International Journal of Environment and Climate Change

Volume 13, Issue 10, Page 3152-3163, 2023; Article no.IJECC.106171
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Seed Treatment Effects on Seed Quality and Longevity of Soybean Seed Collected from Different Locations in Telangana State, India

Pavan Kumar Gaddam [a], Bharathi Y. [a++*], Jagan Mohan Rao P. [a#] and Rajender Reddy M. [b†]

[a] Department of Seed Science and Technology, Seed Research and Technology Centre, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad-30, India.
[b] Agriculture Research Station, Adilabad, PJTSAU, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2023/v13i102984

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/106171

Original Research Article

Received: 07/07/2023
Accepted: 09/09/2023
Published: 13/09/2023

ABSTRACT

The soybean seed (JS 335) was collected from 8 different seed production locations in Telangana state and were treated with different seed treatment chemicals. The seed quality parameters of soybean seed kept at ambient conditions in gunny bag were recorded at monthly intervals during storage. The results revealed that, among the various seed treatments chemicals, the seeds treated with Xelora (Thiophanate Methyl 45% + Pyraclostrobin 5% FS) @ 2 g kg-1 recorded significantly high seed quality parameters viz., seed germination per cent, seedling vigour index-II,

[++]Assistant Professor;
[#]Director Seeds;
[†]Scientist;
**Corresponding author: E-mail: bharathi_yerasi@yahoo.co.in;*

field emergence, moisture per cent, seed infection per cent and low electrical conductivity compared to all other treatments. Among the seeds collected from different seed production locations the seed collected from Nirmal location had shown better seed quality parameters.

Keywords: Soybean; seed treatment; xelora; endophyte; seed quality.

1. INTRODUCTION

Soybean is considered as a miracle crop of the twentieth century because of its great nutritional content, which includes 20% oil and 40% protein and contributes about 58% of the world's total production of vegetable oil. India is sixth in production with 11.23 million tonnes and fourth in area with 12.12 million hectares accounting for 8.86% of the global area in 2020–21 [1].

Soybean being an oilseed crop has a recalcitrant nature, hence cannot retain viability for longer periods. Seed deterioration is faster in soybean than in other crops [2]. Loss of seed viability and vigour in any crop is a natural phenomenon which is inexorable, irreversible and inevitable associated with genetic, physical, physiological and biochemical factors. The seed production locations and the environmental conditions during production *viz*., rain fall, temperature, humidity pest and disease incidence especially at the time of maturity will also influence the quality of the soybean seed. Besides the production environment the storage conditions, such as prevailing relative humidity, temperature, pest and diseases etc., are known to cause both qualitative and quantitative loss of soybean seed. In recent days it is also observed that during seed quality testing of different soybean seed lots are contaminated with fungal infections due to this there is drastic reduction in the germination percentage of the seed lots tested. In order to prevent the seed deterioration during storage, the cold storage structures are recommended, however, they are expensive being a high volume crop it will become highly difficult to go for cold storage of all the certified seed produced both under formal and informal systems of seed production [3]. In search for cheaper alternatives to cold storage, the seed treatments with fungicides will hold promise [4], and are also proved to delay the seed deterioration process during storage [5]. The physiological changes after seed treatment during storage were observed in different genotypes [6,7]. Seed borne infection or infected seed are discouraging factor, which are serious problem during seed certification. Even though the infected seeds are viable with prescribed Germinability, as per the certification standards, they may not be acceptable because of poor physical appearance, high incidence of seed borne fungi. Cabriotop is a broad spectrum fungicide which improves the seed quality and acts as protectant against fungal diseases. Vitavax power (carboxin + thiram) is an effective seed treatment fungicide for control and prevention of diseases within the seeds. Xelora a seed dressing fungicide mainly controls the root rot fungi (*Rhizoctonia* Spp). [8] Endophytes are proven to be the effective biological control agents in crop production and protection. [9] Acknowledged the importance of endophytes extracted from soybean seeds and their role in enhancing seed health and crop productivity and their environmentally friendly nature in agriculture. [10] Soybean seeds of variety JS 335 were treated with different fungicides along with polymer (5 ml kg-1) and seed quality parameters were evaluated during storage and found that the fungicides carbendazim 25% + mancozeb 75% @ 3 g per kg of seed was recorded significantly higher seed quality parameters compared to control. Hence, by keeping all the points in view an experiment was formulated to elucidate the effect of different seed treatment chemicals on seed quality of soybean during storage.

2. METHODOLOGY

The soybean seeds of variety JS-335 were collected from four different seed production locations *viz*., Location 1: Adilabad which includes two places P1: Ichhoda and P2: Talamadugu and the seed were collected with the assistance from Agriculture Research Station (ARS), Adilabad. Location 2: Nizamabad which includes two places P1: Bodhan and P2: Kotagiri and the seed were collected with the assistance from Regional sugarcane and Rice Research station (RS&RRS), Rudrur, Nizamabad. Location 3: Nirmal which includes two places P1: Kubeer and P2: Basara and the seed were collected with the assistance from Telangana State Seed Development and Corporation Limited (TSSDC), Nirmal. Location 4: Sangareddy which includes two places P1: Sangareddy and P2: Narayankhed and the seed were collected with the assistance from District Agricultural Advisory and Transfer of Technology Centre (DAATTC), Sanga Reddy. The laboratory experiment was carried out at the Seed Testing Laboratory of Department of Seed Science and Technology (DSST), Seed Research and Technology Centre (SRTC), PJTSAU, Rajendranagar. The seed treatments include T_0: Control (Untreated seed), T_1: Cabriotop @ 2 g kg-1, T_2: Vitavax power (Carboxin 37.5% + Thiram 37.5%) @ 3 g kg-1, T_3: Xelora (Thiophanate Methyl 45% + Pyraclostrobin 5% FS) @ 2 g kg-1, T_4: Endophytes (Bacillus sps) @ 5.0 ml kg-1. The treated seeds were shade dried overnight to safe moisture level and stored in jute bags and the seed quality parameters viz., germination percentage, moisture percentage; seedling vigour index-II, field emergence test, electrical conductivity and fungal infection were recorded at monthly intervals during storage.

