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Influence of seed treatment with botanicals and chemicals on storability of *Kabuli* chickpea (*Cicer arietinum* L.) varieties

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ABSTRACT

The storage experiment was carried out at Seed Quality and Research Laboratory, Seed Unit (National Seed Project), University of Agricultural Sciences, Dharwad from March 2017 to March 2018 to study the influence of seed treatment with botanicals and chemicals on storability of *Kabuli* chickpea varieties. Seed quality parameters were significantly influenced among varieties and seed treatment with botanicals and chemicals. Among the treatments, seed treatment with Sprint (Mancozeb 50 % + Carbendazim 25 % WS) @ 2 g per kg of seed or Vitavax power @ 3 g/kg of seed or Sweet flag rhizome @ 10 g/kg of seed maintained seed quality for more than ten months during storage. However, Sweet flag rhizome @ 10 g/kg of seed can be used as alternative to chemicals which is safe, eco-friendly and economically feasible for maintaining seed quality for organic seed growers/producers and seed companies.

Key words: HDPE bags, *Kabuli* chickpea, Seed quality, Sprint, Storage, Sweet flag rhizome, Vitavax power powder.

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is the third most important pulse crop in the world after beans and peas. It is popularly cultivated in sub-tropical and semi-arid to warm temperate regions under dry season. Chickpea is valued for its nutritive seed composition with high protein content and used increasingly as a substitute for animal protein. The two most commonly cultivated types *viz.*, white seeded '*Kabuli* chickpea' being grown in Northern parts and brown seeded '*Desi*' type are grown in Southern parts of India. In Asia, India is the largest producer of chickpea contributing over 70 per cent of the world production occupying an area of 86.80 lakh hectare with a production of 80.90 lakh tonnes and with productivity of 932 kg per hectare (Anonymous, 2017).

Seed storage is an integral part of well-planned and timely executed seed programme for maintenance of high quality seeds in terms of germination, vigour and health. Seed deterioration is a natural process which is inevitable, inexorable and irreversible. During storage considerable qualities and quantities of seeds are lost due to biotic factors like storage pests, specially bruchids, other mycoflora and abiotic factors like temperature, moisture content and relative humidity. In order to prevent qualitative and quantitative seed losses in storage, various prophylactic methods are being adopted in many agricultural crops *i.e.* by treating seeds with suitable botanicals and pesticides. However, in this regard, many chemicals have been tried and a few of them are useful in controlling the pest and diseases for maintaining the seed quality. The indiscriminate use of chemicals and their residual toxicity adversely affect the non-targeted animals including human being besides affecting the seed quality. Many of the synthetic chemicals look effective but they are not readily degradable physically or biologically which yield more toxic residues and conversely the pathogen and insects are becoming resistant against it. However, the use of chemical is still in vogue. Hence, an attempt was made to find out the safe and feasible approach of seed treatment with botanicals and chemicals, which will be of immense use to the organic seed producers and seed industry that, how best seeds quality can be maintained by using farm based organics and can be stored by treating the seeds with chemicals or botanicals under ambient condition with minimum qualitative and quantitative losses. With this endeavor, the present investigation entitled "Influence of seed treatment with botanicals and chemicals on storability of *Kabuli* chickpea (*Cicer arietinum* L.) varieties" was undertaken.

MATERIALS AND METHODS

The storage experiment was carried out at Seed Quality and Research Laboratory, Seed Unit (National Seed Project), University of Agricultural Sciences, Dharwad from March 2017 to March 2018 under ambient condition to evaluate the storage performance of two *Kabuli* chickpea varieties *viz.*, V_1 (BG1105) and V_2 (MNK-1) with nine seed treatments *viz.*, T_1: Control (Without treatment), T_2: Neem seed kernel powder @ 10 g per kg of seed, T_3: Neem oil @ 5 ml per kg of seed, T_4: Neem leaf powder @ 5 g per kg of seed, T_5: Castor oil @ 10 ml per kg of seed, T_6: Sweet flag rhizome @ 10 g per kg of seed, T_7: Vitavax power @ 3 g per kg of seed, T_8: Deltamethrin 2.8 EC @ 0.3 ml per kg of seed and T_9: Sprint (Mancozeb 50 % + Carbendazim 25 % WS)

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@ 2 g per kg of seed which were packed in HDPE bags. The experiment was laid out in the completely randomized design with four replications.The seeds obtained from each treatment were evaluated for the following seed quality parameters.

The seed germination percentage was worked out as per the procedure given by ISTA (Anonymous, 2014), speed of germination by Maguire, (1962). Ten normal seedlings were selected randomly in each treatment from all the replications on 8th day and the root length was measured from the tip of the primary root to base of hypocotyl and mean root length was expressed in centimeter (cm), while the shoot length was measured from the base of the primary leaf to the base of the hypocotyl of same seedling which were used for measuring root length and mean shoot length was expressed in centimeter (cm), Electrical conductivity of seed leachate was worked out as per Presley (1958) and seedling vigour index as per the formula given by Abdul-Baki and Anderson (1973) The data of the laboratory experiment were analyzed statistically by the procedure prescribed by Gomez and Gomez (2010).

Method of treatment: The dry powder *viz.*, neem seed kernel powder, neem leaf powder, sweet flag rhizome powder, Vitavax power powder and Sprint (Mancozeb 50 % + Carbendazim 25 % WS) were mixed with water to make slurry powder mixture in 1 : 1 (W : V) proportion. Further, one kg chickpea seed were taken in a polythene bag and slurry powder mixture was added in to the polythene bag. The polythene bag was closed tightly trapping the air in it to form a balloon, then polythene bag was vigorously shaken till the seeds were uniformly coated with slurry mixture powder.

Similarly, treatments available in solution form *viz.*, neem oil, castor oil and deltamethrin were directly mixed with seed (based on the dosage per kg of seed) further the polythene bag was closed tightly trapping the air in it to form a balloon, then polythene bag was vigorously shaken till the seeds were uniformly coated with different oils/ chemicals later the treated seeds were spread on a polythene sheet and dried under the shade. While one kg of seeds of both the varieties were stored without any treatment as control. Later, the treated seeds were spread on a polythene sheet and dried under the shade and packed in HDPE bags.

