yield potential among the cereals. India contributes merely about 2.5% in world maize production. In India, maize is emerging as third most important crop after rice and wheat and the production of maize was 18.7 million tonnes during *kharif* 2017 and 7.02 million tonnes during *rabi* 2016-17 [1]. Karnataka, Rajasthan, Andhra Pradesh, Maharashtra and Uttar Pradesh are the major maize producing states which together contribute 60% of area and 70% of maize production in India. Maize grain is important source of protein (10.4%), fat (4.5%), starch (71.8%), vitamins and minerals like calcium, sulphur and phosphorus. Quality seed indicates the seeds of improved varieties having high genetic and physical purity, high germination rate, high vigour and freedom from seed borne insects and diseases. Quality seed alone accounts for 10-15% increase in production. Viability and vigor are the major determinants of the seed quality. Viability has impact on seed germination whereas germination rate and seedling establishment are influenced by the seed vigor. Different temperature regime may cause variations in seed germination [2], because germination is greatly influenced by temperature and it also has impact on the supply of nutrients and availability of soil water for sustaining the growth and development of maize [2-3].

Maize is grown in wide range of environments, extending from extreme semi-arid to sub-humid and humid regions in *Kharif* (monsoon) and *rabi* (winter) seasons. In India maize is grown throughout the year but mainly as *kharif* crop with 85% of the area under cultivation in the season. In North India it is primarily grown as a monsoon crop (June-October), hence its seed production in this season poses a problem in maintaining isolation from commercial crop, besides the chances of obtaining poor seed quality due to occurrence of biotic stresses. Seed production in winter (October-April) and spring-summer (February-May) season is another possibility. But sub-optimum temperatures during sowing time in winter season (November-February) hamper field emergence and early crop growth. Besides high temperature (>40^{o}C) and hot dry winds during flowering (April-May) in spring-summer season may also result in poor seed set, forced ripening or low seed yield and quality. Environmental factors such as temperature, relative humidity, rainfall and day length have significant influence on the flowering behavior, synchronization pattern and seed yield. It is well known fact that environmental conditions in different growing seasons have great influence in the formation and development of seed that may affect the seed quality. However, information relating to seed quality and seedling growth of maize hybrids over the growing season is limited. Keeping in view the above mentioned facts the present study was planned to evaluate the seasonal effect on seed quality of maize hybrids.

The experiment was conducted on 4 maize hybrids *viz.;* HQPM-1, HQPM-5, HM-8 and HM-9. The freshly harvested seeds of all four hybrids of both the seasons (*kharif* 2016 and *rabi* 2016-2017) were procured from Regional Research Station, Uchani, Karnal and study was conducted in laboratory of Department of Seed Science and Technology, CCS Haryana Agricultural University, Hisar. For germination test, three replications with 100 seeds from all hybrids were placed on sufficiently moistened rolled papers (BP) in the seed germinator at 25^{o}C with relative humidity of 90-95%. The germination was recorded on 7th day and germination percentage was expressed by normal seedlings according to the rules of International Seed Testing Association [4].Ten normal seedlings were randomly selected from each replication of all hybrids at the time of final count of standard germination and average seedling length was calculated

and expressed in centimeters. After the final count in the standard germination test, dry weight of seedlings was recorded. The ten seedlings which were used for measuring seeding lengths in each hybrid were taken for assessing dry weight. Seedlings were kept at 80±1^{0}C in hot air oven for 24 hrs. The dried seedlings of each replication were weighed and average seedling dry weight was calculated in milligrams. Seedling vigour indices were calculated according to the method suggested by [5]:

Vigour index-I = Standard germination (%) x Average seedling length (cm)

Vigour index-II = Standard germination (%) x Average seedling dry weight (mg)

For measurement of seed density (g/cc), twenty five seeds of each hybrid in three replications were taken and weighed by using electric balance. Seeds of all hybrids were dipped in water. Density of water was 1.0 at 20°C. Volume of water displaced by the seeds was recorded and seed density of each hybrid was calculated by using the following formula:

$$\text{Seed density (g/cc)} = \frac{\text{Weight of 25 seeds (g)}}{\text{Vol. of water displaced by 25 seeds (cm}^3\text{)}}$$

For tetrazolium testing, fifty seeds of each hybrid, in three replications were soaked in 50 ml water for 16 hours at 25^{o}C to activate dehydrogenase enzyme. Then the longitudinal cut was made through mid section of the embryo and endosperm. After that the seeds were stained in 0.5 percent tetrazolium solution (2, 3, 5-triphenyl tetrazolium chloride) for 4 hours at 38^{o}C in petri plates. The solution was then poured off and seeds were rinsed briefly in tap water and examined under magnifications. The number of seeds which stained entirely red were considered as normal viable seeds and expressed in percentage [6]. Thousand seeds of each replication of all hybrids were counted at random and weighed individually on electric balance and mean of these observations were recorded as 1000 seed weight in grams. Accelerated ageing test was conducted on adequate number of seeds from each hybrid, taken in single layer on wire mesh tray fitted in plastic boxes having 40 ml distilled water. After closing the lids of boxes, these were placed in ageing chamber. The seeds were aged at 40±1^{0}C temperature and 100% relative humidity for 24, 48, 72 and 96 hours and tested for germination in three replications of 100 seeds for each hybrid. The number of normal seedlings were calculated on 7th day and expressed as germination percentage.

