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Influence of different heaping methods and duration on seed quality in soybean

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Abstract
An experiment was conducted to study the influence of different heaping methods and duration on seed quality in soybean at Agriculture Research Station, Bidar during *Kharif* 2020-21 and 2021-22. The treatments constituted of three heaping methods a) field b) field + covering c) shade and four duration of storage a) 2 weeks after harvest b) 4 weeks after harvest c) 6 weeks after harvest and d) 8 weeks after harvest along with control *i.e.* threshing the seeds immediately after harvest. All the treatments were laid out in factorial randomised block design with three replication. The results revealed that seeds obtained from crop threshed immediately after the harvest (C: control) recorded maximum significant difference in seed quality parameters *viz.*, optimum moisture content, test weight, seed germination, seedling length, seedling dry weight, seedling vigour index, low disease infection, least pest infestation and field emergence (11.42 %, 12.84 g, 76.50 %, 24.25 cm, 383 mg, 1859, 0.64 %, 0.00 % and 74.67 %) respectively when compared todifferent heaping and storage duration treatments.

Keywords: Heaping, storage and seed quality

1. Introduction

The production of high quality seeds is a crucial prerequisite for agricultural output. The seed growers harvest the seed when it is most convenient for them and according to their needs, whether it be later or sooner, at physiological maturity or at harvest maturity. This causes variation in seed quality and production, which will eventually have an impact on seed storage potential (Arulnandhy *et al*. 1987) [5]. Success in storage depends on the quality of the stored seeds. It is universal that when plant attains physiological maturity, on that day only the storage of seeds starts on plant itself. According to Seema *et al*. (2020) [19], initial moisture content of the seed reflectsfurther germination and seed vigour under storage.

Soybean [*Glycine max* (L.) Merrill] has gained significance throughout the world as an important oil seed crop and an annual legume because of its wide range of geographic adaptation, distinctive chemical composition, high nutritional value with functional health benefits and numerous applications in the food and related industries. It is a multipurpose legume rich in both protein and oil content with the ability to resolve food and nutritional security in developing countries hence considered as "Golden bean". Soybean ranks first in the international market among the world's major oil seed crops (FAO, 2020). It accounts for 42 per cent of overall oilseed production, 22 per cent of total oil production and 2/3rd of the global protein concentrates for livestock feeding. Soybean was also named as "wonder crop" or "Miracle crop" as its seed contains diverse nutritional characteristics such as 20 per cent oil with 85 per cent unsaturated fatty acids including 55 per cent poly unsaturated fatty acids (PUFA), 40 per cent good quality protein, antioxidants, 4-5 per centminerals and 25-30 per cent carbohydrates (Karthika and Koti, 2017) [12].

India ranks fourth in terms of production area (129.28 lakh hectares) and fifth in production (12.61 million tonnes) with productivity of 976 kg per hectare. The fastest-growing states in India include Madhya Pradesh, Maharashtra, Rajasthan, and Karnataka. The majority of soybean-growing areas are under rainfed condition. (Anon, 2020) [4]. It is mostly grown in kharif season on black cotton soils and gathered seed is stored till the next year for sowing, which is a challenging operation due to its poor storability. Therefore, the significant barrier to the soybean production each year is the non-availability of high quality seed for farmers.

Due to the fact that soybean seed is a poor storer and is more susceptible to mechanical damage from harvest to the following sowing season, maintaining seed quality after harvest and during storage is a major challenge. (Paulsen et al., 1981) [15]. Greven et al. (2004) [8] reported that stages of harvest are an important factor since seed immaturity reduces seed quality. Between physiological maturity (PM) and harvest maturity (HM), the quality of the seeds did not generally vary considerably, but in some circumstances, the proportion of viable seeds increased, especially when ambient temperatures were rather low. (Muasya et al., 2008) [14]. Kumar et al. (2002) [13] stated that seed yield and quality largely depend upon the stage of maturity of crop. Therefore, it is crucial to harvest seeds at the ideal stage of maturation because collecting seeds earlier than necessary or too late results in inferior yield and seeds of a lower standard.

The post-harvest processing of soybean seed includes threshing, drying, grading, transportation, various handling processes, and storage. Seeds are kept for at least a few months in stacks, heaps, single layers, sacks, or open containers that are shielded from the elements, well aired and rodent-free. Because of its very thin seed coat and low lignin content, soybean seed is regarded as a poor store because it loses its viability and vigour at a faster rate as a result of loss of seed membrane permeability. Mechanical damage is the main cause of this loss of soybean seed quality because the seed's thin seed coat offers little protection to the delicate radical, which is located in a vulnerable position directly beneath the seed coat (Alvarez et al. 1997, Prakobbon, N., 1982 and Puteh et al. 1997) [3, 16, 17].

