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The effects of seed moisture content, storage temperature and hot water-steeping on the quality of *Corchorus olitorius* L. seeds

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Abstract

Seeds packaged at 5.5, 10.6 and 16.8% moisture content were stored at 10 and 30°C for 20 weeks. Germination and seedling emergence were tested at 2 weekly intervals during the storage period. On each testing day, seeds were steeped for 2 or 5 seconds in hot water at 97 °C to enhance germination; un-steeped seeds served as the control. Hot water-steeping resulted in higher, faster and more synchronized germination and seedling emergence. Seeds steeped for 2 seconds recorded significantly higher germination and seedling emergence compared to 5 seconds steeping. Seeds stored better at low moisture content (about 5%) and temperature (about 10°C).

Key words: Storage, moisture, temperature synchronization and germination.

Introduction

Corchorus olitorius is an important tropical vegetable crop with enormous potentials for farmers with low income. The increased utilisation of vegetables like *C. olitorius* has been suggested as one of the ways to alleviate household food insecurity especially among populations with marginal or no income (Bharucha and Pretty, 2010). Reports on the nutritional analysis of the species indicated that *C. olitorius* contains crude protein, iron, calcium and magnesium (Ndlovu and Afolayan, 2008). Poor germination due to dormancy is one of the key production constrains discouraging farmers from the cultivation of this crop (Velempini *et al.*, 2003). Nkomo and Kambizi (2009) suggested that farmers would be more economically empowered if they have available to them means of enhancing the germination of the crop. Many methods of breaking the dormancy of *C. olitorius* seeds have been reported (Traveset and Mas, 2001; Schmitt *et al.*, 2004; Khaduduri *et al.*, 2002; Phartyal *et al.*, 2005). However the use of hot water recommended by Oladiran (1986) appears to be much more adoptable especially among resource poor farmers. Apart from the findings recently reported by Ibrahim *et al.* (2013) and Tolorunse *et al.* (2013), that *Corchorus olitorius* would require hot-water steeping to break its dormancy, not much is known about the longevity of steeped seeds. Despite the acknowledgements that seed dormancy is a problem in *Corchorus* cultivation, there seems to be dearth of information on the depletion of dormancy during the storage of the seeds and on the tolerance of seed lots of different ages to hot water-steeping. The relationship between temperature and moisture content and their combined effect on dormancy has mainly been investigated during the stratification of imbibed seeds in several species (Pritchard *et al.*, 2004). Therefore the objective of this study was to determine the effects hot water pre-treatment, duration, seed moisture content and storage temperature might have on *Corchorus olitorius* seed dormancy depletion and longevity.

Materials and methods

Experiments were conducted in the Department of Crop Production laboratory and nursery at the Federal University of Technology, Minna (9° 40^ N and 6° 30A E,

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altitude 256 m above sea level) in north central Nigeria. Seeds at 5.5, 10.6 and 16.8% were sealed in glass bottles stored at 10 and 30 °C for 20 weeks and tested for germination and seedling emergence at four weekly interval. On each testing day, three samples were drawn from seeds of each moisture content and temperature combination. One of the samples was steeped in water at 97 °C for 2 seconds, another one was steeped for 5 seconds while the third sample was left un-steeped as the control. There were thus three factors: seed moisture content (three levels), storage temperature (at two levels) and hot water steeping (at three levels) resulting in 18 (3 x 2 x 3) treatment combinations. Seed quality determination was done using germination percentages and seed vigour. Germination test was conducted on each testing day on four replicates of 50 seeds from each of the treatment combinations, placed on water-moistened filter paper in plastic Petri dishes at 30°C. Germination counts were taken every-other-day. The total number of seeds that germinated was expressed as a percentage of the total number of seeds sown. Seed vigour was indexed using germination rate (GR) and synchronization (Z). Germination rates (GR) were calculated according to Labouriau (1983) as follows:

$$GR = \frac{(n1 \times t1) + (n2 \times t2) + (n3 \times t3) + \ldots + (ni \times ti)}{T}$$

Where n is the number of days for each germination count; t, the number of germinated seeds at each counting day; T, the total number of germinated seeds.

