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ORIGINAL ARTICLE

The Effects of Storage on Germination Characteristics and Enzyme Activity of Sorghum Seeds

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Seed moisture content (MC) and storage temperature are the most important factors affecting seed longevity and vigor. Exposure to warm, moist air is principally responsible for this. Proper storage and optimum seed moisture content can affect the grain quality significantly. The purpose of this study was to evaluate the different storage treatments on seed quality of sorghum. The seed materials were fresh without any storage period. For storage treatments, 3 seed moisture contents (6, 10, 14 %) were stored for 8 month in 0.5 L capacity sealed aluminum foil packet in 0.3 bar inside incubators set at 4 temperatures (5, 15, 25, 35°C). After storage time, the higher the storage temperature, the lower was the grain quality of sorghum. The highest germination percentage, germination index, normal seedling percentage were achieved in control conditions (0 day of storage). Our results showed that increasing storage duration resulted higher reduction in germination characteristics. Also our results showed that, germination percentage, means time to germination, germination index, normal seedling percentage decrease significantly by storage. Enzyme activity decrease significantly by increased in storage.

Key words: Storage, Germination characteristics, Sorghum, enzyme activity.

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Seed characteristics decrease under long storage condition due to aging. Changes that occur in seed during aging are significant in terms of seed quality, the feature that, among other things, also implies seed longevity (McDonald, 1999). Progress of the technology and industrialization of agricultural production has increased opportunities for long term storage of seed. Aging conditions generally reduce seed vigor (McDonald, 1999). The purpose of proper storage is to inhibit biological processes to the highest possible extent and to eliminate unfavorable environmental factors, which limit duration of the safe storage. The biochemical processes occurring in grain are directly influenced by moisture content, air temperature, contact with air and condition of grain (degree of damage) (Siadat *et al*., 2012; Ghasemnezhad and Honermeier, 2007). Seed deterioration can be defined as the loss of quality, viability and vigour either due to aging or effect of adverse environmental factors. The rate of deterioration rapidly increases in either seed moisture content or

temperature of storage (Kapoor *et al*., 2010). Decrease in seed vigour is due to decrease in seed quality, percentage, rate of germination and yield and also can increase susceptibility to environmental stress (Tekrony *et al*., 1989). Rising of temperature, humidity and oxygen pressure could cause structural damages on DNA and ribosomal RNA, increasing enzyme activity, respiration and membrane permeability (Mc Donald, 1999). The purpose of storage is to maintain harvest quality of product, not to improve it (Sisman and Delibas, 2004). The rate at which the seed aging process takes place depends on the ability of seed to resist degradation changes by protection mechanisms which are specific for each plant species. Loss of viability in crops is also attributed to non-congenial storage environmental factors like higher relative humidity and temperature during storage. In this context storage of seeds has been considered as most important as "seed saved is seed produced". Sorghum bicolor is the fourth most important world cereal grain, following wheat, rice, and corn. Seed quality (viability and vigor) can have a profound influence on the establishment and the yield of a crop. Parera and Cantliffe (1994) reported that rapid and uniform field emergence is an essential prerequisite to reach the yield potential, quality and ultimately profit in annual crops. Therefore, the objectives of this study were to determine how different seed storage methods and storage times affected the germination characteristics of sorghum seeds.

MATERIALS AND METHODS

Moisture content (%)

The moisture content of the seed was calculated as per the International Seed Testing Association (ISTA) Rules (ISTA, 2010) by hot air oven method maintaining 130°C ± 2°C for 2 hr. The moisture content was calculated on wet basis and expressed in percentage by using the following formula:

$$(M\,2 - M\,3)/(M\,2 - M\,1) \times 100$$

Where,

M 1 = Weight of empty moisture tin (g)

M 2 = Weight of moisture tin and seed material before drying (g)

M 3 = Weight of moisture tin and seed material after drying (g)

Storage conditions

Seeds with 3 moisture contents (6, 10 and 14%) were exposed to 4 temperatures (5, 15, 25 and 35 °C) for six months. Seeds were taken every month was measured.