Despite the fact that it is economically significant, there is very little scientific knowledge on the correct way of threshing to obtain good quality seed for long-term preservation. In light of this, the current experiment was conducted to examine how heaping techniques and storage time affected soybean seed quality.

Material and methods

An experiment was framed to study the "Influence of different heaping methods and duration on seed quality in soybean" at Agricultural Research Station, Bidar, Karnataka, India during Kharif 2020-21 and 2021-22. The experiment was laid out in Two Factorial Randomized Complete Block Design, the treatments constituted of two factors, factor one with three heaping methods (H1: Field, H2: Field + covering and H3: Shade), second factor with four durations of storage after harvest in heaps (D1: 2 weeks after harvest, D2: 4 weeks after harvest, D3: 6 weeks after harvest and D4: 8 weeks after harvest) and their interaction along with control (C) i.e. threshing of seeds immediately after the harvest was studied. The observations on seed quality parameters was recorded of respective treatments viz., moisture content (%), test weight (gm), germination (%), seedling length (cm), seedling dry weight (mg), seedling vigour index, disease infection (%), pest infestation (%) and field emergence (%). The statistical analysis and the interpretation of the experimental data was done by using Fischer method of Analysis of Variance technique as outlined by Gomez and Gomez (1984). The level of significance used in F test was 5 per cent for field experiment and 1 per cent for laboratory experiment.

Moisture test was conducted as per ISTA (2018) rules by placing five grams of grounded sample into aluminium box in three replicates and dried at 103oC for 17 hours in hot air oven. The per cent moisture content was calculated by using the formula:

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

W_1 - Weight of the empty container along with lid (gm)
W_2 - Weight of the container along with lid and grounded seed sample before drying (gm)
W_3 - Weight of the container along with lid and grounded seed sample after drying (gm)

Germination test in soybean was conducted as per ISTA (2018) using between paper method. Fifty seeds were placed for germination in eight replicates and kept in the germination chamber at a temperature of 25± 1°Cand relative humidity of 95 per cent. The germination percentage was calculated by using following formula:

$$\text{Germination (\%)} = \frac{\text{Total number of normal seedlings}}{\text{Number of seeds placed for germination}} \times 100$$

Seedling length and seedling dry weight was evaluated and expressed in centimeters and in milligrams, respectively. Seedling vigour index-II were calculated as per procedure given by Abdul-Baki and Anderson (1973) and expressed in whole number.

Seedling Vigour Index-II = Germination (%) × Seedling dry weight (mg)

Field emergence test was conducted by sowing hundred seeds from each treatment in three replications and evaluated on eighth day and expressed in percentage.

$$\text{Field emergence (\%)} = \frac{\text{Number of seeds germinated on } 8^{th} \text{ day}}{\text{Total number of seeds sown}} \times 100$$

Results from the experiment

Seed moisture content

bservations recorded on influence of different heaping methods and duration on moisture content in soybean is depicted in Table 1.

The seed moisture content was significantly influenced by heaping method and duration of storage. The lowest seed moisture content (11.42 %) was recorded in control (C) i.e. threshing on same day of harvest when compared to all treatments in pooled data of two years (Fig. 1). Among the heaping methods treatments of first factor the seed moisture content differed significantly and lowest seed moisture (12.39 %) was recorded in treatment (H3) i.e. seeds placed under the shade when compared to other two treatments among which highest seed moisture was observed in seeds placed in open field condition (H1) (13.60 %). In the treatments of duration of seed storage, the lowest moisture (12.06 %) was observed in seeds heaped for 2 weeks after harvest (D1). Whereas the moisture content of seeds heaped for 8 weeks after harvest was found to be maximum (13.79 %). The interaction effect between heaping method and duration of seed storage, there was no significant difference in seed moisture content, however the numerically the highest SMC was recorded in H1D4 (14.77 %) i.e. seeds placed in open field condition after harvest for duration of 8 weeks after harvest. Whereas the lowest moisture content (11.70 %) was recorded in seeds placed under shade in heap for 2 weeks after harvest (H3D1). Similar trend was noticed in 2021 and 2022. Tubic et al. (2011) [21] reported that the hygroscopic nature of seed which helps in absorbing the moisture when the relative humidity was high in the storage conditions which led to increase in moisture content of the seeds when stored in open field or under the shade. Similar results were observed in findings of Gadhave (2018) [7] who reported that moisture content was found to be increased during storage.

