Influence of High Dry Heat Temperature on Seed Germination, Seedling Emergence and Seedling Vigour of three Cultivars of *Corchorus olitorious* Seeds

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Abstract

This effect of high dry heat treatment of three accessions of *Corchorus olitorious* seeds on seed germination, seedling emergence and seedling vigour was evaluated in the laboratory and horticultural nursery of the School of Agriculture and Industrial Technology, Babcock University Nigeria. The aim was to determine the most suitable dry heat treatment for early seed germination and seedling emergence of *C. olitorious* seeds. The experiment was a 3 X 5 factorial arrangement using completely randomized design (CRD). The treatments consisted of five temperature regimes (80^{0}C, 90^{0}C, 100^{0}C, 110^{0}C and 120^{0}C) with a control (untreated seeds); and heat exposure time of 5 minutes, where three accessions of *C. olitorious* seeds were subjected to the temperature treatments for the time periods in order to break seed dormancy before sowing. There were significant differences in the viability and vigour responses of the crop seed to the varying heat treatments; where seed germination and seedling emergence were initiated at 80^{0}C, but optimum seed germination, seedling emergence and seedling vigour index were obtained at 120^{0}C for 5 minutes of exposure. There is therefore indication that there may be corresponding increase in seed germination and seedling emergence of *C. olitorious* seed if it is exposed to higher temperature treatment(s) for 5 minutes.

Key words: Seed germination, Seedling emergence, Seedling vigour index, Dry heat.

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Introduction

Corchorus olitorius is one of the commonly cultivated indigenous leaf vegetables (ILV) of Africa. Regarding the origin of the crop, Denton (1993) referred to the work of Kundu (1951, 1956) and Kundu *et al*. (1959) which indicated that Africa had a wide diversity of morphologically variable plant types and hence it is generally believed that the crop originated from the region. The species is widely distributed and consumed for the slimy leaves, stretching from the West through the Central to parts of North Africa (Mnzava, 1997; Grubben, 1977). In Nigeria, the fruits are allowed to dry on the plants before they are harvested and processed for seeds. The fruits of some varieties shatter readily on drying and scattered seeds of the crop are left on farmers' plots after harvesting of the dry fruits. The scattered seeds often germinate and produce seedlings after being subjected to a period of bush burning as the farmers prepare for a new cropping season (Denton *et al.,* 2013). Irrespective of the extent of the exposure to bush fire and dry heat generated, there is always a profuse production of *C. olitorius* seedlings from left over seeds on the farmers' plots after the first rain. The seeds of *C. olitorius* have physical dormancy and the inherent hard seed coat might have been cracked through exposure to fire, making it possible for water absorption and subsequent germination of the seeds (Baskin, 2003). The hard seed coats of some species are cracked and become permeable following the effect of fire as in the case of some *Acacia* tree species (Charles *et al.,* 1968, Walters *et al*., 2004). Hard seed coat imposes physical dormancy on seeds, causing delays in the seed germination (Mohammadi *et al.,* 2012). Removal of restriction on water imbibition by seeds as a result of hard seed coat may be effected through the application of various dormancy breaking treatments, including application of heating under constant temperatures (Wahab, 2011), high and highly fluctuating temperatures (Mckeona and Mott, 1982), chilling (Taylor and Gerrie, acta 1987, Nkomo and Kambizi, 2009); seed scarification (Emongor *et al*., 2004), seed pre-treatment with sulphuric acid (Kak *et al*., 2009) to promote early seed germination. Heat treatment of *C. olitorius* seeds is often recommended for farmers to attain early seed germination and seedling emergence. Palada and Chang (2003) suggested the steeping of the seeds in boiled water for promoting seed germination and seedling emergence. Nwashayenyi (1994), using incubators recorded 30^0C as the optimum temperature for the seed germination of vegetable *C. olitorius*. Unchilled seeds of *C. olitorius* subjected to a temperature treatment of 25^0C did not germinate but pre-chilling followed by temperature of 35^0C treatment produced 88% seed germination (Nkomo and Kambizi, 2009). Constant temperature of 30^0C with light applied for 8hrs per day was suggested for the *Corchorus spp.* seed germination test in gene banks (Verma and Arora, 1978, International Board for Plant Genetic Resources, 1985). In a laboratory experiment by Wahab (2011), optimum seed germination of *C. olitorius* was obtained from seeds that were subjected to a constant dry heat pre-treatment at 90^0C for five minutes while other five dry heat temperature regimes tested (40^0C; 50^0C; 60^0C; 70^0C and 80^0C) produced varying percentage germination. This study was set up to investigate the impact of very high temperature treatments of seeds on the germination, seedling emergence and seedling vigour of three accessions of *C. olitorius*.

