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Assessment of seed quality of groundnut (*Arachis hypogaea* L.) during storage

P. A. RAUT[1], M. T. BHINGARDE[2] AND D. V. DESHMUKH*

Department of Agricultural Botany,
Mahatma Phule Krishi Vidyapeeth, Rahuri - 413 722
*dvdeshmukh19@gmail.com

Abstract The kernels and pods of three groundnut varieties were stored in HDPE bags under cold (5-10 °C) and ambient temperatures for a period of 270 days at Gene Bank, Medicinal and Aromatic Plant Project, M.P.K.V., Rahuri and Seed Technology Research Unit, M.P.K.V., Rahuri, respectively to assess the seed quality parameters and storability. The experiment was laid out in Factorial Completely Randomized Design (FCRD) in four replications. The study revealed that varieties, storage temperature, kernels and pods had significant effect on seed quality of groundnut during storage. Among the varieties, the variety Phule Unnati (V_1) showed greater storability than variety RHRG-6021 (V_2) and JL-501 (V_3). The seeds of var. Phule Unnati (V_1) maintained storability above Minimum Seed Certification Standards (MSCS) for 270 days, irrespective of storage temperature and kernels and pods. The seeds in the form of pods (F_2) stored at cold temperature at 5-10°C (T_1) influenced the seed quality and storability significantly. The maximum increase in storability (90 days) was observed in pods (F_2) under the cold temperature (T_1) as compared to ambient temperature (T_2) and maintained storability above MSCS for 270 days irrespective of variety. The variety Phule Unnati stored in the form of pods at cold temperature (5-10 °C) retained better seed quality up to 270 days of storage. It also exhibited higher vigour index, lower electrical conductivity and less seed mycoflora.

Key word: groundnut, seed quality, storage temperatures, pods and kernels, storability

Groundnut (*Arachis hypogaea* L.) is a valuable food and oilseed crop. It is commonly called as the king of vegetable oilseeds crop or poor man's nut. Groundnut is grown over 21.23 million ha all over the world with a total production of 34.42 million tonnes and an average productivity of 1621 kg/ha (www.fas.usda.gov). India is one of the largest groundnut producing county, contributing about 20.74% to world production from 28.73% of the global area. In India, during 2013-2014, the area under this crop was 5.53 million ha with annual production of 9.67 million tones and productivity of 1750 kg/ha (http://www.indiastat.com). Maintaining the quality of groundnut seed in post-harvest environment is a demanding and challenging task. Most of the problems of maintenance of seed quality results from the methods used to harvest, store and process the peanuts. Damage from the equipment used in handling and processing operations, improper drying treatment, poor storage condition, inadequate protection from dirt, mold, insects and rodents and similar causes of quality deterioration are very difficult to control or prevent. After the peanuts are shelled, controlling the quality deterioration becomes more difficult because the seeds are much more sensitive to conditions and environments that causes loss of quality. Better methods and techniques are needed to improve conditions and environments that cause seed quality deterioration. The availability of the viable seeds at planting time is very important for achieving the target of agricultural production; as it acts as a catalyst for realizing the potential of other input. The seed has highest level of viability at maturity, which changes during storage because of deterioration of seed quality. The potential storage life of seed varies from species to species and among the varieties. Thus there is need to understand storage life in terms of pods and kernels of groundnut varieties under different storage conditions. In view of the above, present investigation was undertaken to assess storage potential of pod and kernels of groundnut varieties and to find out the effect of storage conditions on seed quality parameter of summer groundnut.

*Corresponding author

MATERIALS AND METHODS

The kernels (F_1) and pods (F_2) of varieties Phule Unnati (V_1), RHRG-6021 (V_2) and JL-501 (V_3) were collected from Chief Scientist (Seed) and stored in HDPE bags under cold (T_1) and ambient temperature (T_2) for 270 days of storage period at Gene Bank, Medicinal and Aromatic Plant Project, M.P.K.V., Rahuri and Seed Technology Research Unit, M.P.K.V., Rahuri, respectively to assess the seed quality parameters and

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storability. The experiment was conducted at Seed Technology Research Unit, M.P.K.V., Rahuri in Factorial Completely Randomized Design (FCRD) in four replications. The observations were recorded on 100 seed weight (g), moisture content (%), electrical conductivity (dSm^{-1}), seed mycoflora (%) and oil content (%) during various storage periods. The statistical data was analyzed by the FCRD methods as per the procedure given by Snedecor and Cochran [1].

RESULTS AND DISCUSSION

100 seed weight (g)

The differences among the varieties at various storage periods and differences among temperatures after 210 days were statistically significant for 100 seed weight. However, the differences among temperatures before 210 days, pods and kernels, interactions within varieties and temperatures, varieties and forms of seed and temperatures and forms of seed were non-significant (Table 1). It was noticed that, the 100 seed weight of groundnut seed decreased with the advancement of storage periods. The varieties Phule Unnati (40.71 g) and RHRG-6021 (32.62 g) had higher 100 seed weight at initial stage. At the end of storage period of 270 days the 100 seed weight decreased to 39.50 g and 31.54 g in varieties Phule Unnati and RHRG-6021, respectively. Sangha [2] observed highly significant differences for 100 kernel weights showing wide range of variation. The seeds stored in cold temperature recorded significantly higher 100 seed weight at initial (35.39 g) as well as at the end of storage period of 270 days (35.10 g). The seeds stored in the form of pods recorded higher 100 seed weight at initial stage (35.27 g) as well as at the end of storage period of 270 days (34.22 g).

