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Effect of seed invigoration treatments on electrical conductivity and field emergence of different pick American cotton (*Gossypium hirsutum* L.) varieties after fifteen months of controlled storage

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ABSTRACT

The present study was carried out in the Department of Seed Science and Technology Section, CCS Haryana Agricultural University, Hisar, India. The study evaluated the effect of seed invigoration treatments on seed performance under field condition of American cotton varieties (H-1098(I), H- 1117 and H-1236) which were picked at different intervals and stored at 20^{o}C with six per cent moisture content in sealed plastic containers. Study evaluated the effect of different seed priming treatments on Electrical conductivity, mean emergence time, Field emergence index and seedling establishment of cotton varieties to determine and exploit their usefulness in improving cotton seed quality for better seedling establishment. Seed ageing or progress in storage period led to reduction in seed quality, during storage as there is reduction in seed vigor potential and performance, stand establishment, poor emergence and high seedling mortality, thus leading to poor crop stand. Study reveals that improvement in field performance by seed priming may combat this problem as this physiological technique results in faster and synchronous seed germination as found in the study that when cotton seeds were primed for two hr. at 25^o C with different chemicals (Control, KH_2PO_4, KNO_3, PEG, GA_3, Hydration-Dehydration) showed increase in seedling establishment. It was found that seeds primed with GA_3 significantly enhances the field performance in terms of mean emergence time, field emergence index, seedling establishment and lower electrical conductivity Maximum performance was observed in seeds of second pick seeds with priming treatment whereas minimum was observed in third pick seeds.

Key words: *Gossypium, Electrical conductivity, Mean emergence time, Field emergence index and seedling establishment*

INTRODUCTION

Cotton [*Gossypium hirsutum* (L.)] is an important globally cultivated tropical crop of Malvaceae family. It is subjected to several biotic and abiotic constraints during its production and reported to be damaged by many different species of mites and insects.

Field stand establishment is one of the most critical stages and sometimes difficult period in cotton production.

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Cotton seed is rich in oil and looses viability and vigour rapidly in storage, being a poor storer. Moreover, the storage potential of quality enhanced seeds also varies with respect to crop as well as the varieties. Seed is being a living entity, deterioration in it's quality occur with the progress in ageing which is natural but inevitable, irreversible and continuous process. However, shelf life of the seed is determined and accomplished by it's chemical composition to a greater extent. Rapid germination and emergence is an important determinant of successful establishment[14,15] Beriack and Villiers[4] postulated that during ageing, unsaturated fatty acid components of lipid membranes i.e. phospholipids are converted into free radicals and cytotoxic aldehydes by the reaction with atmospheric oxygen and lipoxygenase activity.

Seed invigouration improves seed performance by any postharvest treatment that focused on improvement in germiablity, storability and better field performance. One method of improving seed germination in the field has been through the use of pre-sowing treatments such as seed priming[14,15]. Hydro-priming is used to improve germinations, increase uniformity of germination and helps to enhance plant establishment. Seeds having priming treatment shows greater germination across a wider range of environmental conditions as temperature, than unprimed seed[34,9] and adverse field conditions such as salinity[39], under low water availability[11]. Primed seeds shows greater vigor which leads to greater yield[38]. Hydro-primeng just increase the seed germination but not improve the dead seed[7].

The advantage of seed priming is reducing the germination time and improving emergence in field and laboratory conditions. The benefits of seed priming in all crops included, faster emergence, uniform stands, drought tolerance, earlier flowering, earlier harvest maturity and higher seed yield. Harris *et al*. reported seed priming as one of the most important developments to help rapid and uniform germination and emergence of seeds and to increase seed tolerance to adverse environmental conditions. Seed priming has presented promising, and even surprising results, for many crop seeds[5].