The factorial experiment in completely randomized design (CRD) was conducted in three replicates and data was subjected to the statistical analysis [7].

The results revealed that the seeds produced in *rabi* season showed superiority over *kharif* season by registering highest germination percentage (93.67%), seedling length (41.93 cm), seedling dry weight (601.75 mg), vigour index-I (3931), vigour index-II (56497), 1000 seed weight (237.53 g), seed density (1.24), tetrazolium test (95.67%), accelerated aging test at 24 h (95.17%), accelerated aging test at 48 h (86.34%), accelerated aging test at 72 h (69.84%) and accelerated aging test at 96 h (39.50%). Seed ageing has come to be recognized as major cause of reduced germination, vigour and viability in many species. In present study maize seed lost nearly up to 50% germination when given 72 h artificial ageing at 40^{0}C with 100% RH (Tables 1 and 2). The possible reason of this reduction might be the lowering of biochemical activities in seeds. Aging has damaging effect on enzymes that are necessary to convert reserve food in the embryo to usable form and ultimately production of normal seedling. Alternatively, the reduction in germination might be due to the degradation of mitochondrial membrane leading to reduction in energy supply necessary for germination [8]. Accelerated aging test results are in accordance with the findings of [9] in maize, [10] in rice and [11] in cotton. In *rabi* season seed germination ranged from 90.00 to 96.67%, seedling length varied from 39.51 to 43.81 cm, seed density ranged from 1.15 to 1.36, seedling dry weight ranged from 546.00 to 702.33, vigour index-I varied from 3556 to 4236, vigour index-II varied from 49144 to 67876, 1000 seed weight ranged from 221.14 to 281.67 g, tetrazolium test ranged from 91.33 to 99.33, accelerated aging test at 24 h ranged from 92.67 to 97.33%, accelerated aging test at 48h ranged from 80.00 to 95.33%, accelerated aging test at 72 h ranged from 66.00 to 72.67% and accelerated aging test at 96h ranged from 32.00 to 48.66% while in *kharif* season seed germination ranged from 86.00 to 94.00%, seedling length varied from 30.11 to 37.47 cm, seed density ranged from 1.13 to 1.18, seedling dry weight ranged from 446.00 to 523.67 mg, vigour index-I varied from 2590 to 3522, vigour index-II varied from 38372 to 49227, 1000 seed weight ranged from 156.09 to 245.16 g, tetrazolium test ranged from 90.00 to 96.00%, accelerated aging test at 24 h ranged from 80.67 to 93.33%, accelerated aging test at 48 h ranged from 70.67 to 88.00%, accelerated aging test at 72 h ranged from 64.67 to 71.33% and accelerated aging test at 96 h ranged from 24.00 to 44.00%.

Table 1. Effect of planting season on seed quality parameters in maize hybrids

Hybrids	Standard germination %)			Seedling length (cm)			Seedling dry weight(mg)			Seed vigour index-I			Seed vigour index- II			1000 Seed weight(g)		
	Rabi	*Kharif*	Mean	*Rabi*	*Kharif*	Mean	*Rabi*	*Kharif*	Mean	*Rabi*	*Kharif*	Mean	*Rabi*	*Kharif*	Mean	*Rabi*	*Kharif*	Mean
HQPM 1	94.67 (76.80)*	93.00 (74.73)	93.83 (75.77)	43.47	36.00	39.74	612.34	486.00	549.17	4115	3347	3731	57973	45202	51587	223.28	170.05	196.66
HQPM 5	96.67 (79.57)	94.00 (75.92)	95.33 (77.75)	43.81	37.47	40.64	702.33	523.67	613.00	4236	3522	3879	67876	49227	58552	281.67	245.16	263.41
HM 8	93.33 (75.17)	90.67 (72.35)	92.00 (73.76)	40.91	31.57	36.24	546.33	479.67	513.00	3818	2863	3341	50996	43532	47264	224.01	221.64	222.83
HM 9	90.00 (71.60)	86.00 (68.03)	88.00 (69.82)	39.51	30.11	34.81	546.00	446.00	496.00	3556	2590	3074	49144	38372	43758	221.14	156.09	188.62
Mean	93.67 (75.79)	90.92 (72.76)		41.93	33.79		601.75	483.83		3931	3081		56497	44083		237.53	198.24	
Range	90.00-96.67	86.00-94.00		39.51-43.81	30.11-37.47		546.00-702.33	446.00-523.67		3556-4236	2590-3522		49144-67876	38372-49227		221.14-281.67	156.09-245.16	
CD (p=0.05)																		
Hybrids (H)		2.667			1.349			17.319			140.895			2353.753			1.855	
Seasons (S)		1.886			0.954			12.246			99.628			1664.355			1.312	
Interaction (HXS)		NS			NS			24.493			NS			3328.710			2.624	

* Values in parenthesis are transformed values.

