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Effect of Off-season Planting Dates and Varieties on Seed Quality Parameters of Soybean (*Glycine max* L.) Upon Accelerated Ageing

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Authors' contributions

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

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ABSTRACT

Three soybean varieties AISb-50, Basara and JS-335 were used in the current study in Adilabad. They were seeded on December 15 and January 15, respectively during the Rabi (2021–2022) season. During the off-season, the varieties were sowed on three replications. To make sure that the requirements for the seed quality of off-season soybean (*Glycine max* L. Merrill) at initial, 3 days of ageing and 5 days of accelerated ageing are explained, as well as the results of different varieties and sowing dates. The plants' collected seeds are sent for an examination of their quality. During the experiment, the following features were examined: speed of germination, field emergence (%), electrical conductivity (µScm-1 g-1), and the following: germination (%), seedling length (cm), seedling vigor index I, seedling dry weight (mg), and seedling vigor index II. The study's conclusions demonstrated how cultivars and planting dates had a substantial impact on the parameters. The 15th January seeded crop (85.78%) had the best germination percentage among the initial, 3 days of aging, and 5 days of accelerated ageing. The AISb-50 variety (88.67%) had the greatest germination percentage among interactions, and the AISb-50 of 15th December (89.00%) had the highest germination percentage. The seedling vigour index I was highest in 15th December sown crop (2605), AISb-50 (2447) variety and in JS-335 of 15th December (2803). The highest seedling dry weight (mg) was recorded in 15th December sown crop (838.40mg), Basara (792.7mg) and in AISb-50 of 15th December (853.1mg). Vigor index II was recorded maximum in Basara (65291),15th December sown crop (71541) and in AISb-50 (74571) of 15th December. While field emergence % was highest in 15th December (81.22%), JS-335(83.17%) and in JS-335, AISb-50 of 15th December sown crop (84.33%). The seed quality parameters was recorded at the initial stage were higher for the above parameters except for electrical conductivity, whereas the highest electrical conductivity was recorded after 5 days of ageing in the 15th January crop (65.75 µScm-1 g-1), Basara (82.50 µScm-1 g-1) and in Basara of 15th January (85.00 µScm-1 g-1). It was noticed that seed quality parameters were significantly affected by sowing date, varieties and accelerated ageing, the freshly harvested seed had good seed quality compared to the aged seed.

Keywords: Glycine max L.; seed quality; accelerated ageing; varieties; dates of sowing.

1. INTRODUCTION

Glycine max L. Merrill, or soybeans, are one of the most significant economic oil seed crops. It is a substantial source of protein (40%) and oil (20%) for consumption by humans and animals, and it provides 25% of the production of vegetable oil. Its sprouted grains provide a significant quantity of Vitamin C and it has a fair number of minerals, salts, and vitamins (thiamine and riboflavin). Soybean is a great source of fiber and low in fat. Because of their antioxidative, antitumoral, and anti-anthero sclerotic properties, soybean isoflavones are good for human health (Davis *et al*., 1999). With an area of 3.95 lakh hectares, productivity of 12.45 q ha¬1, and output of 12.50 million tons, India is the world's fifth-largest producer of soybeans.

The seed quality of soybean is low due to various constraints. The different varieties of soybean are sensitive to changes in environmental conditions where the crop is being grown (Calvono, 2003) and seed deterioration during storage is one of the reason for low productivity in soybean, as well as ageing conditions adversely affect the seed vigor [1]. Early or late planting significantly reduces the crop yield (Board *et al.,* 1996), seed germination Andric *et al*., [2] Tekrony *et al*.,[3] and grain yield Egli and Cornelius, [4]. Mainly soybean seed production is being taken up during *kharif* season. For the past few years incessant rains have coincided with pod maturity stage of the crop which results in in-situ germination that results in a shortage of quality seed. In such situation contingency seed production especially in the off-season is very much essential. Hence there is a need to identify the best planting time and ideal genotypes for enhanced quality seed production during off-season in Telangana state.

2. MATERIALS AND METHODS

The experiment was conducted at the Agricultural Research Station, Adilabad (Telangana) during the Rabi season 2021-22. It consisted of three duplicated varieties: AISb-50 (V1), Basara (V2), and JS-335 (V3), and two planting dates: December 15 (D1) and January 15 (D2). Black cotton soils made up the experiment field's soil. The day before seeding,

the crop received irrigation based on need. 30 x 10 cm seed spacing was used to raise the crop. A nutritional treatment of 40 kilogram K2O, 60 kg P2O5, and 30 kg N was treated per acre. Two equal applications of nitrogen were made: one at the time of seeding and the other thirty days later (DAS). Pendimethalin (3 ml/liter) was sprayed as a weed control.

