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Factors Influencing the Deterioration of Groundnut Seed Health and Its Implications on Storage Capacity

P. Anuroopa [a++*], B. Pushpavathi [b#], P. Sujatha [c†] and S. Hari Kishan [d#]

[a] Department of Seed Science and Technology, Professor Jayashankar Telangana State Agricultural University, India.
[b] Seed Pathology, SRTC, PJTSAU, Hyderabad, India.
[c] Department of Seed Science & Technology, SRTC, PJTSAU, India.
[d] Groundnut Pathology, RP - Asia, ICRISAT, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The current study aimed to investigate the factors influencing seed deterioration in groundnut.
Study Design: Three factorial CRD.
Place and Duration of Study: The research was conducted at the Department of Seed Science and Technology, Seed Research and Technology Centre, PJTSAU, Rajendranagar, Hyderabad, between february 2022 to march 2023.
Methodology: Groundnut seeds harvested at different stages (early, normal, and late) were considered, each with varying seed moisture levels (8%, 10%, and 12%). These seeds were stored

[++]Ph.D. Scholar;
[#]Principal Scientist;
[†]Associate Professor;
**Corresponding author: E-mail: anu233p@gmail.com;*

under ambient conditions for one year and evaluated for percentage of seed infection, seed rot, and bruchid infection. The assessments were carried out with three replicates, each consisting of 100 seeds. The study was conducted using a three-factorial design as the experimental setup involved three independent variables.
Results: Results showed that among the different seed moisture levels, seeds harvested early with 8% moisture content exhibited the lowest percentages of seed infection, seed rot, and bruchid infection at 62.75% and 59.58% respectively after one year of storage. Conversely, seeds from the late harvesting window with 12% seed moisture content displayed the highest percentages of these seed health parameters at 53%, 00%, and 49.42% respectively. Notably, there was significant variation in seed infection rates observed in both 8% and 12% seed moisture content groups.
Conclusion: These discoveries reveal the vital significance of timely harvesting and maintaining the right moisture levels to safeguard the quality and health of seeds.

Keywords: Harvesting windows; seed moisture contents; seed health; seed deterioration.

1. INTRODUCTION

Groundnut (*Arachis hypogaea* L.), commonly known as earthnut or monkey-nut, is often referred to as the "poor man's cashew nut" owing to its rich content of oil (40-48%), protein (22-26%), carbohydrates (26%), fats (3%), as well as essential minerals (such as calcium, phosphorus, magnesium, zinc, and iron), vitamins (including E, K, and various B-complex vitamins), antioxidants, and easily digestible fiber. Notably, it also serves as a valuable source of 30 additional essential nutrients [1]. Despite its nutritional significance, groundnut is frequently categorized as an orphan crop, receiving limited attention in terms of agricultural research, training, and extension efforts. Unfortunately, a substantial portion of the population remains unaware of its immense potential. Orphan crops, which encompass yam, cassava, teff, finger millet, cowpea, and others, are not extensively traded on the international market. Nevertheless, these crops hold substantial transformative potential in agriculture, especially in bolstering the food supply for future generations and ensuring global food security [2].

Among oilseeds, groundnut is known to deteriorate quickly during storage. When evaluated using the storability index, they are generally classified as poor storers, with soybeans being the exception among various crop seeds, including other oilseeds [3]. The rate at which seed moisture content increases depends on the type of storage container used; thus, directly impacting the seed's shelf life. Another significant concern regarding seed quality decline is fungal infestation, which negatively affects seed health by reducing germination rates, fatty acid content, as well as the overall oil and protein contents of the seed during storage [4,5]. The primary aim of this experiment is to evaluate seed health parameters, while also considering various other factors that contribute to seed deterioration

2. MATERIALS AND METHODS

The seed samples were collected during the early, normal, and late harvesting stages as illustrated in Table 1.

