Heat Treatment to Break Seed Dormancy of Pre- and Post-Monsoon Sesame (*Sesamum indicum* L.)

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Abstract

Breaking seed dormancy helps to increase uniformity in germination and shorten the time required for seeds to germinate. To evaluate the effect of heat treatments and different packaging materials on viability and dormancy of different seasonal sesame seeds under field storage conditions, the storage experiments were carried out at two locations, Pwintphyu and Pakokku Townships, and heat treatment experiment was conducted at the laboratory of Department of Agronomy, Yezin Agricultural University from August 2016 to September 2017. The seeds were stored in two packaging materials, woven polypropylene bag and superbag for eight months, and the samples were collected two-month interval and tested for seed quality. In the heat treatment used in this study, 60˚C for 10 minutes and 50˚C for 20 minutes showed the better results than control (untreated). Of the two different heat treatments, 50˚C treatment of pre-monsoon sesame had higher germination percentage, earlier germination and more vigorous seedlings than 60˚C treatment, however, there were not different between two temperature treatments of post-monsoon sesame. The germination, germination index and seedling vigour index of non-treated and both treated pre-monsoon sesame stored in woven polypropylene bag were significantly higher than superbag, however, these qualities were not different between packaging materials of post-monsoon sesame storage. The initial germination of non-treated sesame increased during storage, the maximum germination of post-monsoon was observed in four months after storage, while it was obtained in six-month storage of pre-monsoon seeds.

Key words: dormancy, heat treatment, packaging materials, storage, sesame

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). Seed structure plays a critical role in the dormancy establishment. In typical angiosperm seeds, the embryos are surrounded by two covering layers i.e. the endosperm and testa (seed coat). These components may contribute both in single or combination in the dormant state of the seed (Gong et al. 2005).

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 (Baskin and Baskin 2001; Steadman et al. 2003). Temperature is a well-known environmental factor that affects the rate of dry after-ripening (Iglesias-Fernandez et al. 2011). The application of heat during the dry after-ripening period typically accelerates dormancy loss, whereas dry storage at low temperatures tends to slow down or inhibit dormancy loss (Steadman et al. 2003).

Problems derived from either a short or a persistent dormancy are less frequent in oil crops, though they do exist. Seed dormancy was found in

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the Mexican sesame cultivar Cola de Borrego but it disappeared about 6-month after harvest (Ashri and Palevitch 1979). Dormancy is important, particularly for higher latitudes in Australia where maturing crops may be subjected to autumn showers. Dormancy protects seed from premature sprouting and quality deterioration and is thus essential for commercial reasons. Dormancy which occurs in Hnani 25/160 (Myanmar sesame variety) was used in the breeding program. Dormancy can be broken, by heat treatment with 10 minutes at 60 ˚C or 20 minutes at 50 ˚C. Breaking dormancy is necessary in a breeding program when rapid generation turnover is planned (Beech and Imrie 2001). Therefore, the objective of the study was to evaluate the effect of heat treatments and different packaging materials on viability and dormancy in sesame seeds under different storage conditions.

Materials and Methods

Experimental site

The storage experiments were done in farmers' field conditions in Pwintphyu Township for pre-monsoon sesame and in Pakokku Township for post-monsoon sesame. They are the maximum production areas for pre and post-monsoon sesame. The heat treatment experiment was conducted in the Laboratory of Department of Agronomy, Yezin Agricultural University from August 2016 to September 2017.

Sample preparation and treatments

The tested sesame seeds were used from the storage experiment of pre- and post-monsoon sesame seeds under field condition. The samples were taken out in two-month intervals from their storages, 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

Factor (C) – Storage durations

D1 = Initial storage, D2 = 2-months, D3 = 4-months, D4 = 6-months, D5 = 8-months

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).

(ii) Germination index

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

where,

$N_1, N_2, \ldots, N_n$ = Number of seedlings on day 1st, 2nd and nth day after sowing

$D_1, D_2, \ldots, D_n$ = Number of days after sowing

(iii) Seedling vigour index

The seedlings were grown by 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, and then measured mean seedling length. Seed vigour index was calculated by multiplying germination percentage and seedling length (mm). The seed lot showing the higher seed vigour index was considered to be more vigorous (Adbdul-Baki and Anderson 1973).