The seed harvested from the plants are cleaned and carried for seed quality analysis at the initial stage and some seeds are subjected to accelerated ageing for 3 days and 5 days to conduct the following quality parameters *viz*., Germination test as per ISTA using between paper method, the number of normal seedlings is counted on 8th day by following formula;

$$\text{Germination \%} = \frac{\text{Number of normal seedlings}}{\text{Total number of seeds placed}} \times 100$$

Seedling length (cm) is calculated by taking ten random seedlings on the 8th day and root and shoot lengths were measured.

Seedling vigor index I was calculated using a formula and expressed in whole numbers.

SVI-I = Germination (%) × Seedling length (cm),

Seedling dry weight (mg) was determined by measuring the length of 10 typical seedlings, which were then placed in butter paper bags and heated to 85 ± 10C for a whole day. They were subsequently weighed using an electronic balance.

Seedling vigor index II is calculated by the formula

SVI-II = Germination (%) × Seedling dry weight (cm)

Field emergence (%) was calculated by

$$\text{Field emergence (\%)} = \frac{\text{Number of seedlings emerengence at 8th day}}{\text{Total number of seeds sown}} \times 100$$

Speed of germination by using the formula

Speed of germination $= \sum (N_1/d_1 + N_2\text{-}N_1/d_2 \ldots\ldots\ldots N_n\text{-}N_n\text{-}1/d_n)$,

Where,

N = number of seeds germinated on the day,
d = serial number of days

Electrical conductivity (µScm^{-1} g^{-1}) was also calculated

$$\text{Electrical conductivity } (\mu Scm^{-1}g^{-1}) = \frac{Sample\ reading\ (\mu S\ cm{-}1\ g\ {-}1){-}\ \text{Blank}\ reading)}{Weight\ of\ the\ replicate\ (g)}$$

The data was analyzed using a Completely Randomized Block Design, the Critical difference (CD) was calculated and the means were compared to a 5% level of significance.

3. RESULTS AND DISCUSSION

3.1 Effect of Sowing Dates on Seed Quality Parameters of Soybean Upon Accelerated Ageing

The analysis of variance is shown in Tables 1-2, and the impact of accelerated ageing and sowing dates on seed quality indicators is covered below.

The germination percentage for the first and fifth AAT sowing dates revealed a non-significant difference; the third AAT exhibited a significant difference, with the 15th December seeded crop showing the greatest germination percentage at 77.22%. Age-related germination is gradually declining, as seen by the lowest germination percentage of 67.55% obtained on January 15th, when the crop was sowed at 5 AAT and the results were found to be comparable. These results are consistent with those of Uem and Unioeste, [5] who found that while optimal sowing dates provided more favorable climatic conditions for soybean seed growth, a higher percentage of germination was seen in seeds from optimal sowing dates than in delayed planting.

The crop sowed on December 15 at initial and 3 AAT (30.50cm, 25.18cm) had a much greater germination rate, according to the data, whereas 5 AAT showed no significant difference for this feature. Kumar *et al*., [6] found that earlier seeding in Niger resulted in longer seedlings, which supports our findings.

The seedling vigor index I demonstrated a significant difference at initial and 3 AAT in the crop seeded on December 15th, with a greater vigor index at initial (2605) and 3 AAT (1946) depending on the sowing date differences. For 5 AAT, a non-significant difference in vigor index (1403, 1349) was observed for both sowing dates. According to Singh et al., [7] cotton seeds

from early bolls had the greatest seedling vigor index I. According to the study, the seedling vigor index decreased as age progressed, which is consistent with studies on ground nuts Sung and Jeng, [8] and chickpeas Dumbre, [9].

Significantly higher seedling dry weight was found in the 15th December sown crop at initial, 3 AAT and 5 AAT *viz*., 838.40mg, 785.57 mg, 705.17mg. Among all the lowest seedling dry weight was shown by 15th January sown crop of 5 AAT (489.60 mg).

In contrast, greater vigor index II was discovered at the initial stage (71541), followed by 3 AAT (60755) and 5 AAT (49853), for the crop sowed on December 15th. The seedling vigor index II was shown to be considerably superior at initial, 3 AAT, and 5 AAT. However, the crop seeded on January 15 at 5 AAT (33021) showed the noticeably lowest seedling vigor index II. These results are in line with those of Rahman *et al*. [10] and Farhadi *et al*. [11] who found that the best times to sow beans produced plants with higher vigor indexes, and that faster aging led to a decrease in seedling vigor index II, which was linked to lower germination rates and lower seedling dry weights.

It was discovered that there was no discernible variation in the rate of germination between the first planting dates of 3 AAT and 5 AAT. The crop that was first sowed on December 15th had the non-significantly highest value (23.44). For three AAT, the rates of germination on the two seeding dates December 15, 19:58, and January 15, 20:01 were found to be comparable.

