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EFFECT OF STORAGE RELATIVE HUMIDITY ON GERMINATION AND VIGOUR OF SOYBEAN SEED

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ABSTRACT

An experiment was conducted during the period from June to November, 2004 with a view to study the effect of storage relative humidity (RH) on germination and vigour of soybean seed. Four different storage relative humidities (viz. 50%, 60%, 70% and 80%) and two soybean varieties (namely, soybean cv. G-2 and soybean cv. PB-1) were included as experimental treatment. Seed moisture content (SMC), germination and vigour tests of seed were done one month interval starting from 10 July up to 10 November while the initial test for SMC and germination was done on 10 June, 2004. The result showed that storage relative humidity, variety and their interaction significantly influenced the seed moisture content, germination percentage and vigour index. The moisture content of soybean seed during storage were found between 7.9-8.5, 9.6-9.8, 12.0-12.3 and 15.3-16.1% for 50, 60, 70 and 80% storage RH, respectively against their initial moisture content of 8.4-9.5% just before storage. The germination and vigour of all the varieties decreased with increasing storage RH. For each of the soybean variety, the highest germination percentage was obtained from 50% storage RH and no seed germination was occurred in any of the variety stored under 80% storage RH after two months of storage. More than 92% seed germination was maintained for all the varieties after 6 months of storage. The seed stored under 70% RH showed 83% germination in July that reduced to 74% in November, 2004.

Keywords: Relative humidity, Germination, Vigour and Soybean.

INTRODUCTION

Soybean (*Glycine max* L. merill) is a high valued legume crop of the world. Its seeds contain 18-20% fat, 40-45% protein and 24-26% carbohydrate (Gowda and Kaul, 1982). Furthermore, the soybean oil is Cholesterol free and easily acceptable for preparation of daily diet. Soybean seeds also contain a good amount of other nutrient elements like calcium, phosphorus, iron, carotene and vit-B_1, vit B_2, vit-C (Gopalan *et al.* 1971). The use of soybean in preparing high quality fish and livestock feed is also markable. The edaphic and agroclimatic condition of Bangladesh is auspicious for soybean production but the lack of supply of quality seed to the farmers rendered major problem in the expansion of area under soybean cultivation.

Total production of soybean in Bangladesh in 1999 was 8.0 thousand tons from an area of 5.0 thousand hectare with an average yield of 1.5 –2.3 tons/ha (BARI, 2000). It has been reported that soybean seed is short lived and loses its viability in very short period of storage even with good nonporous storage container (Woodruff, 1998). However, the reports are available that the soybean seeds can be stored for more than one year in sealed containers (Arulnandhy and Senanayaka, 1988). Seed moisture content and storage temperature perhaps, plays a most dominant role in maintaining good seed viability during storage (Harrington & Minges, 1961). The seed moisture content comes into equilibrium with the adsorption and desorption phenomenon. The seed moisture equilibrium depends on relative humidity of storage environment in a greater extent and on temperature to a much lesser extent. The higher moisture content in seed deteriorates the seed quality through insect and disease attack (Pingale, 1978). The effect of temperature on seed quality at storage has been explained by Harrington (1973). Low relative humidity (RH) in storage environment ensures longer storing capability. Available reports indicated that 35% storage RH together with 15 ^{0}C resulted in minimum loss in viability and ensured satisfactory

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storage up to 36 months while with 50-70% storage RH storing of soybean seeds for 9 months was possible (Tango *et al*, 1977). Thus this present study was undertaken with the view i) to find out the moisture content of soybean seed in relation to relative humidities during storage and ii) to explore the comparative seed quality performance of soybean varieties under different relative humidities in storage.

MATERIALS AND METHODS

A pot experiment was conducted at the seed laboratory of the Agronomy Department of Bangladesh Agricultural University, Mymensingh during the period from June to November, 2004 with a view to study the effect of relative humidity on physiological qualities of soybean seed. Two soybean varieties (namely, Soybean cv. PB-1 and Soybean cv. G-2B) and four levels of Storage relative humidities (viz. 50%, 60%, 70% and 80%) were used as treatment variables. The experiment was laid out in a Completely Randomized Design (CRD) with three replications. Soybean seeds were sown on 2 December, 2003 and both the varieties were harvested on 1 April, 2004. After harvesting, soybean pods were dried in the sun and the seeds were separated from the pods by hand shelling to avoid seed injury. After proper drying moisture content of the seeds was maintained 8-10% and kept in polythene bags before storing in storage containers at the designed relative humidities.

