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Research Article
Effect of Packaging Materials and Storage Condition on Soybean Germination and Seedling Vigour in Makurdi

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Abstract
Studies were carried out on seeds of TGx-1448-2E and TGx-1951-3F in a 2×3 and 2×2 factorials experiment in a complete randomized designed replicated three times for packaging materials and storage conditions, respectively. The experiment was conducted at the Plant Breeding and Seed Science Laboratory, University of Agriculture, Makurdi. Packaging materials used were paper, cloth and polyethylene bags and the storage conditions were cold at 15°C and ambient at 32°C for 6 months. Germination test was carried out according to the standard procedure of International Seed Testing Association at 5 and 8 days after planting. Twenty five intact seeds were placed in petri-dishes containing double layered rolled filter paper. Petri-dishes were moistened everyday with distilled water and seeds were allowed to germinate. Data were obtained from five normal seedlings for root, shoot and seedling lengths. Seedling dry weight was determined after sun drying to a constant weight and weighed by an electronic balance. Data was subjected to analysis of variance using the Genstat Release 7.2 software. Significant treatment means were separated using LSD at 5% probability. Results indicated that packaging materials did not influence germination, seedling vigour of soybean while, cold storage conditions were significantly different for germination percentage, seedling dry weight however, seedling vigor was not significant. Cold storage had higher germination percentage and seedling dry matter but this did not translate to higher seedling vigour. Varieties performed differently under cold storage.

Key words: Packaging material, storage conditions, soybean, germination, seedling vigour

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Seed quality has significant direct influence on crop productivity levels (Bewley and Black, 1998). Proper packaging and ideal conditions of storage are required to maintain seed quality. Rao *et al*. (2006) reported that packaging container, storage condition and duration affects seed quality (viability and vigour). Seeds deterioration starts after physiological maturity in the field before and after harvesting through processing to storage until seeds become acceptable for planting (El-Borai *et al*., 1993). Seeds are packaged based on quantity, type of package, duration of storage and prevailing environmental conditions.

Quality of seeds in storage is a factor of seed production environment, pests, seed oil content, seed moisture content, mechanical damage, storage period, packaging material, pesticides, air temperature and relative air humidity in storage and biochemical injury of seed tissue (Tekrony *et al*., 1987; Reuzeau and Cavalie, 1995; Anfinrud, 1997; Al-Yahya, 2001; Guberac *et al*., 2003; Heatherly and Elmore, 2004).

Soybean seeds deteriorate rapidly in storage (Nkang and Umho, 1997). Therefore, the objective of this study is to determine the effect of packaging materials and storage condition on viability and vigour of soybean seeds.

MATERIALS AND METHODS

Two varieties of soybean TGx-1448-2E and TGx-1952-3F were obtained from the Molecular Biology Laboratory, University of Agriculture, Makurdi. Seeds so obtained were used for physiological studies in respect to storage and seed packaging materials. Two experiments were conducted at the Plant Breeding and Seed Science Laboratory, University of Agriculture, Makurdi, Nigeria.

Experiment 1 was a 2×3 factorial in CRD replicated three times. Treatment consist of 2 soybean varieties and 3 packaging materials (paper, cloth and polyethylene bags). The seed lot obtained from soybean harvested, treated and cleaned in December, 2013 was for six months (January-June, 2014) under cold storage of 15°C on average.

Experiment 2 was a 2×2 factorial in CRD replicated three times. Treatments consist of two soybean varieties and two storage conditions (cold storage at 15°C and room temperature). The seed lot obtained from soybean harvested, treated and cleaned in December 2013 was stored for six months (January-June, 2014).

Germination data was collected at 5 and 8 days after planting and germination test was carried out according to International Seed Testing Association (ISTA., 2009), for seed testing procedure for standard germination for both experiments. Germination percentage was determined according to Ajayi and Fakorede (2000) as outlined below:

$$\text{Germination percentage} = \frac{\text{No. of seedlings germinated}}{\text{Total No. of seeds planted}} \times 100$$

Germination index was calculated as stated below:

$$\text{Germination index} = \frac{\sum(\text{No. of plants emerged in a day})}{\text{Total No. of plants emerged by the 8th day}}$$

$$\text{Germination rate index} = \frac{\text{Germination index}}{\text{Total germination percentage (Decimal)}}$$

Data was also collected on seedling traits such root length, shoot length seedling dry weight and seedling vigor. Germination and count data were transformed by square root transformation before analysis of variance (ANOVA) using the Genstat Release 7.2DE. The LSD was used to separate significant means at 5% level of probability.

