International Journal of Agriculture Sciences
ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 12, Issue 21, 2020, pp.-10357-10362.
Available online at https://bioinfopublication.org/pages/jouarchive.php?id=BPJ0000217

Research Article

ASSESSMENT OF SEED SENESCENCE IN GROUNDNUT VARIETIES UNDER DIFFERENT STORAGE CONDITIONS

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Received: October 20, 2020; Revised: November 11, 2020; Accepted: November 12, 2020; Published: November 15, 2020

Abstract: The freshly harvested groundnut pods of different varieties *viz*., VRI 2, VRI 6, VRI 7, VRI 8, CO 6, CO 7 TMV 7 and TMV 13 were collected and dried to 9% moisture content, packed in cloth bag without any pod treatment and stored under cold (4 ± 2°C) and ambient storage condition (28 ± 2°C). The seeds were evaluated for the seed quality characters at monthly interval upto 12 months revealed that the varieties VRI 7 and TMV 13 showed higher germination than other varieties irrespective of storage condition. With reference to the storage conditions, seeds stored in cold conditions recorded higher germination than the ambient condition stored seeds irrespective of varieties.

Keywords: *Germination, Varieties, Vigour index, Germination (%), Electrical conductivity*

Citation: K. Nelson Navamani Raj and K. Malarkodi (2020) Assessment of Seed Senescence in Groundnut Varieties under Different Storage Conditions. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 12, Issue 21, pp.- 10357-10362.

Academic Editor / Reviewer: Dr Hemangi Mehta

Introduction

Groundnut is cultivated in more than 100 countries around the world among which, developing countries contribute 97 % and 94 % of global area and production respectively. Six states namely Andhra Pradesh, Gujarat, Karnataka, Maharashtra, Rajasthan and Tamil Nadu account for about 90 % of the total groundnut area of the country. Andhra Pradesh and Gujarat contribute >55 % of the total area and production of groundnut. Irrigated groundnuts are cultivated in Tamil Nadu, Andhra Pradesh, Karnataka and Odisha states during rabi season that constitutes 6 % of the groundnut cultivable area in India.

The high seed rate, cost of seed, low seed multiplication ratio (1:8) and non-availability of quality seed are the major constraints for larger area coverage under groundnut. In addition, poor storability of seeds results in less availability of quality seeds for sowing. Groundnut crop is largely cultivated under rainfed conditions in major parts of Tamil Nadu. A widely prevalent practice among the farmers is to preserve the seeds of the rainfed crop until next sowing. During that particular sowing time, a failure in monsoon will force the farmers to carry over the stored seeds for next season. These practices are accompanied with lose of vigour and viability of seeds. Groundnut kernels are highly sensitive to seed deterioration mainly due to their chemical composition and moisture content. Oil content ranges from 33.6 to 55.0 %. The major fatty acids present in the oil are oleic and linoleic acids which accounts for 78 % of the total fatty acids. The mean oleic/linoleic ratio is 1.14 to 3.66 [1]. The protein content ranges between 22 % to 30 % [2]. Groundnut kernel is a rich source of minerals, carbohydrates and vitamins (vitamin-B and tocopherol). It is also rich in phosphorus. Seed deterioration is an undesirable and detrimental attribute of agriculture. With these insights, the present experiment was conducted to assess the seed storability under different storage condition in groundnut cultivars.

Materials and Methods

The freshly harvested groundnut pods of different varieties *viz*., VRI 2, VRI 6, VRI 7, VRI 8, CO 6, CO 7 TMV 7 and TMV 13 were collected from Tamil Nadu Agricultural University formed the based material for the study. The collected pods were dried to 9% moisture content and packed in cloth bag without any pod treatment and stored under cold (4 ± 2°C) and ambient storage condition (28 ± 2°C). The seeds were evaluated for the seed quality characters at monthly interval.

Moisture content (%)

About five g of seed was ground and transferred to a weighing bottle and placed in a hot air oven maintained at 103 ± 2°C temperature for 16 ± 1 hr. Then it was cooled in a desiccator for 30 min and weighed. The estimations were done in duplicate. The weight of seeds along with moisture bottle before and after drying was recorded. The moisture content was calculated using the following formula and the mean was expressed as percentage [3].

Moisture content (%) = [M2-M3] / [M2-M1] x 100

Where, M1-Weight of moisture bottle alone

M2-Weight of bottle + seed sample before drying

M3-Weight of bottle + seed sample after drying.

Germination (%)

The germination test was conducted with 50 kernels in eight replications using sand as a medium. The seeds were germinated in a germination room maintained at 25 ± 2°C temperatures and relative humidity (90 ± 3%). At the end of tenth day of sowing, the number of normal seedlings in each replication of different varieties was counted and the germination was calculated and the mean expressed as percentage [3].