RESULTS AND DISCUSSION

The results on seed quality as influenced by seed treatment with botanicals and chemicals and varieties and their interaction effects during twelve months of storage period are presented in Tables 1, 2, 3, 4, 5 and 6. Irrespective of varieties and seed treatments the seed quality parameters declined gradually with the advancement in the storage period.

Effect of *Kabuli* chickpea varieties on seed quality during storage: *Kabuli* chickpea varieties showed significant difference for seed quality, The initial seed quality parameters were significantly higher *viz.*, seed germination (97.79 %), speed of germination (56.72), root length (18.66 cm), shoot length (13.31 cm), seedling vigour index (3127) and lower electrical conductivity (0.369 dSm^{-1}) in variety V_1 (BG1105) as compared to variety MNK-1 (V_2) (95.93 %, 37.63, 16.78 cm, 11.54 cm, 2717 and 0.491 dsm^{-1}, respectively). However, with advance in storage period there was a gradual decrease in the seed quality parameters.

The seed quality was maintained for more than nine months in both the varieties. At the end of twelve months of storage, V_1 (BG1105) recorded significantly highest seed germination (81.43 %), speed of germination (40.25), root length (10.31 cm), shoot length (5.33 cm) and seedling vigour index (1300) and lower electrical conductivity (1.692 dSm^{-1}) as compared to MNK-1 (V_2) (79.20 %, 24.14, 9.08 cm, 4.41 cm, 1167 and 1.781 dsm^{-1}, respectively). The marked decrease in the seed quality parameters under advanced storage period may be attributed to seedsize and seed coat characters of genotypes. Where V_1 (BG1105) had better storability than MNK-1 (V_2) due to small to medium seed size of BG1105 (V_1) variety and MNK-1 with bolder seed size having larger surface area of seed which are said to be more prone to mechanical damage leading to fungal invasion and pest incidence. Similar varietal response to seed size was reported by Gnyandev *et al.* (2015) in Chickpea, where variety A-1 and BGD-103 maintained satisfactory germination upto 9 months, the variety Bheema for 8 months and ICCV-2 and KAK-2 for 7 months above Indian Minimum Seed Certification Standards and also observed that smaller and medium sized seeds in both *Kabuli* and Desi chickpea varieties were found better in storability. Similarly Vanangamudi (1988) also observed varietal differences in soybean seed longevity and he further confirmed that small seeded cultivars retained their viability for longer periods than large size seeds. These results were also in conformation with studies conducted by Merwade (2000) and Sushma (2013) in chickpea.

Effect of chemicals and botanicals on seed quality during storage: During storage period, seed treatment with chemicals and botanicals had prominent effect on seed quality. The seed germination was maintained above the prescribed Indian Minimum Seed Certification Standard (85.41%) in T_9[Sprint (Mancozeb 50 % + Carbendazim 25 % WS) @ 2 g per kg of seed)] upto eleven months, while in T_7 (Vitavax power @ 3 g per kg of seed) and T_6 (Sweet flag rhizome @ 10 g per kg of seed) (85.82 and 85.62 %, respectively) as compared to control (83.51 %) upto ten months of storage (Table 1). Similarly, significant higher speed of germination was recorded in T_9 (38.74), T_7 (37.27), T_6 (35.28) as compared to control (27.07) at the end of twelve

Table 1: Influence of seed treatment with botanicals and chemicals on seed germination in *Kabuli* chickpea varieties during storage.

Treatments	Seed germination (%) Months of storage											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Varieties (V)												
V_1	97.79	97.07	96.79	95.15	94.82	93.64	91.64	89.54	87.44	85.46	83.11	81.43
V_2	95.93	95.21	94.49	93.74	92.92	91.93	89.69	87.69	84.94	83.91	80.51	79.20
S. Em. ±	**0.31**	**0.31**	**0.31**	**0.29**	**0.29**	**0.27**	**0.10**	**0.26**	**0.23**	**0.12**	**0.12**	**0.12**
C. D. @ 1 %	**1.18**	**1.18**	**1.17**	**1.09**	**1.08**	**1.02**	**0.37**	**1.00**	**0.87**	**0.46**	**0.45**	**0.46**
Seed treatments (T)												
T_1	95.77	95.05	94.55	93.17	92.53	91.89	89.53	87.48	85.05	83.51	80.64	78.41
T_2	97.50	96.78	96.28	95.46	94.96	93.54	91.58	89.53	87.10	85.53	82.66	80.43
T_3	96.38	95.66	95.16	94.18	93.64	92.49	90.75	88.70	86.28	84.81	81.93	79.71
T_4	96.25	95.53	95.03	93.65	93.01	92.00	89.68	87.63	85.20	83.73	80.85	78.63
T_5	96.00	95.28	94.78	93.40	92.76	92.12	89.76	87.71	85.28	83.78	80.90	78.68
T_6	98.00	97.28	96.78	95.52	95.01	93.79	91.54	89.49	87.07	85.62	82.75	80.52
T_7	98.13	97.41	96.91	95.74	95.19	93.67	91.80	89.75	87.33	85.82	82.95	80.72
T_8	97.63	96.91	96.41	95.46	94.93	93.13	90.97	88.92	86.49	84.86	81.99	79.76
T_9	99.25	98.53	98.03	96.90	97.82	94.69	92.11	90.06	87.63	86.07	85.41	84.24
S. Em. ±	**0.66**	**0.66**	**0.66**	**0.61**	**0.61**	**0.57**	**0.21**	**0.56**	**0.49**	**0.26**	**0.25**	**0.26**
C. D. @ 1 %	**2.50**	**2.51**	**2.49**	**2.30**	**2.28**	**2.16**	**0.78**	**2.11**	**1.84**	**0.97**	**0.95**	**0.98**
Interaction (V × T)												
V_1T_1	96.77	96.05	95.77	94.13	93.77	93.00	90.90	88.80	86.70	84.60	82.25	80.20
V_1T_2	98.25	97.53	97.25	95.61	95.25	94.32	92.43	90.33	88.23	86.33	83.98	81.93
V_1T_3	97.25	96.53	96.25	94.61	94.25	93.48	91.38	89.28	87.18	85.15	82.80	80.75
V_1T_4	97.25	96.53	96.25	94.61	94.25	92.75	90.72	88.62	86.52	84.55	82.20	80.15
V_1T_5	97.00	96.28	96.00	94.36	94.00	93.23	91.13	89.03	86.93	84.90	82.55	80.50
V_1T_6	99.00	98.28	98.00	96.36	96.00	94.34	92.45	90.35	88.25	86.35	84.00	81.95
V_1T_7	99.00	98.28	98.00	96.36	96.25	94.34	92.45	90.35	88.25	86.35	84.00	81.95
V_1T_8	98.50	97.78	97.50	95.86	95.50	93.51	91.41	89.31	87.21	85.18	82.83	80.78
V_1T_9	99.25	98.53	98.25	97.61	96.95	94.75	92.72	90.62	88.52	86.55	85.80	84.70
V_2T_1	94.77	94.05	93.33	92.20	91.29	90.77	88.15	86.15	83.40	82.42	79.02	76.62
V_2T_2	96.75	96.03	95.31	95.31	94.67	92.75	90.72	88.72	85.97	84.74	81.34	78.94
V_2T_3	95.50	94.78	94.06	93.74	93.03	91.50	90.13	88.13	85.38	84.46	81.06	78.66
V_2T_4	95.25	94.53	93.81	92.68	91.77	91.25	88.63	86.63	83.88	82.90	79.50	77.10
V_2T_5	95.00	94.28	93.56	92.43	91.52	91.00	88.38	86.38	83.63	82.65	79.25	76.85
V_2T_6	97.00	96.28	95.56	95.12	94.38	93.00	91.15	89.15	86.40	85.30	81.90	79.50
V_2T_7	97.25	96.53	95.81	94.68	93.77	93.25	90.63	88.63	85.88	84.90	81.50	79.10
V_2T_8	96.75	96.03	95.31	95.06	94.36	92.75	90.52	88.52	85.77	84.54	81.14	78.74
V_2T_9	99.25	98.53	97.81	96.18	95.39	94.63	91.50	89.50	86.75	85.58	85.02	83.78
Mean	**97.21**	**96.49**	**95.99**	**11.02**	**10.78**	**93.04**	**90.86**	**88.81**	**86.38**	**84.86**	**82.23**	**80.12**
S. Em. ±	**0.94**	**0.94**	**0.93**	**0.86**	**0.86**	**0.81**	**0.29**	**0.79**	**0.69**	**0.36**	**0.36**	**0.37**
C. D. @ 1 %	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