Upon acquisition, freshly harvested groundnut pods underwent a systematic process involving sun-drying and thorough cleaning. The initial moisture content of the received produce was 4.6% for pods and 4.4% for kernels. A thin layer of the procured groundnut samples was evenly spread on the floor, and water was lightly sprayed onto them. They were then shade dried until the desired moisture levels were achieved. To increase the moisture content by 1%, approximately 1.071 litres of water were added per 20 kg of groundnut pods. For groundnut kernels, 600 ml of water per 20 kg was introduced to achieve a 1% increase in moisture

Table 1. Showing the categories of different seeds samples collected for the experiment

Cataegory of Seed Samples collected	Sowing window	Harvesting window
EARLY	1st FN* of October	1st FN ofFebruary
NORMAL	2nd FN of October	1st FN of March
LATE	1stFN of November	1st FN of April

**FN- Fortnight*

content. This procedure was repeated as necessary to reach the target moisture levels of 8%, 10%, and 12%.The packing material utilized for this seed storage studies was polypropylene bags for all the treatments.

3. METHODOLOGY

The experiment was conducted at the Department of Seed Science and Technology. The study employed a three-factor completely randomized design, incorporating three independent variables and three replications and the seed health parameters were assessed using the following method:

Groundnut seed health assessment followed the standard blotter method. This entailed placing three blotting paper discs soaked in distilled water at the bottom of 90 mm diameter petri dishes. After excess water was drained, four hundred seeds from each treatment were randomly arranged on the moist blotter paper, with ten seeds per plate, evenly spaced. Subsequently, the petri dishes containing the seeds were placed in a BOD incubator with alternating cycles of light and darkness (12/12 h) at a controlled temperature of 25±2oC for a period of seven days (ISTA, 1999).

After eight days of incubation, a visual assessment was performed to identify fungal infections and seed rots. In each petri dish, the number of infected and decayed seeds was observed and recorded. The results were expressed as a percentage. The percentage of seed infection and seed rot were calculated using the provided formulae.

Per cent seed infection (%) = (Number of infected seeds / Total number of seeds) ×100

Per cent seed rot (%) = (Number of seeds rotted / Total number of seeds) × 100

3.1 Bruchid Infestation (%)

From each replication, a representative sample weighing 20 grams of groundnut pods and kernels was chosen. Subsequently, any bored pods and kernels were separated from the sample. The count of bored pods and kernels was recorded in order to calculate the percentage of damage for both pods and kernels.

Per cent pod / kernel damage (by count) = (Number of bored pods or kernels / Total number of pods/kernels) × 100

4. RESULTS AND DISCUSSION

The data (Table 2 and Fig. 1) illustrates the impact of seed moisture content on seed infection percentage across different harvesting windows over a storage period. The findings reveal a gradual increase in seed infection percentage with higher seed moisture content and as the storage duration extends from one to twelve months, ranging from 18.67% to 94.10%. Specifically, the percentage of seed infection showed a gradual rise as the storage period progressed from 1MAS to 12MAS. This ranged from 18.67% in seeds harvested early with 8% moisture to 48.00% in seeds harvested early with 12% moisture. Notably, seeds with 12% and 8% seed moisture content exhibited significant differences across various harvesting windows. Early-harvested seeds with 8% moisture content demonstrated the lowest mean percentage of seed infection (32.56%), while the highest was recorded in normally harvested seeds with 12% moisture (68.12%). It was observed that early-harvested seeds were more effective in controlling seedborne infections compared to normal and late-harvested seeds. This was especially evident in early-harvested seeds with the lowest moisture content of 8%, showing a lower mean percentage of seed infection (32.56%) compared to seeds from normal and late harvesting windows. This trend was consistent across the other two moisture content levels, namely 10% (50.03%) and 12% (62.14%), over the twelve-month storage period.

The data indicates the combined influence of harvesting windows and seed moisture content on seed infection levels throughout the storage period. Furthermore, statistical analysis reveals a significant interaction effect between seed moisture content, storage period, and harvesting windows. This confirms that seed infection percentage increases with higher seed moisture content and prolonged storage duration. This finding aligns with previous reports by Arulnandhy and Senanayak [6], who similarly observed that fungal infection was correlated with increased moisture content in infested soybean seeds. Srinivas et al. [7] also noted that as the storage period increased, there was an observed rise in the percentage of seed infection caused by various seed mycoflora.