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

Germination percentage

The maximum dormancy loss of pre-monsoon sesame was found in 50˚C treatment (80.77%) followed by 60˚C treatment (68.17%) and no temperature treatment (41.65%) (Table 1). The dormancy release of non-treated post-monsoon sesame seeds showed significantly lower germination (74.35%) than heat treated seeds. The seeds treated with 60˚C resulted 81.65% germination, which was not different from 83.13% germination found in 50˚C treatment (Table 1). The seeds subjected to different heat stress showed variation in germination percentage in different durations of treatment. The dorman-

Table 1. Mean effect of temperature treatments, packaging materials and storage durations on the quality of pre- and post-monsoon sesame under field condition, 2016-17 cropping season

Treatment	Pre-monsoon			Post-monsoon		
	Germination (%)	Germination index	Seedling vigour index	Germination (%)	Germination index	Seedling vigour index
Temperature (T)						
No treatment	41.65 c	9.51 c	308.54 c	74.35 b	18.89 b	619.46 c
60 ˚C	68.17 b	15.32 b	573.57 b	81.65 a	19.98 a	804.64 b
50 ˚C	80.77 a	19.08 a	716.01 a	83.13 a	20.36 a	853.04 a
$LSD_{0.05}$	3.98	1.09	45.73	2.95	0.82	40.88
Packaging material (P)						
Woven polypropylene bag	73.10 a	17.15 a	650.48 a	79.74 a	19.84 a	748.99 a
Superbag	53.95 b	12.12 b	414.94 b	79.67 a	19.65 a	769.11 a
$LSD_{0.05}$	3.25	0.89	37.34	2.41	0.67	33.38
Storage duration (D)						
Initial storage	49.69 d	14.20 b	469.18 b	45.06 c	11.57 d	421.38 d
2-month	58.35 c	14.38 ab	482.42 b	84.38 b	21.27 bc	773.06 c
4-month	64.51 b	14.77 ab	524.93 b	93.91 a	22.88 a	867.57 b
6-month	73.59 a	15.64 a	595.46 a	90.13 a	22.19 ab	952.66 a
8-month	71.49 a	14.19 b	591.55 a	85.05 b	20.81 c	780.56 c
$LSD_{0.05}$	5.140	1.40	59.03	3.80	1.06	52.78
Pr > F						
T	<0.0001	<0.0001	<0.0001	<0.0001	0.0017	<0.0001
P	<0.0001	<0.0001	<0.0001	0.9564	0.5738	0.2355
D	<0.0001	0.2120	<0.0001	<0.0001	<0.0001	<0.0001
T x P	0.6413	0.3507	0.0303	0.1536	0.1732	0.1475
T x D	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
P x D	<0.0001	<0.0001	<0.0001	0.0058	0.0015	0.0022
T x P x D	0.1002	0.4081	0.2877	0.1606	0.0451	0.1510
CV (%)	17.37	20.54	23.79	10.24	11.56	14.93

cy loss of pre-monsoon sesame stored in woven polypropylene bag showed significant higher value of germination (73.1%) than that of superbag in which 53.95% of seeds germinated. However, the effect of packaging materials on the dormancy loss of post-monsoon sesame was not different. The germination of seeds in woven polypropylene bag and superbag were 79.74% and 79.67%. The lowest germination of pre-monsoon sesame was occurred in initial storage, and significantly increased during storage and reached maximum germination in six-month storage. The completely dormancy release of post-monsoon sesame was observed in four months after storage. Therefore, the dormancy release increased with storage time increased.