Materials and Method

Two experiments were conducted, consisting of seed germination test in the laboratory of the Department of Agronomy and Landscape Design, Babcock University, Ogun State Nigeria and seedling emergence test in the Horticultural Nursery unit of the same Department from November 2011 to March 2012.

Water Floatation Test

Fresh seeds of three accessions of leaf *C. olitorius* from the germplasm collection of the Department of Agronomy and Landscape Design, Babcock University, Nigeria were subjected separately to water floatation test to obtain seeds of good quality for the experiments. One hundred grams (100g) seed of each accession was poured in a 200ml glass beaker which was filled with water in order to separate viable seeds from the non-viable ones, using the principle of specific gravity for separation of good seeds based on seed weight. The viable seeds, often with higher weight, settled at the bottom of the glass beaker while the seeds with lesser weight and other impurities floated on the water. The floated seeds were discarded while the whole and viable seeds of each cultivar at the bottom of the beaker were taken out and spread out to dry under room conditions for two days.

Seed Germination experiment

Viable seeds of each accession were put into separate heat resistant petri dish and subjected to dry heat treatments at five temperature regimes (80^0C, 90^oC, 100^oC, 110^0C and 120^oC) in a digital hot air oven with inbuilt temperature control for a period of five minutes (Wahab, 2011).This served as a source of heat treated seeds from where the seeds for all the experiments were obtained. In case of the seed germination experiment, one hundred (100) heat treated seeds were counted separately for each accession from each temperature regime and put in a sterile petri-dish and replicated three times, making a total of 300seeds per cultivar and temperature regime. All the petri-dishes were lined with Whatman No. 1 -filter papers and were moistened with distilled water. The seed germination test was then conducted under room temperature in the laboratory, using a 3 x5 factorial experimental design with three replications. Records on seed germination were taken every day for a total period of seven days after planting, when most of the seeds had germinated. Only germinated seeds with protruded radicles were counted. At seven days after planting, measurement of seedling length was taken with a ruler, using ten randomly selected seedlings from each replicated petri-dish of each accession. The percentage germination was calculated by dividing the total number of seeds that germinated over the number of seed sown and the product multiplied by hundred. The seedling vigour index was calculated as the product of the seedling length multiplied by the percentage germination (Abdul-Baki and Anderson, 1973).

Seedling emergence experiment

The seedling emergence test was conducted at the Horticultural Nursery Unit of the School of Agriculture and Industrial Technology, Babcock University, Nigeria. The experimental design was a 3x5 factorial and the experiment was setup in a completely randomized design with three replications. The heat treated seed of each accession from each temperature regime were sown separately in single plastic seed trays and replicated three times, making a total of forty-five plastic trays used for the whole experiment. One hundred heat treated seeds of each cultivar were planted in each plastic tray measuring 45x30x5cm. All the trays were filled with sterilized black soil and the seeds were drilled in rows, with a spacing of 2.5cm between rows and about 2.0cm depth of planting. The seeds were mixed with fine river sand, weighing 5.5g before drilling in rows to ensure even distribution of seeds in the three planted rows per tray. The trays were watered lightly every day to ensure adequate water supply for germination and to prevent the seed from drifting away from the planted rows. The number of seedling emergence was recorded on daily basis, starting from the second day after sowing until 14 days after sowing. A seedling is said to have emerged when the cotyledons break through the soil surface and the percentage seedling emergence was calculated by dividing the total number of seedlings that emerged by the number of seed sown and the product was multiplied by hundred. On 14 days after sowing, measurement on seedling length was carried out on ten randomly selected seedlings from each replicated plastic tray for each of the accession and temperature. The seedling vigour index was calculated as the product of seedling length multiplied by percentage seedling emergence.

Statistical Analysis

Analysis of variance (ANOVA) was carried out on seed viability and seedling vigour data including percentage seed germination, percentage seedling emergence, seedling length and seedling vigour index; using factorial based on Completely Randomised Design (CRD). Statistical analysis software (SAS version 9.1; SAS, 1999) was used for the analysis of all the data; and treatment means were separated using Duncan's Multiple Range Tests (DMRT).