V_1 -BG1105 V_2 -MNK-1 T_1:Control (Without treatment) T_2: Neem seed kernel powder @ 10 g/kg of seed T_3:Neem oil @5 ml/kg of seed T_4: Neem leaf powder @ 5 g/kg of seed T_5: Castor oil @ 10 ml/kg of seed T_6: Sweet flag rhizome @ 10 g/kg of seed T_7:Vitavax power @ 3 g/kg of seed T_8:Deltamethrin 2.8 EC @ 0.3ml /kg of seed T_9: Sprint (Mancozeb 50% + Carbendazim 25% WS) @ 2 g/kg of seed NS: Non-significant.

month of storage (Table 2). The maintenance of seed germination and speed of germination may be due to seed treatment with Sprint (Mancozeb 50 % + Carbendazim 25 % WS) @ 2 g per kg of seed. Since, the sprint is a combiproduct of Mancozeb and Carbendazim which have contact and systemic action against fungal and insect incidence. In addition, sprint is composed of micronutrients *viz.*, Zinc (Zn) and Manganese (Mn), where Zn helps in the synthesis of tryptophan which is a precursor of Indole acetic acid; it also has an active role in the production of an essential growth hormone *viz.*, auxin which might helped in triggering the metabolic activity of enzymes required for seed

Table 2: Influence of seed treatment with botanicals and chemicals on speed of germination in *Kabuli* chickpea varieties during storage.