Test weight

The test weight of the seeds of heaping and storage treatments differed significantly and the pooled data of two years is presented in Table 1. The maximum test weight (12.84 g) was recorded in seeds obtained from threshing on same day of harvest (C: control) as compared to other treatments of two factors i.e. heaping method and storage duration (Fig. 1). Among the heaping treatments highest test weight (11.82 g) was recorded in treatment (H3) i.e. seeds placed under the shade when compared to seeds stored in open field condition after harvesting (H1) (10.97 g) and in treatments of seed storage the highest test weight (12.34 g) was noticed in (D1) seeds storage for 2 weeks after harvest, whereas the lowest test weight (10.25 g) was recorded in (D4) seed storage for 8 weeks after harvest. The interaction between the both the factors were found to be non-significant.

Seed germination and Seedling length

The seeds stored after the harvest under different treatments differed significantly in germination test and seedling length in which the highest germination and seedling length was recorded in threshing of seeds after the harvest on same day (C: control) (76.50 % and 24.25 cm) i.e. (Table 2 and Fig. 2) compared to other treatments of both factors. Among the heaping treatments, the maximum seed germination and seedling length (65.61 % and 19.08 cm) was recorded in seeds placed under the shade (H3). Whereas, the lowest seed germination and seedling length (52.74 % and 16.66 cm) was recorded in open field condition (H1). While in duration of storage the highest seed germination and seedling length (70.45 % and 21.89 cm) was recorded in seeds storage for 2 weeks after harvest (D1). Whereas the lowest test weight and seedling length (47.95 % and 14.17 cm) was recorded in seed storage for 8 weeks after harvest (D4). In the interaction between the treatments of both factors was found to be significant and the highest germination (74.34 %) was recorded in H3D1 seeds heaped under shade and stored for duration of 2 weeks after harvest as compared to lowest germination (30.50 %) recorded in H1D4 seeds heaped in open field for duration of 8 weeks after harvest. Similar trend was observed in 2021 and 2022. The germination percentage recorded in all the treatments except for the control didn’t fall under Indian Minimum Seed Certification Standards for soybean crop. The results of germination parameter was in line with the findings of Abady and Emam (2012) [1] who reported that higher germination percentage was observed in seeds threshed at proper time with no delay and gradually the germination decreased as storage duration increased. The results of seedling length were in conformity with the findings of Shelar et al. (2008) [20] stated that reduced seedling length was observed when there is gradual increase in storage period.

Seedling dry weight and seedling vigour index

The pooled data of two years on seedling dry weight and seedling vigour index was found to be differed significantly among the treatments. The data is presented in Table 3 and depicted in Fig. 3. The maximum seedling dry weight and seedling vigour index was recorded in control (383 mg and 1859) i.e. seeds threshed on same day of harvest compared different treatments of heaping method and duration of storage. In first factor i.e. in heaping methods, the maximum seedling dry weight and seedling vigour index (330.42 mg and 1306) was recorded in (H3) seeds heaped under the shade after the harvest and the lowest was recorded in seeds heaped in open field (274.38 mg and 920). The seedling dry weight and seedling vigour index of seeds pertaining to treatment duration of seed storage differed significantly and the maximum (356.39 mg and 1547) was recorded in D1 i.e. seed stored for 2 weeks after harvest compared to seeds stored for 8 weeks after harvest (D4) (228.89 mg and 705). The interaction effect in both the parameters was found to be non significant and same trend was noticed in both the year. Similar result was recorded by Kapoor et al. (2010) [11] seedling dry weight was significantly decreased with increased ageing up during storage.

Disease Infection

From the pooled data of two years recorded on disease infection in soybean in all treatments was found to be significant and the data is presented in Table 4 and depicted in Fig. 4. In which the lowest disease infection (0.64 %) was noticed in control (C) i.e. in seeds threshed on same day of harvesting and among the different heaping methods of first factor, the lowest disease infection (1.47 %) was noticed in seeds heaped under the shade (H3) after harvest when compared to highest disease infection (3.77 %) noticed in seeds heaped in field (H1). In seed storage treatment, the lowest disease infection (0.93 %) was observed in seeds stored for 2 weeks after harvest, whereas the highest disease infection (3.95 %) was observed in seed stored for 8 weeks after harvest. The interaction between the different treatments of heaping method and storage of seeds after harvest was found to differ significantly which recorded the lowest disease infection (0.68 %) in (H3D1) i.e. seeds heaped under the shade for duration of 2 weeks after harvest. Whereas, the highest disease infection (6.40 %) was observed in (H1D4) i.e. seeds heaped in open field condition for duration of 8 weeks after harvest.