2.1 Germination (%)

The test for germination per cent was conducted as per [11] ISTA (2019), using paper towel method. The treated seed and control seed samples were placed evenly on the moistened paper towel and another paper towel was used to cover the bottom paper towel and the rolled paper towels are kept in the walk-in seed germination chamber where in the 25±1^{0}C temperature and 95% relative humidity were maintained. On the 8th day the final count of seed germination (%) was calculated by using the following formula:

Seed germination (%) = (Number of normal seedlings / Total number of seeds planted) × 100

2.2 Seed Moisture Content (%)

The moisture content of seed was determined by the hot air oven method as per ISTA rules [11]. Five grams of coarsely ground seed material from each treatment in four replications were dried in a hot air oven maintained at a temperature of 103^{0}C for a period of seventeen hours. Then samples were cooled in a desiccator for one hour and the moisture content was determined by using the formula given below and expressed in percentage.

This was calculated by the following formula.

Moisture content (%) = $((M_2 – M_3) / (M_2 – M_1)) \times 100$

Where,

M_1 = Weight of the metal container along with the lid in grams
M_2 = Weight of the metal container along with lid and the sample before drying in grams
M_3 = Weight of the metal container along with lid and the sample after drying in grams

2.3 Seedling Vigour Index II

The seedling vigour indices were calculated as per the method suggested by [12] as given below and expressed in whole number.

Seedling vigour index II = Germination (%) × Seedling dry weight (mg)

2.4 Field Emergence (%)

The emergence percentage was calculated by dividing the number of emerged seedlings by the number of seeds planted for each entry and multiplying the product by 100.

Field Emergence (%) = (Number of seedlings emerged / Total number of seeds sown) × 100

2.5 Electrical Conductivity (µS cm-1g-1)

Electrical conductivity was conducted as per [11] by randomly selecting fifty seeds and weighing up to two decimals. Seeds were placed in 250 ml conical flask and 250 ml of distilled water was added using measuring cylinder. Conical flasks were covered with aluminium foil to avoid contamination and kept aside for 24 hours at 20^{0}C temperature. After 24 hours, soaked water was transferred into another flask with shaking and those soaked seeds were removed with the help of nylon sieve. The conductivity of the deionized water was measured with the help of electrical conductivity meter and it was considered as control.

Electrical conductivity (µS cm−1g−1) = (Conductivity reading - Control reading) Weight of replicate (g)

2.6 Seed Infection (%)

Four replications with 100 seeds in each were taken and kept for germination in paper towels and seed infection percentage is calculated by counting number of seeds that showed prevalence of fungal growth after 8th day of germination (25 ± 1^{0}C).

2.7 Statistical Analysis

Analysis of means and variances will be done following Factorial Completely Randomized Design (FCRD) and the significance will be tested [13].

3. RESULTS AND DISCUSSION

Seed deterioration is an unavoidable process and it could be slowed down by imposing certain treatments with chemicals or any other protectants. In order to determine the effect of chemicals on seed quality and storability the experiment is formulated by using the seed produced from different seed production locations of Telangana state. The fungicides T_1: Cabriotop @ 2 g kg^{-1}, T_2: Vitavax power (Carboxin 37.5% + Thiram 37.5%) @ 3g kg^{-1}, T_3: Xelora (Thiophanate Methyl 45% + Pyraclostrobin 5% FS) @ 2 g kg^{-1}, and T4: Endophytes @ 5.0 ml kg^{-1} were used. For germination percentage the treatment T_3 recorded highest germination per cent after 5 months of storage. There was significant difference among the treatments T_3, T_0, T_1, and T_4 while T_3 and T_2 were on par with each other, for locations the significant difference was observed among L_1 and L_4 while L_2 and L_3 were on par with each other and for places significant difference was observed (Table 1& Fig. 1). The reduction in seed germination over time was also observed by [14,15]. For moisture per cent there was non-significant difference was observed among locations and places while significant difference was observed among treatments T_0, T_2 and T_3 while T_1 and T_4 were on par with each other (Table 2 & Fig. 2). The moisture fluctuation was more in untreated seeds compared to treated seeds as chemicals covers the pores in the seed coat and prevents the entry of both water and fungal mycelia and provide protection from physical damage which can occur during handling and storage [16]. For seedling vigour index-II there was significant difference was observed among the locations and places and for treatments T0 and T1 whereas the treatments T2, T3 and T4 are on par with each other (Table 3 & Fig. 3). The Fungicides inhibited fungal growth and improved seedling vigour [17]. Similar findings were observed by [18]. For field emergence per cent there was significant difference was observed among the places and for treatments T0 and T1 whereas the treatments T2, T3 and T4 are on par with each other. Significant difference was observed for L1 and L4 while L2 and L3 were on par with each other (Table 4 & Fig. 4). The soil factors including low temperature during imbibition [19], soil resistance [20] and pathogenicity of soil-borne fungi such as *Pythium*, *Fusarium*, and *Rhizoctonia* spp have been implicated in reduced field emergence [21-24]. For electrical conductivity non significance was observed for treatments and places whereas for locations significant difference was observed.