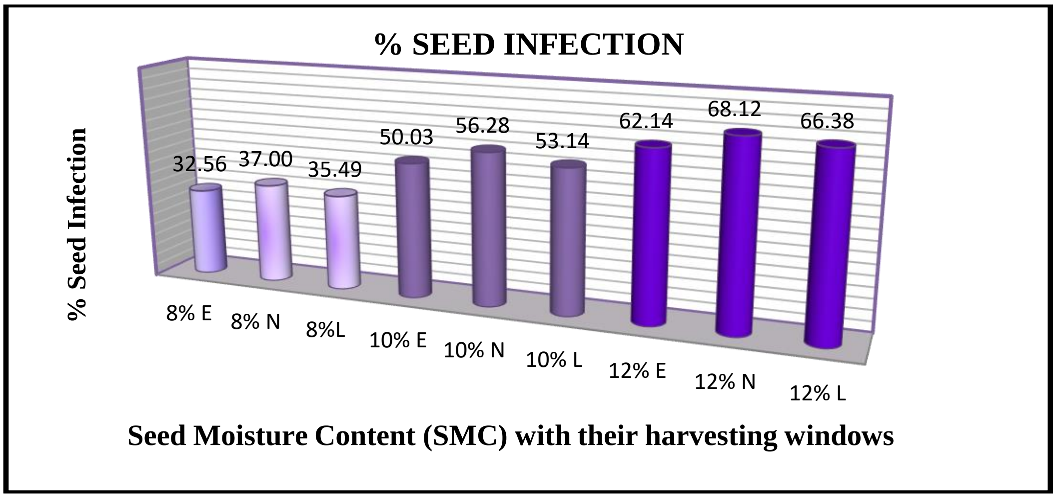

Fig. 1. Mean seed Infection (%) of groundnut seeds with different seed moisture contents and harvesting windows after storage period of 12 months

Table 2. Mean seed Infection (%) of groundnut seeds with different seed moisture contents and harvesting windows after storage period of 12 months

Storage period	% Seed Infection									
	8%			10%			12%			
	E	**N**	**L**	**E**	**N**	**L**	**E**	**N**	**L**	**MEAN**
1 MAS	18.67 (25.56)	18 (25.06)	18.44 (25.39)	20.33 (26.76)	20 (26.53)	20.67 (27)	24 (29.3)	24.33 (29.52)	24 (29.3)	**20.94 (27.16)**
2 MAS	19.33 (26.04)	24 (29.3)	22 (27.94)	26.67 (31.06)	22.67 (28.4)	29.67 (32.98)	28 (31.92)	34 (35.65)	32 (34.43)	**26.48 (30.86)**
3 MAS	20.11 (26.6)	25 (29.97)	23.11 (28.7)	33 (35.04)	28.11 (31.99)	36 (36.85)	36 (36.85)	42 (40.38)	40.11 (39.28)	**31.49 (33.96)**
4 MAS	22 (27.94)	27 (31.28)	26.67 (31.06)	38 (38.04)	39 (38.62)	42.18 (40.48)	45.67 (42.5)	51.67 (45.94)	49.67 (44.79)	**37.98 (37.85)**
5 MAS	25 (29.97)	30 (33.18)	32 (34.43)	42.67 (40.77)	48.67 (44.22)	48 (43.84)	56.23 (48.56)	62.23 (52.07)	60.23 (50.89)	**45 (41.99)**
6 MAS	31 (33.81)	36 (36.85)	36.33 (37.04)	48 (43.84)	58.33 (49.78)	51 (45.56)	65.31 (53.9)	71.31 (57.6)	69.31 (56.35)	**51.84 (46.08)**
7 MAS	36.44 (37.11)	41.72 (40.21)	40 (39.21)	53 (46.7)	66.5 (54.62)	56 (48.43)	72.5 (58.36)	78.5 (62.38)	76.5 (61)	**57.91 (49.78)**
8 MAS	42 (40.38)	47 (43.26)	42 (40.38)	58 (49.59)	72.67 (58.47)	61 (51.34)	76 (60.66)	84.67 (66.97)	82.67 (65.41)	**62.89 (52.94)**
9 MAS	43 (40.96)	48 (43.84)	44 (41.53)	62.67 (52.33)	76.25 (60.83)	65.67 (54.12)	82.25 (65.09)	87 (68.9)	86.25 (68.26)	**66.12 (55.09)**
10 MAS	44 (41.53)	49 (44.41)	46 (42.69)	68 (55.54)	78 (62.03)	71.44 (57.69)	85.67 (67.78)	91.67 (73.31)	89.67 (71.31)	**69.27 (57.37)**
11 MAS	44.11 (41.6)	49.33 (44.6)	47.27 (43.42)	74 (59.34)	82 (64.9)	77 (61.34)	86 (68.05)	94 (75.99)	92 (73.67)	**71.75 (59.21)**
12 MAS	45 (42.11)	50 (44.98)	48 (43.84)	76 (60.66)	83.11 (65.75)	79 (62.73)	88 (69.77)	96.1 (78.97)	94.1 (76.12)	**73.26 (60.55)**
MEAN	**32.56 (34.47)**	**37 (37.24)**	**35.49 (36.3)**	**50.03 (44.97)**	**56.28 (48.84)**	**53.14 (46.86)**	**62.14 (52.73)**	**68.12 (57.31)**	**66.38 (55.9)**	**51.24 (46.07)**
MEAN	**35.01**			**53.15**			**65.55**			
SE(m)	**1.003**									
CD	**Seed Moisture 0.466**		**Storage Period 0.932**		**Harvesting Windows 0.441**			**Interactions 2.795**		