Pest infestation

The pooled data of two year on pest infestation influenced by heaping method and duration of storage of soybean was found to be significant and presented Table 4 and depicted in Fig. 4. Zero pest infestation (0.0 %) was observed in control i.e. seeds threshed on the same day of harvest compared to other treatments. In treatments of heaping methods the results was found to be non significant. In the duration of seed storage the minimum pest infestation was observed in seeds stored for 2 weeks after harvest whereas, the maximum pest infestation was observed in seeds stored for 8 weeks after harvest. The interaction between the heaping methods and duration of storage was found to be non significant.

Field emergence

The observations recorded on influence of heaping method and duration of seed storage on field emergence in soybean was found to be significantly differed between the treatments in both the years (Table 5). The maximum field emergence (74.67 %) was noticed in control (C) i.e. seeds threshed on same day of harvest compared to seeds heaped in different condition for respective storage duration. In heaping methods the maximum field emergence (64.30 %) was recorded in (H3) seeds heaped under shade when compared to (H1) seeds heaped in open field which recorded minimum field emergence (48.67 %). In the treatments of seed storage the maximum field emergence (66.72 %) was recorded in (D1) seeds stored for 2 weeks after harvest, whereas the minimum field emergence (43.72 %) was recorded in (D4) seeds stored for 8 weeks after harvest. The interaction effect of both the factors was found to be non significant from the pooled data of two years. Similar trend was recorded in 2021 and 2022. These results were in line with the findings of Rame (2002) [18] who reported that as the storage advanced there was maximum reduction in field emergence.

Table 1: Influence of different heaping methods and duration on moisture content and test weight in soybean (Pooled data of 2020-21 and 2021-22)

Heaping methods	**Moisture content (%)**	**Test weight (g)**
H_1 (Field)	13.60	10.97
H_2 (Field + covering)	12.91	11.51
H_3 (Shade)	12.39	11.82
SEm±	0.13	0.15
CD @ 1 %	0.50	0.58
Duration		
D_1 (2 weeks after harvest)	12.06	12.34
D_2 (4 weeks after harvest)	12.65	11.91
D_3 (6 weeks after harvest)	13.39	11.24
D_4 (8 weeks after harvest)	13.76	10.25
SEm±	0.11	0.13
CD @ 1 %	0.43	0.50
Interaction (HxD)		
H_1D_1	12.27	12.24
H_1D_2	13.29	11.64
H_1D_3	14.07	10.83
H_1D_4	14.77	9.15
H_2D_1	12.07	12.30
H_2D_2	12.50	11.92
H_2D_3	13.47	11.42
H_2D_4	13.62	10.42
H_3D_1	11.84	12.49
H_3D_2	12.17	12.17
H_3D_3	12.65	11.46
H_3D_4	12.90	11.17
SEm±	0.22	0.25
CD @ 1 %	NS	NS
C(Control)	11.42	12.84

Table 2: Influence of different heaping methods and duration on germination and seedling length in soybean (Pooled data of 2020-21 and 2021-22)

Heaping methods	**Germination (%)**	**Seedling length (cm)**
H_1 (Field)	52.37	16.66
H_2 (Field + covering)	62.21	18.43
H_3 (Shade)	67.52	19.08
SEm±	1.61	0.53
CD @ 1 %	6.37	2.09
Duration		
D_1 (2 weeks after harvest)	70.45	21.89
D_2 (4 weeks after harvest)	66.22	19.18
D_3 (6 weeks after harvest)	58.19	17.00
D_4 (8 weeks after harvest)	47.95	14.17
SEm±	1.40	0.46
CD @ 1 %	5.52	1.81
Interaction (HxD)		
H_1D_1	67.84	20.17
H_1D_2	61.32	18.47
H_1D_3	49.84	16.50
H_1D_4	30.50	11.50
H_2D_1	69.17	22.17
H_2D_2	67.33	19.07
H_2D_3	58.50	17.33

H_2D_4	53.84	15.17
H_3D_1	74.34	23.33
H_3D_2	70.50	20.00
H_3D_3	66.24	17.17
H_3D_4	59.50	15.83
SEm±	2.79	0.92
CD @ 1 %	11.03	NS
C(Control)	76.50	24.25

Table 3: Influence of different heaping methods and duration on seedling dry weight and seedling vigour index in soybean (Pooled data of 2020-21 and 2021-22)

Heaping **methods**	**Seedling dry weight (mg)**	**Seedling vigour index -II**
H_1 (Field)	274.38	920
H_2 (Field + covering)	295.84	1161
H_3 (Shade)	330.42	1306
SEm±	10.06	47
CD @ 1 %	39.80	184
Duration		
D_1 (2 weeks after harvest)	356.39	1547
D_2 (4 weeks after harvest)	330.28	1271
D_3 (6 weeks after harvest)	285.28	993
D_4 (8 weeks after harvest)	228.89	705
SEm±	8.71	41
CD @ 1 %	34.47	160
Interaction (HxD)		
H_1D_1	338.33	1369
H_1D_2	316.67	1133
H_1D_3	264.17	827
H_1D_4	178.34	352
H_2D_1	360.00	1535
H_2D_2	324.17	1281
H_2D_3	280.00	1015
H_2D_4	219.17	815
H_3D_1	370.84	1737
H_3D_2	350.00	1399
H_3D_3	311.67	1137
H_3D_4	289.17	949
SEm±	17.42	81
CD @ 1 %	NS	NS
C(Control)	383.00	1859

