**Factors influencing the deterioration of groundnut seed quality and its implications on storage capacity**

**Abstract**

The current study was aimed to investigate the factors influencing seed deterioration of groundnut with factorial CRD, the experiment was conducted at Department of Seed Science and Technology, Seed Research and Technology Centre, Professor Jaya Shankar Telangana Agricultural University during February 2022 to March 2023. Groundnut seeds from different harvesting windows (early, normal, and late) and varying seed moisture levels (8%, 10%, and 12%) were subjected to ambient storage for a year. They were then evaluated for seed moisture content, germination, and field emergence using three replicates of 100 seeds each. Results indicated that among the different seed moisture contents, seeds from the early harvesting window with 8% moisture content exhibited the highest germination rates, recording 76% after one year of storage. Conversely, seeds from the normal harvesting window with 12% seed moisture content showed the lowest germination percentages, with rates of 51% under similar conditions. The groundnut seeds displayed significant variation in germination rates both in 8% and 12 % seed moistures.

**Keywords:**Harvesting Windows, Seed Deterioration, Seed Moisture Contents, Seed Quality

**INTRODUCTION:**

Groundnut, scientifically known as *Arachis hypogaea* L., and commonly referred to as peanut, is a self-pollinating legume with a tetraploid genetic makeup. It falls under the Fabaceae (or Leguminosae) family and is renowned as the "King of oil seeds". Peanuts are nutritionally rich, containing around 26% protein, substantial 50% oil with a predominance of unsaturated fatty acids exceeding 80%, and 3% fiber. They also boast elevated levels of essential nutrients such as calcium, thiamine, niacin, among others (Biswas and Bhattacharjee, 2019; Reager *et al*., 2022). Groundnut is extensively cultivated in rain-fed regions across the tropics, subtropics, and semi-arid areas worldwide, with India ranking as the second-largest producer after China. In terms of oilseed crop production in India, it holds the third position, following rapeseed and mustard.

The quality of stored peanuts is influenced by factors such as storage humidity, temperature, and the material of the packaging. In efforts to preserve peanut quality and mitigate economic losses, numerous researchers have investigated the impact of various storage conditions on peanut quality changes (Mutegi, 2018). Mutegi's findings indicate that alterations in humidity levels significantly affect the moisture content, rancidity, physical damage, and aflatoxin levels in peanuts. Given that groundnuts are primarily grown as a Rabi season crop for seed production, it becomes paramount to efficiently multiply, store, and distribute the planting material for the ensuing Rabi season. Therefore, preserving seed quality from the time of harvest until the subsequent Rabi season, while maintaining optimal germination rates, is crucial for ensuring successful and economically viable seed production.

Numerous factors, encompassing dormancy, biological and environmental elements, as well as the timing and technique of harvesting, exert significant influence on seed longevity. Seed quality is susceptible to the influence of various environmental factors at different stages, including seed production, genetic composition, harvesting, processing, storage, and seed treatments (Adebisi, 2004; Adebisi *et al.,* 2019). Typically, the crop is sown from early to late October, extending into the first fortnight of November, contingent on the regular onset of the monsoon and the commencement of sowing rains. However, the capricious arrival of monsoon and the initiation of rains at times compel farmers to plant the crop either earlier, within the usual timeframe, or later in the season. This exposes the crop to either severe moisture stress or excessive rainfall, ultimately leading to subpar yields. Consequently, one of the primary objectives of this study was to ascertain the optimal timing for sowing. It is worth noting that studies on critical aspects like the moisture content of unshelled groundnut seeds during storage in relation to their harvesting windows were limited in the field of groundnut research.

**MATERIALS AND METHODS**

The seed samples were obtained from early, normal, and late harvesting windows, as illustrated in Table.1. Freshly harvested groundnut pods underwent a systematic process of sun-drying and thorough cleaning. The initial moisture content of the received produce was 8%, 10% and 12% for pods of different harvesting windows. The packing material utilized for this seed storage studies was polypropylene bags for all the treatments.