Results

Seed germination

The mean squares from ANOVA on the data collected on the seed germination experiment are presented in (Table 1). The result indicated significant differences among the cultivars for percentage seed germination, seedling length and seedling vigour index (Table 1). There were also significant differences among the temperature regimes for all the parameters. The interaction between the accession and temperatures (accession X temperature) was only significant for seedling vigour index. The interaction effect was only significant for the seedling vigour index and not for percentage germination and seedling length (Table 1).

The accession NGSADECO was the most outstanding among the three cultivars with significantly higher mean values than other two cultivars for all the parameters measured

(Table 2). However there was no significant difference between the accessions SOOCT004 and SOOCT003 for all the same set of characters (Table 2).

Table 1: Means square from analysis of variance for percentage seed germination, seedling length and seedling vigour index

Sov	Df	Pegem	Slt	Svi
Acc	2	46.16**	0.05*	2067.07**
Temp	4	173.91**	2.70**	32813.33**
Rep	2	5.42 ns	0.002 ns	62.09ns
AccXtemp	8	2.04 ns	0.007 ns	164.90*
Error	28	1.71	0.004	54.29
Total	44			
Cv(%)		1.54	1.88	2.45

Key: *Significant at 0.05, **Significant at 0.01, ns= Not Significant, Cv-coefficient of variation, Sov – Source of variance; Df- Differential frequency; Pegem- Percentage germination; Slt- Seedling length Svi- Seedling vigorindex;t,Acc-Accession; Temp-Temperature.

Table 2: Means of each accession over five temperatures for percentage seed germination, seedling length and seedling vigour index.

Acc	Pegm	Slt	Svi
Sooct003	84.07[b]	3.48[b]	294.72[b]
Sooct004	83.87[b]	3.48[b]	292.22[b]
Ngsadeco	87.00[a]	3.59[a]	313.69[a]

Key: means with same alphabet along the column are not significantly different from one another. Acc:Accession; Pegm:Percentage germination; Slt:Seedling length; Svi: Seedling Vigour Index

The highest percentage germination was recorded at 120°c while the lowest percentage germination was at 80°c (Table 3). Similarly, the pattern was the same for seedling length and seedling vigour index with the highest values at 120°c for each of the parameters (Table 3).

Accession X Temperature interaction: seed germination response

The accession showed the same pattern of increasing values for seed germination, seedling length and seedling vigour index as the temperature increased. Thus as the temperatures increased, they became more conducive for inducing higher seed germination and better seedling quality (Fig. 1). However, there was significant cultivar X temperature interaction for seedling vigour index only (Table 1), indicating differences among the cultivars in their relative response to temperatures for the seedling vigour index (Fig. 1). There were slight differences between the values for the three cultivars at 80^0 C and 100^0 C but the differences were more apparent at 110^0 C and 120^0 C. This was not the same for other parameters. The accession NGSADECO was the most outstanding in all the temperature regimes and the value for the cultivar was higher than the mean for all the three cultivars in each temperature for percentage germination and seedling vigour index, but the superiority of the accession was not too pronounced for seedling length (Fig. 1).

Table 3: Means of percentage germination, seedling length and seedling vigour index for *Corchorus olitorius* seeds under five temperature regimes.

Temp	Pegem	Sedlt	Svi
80°c	79.56^e	2.71^e	215.77^e
90°c	82.00^d	3.36^d	275.50^d
100°c	84.89^c	3.56^c	302.22^c
110°c	88.00^b	3.75^b	330.32^b
120°c	90.44^a	4.20^a	377.23^a

Key: means with same alphabet along the column are not significantly different from one another. Temp:- Temperature; Pegem- Percentage germination; Sdlt- Seedling length; Svi: Seedling vigour index.