The seeds of variety Phule Unnati stored in cold temperature maintained higher 100 seed weight at initial stage (40.71 g) as well as at storage period of 270 days (40.46 g). Similarly, Phule Unnati stored in the form of pods and kernels maintained higher 100 seed weight at initial stage (40.68 g and 40.73 g) and at the end storage period of 270 days (39.58 g and 39.42 g), respectively. The pods stored in cold temperature recorded higher 100 seed weight at initial stage (35.35 g) and at the end of storage period of 270 days (35.12 g). The variety Phule Unnati stored in the form of pods at cold temperature recorded significantly higher 100 seed weight during all the periods of storage. The variety Phule Unnati stored at cold temperature in the form of pods and kernels recorded higher 100 seed weight at initial stage (40.68 g and 40.73 g) as well as at the end of storage period of 270 days (40.50 and 40.41 g), respectively.

Seed moisture content (%)

The per cent seed moisture content showed variable significant difference during storage period. The moisture content of seeds was highest after harvest and it decreased during storage period and again increased at 120 days of storage irrespective of variety, temperature and kernels and pods (Table 2). Initially the lowest moisture content was recorded in variety Phule Unnati (7.06%) and RHRH-6021 (7.34%). At the end of storage period of 270 days Phule Unnati atained the lowest moisture content (6.51%). The temperature conditions during storage had significant effect on seed moisture content during storage periods except at 0, 30, 120 and 150 days. The fluctuation in the moisture content was higher in seeds stored in ambient condition. Loss in moisture content of seeds stored at cold temperature was very little during all the periods of storage. Initially, the moisture content of 7.25% was recorded in both the temperature conditions. At the end of storage period of 270 days, lowest moisture content was recorded at ambient condition (6.43%). The kernels and pods had non-significant effect on moisture content during storage periods except at 0, 30, 120, 240 and 270 days of storage. The lower moisture content was recorded in kernels at the end of storage period of 270 days (6.65%). Harrington [3] stated that storage life of seed is halved for each 1 per cent increase in moisture content and for every 5°C rise in storage temperature. Boswell *et al.* [4] reported higher seed moisture content for peanut seeds stored at 50°F than at 80°F at the same relative humidity.

The interaction of variety and temperature had non-significant effect on seed moisture content during storage periods except at 120 days of storage. The variety Phule Unnati stored at cold temperature showed lowest moisture content (7.06%) at initial stage of storage and at the end of storage period of 270 days, whereas, the highest moisture content (7.16%) was recorded in variety RHRG-6O21 stored in cold temperature. The interaction of varieties and kernels and pods had significant effect on moisture content during storage periods from 30 to 150 days of storage. At the end of storage period of 270 days, the variety Phule Unnati stored in the form of kernels (6.47%) and pods (6.56%) maintained the lowest moisture. The interaction of temperature and kernels and pods had non-significant effect on moisture content during

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Table 1. Effect of varieties, temperature, kernels and pods and it's interaction on 100 seed weight (g) of groundnut at various storage periods

Storage period (days)	0	30	60	90	120	150	180	210	240	270
Effect of varieties										
V1 Phule Unnati	40.71	40.70	40.65	40.59	40.72	40.63	40.59	40.10	39.88	39.50
V2-RHRG-6021	32.62	32.57	32.51	32.43	32.72	32.60	32.51	32.29	31.96	31.54
V3 JL-501	32.59	32.58	32.50	32.42	32.73	32.67	32.29	32.09	31.75	31.45
SEm (±)	0.12	0.15	0.16	0.16	0.16	0.16	0.16	0.17	0.14	0.16
CD @ 5%	0.35	0.42	0.44	0.45	0.44	0.44	0.43	0.47	0.39	0.44
Effect of temperature										
T1-Cold (5-10 °C)	35.39	35.30	35.28	35.26	35.23	35.21	35.20	35.16	35.14	35.10
T2-Ambient	35.31	35.26	35.16	35.03	35.55	35.44	35.06	34.50	33.92	33.23
SEm (±)	0.10	0.12	0.13	0.13	0.13	0.13	0.13	0.14	0.11	0.13
CD @ 5%	NS	NS	NS	NS	NS	NS	NS	0.38	0.31	0.36
Effect of kernels and pods										
F1-Kernel	35.35	35.32	35.25	35.17	35.41	35.36	35.10	34.82	34.49	34.11
F2-Pod	35.27	35.25	35.19	35.12	35.37	35.31	35.16	34.84	34.57	34.22
SEm (±)	0.10	0.12	0.13	0.13	0.13	0.13	0.13	0.14	0.11	0.13
CD @ 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction (V x T)										
V1T1	40.71	40.71	40.67	40.64	40.63	40.57	40.57	40.50	40.51	40.46
V1T2	40.71	40.69	40.62	40.54	40.82	40.76	40.61	39.71	39.25	38.55
V2T1	32.59	32.59	32.58	32.55	32.53	32.48	32.51	32.48	32.44	32.42
V2T2	32.60	32.55	32.44	32.31	32.91	32.91	32.52	32.11	31.48	30.67
V3T1	32.62	32.62	32.59	32.58	32.55	32.51	32.52	32.51	32.48	32.44
V3T2	32.62	32.55	32.42	32.25	32.91	32.87	32.06	31.68	31.02	30.47
SEm (±)	0.18	0.21	0.22	0.23	0.22	0.22	0.22	0.24	0.20	0.22
CD @ 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction (V x F)										
V1F1	40.73	40.73	40.69	40.62	40.75	40.71	40.54	40.12	39.80	39.42
V1F2	40.68	40.67	40.60	40.56	40.70	40.68	40.64	40.09	39.96	39.59
V2F1	32.47	32.47	32.40	32.32	32.65	32.58	32.44	32.21	31.89	31.36
V2F2	32.72	32.68	32.62	32.55	32.79	32.72	32.58	32.38	32.04	31.73
V3F1	32.84	32.77	32.67	32.59	32.84	32.84	32.32	32.14	31.78	31.40
V3F2	32.40	32.40	32.34	32.24	32.62	32.51	32.26	32.05	31.72	31.51
SEm (±)	0.18	0.21	0.22	0.23	0.22	0.22	0.22	0.24	0.20	0.22
CD @ 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction (T X F)										
T1F1	35.26	35.26	35.24	35.22	35.20	35.15	35.17	35.15	35.14	35.09
T1F2	35.35	35.35	35.32	35.30	35.26	35.21	35.22	35.17	35.15	35.12
T2F1	35.35	35.30	35.19	35.05	35.56	35.51	34.98	34.47	33.82	33.11
T2F2	35.27	35.23	35.13	35.01	35.54	35.47	35.14	34.53	34.01	33.35
SEm (±)	0.14	0.17	0.18	0.18	0.18	0.18	0.18	0.19	0.16	0.18
CD @ 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

