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Effect of Storage Conditions and Containers on Storability of Pole Type Frenchbean cv. Arka Sukomal

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ABSTRACT

Background: Maintenance of seed quality in storage is important without losing its living entity against biotic and abiotic stress. Arka Sukomal seeds are protein rich and include other nutrient composition which is required for seed germination and seedling establishment. There is a need to minimise the deterioration of cellular structure and biochemical compounds by adopting suitable storage conditions and containers.

Methods: The laboratory experiment was carried out to identify the suitable storage conditions and containers on seed quality parameters. The seeds were stored in four different containers *viz*., cloth bag, polythene bag, super grain bag and poly-lined aluminium pouch at ambient and at controlled condition (15°C). The observations were recorded bimonthly up to fourteen months.

Result: The results showed that seeds in poly-lined aluminium pouch at controlled conditions had shown better quality parameters like lower moisture content (7.70%), higher seed germination (93.58%), more increased seedling vigour index II (5316) and low electrical conductivity of seed leachate (0.437 dS m^{-1}) whereas it was lower in cloth bag at ambient condition (10.40%, 80.67%, 3611 and 0.649 dS m^{-1}, respectively) at the end of storage period. Hence, the viability and vigour of seeds could be maintained better by storing in moisture impervious containers (poly-lined aluminium pouch and polythene bag) at the controlled condition, which is cost-effective and easily adaptable.

Key words: Conditions, Containers, Deterioration, Seed quality, Storage period.

INTRODUCTION

French bean cv. Arka Sukomal is a tender, warm-season vegetable crop widely cultivated in subtropical regions that grew up to 10 to 12 feet in height, which is planted against the trellis for support. It is grown over a wide range of well-drained, friable alluvial soils but cannot withstand extreme acidic and alkaline soils. It is valued for its protein (23%) rich seeds and the fresh pods are used as a vegetable. As a nutritious vegetable, it contains calcium (50 mg), phosphorous (28 mg), iron (1.7 mg), carotene (132 mg), thiamine (0.08 mg), riboflavin (0.06 mg) and vitamin C (24.0 mg) in each 100 g of edible pods (Chadha, 2001).

In recent times there has been a demand for the cultivation of pole type French bean as it produces more yield than the bush type. Maintenance of quality seed for next season is critical for getting uniform germination and its establishment in the field. Seed deterioration is a quality reducing attribute that begins immediately after physiological maturity, even on the mother plant (Helmer *et al*. 1962). Physiological deterioration of seeds during storage is considered to be one of the major factors preventing seeds from normal germination and vigorous growth. The process of seed deterioration is rather irreversible and it cannot be eliminated totally; it is aided by adverse storage environment, seed moisture content and containers used for storage. The seed deterioration significantly reduces the germination (Khajeh Hosseini *et al*. 2003), seedling emergence (Basra *et al*. 2003) and growth. The quality of seed does not decrease immediately, but it declines during the increment of time (Harrington 1972). High temperature and moisture play an important role in seed deterioration.

Seed packaging container, storage environment and duration affect seed quality *i.e*., viability and vigour (Rao *et al*. 2006). There is a need to maintain the quality of seeds after harvest for future needs. Seed viability in storage can be maintained by using suitable packaging materials and providing a suitable environment. A comprehensive study was envisaged to study the effect of storage conditions and containers on the storability of French bean seeds of recently developed varieties.

MATERIALS AND METHODS

The experiment was carried out at seed quality control laboratory, Vegetable Seed Production Unit, ICAR-Indian Institute of Horticulture Research, Hesaraghatta, Bengaluru

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from March 2020-March 21. The freshly harvested seeds of pole type French bean variety cv. Arka Sukomal, developed from ICAR-IIHR, Bengaluru, was used in this study. Seeds were processed and sun dried till they attained around 7% moisture content. The seeds were stored in four different containers (C) *viz*., cloth bag (C_1), polythene bag (C_2), supergrain bag (C_3) and poly-lined aluminium pouch (C_4) as one factor, each container was packed with 250 gram of seed and was stored at two different storage conditions (T) as another factor *i.e* Ambient (T_1 and T_2) and controlled 15°C. The seed quality parameters were regularly recorded bimonthly up to the fourteen months of storage.