Figures in parenthesis are angular transformed values

The data (Table.3 and Fig. 2) Provides insights into how seed moisture content influences the percentage of seed rot across different harvesting windows. It was evident that the percentage of seed rot increased gradually as the storage period extended from 1 month after storage (1MAS) to 12 months after storage (12MAS), ranging from 20.11% in seeds harvested early with 8% moisture to a significant 98% in seeds harvested under normal conditions with 12% moisture. Significant differences were observed between seeds with 12% and 8% seed moisture content across various harvesting windows during the storage period. Early-harvested seeds at 1MAS exhibited the lowest mean percentage of seed rot (20.11%), followed by those harvested at 2MAS (21.00%). On the other hand, the highest mean seed rot was observed in normally harvested seeds stored for 12 months (52.00%) with 8% moisture content. The data highlights the effectiveness of early-harvested seeds in mitigating seed rots, as they consistently exhibited lower levels compared to seeds from normal and late harvesting windows. This trend persisted across the other two moisture content levels: 10% (53.11%) and 12% (65.62%), over the twelve-month storage period. Notably, the highest mean seed rot was consistently observed in normally harvested seeds across all moisture contents: 8% (34.41%), 10% (59.68%), and 12% (71.81%). Statistical analysis confirmed a significant interaction effect between seed moisture content, storage period, and harvesting windows. This reinforces the notion that seed rot percentage increases with higher seed moisture content and prolonged storage duration. These findings align with previous research conducted by Hall and Xue [8], Das and Dutta [9], and Goulart et al. [10], further validating the observed trends.

The data provided (Table 4 and Fig. 3) offers valuable insights into how seed moisture content impacts bruchid infection percentages across different harvesting windows. It was observed that as seed moisture content increased, there was a gradual rise in bruchid infection rates, progressing from 8% (0%) to 10% (34.55%). However, beyond 10%, there was a decline in infection rates with a further increase in seed moisture to 12% (12.76%). This trend persisted over the entire storage period, ranging from one to twelve months. Significant disparities in bruchid infection rates were evident among seeds harvested at different timeframes, regardless of seed moisture content, throughout the study period. Specifically, the percentage of bruchid infection increased progressively from 1MAS to 12MAS, ranging from 0% in seeds harvested early with 8% moisture to 21.73% at 12MAS. Aidbhavi et al., [11] also reported a positive correlation between seed moisture levels, storage duration, and both infestation and damage. All harvesting windows displayed noticeable variations in bruchid infection percentages across various seed moisture