Table 1. Influence of Treated chemicals (T), Locations (L), and Places (P) for seed germination (%) of soybean in JS-335

Treatments	Level	1 MAS	2 MAS	3 MAS	4 MAS	5 MAS
Treated chemicals (T)	T0-Control	82.4	81.1	78.4	75.7	72.8
	T1-Cabriotop	83.9	82.2	79.9	77.7	75.2
	T2-Vitavax Power	85.5	83.2	81.2	79.2	77.1
	T3- Xelora	87.3	84.4	82.2	79.7	77.1
	T4-Endophyte	84.6	83.3	80.8	78.3	76.3
Locations(L)	L1-Adilabad	85.7	83.7	81.4	78.8	76.0
	L2- Nizamabad	87.8	86.0	83.6	80.8	77.9
	L3- Nirmal	86.8	85.2	82.5	80.7	78.5
	L4-Sanga Reddy	78.60	76.5	74.5	72.2	70.4
Places(P)	P1	84.2	82.4	79.9	77.2	74.3
	P2	85.2	83.3	81.1	79.1	77.1
CD	T	1.3952	1.3651	1.5938	1.4490	1.2980
	L	1.2479	1.2210	1.4255	1.2961	1.1610
	P	0.8824	0.8634	1.0080	0.9164	0.8209
	T*L	2.7904	2.7303	3.1876	2.8981	2.5961
	T*P	1.9731	1.9306	2.2539	2.0493	1.8357
	L*P	1.7648	1.7268	2.0160	1.8329	1.6419
	T*L*P	1.0195	1.0040	0.9989	1.0288	1.0242

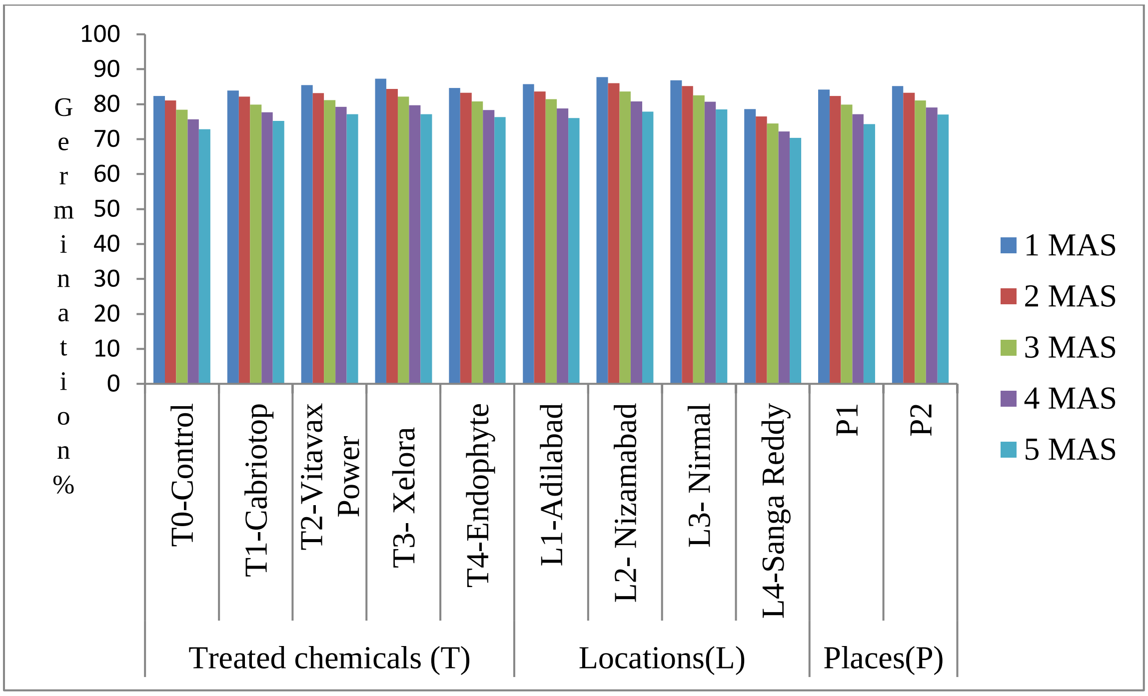

Fig. 1. Effect of seed treatment chemicals and seed production locations on per cent Germination of soybean seed

Table 2. Influence of Treated chemicals (T), Locations (L), and Places (P) for seed Moisture (%) of soybean in JS-335

Treatments	Level	1 MAS	2 MAS	3 MAS	4 MAS	5 MAS
Treated chemicals (T)	T0-Control	8.48	11.00	12.49	13.16	14.22
	T1-Cabriotop	8.39	10.36	11.38	12.03	13.21
	T2-Vitavax Power	7.40	8.67	10.15	11.42	12.71
	T3- Xelora	7.34	8.33	10.04	11.27	11.10
	T4-Endophyte	7.64	10.21	11.21	11.84	13.11
Locations(L)	L1-Adilabad	7.79	9.18	10.78	12.78	12.67
	L2- Nizamabad	8.15	8.75	10.54	12.09	12.95
	L3- Nirmal	7.86	11.04	11.28	11.70	13.10
	L4-SangaReddy	7.60	9.89	11.64	11.20	12.83
Places(P)	P1	7.68	9.81	10.80	12.07	12.84
	P2	8.02	9.62	11.31	11.81	12.90
CD	T	0.5035	0.5869	0.5748	0.5333	0.5289
	L	0.4504	0.5249	0.5141	0.4770	0.4731
	P	0.3185	0.3712	0.3635	0.3373	0.3345
	T*L	1.0071	1.1738	1.1496	1.0666	1.0578
	T*P	0.7121	0.8300	0.8128	0.7542	0.7480
	L*P	0.6370	0.7424	0.7270	0.6746	0.6690
	T*L*P	0.2162	0.5776	0.4729	0.3364	0.3841

The lower electrical conductivity was recorded in treated seeds over untreated seeds which may be due to fungicide that protects the seeds from storage pathogens and thus reduces the seed infection, cracks and aberrations of the seed coat and also the leaching of electrolytes and the results are in agreement with [25] in soybean.

For seed infection significance difference was observed for treatments and locations whereas for places non- significant difference was observed. The seed infection was lowest in treated seeds compared to control because treated seeds help in inhibiting the growth of fungi which might be due to the fungicidal effect on production of pectolytic and cellulolytic enzymes by the fungi and thereby reducing the incidence of fungal pathogen [26]. In conclusion the seeds treated with xelora and vitavax recorded similar results like highest germination (77.1%) and field emergence (77.0%) when compared to control germination per cent (72.8%) and field emergence (72.6%) . Seeds treated with xelora recorded highest seedling vigour index-II (67.8) as compared to control (59.1). The results also showed that lowest (7.56%), seed moisture content (11.10%) and electrical conductivity (265.9 µS cm-1g-1) were recorded by seeds treated with xelora as compared to untreated seeds seed infection (13.31%) seed moisture % (14.22%) and electrical conductivity (309.6 µS cm-1g-1,). And over all the results are indicating the seeds treated with Xelora recorded highest seed quality parameters during storage. The germination per cent, seedling vigour index-II and field emergence were negatively correlated with electrical conductivity and fungal infection percentage. The moisture per cent is negatively correlated with the germination per cent, seedling vigour index-II and field emergence per cent (Table 7 & Fig. 7).

