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RESEARCH ARTICLE

EFFECT OF HEAT TREATMENT, PACKAGING MATERIAL AND STORAGE DURATION ON DORMANCY OF SESAME SEEDS (SESAMUM INDICUM L.) UNDER AMBIENT CONDITION.

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Abstract

Breaking seed dormancy helps to increase uniformity in germination and shorten the time required for seeds to germinate. The effect of dry-heat treatment on seed germination depended on dry-heat intensity and duration of exposure. The germination and germination index of sesame seeds without temperature treatment was the lowest value and followed by 60˚C heat treatment, and the highest germination was obtained from 50˚C treatment. The difference was also observed in packaging materials showing the higher germination percentage, earlier germination and more vigorous seedlings was obtained in woven polypropylene bag under temperature treated and untreated conditions. Moreover, the combination effect of temperature treatments, packaging materials and storage durations on germination percentage, germination index, seedling vigour index I and II were significant. Therefore, the heat treatment and type of packaging material during storage plays a vital role in the dormancy release of sesame. Among the heat treatments, 60˚C for 10 minute and 50˚C for 20 minute showed the better results than control (untreated). And 50˚C treatment had higher percentage germination, earlier germination and more vigorous seedlings than 60˚C treatment.

Introduction:-

Dormancy is presented as a physiological state in which germination is blocked by a seed-related mechanism, as opposed to lack of germination due to inadequate environmental conditions. This state can be induced by environmental and/or maternal effects during seed development or after dispersal, and can consist of many different mechanisms, which arrest continued development at any one of the steps necessary for seed germination (imbibition, activation of metabolism, visible growth) (Wareing, 1969).

Breaking seed dormancy helps to increase uniformity in germination and shorten the time required for seeds to germinate. Just as there are different types of dormancies, there are different methods to overcome it (Marchetti, 2012). Physical dormancy may be easily overcome by making the seed coat permeable by use of heat (Waheed et al., 2012). Temperature and relative humidity are important storage conditions that affect the rate of seed dormancy loss as well as seed viability loss in a number of species (Steadman et al., 2003). Temperature is a well-known environmental factor that affects the rate of dry after-ripening (Iglesias-Fernandez et al., 2011).

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Seed dormancy was found in the Mexican sesame cultivar Cola de Borrego but it disappeared about 6-month after harvest. Dormancy was completely broken by soaking the seeds in GA3 solutions of 100 and 500 ppm for 48 h; soaking in 1000 ppm GA_3 concentration was helpful but not as good as the 100 and 500 ppm treatments (Ashri and Palevitch, 1979). Pallavi et al. (2010) utilized temperature treatments to break dormancy of sunflower seeds. Temperature treatments of 60 ˚C for 15 minutes significantly increased germination over control by desiccating waxes, weakening the impermeable layer, and allowing water to be absorbed. Therefore, the objective of the study was to evaluate the effect of heat treatments, different packaging materials and storage duration on viability and dormancy in sesame seeds under ambient storage.

Materials and Methods:-

Experimental site and treatments

This study was conducted in the Laboratory of Department of Agronomy, Yezin Agricultural University, Myanmar from August 2016 to September 2017. The tested sesame seeds were used from the storage experiment under ambient condition. The samples were taken out in two-month intervals, then heat treatments were carried out and tested viability of seeds. The seed lots were treated by different temperatures, at 60 ˚C for 10 minutes and at 50 ˚C for 20 minutes, in an oven to determine the seed dormancy release. Three factors factorial design was laid out with randomized complete block design.

