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Research Article

Effect of different temperatures on seed quality parameters during storage in Soybean (*Glycine max* (L) Merril)

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ABSTRACT

Two popular cultivars of soybean JS335 and Basara were stored at four different temperatures at 15^{0}C (cold storage), 30^{0}C and 40^{0}C and ambient conditions. The seed quality parameters viz., per cent normal and abnormal seedlings, per cent dead seeds, moisture percentage, seedling vigour index-II and electrical conductivity were estimated at bi- monthly intervals over 8 months in two consecutive years. The seed stored at higher temperatures at 40^{0}C has recorded very low-quality parameters followed by the seed stored at 30^{0}C in both the varieties. The seed quality parameters of the seed stored at ambient and 30^{0}C were almost on par with each other in JS335 and Basara. The highest seed quality is maintained in the seed stored at cold storage conditions only. The highest positive correlation is observed between germination per cent and seedling vigour index-II and between dead seeds and electrical conductivity. The principal component analysis has shown that the biplots for PC2 and PC3 had revealed the germination percentage i.e., normal seedlings (28%) and seedling vigour index-II (33%) have contributed more towards the seed quality.

Keywords- *Soybean, Temperatures, Germination Per cent, Seedling Vigour index-II, Electrical Conductivity*

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INTRODUCTION

Soybean seed especially the breeder and foundation seed generally stored at cold storage conditions (15^{0}C and R.H. 45%) after processing but under informal systems, the seed produced is stored under ambient conditions only without any control over temperature and relative humidity which had a significant effect on seed quality. Production of good quality soybean seeds has always been one of the main challenges in the seed distribution system [1]. It is highly difficult to produce and store the seeds and to maintain the quality of a determined seed lot under ambient conditions [2,3]. The post-harvest storage is important especially in crops like soybean where variations in temperature and relative humidity have negative influences on seed quality [4, 5]. If the storage conditions are not optimum the soybean will lose its activity and in turn result in poor seed quality.

Among the various physiological attributes, vigour has an important role in expressing the physiological potential of the seed, and is associated with essential seed function characteristics such as longevity, germination, rapid and uniform emergence, as well as tolerance to environmental adversity [2, 6]. The evaluation of seedling performance can provide useful results regarding seed quality considering their ability to manifest damage in some points of the production chain such as that generated at harvest and during the processing phase [7, 8].

For efficient storage not only good initial quality seed is necessary to avoid loss of physiological quality such seed will also be stored under ideal conditions under optimum temperatures below 20^{0}C and relative humidity below 60% [9, 10,11]. If proper care is not taken while drying and storage they will harm seed quality [12, 13].

Drying soybean seeds at temperatures of 45^{0}C and 55^{0}C directly affects the viability, germination and vigour of soybean seeds with a further negative impact on the storage potential of the material. Under temperatures greater than 20^{0}C and relative humidities that are not controlled will reduce the potential of seed stored [14]. Storage time will also affect the seed quality and increases seed deterioration [15, 16]. In the present study the JS 335 and Basara seed were stored at cold storage conditions (15^{0}C and 45% RH), 30^{0}C and 40^{0}C temperatures (seed stored in two different incubators) and at ambient conditions where there is no control over temperature and relative humidity. The study is conducted to evaluate the effect of different storage temperatures on soybean seeds stored in jute bags and evaluated how the temperatures will affect the physiological quality of soybean seeds the study was taken up for two consecutive years.

MATERIAL AND METHODS

The experiment was carried out at Seed Testing Laboratory of Department of Seed Science and Technology, Seed Research and Technology Centre, PJTSAU, Hyderabad for two consecutive years 2020-21 and 2021-22. The seed quality parameters about percent normal seedlings, percent abnormal seedlings, percent dead seeds, Moisture percentage, Seedling vigour index-II and Electrical conductivity were tested using the following methods.

i. Seed Germination (%)

The germination test was conducted as per the ISTA rules [17] by adopting between paper method (BP). Each replication with 100 seeds for a treatment were used for the germination test that was placed in seed germinator and maintained at a constant temperature of 25 ± 2 °C and high humidity. On the day of the final count *i.e.*, 7th day, the number of seeds germinated was counted and the per cent normal seedlings, abnormal seedlings and dead seed were calculated as follows:

$$\text{Seed germination (\%)} = \frac{\text{Number of normal seedlings}}{\text{Total number of seeds planted}} \times 100$$

ii. Seedling Dry Weight (mg)

Ten normal seedlings were placed in butter paper bags. These were placed in a hot air oven maintained at 80 ± 1 °C for 24 h. After completion of the drying period, these seedlings were kept in a desiccator for cooling. The weight of dried seedlings was recorded mean weight was calculated per seedling and expressed in milligrams per seedling.

iii. Seedling Vigour Index II

The seedling vigour indices were calculated as per the method suggested by [18] as given below and expressed in whole numbers.

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

iv. Electrical Conductivity ($\mu S\ cm^{-1} g^{-1}$)

Electrical conductivity was measured by following the procedure mentioned in Seed Testing Rules [17]. Three replicates of 50 seeds each drawn randomly from pure seed fraction was weighed to two decimal places. Cleaned conical flasks were used to not affect the conductivity of the samples. We have added 250 ml of distilled water with a conductivity of water less than 5 $\mu S\ cm^{-1}$ to the containers and covered them with aluminum foils to avoid contamination. The containers were placed at 20 ± 2 °C for 18-24 h prior to placing the seeds in the water. Two containers filled with only distilled water were used as control. The seed samples were weighed and placed into the prepared containers and swirled gently to completely immerse all the seeds. Each container was covered and placed at 20 ± 2 °C for 24 h in an incubator. After 24 h, the containers were swirled gently to mix the leachates and the conductivity was measured using a conductivity meter. The conductivity of the samples was calculated by the following formula:

$$\text{Electrical conductivity} = \frac{\text{Conductivity reading } (\mu S\ cm^{-1}) - \text{background reading}}{\text{Weight of replicate (g)}} \ (\mu S\ cm^{-1} g^{-1})$$

v. Seed moisture content (%)

The moisture content of seed was determined by the hot air oven method as per ISTA rules. 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 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.