**Table1: Seed samples of different harvesting windows**

|  |  |  |
| --- | --- | --- |
| **CLASSIFICATION** | **REGULAR SOWING WINDOW** | **CORRESPONDING HARVESTING WINDOW** |
| **EARLY** | 1st and 2nd Fort Night of September | 1st and 2nd Fort Night of January |
| **NORMAL** | 1st and 2nd Fort Night of October | 1stand 2nd Fort Night of February |
| **LATE** | 1st and 2nd Fort Night of November | 1stand 2nd Fort Night of March |

**METHODOLOGY**: The experiment was conducted at the Department of Seed Science and Technology utilizing a completely randomized design with three replicationsduring February 2022 to March 2023. The assessment of seed quality parameters was conducted using the following methods and the resulting parameters were recorded as follows.

**a) Seed moisture content (%)**

The seed moisture content was evaluated using the oven-drying technique for both pod-intact and dehusked kernels, following a dry weight basis approach (ISTA, 1999). This involved determining the weight loss of the pod or kernel after exposure to a constant low temperature of 103˚C for a period of 17 hours, in comparison to the initial sample weight. The calculation was carried out using the following formula by Sutopo (1988).

Moisture content (%) =$\frac{M\_{2}-M\_{3}}{M\_{2}-M\_{1}}x100$

Where,

 M1 = Weight of the metal container along with the lid in grams

 M2 = Weight of the metal container along with lid and the sample before drying in grams

 M3 = Weight of the metal container along with lid and the sample after drying in grams

**b) Germination (%)**

Six sets of 50 seeds each, totalling 300 seeds per treatment, were randomly chosen and subjected to testing using the 'Between paper method' in accordance with ISTA rules (ISTA, 2019). The seeds were placed within rolled paper towels and positioned vertically in a seed germinator cabinet set at a temperature of 25 ± 1º C and a relative humidity of 95 ± 2%. On the tenth day, the number of normal seedlings (those exhibiting typical shoot and root development) was recorded and the mean was expressed as seed germination in percentage. The germination percentage was calculated using the following formula given by Gairola *et al*. (2011).

 Number of normal seedlings

 Germination (%) = x 100

 Total number of seeds

**d) Field Emergence**

In the field emergence study, three hundred seeds were randomly selected from each treatment across three replications. These selected seeds were then planted at a depth of 2.5 to 3.0 cm and covered with soil. The assessment for field emergence was performed on the 10th day after sowing; taking into account the number of seedlings that emerged three centimetres above the soil 2surface. The percentage of emergence was determined using the formula provided by Gairola *et al.* (2011).

Number of normal seedlings

 Field Emergence (%) = x 100

 Total number of seeds

**RESULTS AND** **DISCUSSION:**

During the first season of study, it was noticed that, as the storage period advanced from 1 month after storage (one MAS) to 12 months after storage (12 MAS), there was a gradual reduction in seed moisture content (Table 2). The mean seed moisture content was ranged from 5.32 % to 11.99 % across various harvesting windows and initial seed moistures.

Among the different initial seed moistures, the groundnut seeds stored with 8 % initial SMC showed the lowest mean SMC (7.49 %) compared to the seeds stored with 10 % and 12 % initial SMCwhich recorded 9.09 % and 11.22 % mean SMC respectively across the storage period under study. From these findings it is proved that, the initial SMC with which the seed is kept for storage is observed to be maintained at more or less same mean moisture levels over a twelve-month storage period. Among the HWs of 8 % initial SMC, the early harvested seed recorded the lowest mean SMC (7.40 %) across the storage periods. However, the early harvested seed with 8 % initial SMC recorded 7.96 % SMC at one MAS which was gradually decreased to 5.32 % at 12 MAS. The same decreasing trend was noticed in all harvesting windows with initial seed moistures of 8 %, 10 % and 12 % throughout the storage period.

Among the harvesting windows evaluated, the early harvested seeds of 8 % (7.40 %), 10 % (9.00 %) and 12 % (11.21 %) moistures exhibited significantly lowest mean percent seed moisture contents (SMC) and they were at par with seeds from late harvesting window of their respective seed moistures.

