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Influence of plant geometry and nutrition doses on seed quality parameters of sweet corn (*Zea mays* L.) during storage

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ABSTRACT

Influence of four plant geometries and three nutrition doses on seed quality parameters during storage was studied using Sweet corn cultivar Madhuri in a Randomized block design with factorial concept. The analysis of bimonthly data on seed storage potential after six months indicated significant influence of storage period on all the five seed quality parameters evaluated. The interaction effects between storage, plant geometry and nutrition doses were also highly significant. Marked decline in germination percentage, seedling dimensions and corresponding vigour index was noticed over a period of six months. However, germination percentage did not go below 90 per cent which is much above the minimum seed certification standard of 80 per cent. The study also indicated that shoot length was the most sensitive seed quality parameter affected by ageing due to storage under ambient conditions. The study revealed that the superior combinations for yield and yield components also performed desirably for seed quality attributes indicating better storage potential under ambient conditions. In this context, treatment combinations viz., 45 x 20 cm /120:60:45 NPK kg ha^{-1}, 60 x 15 cm / 150:75:45 NPK kg ha^{-1}, 60 x 20 cm / 120:60:45 NPK kg ha^{-1}, 60 x 20 cm / 150:75:45 NPK kg ha^{-1} performed better at the end of six months of storage in terms germination and seedling parameters.

Key words: Sweet corn; plant geometry; Germination percentage; Vigour index.

INTRODUCTON

In India maize ranks among the top four cereals occupying an area of 7.89 million ha with a production of 15.09 million tonnes and 1904 kg ha^{-1} productivity. Andhra Pradesh is one of the major maize producing states with a production of 4.15 million tonnes from 0.85 million ha averaging 4073 kg ha^{-1} (CMIE, 2010) [6].

Approximately 25 per cent of the total corn produced is used for human consumption either in fresh or processed form. Of late, Sweet corn is emerging as one of the important enterprises projecting diversified and value added uses of maize. Fire baked or steam boiled green cobs of sweet corn have gained immense popularity among the urbanites as a favourite dish, resulting in premium price for growers. Diversification and value addition of sweet corn are currently contemplated in view of rapid growth in the food processing industry. Continuous and growing demand for fresh sweet corn cobs has led to cultivation of sweet corn under varied soil conditions and management practices extending throughout the year. Besides this, timely and healthy seed availability of improved sweet corn cultivars largely depends on the storage potential of the seed. Development and assessment of optimum management practices that have a positive bearing on seed quality attributes of stored seed would be of immense use for farmers. In order to realise this, it was felt necessary to optimise input utilisation including space and nutritional requirement with reference to popular public sector sweet corn variety Madhuri released by ANGR Agricultural University, Hyderabad, India. An attempt was made to quantify the storage potential in terms of germination and seedling parameters under ambient conditions for seed obtained from different plant geometry and nutritional regimes.

MATERIALS AND METHODS

The field experiment to obtain the resultant seed for storage studies was conducted at the Seed Research and Technology Centre and Quality Control Laboratory, Acharya N.G Ranga Agricultural University, Rajendranagar, Hyderabad. The geographical location of the farm is 17.2°N latitude and 78.3° E longitude with altitude of 518 m above mean sea level. The experiment was laid out in randomized block design with factorial concept and replicated thrice with 12 treatments obtained from combining four levels of plant spacing viz., 45 x 15 cm, 45 x 20 cm, 60 x 15 cm and 60 x 20 cm with three fertilizer doses of N P K viz., 90 : 45 : 45 NPK kg ha^{-1}, 120 : 60 : 45 NPK kg ha^{-1} and 150 : 75 : 45 NPK kg ha^{-1}. The produce of sweet corn kernels from all the 12 treatments harvested from net plot separately replication wise was dried, cleaned, processed and the seed moisture was brought to 8 per cent and stored in cotton cloth bags under ambient conditions to generate bimonthly data on storage for six months as described below.