Synchronization (Z) was estimated using the relationship expressed by Primack (1980) thus: $Z = “C_{n_i,2} / N$, with $C_{n_i,2} = n_i(n_i-1)/2$ and $N = “n_i(“n_i-1)/2$

Where $Cn_{i,2}$: combination of the seeds germinated in the time *i* and n_i: number of seeds germinated in the time *i*. Z = 1 when the germination of all seeds occur at the same time and Z = 0 when at least two seeds could germinate, one at each time.

For the seedling emergence and growth tests, four replicates of twenty-five seeds each were sown in to 6 kg soil in plastic pots on each sampling day for each treatment combination. The soils was watered before sowing and daily thereafter. Data were collected on seedling emergence as well as plant height and number of leaves per plant at four weeks after sowing.

The data collected on all the parameters were subjected to analysis of variance (ANOVA) using SAS and where significant differences among treatments were obtained, means were separated using the Least significant difference.

Results

Seed germination was significantly influenced by hot water-steeping (S), seed moisture content (MC) and storage temperature (T). Hot water-steeping resulted in significant improvement in germination compared to what was recorded in un-steeped seeds (Figure 1). Steeping of seeds for 2 seconds gave significantly better germination than 5-second steeping. Furthermore, seeds generally stored best at 5.5% and poorest at 16.8% moisture content (Figure 2). Seeds also stored better at 10 °C than at 30 °C (Figure 3). Hot water-steeping resulted in faster seed germination (Table 1) and steeping of seeds for 2 and 5 seconds generally gave similar results. Germination rate was significantly affected by seed moisture content only in few instances while storage temperature did not significantly affect this attribute.

Significant S x MC and MC x T interactions were recorded only a few instances (data not shown) while S x T and S x MC x T interactions were insignificant all through the storage periods. Figures 4 shows that steeping of seeds in boiling water for 2 or 5 seconds resulted in significantly better germination synchronization compared to un-steeped seeds. There were no significant differences in germination synchronization recorded among the seeds packaged at different moisture content and between storage tempe[illegible]ures.

Table 1 Effect of moisture content, temperature and steeping duration on germination rate of *Corchorus olitorius*

Treatment		Storage duration (weeks)				
		0	4	8	12	16
Steeping duration (S)						
0		3.0	4.0	3.8	3.8	3.1
2		2.0	2.0	2.1	2.1	2.0
5		2.0	2.0	2.1	2.7	2.7
SE±		0.2	0.2	0.1	0.1	0.2
LSD (0.05)		0.6	0.5	0.3	0.4	0.4
Moisture content (MC) %						
5.5		4.0	3.0	3.0	2.7	2.6
10.6		3.0	3.0	3.0	2.7	2.3
16.8		4.0	3.0	3.0	3.2	2.3
SE±		0.2	0.2	0.1	0.1	0.2
LSD (0.05)		0.6	NS	NS	0.4	NS
Temperature (T)						
10		4.0	3.0	2.7	2.9	2.5
30		4.0	3.0	2.6	2.9	2.4
SE±		0.2	0.2	0.8	0.1	0.1
LSD (0.05)		NS	NS	NS	NS	NS
Interactions						
S x MC	**	NS	NS	NS	NS	
S x T		NS	NS	NS	NS	NS
MC x T	NS	NS	*	*	NS	
S x MC x T		NS	NS	NS	NS	NS

**= highly significant; *= significant; NS= not significant

Furthermore, the interaction effects of all factors were generally non-significant. Figure 5 shows that seedling emergence was significantly higher in steeped than in the unsteeped seeds. Steeping of seeds for 2 seconds was superior to 5 seconds steeping at 4, 12 and 16 WAS. The superiority of storage moisture content of 5.3% over 11.6% and 16.5% MC only became evident at 16 and 20 WAS (Figure 6). Though higher emergence values were obtained under the storage temperature of 10 °C than at 30 °C, differences were largely insignificant. S x MC, S x T and MC x T interaction effects were insignificant while S x MC x T interaction was significant at 4 and 12 WAS.