Preparation of storage container with different relative humidities

Glass jar of 28 cm diameter × 35.56 cm height were used as storage container. Glycerine solution was prepared by mixing glycerine with water in different ratio to establish different levels of relative humidities as per experimental specifications as follows (Hill, 1999).

Relative Humidity (RH) %	Glycerine (mls)	Water (mls)
50	95	5
60	92	8
70	72	28
80	55	45

One hundred ml of glycerine solution was kept at the bottom of each glass jar and then a support or bench made of bamboo stick and iron net was inserted into the jar on which cloth bags (10.16 cm×20.32 cm) containing 200 g seeds were kept. Thus in each container two cloth bags containing seeds were placed and the jar was then covered with its lid. Each glass jar was made air tight with the help scotch tape. Before placing the glycerine solution, the glass jar and bamboo bench was thoroughly cleaned and was made sterilized with boiled water. The relative humidity (RH%) was measured with a thermo hygrometer at the time of seed sampling from each container in each month.

Seed moisture test

Seed moisture content was measured using high constant temperature oven dry method following the ISTA rules (1993). About 5-8 g of seeds were taken in the aluminium dish and dried in the oven at 130 ^{0}C for 2 hours. Then the moisture content was calculated by using the following formula:

$$\text{Moisture content (\%)} = \frac{W_1 - W}{W_1 - W_2} \times 100$$

Where, W = Weight of blank aluminium dish with lid.

W_1 = Weight of seed plus aluminium dish with lid before drying

W_2 = Weight of seed plus aluminium dish with lid after drying.

Germination test

Germination test was done following modified paper folding method. Randomly selected 100 seeds in three replicates per bag were used for germination test. Two sheets of kitchen towel were placed upon one sheet of newspaper (30.48cm× 25.40cm) and the papers were moistened with distilled water. One hundred seeds of the test variety was placed on the wet paper and another piece of kitchen towel was placed on it. The paper was moistened further as required with distilled water and folded. The folded

paper was kept in a polythene bag (38.1cm×25.4cm) to prevent moisture loss. The polythene bags were kept standing in a bucket. Additional moisture was given into the polythene bag if needed to keep the paper moist.

Seedling evaluation was done at 7 days after placing the test. The number of normal seedlings, abnormal seedlings and dead seeds were recorded. The sum of three replicates per bag was used and the germination was expressed in percentage.

Vigour index (VI)

Top of the paper (TP) method (using a glass petridish) was used to measure vigour index. Randomly collected 50 seeds in four replicates per bag was used. Kitchen towel paper was placed in a glass petridish and was moistened with distilled water. Vigour test for each variety from each glass container was carried out taking 200 seeds at every sampling time.

The daily record of germination of seeds was noted starting from 1 day up to 7 days of placement of seeds in the test. After sprouting of seedlings having 2 cm long redicle were taken as germinated seeds. Vigour index (VI) was calculated by the following formula (Maguire, 1962).

$$VI = \frac{x_1}{n_1} + \frac{x_2}{n_2} + \frac{x_3}{n_3} + \ldots\ldots\ldots + \frac{x_n}{n_n}$$

Where, x_1 = no of seedlings at first count,

n_1 = no. of days to first count,

x_2 = no of seedlings at 2nd count,

n_2 = no. of days to 2nd count,

x_n = no. of seedlings at final count

n_n =no. of days to final count

Statistical analysis

The collected data were complied and analyzed statistically using the analysis of variance (ANOVA) technique and the means were compared by Duncan's Multiple Range test (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Seed moisture content

Effect of storage relative humidity

The effect of storage relative humidity on moisture content of seed was statistically significant for each months of test from July to November, 2004 (Table 1). At each month's moisture test it was found that the seed moisture content increased with the increases of relative humidity. In July 2004, the highest (15.4%) seed moisture content was found with 80% storage RH compared to only 8.2% with 50% storage RH. In August, September, October and November the highest seed moisture content were 15.6%, 15.7%, 15.7% and 15.9% with 80% storage RH and 8.4%, 8.3%, 8.3% and 8.3% under 50% storage RH, respectively (Table 1).

