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Effect of seed soaking duration on germination and other physiological parameters of Castor (*Ricinus communis* L.)

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ABSTRACT

Castor (*Ricinus communis* L.) is a commercially valued bioenergy crop highly suitable for marginal lands. Slow and uneven germination are the common phenomenon of castor seeds when sown under stressful environmental conditions. Castor seeds that have been soaked in water can germinate quickly and uniformly. When seeds are soaked in water, the duration of time they are soaked has a significant impact on their performance.In the present investigation, castor seeds were soaked for different durations *viz*., 6,8,10,12,14,16,18,20 and 22 hrs at 1:2 ratio. Among different soaking durations, 16 hrs improved the seed physiological parameters,*viz.*,the speed of germination, germination percentage,vigour index, root length (cm), shoot length (cm), dry matter production (g/10 seedlings), when compared with other durations. An improvement of 16% germination over the dry control seeds was also noticed when the castor seeds were soaked for 16 hrs in water at a1:2 ratio.

***Key words**: Soaking duration, Castor seed, Germination, Vigour index.*

Introduction

astor (*Ricinus communis Linn*.) is an annual or perennial species of blooming plant which belongs to the family Euphorbiaceae. It is a nonedible oilseed crop grown in more than 29 countries over a total area of 14.48 million hectares, with a total production of 19.48 million tonnes and a productivity of 1346 kilogrammes per hectare. India has the largest land area (11.48 million hectares) and the highest productivity (1666 kg per hectare).

Castor oil is one of the important raw materials for the chemical and polymer industries and has a large international market. More than 80% of the castor oil supply comes from India and Brazil combined. Castor is an important commercial crop suitable for both rainfed and irrigated cultivation in tropical, subtropical and temperate climatic conditions. Castor requires sufcient soil moisture for germination and growth. Its requirement of rainfall during different growth stages differs, but it requires a minimum of 300 mm of rainfall during its growth. Castor yield fell by 20% in 2018-2019 due to poor monsoon. Reduced emergence of castor seedlings is due to drought, poor soil texture and less water holding capacity. Nowadays, most dry land farmers are shifting from castor to other crops because of lower emergence and lower yields, mainly

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due to drought. As castor is an important industrial oilseed crop fetching more foreign returns, there is a need to maintain the plant population in the field as well as yield in rainfed conditions.

Rapid germination and emergence of healthy seedlings are important factors for maintaining a uniform plant population in the field. Water deficit during germination stage results in a reduction or complete inhibition of seed germination and seedling establishment. Soaking the seeds for optimum duration increases the pre germination metabolic activity of the seed, which helps in rapid and uniform emergence. Therefore, this study was initiated to assess the outcome of seed soaking with varying durations in water to standardise the optimum duration for improved physiological parameters of castor seed.

Materials and Methods

Genetically pure seed materials of castor variety YTP 1 were procured from Tapioca and Castor Research Station, Yethapur. The experiment was carried out at the Department of seed Science and Technology, TNAU, Coimbatore using a Completely Randomized Design with eight treatments and four replications each. The castor bean seeds were subjected to water soaking treatment with different soaking durations of 6,8,10,12,14,16,18,20 and 22 hrs at seed to solution ratio of 1:2 (weight/ volume) and tested for seed quality parameters by following the standard germination test procedure of ISTA (2015).

Speed of germination

Eight replications of 50 seeds each were taken and germinated in trays and germinated seedlings were counted daily up to the final count (14 days). The speed of germination was calculated by using the formula given by Maguire (1962)

Speed of germination $= \frac{G_1}{D_1} + \frac{G_2}{D_2} + \frac{G_3}{D_3} + \cdots \frac{Gn}{Dn}$ Where, G_1, G_2, ……G_n is the number of seeds germinated on D_1, D_2, etc ……D_n day.

Germination (%)

The standard germination test was carried out by following the sand tray method outlined in the ISTA procedure. Eight replications of fifty seeds were taken from each treatment and placed on the sand uniformly. The trays were kept in a germination chamber that was maintained at 25 ± 2°C temperature and 95 ± 2 percent relative humidity. At the end of fourteen days, the final count was taken. The number of normal seedlings from each replication was counted and the mean germination was expressed in percentage (ISTA, 2015).

$$\text{Seed germination (\%)} = \frac{\text{Number of normal seedlings}}{\text{Total number of seeds sown}} \times 100$$

Shoot length (cm)

The shoot length of normal seedlings from each replication of the germination test was measured from the collar region to the apex and the mean was expressed in cm.