Seed moisture content (%) was determined by using a Halogen moisture meter that was calibrated with a hot air oven. About 2 grams of seeds were ground to powder and sprinkled evenly on an aluminium plate. The total moisture was estimated by using a moisture meter set at 130°C ±1°C. The germination test was carried out by using between paper (BP) methods (Anonymouse 2015). One hundred seeds in four replicates were placed on germination paper and rolled towels were incubated in a germination chamber maintained at 25±1°C and 90 per cent relative humidity. The germinated seedlings were evaluated on the fifth day and percentage germination was expressed based on normal seedlings present in the test.

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

Seedling vigour index-II (SV-II) was calculated according to (Abdul Baki and Anderson, 1973) and expressed as the whole number for each treatment using the formula.

SVI-II = Seed germination (%) × Mean seedling dry weight (mg).

The electrical conductivity of seed leachate (dS m^{-1}) was determined according to Presley (1958).

Statistical analysis

The experiment was set up with two factor completely randomized design (CRD) in four replications. Statistical analysis and the interpretation of the experimental data was done by using Fischer's method of analysis of variance Technique as outlined by (Gomez and Gomez,1984) and the level of significance used in "F" and "t" test was at one per cent. The percentage of seed germination was transformed into arcsine values.

RESULTS AND DISCUSSION

The initial seed quality parameters were recorded prior to storage *viz*., seed moisture content (7.08%), seed germination (97.20%), seedling vigour index-II (5804) and electrical conductivity of seed leachate (0.423 dS m^{-1}) (Table 1-4). The seeds are hygroscopic in nature and attain equilibrium moisture content by gaining or losing moisture content depending upon the nature of containers and the conditions in which they are stored (Saisanthosh and Biradar, 2018).

Table 1: Effect of storage condition and containers on seed moisture content (%) in pole type French bean cv. Arka Sukomal.

Treatments	Months of storage from March 2020 to March 2021					
	2	4	8	10	12	14
Storage condition (T)	**Initial : 7.12%**					
T_1: Ambient	7.91	8.25	8.96	9.16	9.32	9.29
T_2: Controlled at 15°C	7.41	7.62	7.93	8.10	8.30	8.30
S.Em±	0.06	0.05	0.03	0.03	0.02	0.02
CD (P≤0.01)	0.21	0.17	0.11	0.11	0.07	0.06
Storage containers (C)						
C_1: Cloth bag	8.03	8.61	9.40	9.61	9.79	9.76
C_2: Polythene bag	7.58	7.82	8.26	8.42	8.55	8.53
C_3: Super grain bag	7.85	8.06	8.61	8.77	8.99	8.98
C_4: Poly lined aluminium pouch	7.04	7.03	7.50	7.72	7.92	7.91
S.Em±	0.07	0.06	0.04	0.04	0.02	0.02
CD (P≤0.01)	0.3	0.24	0.16	0.15	0.09	0.08
Interaction (T×C)						
$T_1 \times C_1$	8.32	9.01	10.03	10.32	10.48	10.40
$T_1 \times C_2$	7.90	8.23	8.95	9.07	9.18	9.15
$T_1 \times C_3$	8.13	8.37	9.21	9.42	9.48	9.46
$T_1 \times C_4$	7.03	7.03	7.64	7.82	8.13	8.12
$T_2 \times C_1$	7.75	8.22	8.77	8.90	9.10	9.10
$T_2 \times C_2$	7.26	7.41	7.57	7.77	7.91	7.91
$T_2 \times C_3$	7.57	7.74	8.01	8.13	8.50	8.50
$T_2 \times C_4$	7.04	7.04	7.36	7.62	7.70	7.70
S.Em±	0.12	0.1	0.06	0.06	0.04	0.03
CD (P≤0.01)	NS	NS	0.22	0.22	0.13	0.12

NS: Non-significant.

In the present study, with the progress in the storage period, there was a rise in the moisture content. The seeds stored at controlled conditions had shown lower moisture content over a period of storage than the seeds stored at ambient conditions. Among the containers, seeds packed in poly-lined aluminium pouch were recorded lower moisture content than compared to other containers (polythene, super grain and cloth bag) (Table 1). Concerning interaction effect initially upto fourth month there was no significant difference change in moisture content and was found to be lower in poly-lined aluminium pouch at controlled condition ($T_2 C_4$) which was raised from 7.36% in sixth month to 7.70% upto 14 month of storage whereas, it was higher in cloth bag at ambient condition (T_1C_1) that raised from 10.03% during sixth month to 10.48% during 12th month and slightly declined to 10.40% at the end of 14 month of storage (Table 1).