Seedling length (cm)

At the time of germination count, ten normal seedlings were selected at random from each replication and used for measuring the seedling length. Seedling length was measured from the tip of primary root to tip of the primary leaves. The mean values were calculated and expressed in centimetre.

Vigour index

Vigour index values were computed using the following formula as suggested by Abdul-Baki and Anderson and the mean values were expressed in whole number.

Vigour index = Germination percentage x Total seedling length (cm).

Electrical conductivity

Ten kernels of eight different groundnut varieties were soaked in 20 ml of distilled water for 8 h at room temperature after preliminary rinsing. The seed steep water was referred as leachate. The electrical conductivity of the seed leachate was measured in an electrical conductivity meter and the conductivity of leachate [5] was expressed as dSm^{-1}.

Statistical Analysis

The data obtained were analysed for the 'F' test of significance6. The critical difference (CD) was calculated at 5 percent (P = 0.05) probability level and wherever 'F' value is non-significant it is denoted by 'NS'.

Result

Moisture content (%)

The significant difference due to containers and period of storage in seed moisture content of groundnut pod stored was observed up to 12 months of storage. However, due to varieties, the seed moisture content showed non-significant difference [Table-1].

The seeds packed in cloth bag and stored under cold condition gained 0.6 percent moisture content as against 3.1 percent in seeds stored under ambient condition over 12 months of storage. In other words, groundnut pods stored under cold storage absorbed less moisture content with the moisture fluctuations of 8.2 to 8.8 percent; whereas, seed stored under ambient condition recorded the moisture fluctuations between 8.2 to 10.9 percent. As the period of storage advanced, seed moisture content got increased significantly from 8.3 percent (P0) to 10.9 percent (P12), irrespective of containers and varieties.

Germination (%)

The difference in germination percentage of groundnut varieties was statistically significant due to storage conditions and period of storage. Among the varieties, VRI 7 and TMV 13 showed higher germination than other varieties irrespective of storage condition. Between the storage conditions, seeds stored under cold storage performed well by registering 96 % germination when compared to ambient condition (90%) over 12 months of storage period, irrespective of varieties.

The germination percent decreased from 95 to 79 percent in cold storage condition and in ambient storage germination percent was decreased from 95 to 73 percent [Table-2]. Among the varieties TMV 7 and TMV 13 were on par with 90 percent germination respectively.

As the period of storage advanced, germination percentage got reduced significantly from 100 percent (P0) to 81 percent (P12), irrespective of varieties and storage condition. However, the rate of deterioration was less in seeds stored under cold storage condition when compared to ambient condition. The interactions (VxS, SxP, PxV and VxSxP) were significantly highlighting the superiority of cold storage for groundnut varieties in extending the shelf life of groundnut seeds.

Seedling length (cm)

Significant difference was observed in seedling length due to varieties, storage conditions and period of storage. Irrespective of storage condition, the varieties VRI 7 and TMV 13 showed higher seedling length than other varieties [Table-3].

Irrespective of varieties and period of storage, the seeds stored under cold storage condition excelled by registering seedling length of 33.5 cm whereas it was 32.9 cm from the seeds stored under ambient condition. The magnitude of reduction was less in the former (18.5 %) than the latter (23.2%).

As the period of storage advanced, irrespective of varieties and storage conditions, the seedlings length was reduced significantly from 36.7 cm (P0) to 29.1 cm (P12), However, the rate of deterioration was less in seeds stored under cold storage when compared to ambient storage condition. The interactions (VxS, SxP, PxV and VxSxP) were significantly highlighting the beneficial effect of cold storage condition for storing of groundnut varieties.

Vigour index

The difference on vigour index values were significant in respect to varieties, storage conditions and period of storage. The varieties namely, VRI 7 and TMV 13 registered higher vigour index value of 3376 and 3321 under cold storage condition and 3263 and 3053 under ambient storage than other varieties over 12 months of storage period. The computed vigour was significantly higher (7.8 %) for the seeds stored under cold storage condition (3220) when compared to ambient condition (2970) [Table-4].

Over 12 months of storage, the mean vigour index value decreased significantly from 3655 (P0) to 2073 (P20), irrespective of varieties and storage conditions, however the rate differed with varieties and storage conditions. However, the rate of deterioration was less in cold storage condition when compared to ambient storage.

The interactions (VxS, SxP, PxV and VxSxP) were significantly highlighting the beneficial effect of cold storage condition when compared to ambient storage across the period of storage.