Table 2 shows the effect of steeping, seed moisture content and storage temperature on emergence rate of *Corchorus olitorius*. Hot water-steeping resulted in significantly faster seedling emergence at 4, 8 and 16 WAS with similar results at 2 and 5 steeping durations. Except at 8 WAS, emergence rate was not significantly affected by seed moisture content. Similarly, storage temperature did not significantly affect emergence rate. S x MC, S x T and MC x T interaction effects were insignificant all through the study period and S x MC x T interaction effect was only significant at 8 WAS. Table 3 shows the effect of moisture content, temperature and steeping

Table 2 Effect of steeping duration, moisture content and temperature on emergence rate of *Corchorus olitorius*

Treatment	Storage duration (weeks)				
	0	4	8	12	16
Steeping duration (S)					
0	5.0	5.7	5.8	3.9	2.3
2	4.5	4.5	4.1	4.3	4.8
5	4.5	4.3	4.1	4.2	5.1
SE±	0.4	0.2	0.3	0.4	0.7
LSD (0.05)	NS	0.6	0.7	NS	2.0
Moisture content (MC) %					
5.5	4.4	4.8	4.6	4.5	4.4
10.6	5.0	5.1	4.3	3.7	4.3
16.8	5.0	4.7	5.1	4.2	3.5
SE±	0.4	0.2	0.3	0.4	0.7
LSD (0.05)	NS	NS	0.7	NS	NS
Temperature (T)					
10	4.7	4.9	4.7	4.1	4.5
30	4.7	4.9	4.6	4.1	3.6
SE±	0.3	0.2	0.2	0.3	0.6
LSD (0.05)	NS	NS	NS	NS	NS
Interactions					
S x MC	NS	NS	NS	NS	NS
S x T	NS	NS	NS	NS	NS
MC x T	NS	NS	NS	NS	NS
S x MC x T	NS	NS	*	NS	NS

*= significant; NS= not significant

duration on emergence synchronization of *Corchorus olitorius*. Seedling emergence synchronization was significantly better in steeped than in unsteeped seeds and there was generally no significant difference between 2 and 5 steeping durations. There were no significant differences in synchronization recorded among seed moisture contents except at 0 and at 20 WAS. At 20 WAS, seedling emergence was best synchronised when seeds were stored at 5%. Though synchronization was better when seeds were stored at 10 °C than at 30 °C, the difference was only significant at 16 WAS.

Discussion

This study revealed that, longevity was better maintained at low seed moisture content and storage temperature. Pita *et al.* (1998) also reported that when *Avena sativa* were stored at low moisture content (6-7%) and temperature (10 – 15°C), the viability and longevity of the seed were maintain for a long period. Low temperature and storage moisture content favoured *Vigna mungo* (mash beans) storability (Syeda, 2000). According to Probert (2003) and

Vodouhe *et al.* (2008), reducing seed moisture content to an acceptable level will prolong seed longevity. The faster and uniform seed germination and seedling emergence after steeping may be explained by an increased permeability of the seed coat as has been reported for clover (Aydin and Uzun, 2001). Furthermore, the current study revealed that dormancy of unsteeped seeds was not alleviated with increasing storage duration irrespective of storage temperature and seed moisture content. Rather, loss in viability was recorded as seed aged. This is

Table 3: Effect of moisture content, temperature and steeping on seedling emergence synchronization of *Corchorus olitorius*

Treatment	Storage duration (weeks)					
	0	4	8	12	16	20
Steeping duration (S)						
0	0.00b	0.26b	0.22b	0.12c	0.00b	0.00b
2	0.57a	0.78a	0.91a	0.99a	0.56a	0.46a
5	0.62a	0.76a	0.97a	0.85b	0.38a	0.42a
SE±	0.6	0.8	0.5	0.3	0.3	0.2
Moisture content (MC) %						
5.5	0.44a	0.59a	0.64a	0.60a	0.35a	0.50a
10.6	0.28b	0.63a	0.73a	0.66a	0.38a	0.21b
16.8	0.47a	0.59a	0.73a	0.69a	0.21a	0.17b
SE±	0.2	0.1	0.2	0.3	0.2	0.1
Temperature (T)						
10	0.39a	0.62a	0.73a	0.70a	0.45a	0.36a
30	0.39a	0.58a	0.66a	0.61a	0.17b	0.22a
SE±	0.2	0.3	0.1	0.2	0.3	0.1
Interactions						
S x MC	NS	NS	NS	NS	NS	*
S x T	NS	NS	NS	NS	NS	NS
MC x T	NS	NS	NS	NS	NS	NS
S x MC x T	NS	NS	NS	NS	NS	NS