Treatments	Speed of germination											
	Months of storage											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Varieties (V)												
V_1	56.72	54.85	54.48	54.01	53.46	52.89	51.92	50.17	48.26	44.53	42.16	40.25
V_2	37.63	37.70	36.16	36.22	35.81	35.23	34.30	32.55	30.64	28.42	26.06	24.14
S. Em. ±	**0.78**	**0.48**	**0.78**	**0.77**	**0.76**	**0.76**	**0.76**	**0.76**	**0.74**	**0.90**	**0.90**	**0.90**
C. D. @ 1 %	**2.95**	**1.82**	**2.95**	**2.9**	**2.88**	**2.87**	**2.87**	**2.87**	**2.81**	**3.38**	**3.39**	**3.41**
Seed treatments (T)												
T_1	41.93	41.31	39.96	39.66	39.16	38.59	37.63	35.88	33.97	31.35	28.99	27.07
T_2	48.79	47.47	46.95	46.48	45.94	45.36	44.40	42.65	40.74	37.61	35.25	33.34
T_3	46.61	46.12	44.77	44.57	44.09	43.52	42.57	40.82	38.91	36.34	33.97	32.06
T_4	46.16	45.90	44.32	44.18	43.72	43.15	42.20	40.45	38.54	36.14	33.77	31.86
T_5	42.75	42.51	40.91	40.85	40.41	39.83	38.89	37.14	35.23	32.77	30.41	28.50
T_6	50.92	49.32	49.08	48.92	48.46	47.88	46.94	45.19	43.27	39.56	37.20	35.28
T_7	53.05	51.29	51.21	51.11	50.66	50.09	49.15	47.40	45.48	41.54	39.18	37.27
T_8	49.22	48.03	47.38	47.14	46.66	46.08	45.13	43.38	41.47	38.24	35.88	33.96
T_9	54.65	52.90	52.81	52.30	51.75	51.17	50.20	48.45	46.54	43.02	40.66	38.74
S. Em. ±	**1.66**	**1.02**	**1.66**	**1.63**	**1.62**	**1.61**	**1.61**	**1.61**	**1.58**	**1.90**	**1.91**	**1.91**
C. D. @ 1 %	**6.26**	**3.86**	**6.25**	**6.16**	**6.12**	**6.08**	**6.09**	**6.10**	**5.96**	**7.17**	**7.2**	**7.23**
Interaction (V × T)												
V_1T_1	48.96	47.81	46.72	46.25	45.71	45.14	44.17	42.42	40.51	37.49	35.12	33.21
V_1T_2	59.71	57.55	57.47	57.00	56.46	55.89	54.92	53.17	51.26	47.23	44.86	42.95
V_1T_3	55.98	54.93	53.74	53.27	52.73	52.16	51.19	49.44	47.53	44.61	42.24	40.33
V_1T_4	55.15	54.43	52.91	52.44	51.90	51.32	50.36	48.61	46.69	44.11	41.74	39.83
V_1T_5	49.96	49.13	47.72	47.25	46.71	46.14	45.17	43.42	41.51	38.81	36.45	34.53
V_1T_6	62.57	59.22	60.33	59.86	59.31	58.74	57.77	56.02	54.11	48.90	46.53	44.62
V_1T_7	64.67	60.87	62.43	61.96	61.42	60.84	59.88	58.13	56.21	50.55	48.19	46.27
V_1T_8	60.28	57.90	58.04	57.57	57.02	56.45	55.48	53.73	51.82	47.57	45.21	43.30
V_1T_9	65.90	62.95	63.66	63.19	62.65	62.07	61.11	59.36	57.44	52.63	50.26	48.35
V_2T_1	34.89	34.82	33.20	33.07	32.61	32.04	31.09	29.34	27.43	25.21	22.85	20.93
V_2T_2	37.88	37.40	36.44	35.96	35.42	34.84	33.88	32.13	30.21	28.00	25.64	23.72
V_2T_3	37.25	37.31	35.81	35.87	35.46	34.88	33.95	32.20	30.28	28.07	25.71	23.79
V_2T_4	37.17	37.36	35.73	35.92	35.55	34.97	34.05	32.30	30.38	28.17	25.81	23.89
V_2T_5	35.53	35.89	34.09	34.45	34.11	33.53	32.62	30.87	28.96	26.74	24.38	22.46
V_2T_6	39.27	39.43	37.83	37.99	37.60	37.03	36.10	34.35	32.44	30.22	27.86	25.95
V_2T_7	41.43	41.71	39.99	40.27	39.91	39.34	38.41	36.66	34.75	32.54	30.17	28.26
V_2T_8	38.16	38.16	36.72	36.72	36.29	35.72	34.78	33.03	31.12	28.90	26.54	24.63
V_2T_9	43.40	42.85	41.96	41.41	40.84	40.27	39.30	37.55	35.63	33.42	31.06	29.14
Mean	**48.23**	**47.21**	**46.38**	**46.14**	**45.65**	**45.08**	**44.12**	**42.37**	**40.46**	**37.40**	**35.03**	**33.12**
S. Em. ±	**2.35**	**1.45**	**2.34**	**2.31**	**2.29**	**2.28**	**2.28**	**2.28**	**2.23**	**2.69**	**2.72**	**2.71**
C. D. @ 1 %	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

V_1 -BG1105 V_2 -MNK-1 T_1:Control (Without treatment) T_2: Neem seed kernel powder @ 10 g/kg of seed T_3:Neem oil @5 ml/kg of seed T_4: Neem leaf powder @ 5 g/kg of seed T_5: Castor oil @ 10 ml/kg of seed T_6: Sweet flag rhizome @ 10 g/kg of seed T_7:Vitavax power @ 3 g/kg of seed T_8: Deltamethrin 2.8 EC @ 0.3ml /kg of seed T_9: Sprint (Mancozeb 50% + Carbendazim 25% WS) @ 2 g/kg of seed NS: Non-significant.

germination leading to rapid cell division, cell enlargement and radical emergence resulting in better seed germination and speed of germination. The similar effect of seed treatment with chemicals and botanicals on storability were studied and reported by Dhanamanjuri *et al.* (2013), Merwade (2000) and Sushma (2013) in chickpea.

Similarly, seeds treated with Sprint (Mancozeb 50 % + Carbendazim 25 % WS) @ 2 g per kg of seed (T_9) recorded significantly higher root length (12.12 cm) (Table 3), shoot length (7.00 cm) (Table 4) and seedling vigour index (1611) (Table 5) when compared to other treatment and control (8.30 cm, 2.86 cm and 874, respectively) at the end

Table 3: Influence of seed treatment with botanicals and chemicals on root length in *Kabuli* chickpea varieties during storage.