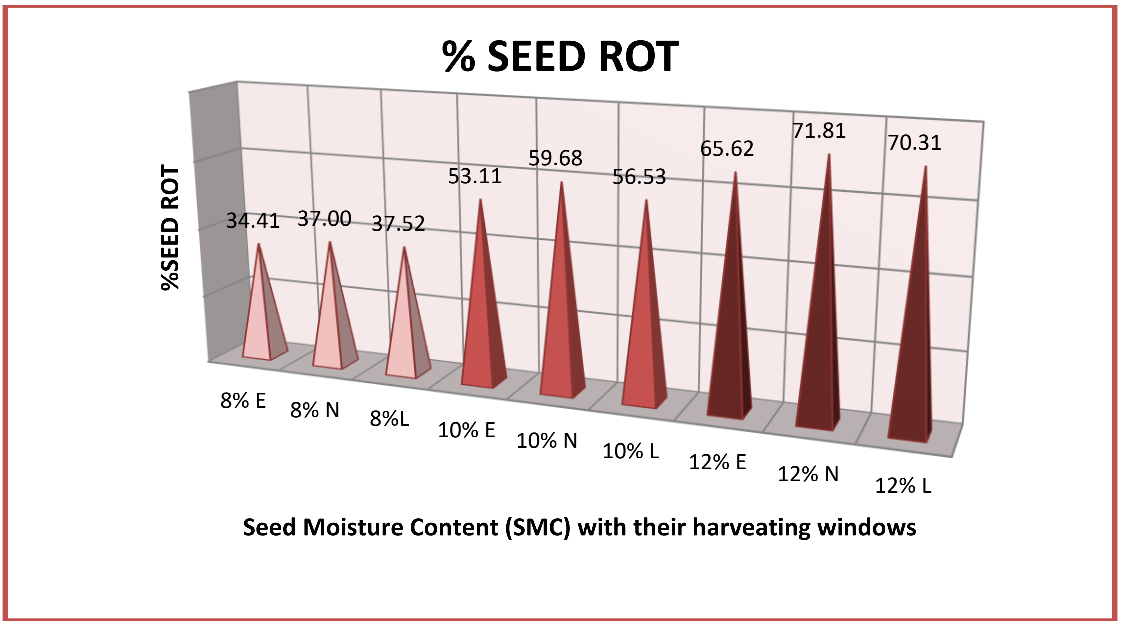

Fig. 2. Mean seed rot (%) of groundnut seeds with different seed moisture contents and harvesting windows after storage period of 12 months

Table 3. Mean seed rot (%) of groundnut seeds with different seed moisture content and harvesting windows after storage period of 12 months