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Table 2. Effect of varieties, temperature, kernels and pods and it's interaction on seed moisture content (%) of groundnut at various storage periods

Storage period (days)	0	30	60	90	120	150	180	210	240	270
Effect of varieties										
V1-Phule Unnati	7.06 (15.41)	7.1 (15.45)	6.8 (15.11)	6.82 (15.13)	7.11 (15.46)	6.98 (15.32)	6.86 (15.19)	6.8 (15.12)	6.75 (15.06)	6.51 (14.8)
V2-RHRG-6021	7.34 (15.71)	7.33 (15.71)	7.21 (15.57)	7.08 (15.43)	7.37 (15.75)	7.32 (15.69)	7.14 (15.49)	7.18 (15.53)	6.97 (15.3)	6.81 (15.1)
V3-JL-501	7.36 (15.73)	7.34 (15.72)	7.18 (15.54)	7.13 (15.48)	7.44 (15.82)	7.08 (15.32)	7.26 (15.63)	7.16 (15.52)	7.05 (15.4)	6.88 (15.2)
SEm (±)	0.07	0.05	0.04	0.05	0.06	0.06	0.05	0.06	0.07	0.07
CD @ 5%	0.20	0.15	0.13	0.15	0.17	0.17	0.16	0.18	0.20	0.2
Effect of temperature										
T1-Cold (5-10 °C)	7.25 (15.62)	7.24 (15.61)	7.22 (15.59)	7.22 (15.58)	7.2 (15.56)	7.18 (15.54)	7.16 (15.51)	7.12 (15.48)	7.09 (15.44)	7.03 (15.4)
T2-Ambient	7.25 (15.62)	7.27 (15.64)	6.9 (15.23)	6.81 (15.12)	7.22 (15.51)	7.27 (15.63)	7.02 (15.36)	6.97 (15.31)	6.76 (15.07)	6.43 (14.7)
SEm (±)	0.05	0.04	0.03	0.04	0.05	0.05	0.04	0.05	0.06	0.06
CD @ 5%	NS	NS	0.10	0.12	NS	NS	0.13	0.14	0.17	0.16
Effect of kernels and pods										
F1-Kernel	7.33 (15.71)	7.34 (15.71)	7.1 (15.45)	7.06 (15.41)	7.31 (15.68)	7.2 (15.49)	7.11 (15.46)	6.99 (15.33)	6.84 (15.16)	6.65 (14.9)
F2-Pod	7.17 (15.53)	7.18 (15.54)	7.02 (15.36)	6.96 (15.3)	7.14 (15.49)	7.21 (15.5)	7.06 (15.41)	7.1 (15.45)	7.01 (15.35)	6.81 (15.1)
SEm (±)	0.05	0.04	0.03	0.04	0.05	0.05	0.04	0.05	0.06	0.06
CD @ 5%	0.16	0.12	NS	NS	1.41	NS	NS	NS	0.17	0.16
Interaction (V x T)										
V1T1	7.06 (15.41)	7.05 (15.41)	7.04 (15.38)	7.01 (15.35)	6.98 (15.32)	6.94 (15.27)	6.91 (15.23)	6.89 (15.22)	6.89 (15.21)	6.84 (15.2)
V1T2	7.07 (15.41)	7.14 (15.49)	6.56 (14.83)	6.63 (14.92)	7.23 (15.6)	7.03 (15.37)	6.82 (15.14)	6.71 (15.01)	6.62 (14.91)	6.19 (14.4)
V2T1	7.34 (15.72)	7.38 (15.71)	7.32 (15.69)	7.31 (15.68)	7.3 (15.68)	7.29 (15.66)	7.26 (15.63)	7.25 (15.62)	7.22 (15.58)	7.16 (15.5)
V2T2	7.33 (15.71)	7.33 (15.71)	7.1 (15.45)	6.86 (15.18)	7.57 (15.97)	7.34 (15.72)	7.02 (15.36)	7.1 (15.44)	6.72 (15.02)	6.46 (14.7)
V3T1	7.35 (15.73)	7.34 (15.72)	7.32 (15.69)	7.34 (15.71)	7.31 (15.68)	7.31 (15.68)	7.3 (15.67)	7.22 (15.59)	7.16 (15.51)	7.1 (15.5)
V3T2	7.36 (15.73)	7.39 (15.71)	7.05 (15.39)	6.93 (15.26)	7.43 (15.82)	6.86 (14.96)	7.22 (15.58)	7.11 (15.46)	6.95 (15.28)	6.65 (14.9)
SEm (±)	0.10	0.07	0.068	0.07	0.091	0.09	0.08	0.09	0.10	0.1
CD @ 5%	NS	NS	NS	NS	0.25	NS	NS	NS	NS	NS
Interaction (V x F)										
V1F1	7.09 (15.44)	7.12 (15.48)	6.69 (14.98)	6.77 (15.08)	7.2 (15.56)	7.1 (15.45)	6.88 (15.21)	6.79 (15.1)	6.65 (14.94)	6.47 (14.7)
V1F2	7.03 (15.37)	7.07 (15.42)	6.91 (15.23)	6.87 (15.19)	7.02 (15.36)	6.87 (15.19)	6.85 (15.17)	6.81 (15.13)	6.86 (15.18)	6.56 (14.8)