Treatments	Root length (cm) Months of storage											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Varieties (V)												
V_1	18.66	18.41	17.61	16.96	16.28	15.48	14.58	13.42	12.09	11.29	11.13	10.31
V_2	16.78	16.09	15.74	15.53	15.04	14.24	13.34	12.37	10.90	10.10	9.76	9.08
S. Em. ±	**0.27**	**0.27**	**0.27**	**0.27**	**0.24**	**0.24**	**0.24**	**0.18**	**0.18**	**0.18**	**0.27**	**0.23**
C. D. @ 1 %	**1.03**	**1.02**	**1.03**	**1.02**	**0.91**	**0.91**	**0.91**	**0.68**	**0.68**	**0.68**	**1.02**	**0.87**
Seed treatments (T)												
T_1	16.15	15.68	15.11	14.68	13.77	12.97	12.07	10.90	9.98	9.18	9.04	8.30
T_2	18.20	17.73	17.15	16.72	16.62	15.82	14.92	13.59	12.55	10.59	9.84	9.27
T_3	17.51	17.04	16.46	16.03	15.45	14.65	13.75	12.84	11.58	10.92	10.78	9.85
T_4	17.41	16.94	16.36	15.93	15.53	14.73	13.83	12.30	11.50	10.70	10.38	9.82
T_5	17.21	16.74	16.16	15.73	14.86	14.06	13.16	12.06	10.58	9.78	9.56	8.75
T_6	18.53	18.06	17.48	17.05	16.33	15.53	14.63	14.06	11.76	11.39	11.75	10.84
T_7	19.04	18.57	17.99	17.56	17.06	16.26	15.36	14.52	12.89	12.09	11.62	11.03
T_8	18.28	17.81	17.24	16.81	15.95	15.15	14.25	12.79	10.99	10.19	10.34	9.10
T_9	20.75	19.65	19.08	18.65	18.11	17.31	16.41	15.26	13.66	12.86	12.78	12.12
S. Em. ±	**0.58**	**0.57**	**0.58**	**0.57**	**0.51**	**0.51**	**0.51**	**0.38**	**0.38**	**0.38**	**0.58**	**0.49**
C. D. @ 1 %	**2.19**	**2.17**	**2.18**	**2.17**	**1.93**	**1.93**	**1.93**	**1.44**	**1.44**	**1.44**	**2.17**	**1.84**
Interaction (V × T)												
V_1T_1	16.65	16.40	15.60	14.95	13.88	13.08	12.18	11.18	9.67	8.87	8.54	7.85
V_1T_2	19.05	18.80	18.00	17.35	17.15	16.35	15.45	14.01	13.03	12.23	12.34	11.33
V_1T_3	18.68	18.43	17.63	16.98	16.47	15.67	14.77	13.26	13.26	12.46	12.04	11.52
V_1T_4	18.55	18.30	17.50	16.85	16.41	15.61	14.71	13.25	11.78	10.98	11.11	9.96
V_1T_5	18.38	18.13	17.33	16.68	15.88	15.08	14.18	13.07	11.53	10.73	10.50	9.69
V_1T_6	19.30	19.05	18.25	17.60	16.67	15.87	14.97	14.09	12.01	11.21	10.76	10.04
V_1T_7	19.98	19.73	18.93	18.28	17.54	16.74	15.84	15.06	13.39	12.64	12.59	11.80
V_1T_8	19.09	18.84	18.04	17.39	16.31	15.51	14.61	13.07	11.15	10.35	10.56	9.22
V_1T_9	21.63	20.13	19.33	18.68	18.09	17.29	16.39	15.21	13.96	13.16	13.01	12.20
V_2T_1	15.66	14.97	14.62	14.41	13.67	12.87	11.97	10.62	10.28	9.48	9.53	8.75
V_2T_2	17.34	16.65	16.30	16.09	16.09	15.29	14.39	13.18	12.07	11.27	11.18	10.34
V_2T_3	16.34	15.65	15.30	15.09	14.44	13.64	12.74	12.42	9.91	9.11	8.13	7.83
V_2T_4	16.27	15.58	15.23	15.02	14.66	13.86	12.96	11.35	11.23	10.43	10.73	9.74
V_2T_5	16.03	15.34	14.99	14.78	13.85	13.05	12.15	11.04	9.62	8.82	8.63	7.82
V_2T_6	17.75	17.06	16.71	16.50	15.99	15.19	14.29	14.03	10.77	9.97	8.93	8.51
V_2T_7	18.10	17.41	17.06	16.85	16.58	15.78	14.88	13.97	12.39	11.59	11.20	10.55
V_2T_8	17.48	16.79	16.44	16.23	15.60	14.80	13.90	12.50	10.84	10.04	10.13	8.97
V_2T_9	19.87	19.18	18.83	18.62	18.12	17.32	16.42	15.31	13.35	12.55	12.55	12.05
Mean	**18.12**	**17.58**	**17.00**	**16.57**	**15.96**	**15.16**	**14.26**	**13.15**	**11.68**	**10.88**	**10.69**	**9.90**
S. Em. ±	**0.82**	**0.81**	**0.81**	**0.81**	**0.72**	**0.72**	**0.72**	**0.54**	**0.54**	**0.54**	**0.81**	**0.69**
C. D. @ 1 %	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

V_1 -BG1105 V_2 -MNK-1 T_1:Control (Without treatment) T_2: Neem seed kernel powder @ 10 g/kg of seed T_3:Neem oil @5 ml/kg of seed T_4: Neem leaf powder @ 5 g/kg of seed T_5: Castor oil @ 10 ml/kg of seed T_6: Sweet flag rhizome @ 10 g/kg of seed T_7:Vitavax power @ 3 g/kg of seed T_8:Deltamethrin 2.8 EC @ 0.3ml /kg of seed T_9: Sprint (Mancozeb 50% + Carbendazim 25% WS) @ 2 g/kg of seed NS: Non-significant

of twelve month of storage. As the storage period advanced there was a decline in root, shoot length and seedling vigour. This may be ascribed to ageing effect leading to death of seeds owing to depletion of food reserves and decline in biological activity of embryo due to fungal invasion, insect damage, fluctuating temperature, relative humidity and storage container in which seeds were stored. Similar results on decline in germination and other quality parameters due to seed treatments in storage were also confirmed by Merwade (2000), Morshed *et al*. (2014) and Patil (2000) in chickpea.

The combiproduct (Mancozeb 50 % + Carbendazim 25 % WS) @ 2 g per kg of seed) seed treatment acted as a physical barrier which is reported to reduce the leaching of

Table 4: Influence of seed treatment with botanicals and chemicals on shoot length in *Kabuli* chickpea varieties during storage.