In recent years, a lot of work has been done on the invigoration of seeds to improve the germination rate and uniformity of growth and reduce the emergence time of many vegetables and some field crops[2]. Furthermore, the invigoration persists under less than optimum conditions such as salinity[21], excessively high and low temperature[26,6]. The present study was, therefore, carried out with the objective to evaluate the effects of seed priming treatments on the electrical conductivity, field emergence and seedling establishment of delinted American cotton varieties after controlled storage

MATERIAL AND METHODS

The present investigation was carried out in Department of Seed Science and Technology, CCS HAU. Desi cotton were picked at different intervals, starting with fifty per cent boll opening and total three pickings were done. After delinting, seeds of all three picking were stored at 20 ± 1^{0}C with 6 % moisture content up to 15 months in a sealed plastic container. After fifteen months of storage initial quality of seeds were analyzed and seeds were treated with different chemicals (Control, KH_2PO_4, KNO_3, PEG, GA_3, Hydration- Dehydration) to enhance its quality. KH_2PO_4 (10 gm/l) 10 gm of KH_2PO_4 was dissolved in one litre of distilled water, GA_3 (0.1 gm/l) 50 miligram of gibberic acid was dissolved in one litre of water to make one litre solution of gibberlic acid solution. One to four drops of acetone were also added to mix GA_3 as it is not dissolved in water. KNO_3 (30 gm/l) 30 gram of KNO3 was added in one litre of water to make one litre solution, PEG (100 gm/ lit) 100 gm PEG was dissolved in one litre of water to make solution of one litre. Priming treatment were given to cotton seeds after 15 months of storage for enhancement of quality. Seeds were primed at 25± 1^{0}C for 2 hours. After priming cotton seeds were dried to original moisture content and seed quality was evaluated.

Electrical conductivity test (µS cm^{-1}g^{-1}) as per ISTA, 1999

Three replicates of 50 normal seeds were soaked in a 100 ml beaker containing 75 ml of distilled water and kept at 25^{0}C. The leachetes were measured after 24 h with systronic conductivity meter 306 and it was expressed as µS cm^{-1}g^{-1}.

Mean Emergence Time (days)

The mean emergence time (MET) was calculated for each treatment combination using the formula cited by Ellis and Roberts (1980).

MET= ∑ nt /∑n Where,

n- number of seeds newly germinated at time 't' t - Days from sowing

∑n - Final emergence of seedlings

3.3.5. Field Emergence Index

The number of seedlings emerged were counted on each day up to seedling establishment. The field emergence index (speed of emergence) was calculated as described by Maguire[20].

$$\text{(FEI)} = \frac{\text{No. of seedlings emerged}}{\text{Day of first count}} + \text{------} + \frac{\text{No. of seedlings emerged}}{\text{Day of final count}}$$

Statistical Analysis

The data presented in this thesis are the mean value of different parameters. The statistical method described by Panse and Sukatme was followed for analysis and interpretation of the experimental results.

RESULTS AND DISCUSSION

Electrical conductivity (EC) of seed leachate has negative effect on seed quality. EC parameter was studied in different seed priming treatments after fifteen months of storage.

The data on electrical conductivity as influenced by storage period and pick store quality of the seeds, seed priming treatments and their interactions are presented in Table 1. The significant difference in EC between the second pick seed and other pick seeds was noticed under storage, irrespective of priming treatments.

Second pick seeds in all varieties recorded significantly lesser EC whereas maximum was noticed under third pick seeds. The interaction between picking and treatment showed that maximum EC found in third pick (0.534) followed by first pick (0.513) and minimum EC was noticed under second pick (0.483) seed. Among treatments it was observed that seeds treated with GA3 (0.350) showed minimum electrical conductivity followed by PEG (0.384). The different EC values recorded after fifteen months of storage with different seed priming treatments indicates the nature and extent of membrane protection offered may not be the same for all seed priming treatments, thus resulting in difference in EC values in American cotton varieties.

At initial month of storage lowest electrical conductivity was recorded in KNO3 primed seed and highest was recorded in unprimed seed. The differential EC values recorded among the seed treatments indicate the nature and extent of membrane protection offered may not be the same for all seed priming treatments, thus resulting in difference in EC values in cotton. Electrical conductivity of seed leachate increased with the increase in storage period due to the leakage of electrolytes from the seed and loss of membrane integrity due to ageing[12,13]. Generally, the electrical conductivity of seed leachate is inversely related to seed quality, higher the EC lower the seed quality and vice versa. In aged seeds or partly deteriorated seed, the EC will be higher owing to decrease in membrane integrity caused by detrimental changes occurring in seeds[18,19]. Seed deterioration is associated with enhanced permeability of seed membranes, which leads to higher leakage of electrolytes during imbibition[24,25], Ray and Gupta[27], similar results by Sung, 1995 in soybean.