The initial germination of non-temperature treated pre-monsoon sesame increased with storage duration and showed the maximum germination in six-month and eight-month in both woven polypropylene bag and superbag. However, the maximum germination was significantly different between packaging materials (Figure 1). In 60˚C treatment, although the germinations of pre-monsoon seeds in initial storage and two-month storage were the same, it increased in four months and maintained germination until eight months after storage in woven polypropylene bag, however, it decreased during the storage period from four-month to eight-month in superbag. This indicated that the fully dormancy release of seeds was found after four-month storage in woven polypropylene bag under 60˚C treatment, and seed deterioration was observed in superbag after two-month storage. For 50˚C treatment, the fully dormancy release was occurred in initial storage and germination of stored seeds was stable until eight months in woven polypropylene bag. In superbag storage, the germination of stored seeds after heat treatment decreased in four months to eight months, which showed the seed degeneration during storage (Figure 1). Although the seed quality of pre-monsoon sesame could be maintained in woven polypropylene bag, it was declined in superbag for eight-month storage under field condition. The initial germination of non-treated post-monsoon seeds increased during storage and reached the maximum germination in four-month storage and maintained this level until eight months in both storage containers. The maximum germination of post-monsoon sesame was observed in two-month storage with 60˚C treatment, while it was found between two-month and six-month storage with 50˚C treatment (Figure 2). The effect of different temperature treatments was similar on the dormancy release of post-monsoon sesame, and complete dormancy release was resulted in two months after storage in both containers. The 50˚C treatment showed the seed deterioration after treatment in eight-month storage. The different dormancy period was observed in pre-monsoon and post-monsoon sesame storage under field condition. Harvest season within the year also affected the rate of dormancy loss of seeds. Seasonal differences in depth of seed dormancy can be attributed to the growing conditions seeds received during their development and can include day length, light quality, mineral nutrition, soil moisture, temperature, and physiological age of mother plants (Simpson 1990; Baskin and Baskin 2001).

Germination index

The treatment with 50˚C resulted the maximum germination index of pre-monsoon sesame (19.08) followed by 60˚C treatment (15.32) and non-treated seeds (9.51) (Table 1). The higher germination index (17.15) was produced by seeds stored in woven polypropylene bag, whereas germination index (12.12) was found in superbag. The initial germination index of seeds (14.2) increased during storage but not significantly different between two months (14.38), four months (14.77), and six months (15.64). They were the maximum values and different from initial germination index and value of eight -month storage (14.19). Although the highest germination appeared in six and eight-month, the decreased germination rate was achieved in eight-month storage. The germination index of non-treated post-monsoon sesame seeds was 18.89, which was lower than the value of 60˚C treatment (19.98) and 50˚C treatment (20.36) (Table 1). The germination indices produced by post-monsoon sesame stored in both woven polypropylene bag (19.84) and superbag (19.65) were not statistically different. The initial germination index of seeds (11.57) increased during storage in two months (21.27), and four months (22.88), which were maximum germination indices and statistically similar with (22.19) in six months after storage. Then, decreased value was observed in eight-month storage.

The germination index of non-temperature treated pre-monsoon seeds increased with storage durations and maximum value was achieved in six-month and eight-month after storage in both woven polypropylene bag and superbag. In 60˚C heat treatment, the maximum germination indices of pre-monsoon sesame were occurred in four-month, six-month and eight-month storages in woven polypropylene bag, while it was achieved in two-month storage of superbag, and significantly decreased in the later period of storage. It indicated that seeds deterioration after heat treatment caused the slow germination rate. In 50˚C treatment, the highest germination index resulted in initial storage, then decreased during storage in both containers. Although the germination index of stored seeds was not different in woven polypropylene bag, it was significantly decreased in superbag (Figure 3). In present study, pre-treatment with 50˚C gave the maximum germination index of pre-monsoon in initial storage among all treatments. The germination index of non-treated post-monsoon sesame seeds increased during storage and the maximum values were obtained during four months and eight months regardless of packaging materials. In 60˚C treatment, the germination index of seeds increased to maximum level and was stable throughout the storage period except six-month storage in superbag. In 50˚C treatment, the maximum germination index was found from two-month to six-month storages, then decreased significantly in eight-month storage (Figure 4).