Table 4: Influence of different heaping methods and duration on disease infection and pest infestation in soybean (Pooled data of 2020-21 and 2021-22)

Heaping methods	**Disease Infection (%)**	**Pest Infestation (%)**
H_1 (Field)	3.77	0.90
H_2 (Field + covering)	1.94	0.70
H_3 (Shade)	1.47	0.86
SEm±	0.20	0.09
CD @ 1 %	0.78	NS
Duration		
D_1 (2 weeks after harvest)	0.93	0.33
D_2 (4 weeks after harvest)	1.74	0.61
D_3 (6 weeks after harvest)	2.95	0.98
D_4 (8 weeks after harvest)	3.95	1.35
SEm±	0.17	0.08
CD @ 1 %	0.68	0.30
Interaction (HxD)		
H_1D_1	1.20	0.35
H_1D_2	2.65	0.65
H_1D_3	4.80	0.93
H_1D_4	6.40	1.67
H_2D_1	0.89	0.25
H_2D_2	1.35	0.42
H_2D_3	2.24	0.99
H_2D_4	3.29	1.13
H_3D_1	0.68	0.39
H_3D_2	1.12	0.77
H_3D_3	1.82	1.02
H_3D_4	2.15	1.25
SEm±	0.34	0.15
CD @ 1 %	1.35	NS
C(Control)	0.64	0.00

Table 5: Influence of different heaping methods and duration on field emergence in soybean (Pooled data of 2020-21 and 2021-22)

Heaping methods	Field emergence (%)
H_1 (Field)	48.67
H_2 (Field + covering)	56.13
H_3 (Shade)	64.29
SEm±	1.74
CD @ 1 %	6.89
Duration	
D_1 (2 weeks after harvest)	66.72
D_2 (4 weeks after harvest)	60.84
D_3 (6 weeks after harvest)	54.17
D_4 (8 weeks after harvest)	43.72
SEm±	1.51
CD @ 1 %	5.97
Interaction (HxD)	
H_1D_1	60.83
H_1D_2	55.17
H_1D_3	48.00
H_1D_4	30.67
H_2D_1	66.83
H_2D_2	59.84
H_2D_3	52.17
H_2D_4	45.67
H_3D_1	72.50
H_3D_2	67.50
H_3D_3	62.33
H_3D_4	54.84
SEm±	3.02
CD @ 1 %	NS
C(Control)	74.67