Means followed by the same letter in a column within a factor are not significantly different at P=0.05 using DMRT.
0= unsteeped (control); 2= 2 seconds steeping on testing day; 5= 5 second steeping on testing day.

contrary to what has been reported in other crop species. Bazin *et al.* (2011) reported that the rate of loss of dormancy in sunflower (*Helianthus annus*) seed depended on both temperature and moisture content and that dormancy was released faster when seeds were stored at temperature 10 °C than at higher temperature. Probert (2000) also observed that alleviation of wheat seed dormancy during dry storage was realised at moisture content ranging from 5-18%. After–ripening at high temperature and seed moisture content has also been reported to result in reduced time to attain 50% germination (Weston *et al.*, 1992).

It is concluded from this study that seed of *Corchorus olitorius* would require hot-water steeping to break its dormancy no matter the storage moisture content, temperature and duration of storage. Steeping of seeds in hot water (about 97 °C) for 2 second is adequate for dormancy alleviation. Furthermore, seed maintained viability better at low moisture content and temperature.

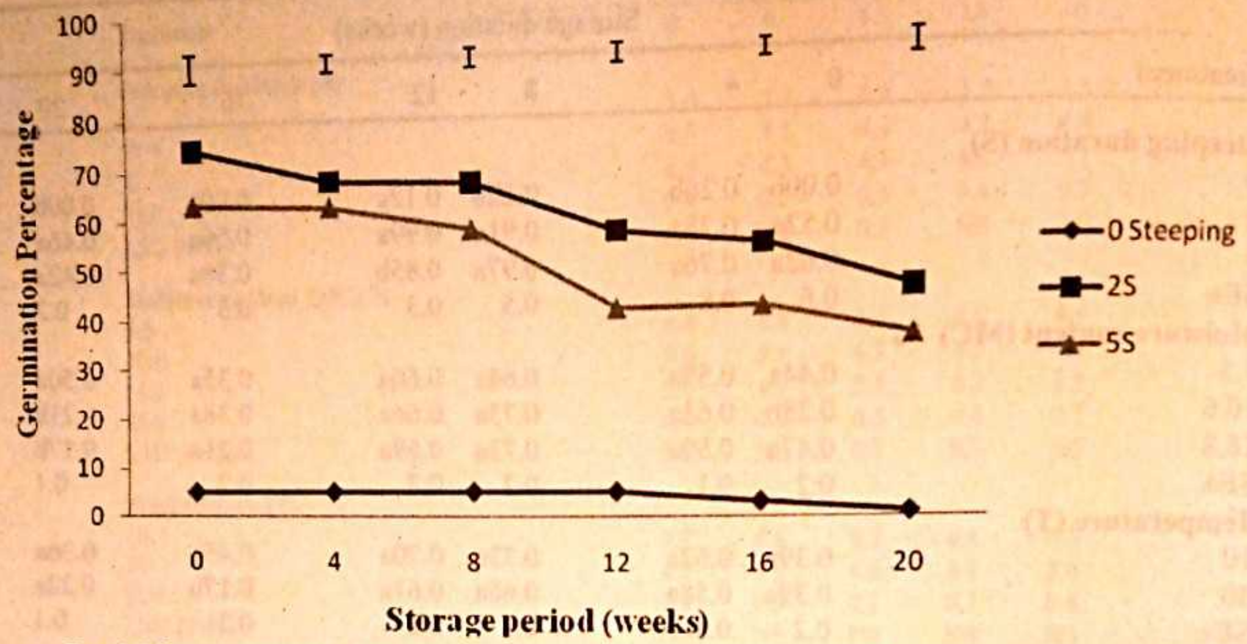

Fig. 1 Effect of steeping duration on seed germination percentage at different storage periods