Factor (A) - Heat treatment

T1 – No treatment, T2 – 60 ˚C for 10 min, T3 – 50 ˚C for 20 min

Factor (B) – Packaging materials

P1 – Woven polypropylene bag, P2 – Superbag, P3 – Metal bin

Factor (C) – Storage durations

D1 – Initial storage, D2 – 2-month, D3 – 4-month, D4 – 6-month, D5 – 8-month

Data collection and statistical analysis

(i) Germination percentage

The germination test was performed using the top paper method. Four replications of one hundred seeds per treatment were randomly distributed on the wet filter paper in 9 cm diameter of petri dishes and placed into an incubator set with a constant temperature of 25°C throughout the testing period. The germinated seeds (2 mm radicle elongation) were counted daily up to the tenth day to calculate germination rate (ISTA, 2004).

$$\text{Germination (\%)} = \frac{\text{Number of seeds germinated}}{\text{Number of seeds tested}} \times 100$$

(ii) Germination index

The germination index (G.I) was computed by using the following formula:

$$\text{G.I.} = \frac{N_1}{D_1} + \frac{N_2}{D_2} + \text{---} + \frac{N_n}{D_n}$$

where,

N1, N2, …, Nn = Number of seedlings on day 1st, 2nd and nth day after sowing

D1, D2, …, Dn = Number of days after sowing

(iii) Seedling vigour index

This was calculated by determining the germination percentage and seedling length of the same seed lot. The seedlings were grown in between rolled towel paper method. Fifty seeds each in four replications were germinated in the moist towel papers in such a way that the micropyles were oriented towards bottom to avoid root twisting. The rolled towel papers were kept in the incubator maintained at a temperature of 25°C. After 10 days, towel papers were removed and five normal seedlings were randomly selected, their length was measured and mean seedling length was calculated. For dry weight determination, the seedlings were removed and dried in an oven at 100°C temperature for 24 hours, then cooled and weighed. Seed vigour index was calculated by multiplying germination percentage and seedling length (mm) or seedling dry weight (g). The seed lot showing the higher seed vigour index was considered to be more vigorous (Adbdul-Baki and Anderson 1973).

Vigour index -I: Germination (%) × total dry weight of seedling (g)

Vigour index -II: Germination (%) × Seedling length (mm)

All data were analyzed by using Statistix (version 8.0) and comparison of treatment means was done by using LSD test at 5 % level of significance.

Results and Discussion:-

(i) Germination percentage

Analysis of variances showed the significant differences among the temperature treatments (Pr<0.0001) (Table 1). The germination of sesame seeds without temperature treatment (40.417%) was the lowest value and followed by 60˚C heat treatment with 73.3%, and the highest germination was obtained from 50˚C treatment with 79.467%. Therefore, the heat treatment can break seed dormancy of sesame, and heat treatment 50˚C for 20 minutes was more effective than 60˚C for 10 minutes. The effect of dry-heat treatment on seed germination depended on dry-heat intensity and duration of exposure. Nayyar et al. (2016) recorded that sesame seeds were subjected to various treatments, including, thermotherapy (by incubation at 50ºC, 60ºC and 70ºC), which increased germination (28%) at 60ºC but caused harmful effect on seeds at 70ºC. Although chemical treatments improved seedling germination but dry heat inhibited germination in rice varieties (Mutinda et al., 2017).

The effect of packaging materials during storage was significantly different on the dormancy release of sesame seeds (Pr<0.0001). The woven polypropylene bag showed significantly higher dormancy loss with 71.144% of germination. The superbag and metal bin showed the same effect on dormancy loss by 60.772% and 61.267% of germination. The effect of storage durations on dormancy loss of sesame seeds was significant, and ANOVA showed the result with Pr<0.0001 (Table 1). The dormancy release increased with the advancement of storage durations, the initial storage showed the minimum dormancy break with 45.333% germination, and it significantly increased in two-month and four-month with 58.63% and 60.102%, respectively. The maximum dormancy loss was occurred in six-month and eight-month storage with 78.435% and 79.472%, respectively. This can be suggested that heat treatments cannot achieve the fully dormancy break at the initial storage.