Standard germination test was carried out at 25°C for 10 days in three replications of 50 seeds. Seeds were germinated on two layers of filter papers (Whatman no. 1) moistened with 5 ml distilled water in petri-dishes. The germinated seeds (2 mm radicle elongation) were counted daily to calculate germination rate. At the end of the germination period, total and germination percentage, normal seedling percentage, germination index and mean time to germination were recorded.

RESULTS AND DISCUSSION

The results indicated that duration of storage (A), temperature (B), moisture contents (C), A×B, A×C, B×C and A×B×C interaction were significant ($P < 0.01, 0.05$) for all traits in seeds under storage (Tab 1). Our results showed that the highest germination percentage (Fig 1), normal seedling percentage (Fig 2), germination index (Fig 3) and the minimum, mean time to germination (Fig 4) were achieved under control conditions (0 day of storage). Therefor the minimum this traits were

attained under 180 days of aging. Seed germination, normal seedling percentage, germination index reduced with increase in seed moisture content and storage temperature (Fig 1, 2 and 3), but mean time to germination increases by increase in seed moisture content and storage temperature (fig 4). The highest germination characteristics in sorghum seed was attained at 6% seed moisture contents at 5, 15 and 25 but reduced at 35 °C (Fig 1, 2, 3 and 4). Germination percentage of seeds with 6% moisture content stored at 5 °C after 180 days was 72%, while the germination percentage of seeds with 6% moisture content stored at 35 °C after 180 days was 44% and Germination percentage of seeds with 14% moisture content stored at 5 °C after 180 days was 60% (Fig 1 a), while the germination percentage of seeds with 14% moisture content stored at 35 °C after 180 days was 28% (Fig 1 c). The results of our study suggested that increases in storage caused a decreased in germination characteristics (Fig 1).

Increasing seed age decreased germination and this result is in accordance with Jan-Mohammadi *et al*. (2008) and Ghassemi-Golezani *et al*. (2010) in rapeseed and Saha and Sultana (2008) in soybean. Also, earlier reports (Bailly, 2004; McDonald, 2004) have shown negative effect of aging in relation to seed performance, germination percentage and seedling indices.

According to Ghasemnezhad and Honermeir (2007), the storage life of sunflower seed can be reduced by long storage and high storage temperature.

Akhtar *et al*. (1992) suggested that decreasing in GP was related to chromosomal aberrations that occur under long storage conditions. Decreasing of GP in aged seeds can be due to reduction of α-amylase activity and carbohydrate contents (Bailly, 2004) or denaturation of proteins (Nautiyal *et al*., 1985). According to Abdalla and Roberts, (1968) barley and pea seeds treated with different combinations of accelerated ageing treatment showed that the amount of genetic damage was solely a function of loss of viability.

Also, our results showed that enzyme activity decreased in seeds after aging (Fig. 5 and 6). The results of our study suggested that increases in storage caused a decreased in enzyme activity (Fig. 5 and 6). Most of these studies suggest that decreases occur in the activity of enzymes in aged seeds (Bailly, 2004; Goel *et al*., 2002; McDonald, 2004). Kibinza *et al*. (2011) reported that the CAT is a key enzyme in seed recovery after aging.

Table 1. Analysis of variance temperature, moisture and storage on traits studied of sorghum seeds.

S.O.V	df	Germination percentage	Normal seedling percentage	Germination index	Mean time to germination
Douration of storage (A)	5	6217.33**	12372.29**	428.17**	1.78**
Temperature (B)	3	2981.231**	3798.01**	401.35**	0.35**
Moisture contents (C)	2	1301.79**	1233.01**	83.95**	0.69**
A×B	15	141.51**	168.12**	4.05**	0.51**
A×C	10	51.11**	49.96**	2.51*	0.2**
B×C	6	62.01**	62.94**	9.96**	0.65**
A×B×C	30	13.69*	15.08*	2.15**	0.11**
Error	-	6.99	8.04	1.11	0.06
C.V%	-	4.22	5.03	7.87	5.97

*and ** indicate significant difference at 5% and 1% probability level respectively.