Electrical conductivity (dSm^{-1})

Significant differences were observed for electrical conductivity among varieties, storage conditions and period of storage. The VRI 7 and TMV 13 varieties had lower electrical conductivity of 0.257 dSm^{-1} and 0.266 dSm^{-1} under cold storage and ambient storage condition, respectively than other varieties. Between the storage condition, the seed leachate content was less in the seeds stored under cold storage condition (0.259 dSm^{-1}) than the seeds stored under ambient condition (0.268 dSm^{-1}), irrespective of varieties and storage period [Table-5].

With the advancement of storage period, the electrical conductivity of groundnut kernel had increased from 0.237 dSm^{-1} to 0.328 dSm^{-1} over 12 months of storage period. No significant differences were observed for the interactions among varieties, storage conditions and period of storage.

Discussion

Oilseeds are highly sensitive to deterioration during storage. An investigation was taken up to examine the physiological and biochemical changes in eight different cultivars of groundnut which were packed in cloth bag and stored under cold (4 ± 2°C) and ambient storage (28 ± 2°C) conditions. During storage of seeds, physical, physiological and biochemical changes occur, that leads to rapid seed deterioration [7]. As seed deterioration increases, seed performance progressively decreases leading to delayed emergence, reduced germination percentage, loss of seedling length, production of week seedlings and loss of vigour, ultimately resulting in seed death [8]. During storage of seeds, the antioxidant enzyme, hydrolytic enzyme and protein content will decrease [9]. Walters *et al*., 2010). During the process of seed deterioration, enzyme activity decreases due to progressive inactivation, reduction and stoppage of its synthesis [10].

Moisture content (%)

The importance of seed moisture content in extending the shelf life of seeds under ideal storage conditions is well established. The Harrington's thumb rule proposes that one percent decrease in seed moisture content nearly doubles the storage potential of the seeds [11]. Seed viability is adversely affected both by high and low moisture contents. The moisture content of the seed plays major role in determination of seed storability and it is most critical factor in maintaining seed longevity [12]. Sensitivity of seeds to high temperatures is strongly dependent on their moisture content, loss of viability being faster with increasing moisture content [13]. In the present study, the seeds packed in cloth bag and stored under cold condition gained 0.6 percent moisture content as against 3.1 percent in seeds stored under ambient condition over 12 months of storage. With the advancement of storage period, there was significant increase in moisture content irrespective of varieties and storage conditions. It is observed that cloth bag acted as a moisture pervious container resulting in increase in moisture [14].

Germination (%)

Groundnut kernels are very sensitive to storage where seeds undergo a series of deterioration processes.

Table-1 *Effect of storage conditions and period of storage on seed moisture content (%) in groundnut varieties*

Variety (V)	Storage Condition (S)	Period of storage in months (P)													MEAN
		Initial	1	2	3	4	5	6	7	8	9	10	11	12	(V)
VRI 2	Cold Storage	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.3	8.5	8.5	8.6	8.8	8.8	8.4
VRI 6		8.1	8.1	8.1	8.2	8.2	8.2	8.2	8.2	8.3	8.4	8.6	8.9	8.9	8.3
VRI 8		8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.6	8.6	8.7	8.8	9.0	9.0	8.6
TMV 7		8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.3	8.5	8.6	8.8	8.8	8.4
CO 6		8.2	8.2	8.2	8.2	8.2	8.3	8.3	8.4	8.4	8.5	8.6	8.8	8.8	8.4
CO 7		8.1	8.1	8.1	8.1	8.1	8.2	8.2	8.2	8.2	8.4	8.5	8.6	8.8	8.3
VRI 7		8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.2	8.3	8.4	8.4	8.5	8.6	8.2
TMV 13		8.2	8.2	8.2	8.2	8.1	8.1	8.1	8.2	8.4	8.4	8.5	8.6	8.8	8.3
MEAN		8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.3	8.4	8.5	8.6	8.8	8.8	8.4
VRI 2	Ambient Storage	8.2	8.2	8.4	8.5	8.5	8.8	9.1	9.5	9.8	10.0	10.2	10.6	10.9	9.3
VRI 6		8.1	8.1	8.2	8.4	8.6	8.7	9.2	9.6	9.9	10.2	10.6	10.8	10.9	9.3
VRI 8		8.5	8.5	8.6	8.6	8.7	8.9	9.1	9.3	9.6	9.7	9.8	10.1	10.5	9.2
TMV 7		8.5	8.5	8.5	8.5	8.7	8.9	9.0	9.2	9.6	9.9	10.3	10.6	10.9	9.3
CO 6		8.5	8.4	8.5	8.5	8.7	8.9	9.0	9.4	9.9	10.3	10.7	10.9	11.0	9.4
CO 7		8.2	8.2	8.2	8.4	8.6	8.7	8.9	9.3	9.6	9.8	10.1	10.5	10.9	9.2
VRI 7		8.1	8.1	8.1	8.2	8.4	8.4	8.9	9.2	9.5	9.8	10.3	10.6	11.0	9.1
TMV 13		8.2	8.2	8.3	8.3	8.6	8.6	8.8	9.2	9.5	9.9	10.4	10.8	11.3	9.2
MEAN		8.3	8.3	8.4	8.4	8.6	8.7	9.0	9.3	9.7	10.0	10.3	10.6	10.9	9.3
MEAN (P)		8.3	8.3	8.3	8.3	8.4	8.5	8.6	8.8	9.1	9.3	9.5	9.7	9.9	8.9