The crop seeded on December 15th showed the lowest field emergence (%) at 5 AAT (41.78%), whereas the crop sown on January 15th showed the highest field emergence (%) at initial (81.22%), followed by 3 AAT (72.89%) and 5 AAT (60.78%). Different planting dates and faster aging are the causes of the decline in field emergence. These results were in line with those of Luka Andric *et al*. [12] who found that as soybeans aged, physiological stress decreased the quality of the seeds, resulting in decreased field emergence and seed vigor.

The initial stage of the crop sowed on December 15th had the lowest electrical conductivity, measuring 45.49 µScm-1g-1. For this feature, there was no statistically significant difference seen between the first sowing dates (3 AAT) and 5 AAT. On January 15, delayed sowing was found to have higher electrical conductivity, measuring 65.75µScm-1g-1 at 5 AAT. The findings showed that seeds' electrical conductivity increased with rapid aging, which is consistent with findings from Basra *et al*. [13] about cotton. Delays in planting also resulted in higher electrical conductivity.

3.2 Effect of Varieties on Seed Quality Parameters of Soybean Upon Accelerated Ageing

The varieties' germination percentages at initial, 3 AAT, and 5 AAT revealed a significant difference. The varieties with the greatest germination percentages were AISb-50 (88.67%) at initial, JS-335 (78.72%) at 3 AAT, and JS-335 (73.34%) at 5 AAT. At first, there was no discernible difference between JS-335 and Basra for this feature. The lower rate of seed germination can be attributed to cellular alterations that transpired when the seeds were exposed to elevated temperatures and relative humidity levels. Plate 1 shows a considerable fall in germination percentage with increased aging. In pigeon pea, Kalpana and Madhava Rao [14] similarly showed a similar decline in germination %.

At the beginning and third AAT, there was no statistically significant variation in the length of the seedlings for any variety. However, at the fifth AAT, JS-335 had substantially longer seedlings (21.14 cm), whereas AISb-50 had significantly shorter seedlings (18.62 cm). At 3 AAT, it was discovered that the variants Basara, JS-335, and AISb-50 were comparable to one another. After maturing, the length of the seedling decreased; these findings are consistent with those of Edje and Burris [15] on soybeans.

JS-335 of 3 AAT, 5 AAT (1966, 1553) was shown to have significantly superior seedling vigor index I, while the cultivars Basara and AISB-50 had non-significant differences in this attribute. In contrast, initial research revealed parity in the varieties JS-335 (2397), AISb-50 (2447), and Basara (2260). These agree with the findings of Babalad et al. [16] for soybeans.

For seedling dry weight (mg) the varieties showed significant difference with the highest dry weight in Basara (792.7mg) at the initial stage, whereas AISb-50 and JS-335 were found to be on par. The variety AISb-50 was found to have a significantly lowest seedling dry weight of

694.7mg. The trait showed a non-significant difference for the varieties at 3 AAT and 5 AAT. As seed aging progressed, seedling dry weight and seed reserve depletion percentage decreased significantly in varieties of soybean.

15th December **15th January**

Initial

3 DAA

5 DAA

Plate 1. Effects of sowing dates on field emergence (%) of soybean varieties sown at Adilabad during off-season

Table 1. Analysis of variance for seed quality parameter of off season soybean (Adilabad)

Source of variation	df	Germination (%)			Seedling length (cm)		
		Initial	3 AAT	5AAT	Initial	3AAT	5AAT
Location (A)	1	0.889	112.500*	46.772	145.636**	11.045	0.094
Varieties (B)	2	60.222*	72.056	100.167*	0.442	7.796	9.541*
A × B	2	9.556	23.167	47.389	19.242**	3.807	1.574
Error (B)	12	15.500	20.556	17.889	2.733	4.670	1.426
Total	17	19.203	32.330	32.735	12.812	5.311	2.320

Source of variation	Df	Seedling vigour index I			Seedling dry weight (mg)		
		Initial	3 AAT	5AAT	Initial	3AAT	5AAT
Location (A)	1	1010094.000**	255612.500*	12906.890	163039.500**	346333.900**	209088.900**
Varieties (B)	2	56650.500	133266.700	140458.200**	14414.330*	2130.890	11785.320
A × B	2	217622.100*	55962.00	29932.390	20355.340*	12118.990*	29088.670*
Error (B)	12	36428.390	34802.550	11368.670	2971.730	2586.160	4684.270
Total	17	117398.800	61864.730	28830.120	15778.800	23874.560	20414.60

Source of variation	Df	Seedling vigour index II			Speed of germination		
		Initial	3 AAT	5AAT	Initial	3AAT	5AAT
Location (A)	1	1168265000.00**	2628318000.00**	1274856000.00**	0.642	0.845	0.405
Varieties (B)	2	21607160.00	70143000.00	86355970.00*	60.024**	151.821**	61.265**
A × B	2	228408900.00**	95294770.00*	199103100.00**	0.157	4.245	13.385**
Error (B)	12	27921510.00	19024890.00	12795010.00	5.145	1.120	1.417
Total	17	117844400.00	187499600.000	117606700.00	10.750	19.201	9.806