Storage period	% Seed Rot									
	8%			10%			12%			
	E	N	L	E	N	L	E	N	L	MEAN
1 MAS	20.11 (26.6)	20.33 (26.76)	20.44 (26.84)	23 (28.62)	23.5 (28.96)	24.11 (29.38)	28 (31.92)	28.33 (32.13)	28 (31.92)	**23.98 (29.24)**
2 MAS	21 (27.24)	26 (30.63)	24 (29.3)	30.17 (33.29)	26.17 (30.74)	33 (35.04)	32 (34.43)	38 (38.04)	36.33 (37.04)	**29.63 (32.86)**
3 MAS	22 (27.94)	27 (31.28)	25 (29.97)	36 (36.85)	31 (33.81)	39.67 (39.02)	40 (39.21)	46 (42.69)	44.11 (41.6)	**34.53 (35.82)**
4 MAS	24 (29.3)	29.11 (32.63)	28.67 (32.35)	41 (39.79)	42.5 (40.67)	45.68 (42.5)	49.67 (44.79)	55 (47.85)	53.67 (47.09)	**41.03 (39.66)**
5 MAS	27.67 (31.71)	32 (34.43)	34.11 (35.71)	46.17 (42.78)	53 (46.7)	51 (45.56)	60.23 (50.89)	66.23 (54.46)	64.23 (53.25)	**48.29 (43.94)**
6 MAS	33 (35.04)	38 (38.04)	38.33 (38.23)	51.5 (45.84)	61.83 (51.83)	54.5 (47.57)	69.31 (56.35)	75 (59.99)	73.31 (58.89)	**54.98 (47.97)**
7 MAS	36.11 (36.91)	43.72 (41.37)	42 (40.38)	56 (48.43)	70 (56.78)	59 (50.17)	72.33 (58.25)	82.5 (65.28)	80.67 (63.92)	**60.26 (51.28)**
8 MAS	44.33 (41.73)	49 (44.41)	44 (41.53)	61 (51.34)	76 (60.66)	64.67 (53.52)	80 (63.44)	88.67 (70.38)	86 (68.05)	**65.96 (55.01)**
9 MAS	45 (42.11)	50 (44.98)	46 (42.69)	66.11 (54.39)	79 (62.73)	69.17 (56.26)	86.25 (68.26)	91 (72.62)	90.25 (71.87)	**69.2 (57.32)**
10 MAS	46 (42.69)	51 (45.56)	48 (43.84)	71 (57.41)	81.5 (64.53)	74.94 (59.96)	88.67 (70.38)	95 (77.31)	93.11 (74.91)	**72.14 (59.62)**
11 MAS	46.67 (43.07)	51.33 (45.74)	49.67 (44.79)	77.33 (61.57)	85 (67.23)	80.11 (63.52)	90 (71.63)	98.4 (82.93)	96 (78.81)	**74.95 (62.14)**
12 MAS	47 (43.26)	52 (46.13)	50 (44.98)	78 (62.03)	86.61 (68.56)	82.5 (65.28)	91 (77.31)	98.4 (82.93)	98.07 (82.13)	**75.95 (63.62)**
MEAN	**34.41 (35.63)**	**37 (38.49)**	**37.52 (37.55)**	**53.11 (46.86)**	**59.68 (51.1)**	**56.53 (48.98)**	**65.62 (55.57)**	**71.81 (60.55)**	**70.31 (59.12)**	**54 (48.21)**
MEAN	**36.31 (37.23)**			**56.44 (48.98)**			**69.25 (58.42)**			
SE(m)	**1.016**									
CD	**0.472**		**0.994**		**0.654**			**2.832**		

**Figures in parenthesis are angular transformed values*

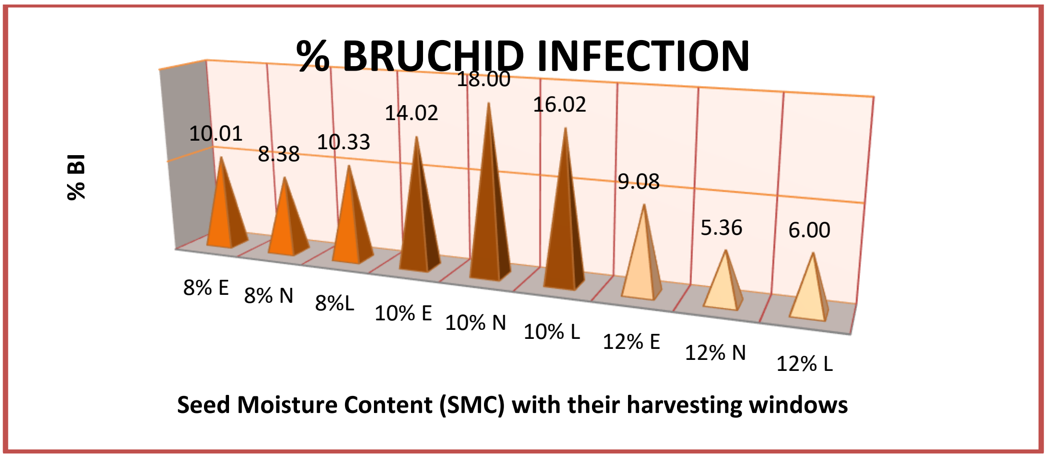

Fig. 3. Mean bruchid infection (%) of groundnut seeds with different seed moisture contents and harvesting windows after storage period of 12 months