Root length (cm)

The root length of normal seedlings from each replication of the germination test was measured from the collar region to the root tip and the mean was expressed in cm.

Dry matter production (g/10 seedlings)

The seedlings used for growth measurement were shade dried for 24 hrs and dried again in a hot air oven at 85± 2°C for 24 hrs and cooled in a desiccator filled with silica gel for 30 min. The dry weight of seedlings was recorded using an electronic balance and expressed as g/10 seedlings.

Seedling vigour index

Seedling vigour index values were calculated by the following formula given by Abdul-Baki and Anderson (1973) and the mean values were expressed in the whole number.

Seedling vigour index I = Germination (%) × Total seedling length (cm).

Seedling vigour index II =Germination (%) × Dry matter production (g/10 seedlings).

Germination rate index (GRI)

The number of seeds that germinated was recorded on a daily basis up to the day of the final count. The germination rate index was calculated by the formula given by Mudaris (1998).

Germination rate index = G/1 + G/2 + ………+Gn/n

Where,

G_1=Germination percentage × 100 on first day

G_n=Germination percentage × 100 on the nth day

Electrical conductivity (dSm^{-1})

Four replications of 25 seeds from each treatment were soaked in 25 ml distilled water and kept in an incubator maintained at 25±1°C for 12 h. After soaking, the seed leachate was decanted. The electrical conductivity of the seed leachate was measured in the digital conductivity bridge (ELICO) with a cell constant of 1.0 and the mean values were expressed in dSm^{-1} (Milosevic *et al*., 2010).

Results

The above results (Table 1and 2) indicated that, among different treatments, the seeds soaked in water for 16 hrs exhibited remarkable effects.The soaking duration significantly influenced the physiological parameters of the castor seed. With reference to the germination percentage, the seeds soaked in water up to 16 hrs exhibited maximum germination (98.7%) which was 16% higher than control (82.7%) followed by 14 hrs (96.0%). After 16 hrs the germination percentage was reduced with increased soaking duration.

Similarly,the highest speed of germination was significantly recorded in the seeds soaked for 16 hrs (4.01),followed by 14 hrs (3.70) and the lowest in control seeds (2.77). Significantly superior root length and dry matter production were observed in 16 hrs soaking (28.05 cm and 2.664 g/10 seedlings respectively)followed by 14 hrs of water soaking and less in control (25.44 cm and 2.320 g/10 seedlingsrespectively).

Significantly, the highest shoot length was observed in seeds soaked for 16 hrs (39.17 cm), followed by 14 hrs (36.39 cm) and the lowest in control (31.67 cm). The significant difference in vigour index I was observed for different soaking durations. The maximum value was recorded for 16 hrs (6630) (Figure 1b) followed by 14 hrs which was on par with 12 hrs. The minimum value was recorded for control (4181) (Figure 1a).Vigour index II was also significantly maximum in 16 hrsof soaked seeds (262.9) and minimum in control (107.7). The highest germination rate index was recorded in 16 hrs (402) followed by 14 hrs. However, the control recorded the lowest (277).

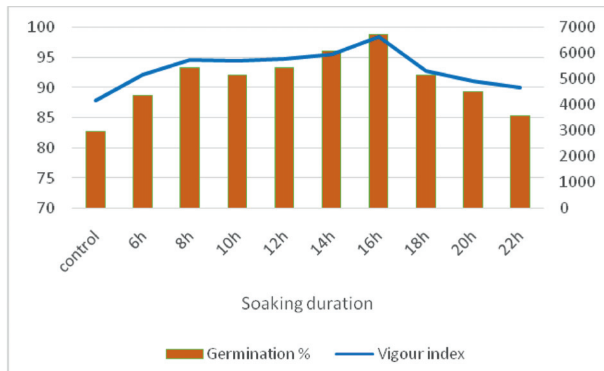

Fig. 1. Effect of different soaking durations on germination (%) and vigour index I