Effect of variety

The effect of soybean variety on seed moisture content at each month except August was statistically significant during July to November, 2004 (Table 1). In July, September, October and November it was found that Soybean cv. PB-1 contained the highest seed moisture and soybean cv. G-2 had the lowest seed moisture content (Table 1). In July 2004, the seed moisture content of soybean cv. G-2 was 11.2% while it was 11.4% in case of Soybean cv. PB-1. In November testing, the seed moisture content for soybean cv. G-2 was 11.4% while it was 11.5% in Soybean cv. PB-1 (Table 1).

Storage relative humidity × Variety

The interaction effect of storage relative humidity and variety on moisture content of soybean seed was significant for the month of July, October and November 2004 (Table 2). The highest seed moisture content was recorded under 80% storage RH which was 15.7% in July, 15.8% in October and 16.1% in November for Soybean cv. PB-1 while those values were lowest and were 7.9, 7.9 and 7.9%, respectively for soybean cv. G-2 treated with 50% storage RH (Table 2).

Table 1. Effect of storage relative humidity and variety on moisture content of soybean seed during storage from July to November, 2004

Storage relative humidity (%)	Seed moisture content (%)				
	July	August	September	October	November
50	8.2 b	8.4 d	8.3 d	8.3 d	8.3 d
60	9.8 c	9.9 c	10.0 c	9.9 c	9.9 c
70	12.2 b	12.3 b	12.3 b	12.3 b	12.4 b
80	15.4 a	15.6 a	15.7 a	15.7 a	15.9 a
Level of significance	***	***	***	***	***
CV (%)	1.74	3.10	2.81	1.06	1.56
Variety					
Soybean cv. G-2	11.2 c	11.4	11.3 b	11.3 c	11.4 b
Soybean cv. PB-1	11.4 bc	11.4	11.4 b	11.4 b	11.5 b
Level of significance	***	NS	***	***	***
CV (%)	1.74	3.10	2.81	1.06	1.56

* = Significant at 5% level, ** = Significant at 1% level, ***= Significant at 0.1% level.
In a column, figures having similar letter(s) do not differ significantly at 5% level as per DMRT.

Table 2. Interaction effect of storage relative humidity and variety on moisture content of soybean seed during storage from July to November, 2004

Storage relative humidity (%) ×Variety	**Seed moisture content (%)**				
	July	**Aug.**	**Sept.**	**Oct.**	**Nov.**
50 × Soybean cv. G-2	7.9 h	8.5	7.9	7.9 g	7.9 f
50 × Soybean cv. PB-1	7.9 h	7.9	7.9	7.9 g	7.9 f
60 × Soybean cv. G-2	9.6 f	9.7	9.6	9.7 e	9.7 d
60 × Soybean cv. PB-1	9.8 ef	9.8	9.8	9.8 de	9.8 d
70 × Soybean cv. G-2	12.0 d	12.0	12.1	12.1c	12.2c
70 × Soybean cv. PB-1	12.0 d	12.2	12.1	12.2 c	12.3 c
80 × Soybean cv. G-2	15.3 b	15.4	15.6	15.6 a	15.9 ab
80 × Soybean cv. PB-1	15.7 a	15.8	15.8	15.8 a	16.1 a
Level of significance	**	NS	NS	***	***
CV (%)	1.74	3.10	2.81	1.06	1.56

* = Significant at 5% level, ** = Significant at 1% level, ***= Significant at 0.1% level.
In a column, figures having similar letter(s) do not differ significantly at 5% level as per DMRT.

Germination

Effect of storage relative humidity

The storage relative humidity had a significant effect on germination of soybean seed at different months in storage from July to November, 2004 (Table 3). At each month's germination test it was found that the germination percentage decreased with the increases of relative humidity. In July 2004, the highest germination percentage (96.7%) was found with 50% storage RH while it decreased to only 57.3% with 80% storage RH (Table 3). In August, the germination percentage at 50% storage RH was

96% which was reduced to 30.2% while the seed stored at 80% RH. In September, the germination percentage under 50% storage RH was 95.3, which was reduced to 82.3% with 70% storage RH but while stored under 80% RH failed to germinate. Final seed testing was done in November when germination percentage with 50% storage RH was 93.9% and it was under 70% storage RH was 73.5% (Table 3). This present result is consisted with the findings reported by Charjan *et al.* (1992) who observed that at 90% storage RH, the seeds lost their germinability within three months of storage. Similarly Kueneman and Wien (1981) reported that germination capacity of soybean seed drop precipitously under an ambient conditions in storage.