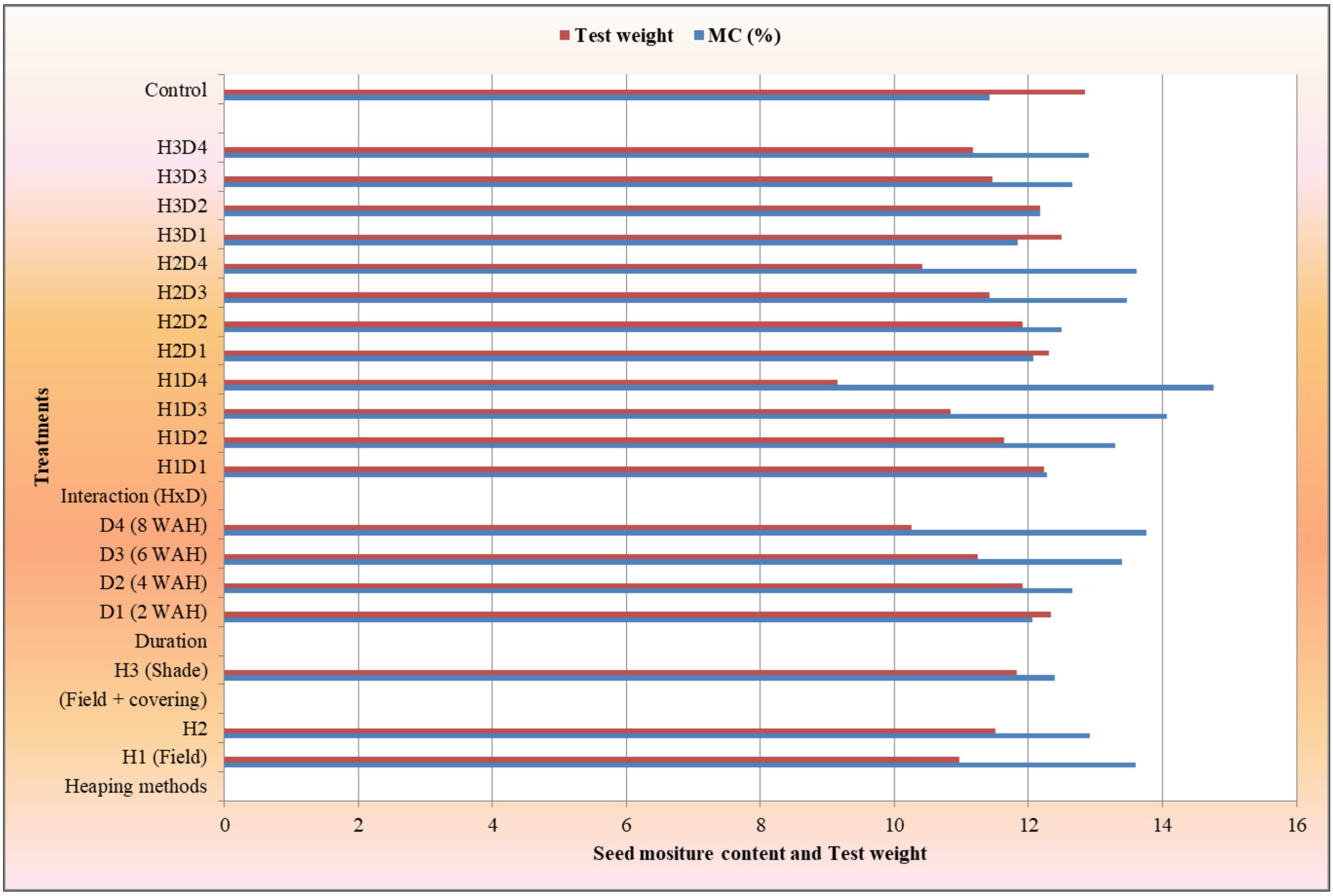

Fig 1: Effect of different heaping methods and duration seed moisture content and test weight in soybean