Treatments	Shoot length (cm) Months of storage											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Varieties (V)												
V_1	13.31	13.01	12.12	11.51	11.41	11.19	10.24	9.57	8.83	8.23	7.16	5.33
V_2	11.54	11.28	10.09	9.92	9.54	9.33	8.78	8.11	7.37	7.07	6.25	4.41
S. Em. ±	**0.18**	**0.18**	**0.18**	**0.17**	**0.14**	**0.12**	**0.12**	**0.13**	**0.13**	**0.14**	**0.14**	**0.14**
C. D. @ 1 %	**0.67**	**0.67**	**0.67**	**0.65**	**0.52**	**0.45**	**0.46**	**0.48**	**0.48**	**0.51**	**0.51**	**0.53**
Seed treatments (T)												
T_1	10.58	10.30	9.28	8.89	8.62	8.25	7.50	6.83	6.09	5.64	4.69	2.86
T_2	12.70	12.42	11.40	11.01	10.82	10.61	9.86	9.18	8.44	7.99	7.05	5.21
T_3	12.46	12.18	11.16	10.77	10.38	10.24	9.48	8.81	8.07	7.62	6.68	4.84
T_4	12.08	11.80	10.78	10.40	10.01	9.65	8.90	8.22	7.49	7.04	6.09	4.26
T_5	11.79	11.51	10.49	10.11	10.13	9.94	9.19	8.52	7.78	7.33	6.38	4.55
T_6	13.46	13.18	12.05	11.67	11.50	11.43	10.68	10.00	9.27	8.82	7.87	6.04
T_7	13.90	13.62	12.56	12.17	11.86	11.72	10.97	10.30	9.56	9.11	8.16	6.33
T_8	13.16	12.88	11.84	11.46	11.16	11.16	10.41	9.73	8.99	8.54	7.60	5.76
T_9	14.59	14.31	13.09	12.70	12.52	12.39	11.64	10.96	10.06	9.78	8.83	7.00
S. Em. ±	**0.37**	**0.38**	**0.38**	**0.37**	**0.29**	**0.25**	**0.26**	**0.27**	**0.27**	**0.29**	**0.29**	**0.30**
C. D. @ 1 %	**1.42**	**1.42**	**1.43**	**1.38**	**1.10**	**0.96**	**0.97**	**1.02**	**1.01**	**1.09**	**1.08**	**1.12**
Interaction (V × T)												
V_1T_1	11.49	11.18	10.34	9.73	9.31	8.99	8.04	7.36	6.63	6.03	4.95	3.12
V_1T_2	13.51	13.21	12.36	11.76	11.53	11.46	10.51	9.84	9.10	8.50	7.43	5.60
V_1T_3	13.33	13.03	12.18	11.58	11.51	11.34	10.39	9.71	8.98	8.38	7.30	5.47
V_1T_4	13.30	13.00	12.15	11.55	11.39	11.08	10.12	9.45	8.71	8.11	7.04	5.21
V_1T_5	13.05	12.75	11.90	11.30	11.52	11.26	10.31	9.63	8.90	8.30	7.22	5.39
V_1T_6	14.20	13.90	12.84	12.23	12.38	12.20	11.24	10.57	9.83	9.23	8.16	6.33
V_1T_7	14.30	13.99	13.05	12.45	12.25	12.04	11.09	10.41	9.68	9.08	8.01	6.17
V_1T_8	13.99	13.68	12.80	12.20	11.77	11.61	10.66	9.98	9.25	8.65	7.57	5.74
V_1T_9	14.98	14.68	13.43	12.82	12.64	12.63	11.68	11.01	10.27	9.67	8.60	6.77
V_2T_1	9.66	9.41	8.21	8.05	7.93	7.52	6.97	6.29	5.56	5.26	4.43	2.60
V_2T_2	11.88	11.63	10.43	10.27	10.11	9.75	9.20	8.52	7.79	7.49	6.66	4.83
V_2T_3	11.59	11.33	10.14	9.97	9.26	9.13	8.58	7.91	7.17	6.87	6.05	4.22
V_2T_4	10.86	10.61	9.41	9.25	8.64	8.22	7.67	7.00	6.26	5.96	5.14	3.30
V_2T_5	10.54	10.28	9.09	8.92	8.74	8.63	8.08	7.40	6.66	6.36	5.54	3.71
V_2T_6	12.71	12.46	11.26	11.10	10.62	10.67	10.11	9.44	8.70	8.40	7.58	5.75
V_2T_7	13.51	13.26	12.06	11.90	11.48	11.41	10.86	10.18	9.44	9.14	8.32	6.49
V_2T_8	12.34	12.08	10.89	10.72	10.55	10.71	10.15	9.48	8.74	8.44	7.62	5.79
V_2T_9	14.20	13.95	12.75	12.59	12.39	12.14	11.59	10.92	9.85	9.88	9.06	7.23
Mean	**12.75**	**12.47**	**11.40**	**11.02**	**10.78**	**10.60**	**9.85**	**9.17**	**8.42**	**7.99**	**7.04**	**5.21**
S. Em. ±	**0.53**	**0.53**	**0.54**	**0.52**	**0.41**	**0.36**	**0.36**	**0.38**	**0.38**	**0.41**	**0.41**	**0.42**
C. D. @ 1 %	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

V_1 -BG1105 V_2 -MNK-1 T_1:Control (Without treatment) T_2: Neem seed kernel powder @ 10 g/kg of seed T_3:Neem oil @5 ml/kg of seed T_4: Neem leaf powder @ 5 g/kg of seed T_5: Castor oil @ 10 ml/kg of seed T_6: Sweet flag rhizome @ 10 g/kg of seed T_7:Vitavax power @ 3 g/kg of seed T_8:Deltamethrin 2.8 EC @ 0.3ml /kg of seed T_9: Sprint (Mancozeb 50% + Carbendazim 25% WS) @ 2 g/kg of seed NS: Non-significant.

inhibitors from seed coverings and might have restricted oxygen diffusion to the embryo. In addition to this, the presence of Zn and Mn in Sprint (Mancozeb 50 % + Carbendazim 25 % WS) might have helped in maintaining the seed quality by reducing the fungal and insect activity leading reduced seed quality losses resulting in better germination and other seed quality parameters. It was observed that the seeds treated with sprint, vitavax power and sweet flag have shown reduced impact of ageing enzymes and acted as protective agents against seed deterioration due to pest infestation, fungal invasion, free radical and physiological ageing due to their antioxidant and ovicidal

Table 5: Influence of seed treatment with botanicals and chemicals on seedling vigour index in *Kabuli* chickpea varieties during storage.