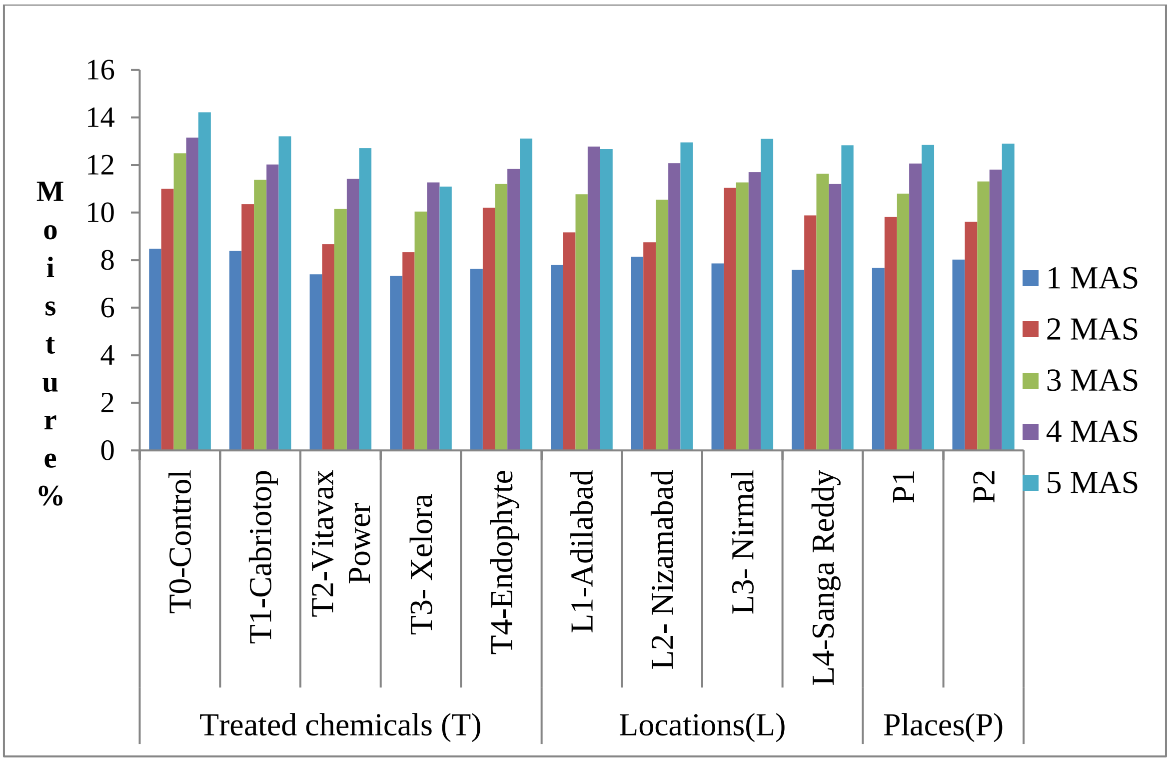

Fig. 2. Effect of seed treatment chemicals and seed production locations on per cent Moisture of soybean seed

Table 3. Influence of Treated chemicals (T), Locations (L), and Places (P) for Seedling Vigour-II of soybean in JS-335

Treatments	Level	1 MAS	2 MAS	3 MAS	4 MAS	5 MAS
Treated chemicals (T)	T0-Control	72.3	70.4	67.8	62.5	59.1
	T1-Cabriotop	74.2	72.0	68.3	65.6	62.5
	T2-Vitavax Power	77.8	75.0	71.7	68.8	66.0
	T3- Xelora	80.1	76.7	73.9	70.6	67.8
	T4-Endophyte	77.4	75.7	72.1	68.8	66.2
Locations(L)	L1-Adilabad	76.13	73.53	70.47	66.83	63.75
	L2- Nizamabad	87.31	84.73	80.65	76.26	72.70
	L3- Nirmal	78.31	76.11	72.94	70.37	67.70
	L4-SangaReddy	63.76	61.44	58.90	55.55	53.13

Treatments	Level	1 MAS	2 MAS	3 MAS	4 MAS	5 MAS
Places(P)	P1	74.98	72.55	69.15	65.17	61.89
	P2	77.77	75.36	72.33	69.33	66.75
CD	T	3.3237	2.8850	3.2186	2.9087	2.8832
	L	2.9728	2.5804	2.8788	2.6017	2.5788
	P	2.1021	1.8246	2.0356	1.8396	1.8235
	T*L	6.6475	5.7700	6.4373	5.8175	5.7664
	T*P	4.7005	4.0800	4.5518	4.1136	4.0775
	L*P	4.2042	3.6492	4.0713	3.6793	3.6470
	T*L*P	2.2677	2.1883	2.1105	2.0905	2.0779

Table 4. Influence of Treated chemicals (T), Locations (L), and Places (P) for field emergence (%) of soybean in JS-335