Across the storage periods evaluated, significantly highest seed moisture percent was recorded at one MAS (9.97 %) followed by two MAS (9.94 %), three MAS (9.90 %) which were at par with each other and followed the same trend till the end of the storage periods, while the lowest of that was recorded at 12 MAS (7.95 %). Additionally, the interaction effect between initial seed moisture content, harvesting windows, and storage period remained statistically non-significant.

In spite the prevalent wet conditions during the ambient storage period, a continuous decline in seed moisture content was consistently noted. This decline may be associated with the semi-permeable nature of the polypropylene bags utilized for packaging, as they impede the permeation of moisture into the bags.Top of Form

Notably, there were no significant differences observed among the different harvesting windows over the storage period, highlighting that seed moisture content was the primary factor influencing seed deterioration. Furthermore, the interaction effect between seed moisture content, storage period, and harvesting windows did not reach statistical significance. The quality of peanuts is significantly influenced by the storage conditions due to their elevated oil content, which can degrade based on the environmental factors during storage. Following harvest, it is advised to dry peanut kernels to moisture levels of 10% or lower for optimal quality, as recommended by Rahmianna and Yusnawan (2007) and WHO/FAO (2012).

**Table2: Mean seed moisture content (%) of groundnut seeds with different seed moisture contents and harvesting windows after storage period of 12 months.**

|  |  |  |
| --- | --- | --- |
| **Storage period**  | **SEED MOISTURE CONTENT (%)**  | **MEAN (SP)** |
| **(SP)** | **8 % INITIAL SMC** | **10 % INITIAL SMC** | **12 % INITIAL SMC** |
|   | **EARLY HW** | **NORMAL HW** | **LATE HW** | **EARLY HW** | **NORMAL HW** | **LATE HW** | **EARLY HW** | **NORMAL HW** | **LATE HW** |
| **1 MAS** | 7.96 | 7.98 | 7.97 | 9.96 | 9.98 | 9.98 | 11.96 | 11.99 | 11.94 | **9.97** |
| **2 MAS** | 7.95 | 7.96 | 7.94 | 9.93 | 9.96 | 9.92 | 11.95 | 11.95 | 11.92 | **9.94** |
| **3 MAS** | 7.92 | 7.90 | 7.98 | 9.92 | 9.95 | 9.85 | 11.81 | 11.88 | 11.90 | **9.90** |
| **4 MAS** | 7.80 | 7.88 | 7.91 | 9.80 | 9.93 | 9.70 | 11.77 | 11.74 | 11.87 | **9.82** |
| **5 MAS** | 7.84 | 7.86 | 7.90 | 9.70 | 9.81 | 9.50 | 11.65 | 11.65 | 11.56 | **9.72** |
| **6 MAS** | 7.82 | 7.60 | 7.83 | 9.57 | 9.64 | 9.21 | 11.54 | 11.47 | 11.32 | **9.56** |
| **7 MAS** | 7.80 | 7.57 | 7.65 | 8.90 | 9.12 | 8.92 | 11.23 | 11.27 | 11.16 | **9.29** |
| **8 MAS** | 7.60 | 7.82 | 7.65 | 8.70 | 9.01 | 8.73 | 11.14 | 11.01 | 10.92 | **9.18** |
| **9 MAS** | 7.20 | 7.53 | 7.45 | 8.40 | 8.70 | 8.54 | 10.89 | 10.95 | 10.74 | **8.93** |
| **10 MAS** | 6.90 | 6.91 | 6.91 | 7.90 | 8.40 | 8.36 | 10.62 | 10.76 | 10.63 | **8.60** |
| **11 MAS** | 6.64 | 6.96 | 6.50 | 7.67 | 8.24 | 8.25 | 10.27 | 10.32 | 10.29 | **8.35** |
| **12 MAS** | 5.32 | 6.82 | 6.33 | 7.50 | 7.82 | 7.78 | 9.65 | 10.50 | 9.83 | **7.95** |
| **MEAN (HW)** | **7.40** | **7.57** | **7.50** | **9.00** | **9.21** | **9.06** | **11.21** | **11.29** | **11.17** |   |
| **MEAN(SMC)** | **7.49** | **9.09** | **11.22** |   |
| **CV (%)** | **5.189** |
| **CD** | Harvesting Windows | Seed moisture | Storage Period | Interactions |
| 0.13 | 0.19 | 0.261 | NS |