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V2F1	7.36 (15.74)	7.37 (15.75)	7.29 (15.66)	7.14 (15.49)	7.48 (15.87)	7.27 (15.64)	7.09 (15.44)	7.01 (15.35)	6.87 (15.19)	6.66 (14.9)
V2F2	7.31 (15.68)	7.3 (15.67)	7.13 (15.48)	7.03 (15.37)	7.4 (15.78)	7.37 (15.75)	7.19 (15.55)	7.34 (15.71)	7.07 (15.41)	6.97 (15.3)
V3F1	7.54 (15.94)	7.52 (15.92)	7.33 (15.71)	7.28 (15.65)	6.94 (15.04)	7.56 (15.96)	7.36 (15.74)	7.18 (15.54)	7.01 (15.35)	6.84 (15.2)
V3F2	7.17 (15.53)	7.16 (15.51)	7.03 (15.37)	6.99 (15.32)	7.23 (15.6)	7.18 (15.54)	7.16 (15.51)	7.15 (15.51)	7.1 (15.45)	6.92 (15.2)
SEm (±)	0.103	0.076	0.068	0.076	0.091	0.09	0.084	0.093	0.106	0.1
CD @ 5%	NS	0.213	0.189	0.212	0.253	0.253	NS	NS	NS	NS
Interaction (T X F)										
T1F1	7.33 (15.71)	7.33 (15.7)	7.3 (15.68)	7.3 (15.67)	7.28 (15.65)	7.25 (15.61)	7.22 (15.58)	7.17 (15.53)	7.1 (15.45)	7.04 (15.4)
T1F2	7.17 (15.53)	7.16 (15.52)	7.14 (15.5)	7.13 (15.4)	7.11 (15.47)	7.11 (15.46)	7.09 (15.45)	7.07 (15.42)	7.07 (15.42)	7.03 (15.4)
T2F1	7.33 (15.71)	7.34 (15.72)	6.91 (15.23)	6.82 (15.1)	7.12 (15.33)	7.37 (15.75)	7.0 (15.34)	6.82 (15.14)	6.59 (14.87)	6.27 (14.5)
T2F2	7.17 (15.53)	7.19 (15.55)	6.9 (15.22)	6.79 (15.1)	7.31 (15.69)	7.16 (15.52)	7.03 (15.38)	7.13 (15.48)	6.94 (15.27)	6.6 (14.9)

storage periods except at 120, 210, 240 and 270 days. The kernels stored at ambient temperature maintained the lowest moisture content at 270 days of storage (6.27%) and at initial stage (7.33%). The three factor interaction had non-significant effect on moisture content during storage periods except at 120 days. RHRG-6021 stored at cold temperature in the form of pods showed less fluctuation in moisture content and recorded higher moisture content at the end of 270 days of storage (7.21%). Lowest moisture content was recorded in Phule Unnati at the end of storage period of 270 days (6.13%) and at initial stage (7.09%).

Electrical conductivity

The electrical conductivity differed significantly during storage periods. It was also noticed that EC increased with the advancement of storage period irrespective of variety, temperature and pods and kernels (Table 3). Parameswaran *et al.* [5], Nautiyal *et al.* [6] and Chakrahorty *et al.* [7] reported high electrical conductivity of the leachates in aged seeds of groundnut. In the present investigation, the electrical conductivity in variety Phule Unnati was initially minimal (0.169 dSm^{-1}) and at the end of storage period it increased to 0.868 dSm^{-1}. The temperatures used for storage had significant effect during storage periods except at 0 days of storage, on electrical conductivity of seed. The cold temperature storage resulted in lower electrical conductivity at the end of storage period of 270 days (0.814 dSm^{-1}) as well as at initial stage (0.181 dSm^{-1}). The kernels and pods had significant effect on electrical conductivity during storage period. The pods had lower electrical conductivity at initial stage (0.180dSm^{-1}) and at the end of 270 days of storage (0.886dSm^{-1}).