RESULTS

Experiment 1: Effects of variety and packaging materials on soybean seed germination and vigour: Results of ANOVA indicated that root, shoot and seedling length at 8 DAP were significant for variety while root and seedling length at 8 DAP and GRI was significant for packaging material (Table 1). All parameters measured were significant for variety×packaging material interaction except for shoot length, seedling dry weight and seedling vigour.

Table 1 also has mean values for the main effects of variety and packaging material. Generally, TGx-1951-3F had higher values than TGx1448-2E for all traits measured and only significantly different at 8 DAP for root, shoot and seedling lengths. TGx1951-3F had highest values for shoot, seedling length at 5 DAP and shoot length at 8 DAP. Paper bag had significant higher performance for traits that were significant at 8 DAP (root and seedling length) whereas polyethylene bags had the lowest values and significantly different from paper and cloth bags for germination rate index. The mean values for interaction of variety×packaging material is presented in Table 1. TGx 1448-2E stored in paper bag had higher values for all traits measured except shoot length and seedling length at 5 DAP, shoot length at 8 DAP, seedling dry weight and seedling vigour. TGx-1448-2E stored

Table 1: Effects of variety, packaging materials and their interactions on soybean seed germination and vigour in Makurdi, Nigeria

	5 DAP			8 DAP							
Variety	RTLTH	SHLTH	SDLTH	RTLTH	SHLTH	SDLTH	G.P	G.I	G.R.I	Seedling dry weight	Seedling vigour
TGx-1448-2E	5.13	2.35	7.48	11.07	5.59	16.65	86.67	3.56	4.21	0.12	10.26
TGx-1951-3F	5.44	2.70	8.15	12.54	6.71	19.25	90.22	3.60	4.02	0.13	11.10
LSD	NS	NS	NS	1.07	0.90	1.58	NS	NS	NS	NS	NS
Packaging materials											
Paper bag (P1)	5.60	2.29	7.89	12.80	6.37	19.16	91.33	3.55	3.96	0.12	11.07
Cloth bag (P2)	5.36	2.55	7.92	12.17	5.99	18.16	87.33	3.34	3.84	0.12	10.20
Sack bag (P3)	4.90	2.73	7.63	10.44	6.09	16.53	86.67	3.85	4.54	0.13	10.77
LSD	NS	NS	NS	1.32	NS	1.94	NS	NS	0.55	NS	NS
Variety×packaging materials											
V1P1	6.01	2.30	8.31	13.04	5.85	18.90	98.67	3.10	3.15	0.11	11.19
V1P2	5.21	2.63	7.84	11.83	5.88	17.71	82.67	3.40	4.11	0.12	10.00
V1P3	4.17	2.12	6.30	8.33	5.02	13.35	78.67	4.18	5.36	0.13	9.60
V2P1	5.18	2.29	7.47	12.55	6.88	19.43	84.00	3.97	4.76	0.13	10.95
V2P2	5.52	2.47	7.99	12.52	6.10	18.62	92.00	3.28	3.58	0.12	10.41
V2P3	5.63	3.34	8.97	12.55	7.16	19.72	94.67	3.53	3.73	0.13	11.95
LSD	1.22	0.84	1.90	1.86	NS	2.74	7.31	0.62	0.78	NS	NS

LSD: Least significant difference, NS: Not significant

Table 2: Influence of variety and storage on germination and seedling vigour of soybeans