$$\text{Moisture content (\%)} = \frac{M_2 - M_3}{M_2 - M_1} \times 100$$

Where,
M_1 = Weight of the metal container along with the lid in grams
M_2 = Weight of the metal container along with the 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

RESULTS AND DISCUSSION

i. Per cent normal seedlings

The two years data on the interaction effects of temperature with soybean varieties Basara and JS 335 stored for 8 months duration for per cent normal seedlings is depicted in Table.1. There is no significant difference observed for normal seedlings per cent in both JS 335 and Basara varieties stored at 30^{0}C and ambient conditions with the Pr (> F) value of 0.0265 after 2 months of storage. While, the interaction effects of year with varieties significant difference is observed in Basara variety with the Pr (> F) value of 0.0377 (Table. 1). After 4 months of storage no significant difference is observed in Basara seed stored at 30^{0}C and ambient conditions while JS 335 recorded significant difference at all temperatures with Pr (> F) value of 0.0001. For years x variety interaction Basara and JS 335 showed significant difference with Pr (> F) value of 0.0256. After 6 months of storage JS335 seed recorded no difference in the per cent normal seedlings stored at 30^{0}C and 40^{0}C but Basara has shown a significant differences at all temperatures with Pr (> F) value of 0.0001and for years x variety interaction both varieties showed significant difference with Pr (> F) value of 0.0299. After 8 months of storage JS335 and Basara showed no difference in the per cent normal seedlings while for years x variety interaction Basara and JS 335 showed significant difference with Pr (> F) value of 0.0198 (Table.1, Fig.1a & 1b). The results were following [19, 11, 20] who observed that climate-controlled storage at lower temperatures is a suitable method for maintaining seed quality in soybean seed and storage environment will play an important role and beneficial in providing better results in a germination test. Several authors have verified the germination rates of soybean seeds during six months of storage in artificially cooled conditions [19, 21, 11, 22, 23, 24, 25 and 26]. However, [27] found that drying at low air temperatures reduced the germination effects of storage in a non-conditioned environment for six months.

ii. Per cent abnormal seedling

The interaction effect of different temperatures on varieties Basara and JS 335 seeds for per cent abnormal seedlings is presented in Table.2. After 2 months of storage there is no significant difference observed in JS 335 seed stored at 40^{0}C and ambient conditions, in Basara, seed stored at 30^{0}C and ambient conditions while for the interaction effect of years with varieties there is no significant difference with Pr(> F) value of 0.6094. After 4 months of storage no significant difference is recorded in Basara seed stored at 30^{0}C and ambient conditions while in JS335 no significant difference is observed for % abnormal seedlings in at 30^{0}C, 40^{0}C and ambient conditions. For years x variety interaction significant difference is recorded with Pr (> F) value of 0.0059. After 6 months of storage no significant difference is recorded in Basara kept at 30^{0}C and ambient temperatures but in JS335 at 30^{0}C and 40^{0}C and ambient conditions while for years x variety interaction revealed a significant difference with Pr(> F) value of 0.0136. After 8 months of storage no significant difference is observed in seed stored at 30^{0}C, 40^{0}C and ambient conditions in both the varieties while for years x variety interaction showed a significant difference with Pr(> F) value of 0.0150 (Table.2, Fig.2a & 2b). [11] found that soybean seeds stored for 180 days maintained their initial germination rate when stored at 20^{0}C, but at 27^{0}C they suffered reductions in germination and losses in the commercial pattern. According to [20], soybean seeds with an initial 94% germination stored for 225 days in an air-conditioned environment at 20^{0}C had a reduced germination rate of 91%, while those stored in a non-conditioned environment were reduced to 84% germination. Soybean seeds stored in environments with ambient temperatures had accelerated deterioration over the storage period.

iii. Per cent dead seeds

There is no significant difference in Basara seeds stored at 40^{0}C and 30^{0}C for per cent dead seeds at 2 months of storage while a significant difference is recorded in JS335 at all temperatures while for the interaction effect of years with varieties also recorded significant difference with Pr (> F) value 0.0013. After 4 months of storage no significant difference is observed in Basara seed stored at 30^{0}C, 40^{0}C and ambient conditions but in JS 335 significant difference is recorded at all temperatures with Pr (> F) value of 0.0295. After 6 months of storage no significant difference is observed in per cent dead seeds stored at 30^{0}C and ambient temperatures in Basara but in JS335 no significant difference was recorded for the seeds stored at 30^{0}C, 40^{0}C and ambient conditions whereas for years x variety interaction both varieties showed significant difference with Pr (> F) value 0.0050. After 8 months of storage, no difference observed in the per cent dead seeds of soybean stored at 30^{0}C and ambient conditions in JS 335 whereas for years x variety interaction significant difference was observed in both the varieties (Table.3& Fig.3a, 3b). The effect of different drying temperatures on the physiological quality of seeds was also observed by [28] in sweet sorghum seeds, where in a reduction in germination was observed especially at temperatures above 40^{0}C each increase in the degree of temperature led to reduction of half germination percentage. The deleterious effect portraying the damage caused by drying in soybean seeds was also observed by [29]. Upon finding that the use of drying temperatures higher than 40^{0}C led to cell damage, such as membrane disarray and leaching of solutes, mainly in the region of the embryonic axis, harmful to the development of seedlings and thus reducing the two main physiological properties of germination and vigour.

iv. Moisture percentage

No significant difference is recorded in Basara seeds stored at 40^{0}C, ambient conditions and 30^{0}C for moisture per cent and for JS 335 no significant difference observed in seed stored at 30^{0}C and 40^{0}C whereas, the interaction effects of years with varieties has recorded no significant difference after 2 months of storage with Pr (> F) value 0.4026. After 4 months of storage, Basara seed recorded significant difference for moisture percentage at all temperature conditions while JS 335 showed no significant difference in the seeds stored at 30^{0}C and ambient conditions. For years x variety interaction has showed no significant difference with Pr (> F) value 0.1755. After 6 months of storage, Basara seed showed no significant difference for moisture percentage but JS335 has shown no significant difference in the seeds stored at 30^{0}C & 40^{0}C and 40^{0}C & ambient conditions whereas for years x variety interaction both the varieties showed no significant difference. After 8 months of storage JS335 recorded no difference in the per cent moisture in the seed stored at 30^{0}C and 40^{0}C while for years x variety interaction both the varieties showed no significant difference with the Pr (> F) value 0.0565 (Table.4, Fig.4a & 4b).