Table 3. Effect of storage relative humidity and variety on germination percentage of soybean seed during storage from July to November, 2004

Storage relative humidity(%)	Germination (%)				
	July	August	September	October	November
50	96.7 (79.7 a)	96.0 (78.7 a)	95.3 (77.7 a)	94.7 (76.8 a)	93.9 (75.8 a)
60	94.9 (76.9 b)	94.3 (76.3 b)	93.9 (75.8 b)	92.8 (74.4 b)	92.0 (73.6 b)
70	83.0 (69.7 c)	82.8 (65.6 c)	82.3 (65.1 c)	78.3 (62.4 c)	73.5 (59.1 c)
80	57.3 (49.2 d)	30.2 (33.3 d)	0.00 (0.14 d)	0.00 (0.14 d)	0.00 (0.14 d)
Level of significance	***	***	***	***	***
CV (%)	2.11	2.21	1.93	2.28	2.11
Variety					
Soybean cv. G-2	86.2 (68.9 a)	77.5 (64.9 a)	68.9 (55.7 a)	68.2 (54.9 a)	66.4 (53.4 a)
Soybean cv. PB-1	83.2 (67.7 ab)	76.2 (63.4 b)	67.8 (54.4 bc)	67.2 (53.7 b)	65.5 (52.4 b)
Level of significance	**	***	***	***	***
CV (%)	2.11	2.21	1.93	2.28	2.11

Figures in parenthesis indicates the Arc Sine transformed value.
* = Significant at 5% level, ** = Significant at 1% level, ***= Significant at 0.1% level.
In a column, figures having similar letter(s) do not differ significantly at 5% level as per DMRT.

Effect of variety

A significant varietal effect on germination of soybean seed at each month of storage was observed from July to November, 2004 (Table 3). At each time of testing it was found that soybean cv. G-2 gave the highest germination percentage while Soybean cv. PB-1 gave the lowest germination percentage. In July, the germination of soybean cv. G-2 was 86% while it was 83% in case of Soybean cv. PB-1 (Table 3). In November testing, the germination for soybean cv. G-2 was 66% while it was 65% in Soybean cv. PB-1 (Table 3).

Storage relative humidity × Variety

The interaction effect of storage relative humidity and variety on germination of soybean seed was statistically significant for the months of September, October, and November but not in July and August, 2004 (Table 4). It was found that in September, October and November the highest germination percentage was found with soybean cv. G-2 seed stored at 50% RH. Whereas, the seeds kept at 80% RH failed to germinate (Table 4). The result showed that germination with 70% storage RH was the lowest with Soybean cv. PB-1 (Table 4).

Table 4. Interaction effect of storage relative humidity and variety on germination percentage of soybean seed during storage from July to November, 2004

Storage relative humidity (%) × Variety	Germination (%) [t]				
	July	Aug.	Sept.	Oct.	Nov.
50 × Soybean cv. G-2	97.3 (80.7 a)	97.0 (80.1 a)	96.3 (79.0 a)	96.0 (78.5 a)	95.0 (77.1 a)
50 × Soybean cv. PB-1	95.3 (77.6 bc)	94.7 (76.7 cd)	94.0 (75.9 cde)	93.3 (75.1 c)	92.7 (74.3 cd)
60 × Soybean cv. G-2	95.3 (77.6 bc)	95.0 (77.1 cd)	94.7 (76.7 bce)	93.3 (75.1 c)	92.7 (74.3 cd)
60 × Soybean cv. PB-1	94.7 (76.7 c)	94.0 (76.0 cd)	93.3 (75.1 de)	92.7 (74.3 c)	92.0 (73.7 cd)
70 × Soybean cv. G-2	85.3 (67.5 d)	85.3 (67.5 e)	84.7 (67.0 f)	83.3 (66.0 d)	78.0 (62.0 e)
70 × Soybean cv. PB-1	84.7 (67.0 d)	84.0 (66.5 ef)	84.0 (66.5 f)	82.7 (65.4 d)	77.3 (61.6 e)
80 × Soybean cv. G-2	58.7 (50.0 f)	32.7 (34.9 h)	0.00 (0.14 h)	0.00 (0.14 f)	0.00 (0.14 g)
80 × Soybean cv. PB-1	58.0 (49.6 f)	32.0 (34.4 hi)	0.00 (0.14 h)	0.00 (0.14 f)	0.00 (0.14 g)
Level of significance	NS	NS	**	***	***
CV (%)	2.11	2.21	1.93	2.28	2.11

Figures in parenthesis indicates the Arc Sine transformed value.
* = Significant at 5% level, ** = Significant at 1% level, ***= Significant at 0.1% level.
In a column, figures having similar letter(s) do not differ significantly at 5% level as per DMRT.