, represent significance at 5% level.*

Source of variation	Df	Field emergence (%)			Electrical conductivity($\mu Scm^{-1}g^{-1}$)		
		Initial	3 AAT	5AAT	Initial	3AAT	5AAT
Location (A)	1	1027.556**	2616.056**	1624.500**	4.371	16.994	58.681
Varieties (B)	2	751.167**	1308.667**	1219.556**	1203.850**	2700.807**	1549.537**
A × B	2	234.722**	366.222**	172.667*	7.130	23.725	14.216
Error (B)	12	24.056	24.222	26.722	10.468	10.651	24.589
Total	17	193.412	368.029	278.212	150.115	329.051	204.780

, represent significance at 5% level*

Table 2 Effect of sowing dates and varieties on seed quality parameters of soybean.

Treatment	Germination (%)			Seedling length(cm)			Seedling vigour index I			Seedling dryweight(mg)		
	Initial	3 AAT	5 AAT	Initial	3 AAT	5 AAT	Initial	3 AAT	5 AAT	Initial	3 AAT	5 AAT
D1	85.33	77.22	70.78	30.50	25.18	19.76	2605	1946	1403	838.40	785.57	705.17
D2	85.78	72.22	67.55	27.63	23.61	19.91	2131	1708	1350	648..03	508.17	489.60
V1	88.67	73.34	69.00	28.47	25.15	18.62	2447	1844	1289	694.70	659.70	546.50
V2	82.34	72.17	65.17	28.27	23.09	19.74	2260	1670	1287	792.70	625.20	627.00
V3	85.67	78.67	73.34	30.47	24.95	21.14	2397	1967	1553	742.40	655.70	618.70
D1V1	89.00	73.67	68.67	30.57	25.23	18.00	2721	1856	1240	838.70	792.50	574.20
D1V2	80.67	76.33	70.00	28.43	23.70	19.74	2290	1812	1377	823.40	722.20	768.10
D1V3	86.33	81.67	73.67	32.50	26.60	21.54	2803	2169	1592	853.10	842.00	773.20
D2V1	88.33	73.00	69.33	26.37	25.07	19.24	2172	1830	1338	550.60	526.09	518.70
D2V2	84.00	68.00	60.33	28.10	22.47	19.74	2229	1528	1196	761.90	528.20	485.90
D2V3	85.00	75.67	73.0	28.43	23.30	20.74	1991	1764	1514	631.60	469.40	464.20
GM	85.56	74.72	69.17	27.66	24.40	19.83	2368	1827	1377	743.22	646.87	597.40
C.D. @5%												
D	4.04	4.66	4.34	1.70	2.22	1.23	196.03	191.61	109.51	55.99	52.23	70.30
V	4.95	5.70	5.32	2.08	2.72	1.50	240.09	234.67	134.13	68.57	63.97	86.10
DxV	7.00	8.07	7.52	2.94	3.84	2.12	339.54	331.88	189.68	96.98	90.47	121.76
C.V.(%)	4.60	6.07	6.12	5.98	8.86	6.02	8.06	10.21	7.75	7.34	7.86	11.46
S. Em.(±)	2.27	2.62	2.44	0.95	1.25	0.69	110.19	107.71	61.56	31.47	29.36	39.51
SE.d.	3.21	3.70	3.45	1.35	1.76	0.98	155.84	152.32	87.06	44.51	41.52	55.88