Mean emergence time (days) increased as period of natural ageing increases in all cotton varieties of pearl millet. Among various treatments, treatment T2 (GA3) resulted in highest decrease of MET in all varieties. Second pick seeds in all varieties recorded significantly lesser (3.59) mean emergence time whereas maximum (4.48) was noticed under third pick seeds. The interaction between picking and treatment showed that maximum EC found in third pick (0.534) followed by first pick (0.513) and minimum EC was noticed under second pick (0.483) seed.

Among treatments it was observed that seeds treated with GA3 (3.43) showed minimum Mean emergence time followed by PEG (3.69). The different Mean emergence time recorded after fifteen months of storage with different seed priming treatments. Early reserve breakdown and reserve mobilization might be the cause of reduction in MET. Due to readily available food during germination[10], primed seed are better able to complete the process of germination in shorter time. Demir and Van de Vanter[8] also reported similar result of decrease mean germination time and increase of seedling establishment percentage in osmoprimed seeds of watermelon. All treatments gave better results and showed reduced MET.

The faster emergence of seeds treated with GA3 may be attributed to stimulation effect in the formation of hydrolytic enzyme activity/synthesis[17]. GA3 induced enzymes rapidly and efficiently digest the endosperm, which are important in the early phases of germination which helps for a fast radicle protrusion and enhanced plumule and radicle length which resulted 2-3 days earlier seedling emergence over control. The results are in conformity with the findings of Andreoli and Lehan[1] in chilli and Verma *et al*.[35] in greengram.

The promotional effect of priming on speed of emergence and seedling establishment may be due to the enhanced hydration of all seed parts and thus reducing the damage to embryonic axis. Similar results were reported by Thakre and Ghate[33] and Tewari *et al.*

Table 1: Effect of priming treatments on Electrical conductivity and Mean germination time of fifteen months stored American cotton Varieties

		EC							Mean Germination Time						
Variety		**T_O**	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**Mean**	**T_O**	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**Mean**
H-1098(I)	P1	**0.486**	0.431	0.395	0.442	0.425	0.465	**0.441**	4.46	3.76	3.16	4.21	3.48	4.38	**3.91**
	P2	**0.456**	0.343	0.297	0.371	0.314	0.409	**0.365**	3.81	3.21	2.94	3.38	3.05	3.56	**3.32**
	P3	**0.494**	0.442	0.396	0.474	0.429	0.485	**0.453**	4.91	4.1	3.46	4.46	3.98	4.63	**4.26**
	Mean	**0.479**	**0.405**	**0.363**	**0.429**	**0.389**	**0.453**	**0.42**	**4.39**	**3.69**	**3.19**	**4.02**	**3.5**	**4.19**	**3.83**
H-1117	P1	**0.532**	0.423	0.328	0.464	0.354	0.508	**0.435**	5.11	4.27	3.76	4.71	3.93	4.86	**4.44**
	P2	**0.509**	0.409	0.336	0.449	0.362	0.496	**0.427**	4.24	3.63	3.45	3.88	3.5	4.11	**3.8**
	P3	**0.567**	0.494	0.439	0.508	0.476	0.524	**0.501**	5.18	4.85	3.86	4.91	4.22	4.97	**4.66**
	Mean	**0.536**	**0.442**	**0.368**	**0.474**	**0.397**	**0.509**	**0.454**	**4.84**	**4.25**	**3.69**	**4.5**	**3.88**	**4.64**	**4.3**
H-1236	P1	**0.52**	0.396	0.33	0.427	0.353	0.468	**0.416**	4.81	4.06	3.46	4.56	3.68	4.73	**4.22**
	P2	**0.486**	0.362	0.287	0.401	0.342	0.461	**0.39**	4.16	3.51	3.05	3.88	3.3	4.06	**3.66**
	P3	**0.542**	0.442	0.341	0.451	0.404	0.532	**0.452**	4.96	4.65	3.71	4.81	4.08	4.83	**4.51**
	Mean	**0.516**	**0.4**	**0.319**	**0.426**	**0.366**	**0.487**	**0.419**	**4.64**	**4.07**	**3.41**	**4.42**	**3.69**	**4.54**	**4.13**
Grand Mean		**0.51**	**0.416**	**0.350**	**0.443**	**0.384**	**0.483**	**0.431**	**4.62**	**4**	**3.43**	**4.31**	**3.69**	**4.46**	**4.09**
CD at 5 %		**Variety = 0.002,Treatment = 0.003, Variety × Treatment = 0.006, Variety × Picking ×Treatment= 0.010**							Variety = 0.026,Treatment = 0.036, Variety × Treatment = 0.063, Variety × Picking ×Treatment= 0.109						
PICKING AND TREATMENT INTERACTION															
	P1	**0.513**	0.417	0.351	0.445	0.377	0.48	**0.43**	4.79	4.03	3.46	4.49	3.7	4.66	**4.19**
	P2	**0.483**	0.371	0.306	0.407	0.339	0.455	**0.394**	4.07	3.45	3.15	3.71	3.28	3.91	**3.59**
	P3	**0.534**	0.46	0.392	0.478	0.436	0.514	**0.469**	5.01	4.53	3.68	4.73	4.09	4.81	**4.48**
	Mean C	**0.51**	**0.416**	**0.35**	**0.443**	**0.384**	**0.483**	**0.431**	**4.62**	**4**	**3.43**	**4.31**	**3.69**	**4.46**	**4.09**
CD at 5 %		*Picking = 0.003, Treatment =0.003, Picking ×Treatment = 0.009*							*Picking = 0.024, Treatment =0.036, Picking ×Treatment = 0.061*						