The interaction effects were observed between temperature treatment and packaging materials, between temperature treatments and storage durations, and between packaging materials and storage durations. The combination effect of temperature, packaging materials and storage durations was also significant (Pr=0.0002) (Table 1). The germination of non heat treated seeds was only 2% before storage, it significantly increased with the time of storage period and the maximum germination was found in eight-month storage in all packaging materials. Among storage containers, woven polypropylene bag showed the statistically higher germination than other containers in each analyzing period except superbag in eight-month storage. Therefore, the highest dormancy was occurred after harvest, and it was released during storage due to after- ripening effect. Dry storage (i.e., dry after-ripening) is a very effective means of breaking tanglehead (Heteropogon contortus) seed dormancy (Baldos et al., 2014). Seeds that have undergone a dry after-ripening period exhibit faster germination rates (Tothill, 1977) and high percent germination (80% to 90%) (Daehler and Goergen, 2005). After-ripening may be defined as a process in which seeds undergo the events from successive reduction of dormancy until the complete loss of it (Bewly and Black, 1994).

The heat treatment with 60˚C effected the dormancy break of sesame, the germination before storage was 56%, and the increased germination was observed in storage seeds. Although maximum germination of seeds in woven polypropylene bag and metal bin was found in two-month storage, it was obtained in four-month for superbag storage. The germination of treated stored seeds was highest in eight-month in every type of container; however, it was different between woven polypropylene bag and metal bin (Figure 1). The heat treatment, 60˚C, did not result fully dormancy loss after harvest, and which resulted in during storage in different containers. Moreover, woven polypropylene bag showed shorter dormancy time. Among the pre-treatment of seed, 50˚C resulted the highest germination in initial storage (78%). In woven polypropylene bag, the germination of treated seeds was not different among storage durations, whereas, that of superbag and metal bin produced decreased value in eight-month storage. The significant difference was found between the germination of non-treated seeds and 50˚C treated seeds in eight-month (Figure 1). It can be said that the deterioration of sesame seeds was observed after treated with 50˚C in superbag. It may be due to longer treatment time, although the temperature is set up at lower level. From the results, 50˚C treatment exhibited the best results for dormancy break of sesame stored under ambient condition except in superbag for eight-month storage. The deterioration rate depends on storage condition that is temperature, relative humidity, seed moisture contents, storage container types, etc. Types of container also regulate temperature, relative humidity, and seed moisture contents. High temperature, relative humidity, and moisture in the storage environment appear to be principle factors involved in deterioration of seed quality.

(ii) Germination index

The differences of germination index was significant among temperature treatments (Pr<0.0001) (Table 1). The lowest germination index (9.658) was observed in non-treated seeds, the statistically higher germination (18.06) was found in 60˚C treatment and highest (19.833) resulted from 50˚C treated seeds. Thus, heat treatment with 50˚C gave the best germination index, which showed the highest ability to break seed dormancy of sesame. The heat treatment for 24 hr at 50°C reduced the time taken to 50% emergence in tomato (Nawaz et al., 2009-10).

The germination index (18.112) of woven polypropylene bag was significantly higher than others containers, 14.662 of superbag and 14.775 of metal bin. The result of ANOVA presented the significant value with Pr<0.0001. There were significant differences among storage durations on the germination index of sesame seeds (Pr<0.0001). The initial germination index (12.987) significantly increased with the storage time increases, 15.618 in two-month, 14.414 in four-month, and reached the maximum in six-month (18.595), then decreased to the lower level (17.636) in eight-month (Table 1).

The interaction effect was occurred between temperature treatment and packaging materials; temperature treatment and storage durations; packaging materials and storage durations. The combination effect of temperature treatment, packaging materials and storage durations was significant (Pr=0.0333). The germination index of non-treated seeds increased significantly and maximum germination index was observed in six-month and eight-month in each packaging material, in which germination index of seeds stored in woven polypropylene bag was higher than other containers. For seeds treated by 60˚C, germination index after harvest was lowest value, however, it rose up to maximum level in two-month storage seeds in all containers which was significantly higher than other storage periods in woven polypropylene bag and metal bin. Regarding germination of this treatment, it increased during storage until eight-month, however, slow germination rate was observed in this treatment during four-month and eight-month storage (Figure 2). In 50˚C heat treatment, the maximum germination index was found in after harvest, it significantly decreased through storage duration. Although high germination was observed during storage, the germination rate was significantly lower during storage.