	5 DAP			8 DAP							
Variety	RTLTH	SHLTH	SDLTH	RTLTH	SHLTH	SDLTH	G.P	G.I	G.R.I	Seedling dry weight	Seedling vigour
TGx-1448-2E	5.54	3.08	8.62	90.1	5.91	14.93	84.70	3.83	4.53	0.13	10.44
TGx-1951-3F	5.29	3.19	8.48	9.44	7.70	17.14	88.00	3.60	4.14	0.13	10.99
LSD	NS	NS	NS	NS	1.26	1.91	NS	NS	NS	NS	NS
Seed storage condition											
Ambient (C1)	4.95	3.01	7.96	9.06	6.95	16.01	82.00	3.64	4.46	0.13	10.57
ColdStore (C2)	5.89	3.26	9.15	9.44	6.66	16.05	90.70	3.78	4.21	0.12	10.85
LSD	0.59	NS	1.06	NS	NS	NS	6.70	NS	NS	0.01	NS
Variety×seed storage condition											
V1C1	5.27	2.91	8.18	9.62	6.18	15.80	82.70	3.59	4.37	0.13	9.92
V1C2	5.82	3.24	9.06	8.41	5.64	14.05	86.70	4.06	4.69	0.13	10.96
V2C1	4.62	3.11	7.73	8.50	7.72	16.22	81.30	3.69	4.56	0.14	11.23
V2C2	5.96	3.28	9.24	10.39	7.67	18.06	94.70	3.51	3.73	0.11	10.75
Mean	5.42	3.13	8.55	9.23	6.80	16.03	86.30	3.71	4.34	0.13	10.71
LSD	NS	NS	NS	2.10	NS	NS	NS	NS	NS	0.02	NS

LSD: Least significant difference, NS: Not significant

in polyethylene bag had the lowest values for all the traits except for seedling dry weight. The TGx 1951-3F stored in polyethylene bag had highest value for shoot seedling length at 5 DAP and shoot length at 8 DAP.

Experiment 2: Effects of variety and storage conditions on soybean seed germination and vigour: Results of ANOVA indicated that shoot and seedling length at 8 DAP were significant for variety while root, seedling length at 5 DAP, germination percentage and seedling dry weight were significantly different for storage conditions (Table 2). Variety×storage condition interaction was significant for root length at 8 DAP and seedling dry weight.

TGx-1951-3F performed better than TGx-1448-2E with significant difference for shoot and seedling lengths only at 8 DAP (Table 2). Cold storage had higher values for most of the traits with significant difference at 5 DAP for root length and seedling length. Seeds stored in cold environment had significantly higher value for germination percentage seedling dry weight.

The interaction effect showed that, TGx-1951-3F under cold storage (V2C2) had higher values for most of the traits except for seedling dry weight while, TGx-1448-2E under cold storage (V1C2) and TGx-1951-3F (V2C1) had the lowest values with no distinct pattern.

DISCUSSION

Soybean variety influences initial seedling establishment but this did not translate to higher accumulation of dry matter

or seed vigour. The significant difference between varieties could be due to the amount of food reserves in the seeds as expressed in seedling establishment at 8 DAP. Kandil *et al*. (2013) reported differences in root and shoot length and root/shoot ratio in soybean.

Packaging materials in this study did not significantly influence viability and vigour of soybean. The superior performance in paper bag could be attributed to its airtight nature thereby maintaining either seed moisture content, respiration rate or food reserves. However, it was reported by Tripathi and Lawande (2014) and Rao *et al*. (2006) both in onions that significant differences exist in seed germination and seedling vigour among various packaging materials. Chuansin *et al*. (2006) reported that prolonged storage life of soybean seed without the use of chemical could be attained by the use of different kinds of packaging materials. There was an increase in germination percentage for seeds stored under cold condition which may be attributed to maintenance food reserves as a result of low respiration rate and low metabolic activity due to controlled temperature, relative humidity in the storage environment. Also, dormancy breaking may be implicated under cold storage. This finding is in line with Balesevic-Tubic *et al.* (2010), who reported that seed germination of soybean declines more in storage under convectional conditions due to variability in temperature and relative humidity than seeds stored under controlled conditions. Similarly, Basavegowda and Hosamani (2013), who reported that high germination percentage, vigor index and seedling vigor in commercial cold storage condition compared to atmospheric condition in chick pea. The differences in these reports could be due to inconsistent measuring techniques.

CONCLUSION

Variety and packaging material affect initial seedling traits (root and seedling length) in soybean but do not affect germination percentage and vigor. Packaging material influences the time it will take for seeds to complete germination. For TGx-1448-2E, storage in paper had a better performance in respect to germination percentage and its indices. Cold storage seems to preserve seed viability but not seedling vigour.

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