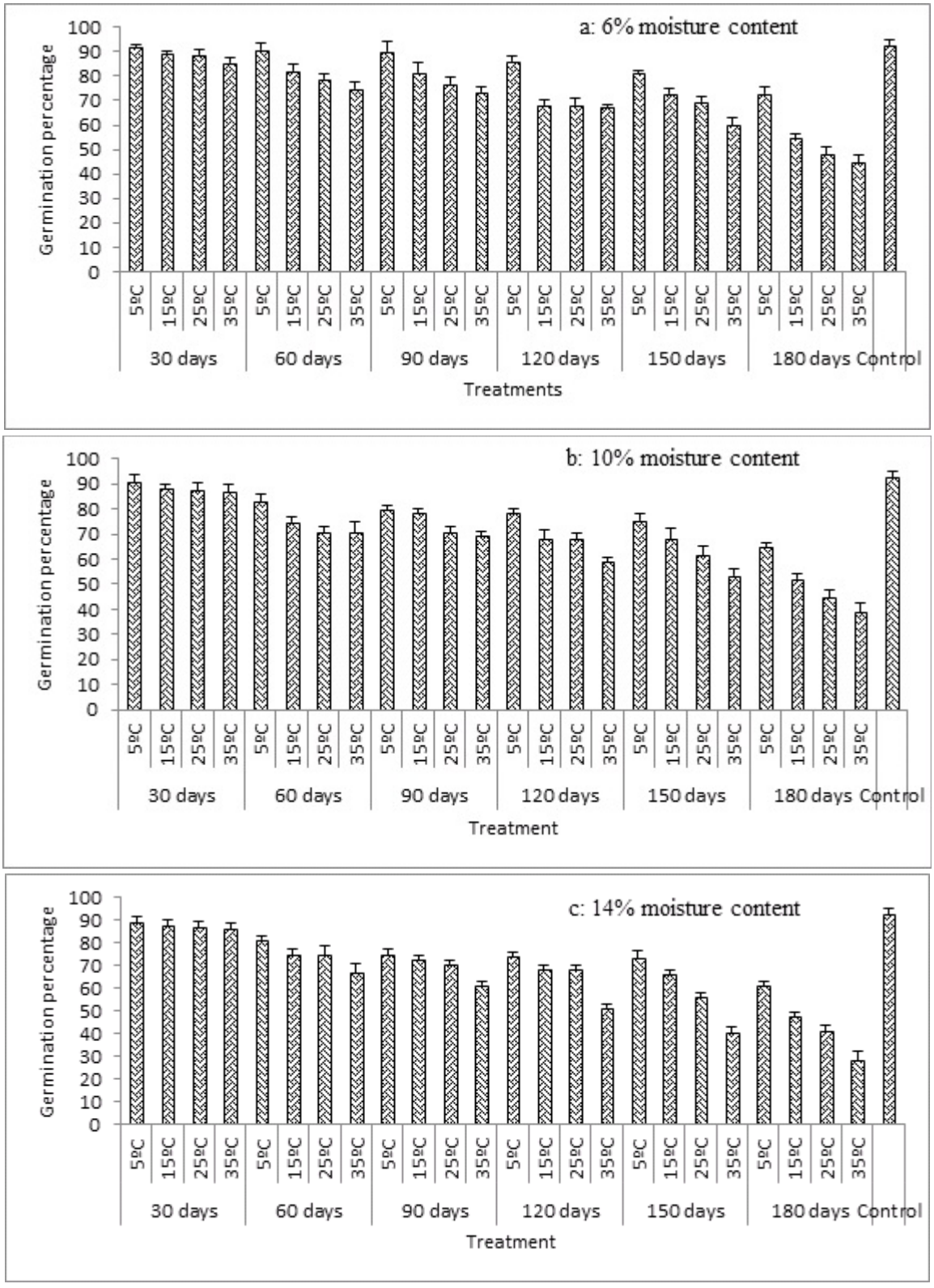

Figure 1. The effect of duration of storage × temperature × moisture contents interaction on germination percentage of sorghum seeds.