	V	S	P	VxS	SxP	PxV	VxSxP
SEd	0.038	0.192	0.483	0.530	0.681	0.137	0.194
C.D (0.05)	NS	0.371	0.952	0.106	0.135	0.270	0.382

Table-2 *Effect of storage conditions and period of storage on seed germination (%) in groundnut varieties*

Variety (V)	Storage Condition(S)	Period of storage in months (P)													MEAN
		Initial	1	2	3	4	5	6	7	8	9	10	11	12	(V)
VRI 2	Cold Storage	100(85.16)	99 (84.26)	99 (84.26)	99 (84.26)	99 (84.26)	99 (84.26)	99 (84.26)	96(78.47)	94 (75.82)	92(73.57)	92(73.57)	90(71.57)	88(69.73)	96(78.47)
VRI 6		100(85.16)	99 (84.26)	99 (84.26)	99 (84.26)	99 (84.26)	98 (81.87)	98 (81.87)	97(80.03)	96(78.47)	95(77.08)	93(74.66)	91(72.54)	88(69.73)	96(78.47)
VRI 8		99 (84.26)	99 (84.26)	99 (84.26)	99 (84.26)	99 (84.26)	99 (84.26)	98 (81.87)	98 (81.87)	97(80.03)	94 (75.82)	93(74.66)	90(71.57)	89(70.63)	96(78.47)
TMV 7		100(85.16)	100(85.16)	100(85.16)	100(85.16)	98 (81.87)	96(78.47)	96(78.47)	94 (75.82)	91(72.54)	90(71.57)	90(71.57)	88(69.73)	88(69.73)	95(77.08)
CO 6		100(85.16)	100(85.16)	100(85.16)	98 (81.87)	98 (81.87)	96(78.47)	96(78.47)	94 (75.82)	94 (75.82)	92(73.57)	91(72.54)	90(71.57)	88(69.73)	95(77.08)
CO 7		100(85.16)	100(85.16)	100(85.16)	100(85.16)	100(85.16)	98 (81.87)	98 (81.87)	96(78.47)	94 (75.82)	94 (75.82)	92(73.57)	90(71.57)	88(69.73)	96(78.47)
VRI 7		99 (84.26)	100(85.16)	100(85.16)	100(85.16)	99 (84.26)	99 (84.26)	99 (84.26)	98 (81.87)	98 (81.87)	96(78.47)	94 (75.82)	92(73.57)	92(73.57)	97(80.03)
TMV 13		99 (84.26)	100(85.16)	100(85.16)	100(85.16)	100(85.16)	98 (81.87)	98 (81.87)	96(78.47)	94 (75.82)	92(73.57)	92(73.57)	90(71.57)	90(71.57)	96(78.47)
MEAN		100(85.16)	100(85.16)	100(85.16)	99 (84.26)	99 (84.26)	98 (81.87)	98 (81.87)	96(78.47)	95(77.08)	93(74.66)	92(73.57)	90(71.57)	89(70.63)	96(78.47)
VRI 2	Ambient Storage	99 (84.26)	99 (84.26)	98 (81.87)	94 (75.82)	90(71.57)	88(69.73)	84(66.42)	82(64.90)	80(63.44)	78(62.03)	70(56.79)	66(54.94)	60(49.44)	84(66.42)
VRI 6		100(85.16)	99 (84.26)	99 (84.26)	96(78.47)	94 (75.82)	92(73.57)	90(71.57)	90(71.57)	88(69.73)	86(68.03)	80(63.44)	76(60.67)	70(56.79)	89(70.63)
VRI 8		100(85.16)	99 (84.26)	99 (84.26)	96(78.47)	94 (75.82)	92(73.57)	90(71.57)	88(69.73)	84(66.42)	80(63.44)	78(62.03)	72(58.05)	68(55.55)	88(69.73)
TMV 7		100(85.16)	99 (84.26)	99 (84.26)	95(77.08)	92(73.57)	90(71.57)	90(71.57)	89(70.63)	86(68.03)	84(66.42)	80(63.44)	78(62.03)	74(59.34)	89(70.63
CO 6		100(85.16)	100(85.16)	99 (84.26)	95(77.08)	95(77.08)	93(74.66)	91(72.54)	90(71.57)	90(71.57)	88(69.73)	86(68.03)	80(63.44)	74(59.34)	91(72.54)
CO 7		100(85.16)	100(85.16)	100(85.16)	97(80.03)	95(77.08)	94 (75.82)	92(73.57)	90(71.57)	88(69.73)	86(68.03)	82(64.90)	78(62.03)	71(56.79)	90(71.57)
VRI 7		99(84.26)	99 (84.26)	99 (84.26)	99 (84.26)	98 (81.87)	94 (75.82)	92(73.57)	92(73.57)	90(71.57)	90(71.57)	88(69.73)	86(68.03)	86(68.03)	93(74.66)
TMV 13		99(84.26)	99 (84.26)	98 (81.87)	98 (81.87)	98 (81.87)	96(78.47)	94 (75.82)	92(73.57)	90(71.57)	88(69.73)	86(68.03)	84(66.42)	84(66.42)	93(74.66)
MEAN		100(85.16)	99 (84.26)	99 (84.26)	96(78.47)	95(77.08)	92(73.57)	90(71.57)	89(70.63)	87(68.87)	85(67.22)	81(64.16)	78(62.03)	73(58.69)	90(71.57)
MEAN (P)		100(85.16)	100(85.16)	100(85.16)	98 (81.87)	97(80.03)	95(77.08)	94 (75.82)	93(74.66)	91(72.54)	89(70.63)	87(68.87)	84(66.42)	81(64.16)	93(74.66)