The data in Table 3 and Figure1 shows the influence of initial seed moisture content on germination per cent across harvesting windows (HW) during the storage period. As the storage duration extended from one to 12 MAS, there was a gradual decline in germination per cent. This ranged from 24 % in seeds from normal HW at 12 % moisture to 91 % in early harvested seeds with 8 % moisture.Groundnut seed harvested from early (76 %) and late (75 %) HW with 8% initial SMC recorded significantly high mean germination compared to normal HW (72 %). A similar trend was also observed in seeds with 10 and 12 % initial moistures stating the importance and superiority of early harvested seeds in terms of storage.

Groundnut seeds across the storage with 8 % initial SMC recorded significantly highest mean seed germination (74%), compared to seeds with 10 % (63 %) and 12 % (53 %) SMC. Across HWs over the storage period, groundnut seed stored with 8 % SMC observed to maintain seed germination above IMSCS (> 70 %) even up to nine months of storage. However, when the seed was stored with 10 % and 12 % initial SMC, the germination was maintained at IMSCS (> 70 %) up to four and two months of storage respectively. This indicates that compared to HW, the initial SMC with which the seed is kept for storage is playing key role on storability of groundnut. From the above findings, it is to conclude that, groundnut seed harvested from early HW packed in PP bags with 8 % initial SMC and storage under ambient conditions is observed to maintain standard seed germination (70 %) even up to nine months of storage.

Among the storage periods, across the HWs and initial SMCs, the mean germination (70 %) was observed to be maintained at above IMSCS even up to five MAS; however from six MAS a decrease in mean seed germination was observed. The significantly highest mean germination percent was recorded at one MAS (83 %) followed by two MAS (80 %), three MAS (76 %) and followed the same decreasing trend till the end of the storage periods and the lowest of that was recorded at 12 MAS (41 %). This similar decreasing trend was observed in all the harvesting windows with 8, 10 and 12 % initial seed moisture contents over a storage period of twelve months. However, the interaction effects between the initial seed moisture content, storage period, and harvesting windows did not show statistical significance.

**Table 3:** Influence of harvesting windows and initial seed moisture content on germination over 12 months of storage during *Yasangi*, 2021-22

|  |  |  |
| --- | --- | --- |
| **Storage****Period** **(SP)** | **SEED GERMINATION (%)** |   |
| **8 % INITIALSMC** | **10 % INITIALSMC** | **12 % INITIALSMC** |   |
| **EARLY****HW** | **NORMAL** **HW** | **LATE HW** | **EARLY HW** | **NORMAL HW** | **LATE HW** | **EARLY HW** | **NORMAL HW** | **LATE HW** | **MEAN** **(SP)** |
| **1 MAS** | 91 (72) | 88 (70) | 90 (71) | 84 (66) | 82 (65) | 83 (66) | 78 (62) | 76 (61) | 77 (61) | **83 (66)** |
| **2 MAS** | 88 (70) | 85 (67) | 87 (69) | 81 (64) | 78 (62) | 80 (63) | 74 (60) | 72 (58) | 73 (59) | **80 (64)** |
| **3 MAS** | 86 (68) | 82 (65) | 85 (67) | 77 (61) | 73 (58) | 76 (61) | 69 (58) | 67 (55) | 68 (55) | **76 (61)** |
| **4 MAS** | 84 (66) | 79 (63) | 83 (66) | 74 (59) | 70 (57) | 72 (58) | 68 (55) | 61 (51) | 63 (53) | **73 (59)** |
| **5 MAS** | 82 (65) | 77 (61) | 80 (63) | 69 (56) | 63 (53) | 65 (54) | 64 (53) | 57 (49) | 58 (50) | **70 (57)** |
| **6 MAS** | 80 (63) | 75 (60) | 78 (61) | 68 (56) | 61 (51) | 63 (53) | 59 (50) | 53 (47) | 55 (48) | **66 (54)** |
| **7 MAS** | 78 (62) | 72 (58) | 75 (60) | 64 (53) | 56 (48) | 58 (50) | 54 (47) | 50 (45) | 53 (47) | **62 (52)** |
| **8 MAS** | 74 (59) | 70 (57) | 72 (58) | 60 (51) | 55 (48) | 56 (48) | 50 (45) | 43 (41) | 47 (43) | **59 (50)** |
| **9 MAS** | 70 (57) | 67 (55) | 68 (56) | 58 (49) | 53 (47) | 54 (47) | 48 (44) | 39 (38) | 40 (39) | **55 (48)** |
| **10 MAS** | 66 (54) | 62 (52) | 65 (54) | 53 (47) | 50 (45) | 51 (46) | 42 (40) | 36 (37) | 35 (36) | **51 (46)** |
| **11 MAS** | 61 (51) | 57 (49) | 61 (51) | 49 (44) | 46 (43) | 47 (43) | 35 (36) | 32 (34) | 31 (34) | **47 (43)** |
| **12 MAS** | 53 (47) | 50 (45) | 52 (46) | 45 (42) | 41 (40) | 42 (40) | 33 (35) | 24 (29) | 26 (31) | **41 (39)** |
| **MEAN (HW)** | **76 (61)** | **72 (58)** | **75 (60)** | **65 (54)** | **61 (51)** | **62 (52)** | **56 (49)** | **51 (45)** | **52 (46)** |  |
| **MEAN(SMC)** | **74 (59)** | **63 (53)** | **53(47)** |   |
| **CV (%)** | **4.45** |
| **CD(0.05)** | Harvesting Windows | Seed moisture | Storage Period | Interactions |
| 0.629 | 0.629 | 1.258 | NS |