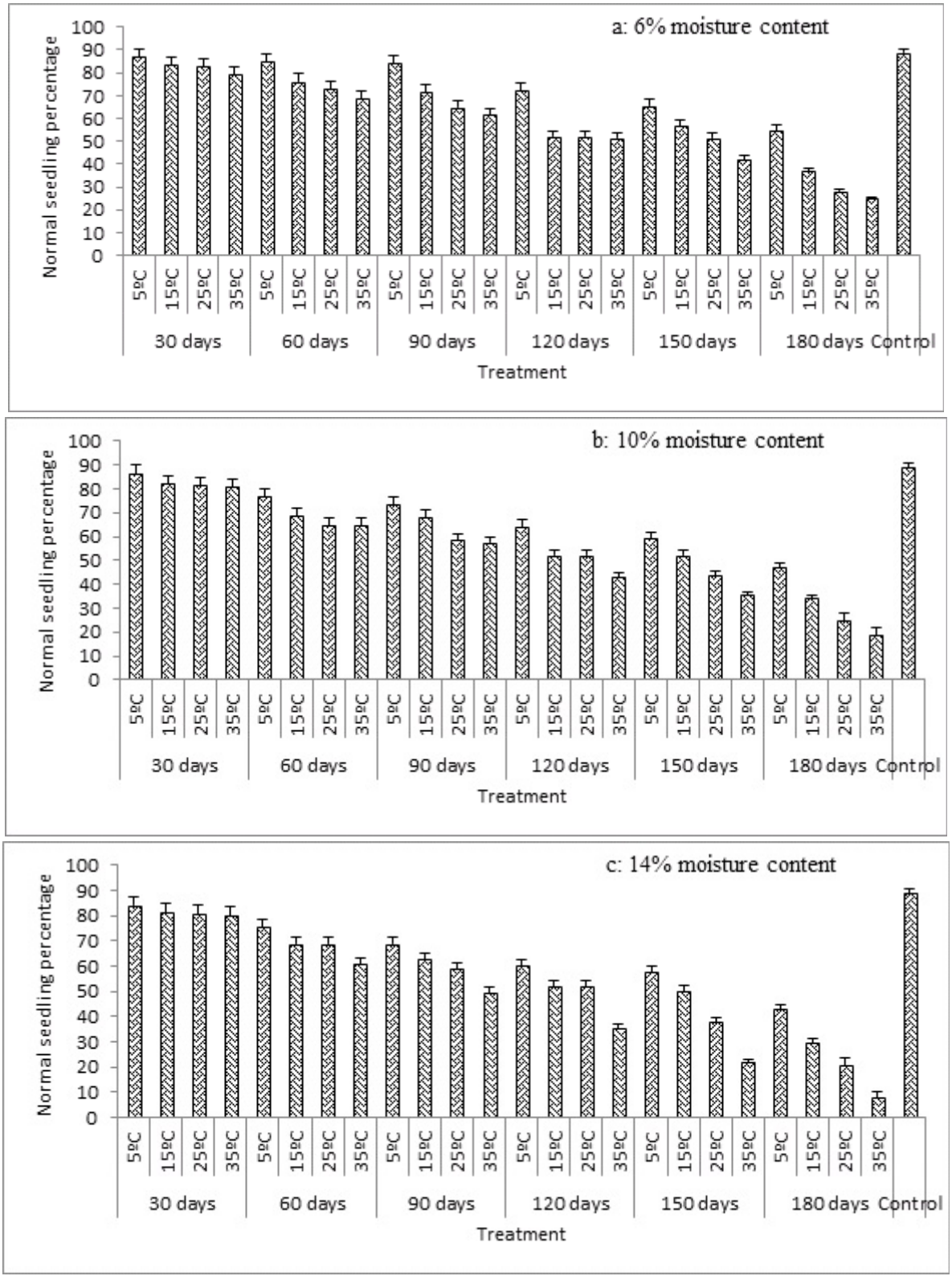

Figure 2. The effect of duration of storage × temperature × moisture contents interaction on normal seedling percentage of sorghum seeds.