	V	S	P	VxS	SxP	PxV	VxSxP
SEd	0.404	0.202	0.515	0.572	0.729	1.458	2.062
C.D (0.05)	0.795	0.397	1.013	1.124	1.433	2.866	4.054

(Figures in parentheses are arcsine values)

The present study revealed that the varieties VRI 7 and TMV 13 showed higher germination than other varieties irrespective of storage condition. This may be due to initial dormancy nature of said varieties [15]. With reference to the storage conditions, seeds stored in cold conditions recorded higher germination than the ambient condition stored seeds and the difference was 6 %. This may be due to in cold storage condition, where the respiration rate was less and the biochemical reactions were slower and the lipid peroxidation and protease activity were lower than ambient. The beneficial effect of storage of short-lived seeds at cold storage was reported by several scientists. The soybean seeds cannot withstand ambient storage conditions but they can be stored well under controlled conditions with low temperature and relative humidity [16]. The storage potential of peanut seeds was higher under cold room than under ambient condition [17].

In the present study, the germination decreased with increase in the storage period. The percentage of germination had decreased from 100 % to 81 % within 12 months of storage. Drastic reduction in germination was attributed to the lipid peroxidation which is a physiological deterioration process in oilseeds particularly groundnut. Such process closely coincided with the products of ROS, free fatty acids and disintegration of cell wall. The decline in germination over period of storage was also due to depletion of food reserves, decline in synthetic activities [18]. The DNA degradation with ageing will also lead to impaired transcription and cause incomplete or faulty enzyme synthesis essential for earlier stages of germination [19]. Our data are in conformity with the findings in groundnut [20-22].

The decline in germination percentage over the storage period may be attributed due to ageing effect leading to depletion of food reserves and decline in synthetic activity of embryo apart from the death of seed because of fungal invasion, insect attack, fluctuating temperature, relative humidity and storage containers [23]. Overall, the reported literatures in combinations with our data clearly demonstrated that groundnut kernels are badly affected during storage as a consequence of physiological and biochemical changes.

Seedling length (cm)

In this present study the varieties VRI 7 and TMV 13 had higher seedling length compared to other varieties. The seedling length of the cold stored seeds was higher than control. The percentage increase was 1.8 %. The results indicated that a progressive fall in the physiological stamina of deteriorating seed reduces seedling length. However, the seedling length was maintained at cold storage [24]. With the increased storage period, irrespective of varieties and storage conditions, the seedling length was decreased from 36.7 cm to 29.1 cm and the percentage increase was 20.7 %. It may also accumulation of toxic metabolites and damage of the mitotic apparatus of the embryonic axis and increased frequency of the root aberrations [25]. Decline in growth of seedlings with increase in period of storage, irrespective of varieties might be due to lack of food mobilization in the aged seeds [21, 22, 26] and decline in weight of mobilized seed reserve, not seed reserve utilization efficiency [27].