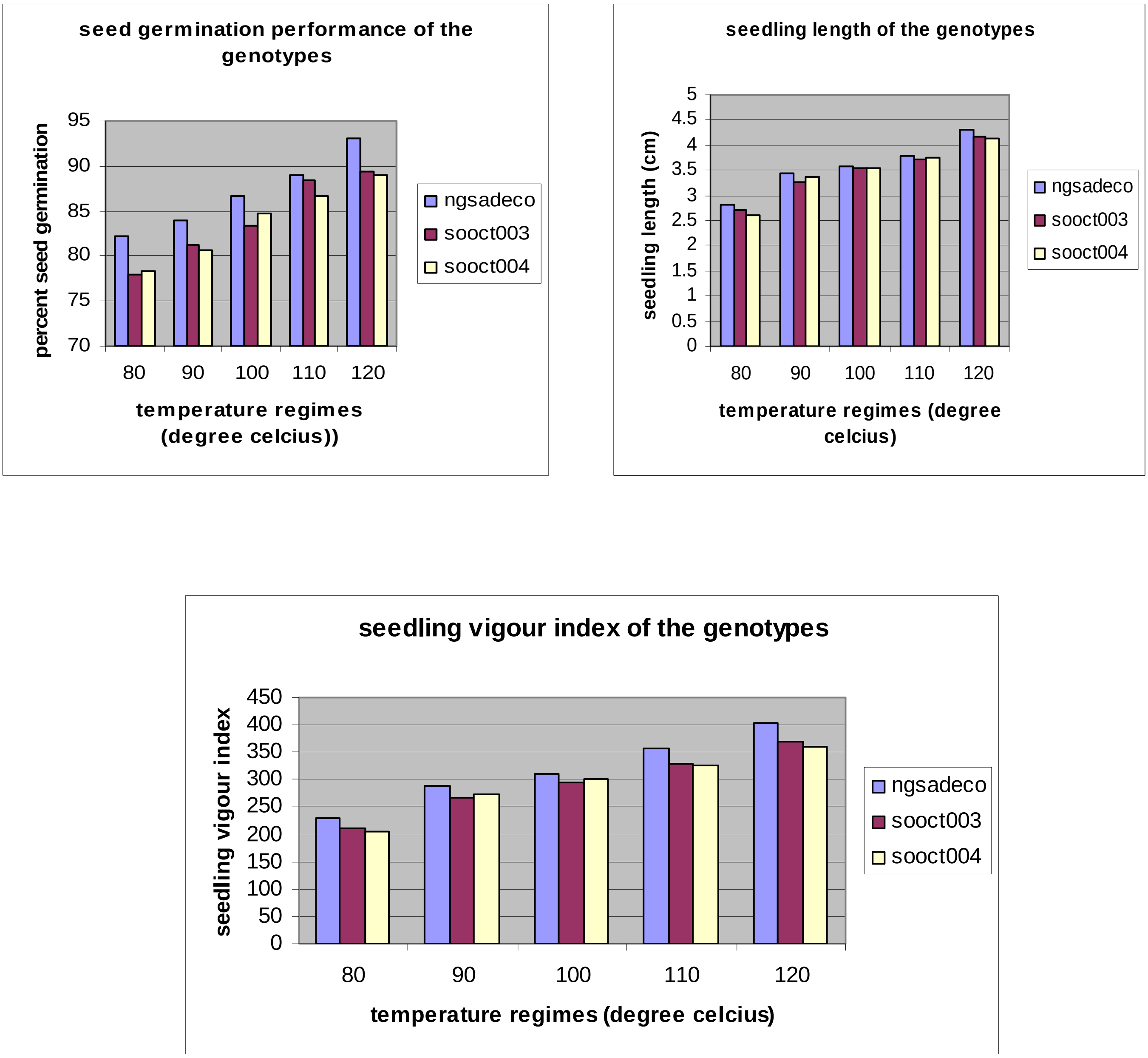


Fig. 1. Seed germination and seedling vigour performance of the three genotypes of *Corchorus olitorius* seeds during seed viability test.

Seedling Emergence

The means square for the accession, temperature regimes and the accession X temperature interaction were significant for percentage seedling emergence, seedling length and seedling vigour index (Table 4) .There were also significant differences between the temperatures for all the parameters. The interaction between the cultivar and temperature was quite important with significant differences for percentage germination, seedling length and seedling vigour index.

Table 4: Means square from analysis of variance for percentage emergence, early seedling length and seedling vigour index.

Sov	Df	Percemer	Seedlt	Svi
Cult	2	4.67*	0.10**	1346.22**
Temp	4	139.57**	2.51**	34028.58**
Rep	2	3.49 ns	0.00 ns	33.33 ns
AccXTemp	8	2.36*	0.02**	169.56**
Error	28	0.82	0.00	22.26
Total	44			
Cv(%)		1.02	1.03	1.44

Key: *significant at 0.05, **significant at 0.01, ns= Not significant, Cv-coefficient of variation, Sov – Source of variance;Df- Differential frequency ; Percemer- Percentage emergence; Seedlt- Seedling length; Svi- Seedling vigour index; Acc-Accession; Temp-Temperature.

The mean for temperature 120^0 C was the highest and it was significantly better than other temperatures for all the characters measured. On the other hand the lowest mean was recorded at 80^0C temperature for all the parameters (Table 5).

Table 5: Means of percentage seedling emergence, seedling length and seedling vigour index for *Corchorus olitorius* seeds under five temperature regimes of high dry heat treatment.