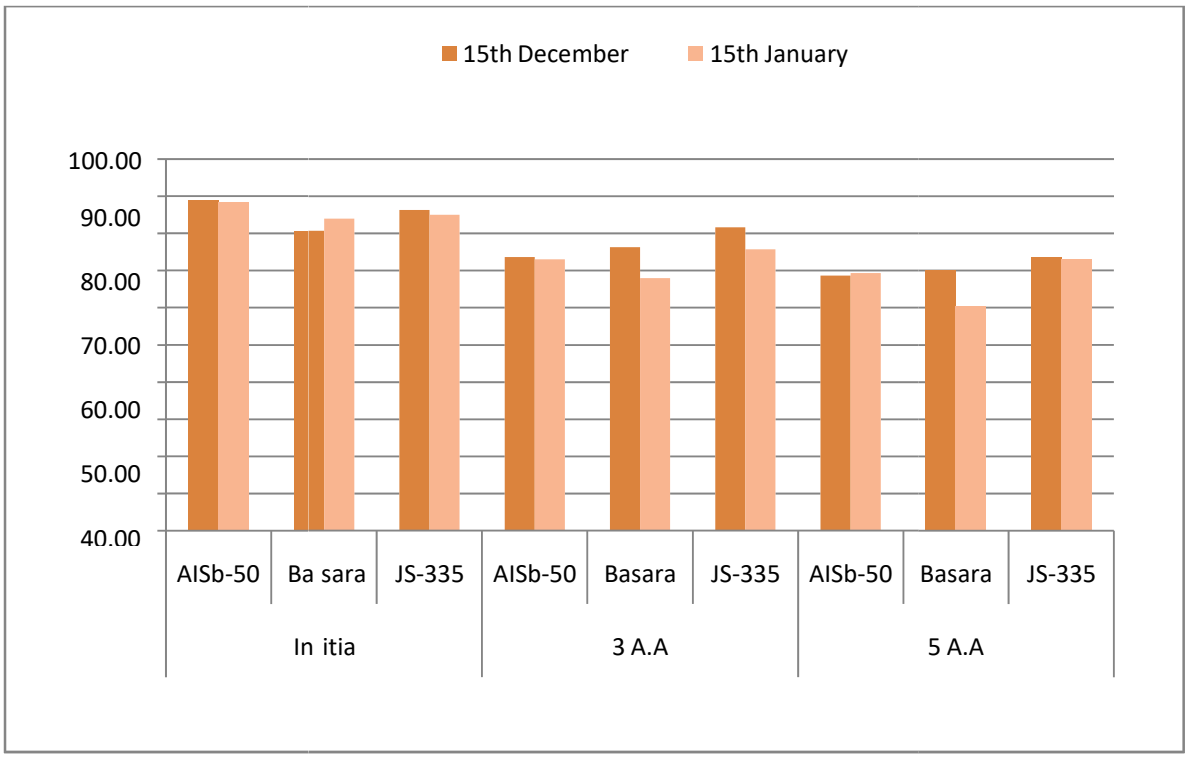

Fig. 1. Effect of dates of sowing and varieties on germination (%) of soybean seed produced during off-season at Adilabad

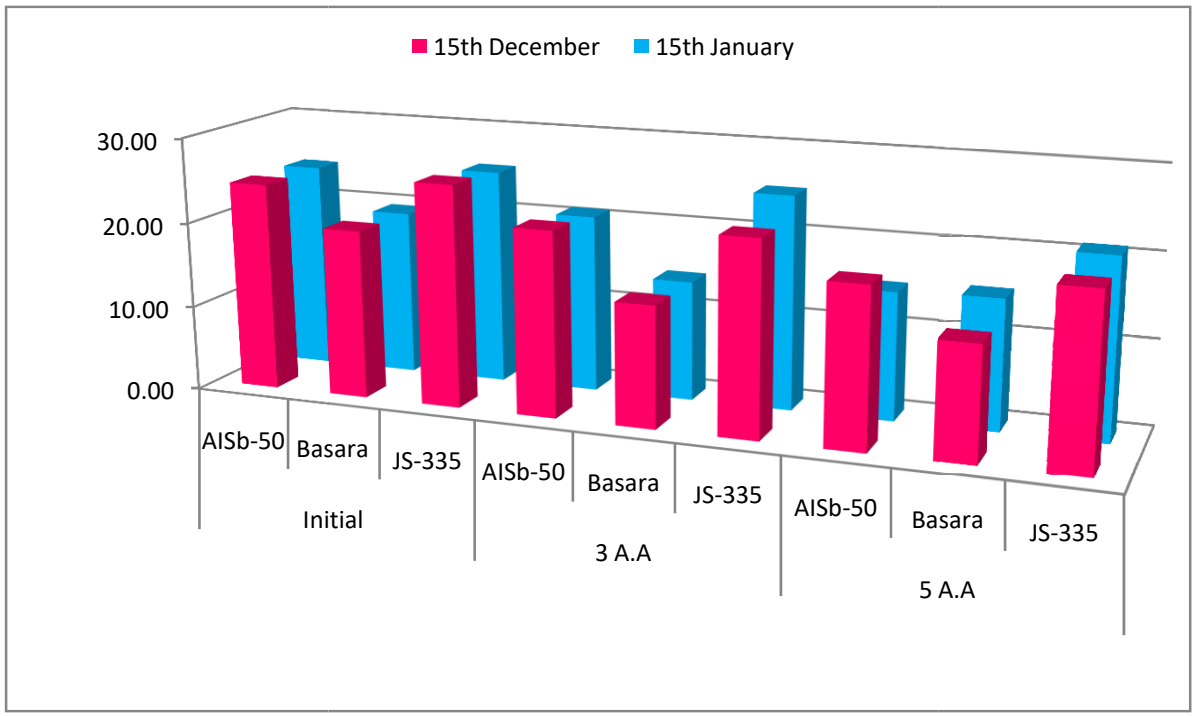

Fig. 2. Effect of dates of sowing and varieties on speed of germination ofsoybean seed produced during off-season at Adilabad