Poly-lined aluminium pouch is a moisture vapour proof container which is impervious to moisture exchange. Hence the seeds packed in poly-lined aluminium pouch under controlled conditions is better to store the seeds over a long period because the property of film used for packaging maintained lower moisture and oxygen and as such unlikely to suffer because of higher oxidation (Hong and Kim, 2004; Netra *et al.,* 2015). These results are in agreement with the findings of Shushma Malimath (2007) in pea, Monira *et al*. (2012) in soybean and Patel *et al*. (2017) in onion.

Germination is the most crucial function of a seed as an indicator of its viability and worth as a seed. As the storage period progressed, there was a decline in germination. At the end of storage period, the highest seed germination was observed at controlled condition (91.88%) than at ambient (87.58%). Among the containers, seeds stored in poly-lined aluminium pouch recorded the highest seed germination (93.56%) followed by polythene (91.29%) and super grain bag (87.53%). The lowest seed germination was noticed with cloth bag (86.54%). Among the storage temperature and containers interactions, germination percentage did not differ significantly upto fourth of storage. It was varied considerably from the sixth month up to the fourteenth month of storage. At the end of the storage period,the highest seed germination (93.58%) was recorded in T_2C_4 (poly-lined aluminium pouch at the controlled condition), which was on par with T_1C_4 (93.54%), T_2C_2 (92.40%) and T_2C_1 (92.02%) but significantly different from other interaction effect. The lowest seed germination (80.67%) was noticed in T_1C_1 (cloth bag at ambient condition) (Table 2). The germination was higher when the seeds were stored in moisture vapour proof containers at both the conditions and in moisture resistant

Table 2: Effect of storage condition and containers on seed germination (%) in pole type French bean cv. Arka Sukomal.

Treatments	Months of storage from March 2020 to March 2021						
	2	4	6	8	10	12	14
Storage condition (T)	**Initial : 97.2%**						
T_1: Ambient	95.74 (78.17)*	95.33 (77.56)	94.47 (76.05)	93.34 (75.23)	91.65 (73.55)	90.08 (72.01)	87.58 (69.76)
T_2: Controlled at 15°C	96.76 (79.72)	96.20 (78.78)	95.33 (77.62)	94.72 (76.80)	93.29 (75.10)	92.08 (73.69)	91.88 (73.51)
S.Em±	0.25	0.16	0.24	0.3	0.46	0.36	0.38
CD (P≤0.01)	0.85	0.54	0.82	1.03	1.57	1.22	1.29
Storage containers (C)							
C_1: Cloth bag	95.36 (78.08)	95.20 (77.40)	94.33 (76.34)	92.65 (74.43)	90.22 (71.96)	88.64 (70.50)	86.54 (68.95)
C_2: Polythene bag	96.29 (79.55)	95.90 (78.35)	94.66 (76.66)	94.31 (76.24)	93.67 (75.51)	92.96 (74.67)	91.29 (72.89)
C_3: Supergrain bag	95.73 (78.13)	95.219 (77.38)	94.28 (76.24)	93.19 (74.97)	91.01 (72.72)	89.09 (70.81)	87.53 (69.40)
C_4: Poly lined Aluminium pouch	96.95 (80.02)	96.70 (79.56)	96.33 (79.00)	95.96 (78.41)	94.97 (77.11)	93.63 (75.41)	93.56 (75.30)
S.Em±	0.29	0.18	0.28	0.35	0.53	0.41	0.36
CD (P≤0.01)	1.2	0.77	1.17	1.46	2.22	1.73	1.49
Interaction (T×C)							
$T_1×C_1$	94.69 (76.72)	94.29 (76.19)	92.85 (74.50)	90.78 (72.33)	87.74 (69.58)	85.26 (67.42)	80.67 (63.91)
$T_1×C_2$	96.61 (79.41)	95.84 (78.23)	95.31 (77.49)	94.74 (76.77)	94.74 (76.77)	93.85 (75.70)	90.56 (72.19)
$T_1×C_3$	95.13 (77.25)	94.84 (76.86)	93.63 (75.39)	92.06 (73.65)	89.09 (70.72)	87.23 (69.12)	85.53 (67.67)
$T_1×C_4$	96.54 (79.31)	96.35 (78.98)	96.10 (78.63)	95.80 (78.16)	95.03 (77.14)	93.98 (75.80)	93.54 (75.27)
$T_2×C_1$	96.57 (79.45)	96.11 (78.62)	95.82 (78.19)	94.53 (76.54)	92.71 (74.35)	92.01 (73.58)	92.02 (74.00)
$T_2×C_2$	96.77 (79.69)	95.97 (78.46)	94.01 (75.83)	93.89 (75.72)	92.60 (74.25)	92.073 (73.64)	92.40 (73.59)
$T_2×C_3$	96.34 (79.01)	95.60 (77.89)	94.93 (77.10)	94.33 (76.29)	92.95 (74.71)	90.95 (72.51)	89.53 (71.13)
$T_2×C_4$	97.36 (80.72)	97.06 (80.14)	96.57 (79.37)	96.12 (78.65)	94.93 (77.08)	90.95 (75.02)	93.58 (75.34)
S.Em±	0.49	0.32	0.48	0.6	0.91	90.95	0.76
CD (P≤0.01)	NS	NS	1.65	2.07	3.13	90.95	2.59

NS: Non-significant.