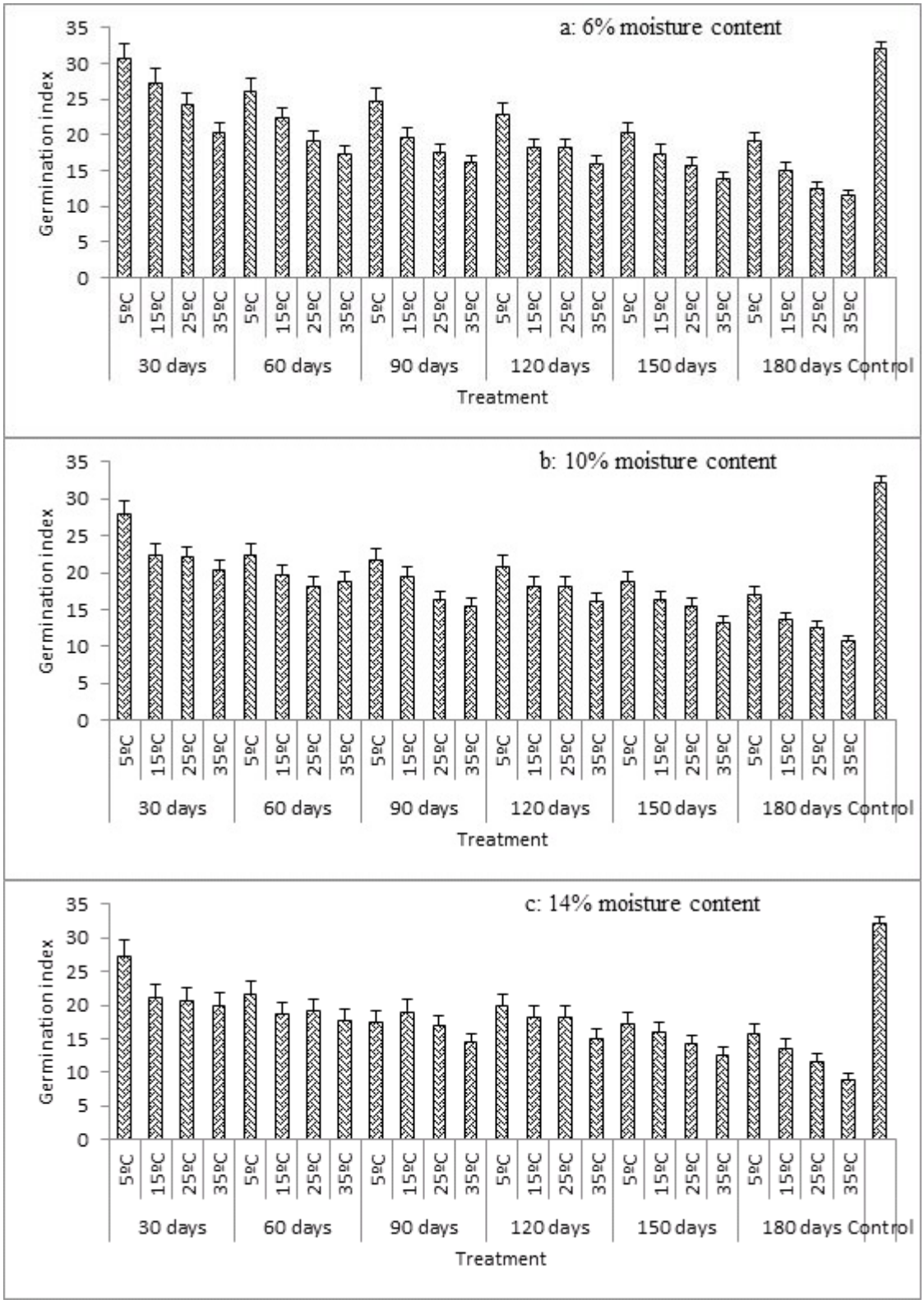

Figure 3. The effect of duration of storage × temperature × moisture contents interaction on germination index of sorghum seeds.