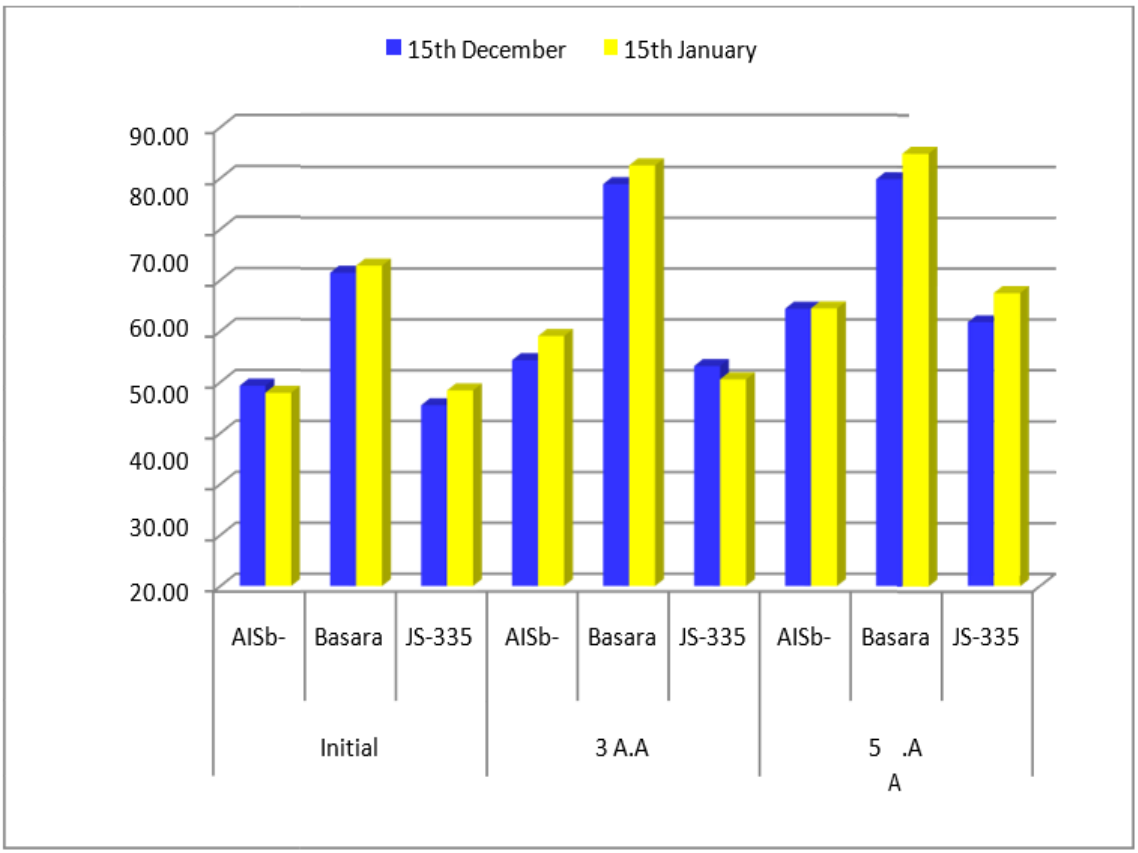

Fig. 3. Effect of dates of sowing and varieties on electrical conductivity (µScm^{-1} g^{-1}) of soybean seed produced during off season at Rajendranagar

The varieties differed considerably in this feature at the beginning, 3 AAT, and 5 AAT. Basara (65291) had the greatest seedling vigor index II at the beginning, followed by JS-335 (52212) at 3 AAT, and JS-335 at 5 AAT (45205). AISb-50 (37618) of 5 AAT had the considerably lowest seedling vigor index II of all. The seedling vigour index II decreased with rapid aging; these findings are consistent with those of Farhadi *et al*. [11] in chickpea.

The difference among the varieties revealed that speed of germination was significantly superior for JS-335 at initial, 3 AAT and 5AAT *viz*., 25.70, 23.90 and 20.64. At initial stage the varieties AISb-50 (24.38) and JS-335 (25.70) found to be on par with each other. Where as significantly lowest speed of germination was found in Basara at 5 days of accelerated aging (14.29). A similar result was found by Saha and Sultana, [17] in soybean.

The field emergence (%) showed significant difference for varieties, with highest field emergence in JS-335 at initial (83.17%), 3 AAT (77.84%) and 5 AAT (66.84%), where as AISb-50 showed lowest field emergence of 38.83% at 5 AAT. The varieties Basara (51.17%), AISb-50 (53.50%) found to be on par with each other for 3 AAT.

Significantly lowest electrical conductivity (µScm^{-1}g^{-1}) was found in JS-335 at initial stage, 3 AAT (37.02, 41.96 µScm^{-1}g^{-1}) and in AISb-50 at 5AAT (54.57 µScm^{-1}g^{-1}), where as the varieties JS-335 and AISb-50 at initial and 5 AAT showed non-significant difference for this trait. The electrical conductivity increases upon ageing among the varieties, whereas similar findings was reported by Panobianco and Vieira, [18] in soybean.