Treatments	Level	1 MAS	2 MAS	3 MAS	4 MAS	5 MAS
Treated chemicals (T)	T0-Control	81.4	79.9	78.1	75.1	72.6
	T1-Cabriotop	82.7	80.5	78.8	76.5	74.4
	T2-Vitavax Power	84.3	82.7	80.8	78.9	77.0
	T3- Xelora	85.7	84.0	82.4	80.3	77.0
	T4-Endophyte	83.4	82.1	80.1	77.9	76.3
Locations(L)	L1-Adilabad	84.4	82.70	80.85	78.55	75.60
	L2- Nizamabad	86.3	84.50	82.75	80.40	77.82
	L3- Nirmal	85.15	83.85	82.15	80.15	78.40
	L4-SangaReddy	78.15	76.30	74.30	71.75	69.90
Places(P)	P1	83.1	81.4	79.4	77.00	74.20
	P2	83.9	82.3	80.6	78.43	76.98
CD	V	1.4644	1.3200	1.3487	1.2555	1.1410
	L	1.3098	1.1806	1.2063	1.1230	1.0206
	P	0.9261	0.8348	0.8530	0.7941	0.7216
	T*L	2.9288	2.6400	2.6974	2.5111	2.2821
	T*P	2.0709	1.8667	1.9073	1.7756	1.6137
	L*P	1.8523	1.6696	1.7059	1.5881	1.4433
	T*L*P	0.9187	0.9371	0.9749	1.0482	1.0687

Table 5. Influence of Treated chemicals (T), Locations (L), and Places (P) for electrical conductivity of soybean in JS-335

Treatments	Level	1 MAS	2 MAS	3 MAS	4 MAS	5 MAS
Treated chemicals (T)	T0-Control	292.5	324.6	361.4	318.3	309.6
	T1-Cabriotop	336.5	276.2	265.4	278.5	273.5
	T2-Vitavax Power	277.2	300.5	292.3	290.2	275.6
	T3- Xelora	274.5	287.6	285.9	276.9	265.9
	T4-Endophyte	334.9	290.7	284.0	286.5	281.2
Locations(L)	L1-Adilabad	298.0	320.5	325.2	319.0	322.9
	L2- Nizamabad	277.0	253.8	264.5	246.0	224.2
	L3- Nirmal	238.8	250.8	241.2	240.8	222.9
	L4-SangaReddy	398.6	358.6	360.4	354.4	354.5
Places(P)	P1	314.6	297.5	307.0	295.8	283.5
	P2	291.7	294.4	288.6	284.3	278.8
CD	T	47.75	19.75	22.17	19.20	29.191
	L	42.71	17.66	19.83	17.18	26.109
	P	30.20	12.49	14.02	12.14	18.462
	T*L	95.51	39.50	44.35	38.41	58.382
	T*P	67.53	27.93	31.36	27.16	41.282
	L*P	60.40	24.98	28.05	24.29	36.924
	T*L*P	24.391	15.375	18.488	16.048	19.444

Table 6. Effects of seed treated chemicals (T), Locations (L), and Places (P) on fungal infection (%) in soybean during storage

Factors	Treatments	1 MAS	2 MAS	3 MAS	4 MAS	5 MAS
Chemicals (T)	T0-Control	7.813	9.00	10.50	11.88	13.31
	T1-Cabriotop	5.063	6.06	7.06	8.00	8.81
	T2-Vitavax Power	3.875	4.88	5.88	6.88	7.88
	T3- Xelora	3.563	4.50	5.50	6.56	7.56
	T4-Endophyte	4.500	5.50	6.50	7.50	8.44
Locations (L)	L1-Adilabad	4.850	5.750	6.800	8.050	9.100
	L2- Nizamabad	4.250	5.350	6.450	7.400	8.450
	L3- Nirmal	4.950	6.050	7.100	8.200	9.100
	L4-Sanga Reddy	5.800	6.800	8.000	9.000	10.150
Places (P)	P1	4.875	5.900	6.975	8.050	9.200
	P2	5.050	6.075	7.200	8.275	9.200
CD	T	0.4726	0.4989	0.5816	0.4448	0.4793
	L	0.4227	0.4462	0.5202	0.3978	0.4287
	P	0.2989	0.3155	0.3678	0.2813	0.3031
	T*L	0.9452	0.9978	1.1632	0.8896	0.9586
	T*P	0.6684	0.7055	0.8225	0.6290	0.6778
	L*P	0.5978	0.6310	0.7356	0.5626	0.6063
	T*L*P	0.4058	0.4199	0.4690	0.4801	0.5276