The interaction of variety and temperature had significant effect on electrical conductivity during storage periods except at 0, 120 and 210 days of storage. The seeds of var. Phule Unnati (0.718 dSm^{-1}) and RHRG-6021 (0.765 dSm^{-1}) stored in cold temperature recorded lower electrical conductivity at the end of storage period. The interaction effect of variety and kernels and pods had significant effect on groundnut seed germination during storage periods except at 90, 120, 210, 240 and 270 days. The seeds of Phule Unnati (0.823 dSm^{-1}) and RHRG-6021 (0.864 dSm^{-1}) stored in the form of pods recorded the lowest electrical conductivity at the end of storage period of 270 days. The interaction effect of temperatures and kernels and pods had significant effect on electrical conductivity of leachates during storage periods except at 0, 30, 60, 210 and 240 days of storage. The groundnut stored in the form of pods at cold temperature recorded lower electrical conductivity at the end of 270 days of storage period (0.813 dSm^{-1}) as well as at initial stage (0.180 dSm^{-1}). The three factor interaction had significant effect on groundnut electrical conductivity except at 0, 120, 210 and 240 days of storage. The interaction in the form of pods of variety Phule Unnati stored at cold temperature

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Table 3. Effect of varieties, temperature, kernels and pods and it's interaction on electrical conductivity (dSm^{-1}) of groundnut at various storage periods

Storage period (days)	0	30	60	90	120	150	180	210	240	270
Effect of temperature										
V1-Phule Unnati	0.169	0.214	0.287	0.381	0.465	0.516	0.633	0.749	0.813	0.868
V2-RHRG-6021	0.188	0.224	0.286	0.397	0.492	0.574	0.661	0.781	0.849	0.899
V3-JL-501	0.187	0.228	0.287	0.409	0.508	0.568	0.646	0.790	0.931	1.028
SEm (±)	0.001	0.001	0.002	0.003	0.004	0.003	0.004	0.004	0.005	0.006
CD @ 5%	0.002	0.002	NS	0.007	0.010	0.009	0.010	0.011	0.014	0.017
Effect of temperature										
T1-Cold (5-10 °C)	0.181	0.204	0.253	0.355	0.435	0.502	0.570	0.671	0.719	0.814
T2-Ambient	0.181	0.240	0.321	0.436	0.542	0.603	0.723	0.876	1.010	1.049
SEm (±)	0.000	0.001	0.001	0.002	0.003	0.003	0.003	0.003	0.004	0.005
CD @ 5%	NS	0.002	0.004	0.006	0.008	0.007	0.008	0.009	0.011	0.014
Effect of kernels and pods										
F1-Kernel	0.182	0.232	0.301	0.412	0.507	0.569	0.642	0.794	0.883	0.977
F2-Pod	0.180	0.212	0.273	0.380	0.470	0.536	0.651	0.753	0.845	0.886
SEm (±)	0.000	0.001	0.001	0.002	0.003	0.003	0.003	0.003	0.004	0.005
CD @ 5%	0.001	0.002	0.004	0.006	0.008	0.007	0.008	0.009	0.011	0.014
Interaction (V x T)										
V1T1	0.169	0.188	0.256	0.336	0.409	0.466	0.527	0.640	0.675	0.718
V1T2	0.169	0.240	0.319	0.427	0.521	0.565	0.739	0.858	0.951	1.018
V2T1	0.188	0.206	0.254	0.353	0.441	0.494	0.566	0.679	0.727	0.765
V2T2	0.188	0.243	0.318	0.441	0.544	0.655	0.757	0.883	0.971	1.034
V3T1	0.187	0.218	0.248	0.378	0.455	0.546	0.617	0.694	0.754	0.960
V3T2	0.187	0.237	0.327	0.441	0.562	0.590	0.675	0.887	1.108	1.096
SEm (±)	0.001	0.001	0.002	0.004	0.005	0.004	0.005	0.006	0.007	0.009
CD @ 5%	NS	0.003	0.006	0.010	NS	0.012	0.014	NS	0.019	0.025
Interaction (V x F)										
V1F1	0.170	0.219	0.299	0.396	0.483	0.546	0.656	0.772	0.832	0.913
V1F2	0.168	0.208	0.276	0.367	0.447	0.486	0.610	0.726	0.794	0.823
V2F1	0.185	0.236	0.305	0.411	0.517	0.592	0.683	0.802	0.862	0.935
V2F2	0.190	0.213	0.266	0.383	0.468	0.557	0.640	0.760	0.836	0.864
V3F1	0.191	0.240	0.299	0.429	0.522	0.570	0.587	0.808	0.956	1.084
V3F2	0.182	0.215	0.276	0.390	0.495	0.566	0.705	0.773	0.906	0.972
SEm (±)	0.001	0.001	0.002	0.004	0.005	0.004	0.005	0.006	0.007	0.009
CD @ 5%	0.002	0.003	0.006	NS	NS	0.012	0.014	NS	NS	NS
Interaction (T X F)										
T1F1	0.182	0.213	0.267	0.379	0.458	0.535	0.587	0.696	0.736	0.816
T1F2	0.180	0.194	0.238	0.332	0.411	0.469	0.553	0.646	0.701	0.813
T2F1	0.182	0.250	0.335	0.445	0.556	0.603	0.697	0.892	1.030	1.141
T2F2	0.180	0.229	0.307	0.427	0.528	0.603	0.750	0.860	0.989	0.957
SEm (±)	0.001	0.001	0.002	0.003	0.004	0.004	0.004	0.005	0.006	0.007
CD @ 5%	NS	NS	NS	0.008	0.011	0.010	0.012	NS	NS	0.020

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recorded lowest electrical conductivity at initial stage (0.168 dSm^{-1}) and at the end of 270 days (0.732 dSm^{-1}).