Vigour Index

Effect of Storage relative humidity

The effect of storage relative humidity on vigour index of soybean seed was significant for each months of test from July to November, 2004 (Table 5). At each month's test, it was found that the vigour index decreased with the increases of storage relative humidity. In July 2004, the highest vigour index (29.9) was found from the seeds stored with 50% RH while it decreased to only 18.4 with 80% storage RH (Table 5). In August, September, October and November the highest vigour index were 29.9, 29.6, 29.5 and 29.2 at 50% storage RH while those were 24.8, 23.9, 22.3, 22.0 and 21.4 treated with 70% storage RH, respectively (Table 5). But after two months of storage the vigour index reduced to zero at 80% storage RH, as there was no germinated seeds (Table 5).

Effect of variety

The soybean variety had a significant effect on vigour index of seed at each month of storage from July to November, 2004 (Table 5). It was found that Soybean cv. G-2 maintained the highest vigour index and soybean cv. PB-1 had the lowest vigour index. In July, August, September, October and November the highest vigour index of Soybean cv. G-2 were 25.0, 24.1, 19.9, 19.7 and 19.3 while those were 24.5, 23.8, 19.5, 19.3 and 19.0, respectively from the soybean cv PB-1 (Table 5). Arulnandhy and Hearth (1987) experimentally showed that soybean seed's viability and vigour declined slowly during the first 3 month storage and declined rapidly there after which is in agreement with the present result.

Storage relative humidity × Variety

A significant interaction effect between storage relative humidity and variety on vigour index of soybean seed was obtained for each months of test from July to November, 2004 (Table 6). It was noticed that in each month of testing the highest vigour index was found with Soybean cv. G-2 stored under 50% RH while the lowest from the Soybean cv. PB-1 with 80% storage RH (Table 6). The vigour index of soybean seed decreased with the advancement of storage time and reached to zero with 80% storage RH after two months of storage (Table 6).

Table 5. Effect of storage relative humidity and variety on vigour index of soybean seed during storage from July to November, 2004

Storage relative humidity(%)	Vigour index				
	July	August	September	October	November
50	29.9 a	29.9 a	29.6 a	29.5 a	29.2 a
60	29.6 b	29.6 b	29.3 b	29.1 b	28.7 b
70	24.8 c	23.9 c	22.3 c	22.0 c	21.4 c
80	18.4 d	14.9 d	0.00 d	0.00 d	0.00 d
Level of significance	***	***	**	***	***
CV (%)	0.37	0.24	0.17	0.14	0.12
Variety					
Soybean cv. G-2	25.0 c	24.1 c	19.9 c	19.7 c	19.3 c
Soybean cv. PB-1	24.5 d	23.8 d	19.5 d	19.3 d	19.0 d
Level of significance	***	***	**	***	***
CV (%)	0.37	0.24	0.17	0.14	0.12

* = Significant at 5% level, ** = Significant at 1% level, ***= Significant at 0.1% level.
In a column, figures having similar letter(s) do not differ significantly at 5% level as per DMRT.

Table 6. Interaction effect of storage relative humidity and variety on vigour index of soybean seed during storage from July to November, 2004

Storage relative humidity (%)× Variety	Vigour index				
	July	Aug.	Sept.	Oct.	Nov.
50 × Soybean cv. G-2	28.8 d	28.7 e	28.7 d	28.6 c	28.2 e
50 × Soybean cv. PB-1	27.9 e	27.9 f	27.7 f	27.6 f	27.3 f
60 × Soybean cv. G-2	28.0 e	27.9 f	27.8 e	27.5 g	27.1 g
60 × Soybean cv. PB-1	27.9 e	27.9 f	27.6 g	27.4 g	26.9 h
70 × Soybean cv. G-2	24.9 g	24.0 g	22.9 h	22.6 h	21.8 I
70 × Soybean cv. PB-1	24.0 h	23.8 h	22.7 i	22.2 i	21.6 j
80 × Soybean cv. G-2	18.2 k	16.0 i	0.00 l	0.000 l	0.00 m
80 × Soybean cv. PB-1	18.1 k	15.8 j	0.00 l	0.00 l	0.00 m
Level of significance	***	***	***	***	***
CV (%)	0.37	0.24	0.17	0.14	0.12