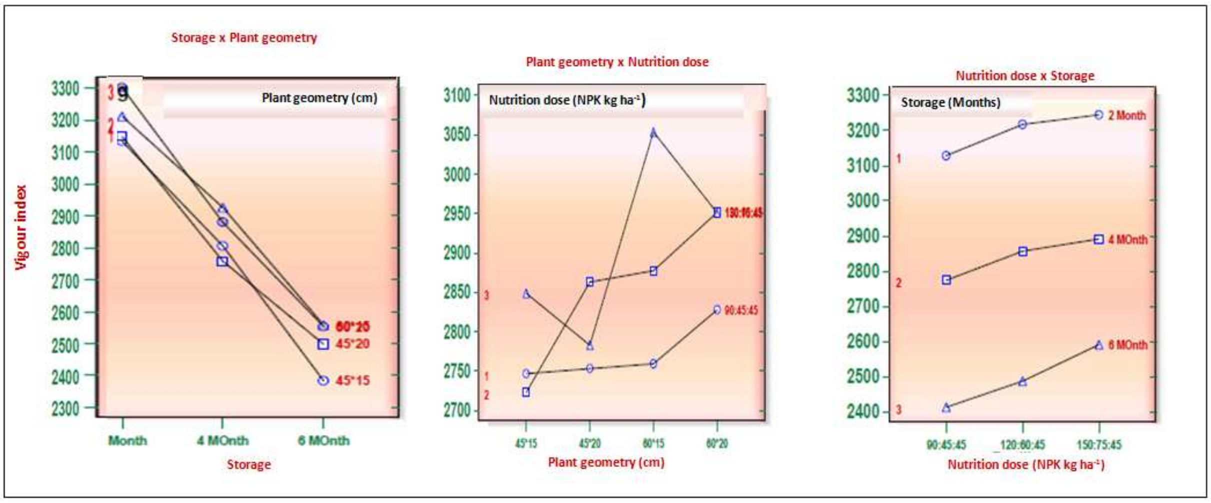
Four hundred seeds in four replications of hundred seeds each were subjected to germination test following between paper method as prescribed by ISTA (1985) [11]. Hundred seeds in 4 replications of 25 seeds each were placed in petridish containing moistened filter paper. These petridishes were placed in germinator and daily data on germination was recorded. The speed of germination was then calculated by adding the quotients of daily counts divided by number of days of germination (Maguire, 1962) [13]. Shoot length was measured from collar region to the tip of plumular bud on ten randomly selected seedlings. The mean shoot length was expressed in cm. Root length was measured from collar region to the tip of primary root on ten randomly selected seedlings. The mean of root length was expressed in cm. Vigour index of the seedlings was calculated by adopting the formula (Abdul Baki and Anderson, 1973) [2].

RESULTS AND DISCUSSION

Crop seeds differ considerably for viability and longevity depending on plant species and varieties as well as the conditions of storage (Harrington, 1972[9]; Bewley and Black, 1982) [5]. Seed deterioration as a result of ageing results in the loss of capacity to germinate during storage under ambient conditions which is usually due to alteration in cellular physiology of seeds, fluctuation in moisture content, changes in biochemical composition and increased leaching of electrolytes and other low molecular weight substances during imbibition (Kalpana and Madhava Rao, 1991) [12]. The ageing of seeds is indicated by delayed germination, slower growth and increased susceptibility to environmental stresses (Mc Donald and Nelson, 1986) [13]. Further, it has been demonstrated that early deteriorative change in seeds under storage was due to various biochemical processes viz., denaturation of biomolecules and accumulation of toxic substances in addition to loss of membrane integrity (Abdul Baki and Anderson, 1972) [1].