Seed mycoflora (%)

The seed mycoflora increased with the advancement of storage period irrespective of variety, temperature and kernels and pods (Table 4). The different varieties of groundnut had non-significant effect on seed mycoflora during storage periods except at 270 days of storage. Initially, less seed mycoflora was observed in Phule Unnati and RHRG-6021 (2.50%). At the end of storage period of 270 days, the seed mycoflora increased to 19.38% and 25.63% in Phule Unnati and RHRG-6021, respectively. The storage temperatures had significant effect on seed mycoflora during storage periods except at 0, 30, 60 and 90 days of storage. Lower seed mycoflora were recorded in seeds stored in cold temperature at initial stage (2.50%) as well as at the end of storage period of 270 days (18.75%). The kernels and pods had significant effect on seed mycoflora from 180 days till the end of storage period. The seeds stored in the form of pods recorded significantly lower seed mycoflora during all the periods of storage. The highest seed mycoflora was recorded in kernels (28.33%) and (20.83%) pods at the end of storage period, whereas the lowest seed mycoflora was recorded in the pods (2.50%) and kernels (2.92%) at initial stage. Ameer *et al.* [8] stated the invasion of fungal pathogen also play a major role in decreasing the viability of a seed lot in groundnut. Ibiam and Egwu [9] reported that among different species of fungal infection, *Aspergillus flavus* was the most preponderant one in groundnut.

Interaction effect of variety and temperature on seed mycoflora was non-significant during storage periods. The seeds of variety Phule Unnati (2.50 and 13.75%) and RHRG-6021 (2.50 and 20.00%) stored at cold temperature recorded significantly less seed mycoflora at initial stage and also at the end of storage period. The interaction of variety and kernels and pods had non-significant effect on seed mycoflora during storage periods. At the end of storage period, the lowest seed mycoflora was recorded in the variety Phule Unnati (15.00%) and RHRG-6021 (22.50%) stored in the form of pods. Interaction of temperature and kernels and pods showed non-significant effect on seed mycoflora percentage during storage periods. The pods stored at cold temperature recorded lower seed mycoflora duringentire period of storage. Higher seed mycoflora was recorded in kernels stored at ambient temperature at initial stage (3.33%) as well as at the end of storage period (35.00%). At the end of storage period lowest seed mycoflora was recorded in pods stored at cold temperature (15.83%) followed by kernels stored at cold temperature (21.67%). The interaction of varieties, temperature and pods and kernels had non-significant effect on seed mycoflora during storage period. The variety Phule Unnati (10.00%) stored as pods at cold temperature recorded numerically significant lower seed mycoflora at the end of storage period of 270 days, followed by RHRG-6021 (17.50%).

Oil content (%)

The oil content decreased with advancement of storage period irrespective of variety, temperature, kernels or pods (Table 5). The groundnut varieties had significant effect on oil content of seed during storage. RHRG-6021 (51.61%) followed by Phule Unnati (50.73%) recorded higher oil content at initial stage. It decreased to 47.61% and 47.38% in varieties Phule Unnati and RH RG-6021 respectively, at the end of storage period of 270 days. Verma *et al.* [10] reported that the variation in oil content and fatty acids of castor seed was mainly due to difference in the genetic makeup of varieties. The storage temperatures had non-significant effect at 0 to 90 days of storage. Narayanaswamy [11] concluded that oil, protein and field emergence of groundnut seeds decreased but free fatty acid and EC increased with advancement of storage period. The higher oil content was recorded in seeds stored in cold temperature (50.72%) followed by seeds stored in ambient temperature (50.68%), at initial stage. At the end of storage period of 270 days, higher oil content was recorded in seeds stored in cold temperature (48.11%) followed by seeds stored in ambient temperature (46.11%). The kernels and pods had non-significant effect on oil content through out the storage period except at 270 days of storage. The seeds stored in the form of pods (50.71%) and kernels (50.69%) recorded higher oil content at initial stage.

Interaction of variety and temperature was non-significant for oil content during the storage periods except at 210 and 270 days of storage. At initial stage, RHRG-6021 (51.67%) stored at cold temperature recorded high oil content while at the end of storage period, Phule Unnati (48.78%) and RHRG-6021 (48.21%) recorded the highest oil content. The interaction of variety and kernels and pods had non-significant effect on oil content during storage period. The variety RHRG-6021 recorded higher oil content when stored in the form of pods (51.69%) and kernels (51.52%) at initial stage. However, at the end of storage

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Table 4. Effect of varieties, temperature, kernels and pods and it's interaction on seed mycoflora (%) of groundnut at various storage periods