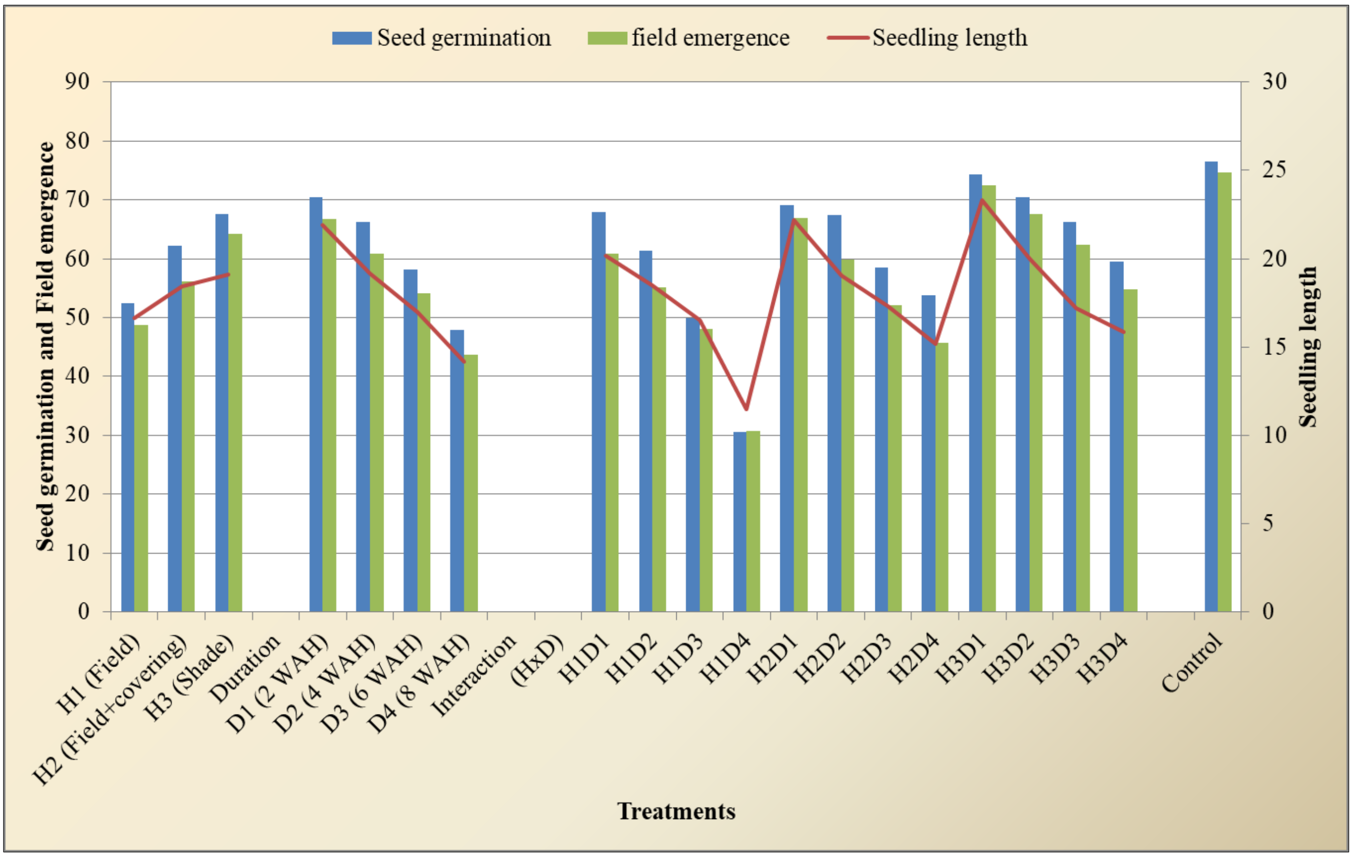

Fig 2: Influence of different heaping methods and duration on seed germination, field emergence and seedling length in soybean

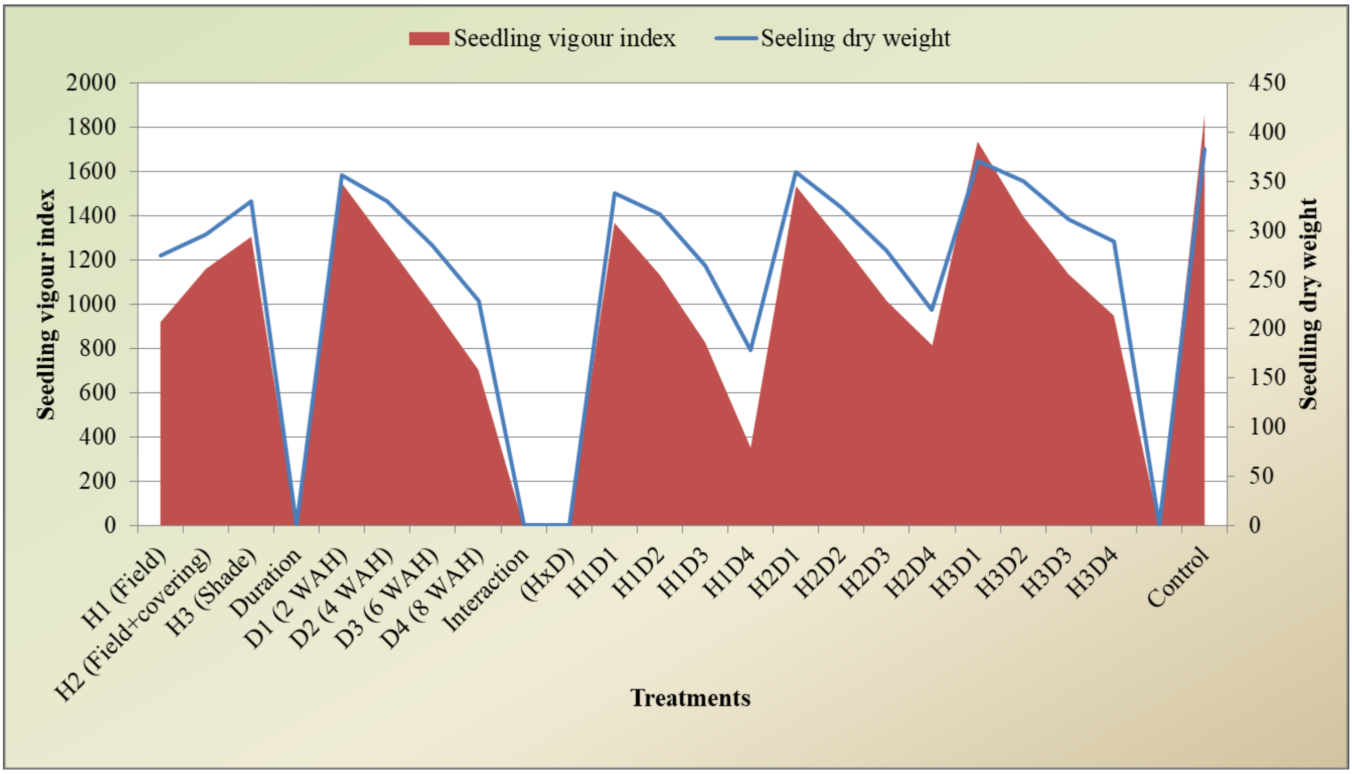

Fig 3: Influence of different heaping methods and duration on seedling dry weight and seedling vigour index in soybean