(iii) Seedling vigour index I

Vigor is defined as those seed properties, which determine the potential for rapid, uniform emergence and development of normal seedlings under a wide range of field conditions (Bewley and Black, 1994). The effect of heat treatment prior to germination was significantly different on the seedling vigour index I of sesame seeds (Pr<0.0001) (Table 1). The maximum seedling vigour index I (0.135) was obtained in 50˚C treatment followed by (0.128) in 60˚C treatment and (0.067) in non-treated seeds. Dry heat treatments significantly influenced the seedling vigour of the two tomato cultivars tested which is shown by more root and shoot length as well as higher fresh and dry weight of the seedlings (Nawaz et al., 2009-10).

The significant difference was occurred in seedling vigour index I effected by different packaging materials (Pr<0.0001). The seedling vigour index I (0.124) was resulted in woven polypropylene bag, which was significantly higher than (0.105) of superbag and (0.101) of metal bin. The differences of the effect of storage durations on seedling vigour index I of sesame seeds was significant (Pr<0.0001). The seedling vigour index I of seeds increased with the advancement of storage period. The initial seedling vigour index I (0.093) increased to (0.112) in two-month, (0.103) in four-month, (0.115) in six-month and (0.126) in eight-month after storage (Table 1).

The interaction effect between temperature treatment and packaging materials (Pr=0.0476), between temperature treatment and storage durations (Pr<0.0001), and packaging materials and storage durations (Pr=0.0201). The combination effect of temperature treatment, packaging materials and storage durations was also significant (Pr=0.0017) (Table 1). The non-heat treated seeds showed increasing seedling vigour index I in two-month after storage in woven polypropylene bag, however, it was not exhibited until four-month in superbag and metal bin, and produced most vigorous seedling in six-month and eight-month storage except in superbag. In 60˚C temperature treatment, the maximum seedling vigour index I appeared in two-month and four-month after storage, after this period it decreased in all storage containers. In 50˚C temperature treatment, the seedling index I obtained in initial storage and two-month storage in woven polypropylene bag and superbag, and two-month storage in metal bin were higher than that of other treatments except eight-month storage in woven polypropylene bag (Figure 3).

(iv) Seedling vigour index II

The effect of temperature treatment was significantly different on the seedling vigour index II of sesame stored under ambient condition (Pr<0.0001) (Table 1). The maximum seedling vigour index II (709.16) was resulted in 50˚C treatment followed by (592.19) in 60˚C treatment and (289.42) in non-treatment. The mean seedling vigour index II of seeds was significantly different among packaging materials (Pr<0.0001). The seedling vigour index II of seeds in woven polypropylene bag (597.93) was statistically higher than that of superbag (478.94) and metal bin (513.9). The variation in seed vigour may also be due to variations in temperature, moisture content, relative humidity and pathogen activity in the different packaging materials (Raikar et al., 2011).

The mean effect of storage durations on seedling vigour index II was siginificant (Pr<0.0001). The seedling vigour index II increased during storage, the initial seedling vigour index II (424.20) increased in two-month (489.86), four-month (498.39), six-month (596.59) and eight-month (642.24). The similar trend was occurred in germination percentage. The interaction effect between temperature treatments and packaging materials, and between packaging materials and storage durations was not observed. However, the effect between temperature treatments and storage durations exhibited the interaction. The combination effect of temperature treatments, packaging materials and storage durations was significant (Pr=0.4456). The seedling vigour index II of non-temperature treated seeds increased during storage, and reached the maximum level in six-month storage seeds, then decreased in eight-month in woven polypropylene bag. In superbag and metal bin, the seedling vigour index II was stable until four-month after storage, and the differences in seedling vigour index II was not observed between superbag and metal bin.
In 60˚C treatment, although the initial seedling vigour index II increased in two-month and maintained the level until the end of storage in woven polypropylene bag, the seedling vigour index II of seeds in super bag and metal bin was the same in all treatments. In 50˚C treatment, the maximum seedling vigour index II was obtained in eight-month, which was not different from that of initial and four-month storage, and all treatments in superbag and metal bin exhibited the statistically same seedling vigour index II (Figure 4).