3.3 Effect of Interaction between Varieties and Dates of Sowing on Seed Quality Parameters of Soybean Upon Accelerated Ageing

The interaction effect showed significantly highest germination percentage in AISb-50 of 15th December (89.00%), where as lowest was found in Basara of 15th December (80.67%) at

initial stage (Table 2 and Plate 1). After 3 AAT this trait exhibited significant superiority for JS-335 of 15th December (81.67%), where as remaining interactions are found to be on par with each other except Basara of 15th January (68.00%). Significantly superior germination % was shown by JS-335 variety sown on 15th December. Among all the variety Basara of 15th January exhibited lowest germination percentage (60.33%).

The interaction between varieties and dates of sowing revealed that significant difference was shown for this trait with higher seedling length in JS-335 of 15th December at initial, 3 AAT and 5 AAT *viz*., 32.50cm, 26.60cm and 21.54cm. Whereas the lowest length was recorded in AISb-50 of 15th December sown crop (18.00cm) at 5 AAT. These results are is in accordance with the findings of Farhadi *et al*., [11] in cotton, stated that upon accelerated ageing there is decrease in seedling length of varieties.

Significantly highest seedling vigour index I was found in JS-335 of 15th December sown crop among all the interactions at initial (2803), 3 AAT (2169) and 5 AAT (1592). The seedling vigour index I was highest at initial stage compared to 5 AAT, while lowest vigour index I was shown in Basara (1196) of 15th January sown crop. The study reveals that with an advancement of ageing the seedling vigour index was declined, which is in line with the studies of Sung and Jeng, [8] in ground nut.

Among the treatments significantly higher seedling dry weight (mg) was found in JS-335 of 15th December sown crop at initial (853.1 mg), 3 AAT (842 mg) and 5 AAT (773.2mg), with the increase of ageing period the seeding dry weight is declined as lowest seedling dry weight (mg) was recorded in JS-335 of 15th January sown crop (464.2mg).

Seedling vigour index II was found to be significantly superior for the variety AISb-50 sown on 15th December at initial (73597), JS-335 at 3 AAT (68890) and in JS-335 at 5 AAT (56545) sown on 15th December, whereas the varieties sown on 15th January showed non-significant difference for this trait for 3 days of accelerated ageing. These findings are similar with the results of Alvarenga and Marcos-Filho, [19] in cotton.

The results revealed that among the interactions significantly superior speed of germination was found in JS-335 sown on 15th December (26.07) at initial stage, JS-335 at 3 AAT (25.06) and 5 AAT (21.00) of 15th January sown crop. Upon 5 AAT lowest speed of germination was found in Basara sown on 15th December (13.27).

The interaction between varieties and dates of sowing revealed that the field emergence (%) was significantly higher for JS-335 of 15th December sown crop at initial,3 AAT respectively and in 5 AAT *viz*., 84.33%, 81.00% and 70.67%. Whereas lowest field emergence (%) was exhibited in Basara of 15th January sown crop at initial (47.67%) and at 3 AAT (33.33%). These results were consistent with the findings of Luka Andric *et al*., [12] in soybean who reported that seed vigor and field emergence in soybean were reduced upon ageing as physiological stress reduces the seed quality of soybeans.

Among the interactions lowest electrical conductivity ($\mu Scm^{-1}g^{-1}$) was found in JS-335 of 15th December sown crop with values of 35.55 $\mu Scm^{-1}g^{-1}$ at initial, 43.26 µS $cm^{-1}g^{-1}$ at 3 AAT and 51.88 $\mu Scm^{-1}g^{-1}$ at 5 AAT and among all the varieties Basara showed more electrical conductivity (Table 3) Upon accelerated ageing there is an increase in electrical conductivity among the interactions, meanwhile the variety Basara sown on 15th January showed higher electrical conductivity 85.00$\mu Scm^{-1}g^{-1}$ for 5 AAT. Irrespective of the dates of sowing and ageing period studied the variety Basara showed very high electrical conductivity which indicates the more leakage of leachates. This may be due to the lack of intactness of the seed coat. The varieties AISb-50 and JS-335 showed less leachates and more storability which is evident from lower EC levels at different ageing studies.

The paper investigates the impact of off-season planting dates and varieties on seed quality parameters of soybeans, particularly focusing on the accelerated aging process. This research was conducted in Adilabad, where soybean cultivation faces unique challenges related to agro-environmental factors Bertorelli and Olivares, [20] Hernandez *et al*., 2018c), climate dynamics Campos, [21] Olivares, [22] soil characteristics Olivares, [23] Olivares *et al*., 2022), and agronomic management practices typical of tropical environments in Latin America [24,25,26].