I= SED bar

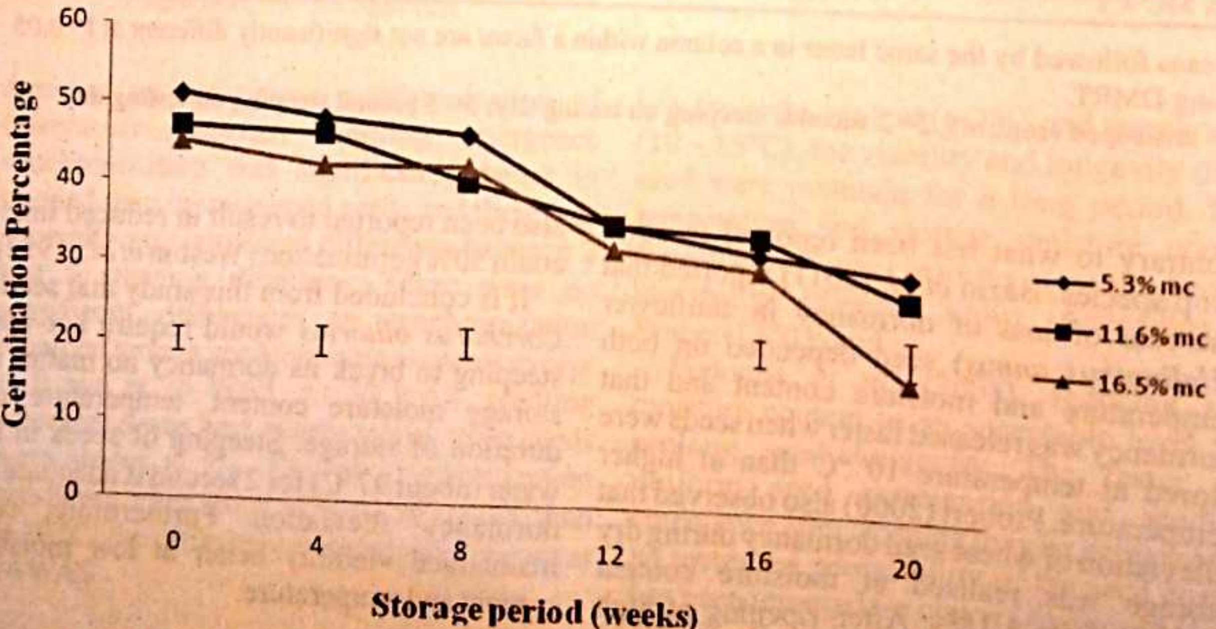

Fig. 2: Effect of moisture content on seed germination percentage at different storage periods

I= SED bar

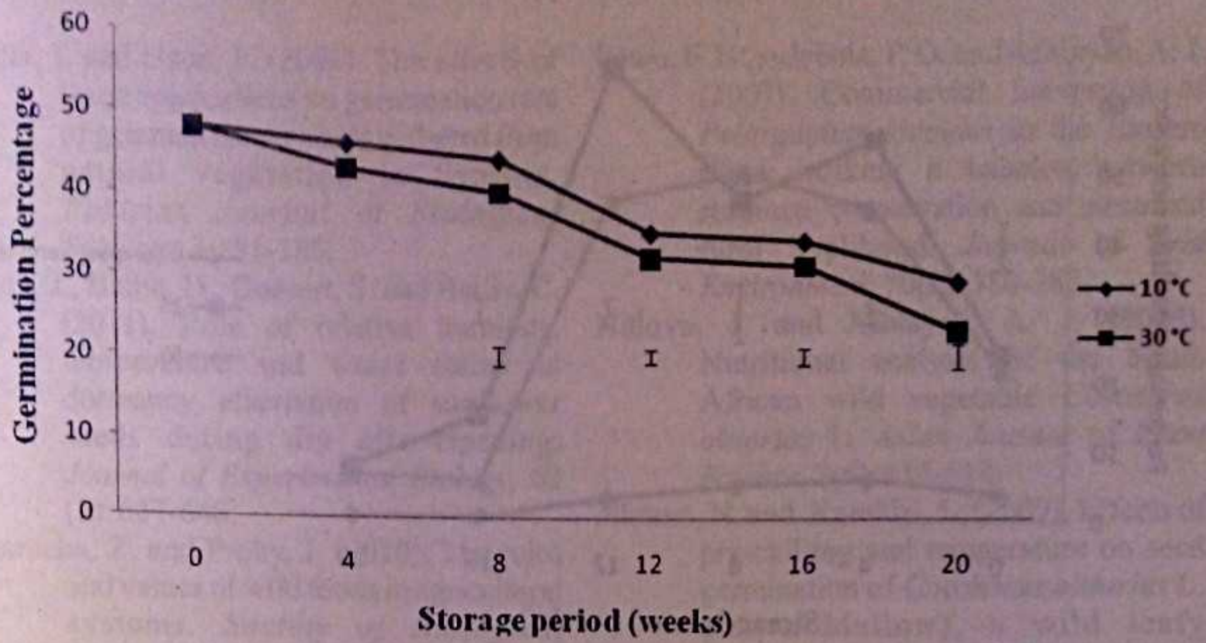

Fig. 3 Effect of temperature on the germination percentage at different storage periods