**\***Figures in parenthesis are angular transformed values.

**Figure 1:Influence of initial seed moisture on mean germination and field emergence across groundnut harvesting windows after 12 months of storage during *Yasangi,* 2021-22**

**Note: E-Early HW, N-Normal HW, L-Late HW, G-Germination, FET- Field Emergence Test**

These findings are consistent with those of Patra *et al.* (2000), who observed an increase in pathogen activity and seed moisture leading to a gradual decrease in viability with extended storage of groundnut seeds.The results are in conformity with Sampath *et al.* (2020) who disclosed that concerning sowing/harvesting windows, the greatest mean pod yield was attained in the, equivalent to the early sowings. These two periods exhibited a notable superiority over the other sowing dates, specifically the initial normal and the latesowing dates.

Sogut*et al.* (2016) determined that the timing of sowing significantly influenced pod yield, demonstrating that early sowing led to increased pod yields. Notably, early sowing was identified as a beneficial practice for enhancing both pod yield and oil content across all cultivars investigated in the study. This emphasizes the significance of monitoring seed moisture levels in understanding the dynamics of seed storage.

The data presented in Table 4 and Figure 1elaborates the influence of initial seed moisture content on field emergence per cent across various harvesting windows during the storage period. Results demonstrate the gradual decrease in meanfield emergence per cent as the storage period progresses from one MAS (82 %) to 12 MAS (36 %). Among all the initial seed moisture contents, groundnut seeds stored with 8 % initial SMC recorded significantly highest mean field emergence (73 %), compared to seeds with 10 % (61%)and 12 % (51 %) initial SMC over the storage.

 Among all the harvesting windows over the storage, seeds with 8 % initial SMC from early HW have shown the highest mean field emergence per cent (75 %), followed by late ( 73 %) and normal harvested seeds with the lowest of mean (71 %). A similar decreasing trend was observed in all the harvesting windows with 8, 10 and 12 % initial SMC’s over a storage period of twelve months. However, the interaction effect between the initial seed moisture content, storage period and harvesting windows did not show any statistical significance.