Figures in the parentheses indicate arcsine root transformed values.

and moisture pervious at controlled condition as this limits the exchange of moisture and gases with the atmosphere there by reducing the biochemical changes of sugars and starch which is required for germination. These results are in agreement with the findings of Ravi Hunje *et al*. (2007) in Byadgi chilli, Moharana (2017) in Indian bean and Khan *et al*. (2018), (Rahmawati and Muhammad, 2020) in maize and (Saisanthosh and Biradar, 2018) in onion.

As the storage period advanced, there was a decline in seedling vigour index-II and it was significantly influenced by storage conditions and containers over a period of storage. At the end of the storage period seeds stored at controlled condition (T_2) showed higher (4772) seedling vigour index-II than at ambient ones (T_1) (4319) and the seeds stored in poly-lined aluminium pouch (C_4) recorded higher (5094) seedling vigour index-II followed by polythene (C_2) (4886) and super grain (C_3) (4177) whereas, the lowest was noticed in cloth bag (C_1) (4024). Interactions between storage temperature and containers had shown significant variation in seedling vigour index-II and recorded maximum (5316) in T_2C_4 followed by T_1C_4 (4892) and T_2C_2 (4884) whereas, it was minimum (4034) noticed inT_1C_1 at the fourteenth month of storage (Table 3).

The decline in seedling vigour index-II over a period of storage can be attributed to decline in germination per cent, seedling length and dry matter accumulation in seedling Meena *et al*. (1998). As the storage period advanced, the vigour of seed declined due to the catabolic activity going on in the seed and thus the seed though viable yet failed to emerge Geetanjali *et al*. (2019). The impervious nature of the container and low temperature decreased the respiration rate and metabolic activities of the seed, thereby reduce the deterioration of the seed and enhancing the dry matter accumulation and increase the seedling weight. The results are in agreement with the findings of Ravi Hunje *et al*. (2007) in chilli, Geetanjali *et al*. (2019) in onion and Umesha *et al*. (2017) in cluster bean.

The electrical conductivity is based on the principle that the deterioration process is the leaching of the cells of seeds soaked in water due to the loss of integrity of cellular systems. Low conductivity means a high quality of seed and high conductivity that is greater output seed leachate, it suggests less force Vieira and Krzyzanowski (1999). As described in Table 4, there was an increase in electrical conductivity of seed leachate as the storage period advanced and it was found to be low at controlled conditions than compared to ambient. Among the containers, poly-lined aluminium pouch was recorded the lower EC values followed by polythene bag < super grain bag < cloth bag. At the end of fourteenth month of storage period, seeds stored at controlled condition showed a lower EC value (0.455 dS m^{-1}) than at ambient (0.557 dS m^{-1}). The seeds in poly-lined aluminium pouch (C_4) resulted in a lower EC value (0.454 dS m^{-1}) and were higher (0.556 dS m^{-1}) in a cloth bag (C_1). Among the interactions, the EC value of seed leachate was found to be low (0.437 dS m^{-1}) in poly-lined aluminium pouch

Table 3: Effect of storage condition and containers on mean seedling vigour index-II in French bean cv. Arka Sukomal.