Table 3 Effect of sowing dates and varieties on seed quality parameters of soybean

Treatment	Seedling vigour index II			Speed of germination			Field emergence (%)			Electrical conductivity(μScm^{-1}g^{-1})		
	Initial	3 AAT	5 AAT	Initial	3 AAT	5 AAT	Initial	3 AAT	5 AAT	Initial	3 AAT	5 AAT
D1	71541	60755	49854	23.44	19.58	17.40	81.22	72.89	60.78	45.49	55.57	62.14
D2	55429	36587	33022	23.06	20.01	17.10	66.11	48.78	41.78	46.47	57.51	65.75
V1	61507	48412	37618	24.38	21.31	16.84	76.50	53.50	38.83	38.62	46.79	54.57
V2	65291	45389	41489	19.68	14.19	14.29	61.34	51.17	48.17	62.31	80.88	82.50
V3	63657	52212	45205	25.70	23.90	20.64	83.17	77.84	66.84	37.02	41.96	54.76
D1V1	74571	58432	39398	24.43	21.74	18.67	84.33	68.67	53.33	39.30	44.42	54.53
D1V2	66454	54942	53617	19.83	14.27	13.27	75.00	69.00	58.33	61.61	79.03	80.00
D1V3	73597	68890	56545	26.07	22.74	20.27	84.33	81.00	70.67	35.55	43.26	51.88
D2V1	48443	38391	35838	24.33	20.87	15.00	68.67	38.33	24.33	37.93	49.16	54.61
D2V2	64127	35835	29361	19.53	14.10	15.30	47.67	33.33	38.00	63.01	82.73	85.00
D2V3	53716	35534	33865	25.33	25.06	21.00	82.00	74.67	63.00	38.48	40.65	57.64
GM	63485	48671	41437	23.25	19.80	17.25	73.67	60.83	51.28	45.98	56.54	63.94
C.D. @5%												
D	5427	4480	3674	2.33	1.09	1.22	5.04	5.06	5.31	3.32	3.35	5.09
V	6647	5487	4500	2.85	1.33	1.50	6.17	6.19	6.50	4.07	4.11	6.24
DxV	9400	7759	6363	4.04	1.88	2.12	8.73	8.76	9.20	5.76	5.81	8.82
C.V.(%)	8.32	8.96	8.63	9.75	5.35	6.90	6.66	8.09	10.08	7.04	5.77	7.76
S. Em.(±)	3051	2518	2065	1.31	0.61	0.69	2.83	2.84	2.98	1.87	1.88	2.86
SE.d.	4314	3561	2921	1.85	0.86	0.97	4.00	4.02	4.22	2.64	2.66	4.05

Understanding the effects of off-season planting dates and varieties on seed quality parameters is of paramount importance for soybean production in these regions. Soybean (*Glycine max* L.) is a major crop globally, contributing significantly to food security and agricultural economies [27,28]. However, achieving optimal seed quality is essential for ensuring successful crop establishment and maximizing yield potential, especially in off-season cultivation scenarios [29] Hernandez *et al*., 2017).

The findings of this study provide valuable insights into the interactions between planting dates, soybean varieties, and seed quality parameters under off-season conditions [30,31]. By evaluating parameters such as germination speed, field emergence, electrical conductivity, seedling length, seedling vigor index, seedling dry weight, and vigor index II, the research elucidates the impact of different factors on seed quality throughout the aging process [32,33].

The observed variations in seed quality parameters highlight the significance of planting dates and soybean varieties in influencing seed performance [34,35,36]. For instance, the study identifies the 15th January sowing date as yielding the highest germination percentage, while certain varieties, such as AISb-50, exhibit superior performance across multiple parameters. Additionally, the analysis of electrical conductivity after accelerated aging underscores the deterioration of seed quality over time, emphasizing the importance of timely seed harvesting and storage practices [37].

The implications of these findings extend beyond academic discourse to practical applications in soybean cultivation in tropical environments [38,39]. Farmers, agricultural extension services, and policymakers can utilize this research to optimize planting schedules [40] select suitable varieties, and implement effective seed management strategies to enhance soybean productivity and quality [41,42].

In conclusion, the investigation into off-season planting dates and varieties' effects on soybean seed quality parameters offers valuable scientific insights with direct relevance to agricultural practices in tropical environments of Latin America [43,44]. By addressing the complex interplay between agro-environmental factors [45] agronomic management practices [46] and seed quality dynamics, this study contributes to the development of sustainable soybean production strategies, ultimately fostering agricultural resilience [47,48] and food security in the region [49-57].

4. CONCLUSION

The seed quality parameters were significantly affected by sowing date, varieties and accelerated ageing, the freshly harvested seed of 15th December sown crop had good seed quality compared to the seed subjected to 3 AAT and 5 AAT.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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