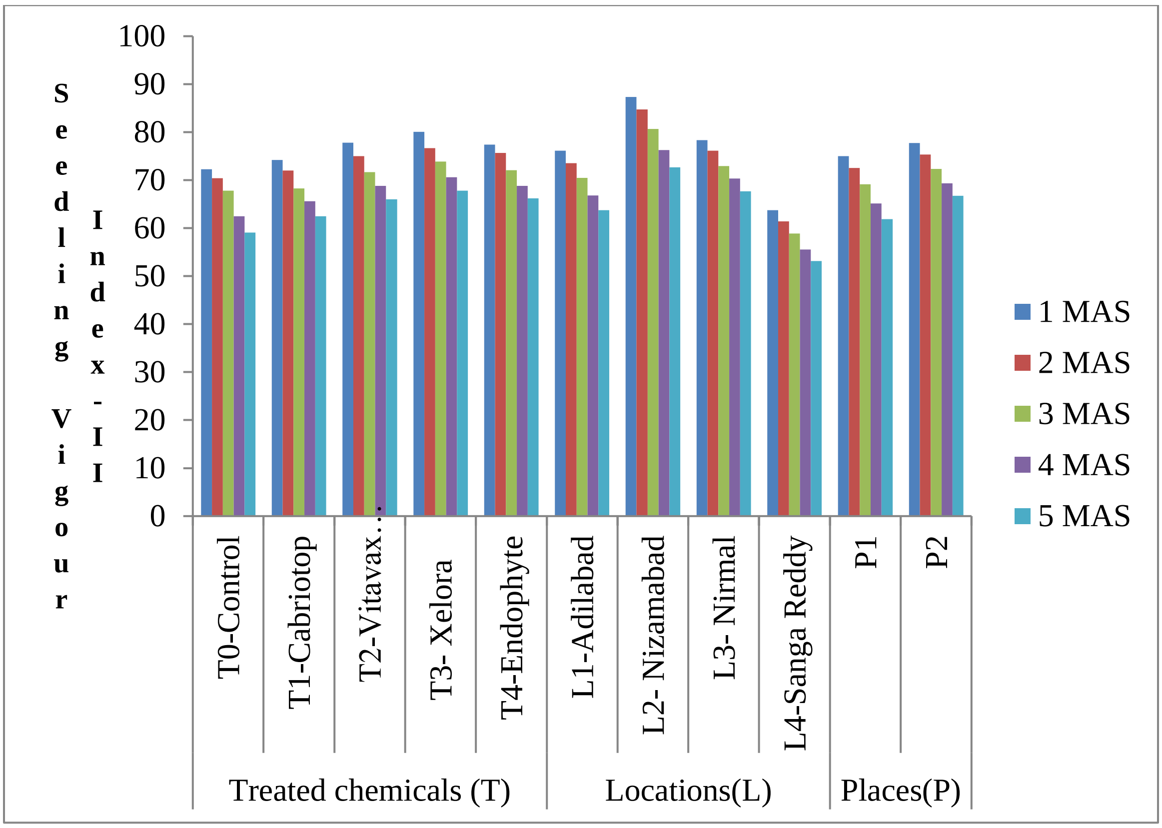

Fig. 3. Effect of seed treatment chemicals and seed production locations on seedling vigour index-II of soybean seed

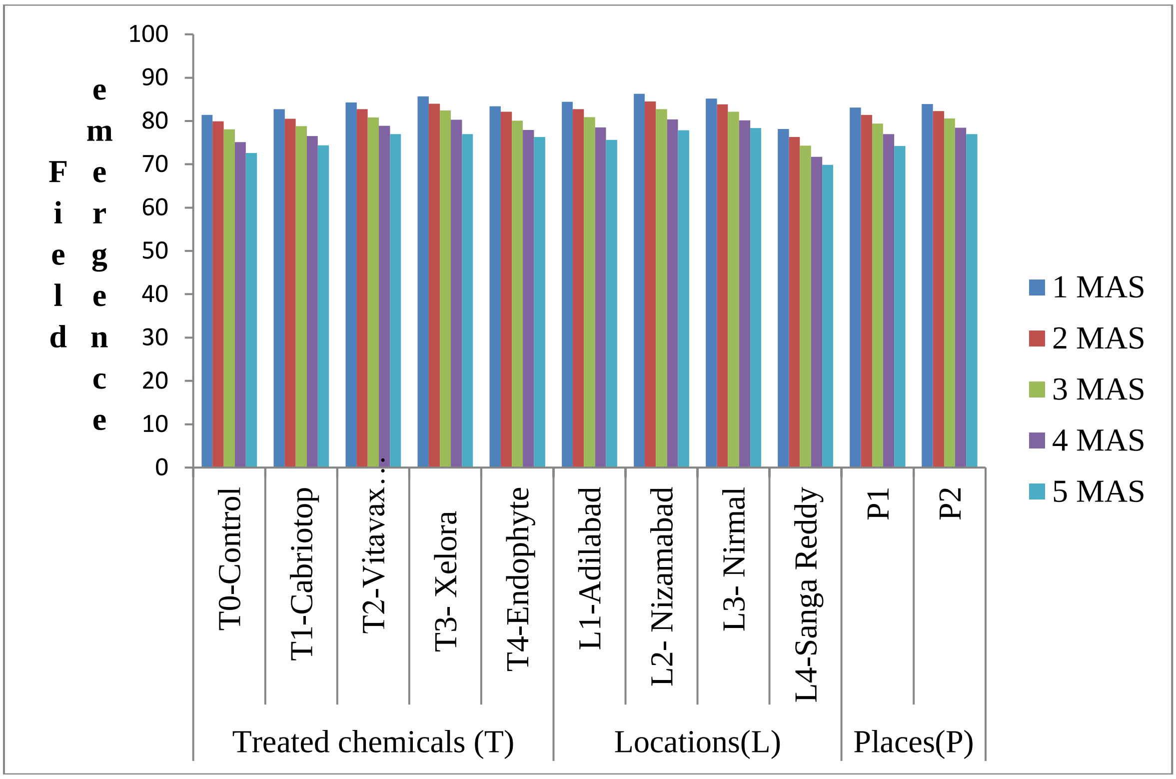

Fig. 4. Effect of seed treatment chemicals and seed production locations on per cent Field emergence of soybean seed