Table 4. Mean bruchid infection (%) of groundnut seeds with different seed moisture contents and harvesting windows after storage period of 12 months

Storage period	% Bruchid Infection									
	8%			10%			12%			
	E	N	L	E	N	L	E	N	L	MEAN
1 MAS	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	**0 (0)**
2 MAS	1.33 (6.62)	0.43 (3.75)	0 (0)	2 (8.13)	3 (9.95)	2.42 (8.95)	0.65 (4.62)	0 (0)	0.33 (3.28)	**1.13 (5.03)**
3 MAS	3.94 (11.43)	1.28 (6.49)	3 (9.95)	4.58 (12.34)	4.87 (12.73)	4.73 (12.55)	4.88 (12.75)	1 (5.74)	2.45 (9)	**3.41 (10.33)**
4 MAS	4.73 (12.55)	3.82 (11.25)	5 (12.91)	7.28 (15.64)	8.91 (17.36)	8.9 (17.35)	5.73 (13.84)	1.5 (7.03)	3.16 (10.22)	**5.45 (13.13)**
5 MAS	5.94 (14.09)	5 (12.91)	7 (15.33)	8.44 (16.88)	10.66 (19.05)	9.55 (17.99)	4.88 (12.75)	1.81 (7.73)	3.63 (10.96)	**6.32 (14.19)**
6 MAS	7.8 (16.21)	7 (15.33)	9 (17.45)	11.3 (19.56)	14.94 (22.68)	13.21 (21.24)	6.59 (14.86)	2.88 (9.74)	4.43 (12.13)	**8.57 (16.58)**
7 MAS	10.21 (18.62)	9 (17.45)	12 (20.19)	14.71 (22.49)	20.7 (27.02)	17.17 (24.43)	8.42 (16.86)	4.94 (12.83)	6.8 (15.1)	**11.55 (19.44)**
8 MAS	12.18 (20.35)	12 (20.19)	13 (21.06)	17.61 (24.77)	22.41 (28.22)	21.1 (27.31)	10.21 (18.62)	6.97 (15.3)	7.73 (16.13)	**13.69 (21.33)**
9 MAS	14.72 (22.5)	13 (21.06)	15 (22.73)	20.22 (26.68)	24.33 (29.52)	24.28 (29.49)	12.44 (20.58)	8.29 (16.72)	9.21 (17.66)	**15.72 (22.99)**
10 MAS	17.89 (24.98)	15 (22.73)	19 (25.8)	24.48 (29.62)	34.72 (36.08)	28.06 (31.96)	14.96 (22.7)	10.42 (18.82)	10.05 (18.47)	**19.4 (25.68)**
11 MAS	19.62 (26.25)	16 (23.52)	20 (26.53)	27.26 (31.45)	36.89 (37.38)	30.18 (33.3)	18.52 (25.45)	12.5 (20.63)	11.43 (19.67)	**21.38 (27.13)**
12 MAS	21.73 (27.75)	18 (25.06)	21 (27.24)	30.37 (33.42)	34.55 (35.98)	32.64 (34.82)	21.73 (27.75)	14.03 (21.93)	12.76 (20.86)	**22.98 (28.31)**
MEAN	**10.01 (16.78)**	**8.38 (14.98)**	**10.33 (16.6)**	**14.02 (20.08)**	**18 (23)**	**16.02 (21.61)**	**9.08 (15.9)**	**5.36 (11.37)**	**6 (12.79)**	**10.8 (17.01)**
MEAN SE(m)	**9.57 0.757**			**16.01**			**6.81**			
CD	**Seed Moisture**		**Storage Period**		**Harvesting Windows**			**Interactions**		
	0.352		**0.704**		**0.352**			**2.111**		