V. Seedling vigour index-II

After 2 months of storage, there is a significant difference observed for the seedling vigour index-II in Basara seeds but in JS 335 no significant difference is recorded in the seed stored at 30^{0}C, 40^{0}C and ambient temperatures whereas, for the interaction effect of years with varieties has recorded significant difference with Pr (> F) value of 0.0267. After 4 & 6 months of storage no significant difference is observed in Basara seed stored at 30^{0}C and ambient conditions while JS 335 has shown a significant difference at all temperatures whereas, for years x variety interaction significant difference is observed at all temperatures for seedling vigour index-II. After 8 months of storage JS335 and Basara had shown significant differences in the seedling vigour index-II of soybean seed stored at all temperatures whereas for years x variety interaction Basara and JS 335 showed a significant difference with Pr (> F) value of 0.0001 (Table.5, Fig.5a & 5b). [30]Garcia *et al*. (2004) observed that thermal damages might not manifest immediate effects on germination however, after a period of storage; seed vigour will undergo considerable reductions. [31] noted that analysis of seedling growth and other complementary tests compose a vigour index for evaluation of soybean seed quality and results inferred that the deleterious effects of high temperatures during drying and storage were more expressive on the growth of the shoots and roots.

Vi. Electrical Conductivity

There is no significant difference observed in Basara seed stored at 30^{0}C & 40^{0}C whereas, JS335 recorded significant difference for electrical conductivity at all temperatures after 2 months of storage while years x variety interactions significant difference is observed at all temperatures with Pr (> F) value of 0.0076. After 4 months of storage no significant difference was observed in Basara seed stored at 30^{0}C and ambient conditions while JS 335 has recorded significant difference at all temperatures while for years x variety interaction both the varieties showed significant differences. After 6 months of storage Basara has recorded no significant difference in the seed stored at 30^{0}C and ambient conditions while JS 335 has shown a significant difference among all the temperatures whereas, for years x variety interaction both the varieties showed significant difference with Pr (> F) value of 0.024. After 8 months of storage no significant difference is observed in JS 335 seed stored at 30^{0}C and ambient conditions but Basara has recorded a significant difference at all temperatures with Pr (> F) value of 0.0314. [18, 10] observed lower electrical conductivity in seeds stored in a refrigerated environment than those stored without climate control. [32, 33, 34] found that soybean seeds showed increased electrical conductivity values over time of storage. [23] found that soybean seeds stored in Kraft paper packaging had lower values of electrical conductivity than those in uncooled conditions. According to [22], soybean seed lots with high vigour have high electrical conductivity values below 80 mS cm/1/g. [33] observed that soybean seeds had higher values of electrical conductivity after 180 days of storage.

Vii. Correlation analysis

The correlation analysis showed significant and positive correlation with the majority of seed quality traits (Fig 7). The highest positive correlation is observed between germination per cent and seedling vigour index-II (r = 0.90**) and also between dead seeds and electrical conductivity (r = 0.91**). Significantly positive correlations were observed between abnormal seedlings with dead seeds (r = 0.63**) and moisture per cent (r = 0.85**) also.

Viii. Principal component analysis

The principal component analysis has shown that the biplots for PC2 and PC3 had revealed the germination percentage i.e., normal seedlings (28%) and seedling vigour index-II (33%) have contributed more towards the seed quality (Fig.8).

CONCLUSIONS

The increase in the storage temperatures above 40^{0}C affects seedling performance and in turn the effect is accentuated over the time of storage. Cold storage or ambient storage conditions can be preferred for storage up to 180 days under storage conditions to maintain good seed quality.

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Table 1. Interaction effects on JS 335 and Basara soybean seed stored at different temperatures for per cent normal seedlings

S.no	Interactions	2MAS		4 MAS		6 MAS		8MAS	
		Basara	JS335	Basara	JS335	Basara	JS335	Basara	JS335
	Temperature x variety								
1	30 ^{0}C	82.25 b	84.00 b	82.00 b	76.50 c	72.50 b	73.25 b	65.50 b	67.50 b
2	40^0 C	81.00 c	82.50 c	80.50 c	75.50 d	70.50 c	73.75 b	62.50 c	64.00 c
3	Ambient	82.25 b	84.00 b	82.50 b	77.50 b	72.00 b	72.00 c	66.00 b	67.50 b
4	cold storage	88.00 a	87.50 a	87.50 a	85.50 a	85.50 a	83.00 a	83.00 a	81.50 a
	Pr(> F)	0.0265	-	0.0001	-	0.0001	-	0.0491	-
	Years x Variety								
1	1st year	84.37 b	86.12 a	81.00 b	82.50 a	72.50 b	72.50 a	64.25 a	64.50 a
2	2nd year	82.37 a	82.87 a	80.50 a	80.50 b	70.50 a	71.00 b	66.50 b	67.25 b
	Pr(> F)	0.0377	-	0.0256	-	0.0299	-	0.0198	-

** Means with the same letter are not significantly different*

Table 2 Interaction effects on JS 335 and Basara soybean seed stored at different temperatures for per cent Abnormal Seedlings

S.no	Interactions	2MAS		4 MAS		6 MAS		8MAS	
		Basara	JS335	Basara	JS335	Basara	JS335	Basara	JS335
	Temperature x variety								
1	30^{0}C	13.00 ab	10.50 b	15.50 a	16.50 a	15.50 a	18.75 b	21.00 a	25.00 a
2	40^0 C	14.00 a	12.75 a	13.25 b	16.75 a	13.25 b	20.50 a	22.50 a	23.50 a
3	Ambient	14.50 a	10.50 b	14.75 a	16.75 a	14.75 a	19.75 ab	20.50 a	23.50 a
4	cold storage	11.50 b	6.75 c	10.75 c	9.50 b	10.75 c	10.25 c	12.00 b	12.50 b
	Pr(> F)	0.0168	-	0.0187	-	0.0745	-	0.0447	-
	Years x Variety								
1	1st year	12.50 a	11.75 a	15.12 a	13.00 a	17.12 a	17.00 a	20.10 a	18.23 a
2	2nd year	12.00 a	11.50 a	16.62 b	14.12 b	18.12b	16.50 b	21.50 b	20.42 b
	Pr(> F)	0.6094	-	0.0059	-	0.0136	-	0.0150	-