Table-3 *Effect of storage conditions and period of storage on seedling length (cm) in groundnut varieties*

Variety (V)	Storage Condition (S)	Period of storage in months (P)													MEAN
		Initial	1	2	3	4	5	6	7	8	9	10	11	12	(V)
VRI 2	Cold Storage	36.7	36.2	35.9	35.3	35.1	33.2	32.4	33.1	31.4	30.1	30.0	29.4	29.1	32.9
VRI 6		35.7	35.2	34.8	34.2	33.1	32.4	32.1	31.8	30.5	30.2	29.4	28.2	28.0	32.0
VRI 8		35.3	35.2	35.0	34.8	34.0	33.9	32.8	32.2	31.9	31.4	30.1	29.1	28.4	32.6
TMV 7		36.3	36.1	35.8	35.4	35.1	34.2	33.9	33.3	33.1	32.4	32.1	31.8	31.2	33.9
CO 6		36.8	36.2	35.7	35.3	34.4	34.2	33.8	33.3	32.4	31.8	30.3	30.1	29.3	33.4
CO 7		36.7	36.2	35.2	34.2	34.1	33.9	33.2	32.9	32.1	31.6	31.2	30.9	30.4	33.3
VRI 7		38.5	37.3	37.0	36.8	36.2	35.8	35.2	34.9	34.2	33.8	33.2	32.4	32.0	35.2
TMV 13		37.5	36.9	36.3	36.0	35.8	35.0	34.8	34.1	33.4	32.7	32.1	31.4	31.1	34.4
MEAN		36.7	36.2	35.7	35.3	34.7	34.1	33.5	33.2	32.4	31.8	31.1	30.4	29.9	33.5
VRI 2	Ambient Storage	36.7	36.2	35.8	35.1	34.8	33.9	33.1	32.1	31.8	31.2	29.3	28.1	27.2	32.7
VRI 6		37.5	36.5	36	35	35	34.3	34.2	33.1	33	28.5	27.8	27.2	27	32.7
VRI 8		35.3	35	34.3	34	33.2	32.8	32.5	32.1	31.3	31	30.3	28.3	27.5	32.1
TMV 7		35.7	35.1	34.8	33.5	32.1	32	31.9	31.1	30.5	29.4	28.4	27.8	26.3	31.4
CO 6		36.8	36.2	35.9	35.4	34.8	33.9	33.1	32.3	31.8	31.3	30.8	30.2	29.2	33.2
CO 7		36.7	36.3	35.3	34.8	34.2	33.2	32.3	31.8	30.1	29.3	29.2	29	28.2	32.3
VRI 7		38.5	38.5	37.5	37	36.5	36	34.3	34	33.5	33	32	31.5	31	34.9
TMV 13		36.3	36.2	36	35.7	35.2	34.7	34.2	33.8	33.2	32.7	31.8	30.8	29.2	33.8
MEAN		36.7	36.3	35.7	35.1	34.5	33.9	33.2	32.5	31.9	30.8	30.0	29.1	28.2	32.9
MEAN(P)		36.7	36.3	35.7	35.2	34.6	34	33.4	32.9	32.2	31.3	30.6	29.8	29.1	33.2

	V	S	P	VxS	SxP	PxV	VxSxP
SEd	0.140	0.070	0.178	0.198	0.252	0.505	0.715
C.D (0.05)	0.275	0.137	0.354	0.389	0.496	0.993	1.040

Table-4 *Effect of storage conditions and period of storage on vigour index in groundnut varieties*