Storage period (days)	0	30	60	90	120	150	180	210	240	270
Effect of temperature										
V1-Phule Unnati	2.50 (4.61)	2.50 (4.61)	2.50 (4.61)	3.13 (5.76)	5.00 (9.22)	7.50 (12.54)	10.63 (15.72)	12.50 (19.09)	15.63 (22.18)	19.38 (24.91)
V2-RHRG-6021	2.50 (4.61)	2.50 (4.61)	3.13 (5.76)	3.13 (5.76)	5.63 (10.37)	8.75 (14.20)	11.88 (16.65)	14.38 (20.61)	17.50 (23.48)	25.63 (30.09)
V3-JL-501	3.13 (5.76)	3.13 (5.76)	3.13 (5.76)	3.13 (5.76)	4.38 (8.07)	8.13 (13.05)	13.75 (19.37)	15.00 (21.58)	17.50 (23.48)	28.75 (32.02)
SEm (±)	2.34	2.34	2.37	2.40	2.17	2.26	1.88	1.66	1.72	1.50
CD @ 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	4.20
Effect of temperature										
T1-Cold (5-10 °C)	2.50 (4.61)	2.50 (4.61)	2.50 (4.61)	2.50 (4.61)	2.50 (4.61)	4.58 (7.59)	4.58 (8.45)	8.33 (14.93)	10.83 (17.82)	18.75 (24.87)
T2-Ambient	2.92 (5.38)	2.92 (5.38)	3.33 (6.14)	3.75 (6.91)	7.50 (13.83)	11.67 (18.93)	19.58 (26.04)	19.58 (25.92)	22.92 (28.27)	30.42 (33.14)
SEm (±)	1.91	1.91	1.93	1.96	1.77	1.84	1.53	1.36	1.40	1.23
CD @ 5%	NS	NS	NS	NS	4.96	5.15	4.28	3.79	3.92	3.43
Effect of kernels and pods										
F1-Kernel	2.92 (5.38)	2.92 (5.38)	3.33 (6.14)	3.75 (6.91)	5.42 (9.99)	10.00 (15.86)	14.17 (19.49)	16.25 (23.27)	19.58 (25.68)	28.33 (31.84)
F2-Pod	2.50 (4.61)	2.50 (4.61)	2.50 (4.61)	2.50 (4.61)	4.58 (8.45)	6.25 (10.66)	10.00 (15.00)	11.67 (17.58)	14.17 (20.41)	20.83 (26.18)
SEm (±)	1.91	1.91	1.93	1.96	1.77	1.84	1.53	1.36	1.40	1.23
CD @ 5%	NS	NS	NS	NS	NS	NS	4.28	3.79	3.92	3.43
Interaction (V x T)										
V1T1	2.50 (4.61)	2.50 (4.61)	2.50 (4.61)	2.50 (4.61)	2.50 (4.61)	2.50 (5.63)	3.75 (6.91)	7.50 (13.83)	10.00 (17.15)	13.75 (20.20)
V1T2	2.50 (4.61)	2.50 (4.61)	2.50 (4.61)	3.75 (6.91)	7.50 (13.83)	11.25 (19.45)	17.50 (24.53)	17.50 (24.35)	21.25 (27.21)	25.00 (29.62)
V2T1	2.50 (4.61)	2.50 (4.61)	2.50 (4.61)	2.50 (4.61)	2.50 (4.61)	6.25 (10.23)	3.75 (6.91)	8.75 (14.84)	11.25 (18.16)	20.00 (26.38)
V2T2	2.50 (4.61)	2.50 (4.61)	3.75 (6.91)	3.75 (6.91)	8.75 (16.13)	11.25 (18.16)	20.00 (26.38)	20.00 (26.38)	23.75 (28.79)	31.25 (33.81)
V3T1	2.50 (4.61)	2.50 (4.61)	2.50 (4.61)	2.50 (4.61)	2.50 (4.61)	3.75 (6.91)	6.25 (11.52)	8.75 (16.13)	11.25 (18.16)	22.50 (28.04)
V3T2	3.75 (6.91)	3.75 (6.91)	3.75 (6.91)	3.75 (6.91)	6.25 (11.52)	12.50 (19.18)	21.25 (27.21)	21.25 (27.02)	23.75 (28.79)	35.00 (36.00)
SEm (±)	3.30	3.30	3.35	3.39	3.07	3.19	2.65	2.35	2.43	2.13
CD @ 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction (V x F)										
V1F1	2.50 (4.61)	2.50 (4.61)	2.50 (4.61)	3.75 (6.91)	6.25 (11.52)	8.75 (13.55)	12.50 (17.89)	15.00 (22.31)	18.75 (25.18)	23.75 (28.79)
V1F2	2.50 (4.61)	2.50 (4.61)	2.50 (4.61)	2.50 (4.61)	3.75 (6.91)	6.25 (11.52)	8.75 (13.55)	10.00 (15.86)	12.50 (19.18)	15.00 (21.03)
V2F1	2.50 (4.61)	2.50 (4.61)	3.75 (6.91)	3.75 (6.91)	6.25 (11.52)	11.25 (18.16)	13.75 (18.72)	16.25 (23.33)	20.00 (25.93)	28.75 (32.22)

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V2F2	2.50 (4.61)	2.50 (4.61)	2.50 (4.61)	2.50 (4.61)	5.00 (9.22)	6.25 (10.23)	10.00 (14.57)	12.50 (17.89)	15.00 (21.03)	22.50 (27.96)
V3F1	3.75 (6.91)	3.75 (6.91)	3.75 (6.91)	3.75 (6.91)	3.75 (6.91)	10.00 (15.86)	16.25 (21.86)	17.50 (24.16)	20.00 (25.93)	32.50 (34.50)
V3F2	2.50 (4.61)	2.50 (4.61)	2.50 (4.61)	2.50 (4.61)	5.00 (9.22)	6.25 (10.23)	11.25 (16.88)	12.50 (18.99)	15.00 (21.03)	25.00 (29.55)
SEm (±)	3.30	3.30	3.35	3.39	3.07	3.19	2.65	2.35	2.43	2.13
CD @ 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction (T X F)										
T1F1	2.50 (4.61)	2.50 (4.61)	2.50 (4.61)	2.50 (4.61)	2.50 (4.61)	6.67 (10.57)	5.83 (10.75)	10.00 (18.43)	12.50 (20.47)	21.67 (27.55)
T1F2	2.50 (4.61)	2.50 (4.61)	2.50 (4.61)	2.50 (4.61)	2.50 (4.61)	2.50 (4.61)	3.33 (6.14)	6.67 (11.43)	9.17 (15.18)	15.83 (22.20)
T2F1	3.33 (6.14)	3.33 (6.14)	4.17 (7.68)	5.00 (9.22)	8.33 (15.36)	13.33 (21.14)	22.50 (28.23)	22.50 (28.10)	26.67 (30.89)	35.00 (36.13)
T2F2	2.50 (4.61)	2.50 (4.61)	2.50 (4.61)	2.50 (4.61)	6.67 (12.29)	10.00 (16.72)	16.67 (23.86)	16.67 (23.73)	19.17 (25.64)	25.83 (30.16)
SEm (±)	2.70	2.70	2.73	2.77	2.51	2.61	2.17	1.92	1.98	1.74
CD @ 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 5. Effect of varieties, temperature, kernels and pods and it's interaction on oil content (%) of groundnut at various storage periods