**Means with the same letter are not significantly different*

Table 3. Interaction effects on JS 335 and Basara soybean seed stored at different temperatures for per cent Dead seeds

S.NO	Interactions	2MAS		4 MAS		6 MAS		8MAS	
		Basara	JS335	Basara	JS335	Basara	JS335	Basara	JS335
	Temperature x variety								
1	30^0 C	3.0 a	6.0 d	6.50 a	4.00 b	6.50 b	7.00 a	13.75 a	9.75 b
2	40^0 C	3.0 a	4.5 b	10.0 a	7.50 b	10.00 a	7.00 a	12.25 ab	13.25 a
3	Ambient	4.0 c	5.0 c	5.50 a	4.50 a	5.50 b	6.50 a	11.75 b	8.25 b
4	cold storage	3.5 b	3.5 a	2.50 b	3.00 a	2.50 c	4.50 b	5.25 c	5.75 c

	Pr (> F)	0.0241	-	0.0295	-	0.0212	-	0.0085	-
	Years x Variety								
1	1^{st} year	3.0 a	5.3 a	7.5 a	6.4 a	8.6 a	7.7 a	11.5 a	11.8 a
2	2^{nd} year	3.8 b	5.7 b	8.1 b	8.9 b	8.3 b	9.1 b	12.1 b	12.4 b
	Pr(> F)	0.0013	-	0.0091	-	0.0050	-	0.0182	-

Table 4. Interaction effects on JS 335 and Basara soybean seed stored at different temperatures for moisture percentage

S.No	Interactions	2MAS		4 MAS		6 MAS		8MAS	
		Basara	JS335	Basara	JS335	Basara	JS335	Basara	JS335
	Temperature x variety								
1	30^0 C	10.55 b	10.77 b	11.42 b	11.82 b	11.45 b	12.45 a	12.25 b	13.20a
2	40^0 C	10.65 b	10.87 b	10.30 d	12.25 a	10.30 d	12.35 ab	11.50 c	13.35 a
3	Ambient	10.90 a	11.12 a	11.75 a	11.77 b	11.75 a	12.20 b	12.60 a	12.85 b
4	cold storage	10.52 b	10.42 c	10.90 c	11.05 c	10.70 c	10.95 c	11.30 c	11.20 c
	Pr(> F)	0.0362		0.0000		0.0000			0.0000
	Years x Variety								
1	1^{st} year	10.37 a	11.25 a	11.20 a	12.45a	12.50a	13.20 a	12.45 a	12.35 a
2	2^{nd} year	10.27 a	11.10 a	11.30 a	12.75a	13.02a	13.35 a	12.75 a	12.20a
	Pr(> F)	0.4026		0.1755		0.1917		0.0565	

**Means with the same letter are not significantly different*

Table 5. Interaction effects on JS 335 and Basara soybean seed stored at different temperatures for seedling vigour index-II

S.NO	Interactions	2MAS		4 MAS		6 MAS		8MAS	
		Basara	JS335	Basara	JS335	Basara	JS335	Basara	JS335
	Temperature x variety								
1	30 C	155.62 b	150.62b	97.30 b	105.22 c	93.20b	79.65 c	82.25 c	67.80 c
2	40 C	139.45 d	150.90 b	90.02 c	95.62 d	84.15 c	75.50 d	73.30 d	56.70 d
3	Ambient	147.10 c	149.75 b	98.05 b	111.00 b	90.65 b	86.30 b	88.75 b	82.70 b
4	Cold storage	171.82 a	171.12 a	130.95a	129.10 a	118.15a	121.20a	115.20a	102.20a
	Pr(> F)	0.0000		0.0000		0.0375		0.0000	
	Years x Variety								
1	1^{st} year	154.10 a	152.15 a	98.9 a	103.5 a	87.2 a	76.2 a	76.9 a	81.2 a
2	2^{nd} year	148.75b	148.10 b	102.4 b	106.8 b	86.2 b	79.2 b	80.2 b	82.4 b
	Pr(> F)	0.0267		0.0300		0.0074		0.0001	

**Means with the same letter are not significantly different*

Table 6. Interaction effects of varieties JS 335 and Basara over different temperatures and years for Electrical conductivity

S.NO	Interactions	2MAS		4 MAS		6 MAS		8MAS	
		Basara	JS335	Basara	JS335	Basara	JS335	Basara	JS335
	Temperature x variety								
1	30^0 C	264.15 b	244.92 b	287.55 b	266.47 b	312.32 b	289.42 b	346.40 b	320.22 b
2	40^0 C	299.10 a	281.42 a	318.10 a	304.42 a	342.00 a	332.32 a	371.85 a	366.32 a
3	Ambient	255.95 b	232.80 c	283.62 b	251.12 c	304.85 b	279.07 c	328.55 c	307.52 b
4	cold storage	191.90 c	198.85 d	223.12 c	227.87 d	242.67 c	255.95 d	277.40 d	286.80 c
	Pr (> F)	0.0018		0.0055		0.0002		c	

	Years x Variety								
1	1st year	251.4 a	230.5 a	268.5 a	277.2 a	305.4 a	311.6 a	340.6 a	330.4 a
2	2nd year	243.2 b	225.4 b	276.8 b	281.4 b	304.2 b	310.7 b	325.7 b	336.8 b
	Pr(> F)	0.0076		0.0018		0.024		0.0314	

**Means with the same letter are not significantly different*

Fig.1 a) Normal seedlings percentage in Basara and JS 335 seed stored at different temperatures at bi-monthly intervals up to 8 months during 1st year