Variety (V)	Storage Condition (S)	Period of storage in months (P)													MEAN
		Initial	1	2	3	4	5	6	7	8	9	10	11	12	(V)
VRI 2	Cold Storage	3670	3620	3590	3459	3440	3187	3110	3111	2952	2769	2730	2646	2619	3146
VRI 6		3570	3520	3480	3420	3310	3175	3146	3053	2867	2839	2705	2538	2464	3084
VRI 8		3495	3485	3465	3445	3366	3356	3214	3156	3094	2952	2799	2619	2528	3152
TMV 7		3630	3610	3580	3540	3475	3386	3356	3263	3244	3110	3017	2926	2870	3308
CO 6		3680	3620	3570	3530	3371	3283	3245	3130	2948	2862	2727	2649	2578	3169
CO 7		3670	3620	3520	3420	3410	3322	3254	3158	3017	2907	2870	2781	2736	3207
VRI 7		3812	3693	3663	3643	3584	3544	3485	3350	3215	3110	3054	2916	2816	3376
TMV 13		3713	3653	3594	3564	3544	3430	3410	3308	3206	3107	2985	2857	2799	3321
MEAN		3655	3603	3558	3503	3437	3335	3278	3191	3068	2957	2861	2741	2676	3220
VRI 2	Ambient Storage	3670	3620	3544	3335	3306	3153	3012	2889	2862	2746	2520	2248	2013	2994
VRI 6		3570	3510	3480	3250	3050	3008	2935	2799	2684	2528	2329	2168	1867	2860
VRI 8		3495	3465	3361	3196	2988	2886	2730	2632	2504	2418	2121	1868	1650	2717
TMV 7		3630	3584	3564	3427	3309	3192	3078	2974	2789	2616	2480	2279	1986	2993
CO 6		3680	3584	3554	3363	3202	3051	2979	2875	2735	2629	2464	2356	2161	2972
CO 7		3670	3594	3495	3341	3215	3054	2907	2862	2649	2520	2336	2204	1974	2909
VRI 7		3812	3812	3713	3663	3577	3384	3156	3128	3015	2970	2816	2709	2666	3263
TMV 13		3713	3614	3528	3430	3430	3293	3215	3045	2970	2508	2391	2285	2268	3053
MEAN		3655	3598	3530	3376	3259	3128	3001	2901	2776	2617	2432	2265	2073	2970
MEAN(P)		3655	3601	3544	3440	3348	3232	3140	3046	2922	2787	2647	2503	2375	3095

	V	S	P	VxS	SxP	PxV	VxSxP
SEd	13.236	6.618	16.870	18.719	23.862	47.725	67.493
C.D (0.05)	26.019	13.009	33.167	36.796	46.906	93.813	132.671

Table-5 *Effect of storage conditions and period of storage on electrical conductivity (dSm^{-1}) in groundnut varieties*

Variety (V)	Storage Condition (S)	Period of storage in months (P)													MEAN
		Initial	1	2	3	4	5	6	7	8	9	10	11	12	(V)
VRI 2	Cold Storage	0.238	0.239	0.240	0.241	0.243	0.246	0.248	0.252	0.258	0.270	0.290	0.308	0.319	0.260
VRI 6		0.236	0.236	0.239	0.240	0.242	0.243	0.242	0.251	0.256	0.263	0.289	0.309	0.323	0.259
VRI 8		0.239	0.239	0.241	0.242	0.244	0.248	0.251	0.253	0.255	0.261	0.288	0.308	0.326	0.261
TMV 7		0.239	0.240	0.242	0.243	0.245	0.249	0.252	0.257	0.258	0.260	0.281	0.302	0.321	0.260
CO 6		0.240	0.240	0.242	0.244	0.245	0.248	0.250	0.256	0.258	0.262	0.281	0.306	0.326	0.261
CO 7		0.236	0.236	0.238	0.239	0.244	0.246	0.252	0.254	0.258	0.260	0.281	0.304	0.321	0.259
VRI 7		0.234	0.235	0.235	0.239	0.242	0.245	0.248	0.251	0.253	0.259	0.279	0.301	0.321	0.257
TMV 13		0.235	0.235	0.239	0.242	0.243	0.246	0.249	0.253	0.256	0.260	0.278	0.298	0.317	0.257
MEAN		0.237	0.237	0.239	0.241	0.243	0.246	0.249	0.253	0.256	0.261	0.283	0.304	0.321	0.259
VRI 2	Ambient Storage	0.238	0.239	0.240	0.245	0.249	0.255	0.260	0.269	0.273	0.278	0.298	0.316	0.336	0.268
VRI 6		0.236	0.238	0.241	0.246	0.251	0.254	0.259	0.265	0.271	0.275	0.292	0.312	0.331	0.267
VRI 8		0.240	0.242	0.245	0.248	0.249	0.251	0.256	0.265	0.267	0.278	0.298	0.310	0.331	0.267
TMV 7		0.235	0.240	0.243	0.248	0.251	0.254	0.257	0.263	0.266	0.275	0.295	0.312	0.335	0.267
CO 6		0.234	0.238	0.243	0.246	0.253	0.256	0.260	0.269	0.273	0.279	0.298	0.316	0.338	0.269
CO 7		0.236	0.239	0.246	0.249	0.255	0.259	0.267	0.271	0.277	0.281	0.301	0.319	0.341	0.272
VRI 7		0.239	0.241	0.243	0.244	0.249	0.253	0.256	0.262	0.270	0.274	0.290	0.310	0.334	0.266
TMV 13		0.239	0.240	0.243	0.245	0.248	0.254	0.259	0.263	0.268	0.275	0.295	0.311	0.330	0.266
MEAN		0.237	0.239	0.243	0.246	0.250	0.254	0.259	0.265	0.270	0.276	0.295	0.313	0.334	0.268
MEAN (P)		0.237	0.238	0.241	0.244	0.247	0.250	0.254	0.259	0.263	0.269	0.289	0.309	0.328	0.264