I= SED bar

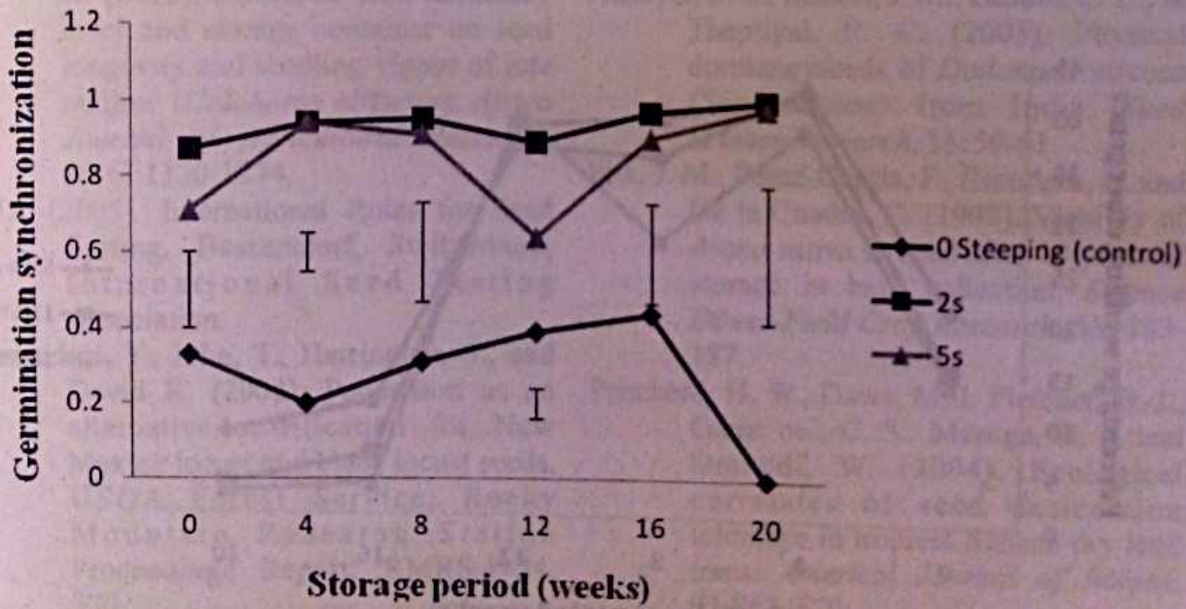

Fig. 4 Effect of steeping duration on germination synchronization at different storage periods.