T_0 – Control, T_1 – Priming with KH_2PO_4 T_2 – Priming with GA_3, T_3 – Priming with KNO_3, T_4 – Priming with PEG
T_5 – Hydration- Dehydration, P1- First pick, P2- Second pick, P3- Third pick

Mean emergence time (days) increased as period of natural ageing increases in all cotton varieties of pearl millet. Among various treatments, treatment T2 (GA3) resulted in highest decrease of MET in all varieties. Second pick seeds in all varieties recorded significantly lesser (3.59) mean emergence time whereas maximum (4.48) was noticed under third pick seeds. The interaction between picking and treatment showed that maximum EC found in third pick (0.534) followed by first pick (0.513) and minimum EC was noticed under second pick (0.483) seed.

Field emergence index differed significantly due to priming treatments in all pick stored cotton varieties Highest field emergence index was noticed in seed treatment with GA3 (15.57) followed by PEG (15.13) over control (13.50). The interaction between picking and treatment showed that second pick seeds in all varieties recorded significantly higher (64.25) field emergence index whereas minimum (57.35) was noticed under third pick seeds. Higher field emergence index in these treatments might be due to the growth regulator set up of the germination as stated by Onkar Singh *et al*.[23] in partially aged tomato seeds, correcting enzymatic and substrate deficiencies at the initial stages of germination. Stimulation of hydrolytic enzymes bring about the break down of stored food material and also increased the metabolic activity providing energy to start and sustain embryo growth. The results are in agreement with the findings of Omran *et al*.[22] in bhendi, Sanjay kumar *et al*.[28,29] in okra, Vijayaraghavan[36,37] in bhendi, Jaswinder Singh *et al*.[16] in okra and Sathishkumar *et al*.[30] in chilli.

Table 2: Effect of priming treatments on Field Emergence Index and Seedling Establishment of fifteen months stored American cotton Varieties