Seedling vigour index

The minimum seedling vigour index (308.54) was found in non-temperature treatment, whereas (573.57) and (716.01) were resulted in 60˚C treatment and 50˚C treatment (Table 1). The seedling

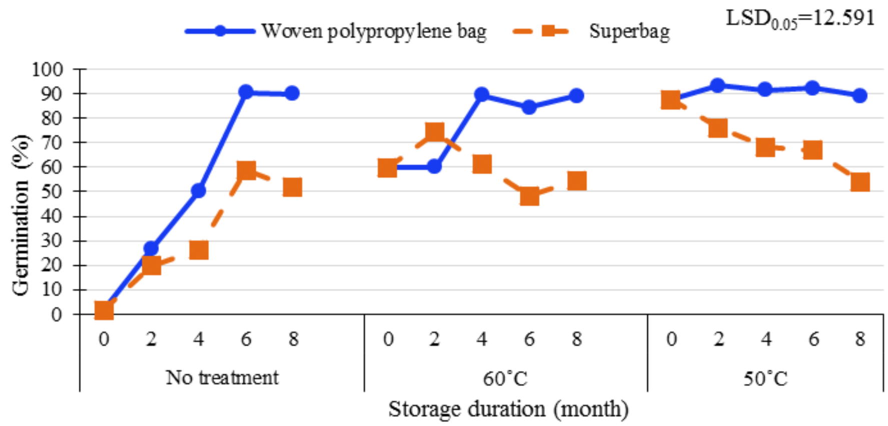

Figure 1: Combination effect of heat treatments, packaging materials and storage durations on germination percentage of pre-monsoon sesame under farm storage, 2016-17 cropping season

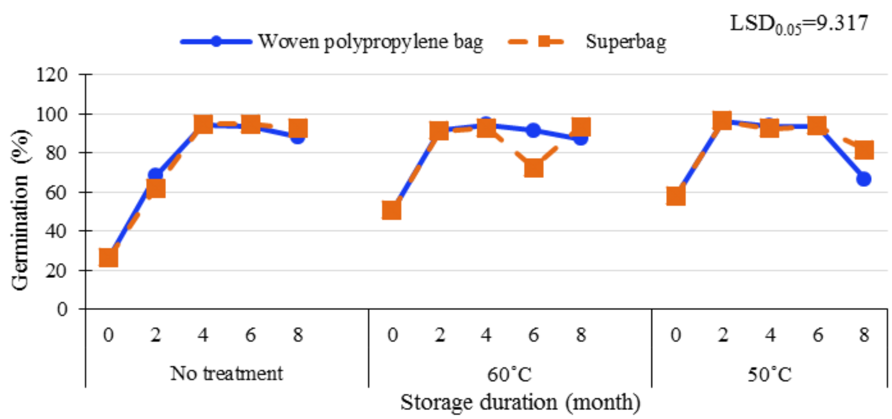

Figure 2: Combination effect of heat treatments, packaging materials and storage durations on germination percentage of post-monsoon sesame under farm storage, 2016-17 cropping season

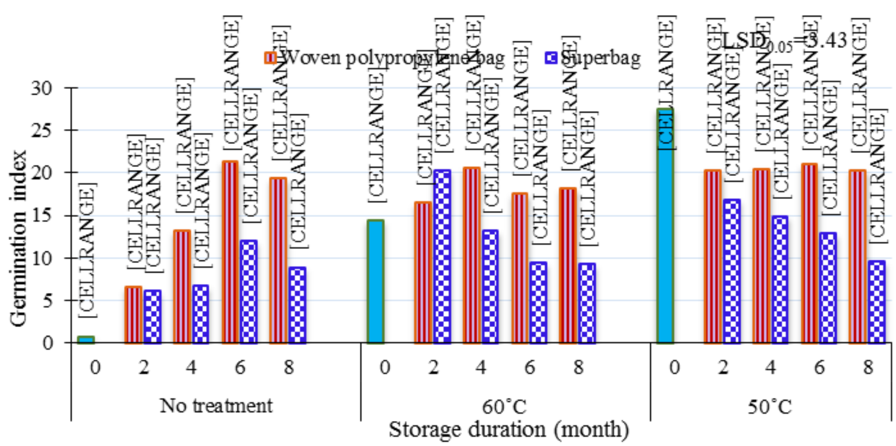

Figure 3: Combination effect of heat treatments, packaging materials and storage durations on germination index of pre-monsoon sesame under farm storage, 2016-17 cropping season

vigour index of pre-monsoon sesame (650.48) appeared in woven polypropylene bag, which was significantly higher than the index found in superbag (414.91). The seedling vigour index of pre-monsoon sesame was stable until four-month storage, and increased in six-month (595.46) and eight-month (591.55) storages.