Conclusion:-

The findings of the study showed that the heat treatment and the type of packaging material during storage plays a vital role in the dormancy release of sesame. Among the heat treatment used in this study, 60˚C for 10 minute and 50˚C for 20 minute showed the better results than control (untreated). Of the two different heat treatments, 50˚C treatment had higher percentage germination, earlier germination and more vigorous seedlings than 60˚C treatment. The heat treatment completely broke seed dormancy of sesame, showing no significant difference with maximum germination of untreated seeds after storage. However, these two temperature treatments could not be able to release dormancy completely before storage. In general, at least two-month storage time was required to achieve fully dormancy.

This study also showed that storage temperature, packaging materials, and storage duration impacted dormancy loss and viability of sesame seeds. Moreover, the difference was observed in packaging materials showing the higher germination percentage, earlier germination and more vigorous seedlings was obtained in woven polypropylene bag under temperature treated and untreated conditions. Breaking dormancy or successful completion of the germination process is required to achieve uniform and vigorous crops, and dry heat treatment has been successful in breaking dormancy in sesame. And the study showed that heat treating seeds of sesame at 50˚C for 20 minutes will break the dormancy and allow farmers to plant seeds shortly after harvest. Therefore, if farmers and seed distributers want to use the seed before fully dormancy release time, the heat treatment at 50˚C for 20 minutes should be used to achieve high germination.

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Table 1:- Mean effect of temperature treatments, packaging materials and storage durations on the quality of sesame stored under ambient condition

Treatment	Germination (%)	Germination index	Seedling vigour index I	Seedling vigour index II
Temperature (T)				
No treatment	40.417 c	9.658 c	0.067 c	289.420 c
60 ˚C	73.300 b	18.060 b	0.128 b	592.190 b
50 ˚C	79.467 a	19.833 a	0.135 a	709.160 a
$LSD_{0.05}$	1.925	0.665	0.007	36.044
Packaging material (P)				
Woven polypropylene bag	71.144 a	18.112 a	0.124 a	597.930 a
Superbag	60.772 b	14.662 b	0.105 b	478.940 b
Metal bin	61.267 b	14.775 b	0.101 b	513.900 b
$LSD_{0.05}$	1.925	0.665	0.007	36.044
Storage duration (D)				
Initial storage	45.333 c	12.987 e	0.093 d	424.200 c
2-month	58.630 b	15.618 c	0.112 bc	489.860 b
4-month	60.102 b	14.414 d	0.103 c	498.390 b
6-month	78.435 a	18.595 a	0.115 b	596.590 a
8-month	79.472 a	17.636 b	0.126 a	642.240 a
$LSD_{0.05}$	2.486	0.859	0.009	46.533
Pr > F				
T	<0.0001	<0.0001	<0.0001	<0.0001
P	<0.0001	<0.0001	<0.0001	<0.0001
D	<0.0001	<0.0001	<0.0001	<0.0001
T x P	<0.0001	0.0002	0.0476	0.7306
T x D	<0.0001	<0.0001	<0.0001	<0.0001
P x D	<0.0001	<0.0001	0.0201	0.1084
T x P x D	0.0002	0.0333	0.0017	0.4456
CV (%)	7.14	10.02	14.89	16.22

In each column, means having a common letter are not significantly different at 5 % LSD.