Field Emergence Index									Seedling Establishment						
Variety		**T_O**	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**mean**	**T_O**	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	Mean
H-1098(I)	P1	13.57	15.4	16.53	15.17	15.7	14.77	**15.19**	61.22	64.63	68.7	63.17	67.5	63.22	**65.04**
	P2	14.33	15.93	16.9	15.23	16.2	14.3	**15.48**	64	63.67	70.34	67.97	68.52	66.33	**66.9**
	P3	13.67	14.4	14.67	14.33	14.73	14.2	**14.33**	57.38	59.29	63.38	58.6	61.55	57.74	**60.04**
	Mean	13.02	14.71	15.31	14.22	14.96	13.63	**15**	60.87	62.53	67.47	63.24	65.86	62.43	**63.99**
H-1117	P1	13.9	15.23	15.77	14.83	15.4	14.17	**14.88**	56.19	59.65	61.26	57.75	60.08	56.81	**58.99**
	P2	14.1	15	16.1	14	15.67	14.67	**14.92**	62.95	65.65	69.7	64.07	66.11	63.26	**65.69**
	P3	11.07	13.9	14.07	13.83	13.8	12.07	**13.12**	51.22	55.45	58.04	53.26	56.43	52.19	**54.88**
	Mean	13.86	15.24	16.03	14.91	15.54	14.42	**14.31**	56.79	60.25	63	58.36	60.87	57.42	**59.85**
H-1236	P1	13.53	14.47	15.47	14.2	15.2	14.13	**14.5**	60.14	61.11	65.3	60.81	63.41	60.19	**62.16**
	P2	13.97	14.67	15.57	14.13	15.1	14	**14.57**	62.38	63.44	67.6	62.94	65.68	62.52	**64.41**
	P3	13.33	13.23	15.1	14.67	14.33	14	**14.11**	56.35	57.3	60.08	57.14	58.36	56.85	**57.85**
	Mean	13.61	14.12	15.38	14.33	14.88	14.04	**14.39**	59.63	60.62	64.33	60.3	62.48	59.85	**61.47**
Grand Mean		**13.5**	**14.69**	**15.57**	**14.49**	**15.13**	**14.03**	**14.57**	**59.09**	**61.13**	**64.93**	**60.63**	**63.07**	**59.9**	**61.77**
CD at 5 %		**Variety = 0.114,Treatment = 0.198, Variety × Treatment = 0.279, Variety × Picking ×Treatment= 0.484**							**Variety = 0.114,Treatment = 0.198, Variety × Treatment = 0.279, Variety × Picking ×Treatment= 0.484**						
PICKING AND TREATMENT INTERACTION															
PICKING															
P1		13.92	59.19	60.57	60.08	65.09	63.66	**61.8**	61.73	59.19	60.57	60.08	65.09	63.66	**61.8**
P2		13.88	63.11	64.99	64.04	69.21	66.77	**64.25**	65.4	63.11	64.99	64.04	69.21	66.77	**64.25**
P3		12.69	54.98	56.33	55.59	60.5	58.78	**57.35**	57.26	54.98	56.33	55.59	60.5	58.78	**57.35**
Mean C		13.5	59.09	60.63	59.9	64.93	63.07	**61.13**	61.77	59.09	60.63	59.9	64.93	63.07	**61.13**
CD at 5 %		Picking = 0.109, Treatment =0.198, Picking ×Treatment = 0.0.271							Picking = 0.109, Treatment =198, Picking ×Treatment = 0.0.271						

T_0 – Control, T_1 – Priming with KH_2PO_4, T_2 – Priming with GA_3, T_3 – Priming with KNO_3, T_4 – Priming with PEG
T_5 – Hydration- Dehydration, P1- First pick, P2- Second pick, P3- Third pick

All the treatments enhanced seedling establishment significantly in all pick stored seeds and in all varieties. It was found that among the various treatments, treatment GA3 (64.93) increased seedling establishment in all varieties and in all pick seeds followed by PEG (63.07). Interaction table showed that among pickings, second pick stored seeds showed maximum seedling establishment (64.25) followed by first pick (61.80) whereas minimu was noticed in third pick (57.35). The faster emergence of seeds treated with GA3 may be attributed to stimulation effect in the formation of hydrolytic enzyme activity[17]. GA3 induced enzymes rapidly and efficiently digest the endosperm, which are important in the early phases of germination which helps for a fast radicle protrusion and enhanced plumule and radicle length which resulted 2-3 days earlier seedling emergence over control. This decrease in seedling establishment in all pickings and varieties may be due to age induced deteriorative changes in cell and cell organells and germinative capacity of seed under natural soil conditions. Improved seedling establishment were due to efficient mobilization and utilization of seed reserves[2] and better genetic repair[31]. Bose and Mishra[3] reported faster emergence rate after osmopriming due to an increased rate of cell division in the root tips of wheat. The results are in conformity with the findings of Andreoli and Lehan[1] in chilli and Verma *et al.*[35] in greengram.