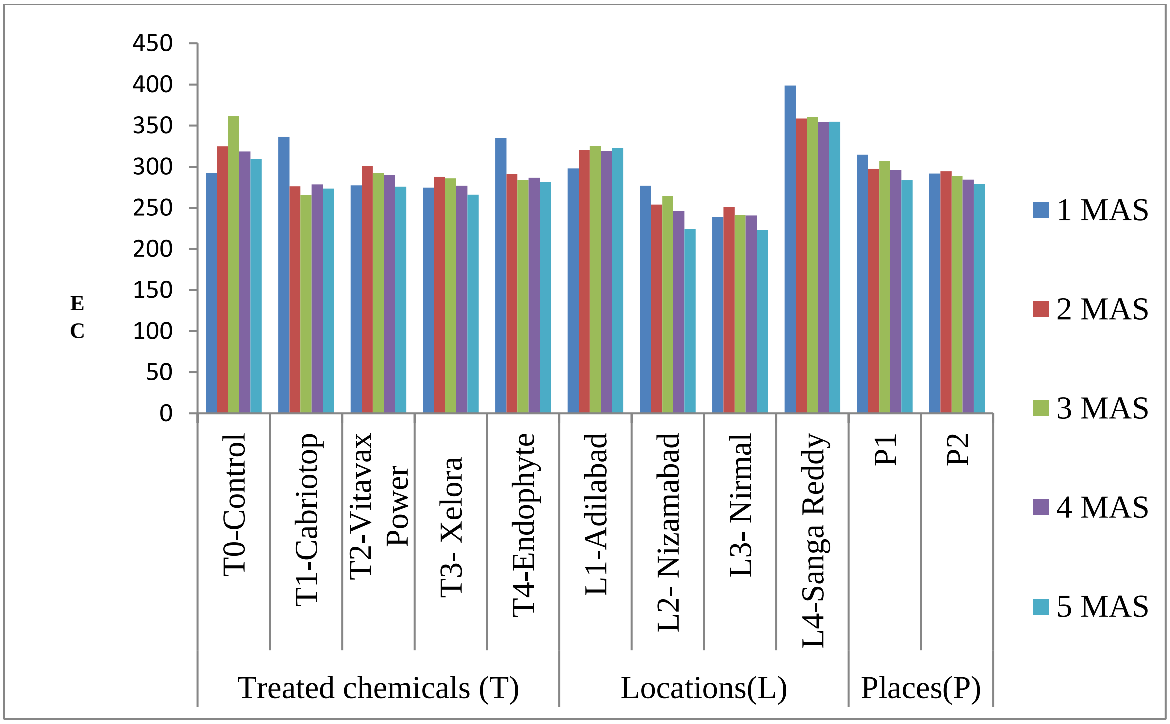

Fig. 5. Effect of seed treatment chemicals and seed production locations on electrical conductivity of soybean seed

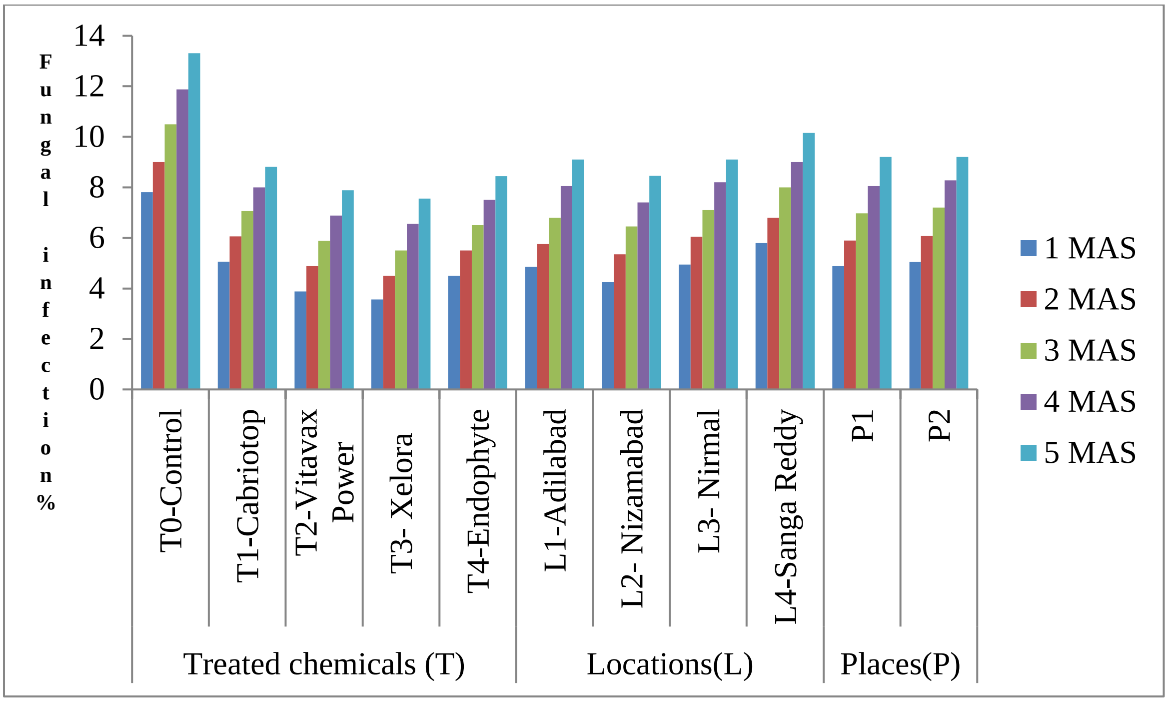

Fig. 6. Effect of seed treatment chemicals and seed production locations on per cent fungal infection of soybean seed

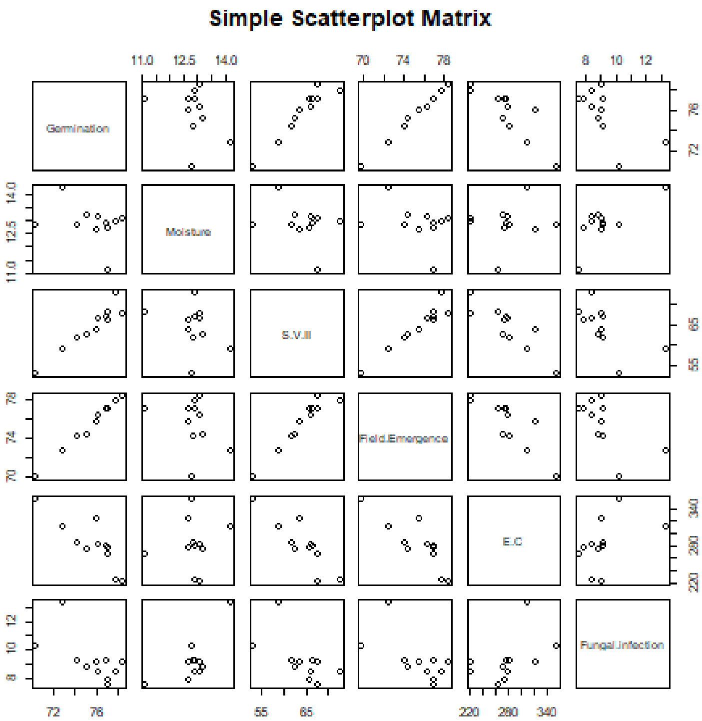

Fig. 7. Scatter plot showing the correlation among the seed quality parameters of soybean seed produced from different locations

Table 7. Correlation for seed quality parameters of soybean seed produced from different locations

	Germination	Moisture	SV-II	Field emergence	EC	Fungal infection
Germination	1.0000	-0.3204	0.9493	0.9964	-0.8394	-0.6379
Moisture		1.0000	-0.3061	-0.3195	0.1226	0.7396
SV-II			1.0000	0.9559	-0.8641	-0.6012
Field emergence				1.0000	-0.8404	-0.6226
EC					1.0000	0.4548
Fungal infection						1.0000

4. CONCLUSION

Among the seed treatment chemicals used in the study the seed treated with xelora had showed the better seed quality parameters *viz*., germination per cent, moisture per cent, seedling vigour index-II, field emergence per cent, electrical conductivity and fungal infection per cent while in locations the seed procured from nirmal had showed the better quality.