In the present investigation, significant differences were observed among the treatment combinations of plant geometry and nutrition doses in response to storage under ambient conditions. Information on germination behaviour, viability and longevity of seeds under ambient conditions is needed to ascertain the storability and to prevent stand failure in the field on sowing (Dhakal and Pandey, 2001) [7]. The temperature during the storage period ranged from 31.4 to 38.9º C while the relative humidity ranged from 59 to 84 per cent. The mode of storage using cotton cloth bags under ambient condition facilitated free passage of moisture from outside atmosphere into the actual storage environment of the seed. In this context earlier researchers Hari Singh and Gurmith Singh (1992)[8] opined that seed moisture and temperature are the two main factors determining the seed longevity. However, in the present study apart from these abiotic factors, storage time, plant geometry and nutrition doses were also found to be significantly influencing germination percentage under ambient conditions. The influence of spacing or plant geometry on germination during storage was evident as higher percentage of germination was recorded at wider plant geometry of 60 x 15 cm. The interaction effects also revealed that wider geometry of 60 x 15 cm in combination with 150: 75: 45 NPK kg ha^{-1} and 120: 60:45 NPK kg ha^{-1} recorded highest percentage of germination of 97.7 during first bimonthly period and maintained the higher germination percentage throughout six months of storage (92.0%). These were followed by 60 x 20 cm / 120: 60: 45 NPK kg ha^{-1} which had 96.7 and 91.3 per cent of germination at the end of second and sixth months, respectively (Table 1). It appears that days to 50 per cent flowering which is related to attaining physiological maturity of seeds and seed size influenced germination during storage (Appa Rao *et al*. 1991) [3]. In the present study, the interactions with plant geometry of 60 x 15 cm and 60 x 20 cm were among the earliest to flower and had comparatively higher seed weight and recorded higher germination percentages at the end of six months. However, considering the percentage reduction in germination during storage period, highest reduction of 6.30 per cent (Table 5) was observed in the produce obtained from 45 x 15 cm plant geometry fertilized at 150: 75: 45 NPK kg ha^{-1}. Seeds obtained from these treatments could have accumulated lesser seed reserves as they flowered late and also due to shortened reproductive period comparatively. This could have resulted in reduced germination during subsequent storage in view of inadequate food material in the seed. Further, treatment combinations involving 45 x 20 cm at nutritional dose of 120: 60: 45 NPK kg ha^{-1} and 150: 75: 45 NPK kg ha^{-1} recorded moderate decrease of 5.95 and 5.87 per cent, respectively after six months. The mean percentage reduction ranged from 4.59 to 6.30 per cent at the end of six months storage. Cloth bags are porous and less resistant to the passage of moisture, therefore the seeds stored in them adjusted to the changes in relative humidity of the surrounding environment and lost germination at a faster rate (Bass, 1973) [4]. Since the storage conditions are same for resultant produce of all the treatments and considering the lower reduction in percentage of germination during test period the combinations of 45 x 20 cm / 120: 60: 45 NPK kg ha^{-1} and 45 x 20 cm / 150: 75: 45 NPK kg ha^{-1} along with combinations mentioned earlier seem to have practical significance, in terms of storability for longer period.

Figure 1: Vigour index as influenced by the interaction between storage period, plant geometry and nutrition doses



Speed of germination is an indirect indication of seed viability and seed vigour. Estimates of speed of germination could be applied with reasonable accuracy to the seeds under the influence of natural ageing to predict the storability. In this study, storage had a profound influence on reducing the speed of germination from 44.12 to 38.03 during six months of storage (Table 2). Considering the mean values for speed of germination and lower percentage of reduction in speed of germination during storage period the interactions viz., 45 x 20 cm / 150: 75: 45 NPK kg ha^{-1}, 60 x 15 cm / 120: 60: 45 NPK kg ha^{-1}, 60 x 20 cm / 150: 75: 45 NPK kg ha^{-1} and 60 x 15 cm / 150: 75: 45 NPK kg ha^{-1} were found to be superior. In view of better performance for important yield attributes like seed size and seed weight these elite combinations have resulted in seed material that could register higher percentage of initial germination during the total period to complete the process of germination. Reduction in speed of germination is one of the important physiological changes reported to take place in seed during ageing and the extent of decline is related to initial degree of deterioration in the seed lot.