Table 2. Effect of planting season on seed quality parameters in maize hybrids

Hybrids	Seed density(g/cc)			Tetrazolium test (%)			Accelerated ageing (24h) (%)			Accelerated ageing (48 h) (%)			Accelerated ageing (72h) (%)			Accelerated ageing (96h) (%)		
	Rabi	*Kharif*	Mean	*Rabi*	*Kharif*	Mean	*Rabi*	*Kharif*	Mean	*Rabi*	*Kharif*	Mean	*Rabi*	*Kharif*	Mean	*Rabi*	*Kharif*	Mean
HQPM 1	1.27	1.17	1.22	98.00 (83.42)*	94.00 (75.92)	96.00 (79.67)	96.00 (78.69)	91.34 (73.04)	93.67 (75.87)	87.33 (69.14)	78.00 (62.02)	82.67 (65.58)	72.00 (58.04)	70.00 (56.78)	71.00 (57.41)	43.33 (41.15)	34.67 (36.05)	39.00 (38.6)
HQPM 5	1.36	1.18	1.27	99.33 (87.28)	96.00 (78.69)	97.67 (82.99)	97.33 (80.70)	93.33 (75.04)	95.33 (77.87)	95.33 (79.78)	88.00 (69.75)	91.67 (74.77)	72.67 (58.49)	71.33 (57.63)	72.00 (58.06)	48.66 (44.22)	44.00 (41.54)	46.33 (42.88)
HM 8	1.17	1.15	1.16	94.00 (76.30)	92.55 (74.67)	93.28 (75.49)	94.67 (76.67)	90.00 (71.60)	92.33 (74.14)	82.67 (65.47)	76.66 (61.09)	79.67 (63.28)	68.67 (55.94)	66.00 (54.32)	67.33 (55.13)	34.00 (35.65)	30.00 (33.20)	32.00 (34.43)
HM 9	1.15	1.13	1.14	91.33 (72.96)	90.00 (71.60)	90.67 (72.28)	92.67 (74.37)	80.67 (63.94)	86.67 (69.16)	80.00 (63.48)	70.67 (57.21)	75.33 (60.35)	66.00 (54.32)	64.67 (53.52)	65.33 (53.92)	32.00 (34.44)	24.00 (29.32)	28.00 (31.88)
Mean	1.24	1.16		95.67 (79.99)	93.14 (75.22)		95.17 (77.61)	88.84 (70.91)		86.34 (69.47)	78.33 (62.52)		69.84 (56.70)	68.00 (55.56)		39.50 (38.87)	33.17 (35.03)	
Range	1.15-1.36	1.13-1.18		91.33-99.33	90.00-96.00		92.67-97.33	80.67-93.33		80.00-95.33	70.67-88.00		66.00-72.67	64.67-71.33		32.00-48.66	24.00-44.00	
CD (p=0.05)																		
Hybrids (H)		0.018			3.181			2.655			3.634			3.024			1.782	
Seasons (S)		0.013			2.250			1.877			2.570			NS			1.260	
Interaction(HXS)		0.026			NS			3.754			NS			NS			2.520	

* Values in parenthesis are transformed values.

Among hybrids, Hybrid HQPM-5 registered superiority over the other hybrids for almost all the seed quality parameters in both the seasons (*rabi* and *kharif*). Hybrids HQPM 5 recorded maximum germination (95.33%), seedling length (40.64cm), seedling dry weight (613.00mg), vigour index-I (3879), vigour index-II (58552), 1000 seed weight (263.41g), seed density (1.27), tetrazolium test (97.67%), accelerated aging test at 24h (95.33%), accelerated aging test at 48h (91.67%), accelerated aging test at 72h (72.00%) and accelerated aging test at 96h (46.33%). On the contrary, hybrid HM-9 recorded minimum germination (88.00%), seedling length (34.81cm), seedling dry weight (496.00mg), vigour index-I (3074), vigour index-II (43758), 1000 seed weight (156.09g), seed density (1.14), tetrazolium test (90.67%), accelerated aging test at 24h (86.67%), accelerated aging test at 48h (75.33%), accelerated aging test at 72h (65.33%) and accelerated aging test at 96h (28.00%). The difference in the seed quality parameters of hybrids might be due to the difference in genetic makeup of these hybrids.

In *kharif* season all quality parameters were significantly lower than *rabi*, this variation might be due to fact that crop had to be harvested under high relative humidity and temperature. Maximum seedling length, seedling dry weight, 1000 seed weight, seed density and tetrazolium test in *rabi* compared to the *kharif* was due to the seeds being heavy with better food reserves. These results are similar in sunflower [12, 15], soybean [13, 14], pigeon pea [16, 17], mungbean [18-20]. It can be concluded that *rabi* season produced seeds had better seed quality compared to *kharif* season, thus *rabi* season can be considered as a better option for production of quality seed in Haryana.

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