Temp	Percemer	Seedlt	Svi
80°c	83.58[e]	3.08[e]	257.60[e]
90°c	86.22[d]	3.28d	283.13d
100°c	88.78[c]	3.67[c]	325.61[c]
110°c	90.89[b]	3.92[b]	355.92[b]
120°c	93.67[a]	4.42[a]	413.86[a]

Key: means with same alphabet along the column are not significantly different from one another. Temp- Temperature;Percemer- Percentage emergence; Seedlt- Seedling length ;Svi- Seedling vigor index.

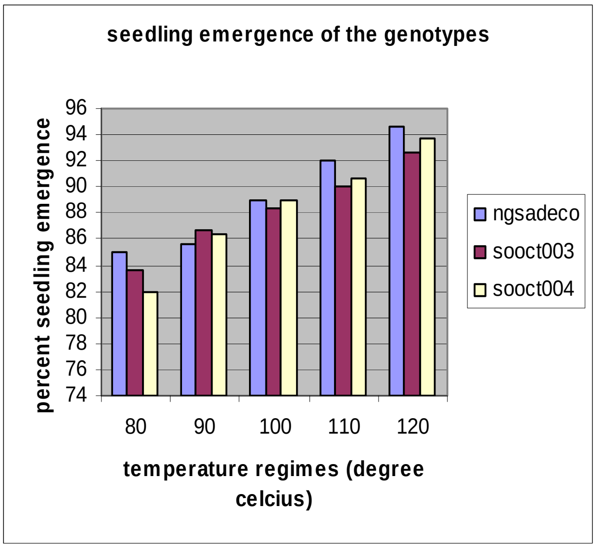
Accession X Temperature interaction: seedling emergence response

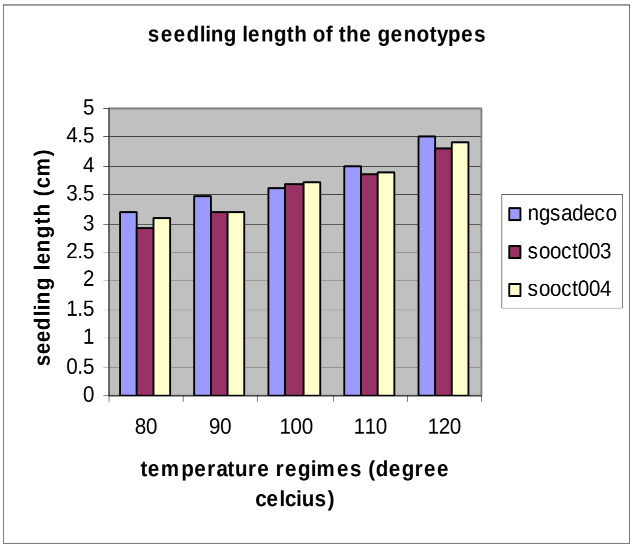
The cultivars reacted to the temperature treatments differently for all the parameters except for percentage emergence where there was no significant difference between the means of SOOCT003 and SOOCT004 (Table 6). The means for the accession NGSADECO was significantly higher than SOOCT004 and SOOCT003 for percentage emergence, seedling length and seedling vigour index (Table 5). While the cultivar NGSADECO had the highest mean values for all the parameters, accession SOOCT003 was however the poorest. (Table 6).The accessions showed increasing response to increases in the temperatures for all the parameters and temperature 120^0C was the most favourable with the highest values for all the cultivars (Fig. 2). Differences in accession responses were more marked in certain temperatures than others, for example at 80^0 C for percentage seedling emergence and 120^0 C for seedling vigour index. But in contrast, there were no marked differences in the accession responses at 100^0 C for all the parameters.

Table 6: Means of percentage seedling emergence, seedling length and seedling vigour index for three accessions of *Corchorus olitorius* under different temperatures.

Acc	Percemer	Seedlt	Svi
Sooct003	88.27[b]	3.59[c]	318.19[c]
Sooct004	88.33[b]	3.68[b]	326.41[b]
Ngsadeco	89.27[a]	3.76[a]	337.08[a]

Key: means with same alphabet along the column are not significantly different from one another.-Acc-Accession;Percemer- Percentage emergence;Seedlt- Seedling length;Svi- Seedling vigor index.