Table 1: Germination (%) as influenced by the interaction between Storage period, plant geometry and nutrition doses

Plant geometry (cm)	Storage period											
	2 Months				4 Months				6 Months			
	Nutrition dose (NPK kg ha^{-1})				Nutrition dose (NPK kg ha^{-1})				Nutrition dose (NPK kg ha^{-1})			
	90:45:45	**120:60:45**	**150:75:45**	**MEAN**	**90:45:45**	**120:60:45**	**150:75:45**	**MEAN**	**90:45:45**	**120:60:45**	**150:75:45**	**MEAN**
45 x 15	95.7 (78.0)	96.0 (78.5)	96.7 (79.5)	**96.1 (78.7)**	94.3 (76.2)	93.3 (75.1)	94.0 (75.9	**93.8 (75.7)**	91.3 (72.9)	90.6 (72.2)	90.6 (72.2)	**90.8 (72.4)**
45 x 20	95.7 (78.0)	95.7 (78.0)	95.3 (77.6)	**95.5 (77.8)**	94.0 (75.8)	93.0 (74.7)	92.0 (73.6)	**93.0 (74.7)**	91.0 (72.6)	90.0 (71.6)	89.7 (71.3)	**90.2 (71.7)**
60 x 15	95.3 (77.5)	97.7 (81.3)	97.7 (81.3)	**96.9 (80.0)**	92.3 (73.9)	95.7 (78.0)	95.7 (78.0)	**94.5 (76.7)**	90.3 (71.9)	92.0 (73.6)	92.0 (73.6)	**91.4 (73.0)**
60 x 20	96.3 (78.6)	96.7 (79.5)	95.7 (78.0)	**96.2 (78.7)**	93.7 (75.4)	94.0 (75.8)	92.3 (73.9)	**93.3 (75.1)**	91.3 (72.9)	91.7 (73.2)	90.0 (71.6)	**91.0 (72.6)**
MEAN	**95.7 (78.1)**	**96.5 (79.3)**	**96.3 (79.1)**	96.2 (78.8)	**93.6 (73.4)**	**94.0 (75.8)**	**93.5 (75.3)**	93.7 (74.8)	**90.9 (72.5)**	**91.0 (72.6)**	**90.6 (72.2)**	90.8 (72.4)
	Storage x Plant geometry			**Storage x Nutrition dose**			**Plant geometry x Nutrition dose**			**Storage x Plant geometry x Nutrition dose**		
S Em ±	NS			NS			0.26			NS		
CD (0.05)	NS			NS			0.75			NS		

Figures in parentheses indicate angular transformed values ; NS – Non significant

Table 2: Speed of germination as influenced by the interaction between Storage period, plant geometry and nutrition doses

Plant geometry (cm)	Storage period											
	2 Months				4 Months				6 Months			
	Nutrition dose (NPK kg ha^{-1})				Nutrition dose (NPK kg ha^{-1})				Nutrition dose (NPK kg ha^{-1})			
	90:45:45	120:60:45	150:75:45	MEAN	90:45:45	120:60:45	150:75:45	MEAN	90:45:45	120:60:45	150:75:45	MEAN
45 x 15	45.40	43.47	46.10	**44.99**	40.87	39.30	41.97	**40.71**	39.40	38.57	41.47	**39.81**
45 x 20	44.63	43.20	42.97	**43.60**	40.40	38.83	41.23	**40.15**	35.67	35.97	40.60	**37.41**
60 x 15	39.83	34.73	44.83	**39.71**	37.07	33.13	39.07	**34.65**	33.17	32.00	37.80	**34.32**
60 x 20	46.80	49.10	48.57	**48.16**	41.47	43.43	42.60	**42.50**	39.47	41.17	41.10	**40.58**
MEAN	**44.16**	**46.63**	**45.62**	**44.12**	**39.95**	**38.67**	**41.22**	**39.50**	**36.92**	**36.93**	**40.24**	**38.03**
	Storage x Plant geometry			**Storage x Nutrition dose**			**Plant geometry x Nutrition dose**			**Storage x Plant geometry x Nutrition dose**		
S Em ±	0.44			NS			0.38			0.44		
CD (0.05)	1.24			NS			1.07			1.24		