Table 1. Effect of water soaking duration on the speed of germination, shoot length (cm), root length (cm) and seedling dry weight (g/ 10 seedlings) in castor seeds

Treatments	Speed of germination	Shoot length (cm)	Root length (cm)	Seedling dry weight (g/10 seedlings)
T_0 – Without soaking (control)	2.77	31.67	18.79	1.302
T_1 – soaking seeds in water for 6 hrs	3.13	34.57	23.89	1.749
T_2 – soaking seeds in water for 8 hrs	3.22	35.10	26.60	1.892
T_3 – soaking seeds in water for 10 hrs	3.36	35.82	25.78	1.967
T_4 – soaking seeds in water for 12 hrs	3.41	36.81	25.36	2.150
T_5 – soaking seeds in water for 14 hrs	3.70	36.39	25.44	2.320
T_6 – soaking seeds in water for 16 hrs	4.01	39.17	28.05	2.664
T_7 – soaking seeds in water for 18 hrs	3.79	34.66	24.31	2.347
T_8 – soaking seeds in water for 20 hrs	3.45	33.04	22.89	2.225
T_9 – soaking seeds in water for 22 hrs	3.26	32.69	22.24	2.171
MEAN	**3.41**	**34.99**	**24.34**	**2.079**
SE d	0.16	0.80	1.12	0.07
CD @ 5%	0.34	1.67	2.33	0.14

Discussion

Physiological and biochemical changes followed by morphological changes during germination are strongly related to early establishment, seedling survival rate and vegetative growth which affect seed yield and quality. These changes begin with water imbibition, which triggers the activation of various metabolic processes. As a result, soaking seeds in water helps to shorten the time required for germination and improves germination percentage. Each crop cultivar requires a critical soaking duration and it should be less than the safe limit (Harris *et al.*, 2000). The optimum soaking duration for castor seed is identified as 16 hrs for early emergence, which ensures maximum germination, uniformity in seedling emergence and increased seedling vigour. A similar study has been conducted by Sabongari and Aliero (2004) and they have reported that soaking treatment enhanced the performance in all the parameters and for all the seed varieties of tomato seeds tested.Similarly, improved speed of emergence, vigour index and seedling dry weight were reported in hydro primed wheat seeds by Ahmadi *et al*. (2007).

The uptake of water in seeds follows a tri-phasic pattern. In the first stage, water uptake takes place rapidly due to low seed water potential. Biochemi-

Fig. 2. Effect of different soaking durations on vigour index of castor.

Table 2. Effect of water soaking duration on vigour index I, vigour index II, germination rate index and electrical conductivity (dSm^{-1}) in castor seeds

Treatments	Vigour index II	Germination rate index	Electrical conductivity (dSm^{-1})
T_0 – Without soaking (control)	108	277	0.096
T_1 – soaking seeds in water for 6 hrs	155	335	0.118
T_2 – soaking seeds in water for 8 hrs	177	322	0.142
T_3 – soaking seeds in water for 10 hrs	181	336	0.167
T_4 – soaking seeds in water for 12 hrs	206	341	0.178
T_5 – soaking seeds in water for 14 hrs	217	371	0.191
T_6 – soaking seeds in water for 16 hrs	263	402	0.201
T_7 – soaking seeds in water for 18 hrs	216	379	0.277
T_8 – soaking seeds in water for 20 hrs	196	345	0.319
T_9 – soaking seeds in water for 22 hrs	187	326	0.373
MEAN	**191**	**343**	**0.206**
SE d	10.95	16.79	0.007
CD @ 5%	22.85	35.02	0.014

cal activities take place in the second stage, followed by the process of germination in the last stage (Bewley, 1997). Uche *et al*. (2016) reported that the improved seed performancedue to priming in *Capsicum annuum* is traceable to the completion of the pre-germination process such as DNA replication, increased RNA and protein synthesis, greater ATP, faster embryo growth, repair of deteriorated seed parts, reduced leakage of metabolites, decrease in lipid peroxidation and increased in the antioxidant activities (Issam *et al.,* 2012) compared with control.