ACKNOWLEDGEMENT

We are grateful to The Professor Jayashankar Telangana State Agricultural University for the financial support, Department of Seed Science and Technology, Seed Research and Technology Centre, Central Instrumentation Cell (CIC), Hyderabad for providing lab facilities and Agriculture Research Station (ARS) Adilabad, Regional Sugarcane and Rice Research Station (RS&RRS), Rudrur, Nizamabad, Telangana State Seed Development Corporation (TSSDC) Nirmal and District Agricultural Advisory Training Centre (DAATTC) Sanga Reddy for providing soybean seed.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Soybean outlook, Agricultural Marketing Intelligence Centre, PJTSAU; December 2022.
2. Priestley DA, Cullinan VI, Wolfe J. Differences in seed longevity at the species level. Plant Cell Environ. 1985;8:557-562.
3. Ng NQ. Long-term seed conservation. In: Proceedings of International Conference on Crop Genetic Resources of Africa, Kenya. 1988;135-148.
4. Subramanya KN, Prakash HS, Shetty HS, Karanth NGK. Effect of Thiram and Bastin on sorghum seeds stored under different conditions. Pesticides. 1988;22:25-27.
5. Shekaramurthy SK, Patkar L, Shetty SA, Prakash HS, Shetty HS. Effect of Thiram treatment on sorghum seed quality in relation to accelerated ageing. Seed Sci. Technol. 1994;22:607-617.
6. Daniel IO. Conservation of West African yam (*Dioscorea spp*.) germplasm: Physiology of seed and pollen storage. PhD Thesis, University of Ibadan, Nigeria. 1997;148.
7. Daniel IO, Ng NQ, Tayo TO, Togun AO. West African yam seeds stored under cold and desiccated conditions are orthodox. Seed Sci. Technol. 1999;27:969-975.
8. Jitendra Dalal, Nikhilesh Kulkarni. Effect of Endophytic Treatments on Plant Growth Performance and Disease Incidences in Soybean (*Glycine max* (L.) Merril) Cultivar JS-335 against Challenge Inoculation with *R. solani.* American Journal of Agricultural and Biological Sciences. 2015;10(2):99-110.
9. Kim J, Roy M, Ahn SH, Shanmugam G, Yang JS, Jung HW, Jeon J. Culturable Endophytes Associated with Soybean Seeds and Their Potential for Suppressing Seed-Borne Pathogens. The Plant Pathology Journal. 2022;38(4):313.
10. Venkatesh B, Basave Gowda, Vasudevan SN, Doddagoudar SR, Gururaj Sunkad, Konda CR. Effect of seed coating with fungicides along with polymer on seed storability of soybean (*Glycine max* L. Merril). International Journal of Chemical Studies. 2018;6(5):598- 602.
11. ISTA. International rules for seed testing. International Seed Testing Association, Zurich, Switzerland; 2019.
12. Abdul-Baki AA, Anderson JD. Vigour determination in soybean seed by multiple criteria. Crop Sci. 1973;13(6):630-633.

13. Gomez KA, Gomez AA. Statistical procedures for agricultural research (2nd ed.). John wiley and sons. New York; 1984.
14. Ruzrokh M, Golozani KG, Javanshir A. Relation between seed vigour with growth and yield in pea (*Cicer arietinum* L.). Nahal o Bazr. 2003;18:156-169.
15. Demirkaya M, Dietz KJ, Sivritepe HO. Changes in antioxidant enzymes during aging of onion seeds. Notulae Botanicae Horti. Agrobotanici. 2010;38(1):49-52.
16. West SH, Loftin SK, Wahl M, Batich, Beatty CL. Polymer and seed treatment as a moisture barrier to maintain seed quality. Crop Sci. 1985;25:941-944.
17. Zote KK, Mayee CD. Influence of fungicidal seed treatment during storage on seed-borne fungi of mungbean. Pesticides. 1982;16(4):10-12.
18. Khatun A, Kabir G, Bhuiyan MAH. Effect of harvesting stages on the seed quality of lentil (*Lens culinaris* L.) during storage. Bangladesh J Agril. Res. 2009a;34(4):565-576.
19. Thomas CA, Miller VL, Hill RF. Stand loss of soybeans from preemergence damping-off and low temperature imbibition. Plant Dis. Rep. 1975;59:293-296.
20. Knittle KH, Burris JS, Erbach DC. Regression equation for rate of soybean hypocotyl elongation by usmg field data. Crop Sci. 1979;19:41-46.
21. Pieczarka DJ, Abawi GS. Effect of interaction between Fusarium, Pythium, and Rhizoctonia on severity of bean root rot. Phytopathology. 1978;68:403-408.
22. Schlub, RL, Lockwood JL. Etiology and epidemiology of seedling rot of soybean by *Pythium ultimum*. Phytopathology 1981a;71:134-138.
23. Schlub RL, Lockwood JL, Komada H. Colonization of Soybean Seeds and Plant Tissue by Fusarium Species in Soil. Phytopathology. 1981b;71(7):693-696.
24. Thomson TB, Athow KL, Laviolette FA. The effect of temperature on the pathogenicity of *Pythium aphanidermatum*, *P. debaryanum*, and *P. ultimum* on soybean. Phytopathology. 1971;61:933-935.
25. Maheshbabu HM, Ravi H. Effect of seed treatment with botanicals on storability of soybean. Karnataka J Agric. Sci. 2008; 21(3):357-360.
26. Mehta A, Chopra, Mehta P. Fungicide's inhibitory agent of cell wall degrading enzymes. J Indian Phytopathology. 1990; 43:117-120.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/106171