The seedling vigour index of non-treated post-monsoon seeds exhibited the lowest value (619.46), and statistically higher seedling vigour index were obtained in 60˚C treatment (804.64) and in 50˚C treatment (853.04) (Table 1). Although the germination percentage of seeds was not different between 60˚C and 50˚C treatments, the seedling vigour index was different between them. Therefore, it can be said that the seedling length of seeds treated by 50˚C was longer than that of 60˚C treatment. The seedling vigour index of seeds stored in woven polypropylene bag (748.99) was not statistically different from that of superbag (769.11). The seedling vigour index of post-monsoon sesame at initial stage (421.38) significantly increased with storage duration, 773.06 in two months, 867.57 in four months, and maximum value in six months (952.66), then decreased to 780.56 in eight months after storage.

The seedling vigour index of non-temperature treated pre-monsoon sesame was the highest value in six-month storage in both packaging materials. In 60˚C treatment, the maximum seedling vigour index was found between four-month and eight-month storages in woven polypropylene bag, however, the opposite trend was observed in superbag, in which the seedling vigour index decreased in six-month and eight-month storages. The same result was occurred in the same package material of 50˚C treatment. The seed deterioration may exist in the superbag storage. The 50˚C treatment of the seeds stored in woven polypropylene bag showed the best result by indicating the stable maximum seedling vigour index throughout the storage period (Figure 5). The seedling vigour index of non-heat treated post-monsoon seeds increased during storage and showed maximum value in six months after storage, and decreased in eight-month storage in both containers. In 60˚C treatment, seeds stored in woven polypropylene bag produced the highest value of seedling vigour index in four-month and six-month storages, however, it was observed in four-month and eight-month storages in superbag. In 50˚C treatment, the maximum seedling vigour indices were found in two-month, four-month and six-month storages in both storage containers (Figure 6). The seedling vigour index decreased at eight-month storage in all treatments except in eight months of superbag.

Conclusion

The heat treatment experiment showed that 60˚C for 10 minute and 50˚C for 20 minute gave the better results than control (untreated). Among the two different heat treatments, 50˚C treatment had higher percentage germination, earlier germination and more vigorous seedlings than 60˚C treatment under field condition storage of pre-monsoon sesame. The heat treatment completely broke seed dormancy of stored sesame, however, these two temperature treatments could not be able to release dormancy completely before storage in post-monsoon sesame. At least two-month storage period was required to achieve fully breaking dormancy. Moreover, differences in the degree of dormancy could also be detected. The maximum germination of post -monsoon sesame was observed in four months after storage, while it was obtained in six-month storage of pre-monsoon sesame. Thus, harvest season (i.e., harvest month) within the year also affected the rate of dormancy loss of seeds. The higher germination percentage, earlier germination and more vigorous seedlings were obtained in the storage of woven polypropylene bag under both temperature treated and untreated conditions for pre and post-monsoon sesame. 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. Therefore, the study showed that heat treated seeds of sesame at 50˚C for 20 minutes break the dormancy and allow farmers to plant seeds shortly after harvest.

Acknowledgement

This research was financially supported by YAU-JICA Technical Cooperation Project.

