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Impact of Stages of Harvesting and Threshing Methods on Moisture, Protein and Oil Content of Soybean [*Glycine max* (L.) Merrill] cv. DSb-21

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A B S T R A C T

Investigations were carried out to determine the most appropriate stage of harvesting and threshing method with minimal impact on seed quality characteristics of soybean seeds. The field experiment was conducted in 'H' Block of seed unit in two factorial randomized complete block design (RCBD) in three replications with the different treatments of harvesting soybean pods at 90, 100 and 110 days after sowing (DAS) and the threshing of seed crop was done by three methods *viz*., Stick beating (T_1), Tractor trampling (T_2) and Mechanical thresher (T_3) and storage experiment was conducted for a period of 180 days under the ambient conditions in Post Graduate laboratory of the Department of Seed Science and Technology, University of Agricultural Sciences, Dharwad. The results revealed that among harvesting stages, soybean harvested at 90 DAS recorded the highest oil content (20.68 %) and lowest protein content (39.11%). Delayed harvest *viz*., 100 DAS and 110 DAS resulted in increased protein and decreased moisture and oil content. Among threshing methods, beating with sticks proved superior for oil (20.10 %), protein content (39.60 %). During storage there was no significant difference in protein, oil and moisture content of seeds. Results obtained indicated that for good seed quality, soybean pods should be harvested at 90 DAS and threshed by beating with sticks and can be stored for long period without affecting protein and oil content.

Introduction

Soybean is an important oil seed crop and is an annual legume. It is originated in China and classified as an oilseed rather than a pulse by the UN Food and Agriculture Organization and is popularly known as 'Meat of fields' in china and also as "Miracle crop" due to its high protein (42-45 %) and oil (19-20 %) content. It is important oil seed crop accounts for 30 percent of the world edible oil production and its protein is composed of 10 properly balanced amino acids.

It is also called as "Wonder crop" due to its multiplicity of uses in food and industrial areas. As it fixes atmospheric nitrogen in the soil to maintain the soil fertility and has beneficial effect on successive crops, it is called as “Golden bean” or “Gold of soil”.

Soybean is good for diabetic patients as it contains less starch. Its oil is used for cooking and for preparing vanaspati ghee, soya-milk, soya-flour, soya-cake, biscuit, varnish and paint.

About 5-6 kg of soya-milk is obtained by one kilogram of soybean. Soya lecithin- used as an emulsifier in cosmetics and pharmaceuticals. Soybean plants are used for fodder purpose and soya cake is used as feed for cattle. It is used to prepare many other products like macaroni, bean curd, soya-sauce, green bean, baked bean *etc*. Its protein creates alkalizing effects. It is also used as green manure, hay and silage. Major constraint in soybean seed production is the loss of seed viability during storage subsequently resulting in low germination. Presence of high lipid content and high level of polyunsaturated oleic acid, linolenic and linoleic acid is the main reason for short shelf life of soybean seed. Storability of seed is mainly a genetic character and it is influenced by pre storage history of seeds, seed maturation and environmental factors during pre and post harvest stages. (Mahesha *et al.,* 2001).

Quality seed production is an important pre requisite for the agricultural production. The seed producers harvest seed as per their need and convenience, *i.e*., may be later or earlier or at physiological maturity or at harvest maturity. This, leads to variation in quality and yield of seeds and finally effect storage. The storage becomes successful depending upon quality of seeds to be stored. It is universal that when plant attains physiological maturity, on that day only the storage of seeds starts on plant itself. Initial moisture content reflects further germination and vigour of seed under storage. Threshing is an important post harvest operation. In India threshing of soybean seed is generally done by hand beating of pods with sticks and trampling the pods under the feet of bullocks or using a stone roller yoked to a pair of bullocks or other common practice is the use of tractors and mechanical thresher. These methods involve the rubbing action for separating the seed and threshing.

Optimum stage of harvesting is a crucial factor as it directly impacts on seed quality. Soybean seed with a thin seed coat, high protein and oil, the embryo placed outwards is susceptible during the threshing operations as the seeds are being rubbed. Beating with sticks seems to be an alternative to avoid the damage to the seeds. But, it becomes impractical, as it is time consuming and requires more labour and huge cost.

Keeping this in view the present experiment impact of stages of harvesting and threshing methods on protein and oil content of soybean [*Glycine max* (L.) Merrill] cv. DSb-21 was carried out.