	V	S	P	VxS	SxP	PxV	VxSxP
SEd	0.001	0.001	0.002	0.001	0.002	0.001	0.002
C.D (0.05)	0.002	0.002	0.004	NS	NS	NS	NS

Vigour index

The seedling vigour is the ultimate most relevant expression of the seed quality18. Vigour is usually characterized by the weight of seedlings after a period of growth28 and this is essentially a physiological phenomenon influenced by reserve metabolites, enzyme activities and growth regulators. The vigour index value which is the totality of germination and seedling growth has been regarded as a good index to measure the vigour of seeds4. In this present investigation the varieties VRI 7 and TMV 13 had higher vigour index than other varieties which might be due to initial dormant nature of varieties [15]. The higher vigour index 7.8% was observed in cold storage condition than in ambient. This may have resulted in lower respiration rate and lower metabolic activity and maintenance of higher seed vigour during storage [29]. Irrespective of varieties and storage conditions the vigour index declined from as the storage period advanced [30,31], where the difference was up to 560. The reduction in weight of seedlings due to hydrolysis of reserve metabolities, activation of endogenous enzymes and break down of food reserves might be the reason for reduced vigour over period of storage. The germination and seedling vigour of groundnut seeds declined in correspondence with the storage period32.

Electrical conductivity (dSm^{-1})

The electrical conductivity is a good indicator for the intensity of deterioration of seeds. In the EC test, seed quality is indirectly evaluated through the determination of the EC of the solution resulting from the soaking of seeds in water. The conductivity of the seed leachate was found to be an indicator of seed viability, deterioration and membrane integrity of the seed. The electrical conductivity of seed leachate is negatively associated with membrane integrity and so with germination and vigour. The number of electrolytes leached from high vigour seeds are low leading to low conductivities. Low conductivities are considered to be an indication of high vigour because it is thought to represent a low level of cell membrane system disorganization. The electrical conductivity test measures the electrolytes that leach out of seeds when they are immersed in water and this leakage is an indication of seed vigour; the lower the vigour the greater the amount of leaching [33].

In the present study, irrespective of varieties, the cold storage condition registered low electrical conductivity than ambient. This is attributed to the maintenance of biochemical activity in cold storage while cell membrane integrity got weakened in ambient storage which leads to exudation of higher amounts of leachates. The membranes stabilized for soybean seeds stored at low temperature, resulting in no increase in conductivity as a result of no increase in the ions leached [33]. Functional membranes are a perquisite for all viability and efficient metabolism. Aged seeds disintegrate and leaching out of electrolytes which eventually results in loss of cell membrane integrity [34]. In this present study, the electrical conductivity had increased steeply at the end of storage period and the difference was 0.027. This may due to the cell wall membrane of seed coat collapsed and disrupted with the advancement of storage period [35, 36]. The higher electrical conductivity of seed leachate was mainly governed by higher cell wall permeability which indicated higher respiration rate and metabolic activity maintenance of vigour during storage.

Conclusion

Storage potential of freshly harvested groundnut pods of different varieties *viz*., VRI 2, VRI 6, VRI 7, VRI 8, CO 6, CO 7 TMV 7 and TMV 13 were assessed by storing seeds in cloth bag under cold and ambient storage condition revealed that the varieties VRI 7 and TMV 13 showed higher germination than other varieties irrespective of storage condition.

Application of research: With reference to the storage conditions, seeds stored in cold conditions recorded higher germination than the ambient condition stored seeds irrespective of varieties.

Research Category: Agriculture Extension education

Acknowledgement / Funding: Authors are thankful to ICAR-Krishi Vigyan Kendra, Vamban, Pudukkottai, 622303, Tamil Nadu Agricultural University, Coimbatore, 641003, Tamil Nadu, India

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Research project name or number: Research station study

Author Contributions: All authors equally contributed

Author statement: All authors read, reviewed, agreed and approved the final manuscript. Note-All authors agreed that- Written informed consent was obtained from all participants prior to publish / enrolment

Study area / Sample Collection: Tamil Nadu Agricultural University, Coimbatore, 641003, Tamil Nadu, India

Cultivar / Variety / Breed name: Groundnut VRI 2, VRI 6, VRI 7, VRI 8, CO 6, CO 7 TMV 7 and TMV 13

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.
Ethical Committee Approval Number: Nil

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