Storage period (days)	0	30	60	90	120	150	180	210	240	270
Effect of temperature										
V1-Phule Unnati	50.73	50.66	50.45	50.10	49.87	49.62	49.25	48.48	47.93	47.61
V2-RHRG-6021	51.61	51.53	51.16	51.04	50.90	50.48	50.24	49.12	47.70	47.38
V3-JL-501	49.76	49.64	49.44	49.41	49.08	48.72	48.60	48.24	47.01	46.78
SEm (±)	0.16	0.16	0.44	0.28	0.16	0.17	0.17	0.18	0.19	0.16
CD @ 5%	0.45	0.44	1.22	0.78	0.43	0.46	0.49	0.49	0.54	0.44
Effect of temperature										
T1-Cold (5-10 °C)	50.72	50.67	50.51	50.38	50.20	49.93	49.80	49.27	48.44	48.11
T2-Ambient	50.68	50.55	50.20	49.98	49.70	49.28	48.92	47.96	46.65	46.41
SEm (±)	0.13	0.13	0.36	0.23	0.13	0.13	0.14	0.14	0.16	0.13
CD @ 5%	NS	NS	NS	NS	0.35	0.38	0.40	0.40	0.44	0.36
Effect of kernels and pods										
F1-Kernel	50.71	50.57	50.31	50.12	49.91	49.53	49.30	48.50	47.42	47.06
F2-Pod	50.69	50.64	50.40	50.24	49.99	49.68	49.42	48.72	47.68	47.45
SEm (±)	0.13	0.13	0.36	0.23	0.13	0.13	0.14	0.14	0.16	0.13
CD @ 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.36
Interaction (V x T)										
V1T1	50.73	50.70	50.60	50.42	50.21	50.00	49.73	49.50	49.05	48.78
V1T2	50.73	50.62	50.31	49.78	49.53	49.23	48.77	47.46	46.82	46.45
V2T1	51.67	51.59	51.33	51.21	51.09	50.94	50.81	49.56	48.55	48.21
V2T2	51.54	51.47	51.00	50.87	50.71	50.02	49.67	48.69	46.85	46.56
V3T1	49.76	49.72	49.61	49.53	49.29	48.86	48.86	48.74	47.73	47.35

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V3T2	49.76	49.57	49.28	49.28	48.87	48.59	48.34	47.74	46.29	46.22
SEm (±)	0.23	0.22	0.62	0.40	0.22	0.23	0.25	0.25	0.27	0.22
CD @ 5%	NS	NS	NS	NS	NS	NS	NS	0.70	NS	0.62
Interaction (V x F)										
V1F1	50.71	50.63	50.41	50.04	49.80	49.53	49.19	48.38	47.82	47.40
V1F2	50.75	50.69	50.49	50.15	49.95	49.70	49.30	48.58	48.05	47.83
V2F1	51.69	51.49	51.12	51.00	50.86	50.43	50.16	48.95	47.50	47.15
V2F2	51.52	51.57	51.21	51.08	50.94	50.53	50.31	49.29	47.90	47.61
V3F1	49.71	49.61	49.40	49.33	49.08	48.65	48.56	48.18	46.93	46.64
V3F2	49.80	49.68	49.49	49.49	49.07	48.80	48.64	48.30	47.09	46.93
SEm (±)	0.23	0.22	0.62	0.40	0.22	0.23	0.25	0.25	0.27	0.22
CD @ 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction (T X F)										
T1F1	50.71	50.65	50.47	50.31	50.14	49.85	49.73	49.12	48.33	47.96
T1F2	50.73	50.69	50.55	50.46	50.26	50.02	49.87	49.41	48.55	48.25
T2F1	50.71	50.50	50.15	49.94	49.68	49.22	48.88	47.88	46.50	46.16
T2F2	50.65	50.60	50.24	50.02	49.72	49.33	48.97	48.04	46.80	46.65
SEm (±)	0.19	0.18	0.50	0.32	0.18	0.19	0.20	0.20	0.22	0.18
CD @ 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

period, Phule Unnati (47.83%) recorded higher oil content when stored in the form of pods. Interaction effect of temperature and kernels and pods showed non-significant effect on oil content during storage. The pods stored at cold temperature recorded significantly higher oil content at initial stage (50.73%) as well as at the end of storage period (48.25%). The interaction of varieties, temperature and pods and kernels had non-significant effect on oil content during storage period. The variety Phule Unnati (50.75 and 48.98%) and RHRG-6021 (51.64 and 48.28%) stored in the form of pods at cold temperature recorded numerically higher oil content at initial stage and the end of storage periods, respectively.

The study revealed that the variety Phule Unnati (V_1) showed greater storability than variety RHRG-6021 (V_2) and JL-501 (V_3). The seeds of var. Phule Unnati (V_1) maintained storability above MSCS for 270 days irrespective of storage temperature and kernels and pods. The seeds in the form of pods (F_2) stored at cold temperature (5-10^{0}C) (T_1) influenced the seed quality and storability significantly. The maximum increase in storability (90 days) was observed in pods (F_2) under the cold temperature (T_1) as compared to ambient temperature (T_2) and maintained storability above MSCS for 270 days irrespective of variety. The variety Phule Unnati stored in the form of pods at cold temperature (5-10 ^{0}C) ($V_1T_1F_2$) retained better seed quality up to 270 days of storage. It also exhibited higher vigour index, lower electrical conductivity and less seed mycoflora.

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