**Table 4:** Influence of harvesting windows and initial seed moisture content on field emergence over 12 months of storage during *Yasangi*, 2021-22

|  |  |  |
| --- | --- | --- |
| **Storage period** **(SP)** | **FIELD EMERGENCE TEST (%)** |   |
| **8 % INITIAL SMC** | **10 % INITIAL SMC** | **12 % INITIAL SMC** |   |
| **EARLY HW** | **NORMAL HW** | **LATE HW** | **EARLY HW** | **NORMAL HW** | **LATE HW** | **EARLY HW** | **NORMAL HW** | **LATE HW** | **MEAN****(SP)** |
| **1 MAS** | 90(71.44) | 86(68.12) | 89(70.78) | 83(65.43) | 80(63.7) | 82(64.7) | 77(61.36) | 74(59.36) | 76(60.69) | **82(65.06)** |
| **2 MAS** | 88(69.58) | 84(66.49) | 86(67.86) | 80(63.47) | 76(60.47) | 79(62.76) | 73(58.7) | 75(60.02) | 73(58.7) | **79(63.12)** |
| **3 MAS** | 86(68.12) | 83(65.43) | 84(66.49) | 76(60.69) | 74(59.36) | 75(60.02) | 70(56.79) | 65(53.73) | 67(54.94) | **76(60.62)** |
| **4 MAS** | 87(68.64) | 80(63.47) | 86(67.85) | 73(58.48) | 70(56.79) | 71(57.42) | 67(54.94) | 59(50.18) | 62(51.94) | **73(58.86)** |
| **5 MAS** | 84(66.49) | 78(61.61) | 79(62.76) | 75(60.02) | 64(53.13) | 66(54.33) | 63(52.53) | 53(46.71) | 55(47.86) | **69(56.16)** |
| **6 MAS** | 81(63.94) | 76(60.47) | 77(61.36) | 70(56.79) | 57(49.01) | 62(51.94) | 58(49.59) | 51(45.56) | 54(47.28) | **65(53.99)** |
| **7 MAS** | 75(59.78) | 73(58.7) | 74(59.36) | 66(54.33) | 54(47.28) | 57(49.01) | 53(46.71) | 48(43.84) | 52(46.13) | **61(51.68)** |
| **8 MAS** | 70(56.79) | 68(55.35) | 72(58.06) | 64(53.13) | 53(46.71) | 55(47.86) | 49(44.41) | 40(39.21) | 46(42.69) | **57(49.35)** |
| **9 MAS** | 68(55.55) | 64(52.93) | 66(54.33) | 56(48.43) | 50(44.98) | 52(46.13) | 44(41.53) | 36(36.84) | 38(38.03) | **53(46.53)** |
| **10 MAS** | 63(52.33) | 58(49.59) | 62(51.93) | 51(45.56) | 47(43.26) | 48(43.84) | 40(39.21) | 30(33.17) | 33(35.03) | **48(43.77)** |
| **11 MAS** | 58(49.4) | 53(46.51) | 58(49.79) | 42(40.37) | 44(41.53) | 45(42.11) | 33(34.82) | 29(32.54) | 27(31.26) | **43(40.93)** |
| **12 MAS** | 49(44.41) | 45(42.3) | 47(43.26) | 37(37.44) | 33(35.03) | 35(36.24) | 31(33.8) | 22(27.91) | 24(29.28) | **36(36.63)** |
| **MEAN****(HW)** | **75(60.54)** | **71(57.58)** | **73(59.48)** | **64(53.68)** | **59(50.1)** | **61(51.36)** | **55(47.87)** | **49(44.09)** | **51(45.32)** |  |
| **MEAN****(SMC)** | **73(59.2)** | **61(51.71)** | **51(45.76)** |   |
| **CV (%)** | **4.514** |
| **CD** | Harvesting Windows | Seed moisture | Storage Period | Interactions |
| 0.629 | 0.629 | 1.258 | NS |

**\***Figures in parenthesis are angular transformed values.

 Narayanaswamy (2003) also reported a decrease in oil content, protein, and field emergence of groundnut seeds, along with an increase in free fatty acids and electrical conductivity with the advancement of the storage period.

**CONCLUSION:**

The outcome of our study demonstrates a clear relationship between seed moisture content and the timing of harvest with regards to seed germination and field emergence. Specifically, seeds harvested early with 8% moisture content exhibited the highest rates of germination and field emergence. Conversely, seeds from normal harvesting window with 12% moisture content showed the lowest performance in both aspects, especially after a 12-month storage period under ambient conditions. These findings highlight the critical importance of considering both moisture content and the timing of harvest in optimizing seed quality and subsequent field performance. This knowledge is valuable for practitioners seeking to enhance crop yield and overall agricultural productivity.

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