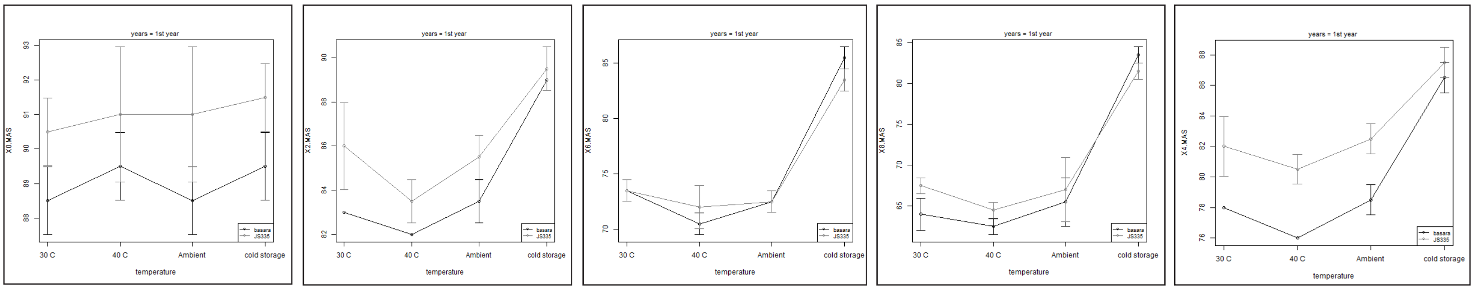


Fig.1 b) Normal seedlings percentage in Basara and JS 335 seed stored at different temperatures at bi-monthly intervals up to 8 months during 2nd year

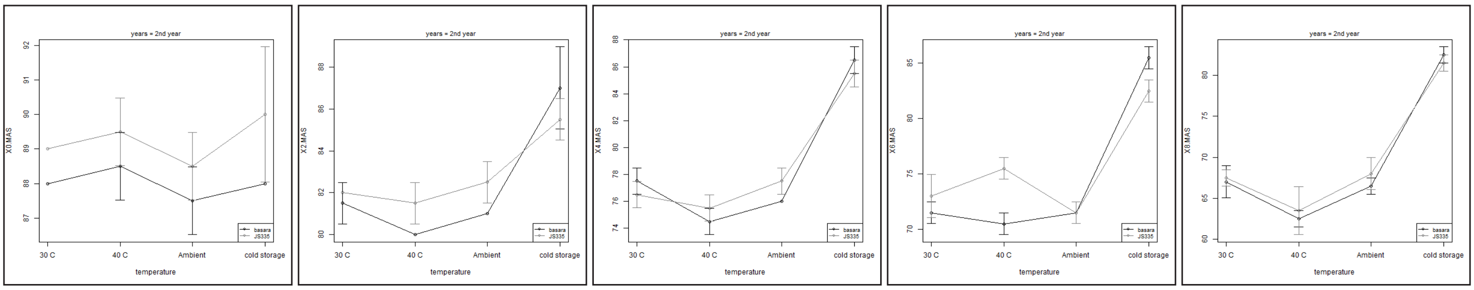


Fig.1 b) Normal seedlings percentage in Basara and JS 335 seed stored at different temperatures at bi-monthly intervals up to 8 months during 2nd year

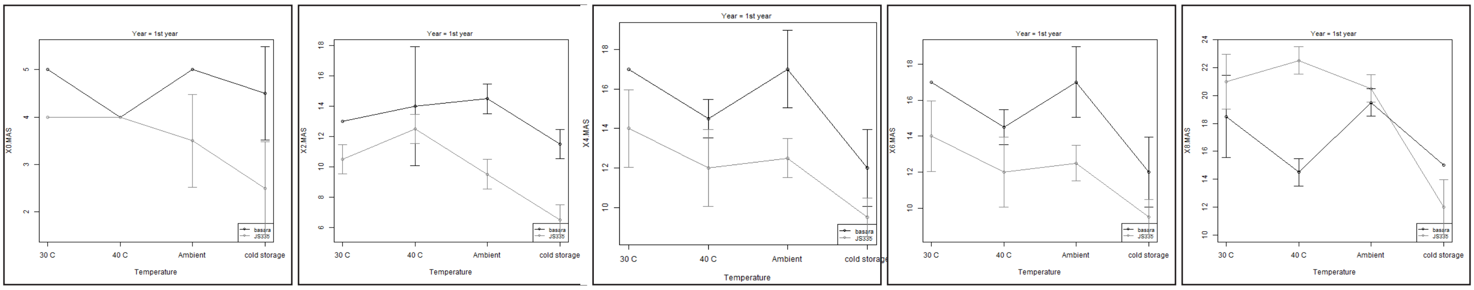


Fig.2 a) Abnormal seedlings percentage in Basara and JS 335 seed stored at different temperatures at bi-monthly intervals up to 8 months during 1st year

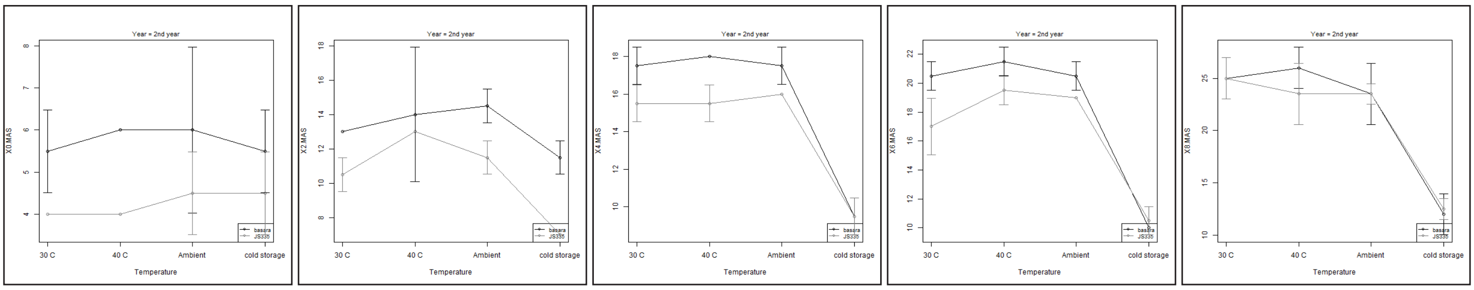


Fig.2 b) Abnormal seedlings percentage in Basara and JS 335 seed stored at different temperatures at bi-monthly intervals up to 8 months during 2nd year