NS – Non significant

Table 3: Shoot length (cm) as influenced by the interaction between Storage period, plant geometry and nutrition doses

Plant geometry (cm)	Storage period											
	2 Months				4 Months				6 Months			
	Nutrition dose (NPK kg ha^{-1})				Nutrition dose (NPK kg ha^{-1})				Nutrition dose (NPK kg ha^{-1})			
	90:45:45	**120:60:45**	**150:75:45**	**MEAN**	**90:45:45**	**120:60:45**	**150:75:45**	**MEAN**	**90:45:45**	**120:60:45**	**150:75:45**	**MEAN**
45 x 15	13.33	13.50	14.23	**13.69**	12.00	11.73	12.63	**12.12**	9.83	10.33	10.96	**10.37**
45 x 20	13.87	14.57	14.77	**14.40**	11.77	13.37	12.53	**12.15**	10.30	12.07	11.60	**11.32**
60 x 15	13.53	13.73	15.13	**14.13**	12.13	12.30	13.07	**12.50**	11.10	11.20	12.20	**11.5**
60 x 20	14.13	15.30	15.43	**14.95**	11.47	12.50	12.57	**12.18**	11.33	11.40	12.47	**11.73**
MEAN	**13.72**	**14.28**	**14.89**	**14.29**	**11.84**	**12.84**	**12.7**	**12.24**	**10.64**	**11.25**	**11.81**	**11.23**

	Storage x Plant geometry	Storage x Nutrition dose	Plant geometry x Nutrition dose	Storage x Plant geometry x Nutrition dose
S Em ±	0.89	0.08	0.07	0.08
CD (0.05)	0.25	0.21	0.21	0.25

Table 4 : Root length (cm) as influenced by the interaction between Storage period, plant geometry and nutrition doses

Plant geometry (cm)	Storage period											
	2 Months				4 Months				6 Months			
	Nutrition dose (NPK kg ha^{-1})				Nutrition dose (NPK kg ha^{-1})				Nutrition dose (NPK kg ha^{-1})			
	90:45:45	120:60:45	150:75:45	MEAN	90:45:45	120:60:45	150:75:45	MEAN	90:45:45	120:60:45	150:75:45	MEAN
45 x 15	19.33	18.33	18.60	**18.75**	17.53	17.70	18.00	**17.74**	15.67	15.33	16.53	**15.84**
45 x 20	18.47	18.93	18.16	**18.52**	17.13	17.33	17.36	**17.27**	16.67	16.03	15.47	**16.05**
60 x 15	18.63	19.00	19.30	**18.98**	18.20	18.13	18.93	**18.42**	15.60	16.23	17.53	**16.43**
60 x 20	19.37	19.57	19.07	**19.34**	17.87	18.50	19.13	**18.50**	15.63	16.63	16.70	**16.32**
MEAN	**18.95**	**18.96**	**18.78**	**18.90**	**17.68**	**17.92**	**18.36**	**17.98**	**15.89**	**16.06**	**16.56**	**16.16**

	Storage x Plant geometry	Storage x Nutrition dose	Plant geometry x Nutrition dose	Storage x Plant geometry x Nutrition dose
S Em ±	NS	NS	0.21	NS
CD (0.05)	NS	NS	0.59	NS