CONCLUSION

Finally, it can be concluded based on above discussion, that the seed quality through out the storage period could be maintained better if it is harvested at right time and can be maintained under controlled storage and seed quality could be improved by the various seed priming treatments. Seed priming resulted in increased plant growth response as indicated by the increase in seedling establishment, field emergence index. Plant growth response was also improved under field condition which advocated the applicability of seed priming in American cotton varieties under field condition too.

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REFERENCES

1. Andredi, C. and Leon, Matriconditioning integrated with gibberellic acid to hasten seed germination and improve stand establishment of pepper and tomato. *Pesq. Agropec. Bras*. brasilia, **34(10):** 1953-1958 (2000).
2. Basra, S. M. A., Farooq, M., Tabassum, R. and Ahmed, N., Physiological and biochemical aspects of seed vigour enhancement treatments in fine rice. *Seed Sci Technol.*, **3:** 33 (2005).
3. Bose, B. and Mishra, T., Response of wheat seed to presowing seed treatment with Mg (NO_3). *Annals of Agric. Res*., **5:** 11-16 (1992).
4. Berjak, P. and Villiers, T. A., Ageing in plant embryos. Lysis, V., of the cytoplasm in non-viable embryos. *New Phytol*, **71:** 1075-1079 (1972).
5. Bradford, K. J., Manipulation of seed water relations via osmotic priming to improve germination under stress conditions. *Hort Sci* **21:** 1105–1112 (1986).
6. Bradford, K. J., Steiner, J. J. and Trawatha, S. E., Seed priming influence on germination and emergence of pepper seed lots. *Crop Sci*., **30:** 718–21 (1990).
7. Cantliffe, D. J., Stand stablishment. *Acta Hort*. **247:** 175-179 (1989).
8. Demir, J., Van de Venter, H. A., The effect of priming treatments on the performance of watermelon (*Citrullus lanatus* (Thunb) Matsun and Nakai seeds under temperature and osmotic stress. *Seed Sci Technol*., **27:** 871-875 (1999).

9. Ellis, R. H. and Butcher, P. D., The effects of priming and 'natural' differencesin quality amongst onion seed lots on the response of the rate of germination to temperature and identification of the characteristics under genotypic control. *J. of Experimental Bot*. **39:** 935-950 (1988).
10. Farooq, M., Basra, S. M. A. and Wahid, A., Priming of field-sown rice seed enhances germination, seedling establishment, allometry and yield. *Plant Growth Regul*, **49:** 285-294 (2006).
11. Frett, J. J. and Pill, W. G., Germination characteristics of osmotically primed and stored impatiens seeds. *Scientia Hort*. **40:** 171-179 (1989).
12. Ghosh, T. and Basak, M., Method of storing jute seed and effect of age of seed on seed yield of fibre. *Indian J. Agril. Sci*., **28(2):** 235-242 (1958).
13. Ghosh, T. and Basak, M., Method of storing jute seed and effects of age of seed on yield of fibre. *Indian Journal of Experimental Biology*, **16:** 411-413 (1958).
14. Heydecker, W., Germination of an idea: the priming of seeds. *University of Nottingham School of Agriculture Report* 50–67 (1973).
15. Heydecker, W., Higgins, J. and Gulliver, R. L., Accelerated germination by osmotic seed treatment. Nature (London), **246:** 42-44. Basu, R. N., Seed invigouration for extended storability. Proceedings of the *International conference on Seed Science and Technology*, New Delhi (1973).
16. Singh, J., Kanwar, J. S., and Geeta, B., Seed vigour as influenced by different seed priming treatments in okra (Abelmoschus esculentus L. Moench). *Seed Res*., **32(2):** 122-125 (2004).
17. Jhorar, B. S., Varma, S. K. and Agarwal, R. P., Effect of giberellic acid on the seedling emergence and early growth of cotton (Gossypium hirsutum L.). *Indian J. Pl. Physiol*., **115(4):** 423-426 (1982).
18. Koostra, P. T. and Harrington, J. F., Bio-technical effects of age on membrane lipids of *cucumis sativus* L. seed. *Proc. International Seed Test. Assoc.* **34:** 329-340 (1969).
19. Koostra, P. T. and Harrington, J. F., Bio-technical effects of age on membrane lipids ofcucumis sativus L. seed. Proc. *International Seed Testing Association*, **34:** 329-340 (1969).
20. Maguire, J. D., Speed of germination-aid selection and evaluation for seedling emergence and vigor. *Crop Science*, **2:** 176-177 (1962).
21. Muhyaddin, T. and Weibe, H. J., Effect of seed treatments with polyethylene glycol (PEG) on emergence of vegetable seeds. *Seed Sci. and Technol*., **17:** 49–56 (1989).
22. Omran, A. F., El-Bakry, A. M. and Gawish, R. A., Effect of soaking seeds in some growth regulator solutions on the growth, chemical constituents and yield of okra. *Seed Sci. Tech*., **8:** 161-168 (1980).
23. Singh, O., Deepte, and Kumar, A., Effect of plant growth regulators on seed quality in partially aged seeds of pigeonpea (Cajanus cajan). *Seed Res*., **27(1):** 54-59 (1999).
24. Parish, D. J. and Leopold, A. C., On the mechanism of aging in soybean seeds. *Plant Physiol*. **61:** 365–368 (1978).
25. Parrish, D. J. and Leopoid, A. C., On the mechanism of ageing of soybean seeds. *Plant Physiology*, **59:** 467-509 (1978).
26. Pill, W. G. and Finch-Savage, W. E., Effects of combining priming and plant growth regulator treatments on the synchronization of carrot seed germination. *Ann. App. Biol*., **113:** 383–9 (1988).
27. Ray, M. D. and Gupta, K., Effect of storage of rice seeds on solute leaching and nucleic acid synthesis. *Indian Journal of Agricultural Science*, **49(9):** 715-719 (1979).
28. Sanjay kumar, Poonam Singh, R.P., Katiyar, C.P., vaish and Khan, A.A., Beneficial effect of some plant growth regulators on aged seeds of okra (Abelmoschus esculentus (L.) Moench.) under field conditions (1996).