Treatments	Seedling vigour index (Months of storage)											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Varieties (V)												
V_1	3127	3051	2878	2710	2627	2499	2276	2059	1860	1698	1556	1300
V_2	2717	2607	2442	2389	2286	2170	1986	1798	1665	1552	1407	1167
S. Em. ±	**29**	**28**	**28**	**29**	**23**	**26**	**23**	**23**	**20**	**20**	**24**	**25**
C. D. @ 1 %	**108**	**105**	**104**	**108**	**86**	**99**	**87**	**85**	**77**	**76**	**89**	**93**
Seed treatments (T)												
T_1	2561	2473	2307	2198	2072	1951	1753	1552	1367	1238	1106	874
T_2	3013	2919	2750	2648	2604	2473	2269	2040	1830	1689	1555	1292
T_3	2888	2793	2629	2525	2420	2306	2111	1920	1698	1561	1400	1171
T_4	2841	2748	2583	2468	2378	2245	2040	1802	1621	1487	1376	1111
T_5	2787	2694	2530	2416	2320	2214	2009	1807	1569	1435	1293	1050
T_6	3134	3038	2858	2751	2651	2528	2325	2159	1805	1666	1470	1237
T_7	3233	3137	2962	2841	2749	2625	2411	2220	1955	1815	1637	1398
T_8	3072	2976	2806	2699	2574	2450	2243	2001	1728	1591	1471	1186
T_9	3507	3347	3153	3037	2944	2812	2583	2362	2079	1948	1846	1611
S. Em. ±	**61**	**59**	**58**	**61**	**48**	**56**	**49**	**48**	**43**	**42**	**50**	**52**
C. D. @ 1 %	**230**	**223**	**220**	**230**	**183**	**210**	**184**	**181**	**164**	**160**	**189**	**197**
Interaction (V × T)												
V_1T_1	2721	2652	2482	2326	2173	2052	1838	1647	1413	1260	1110	880
V_1T_2	3200	3123	2954	2784	2729	2623	2399	2154	1952	1789	1660	1387
V_1T_3	3113	3034	2869	2699	2635	2525	2299	2051	1938	1773	1651	1395
V_1T_4	3098	3021	2854	2686	2619	2475	2253	2011	1773	1614	1492	1216
V_1T_5	3050	2973	2808	2640	2574	2456	2231	2022	1775	1615	1463	1214
V_1T_6	3317	3238	3047	2875	2789	2648	2424	2228	1927	1765	1589	1341
V_1T_7	3393	3314	3134	2960	2867	2715	2490	2302	2035	1871	1683	1450
V_1T_8	3259	3179	3008	2836	2681	2536	2309	2059	1780	1619	1503	1210
V_1T_9	3633	3430	3218	3074	2977	2836	2603	2376	2145	1976	1854	1606
V_2T_1	2400	2293	2132	2069	1971	1850	1669	1458	1321	1215	1102	868
V_2T_2	2826	2714	2547	2513	2480	2323	2139	1926	1708	1589	1451	1198
V_2T_3	2663	2553	2389	2351	2206	2087	1923	1790	1459	1349	1149	947
V_2T_4	2585	2476	2312	2251	2137	2015	1827	1592	1468	1359	1261	1005
V_2T_5	2524	2416	2253	2192	2066	1973	1787	1593	1362	1255	1122	885
V_2T_6	2951	2838	2669	2627	2513	2409	2225	2089	1683	1567	1351	1132
V_2T_7	3074	2960	2790	2721	2631	2535	2333	2139	1875	1760	1590	1347
V_2T_8	2885	2773	2605	2561	2467	2365	2177	1944	1676	1562	1440	1162
V_2T_9	3381	3263	3088	3001	2910	2788	2563	2348	2013	1920	1837	1615
Mean	**3004**	**2903**	**2731**	**2620**	**2524**	**2401**	**2194**	**1985**	**1739**	**1603**	**1462**	**1214**
S. Em. ±	**86**	**84**	**83**	**86**	**68**	**79**	**69**	**68**	**61**	**60**	**71**	**74**
C. D. @ 1 %	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

V_1 -BG1105 V_2 -MNK-1 T_1:Control (Without treatment) T_2: Neem seed kernel powder @ 10 g/kg of seed T_3:Neem oil @5 ml/kg of seed T_4: Neem leaf powder @ 5 g/kg of seed T_5: Castor oil @ 10 ml/kg of seed T_6: Sweet flag rhizome @ 10 g/kg of seed T_7:Vitavax power @ 3 g/kg of seed T_8: Deltamethrin 2.8 EC @ 0.3ml /kg of seed T_9: Sprint (Mancozeb 50% + Carbendazim 25% WS) @ 2 g/kg of seed NS: Non-significant.

properties, as a result of which all the seed protectents have maintained seed viability satisfactorily for longer period of storage as against control. Generally, electrical conductivity of seed leachates and seed moisture content is negatively correlated with the seed viability and vigour, these are positively correlated with seed size. As seed ages, the cell and cell organelles membrane become weak and leaky on account of decrease in phospholipids content due to either non enzymic lipid auto oxidation or enzymically or due to fungi and insect activities. These results corroborate with the studies of Maheshbabu (2008) in soybean, Merwade (2000), Gnyandev (2015) and Sushma (2013) in chickpea.

Table 6: Influence of seed treatment with botanicals and chemicals on electrical conductivity in *Kabuli* chickpea varieties during storage.