Materials and Methods

The field experiment was conducted in ‘H’ Block of seed unit in two factorial randomized complete block design (RCBD) in three replications with the different treatments of harvesting soybean pods at 90 DAS (H_1), 100 DAS (H_2) and 110 DAS (H_3) and the threshing of seed was done by three methods viz., Stick beating (T_1), Tractor trampling (T_2) and Mechanical thresher (T_3) and the quality analysis was carried out in the Post Graduate laboratory of the Department of Seed Science and Technology, University of Agricultural Sciences, Dharwad.

Seed moisture content (%)

Moisture content of seeds was determined by adopting the Low Constant Temperature Oven method ($103^0 + 10^0$C for 17 + 1 hr) as per the ISTA Rules (Anon., 2011) and was expressed as moisture content in percentage on wet basis by using the following formula

$$\text{Moisture content (\%)} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Where,

W_1 – Weight of the empty aluminium dish with lid (g)

W_2 – Weight of empty aluminium dish + seed sample before drying (g)

W_3- Weight of the empty aluminium dish + seed sample after drying (g)

Protein content

A known quantity of seeds from each treatment replication were subjected to Nuclear Magnetic Spectrometer (NMR) to determine the protein content of seed, which gives the direct value of protein content in seeds and values obtained were expressed in percentage (%).

Oil content

A known quantity of seeds from each replication were subjected to Nuclear Magnetic Spectrometer (NMR) to determine the oil content of seed, which gives the direct value of oil content in seeds and values obtained were expressed in percentage (%).

Statistical analysis

The data collected from the experiment was analyzed statistically and subjected to the analysis of variance by adopting the appropriate methods as outlined by Sundar rajan *et al.,* (1972). Critical differences were calculated at one per cent level. In the tables, the critical difference values were given for those observations which were significant at one per cent.

Results and Discussion

Effect of stages of harvesting and threshing methods on initial seed quality parameters of soybean seeds cv. DSb -21

Moisture content (%)

The results on moisture content (%) as influenced by stages of harvesting, threshing methods and their interaction effects at different months of storage period are presented in Table 1. Stages of harvesting showed significant difference. Highest moisture content of seed (13.19%) was observed in H1 (90 DAS) and lowest (10.39%) was observed in H3 (110 DAS). Threshing methods has shown non-significant differences for moisture content of seed (%). Numerically highest moisture content of seeds (11.67%) was observed in T1 and lowest (11.52%) was in T2. Among interaction H3T2 had lowest seed moisture content (10.33%) as compared to other treatment combinations.

Oil content (%)

The results on oil content (%) as influenced by stages of harvesting, threshing methods and their interaction effects are presented in Table 1. Stages of harvesting, threshing methods and their interaction showed non-significant differences for oil content (%).

Numerically lowest oil content (19.33%) was observed in H3 (100 DAS) and highest (20.68%) was observed in H1 (90 DAS). Among threshing methods numerically lowest oil content (20.07 %) was observed in tractor trampling (T2) and highest (20.10%) was observed in T1. Among interaction highest oil content (20.70 %) was observed in H1T2 and lowest oil content (19.30 %) was observed in H3T2 treatment combination.

Protein content (%)

The results on protein content (%) as influenced by stages of harvesting, threshing methods and their interaction effects are presented in Table 1. Stages of harvesting, threshing methods and their interaction showed non-significant differences for protein content (%). Numerically lowest protein content (39.11%) was observed in H1 (90 DAS) and highest (40.05%) was observed in H3 (110 DAS). Among threshing methods, numerically lowest protein content (39.55%) was observed in tractor trampling (T2) and highest (39.60%) was observed in T1.

Interaction showed non-significant differences, but numerically higher protein content (40.08 %) was observed in H3T1 and lowest protein content (39.10 %) was observed in H1T2 treatment combination. As the harvesting stage proceeded from H1 to H3 (90 DAS to 110 DAS), seed moisture content reduced (13.19% to 10.39%). At moistures higher and lower than the optimum level, the extent of damage as seed crushing and bruising or breakage and cracks will be more. It can be concluded that at optimum moisture content, the physical properties of soybean seed such as seed size, porosity and density are in the best condition, reducing the mechanical damage. The results of Kashaninejad *et al.,* (2008), Sosnowski (1999), Khazaie *et al.,* (2009) studies also verify it.