Treatments	Months of storage from March 2020 to March 2021						
	2	4	6	8	10	12	14
Storage condition (T)	**Initial : 5804**						
T_1: Ambient	5081	4948	4805	4706	4592	4474	4319
T_2: Controlled at 15°C	5259	5174	5062	5000	4908	4821	4772
S.Em±	36.62	22.92	22.3	21.28	25.53	20.9	15.34
CD (P≤0.01)	125.44	78.52	76.4	72.9	87.44	71.6	52.55
Storage containers (C)							
C_1: Cloth bag	4789	4665	4536	4427	4268	4132	4024
C_2: Polythene bag	5361	5275	5119	5068	5003	4953	4886
C_3: Super grain bag	4894	4771	4630	4544	4411	4273	4177
C_4: Poly lined aluminium pouch	5635	5531	5449	5372	5319	5232	5094
S.Em±	42.28	26.47	25.75	24.57	29.48	24.14	17.71
CD (P≤0.01)	177.4	111	108.05	103.1	123.66	101.26	74.31
Interaction (T×C)							
$T_1 \times C_1$	4678	4525	4381	4263	4034	3831	3611
$T_1 \times C_2$	5393	5266	5139	5071	5041	4977	4880
$T_1 \times C_3$	4773	4626	4434	4319	4148	4009	3904
$T_1 \times C_4$	5479	5373	5267	5171	5145	5080	4892
$T_2 \times C_1$	4900	4805	4691	4592	4502	4434	4437
$T_2 \times C_2$	5328	5285	5099	5066	4964	4930	4884
$T_2 \times C_3$	5016	4916	4827	4768	4674	4536	4451
$T_2 \times C_4$	5792	5689	5630	5574	5494	5384	5316
S.Em±	73.24	45.84	44.61	42.56	51.05	41.81	30.68
CD (P≤0.01)	250.88	157	152.81	145.81	174.89	143.21	105.1

Table 4: Effect of storage condition and containers on electrical conductivity of seed leachate in French bean cv. Arka Sukomal.

Treatments	Months of storage from March 2020 to March 2021						
	2	4	6	8	10	12	14
Storage condition (T)	**Initial : 0.450 dS m^{-1}**						
T_1: Ambient	0.452	0.459	0.479	0.492	0.512	0.542	0.557
T_2: Controlled at 15°C	0.407	0.414	0.426	0.428	0.441	0.449	0.455
S.Em±	0.003	0.001	0.001	0.001	0.002	0.003	0.003
CD (P≤0.01)	0.011	0.003	0.004	0.003	0.008	0.009	0.009
Storage containers (C)							
C_1: Cloth bag	0.443	0.453	0.479	0.482	0.501	0.535	0.556
C_2: Polythene bag	0.431	0.432	0.446	0.449	0.462	0.479	0.492
C_3: Super grain bag	0.438	0.444	0.464	0.477	0.501	0.517	0.523
C_4: Poly lined aluminium pouch	0.406	0.416	0.422	0.434	0.441	0.451	0.454
S.Em±	0.004	0.001	0.001	0.001	0.003	0.003	0.003
CD (P≤0.01)	0.015	0.004	0.006	0.005	0.012	0.012	0.013
Interaction (T×C)							
$T_1 \times C_1$	0.474	0.488	0.519	0.523	0.551	0.614	0.649
$T_1 \times C_2$	0.456	0.45	0.472	0.478	0.496	0.528	0.545
$T_1 \times C_3$	0.466	0.477	0.497	0.52	0.544	0.557	0.564
$T_1 \times C_4$	0.412	0.42	0.43	0.449	0.456	0.469	0.472
$T_2 \times C_1$	0.411	0.419	0.439	0.441	0.452	0.456	0.462
$T_2 \times C_2$	0.407	0.413	0.42	0.42	0.429	0.431	0.44
$T_2 \times C_3$	0.409	0.412	0.431	0.434	0.458	0.477	0.482
$T_2 \times C_4$	0.401	0.411	0.413	0.418	0.425	0.433	0.437
S.Em±	0.006	0.002	0.002	0.002	0.005	0.005	0.005
CD (P≤0.01)	0.021	0.006	0.008	0.007	0.017	0.017	0.019

at controlled conditions (T_2C_4) and it was high (0.649 dS m^{-1}) when the seeds were stored at the ambient condition in a cloth bag (T_1C_1).

Loss of membrane integrity during storage would be the main reason for increased electrical conductivity, as evidenced by structural changes and changes in membrane composition Delouche and Baskin (1973). The weaker the membrane system, the larger the number of electrolytes leached from the seeds and the greater the conductivity of steep water. These results support the findings of Maristela (2007), which resulted in low seed leachate in peas when stored at 10°C than at 20 and 25°C upto 18 months of storage. Ravi Hunje *et al*. (2007) in byadagi chilli, Geetanjali *et al*. (2019) in onion and Shushma Malimath (2007) in peas.

CONCLUSION

From the present investigations, it can be concluded that viability and vigour of French bean seeds of cultivar Arka Sukomal can be maintained better upto fourteen months by storing the seeds in poly-lined aluminium pouch at controlled condition without losing its biochemical, genetic and physiological quality of seed.

Conflict of Interest: None.

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