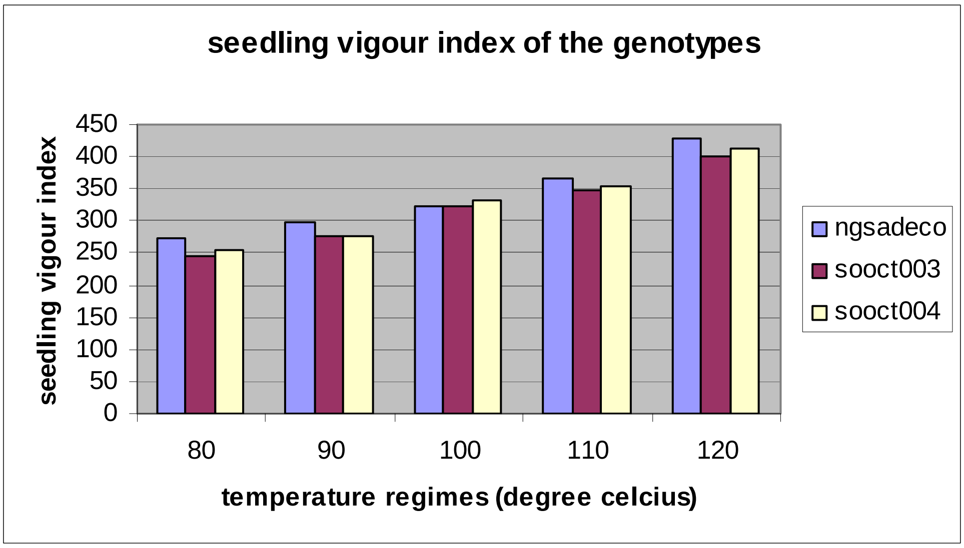


Fig. 2. Seedling emergence and seedling vigour performance of the three genotypes of *Corchorus olitorius* seeds during seedling evaluation.

DISCUSSION AND CONCLUSION

The five temperature treatments tested in the trials were much higher than the recommended constant temperature (30^0C) for testing *Corchorus olitorius* seed germination in gene banks (Verma and Arora, 1978, International Board for Plant Genetic Resources, 1985).The results showed that satisfactory germination of *C. olitorius* seeds can still be obtained at a much higher temperatures up to 120^0C. Increasing the temperature treatments from 80^0C to 120^0C did not hamper the seed germination under suitable room conditions used for the seed germination test. This is in line with the work of Wahab, 2011 which also demonstrated improvement in *C. olitorius* seed germination with increasing dry heat temperatures up to 90^0C. In contrast, hot water treatment of *Astragalus cyclophyllon* with temperature above 80°C was found to be harmful to the seed germination (Keshtkar *et al*., 2008). *C. olitorius* is characterised by hard seed coat and hot water treatment has been reported to enhance germination of hard coated seeds through improved water and oxygen permeability of the testa (Msanga and Maghembe, 1986; Teketay, 1998). This may also explain the improvement in seed germination at high dry high temperatures adopted in this trial.

Similar improvement in the means of cultivars with increases in temperature treatments was recorded for seedling emergence, seedling length and seedling vigour index in the nursery experiment. The optimum temperature treatment was also obtained at 120^0C for all the characters. This work showed that the higher the temperature treatments the higher the mean value for each of the three characters considered in the experiments either under room temperature or in the nursery. Thus, high dry temperatures appeared to be quite favourable for improved seed germination, seedling emergence, seedling length and seedling vigour index of *C. olitorius.* Although the cultivars exhibited the same pattern of response to the temperature treatments, the magnitude of their response was significantly different, indicating genetic variability among the cultivars for reaction to high dry heat temperatures. The differences in the cultivars reactions may be a reflection of the nature and hardiness of their seed coats. Thus light seed coat structure will be associated with high percentage germination at each temperature regime while thick seed coat structure will cause low seed germination. Based on the mean values of the cultivars over the five temperatures, the cultivar NGSADECO was the best for all the characters and it can be selected and used in breeding varieties for better response to high temperatures. As the high dry heat temperature treatments can be likened to exposure to bush fire on farmers plots, there is therefore little fear that the seed of *C. olitorius* genotypes can be lost to fire incidence. Rather the fire can only improve the seed germination, seedling emergence and seedling vigour index of the genotypes. The ability of the seed of *C. olitorius* to tolerate high temperatures might have contributed to the success of the species under developing African agriculture where annual practice of bush burning is rampant. The cultivar X temperature interaction was significant for all the characters under the nursery experimental conditions, suggesting that the cultivars are unstable and susceptible to the effects of combined variations in the temperature regimes and the natural environmental conditions in the nursery.

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