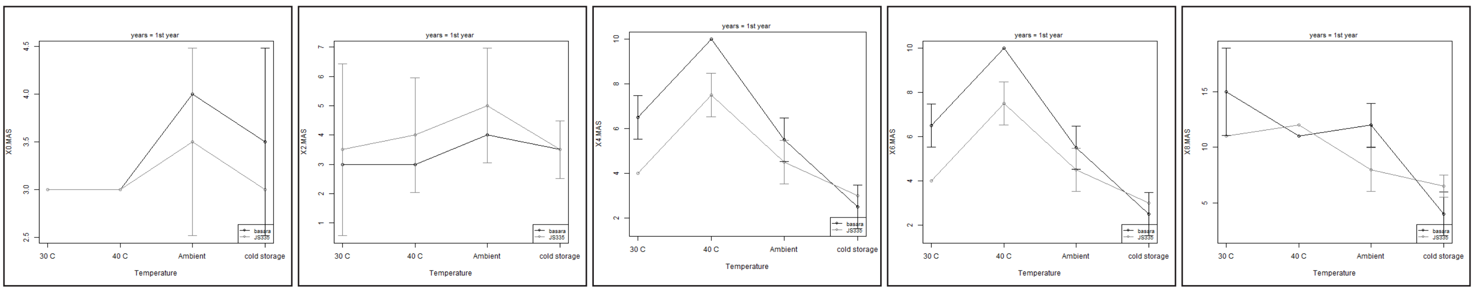


Fig.3 a) Dead Seeds percentage in Basara and JS 335 seed stored at different temperatures at bi-monthly intervals up to 8 months during 1st year

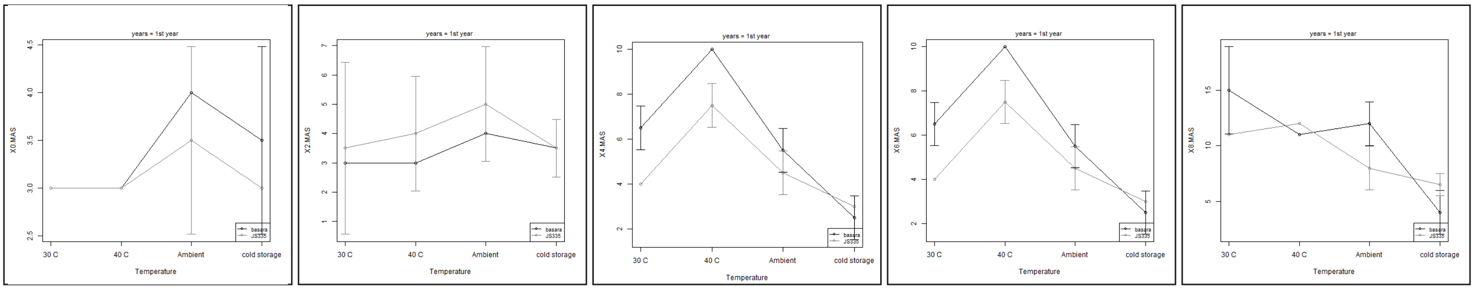


Fig.3 b) Dead seed percentage in Basara and JS 335 seed stored at different temperatures at bi-monthly intervals up to 8 months during 2nd year

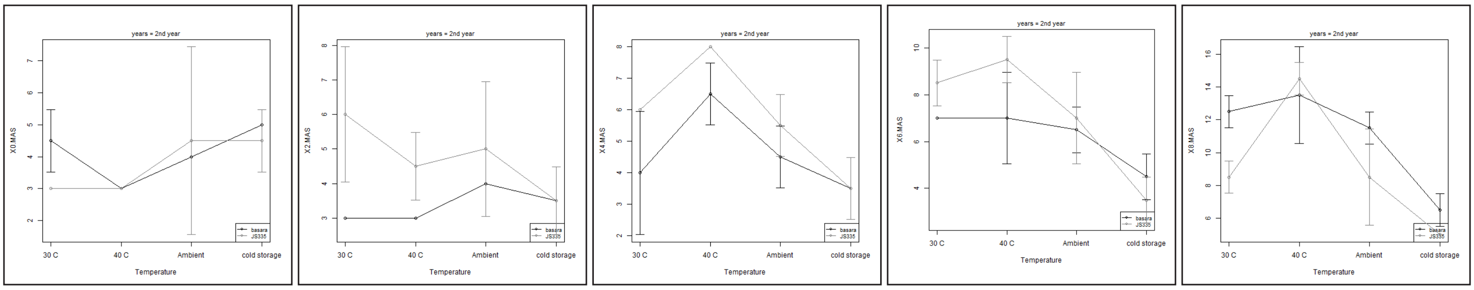


Fig.4 a) Moisture percentage in Basara and JS 335 seed stored at different temperatures at bi-monthly intervals up to 8 months during 1st year

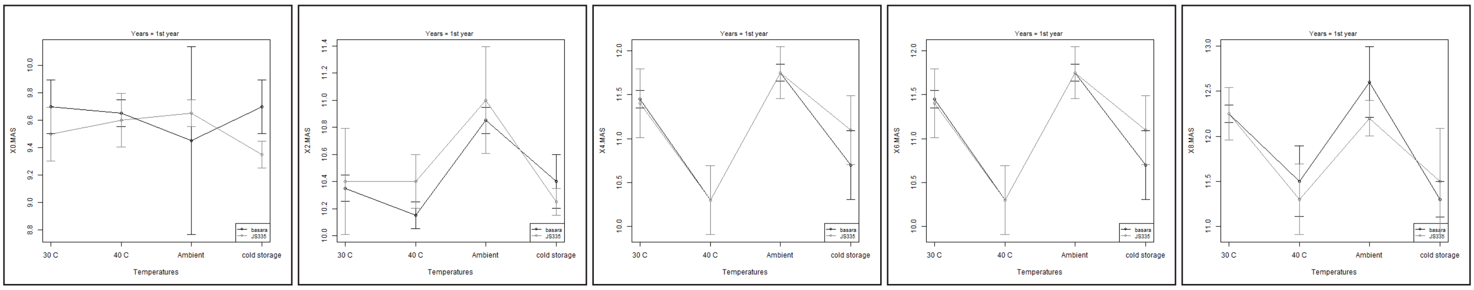


Fig.4b) Moisture percentage in Basara and JS 335 seed stored at different temperatures at bi-monthly intervals up to 8 months during 2nd year