29. Kumar, S., Singh, P., Katiyar, R. P., vaish, C.P. and Khan, A. A., Beneficial effect of some plant growth regulators on aged seeds of okra (Abelmoschus esculentus (L.) Moench.) under field conditions (1996).
30. Kumar, S., Influence of pre-sowing seed treatment and seed pelleting on storability in brinjal (Solanum melongena L.). M.Sc. (Agri.) Thesis, *Univ. Agric. Sci*., Dharwad (2005).
31. Srivastava, L. M., Plant Growth and Development: Hormones and Environment. *Academic Press*, London (2002).
32. Sung, J. M. and Chiu, C. C., Lipid peroxidation and peroxide scavenging enzymes of naturally aged edible soybean seeds. *Pl. Sci.,* **110:** 45-52 (1995).
33. Thakre, S. K. and Ghate, N. N., Effect of seed soaking with hormones on grain and fodder yield of sorghum and uptake of nutrients by the crop. *PKU Res. J.,* **8:** 10-12 (1984).
34. Valdes, V. M. and Bradford, K. J., Effects of seed coating and osmotic priming on the germination of lettuce seeds. *J. of American Society for Horti. Sci*. **112:** 153-156 (1987).
35. Verma, S. S., Punia, R. C. and Dahiya, O. S., Pre-sowing seed treatment for better crop establishment in mungbean. National Seed Seminar, Abstract XII ANGRAU, Hyderabad, p. 145 (2006).
36. Vijayaraghavan, H., Effect of seed treatment with plant growth regulators on bhendi (Abelmoschus esculentus L.) grown under sodic soil conditions. *Madras Agric. J.,* **86(4-6):** 247-249 (1999).
37. Vijayaraghavan, H., Effect of seed treatment with plant growth regulators on bhendi (Abelmoschus esculentus L.) grown under sodic soil conditions. *Madras Agric. J.,* **86(4-6):** 247-249 (1999).
38. Warren, J. E. and Bennett, M. A., Seed hydration using the drum priming system.HortScience **32:** 1220–1221 (1997).
39. Weibe, H. J. and Muhyaddin, T., Improvement of emergence by osmotic treatment in soil of high salinity. *Acta Hort*. **198:** 91-100 (1987).