I= SED bar

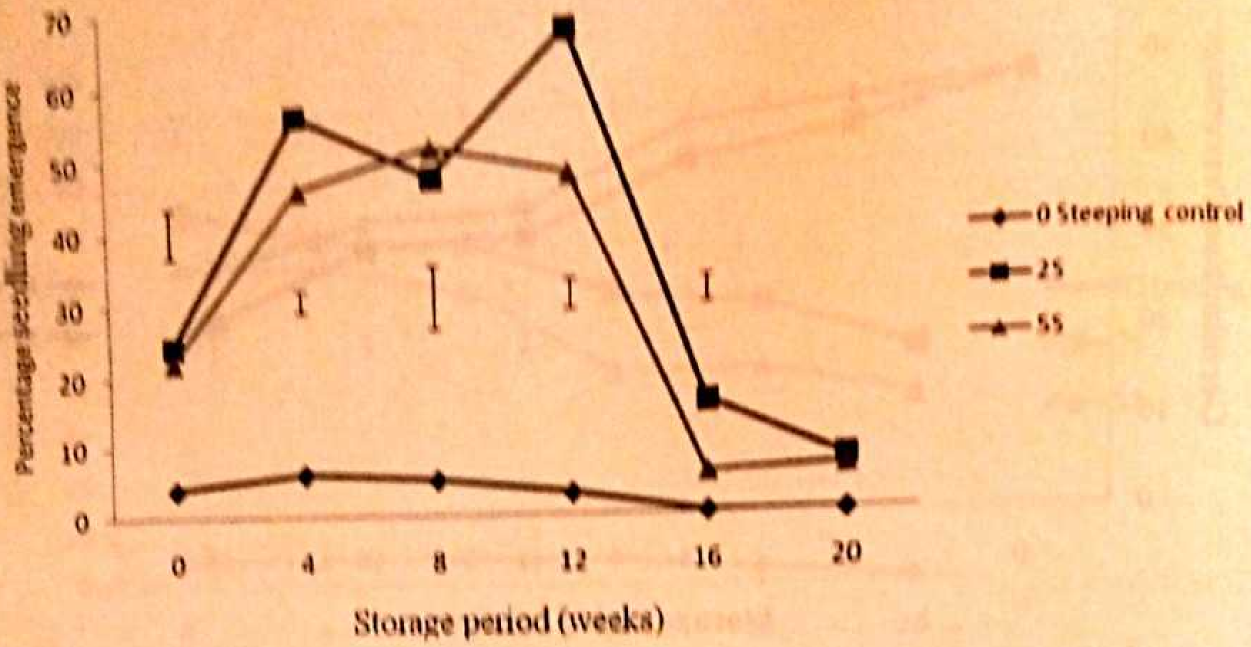

Fig. 5 Effect of steeping protocol on percentage seedling emergence at different storage periods

I= SED bar

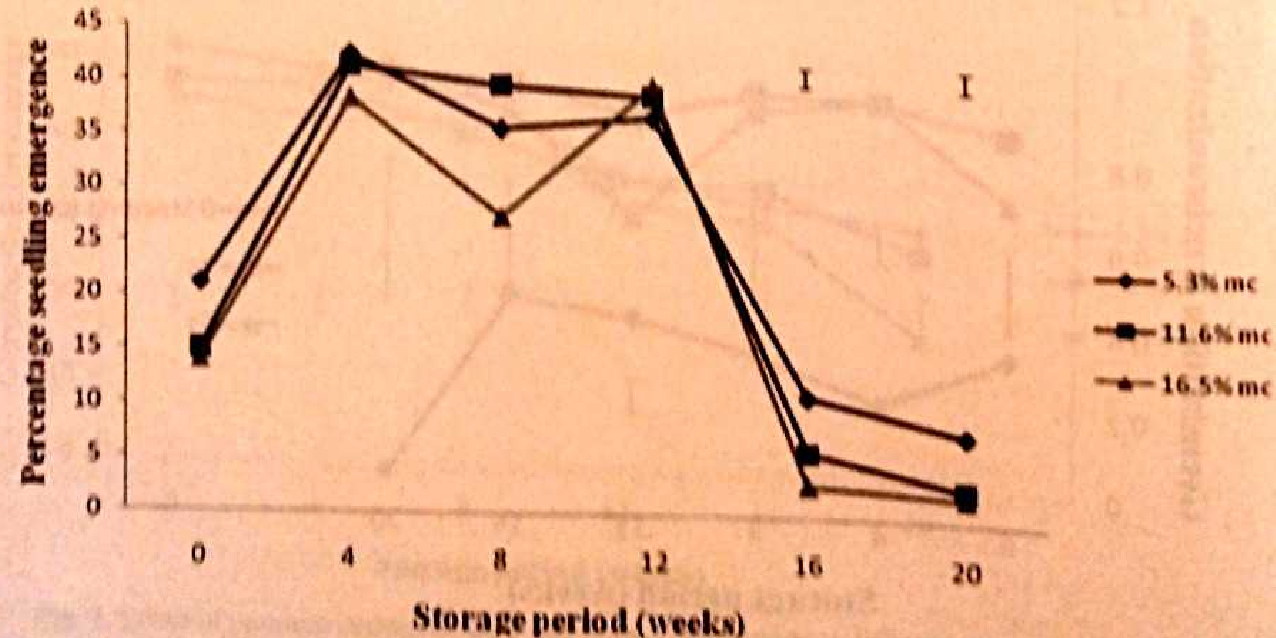

Fig. 6 Effect of moisture content on percentage seedling emergence

I= LSD bar

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