As the harvesting stage delayed protein content was increased and oil content was decreased, as there is negative correlation between both protein and oil content of seeds. Increasing trend of protein, reducing sugar and decreasing oil content with the decrease in the moisture content of seeds was noticed. Similar results were reported by Thompson and Kieiman (1988), Wilson (2004), Kumar *et al.,* (2006), Sowmya *et al.,* (2012), Gaikwad (2014) and Tutu (2014).

Effect of stages of harvesting and threshing methods on storability of soybean seeds cv. DSb -21

Moisture content (%)

The results of moisture content (%) as influenced by stages of harvesting, threshing methods and their interaction effects at different months of storage period are presented in Table 2. Stages of harvesting shown non significant difference for seed moisture content, the highest moisture content (12.17%) was recorded in the first month of storage in H1(90DAS) and lowest (9.92%) in H3. As the storage month proceeded moisture content also decreased and highest moisture content (11.04%) was recorded in H1 and lowest (9.11) in H3 at the end of six months of storage. Threshing methods showed significant differences in moisture content (%) during storage.

The mean moisture content (%) decreased with the advancement of storage period. Whereas, higher moisture content (11.19%) was recorded at first month in T1 (Beating with sticks). While, lower moisture content (10.55 %) was recorded in T3. At the end of six months of storage period, higher moisture content (10.28 %) was recorded in T1 (Beating with sticks) and T2 (Tractor trampling) (10.12 %), while significantly lowest moisture content (9.50%) was recorded in T3 (Mechanical thresher). At the end of storage period lowest moisture (8.98%) content was observed in H3T3 (110 DAS with mechanical thresher) and highest (11.56%) in H1T1.

Oil content (%)

The data on oil content (%) due to stages of harvesting, threshing methods and their interaction are depicted in the Table 3. Stages of harvesting, threshing methods and their interactions showed non-significant difference for oil content for different storage period. Initially, highest oil content (20.64%) was observed in H1 and lowest (19.19%) in H3. Similarly, among threshing methods, highest oil content (20%) was observed in T1 and lowest (19.97%) in T2. At the end of storage period, the maximum oil content (19.97%) was maintained in H1 and T1(19.03%) and lowest was in H3(17.81%) and T2(18.97%). Oil content as influenced by interaction of stages of harvesting and threshing methods was found non significant. After 180 days of the storage maximum oil content was maintained in H1T1 (20.00%) and lowest was in H3T2 (17.79%).

Protein content (%)

The data on protein content (%) due to stages of harvesting, threshing methods and their interaction are depicted in the Table 4. Regard less of stages of harvesting and threshing methods protein content (%) decreased as the storage period advanced. Stages of harvesting and threshing methods showed non-significant difference for protein content for different storage period. Initially, highest protein content (39.98%) was observed in H3 and lowest (38.90%) in H1. Similarly, among threshing methods, highest protein content (39.45%) was observed in T1 and lowest (39.42%) in T2. At the end of storage period, the maximum protein content (39.27%) was maintained in H3 and T1 (38.10%) and lowest (37.08%) was in H1and T2 (38.04%). Protein content as influenced by interaction of stages of harvesting and threshing methods was found non significant. After 180 days of the storage maximum protein content was maintained in H3T1 (39.30%) and lowest was in H1T2 (37.05%).

The data revealed that seed looses the water and showed decreasing trend in seed moisture content upto 120 days of storage irrespective of stage of harvesting and threshing methods.

The decreasing moisture content of seed could be due to low relative humidity and high temperature. The first rains of the season during the conduct of the experiment resulting in increase in relative humidity which reflected increase in moisture content of seed.

High seed moisture content is the most important single factor governing loss of germinability during storage. Since, seeds are hygroscopic in nature, they absorb or loose moisture until the vapour pressure of seed moisture and atmospheric moisture reach equilibrium.

The seed moisture content attained under these conditions is referred as equilibrium moisture content (EMC). The EMC in seed at given RH decrease slowly with increasing temperature. The results are analogous with those reported by Gupta (1976) who stated that in winter, seed is protected by low temperature and during early summer, the seed is protected by low humidity.