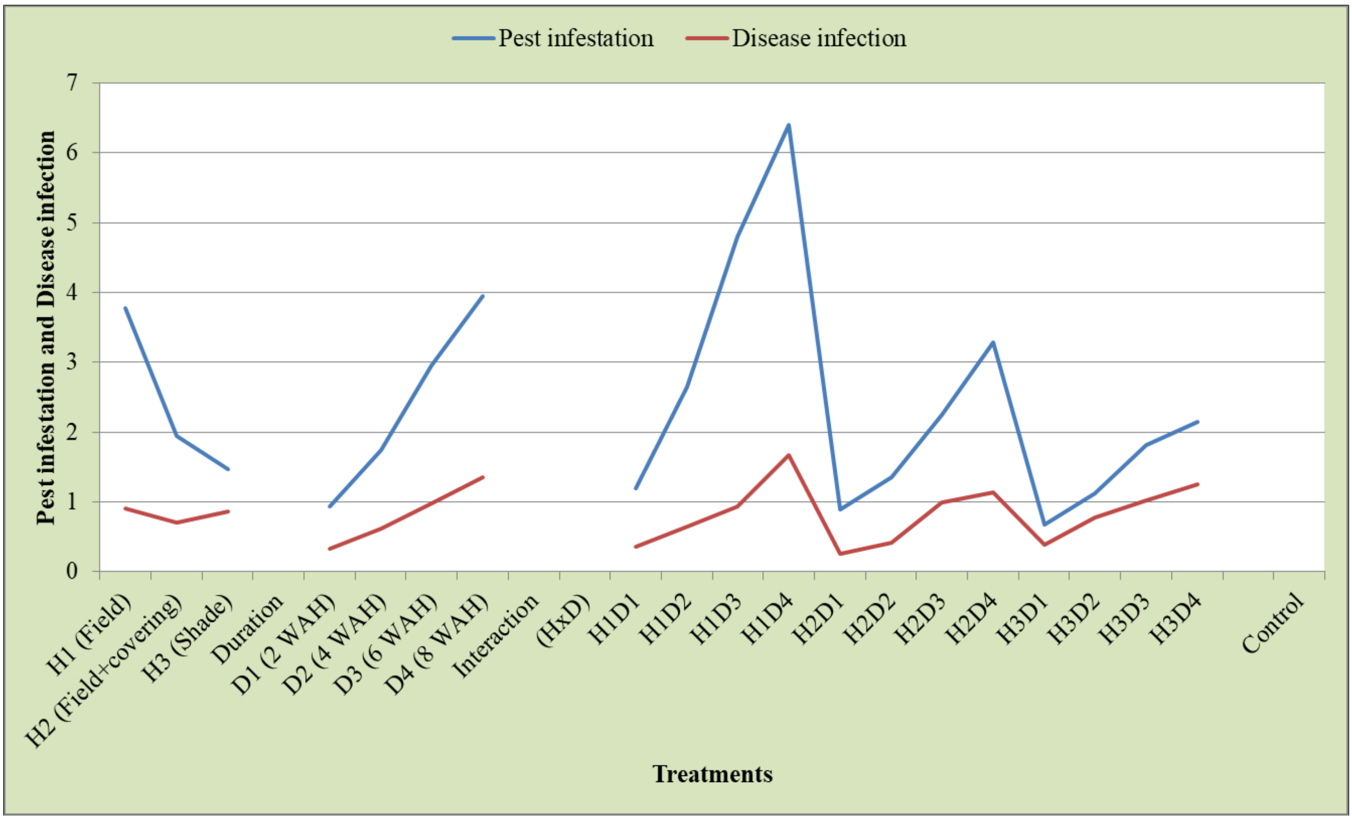

Fig 4: Influence of different heaping methods and duration on pest infestation and disease infection in soybean

Conclusion

Post-harvest operation like heaping and seed storage is important step which decide the quality of the seed produced. From the results of the experiment, seeds threshed on the same day of harvest showcased better seed quality parameters with least pest infestation and disease infection compared to other heaping methods and seed storage. It might be due to immediately threshing the seeds after harvest didn't allowed the seeds to experience the varied weather conditions in field and which helped in maintaining the structural integrity of the seed and maintained quality of the seed when compared to other treatments which exposed the seeds to varying weather conditions in field and as storage duration advances the quality of seed reduced as seeds are infected with field pests and there are more chances of occurrence of seed diseases as storage pronounces.

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