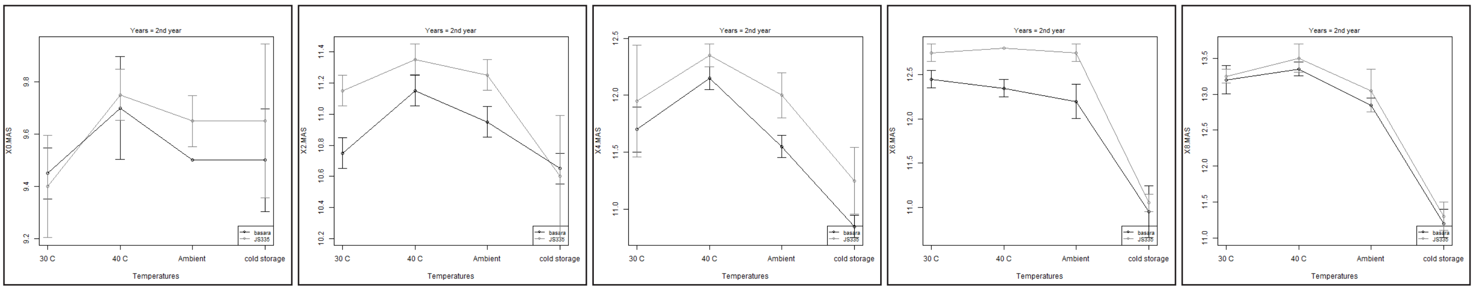


Fig.5a) Seedling Vigour Index-II in Basara and JS 335 seed stored at different temperatures at bi-monthly intervals up to 8 months during 1st year

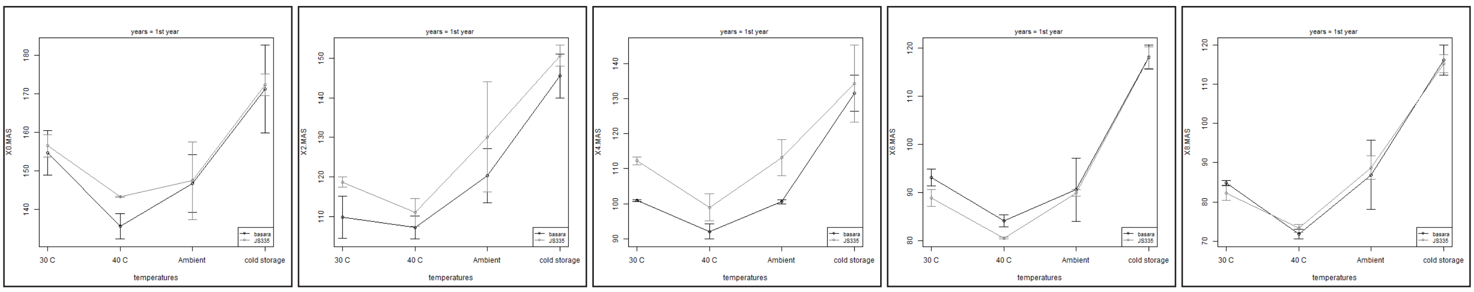


Fig.5 b) Seedling Vigour Index-II in Basara and JS 335 seed stored at different temperatures at bi-monthly intervals up to 8 months during 2nd year

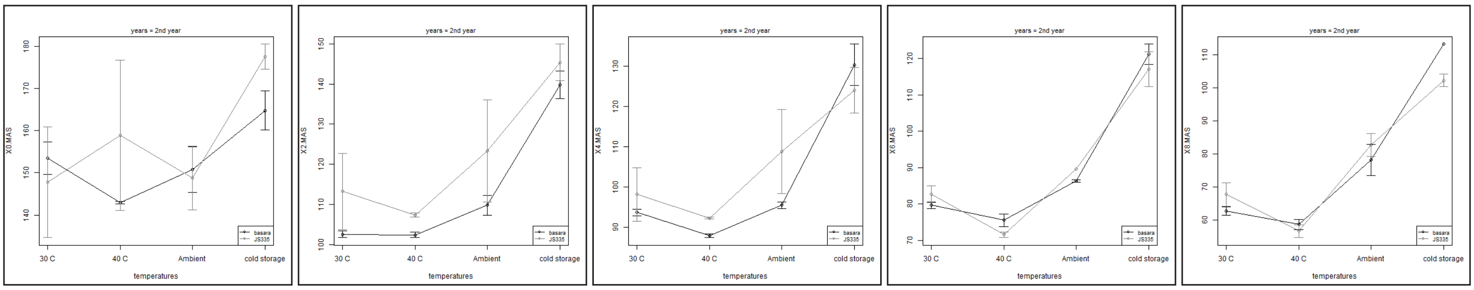


Fig.6a) Electrical conductivity in Basara and JS 335 seed stored at different temperatures at bi-monthly intervals up to 8 months during 1st year