Treatments	Electrical conductivity (dSm^{-1}) Months of storage											
	1	2	3	4	5	6	7	8	9	10	11	12
Varieties (V)												
V_1	0.369	0.526	0.556	0.673	0.744	0.763	0.838	0.930	1.057	1.277	1.482	1.692
V_2	0.491	0.648	0.678	0.780	0.866	0.869	0.945	1.019	1.146	1.366	1.571	1.781
S. Em. ±	**0.014**	**0.013**	**0.014**	**0.013**	**0.012**	**0.011**	**0.014**	**0.007**	**0.008**	**0.009**	**0.013**	**0.014**
C. D. @ 1 %	**0.051**	**0.048**	**0.051**	**0.049**	**0.044**	**0.042**	**0.053**	**0.028**	**0.030**	**0.032**	**0.047**	**0.053**
Seed treatments (T)												
T_1	0.551	0.708	0.738	0.842	0.926	0.913	1.007	1.098	1.225	1.445	1.650	1.860
T_2	0.398	0.556	0.586	0.711	0.773	0.788	0.876	0.982	1.109	1.329	1.534	1.744
T_3	0.452	0.609	0.639	0.755	0.827	0.842	0.920	0.987	1.115	1.335	1.540	1.750
T_4	0.466	0.624	0.654	0.758	0.841	0.856	0.923	1.008	1.136	1.356	1.561	1.771
T_5	0.485	0.643	0.673	0.773	0.860	0.875	0.938	1.021	1.149	1.369	1.574	1.784
T_6	0.362	0.519	0.549	0.672	0.737	0.752	0.837	0.900	1.027	1.247	1.452	1.662
T_7	0.295	0.452	0.482	0.575	0.670	0.685	0.740	0.809	0.937	1.157	1.362	1.572
T_8	0.392	0.550	0.580	0.676	0.767	0.782	0.841	0.915	1.042	1.262	1.467	1.677
T_9	0.104	0.262	0.292	0.401	0.479	0.505	0.566	0.654	0.782	1.002	1.207	1.417
S. Em. ±	**0.029**	**0.027**	**0.029**	**0.028**	**0.025**	**0.022**	**0.030**	**0.016**	**0.017**	**0.018**	**0.027**	**0.030**
C. D. @ 1 %	**0.109**	**0.101**	**0.109**	**0.104**	**0.094**	**0.091**	**0.112**	**0.061**	**0.064**	**0.069**	**0.100**	**0.113**
Interaction (V × T)												
V_1T_1	0.486	0.644	0.674	0.791	0.861	0.880	0.956	1.066	1.193	1.413	1.618	1.828
V_1T_2	0.336	0.494	0.524	0.672	0.711	0.730	0.837	0.967	1.094	1.314	1.519	1.729
V_1T_3	0.398	0.555	0.585	0.708	0.773	0.792	0.873	0.959	1.087	1.307	1.512	1.722
V_1T_4	0.418	0.575	0.605	0.707	0.793	0.812	0.872	0.945	1.073	1.293	1.498	1.708
V_1T_5	0.435	0.593	0.623	0.718	0.810	0.829	0.883	0.954	1.082	1.302	1.507	1.717
V_1T_6	0.281	0.439	0.469	0.613	0.656	0.675	0.778	0.863	0.990	1.210	1.415	1.625
V_1T_7	0.229	0.387	0.417	0.501	0.604	0.623	0.666	0.754	0.881	1.101	1.306	1.516
V_1T_8	0.332	0.489	0.519	0.631	0.707	0.726	0.796	0.858	0.985	1.205	1.410	1.620
V_1T_9	0.105	0.263	0.293	0.398	0.480	0.489	0.563	0.651	0.778	0.998	1.203	1.413
V_2T_1	0.615	0.773	0.803	0.892	0.990	0.946	1.057	1.130	1.257	1.477	1.682	1.892
V_2T_2	0.461	0.618	0.648	0.749	0.836	0.847	0.914	0.997	1.124	1.344	1.549	1.759
V_2T_3	0.506	0.664	0.694	0.802	0.881	0.892	0.967	1.057	1.185	1.405	1.610	1.820
V_2T_4	0.515	0.672	0.702	0.809	0.890	0.901	0.974	1.029	1.157	1.377	1.582	1.792
V_2T_5	0.535	0.693	0.723	0.828	0.910	0.921	0.993	1.088	1.216	1.436	1.641	1.851
V_2T_6	0.443	0.600	0.630	0.732	0.818	0.829	0.897	0.967	1.094	1.314	1.519	1.729
V_2T_7	0.361	0.518	0.548	0.648	0.736	0.747	0.813	0.865	0.993	1.213	1.418	1.628
V_2T_8	0.453	0.610	0.640	0.721	0.828	0.839	0.886	0.942	1.069	1.289	1.494	1.704
V_2T_9	0.103	0.261	0.291	0.404	0.478	0.520	0.569	0.658	0.785	1.005	1.210	1.420
Mean	**0.390**	**0.547**	**0.577**	**0.685**	**0.765**	**0.778**	**0.850**	**0.930**	**1.058**	**1.278**	**1.483**	**1.693**
S. Em. ±	**0.041**	**0.038**	**0.041**	**0.039**	**0.035**	**0.035**	**0.042**	**0.023**	**0.024**	**0.026**	**0.038**	**0.042**
C. D. @ 1 %	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

V_1 -BG1105 V_2 -MNK-1T_1:Control (Without treatment) T_2: Neem seed kernel powder @ 10 g/kg of seed T_3:Neem oil @5 ml/kg of seed T_4: Neem leaf powder @ 5 g/kg of seed T_5: Castor oil @ 10 ml/kg of seed T_6: Sweet flag rhizome @ 10 g/kg of seed T_7:Vitavax power @ 3 g/kg of seed T_8:Deltamethrin 2.8 EC @ 0.3ml /kg of seed T_9: Sprint (Mancozeb 50% + Carbendazim 25% WS) @ 2 g/kg of seed NS: Non-significant

The results of the present study showed that electrical conductivity increased with the increase in storage period irrespective of seed treatments. However, different seed treatments also showed differential influence on electrical conductivity values. Among various seed treatments, the lowest electrical conductivity was recorded in the seeds treated with Sprint (T_9) (1.417 dSm^{-1}), vitavax (T_7) (1.572 dSm^{-1}), sweet flag rhizome (T_6) (1.662 dSm^{-1}) as compared to untreated (control) (T_1) (1.860 dSm^{-1}), at the end of twelve month of storage period (Table 6). The differential electrical conductivity values recorded among the seed treatments indicated that the nature and extent of

membrane protection offered may not be same for all the treatments, thus resulting in difference in electrical conductivity values by the seeds of variable storage period. One of the factor affecting storability of *Kabuli* chickpea varieties is the presence of thin seed coat which become more prone to liquid/oils which helps in quick deterioration and invasion of pathogen present in surrounding environment when compared to the dry powder formulation seed treatment. The results are in conformation with Maheshbabu (2008) in soybean, Merwade (2000), Gnyandev (2015) and Sushma (2013) in chickpea.

However, the interaction effect between *Kabuli* chickpea varieties and seed treatment with chemicals and botanicals did not differ significantly in ambient conditions during storage period.

CONCLUSION

Seed treatment with Sprint (Mancozeb 50 % + Carbendazim 25 % WS) @ 2 g per kg of seed or Vitavax power @ 3 g/kg of seed or Sweet flag rhizome @ 10 g/kg of seed can be used for maintaining seed quality of *Kabuli* chickpea varieties upto eleven months during storage. However, sweet flag rhizome @ 10 g/kg of seed can be used as alternative to chemicals which is safe, eco-friendly and economically feasible for maintaining seed quality for organic seed growers and seed companies.

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