Table.1 Effect of stages of harvesting and threshing methods on initial seed moisture (%), protein (%) and oil content (%) in soybean seed cv. DSb -21

Treatments	Moisture content (%)	Oil content (%)	Protein content (%)
H_1	13.19	20.68	39.11
H_2	11.2	20.24	39.55
H_3	10.39	19.33	40.05
Mean	11.59	20.08	39.57
S. Em. ±	0.07	0.48	0.94
C. D. (P=0.01)	0.27	NS	NS
T_1	11.67	20.1	39.6
T_2	11.52	20.07	39.55
T_3	11.59	20.08	39.57
Mean	11.59	20.08	39.57
S. Em. ±	0.07	0.48	0.94
C. D. (P=0.01)	NS	NS	NS
H_1T_1	13.27	20.7	39.13
H_1T_2	13.11	20.67	39.1
H_1T_3	13.18	20.68	39.11
H_2T_1	11.3	20.25	39.58
H_2T_2	11.11	20.24	39.53
H_2T_3	11.2	20.24	39.55
H_3T_1	10.45	19.35	40.08
H_3T_2	10.33	19.3	40.03
H_3T_3	10.4	19.33	40.05
Mean	11.59	20.08	39.57
S. Em. ±	0.11	0.83	1.63
C. D. (P=0.01)	NS	NS	NS

Table.2 Effect of stages of harvesting and threshing methods on seed moisture content (%) in soybean seed cv. DSb -21 during storage

Treatments	30 days (After harvest)	60 days (After harvest)	90 days (After harvest)	120 days (After harvest)	150 days (After harvest)	180 days (After harvest)
H_1	12.17	12.01	12.08	11.89	8.48	11.04
H_2	10.55	10.65	10.73	10.54	8.30	9.75
H_3	9.92	10.03	10.10	9.91	8.12	9.11
Mean	10.88	10.90	10.97	10.78	8.30	9.97
S. Em. ±	0.26	0.26	0.26	0.26	0.20	0.24
C. D. (P=0.01)	NS	NS	NS	NS	NS	NS
T_1	11.19	11.29	11.35	11.10	8.32	10.28
T_2	10.90	11.01	11.08	10.93	8.28	10.12
T_3	10.55	10.39	10.47	10.31	8.30	9.50
Mean	10.88	10.90	10.97	10.78	8.30	9.97
S. Em. ±	0.26	0.26	0.26	0.26	0.20	0.24
C. D. (P=0.01)	NS	NS	NS	NS	NS	NS
H_1T_1	12.50	12.63	12.68	12.42	8.50	11.56
H_1T_2	12.11	12.23	12.29	12.12	8.45	11.23
H_1T_3	11.90	11.18	11.26	11.14	8.48	10.34
H_2T_1	10.94	11.02	11.09	10.84	8.32	10.08
H_2T_2	10.75	10.83	10.90	10.78	8.29	10.00
H_2T_3	9.97	10.11	10.19	10.00	8.30	9.18
H_3T_1	10.13	10.22	10.28	10.04	8.15	9.21
H_3T_2	9.84	9.98	10.05	9.90	8.10	9.14
H_3T_3	9.78	9.89	9.96	9.78	8.12	8.98
Mean	10.88	10.90	10.97	10.78	8.30	9.97
S. Em. ±	0.45	0.45	0.46	0.45	0.34	0.41
C. D. (P=0.01)	NS	NS	NS	NS	NS	NS

Table.3 Effect of stages of harvesting and threshing methods on oil content (%) in soybean seed cv. DSb -21 during storage

Treatments	30 days (After harvest)	60 days (After harvest)	90 days (After harvest)	120 days (After harvest)	150 days (After harvest)	180 days (After harvest)
H_1	20.64	20.55	20.46	20.37	20.29	19.97
H_2	20.13	20.03	19.9	19.77	19.56	19.21
H_3	19.19	19.08	18.88	18.67	18.37	17.81
Mean	19.99	19.89	19.75	19.6	19.41	19
S. Em. ±	0.48	0.47	0.47	0.47	0.46	0.45
C. D. (P=0.01)	NS	NS	NS	NS	NS	NS
T_1	20	19.91	19.76	19.63	19.42	19.03
T_2	19.97	19.87	19.74	19.58	19.39	18.97
T_3	19.98	19.89	19.74	19.60	19.40	18.99
Mean	19.98	19.89	19.75	19.60	19.40	19.00
S. Em. ±	0.48	0.47	0.47	0.47	0.46	0.45
C. D. (P=0.01)	NS	NS	NS	NS	NS	NS
H_1T_1	20.65	20.57	20.48	20.39	20.29	20
H_1T_2	20.63	20.54	20.44	20.35	20.28	19.94
H_1T_3	20.63	20.55	20.45	20.36	20.29	19.96
H_2T_1	20.14	20.06	19.91	19.79	19.58	19.25
H_2T_2	20.11	20.00	19.9	19.75	19.54	19.19
H_2T_3	20.13	20.03	19.9	19.78	19.55	19.20
H_3T_1	19.21	19.09	18.9	18.7	18.39	17.83
H_3T_2	19.18	19.06	18.87	18.65	18.35	17.79
H_3T_3	19.18	19.09	18.88	18.67	18.36	17.8
Mean	19.98	19.89	19.75	19.60	19.40	19.00
S. Em. ±	0.83	0.82	0.82	0.81	0.8	0.79
C. D. (P=0.01)	NS	NS	NS	NS	NS	NS