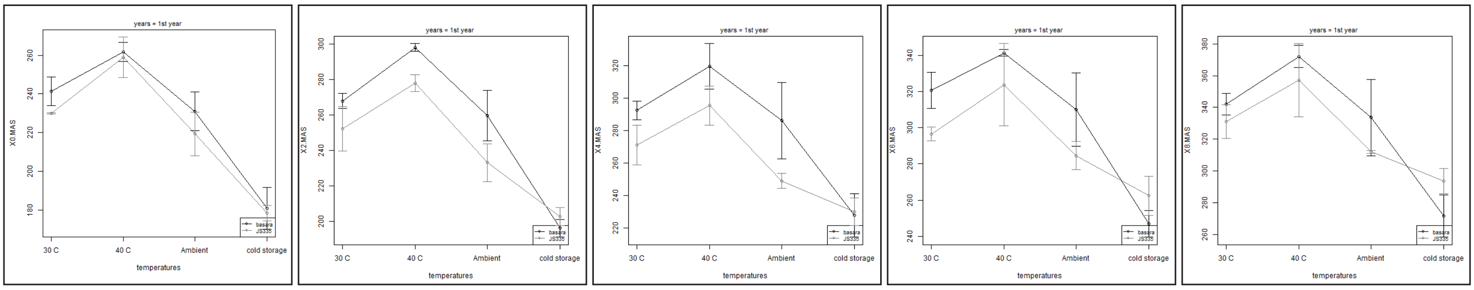


Fig.6 b) Electrical conductivity in Basara and JS 335 seed stored at different temperatures at bi-monthly intervals up to 8 months during 2nd year

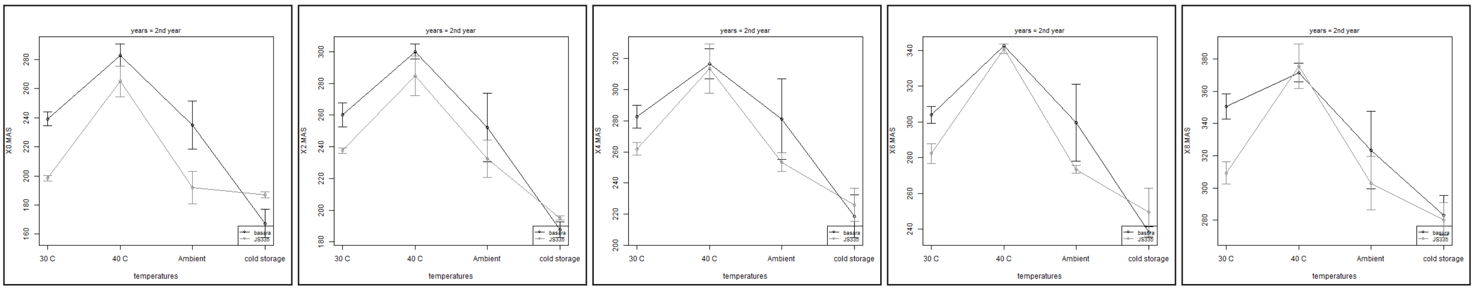
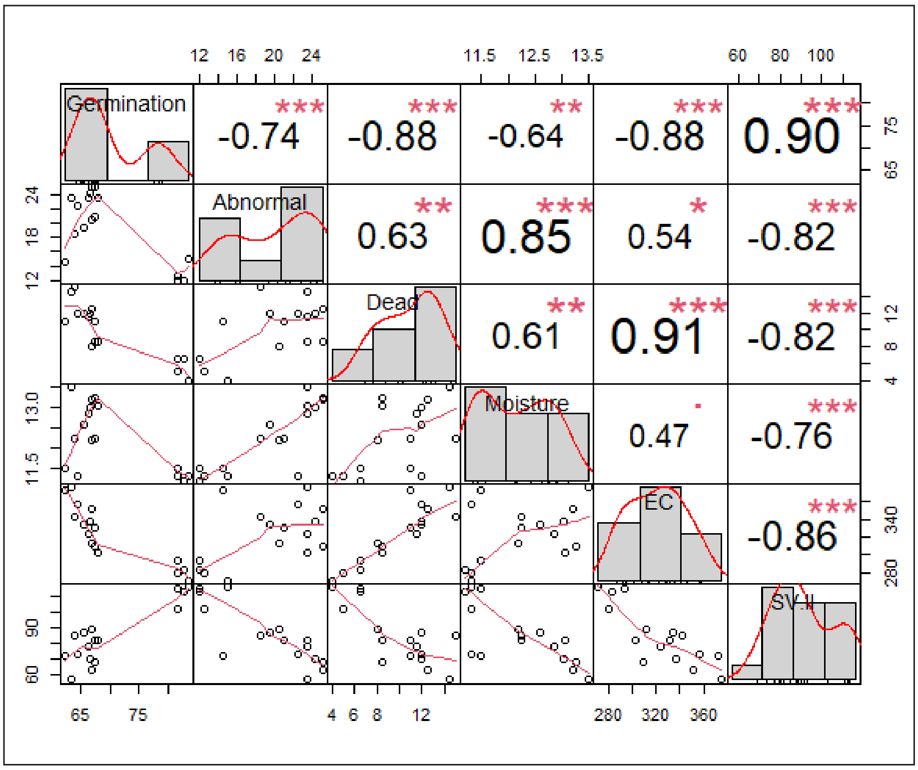
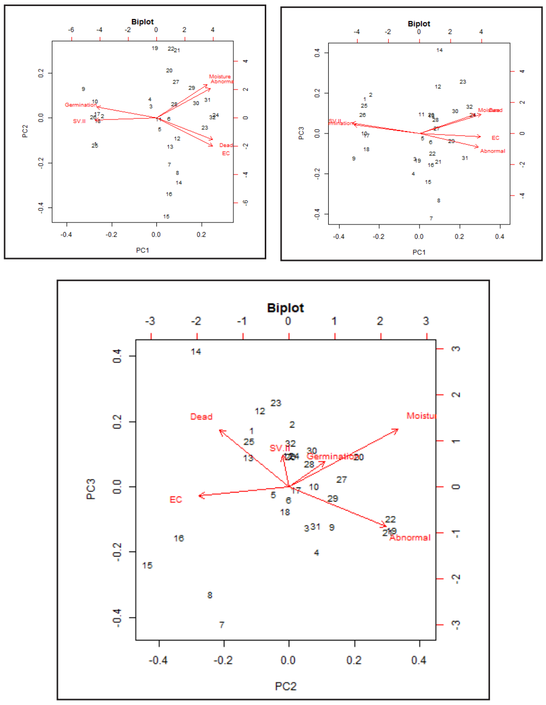


Fig.7: Correlation analysis for seed quality parameters



*EC: Electrical conductivity, SV-II: Seedling vigour index-II. ** P< 0.05*

Fig 8. Biplots for the seed quality parameters tested in Soybean seed stored at different temperatures



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