Seeds soaked for 16 hrs recorded the highest germination percentage, followed by 14 hrs and the lowest germination percentage was recorded in control. Matsushima and Sakagami (2013) also stated that the higher seed germination percentage of hydro-primed seeds isdue to the activation of á-amylase related metabolic process of seeds by water absorption.When seeds imbibe, the water content reaches a plateau and changes little until radicle emergence (Bradford, 1986). Soaking the seeds up to this point can have a positive effect, while extended soaking duration will negatively affect germination (Shakuntala *et al.,* 2020).

The speed of germination increased with an increase in soaking duration from6 hrs up to 16hrs, thereafter it decreased with increasingsoaking duration. Adhikari *et al.* (2021) reported that hydropriming of seeds before sowing facilitates softening of the seed coat and promotes the biological process required for germination, resulting in early germination. Adhikari *et al*. (2021) stated that early emergence and germination bring on the rapid growth of seedlings, making them taller.

Seeds soaked for 16 hrs recorded the highest shoot and root length compared to control. Abdulrahmani *et al.* (2007) reported that pre-sowing treatment of barley involving hydration of seeds in priming solutions improved germination, root and shoot length, seedling dry weight and low electrical conductivity (EC) of leachates from seeds.Kavitha (2009) observed the maximum shoot length in soaked chilli seeds as compared to control. The increase in root length is mainly due to metabolic repair of damage during treatment and change in germination events *i.e.,* changes in enzyme concentration and formation, and reduction of lag time between imbibition and radicle emergence (Bradford, 1990).

The highest seedling vigour index I and II were observed in seedssoaked in water for 16 hfollowed by 14 hrs and the lowest was recorded in control. The reason for poor seed vigour of un-primed seed may be due to a slower rate of imbibition. Priming also causes physiological and biochemical changes in seeds during the seed treatments and metabolic activities like increased amylase activity, which result in a higher seedling vigour index (Shakuntala *et al.,*2020). Adhikari *et al*. (2021) specified that water soaking induces physiological and biochemical changes, increases amylase production and enhances metabolic tasks resulting in higher seedling vigour.

The reason for the faster germination rate index of water-soaked seeds is due to rapid water uptake and the sooner initiation of the metabolic process which boosts radicle protrusion. Generally, earlier germination occurred due to higher synthesis of DNA, RNA and protein during priming. These results conform with the findings of Bray *et al.* (1989) in leek seeds. Generally, electrical conductivity indicates the membrane integrity and quality of the seeds. The EC value increased with increasing soaking duration. The electrical conductivity value of seeds soaked for 16 hrs is 0.201dSm^{-1}.

The second-best performance was reported in seeds soaked for 14 hrs in terms of speed of germination,germination percentage, dry matter production, as well as vigour, which was higher than the seeds soaked for18 hrs. The performance of the seeds soaked for more than 16 hrsis lowered thus suggesting harmful effects of excessive soaking.The seed quality parameters of sugar beet were reduced when soaked for less than 14 d which might be due to incomplete imbibition resulting in reduced activity of hydrolytic enzymes required for reserve mobilisation of storage food (Perry and Harrison, 1974).

Excessive soaking was said to increase carbon dioxide, ethanol and lactic acid concentrations in seeds and reduce the level of oxygen, leading to poor growth (Irwin, 1982; Street and Helji, 1991). Other possible effects are leaching essential soluble food reserves in the seeds and exosmosis of enzymes and hormones leading to a fall in protein synthesis and respiration rate (Copeland, 1976 and Street and Helji, 1991). The optimal level of soaking is thought to have enhanced effects on germination and growth, probablydue to hydrolysis of the complex into simple sugars that are readily utilised in the synthesis of auxins and proteins.Significantly higher performance in 16 hrs soaking suggests that seeds require an optimum level of moisture rather than full saturation to induce the embryo to commence the process of cell division, differentiation and multiplication to grow into a seedling.

Conclusion

Due to the late onset of monsoon and below-average rainfall, castor production suffers from poor field stand and yield declines.Water soaking is a simple and cost-effective procedure to improve the germination and the emergence of castor. The findings of this study showed that for enhanced germination and uniform emergence of castor, the castor seeds may be soaked in water for 16 hrs at 1:2 ratio.

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