Table.4 Effect of stages of harvesting and threshing methods on protein content (%) in soybean seed cv. DSb -21 during storage

Treatments	30 days (After harvest)	60 days (After harvest)	90 days (After harvest)	120 days (After harvest)	150 days (After harvest)	180 days (After harvest)
H_1	38.90	38.67	38.40	38.08	37.65	37.08
H_2	39.43	39.28	38.98	38.60	38.27	37.87
H_3	39.98	39.88	39.82	39.71	39.49	39.27
Mean	39.44	39.28	39.07	38.80	38.47	38.07
S. Em. ±	0.94	0.94	0.93	0.92	0.92	0.91
C. D. (P=0.01)	NS	NS	NS	NS	NS	NS
T_1	39.45	39.30	39.09	38.82	38.50	38.10
T_2	39.42	39.26	39.05	38.77	38.45	38.04
T_3	39.43	39.28	39.07	38.80	38.47	38.07
Mean	39.43	39.28	39.07	38.80	38.47	38.07
S. Em. ±	0.94	0.94	0.93	0.92	0.92	0.91
C. D. (P=0.01)	NS	NS	NS	NS	NS	NS
H_1T_1	38.91	38.70	38.42	38.11	37.67	37.12
H_1T_2	38.90	38.65	38.37	38.04	37.62	37.05
H_1T_3	38.90	38.67	38.40	38.09	37.65	37.07
H_2T_1	39.44	39.30	39.00	38.62	38.30	37.89
H_2T_2	39.41	39.26	38.97	38.58	38.25	37.84
H_2T_3	39.43	39.28	38.98	38.61	38.27	37.88
H_3T_1	40.00	39.90	39.85	39.74	39.53	39.30
H_3T_2	39.96	39.86	39.80	39.68	39.47	39.24
H_3T_3	39.97	39.89	39.82	39.71	39.48	39.27
Mean	39.44	39.28	39.07	38.80	38.47	38.07
S. Em. ±	1.63	1.62	1.61	1.60	1.59	1.57
C. D. (P=0.01)	NS	NS	NS	NS	NS	NS

The temperature generally rises from March onwards while RH goes down making storage safe for soybean. It is only from late June or early July that the RH rises and the bulk storage become problem. The soybean seed imbibes high amount of water to create equilibrium inside and outside the seed.

The hydrophilic nature of high protein content of soybean (Hartwig and Potts, 1987) helps in more absorption of water and high oil content in seed increases deterioration of seed (Potts, 1972) by increased hydrolytic enzyme activity, enhanced respiration and increase in free fatty acids. High temperature accelerated the rate of these biochemical processes causing more rapid deterioration that might have resulted in rapid losses in seeds having high moisture content.

As the storage period progressed the protein and oil content of seeds decreased irrespective of harvesting stages and threshing methods. Both loss of membrane integrity and decrease in proportion of unsaturated fatty acids have been reported as seed deteriorates. It is suggested that seed deterioration is generally initiated in meristematic areas of the seed and embryonic axes were the most sensitive seed part to deterioration in soybean (Seneratna *et al.,* 1988). Decrease in oxygen consumption with soybean seed ageing and proposed that the mitochondria may be the site most sensitive to deterioration. The general consensus is that DNA is somehow degraded leading to impaired transcription causing incomplete or faulty enzyme synthesis essential for the earliest stage of germination. Without enzyme activity, storage reserves are not hydrolysed and energy molecules remain unavailable for the synthesis of ATP.

The results revealed that among harvesting stages, delayed harvest *viz*., 100 DAS and 110 DAS resulted in increased protein and decreased moisture and oil content. Among threshing methods, beating with sticks proved superior for oil, protein content. Seeds can be stored for longer period of time as there was no significant difference in protein, oil and moisture content of seeds during storage.

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