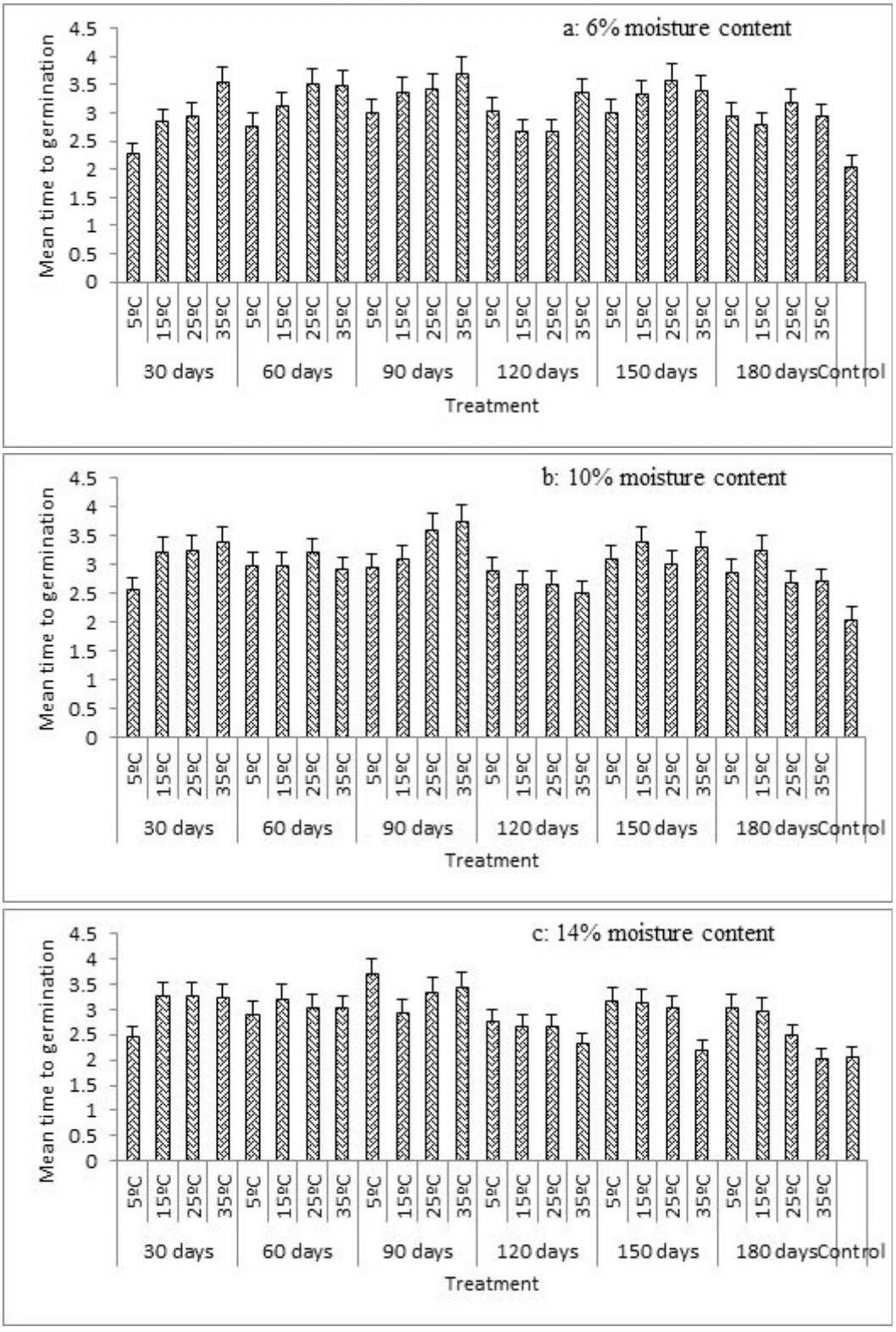

Figure 4. The effect of duration of storage × temperature × moisture contents interaction on normal mean time to germination of sorghum seeds.