NS – Non significant

Table 5: Percentage change in seed quality during storage

Plant geometry (cm) / Nutrition dose (NPK kg ha^{-1})	Percentage reduction in germination		Percentage reduction in speed of germination		Percentage reduction in shoot length		Percentage reduction in root length		Percentage reduction in vigour index	
	4 months	6 months	4 months	6 months	4 months	6 months	4 months	6 months	4 months	6 months
45×15 /90:45:45	1.46	4.59	9.97	13.21	9.97	26.25	9.31	18.93	10.87	25.49
45×15/120:60:45	2.81	5.52	9.59	11.52	13.11	23.48	3.43	16.36	11.22	24.79
45×15/150:75:45	2.79	6.30	8.95	10.04	11.24	22.97	3.22	11.12	9.26	21.45
45×20/90:45:45	1.77	4.91	9.47	20.07	15.14	25.73	7.25	9.74	12.20	22.26
45×20/120:60:45	2.82	5.95	10.11	16.73	8.23	17.15	8.45	15.32	10.93	21.09
45×20/150:75:45	3.46	5.87	4.04	5.51	15.16	21.46	4.40	14.81	14.04	19.96
60×15/90:45:45	3.14	5.24	6.92	16.72	10.34	17.96	2.30	16.26	6.06	21.33
60×15/120:60:45	2.04	5.83	4.66	7.86	10.41	18.42	4.57	14.57	8.91	20.48
60×15/150:75:45	2.04	5.83	12.84	15.68	13.61	19.36	1.91	9.17	8.98	18.64
60×20/90:45:45	2.69	5.19	11.38	15.66	18.82	19.81	7.74	19.30	13.40	23.67
60×20/120:60:45	2.79	5.17	11.54	16.15	18.30	25.49	5.46	15.02	13.54	24.97
60×20/150:75:45	3.55	5.95	12.29	15.37	18.53	19.18	0.31	12.43	11.35	20.47
MEAN	**2.61**	**5.53**	**9.45**	**13.80**	**13.64**	**21.41**	**4.82**	**12.60**	**10.81**	**22.04**

Seeds attain maximum vigour and full germination capacity at physiological maturity which is widely considered as optimum time to harvest the crop to obtain high quality seed. After physiological maturity seeds begin to age on the mother plant and would result in weathering and loss of much of the initial seed quality (Harrington, 1972) [9]. This initial seed quality is comprised of values pertaining to vigour index and seedling dimensions like shoot and root length. As discussed earlier the source crop of the material used in this study differed considerably for days to 50 per cent tasseling under the influence of various plant geometries in combination with different fertilizer doses of NPK. Even though the crop was harvested during same period, due to differences in crop phenology during vegetative growth and maturity period the seed size, seed weight etc., varied which had a clear impact on the seedling vigour parameters during storage. Further, amongst different factors influencing seed longevity, storage environment, relative humidity and temperature contributed to a larger extent. The oxidative deterioration of poly unsaturated lipids in cellular membrane leading to free radical chain reaction is considered to be the primary reason of ageing (ISTA, 1985) [10].

Accordingly, close similarity was earlier observed among the patterns of seedling growth, germination percentage and vigour indices (Dhakal and Pandey, 2001) [7]. Seedling vigour traits in maize viz., coleoptile and seedling length show a greater response to ageing than germination with sequential and gradual reduction after ageing (Santipracha *et al*., 1997) [14]. In the present study also all seedling traits declined under natural ageing conditions but maximum reduction of 21.41 per cent was observed in shoot length at the end of six months indicating that it is the most sensitive character affected during storage thus can be a reliable parameter for assessing seed quality. The strong influence of plant geometry of 60 x 20 cm was evident with realisation of higher shoot length in combination with 120:60:45 NPK kg ha^{-1} and 150:75:45 NPK kg ha^{-1}. Apart from these interactions 60 x 15cm / 150:75:45 NPK kg ha^{-1} also performed desirably for this trait. The results further suggested that the plant geometry of 45 x 20 cm at 120:60:45 NPK kg $ha^{-1}$and 150:75:45 NPK kg ha^{-1} (Table 3) has contributed to relatively higher shoot length values indicating its importance in maintaining optimum seed quality parameters.