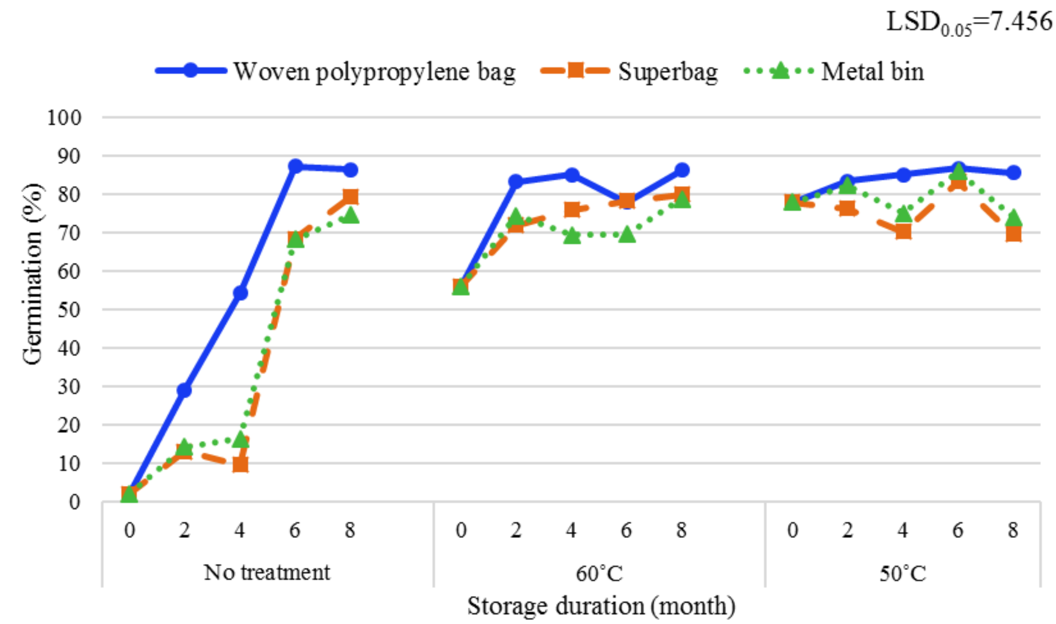

Figure 1: Combination effect of heat treatments, packaging materials and storage durations on germination percentage of sesame stored under ambient condition, 2016-17 cropping season

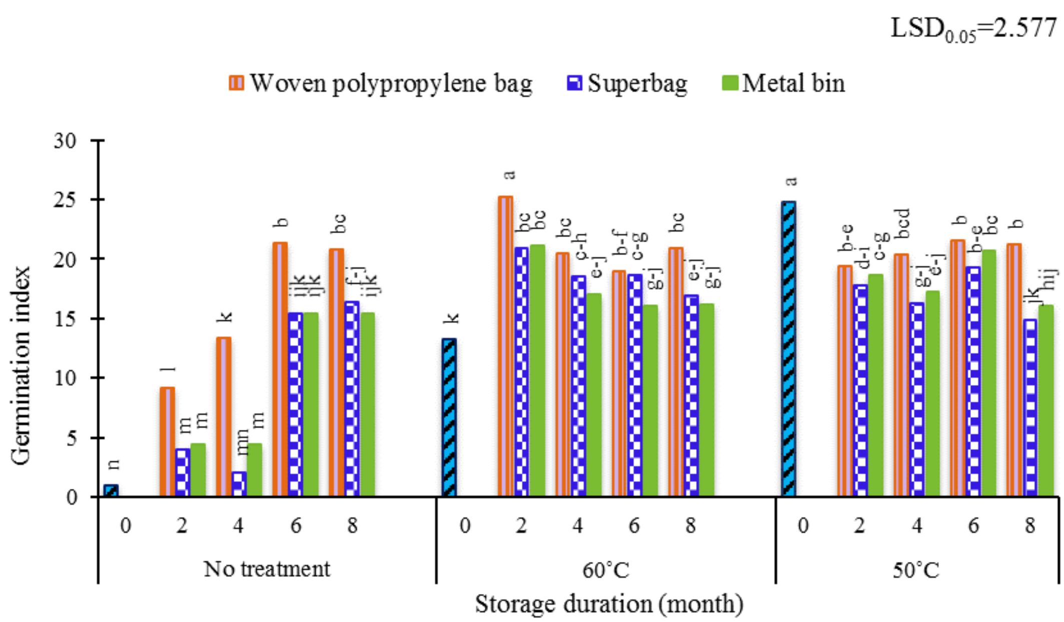

Figure 2: Combination effect of heat treatments, packaging materials and storage durations on germination index of sesame stored under ambient condition, 2016-17 cropping season