* = Significant at 5% level, ** = Significant at 1% level, ***= Significant at 0.1% level.
In a column, figures having similar letter(s) do not differ significantly at 5% level as per DMRT.

CONCLUSION

After one month of storage, soybean seed moisture content (SMC) was increased with increases of storage RH. At 50% storage RH the SMC was 7-8% while it was 15-16% under 80% storage RH. Similarly, germination percentage and vigour of soybean seed decreased with increases of storage RH. The germination in August under 50% storage RH was 96%, but with 80% storage RH it was 30%. The seed failed to germinate at 80% storage RH in September and thereafter. The germination of seed was above 92% stored in 50-60% RH while it was recorded 73% under 70% storage RH after 6 months of storage. The result suggests that soybean seed can be stored from one rabi season to the next maintaining above 92% germination capability if stored at 50-60% storage RH or seed moisture content below 10% in storage under normal room temperature.

REFERENCES

Arulnandhy, V. and H. M. E. Herath. 1987. Cultivar variation in storability of soybean seed under a lowland humid environment in Sri Lanka. Trop.l Agric. 143:1-11. [Cited from Soybean Abst. (1990) 13 (2): 74].

Arulnandhy, V. and Y. D. A. Senanayaka. 1988. Deterioration of soybean seed stored in different container under ambient conditions. *Seed Res*. 16 (2): 183-192. [Soybean Abst. 1990. 13 (3): 125].

BARI. 2000. Krshi Projukti Hatboi Bangladesh Agril. Res. Inst., Joydebpur, Gazipur. p. 155.

Charjan, S. K. U. and J. L. Tarar. 1992. Effect of relative humidity on viability and vigour in soybean. Department of Botany, Institute of Science Nagpur 440001, Maharashtra, India. Ann. Plant Physiol. 6 (1): 15-20.

Gomez, K. A. and A. A. Gomez. 1984. Statistical Procedures for Agricultural Research. 2nd Edn. John Willey and Sons., New York. pp. 97-111.

Gopalan, C., B. V. Sastri Rama and S. C. Balasubramanian. 1971. Nutritive value of Indian foods.Home Economist. I. C. M. R., Hydrabad, India.

Gowda, C. L. L. and A. K. Kaul. 1982. Pulses in Bangladesh, BARI and FAO pub. pp. 338-407.

Harrington, J. F and P.A. Minges. 1961. Vegetable seed germination, the effect of temperature, moisture, oxygen, storage dormancy, how they influence the development of the seed. Agricultural Extension Service, University of California, Davis, U.S.A. pp. 1-11.

Harrington, J. F. 1973. Packaging seed for storage and shipment. *Seed Sci*. & *Tech*.1: 701-709.

Hill, M. J. (1999). The drying and storage of grain and Herbage seeds. FAR. Iinclon, New Zealand.

ISTA. 1993. International rules for seed testing. Zurich Switzerland 21. Supplement 1993. p. 45.

Kueneman, E. A. and H. C. Wien. (1981). Improving soybean establishment in the tropics by varietal selection for superior seed storability. Cooperation of National Programs. IITA. Ibadan Nigeria. Research Briefs.2:8-10.

Maguire, J. O. 1962. Speed of germination aid in selection and evaluation for seedling emergence and vigour. Crop Sci. 2: 176-177.

Pingale, S. V. 1978. Handling and storage of food grains. The Food Corporation of India, New Delhi. P. 58.

Tango, J. S., I. M. Nakamura, M. F .F. Leito and B. A. Jardao. 1977. Effect of relative humidity on the storage stability of peanut seed. Tropical oil seed Abs. 2 (4): 73.

Woodruff, M. J. (1998). Reports on the soybean. Its starts, and potential Bangladesh Agrobased industries and Technology Devolopment Project (ATDP). May 1998. Ministry of Agriculture and International Fertilizer Development Centre (IFDC).