This was further strengthened by the percentage of reduction which was lowest in 45 x 20 cm/120:60:45 NPK kg ha^{-1} at 8.23 and 17.15 per cent after four and six months, respectively (Table 5). With this conclusion it can be further interpreted that this treatment combination is more tolerant to natural ageing due to storage under ambient conditions. Among other interactions, 60 x 20 cm/150:75:45 NPK kg ha^{-1}, 60 x 15 cm/150:75:45 NPK kg ha^{-1} recorded highest shoot length values with lower percentage of reduction after six months(Table 5). Incidentally similar response of plant geometry in combination with fertilizer doses was observed with regard to another important seed quality attribute i.e., root length of seedlings at all periods of storage. Greater root length values after six months of storage were recorded in 60 x 20 cm/120:60:45 NPK kg ha^{-1}, 60 x 15 cm/150:75:45 NPK kg ha^{-1}, 60 x 20 cm/150:75:45 NPK kg ha^{-1} (Table 4) indicating their superior storability in terms of expressing better root length thus contributing to the higher vigour index. The perusal of data presented in Table 5 indicated that mean reduction percentage in root length after six months was 12.60 while it was 21.41 per cent for shoot length. This phenomenon clearly suggested that shoot length of maize seed stored under ambient conditions is more sensitive to ageing compared to root length which had registered only 50 per cent of reduction in comparison to that of shoot length at the end of six months.

The vigour index tests are commonly evaluated for their ability to predict crop performance particularly field emergence, plant uniformity and storability (Dhakal and Pandey, 2001) [7]. Vigour indices worked out in the present study indicated significant reduction among all interaction effects under the influence of storage period, plant geometry, nutrition doses. The vigour index has also declined from 3196 after two months to 2498 after six months. This could be mainly attributed to significant reduction in percentage of germination and seedling dimensions during storage period (Table 5). As in the case of seedling parameters, greater vigour index was observed at wider spacing of 60 x 20 cm, 60 x 15 cm and higher fertilizer dose of 150:75:45 NPK kg ha^{-1}. Treatment combinations viz., 60 x 20 cm/120:60:45 NPK kg ha^{-1}, 60 x 20 cm/150:75:45 NPK kg ha^{-1}, 60 x 15 cm/150:75:45 NPK kg $ha^{-1}$and 45 x 20 cm /120:60:45 NPK kg ha^{-1}recorded significantly higher vigour index values at the end of two months storage (Figure 1). These interactions also registered comparatively lower percentages of reduction (8.98 to 13.54) after four months of storage. Further, the data revealed that these elite combinations had also retained highest vigour index values after six months of storage indicating their ability to tolerate ageing under ambient conditions and the capacity to establish a uniform plant stand on the field. Similar results of decline in seedling vigour index after 9 months of storage were reported by Srivastava and Kooner (1974) [15]. They have attributed this decline in vigour index to decreased mobilisation of reserve substances during germination of the stored seed. However, considering the better performance of interactions mentioned earlier for vigour index it could be stated that higher seed weight could have resulted in higher amount of seed reserves which could have supported for better seedling dimensions upon germination even after six months of storage.

CONCLUSION

The study revealed that the superior combinations of plant geometry and nutrition doses for yield and yield components which resulted in the seed material for the present study on storability also performed desirably for seed quality attributes indicating better storage potential under ambient conditions. In this context, combinations viz., 45 x 20 cm /120:60:45 NPK kg ha^{-1}, 60 x 15 cm / 150:75:45 NPK kg ha^{-1}, 60 x 20 cm / 120:60:45 NPK kg ha^{-1}, 60 x 20 cm / 150:75:45 NPK kg ha^{-1} performed better at the end of six months of storage. This indicated that sweet corn seed can be safely stored under farmer conditions up to six months without compromising desired germination percentage.

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