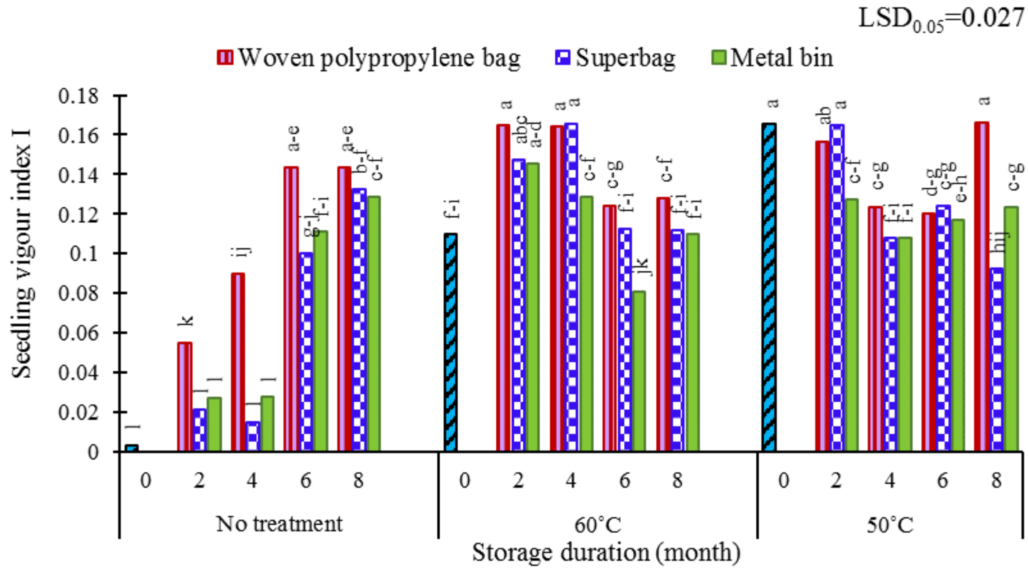

Figure 3: Combination effect of heat treatments, packaging materials and storage durations on seedling vigour index I of sesame stored under ambient condition, 2016-17 cropping season

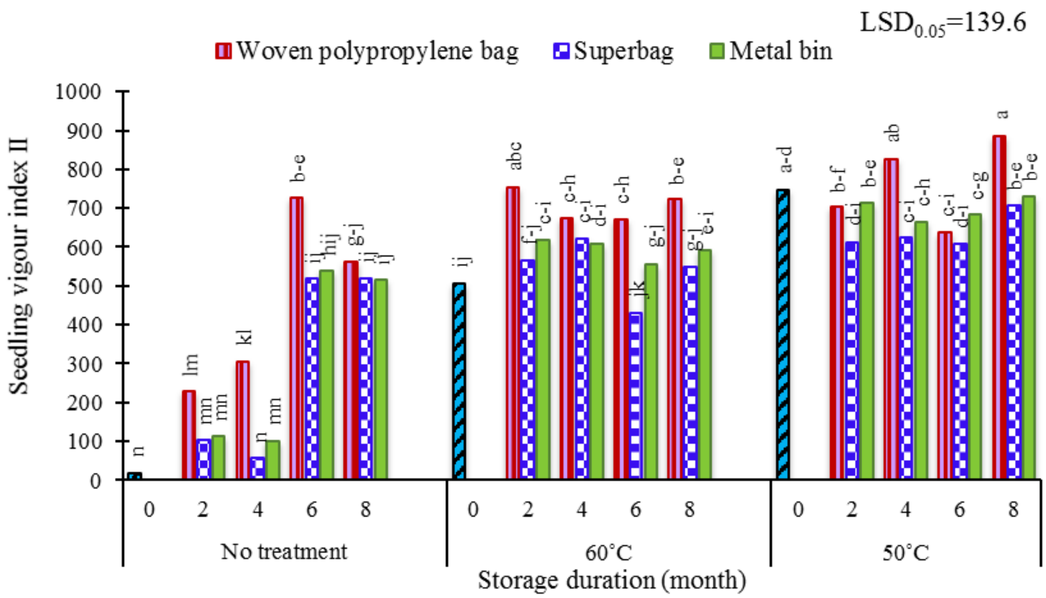

Figure 4: Combination effect of heat treatments, packaging materials and storage durations on seedling vigour index II of sesame stored under ambient condition, 2016-17 cropping season

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