***Figures in parenthesis are angular transformed values*

contents over the storage period. Interestingly, the observed decrease in bruchid infection percentages at the highest seed moisture content of 12% could potentially be attributed to bruchids exhibiting a preference for seeds of lower quality. Statistical analysis confirmed a significant interaction effect between seed moisture content, storage period, and harvesting windows. This suggests that both higher seed moisture content and prolonged storage contribute to an increase in bruchid infection rates, resulting in secondary seed infections and ultimately compromising the overall health of groundnut seeds. This indicates the critical importance of maintaining proper storage conditions and adhering to timely harvesting practices to preserve seed quality and mitigate pest-related issues. Furthermore, H. Sudini [12] also noted comparable findings, where in mold growth and the subsequent accumulation of aflatoxins were markedly inhibited due to reduced pod damage caused by bruchids.

5. CONCLUSION

In conclusion, our study highlights a significant relationship between seed moisture content, harvesting window, and seed health. Among the various combinations of seed moisture contents and harvesting windows, seeds harvested early with 8% moisture content demonstrated the lowest levels of seed infection, rot, and bruchid infestation. Conversely, seeds harvested under normal conditions with 12% moisture content exhibited the highest percentages of these issues after 12 months of ambient storage. These findings uncover the critical importance of early harvesting and optimal moisture levels in preserving seed quality and health. These insights are invaluable for practitioners seeking to enhance crop yield and overall agricultural productivity.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Maiti D, Dasgupta B, Sen C. Antagonism of *Trichoderma harzianum,Gliocladium virens* isolates to *Sclerotium rolfsii* and biological control of stem rot ofgroundnut and betelvine. Journal of Biological Control. 1991;5:105-109.
2. Arya A, Abhimanyu Dhanrajand Touseef Hussain Orphan Crops: A Miracle Crops for Future Farming and Sustainability. Bio Bulletin. 2022;8(1):01-12.
3. Pristley D A, Cullinan VI, Wolfe J. Differences in seed longivity at the species level. Plant cell and Environment. 1985; 8(8):557-562.
4. Shephard GS. Aflatoxin and food safety: recent African perspectives. Journal of Toxicology. 2003;22(2&3):267–286.
5. Strosnider H, Azziz-Baumgartner E, Banziger M, Bhat RV, Breiman R, Brune M, et al. Workgroup report: Public health strategies for reducing aflatoxin exposure in developing countries. Environmental Health Perspectives. 2006;114:1989-1903.
6. Arulnandhy V, Senanayak YDA. Deterioration of soybean seed stored in different containers under ambient conditions. Seed Research. 1988;16(2): 183-192.
7. Srinivas A, Pushpavathi B, Lakshmi BKM, Shashibushan V. Efficacy of Fungicides on Seed Mycoflora of Groundnut at Different Storage Periods. International Journal of Bio-resource and Stress Management. 2023;4(1):161-168.
8. Hall R, Xue AG. Effectiveness of fungicidal seed treatments applied to smooth or shriveled soybean seeds contaminated by *Diaporthephaseolomia* charcoal rot of sunflower and mungbean. Journal of Phytopathology. 1995;130:157-160.
9. Das BC, Dutta P, Biological management of stem rot of soybean caused by *Rhizoctoniasolani*. kuhn. Journal of the Agriculture Science Society of North East India. 1999;12(2): 28-31.
10. Goulart ACP, Andrade PJM, Borges EP. Control of soybean seed borne pathogens by fungicide treatment and its effects on emergence and yield. Summa-Phytopaathologica. 2000;26(3): 341-356.
11. Aidbhavi R, Murali MK , Soren KR , Sanjay MB, Ranjitha MR , Kodandaram MH . Infestation, distribution and diversity indices of bruchid species on edible stored pulses in India. Journal of Stored Products Research. 2023;101:102085.
12. Sudini H, Ranga Rao, GV, Gowda CLL, Chandrika R, Margam V, Rathore A and Murdock, LL. Purdue Improved Crop Storage (PICS) bags for safe storage of groundnuts. Journal of Stored Products Research. 2014;1-6.

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