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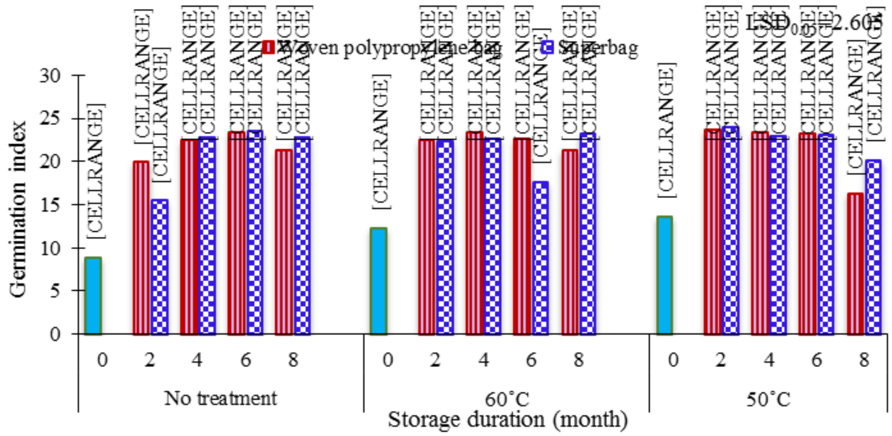

Figure 4: Combination effect of heat treatments, packaging materials and storage durations on germination index of post-monsoon sesame under farm storage, 2016-17 cropping season

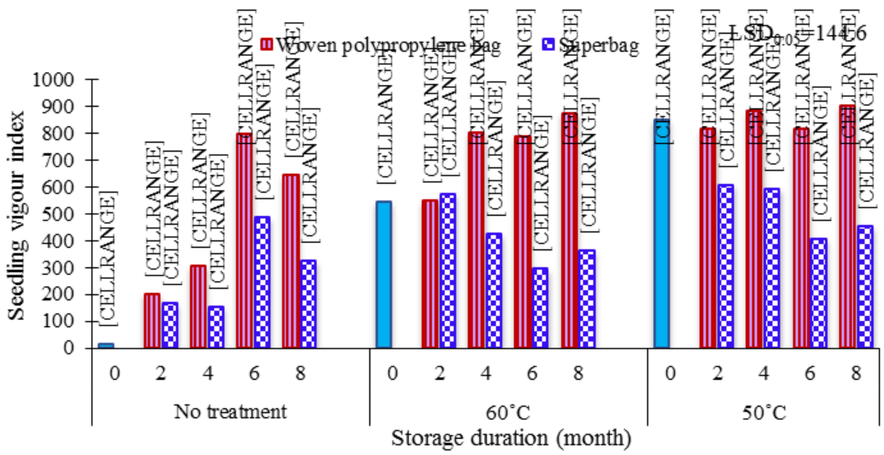

Figure 5: Combination effect of heat treatments, packaging materials and storage durations on seedling vigour index of pre-monsoon sesame under farm storage, 2016-17 cropping season

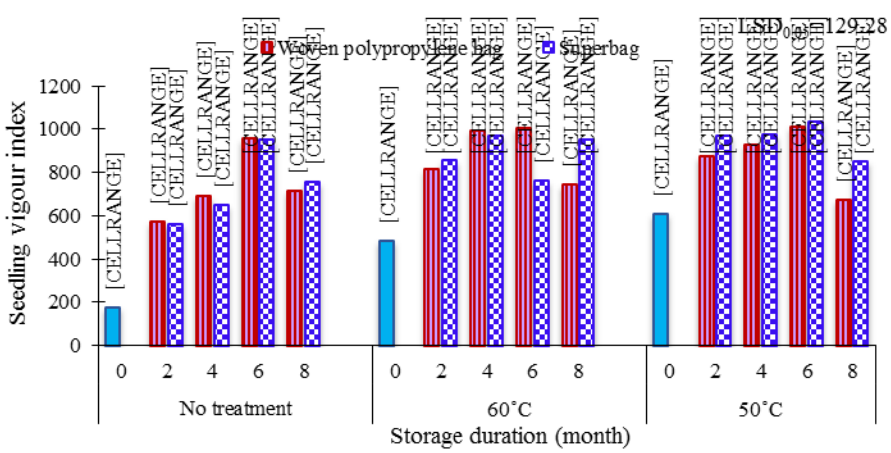

Figure 6: Combination effect of heat treatments, packaging materials and storage durations on seedling vigour index of post-monsoon sesame under farm storage, 2016-17 cropping season

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