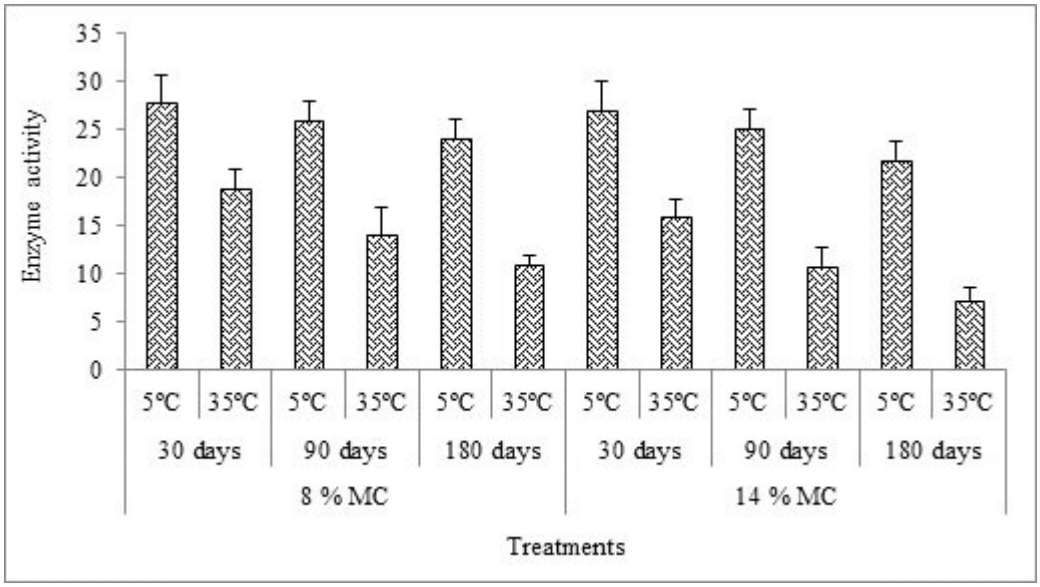

Figure 5. The effect of duration of storage × temperature × moisture contents interaction on catalase activity of sorghum seeds.

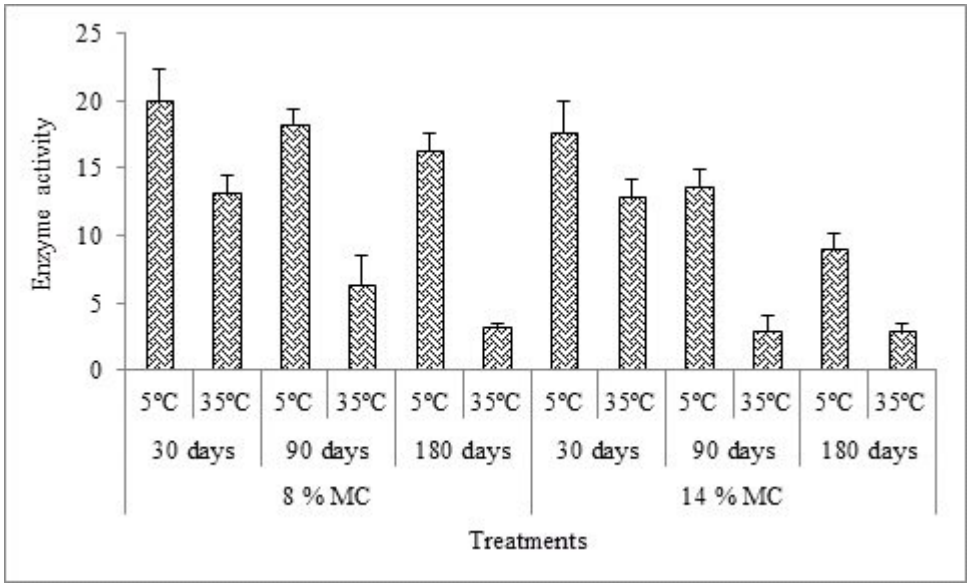

Figure 6. The effect of duration of storage × temperature × moisture contents interaction on ascorbate peroxidase activity of sorghum seeds.

CONCLUSION

The higher the storage temperature, the lower was the grain quality of sorghum. The highest germination percentage, germination index, normal seedling percentage were achieved in control conditions (0 day of storage). Our results showed that increasing storage duration resulted higher reduction in germination characteristics and enzyme activity.

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