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Optimizing Priming Concentration and Duration of PEG 6000 for Improving Seed Germination and Vigour in Chickpea (*Cicer arietinum* L.)

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ABSTRACT

This study was undertaken with different concentration and duration of PEG-6000 to observe the effect of germination and seedling vigour in chickpea seeds. The experiment was conducted in seed testing laboratory, Department of Seed Science and Technology, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India during 2020-2021 following Complete Randomized Block Design with three replications in order to standardize the appropriate concentration and duration while soaking the seeds within PEG-6000 solution for screening a range of duration concentrations viz, 10 g liter^{-1} for 6 hrs, 10 g liter^{-1} for 8 hrs, 10 g liter^{-1} for 10 hrs, 15 g liter^{-1} for 6 hrs , 15 g liter^{-1} for 8 hrs, 15 g liter^{-1} for 10 hrs, 20 g liter^{-1} for 6 hrs, 20 g liter^{-1} for 8 hrs, 20 g liter^{-1} for 10 hrs, 25 g liter^{-1} for 6 hrs, 25 g liter^{-1} for 8 hrs, 25 g liter^{-1} for 10 hrs. Untreated dry seeds were considered as control. It was found that all the priming treatments showed significance difference in overall including the control. The best performer or the better result was shown by T_8 which is 20 gm/ liter solution with the soaking duration of 8 hrs. It was highest performer in germination percentage (93.77), root length (6.57 cm), shoot length (16.57 cm), seedling fresh weight (1.66 g), seedling dry weight (0.14 g), seedling vigour index I (2137.07), time to 50% germination (2.33 days) and germination index (77.82). This study showed that seed priming with osmotic solution could improve some seedling parameters in chickpea. In seed priming, its simplicity such as no requirements for extensive equipment and chemicals could be used method for overcoming problems related to a poor germination and further seedling establishment and helps in sustaining agriculture with a cost effective approach and with the help of seed priming treatments which are non-toxic and from eco-friendly sources.

Keywords Chickpea, Germination, PEG 6000, Osmo priming, Vigour.

INTRODUCTION

Among the pulses chickpea is the highly nutritious crop. By consumption of crops, it will provide the nutritional security of people as it is a good source of protein, carbohydrate and several essential minerals.

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Chickpea (*Cicer arietinum* L.) is a self-pollinated crop. It is diploid (2n=16) species with genome size 1C=740 Mbp (Arumuganathan and Earle 1991) and belonging to sub family Papilionaceae of the family Leguminaceae (Poehlman and Sleper 1995). It is the world's third-most important food legume (pulse) and is consumed as a high-quality protein food with India being the world's largest producer and consumer of pulses. Chickpea contains 17-22 % protein and 60-64% carbohydrates and helps in sustaining the productivity of the cropping systems through their ability to fix atmospheric nitrogen. India is the largest chickpea producing country accounting for 64% of the global chickpea production. Moreover, in rice-based cropping systems and rainfed regions, chickpea planting is often delayed due to late harvest of rice and/or untimely rainfall. This delay in chickpea planting is often tied with low temperature (Srinivasan *et al.* 1998), which limits the germination and stand establishment (Jame and Cutforth 2004). Priming of seeds in osmoticums such as mannitol, polyethylene glycol and sodium chloride has been reported to be an economical, simple and a safe technique for increasing the capacity of seeds to osmotic adjustment and enhancing seedling establishment and crop production under stressed conditions (Kaur *et al.* 2001). This could be due to faster emergence of roots and shoots, lower incidence of resowing, more vigorous plants, better drought tolerance, earlier flowering, earlier harvest and higher grain yield under adverse conditions (Amzallag *et al.* 1990, Cayuela *et al.* 1996). The beneficial effect of priming on germination has been reported in tomato seeds (Ozbingol *et al.* 1998). Saglam *et al.* (2010) reported priming treatments decreased the effects of water stress and (Ghassemi-Golezani *et al.* 2013) observed that osmo and hydropriming treatments to lentil seeds increased the plant height, number of pods and number of seeds per plant, the 1,000 grain weight, the biological yield, the grain yield and the harvest index when compared to the control. The aim of this study was to observe the effects of osmo-priming treatments with different concentration and duration to chickpea seeds, to analyze the influence of such a treatment over seed germination properties and identify the best concentration with duration for the betterment of plant characteristics, yield components in an experiment conducted with field conditions.

MATERIALS AND METHODS

The experiment was carried out in seed testing laboratory, Department of Seed Science and Technology, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India during 2021 following Complete Randomized Design with three replications. Chickpea (vatiety-Anuradha) was collected from AICRP pulses in Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal for this investigation. Seed priming was done with 10 g liter^{-1} for 6 hrs (T_1), 10 g liter for 8 hrs (T_2), 10 g liter^{-1} for 10 hrs (T_3), 15 g liter^{-1} for 6 hrs (T_4), 15 g liter^{-1} for 8 hrs (T_5), 15 g liter^{-1} for 10 hrs (T_6), 20 g liter^{-1} for 6 hrs (T_7), 20 g liter^{-1} for 8 hrs (T_8), 20 g liter^{-1} for 10 hrs (T_9), 25 g liter^{-1} for 6 hrs (T_{10}), 25 g liter^{-1} for 8 hrs (T_{11}), 25 g liter^{-1} for 10 hrs (T_{12}). Non-primed seeds were the control (T_0). Following observations were taken for this experiment.

Time to 50% germination

According to Association of Official Seed Analysis 1983 number of seeds germinated was recorded in daily basis. The time to obtain 50% germination (T_{50}) was calculated according to the following formulae given by Coolbear *et al.* (1984) which was modified by Farooq *et al.* (2005).

$$T_{50} = t_i + \frac{\left(\frac{N}{2} - n_i\right)\left(t_j - t_i\right)}{(n_j - n_i)}$$

Where, N stands for final number of germination and n_i, n_j are cumulative number of seeds germinated by adjacent counts at times t_i and t_j when $n_i < N/2 < n_j$.

Mean germination time (MGT)

Mean Germination Time (MGT) was calculated with the following equation suggested by Ellis and Roberts (1981).

$$MGT = \frac{\sum D_n}{\sum n}$$

Where D is the number of days counted from the beginning of germination and n indicates the number of seeds germinated on day D.

Germination percentage

Germination percentage (G) was expressed in percentage. It was calculated as :

$$\frac{\text{Number of normal seedlings produced}}{\text{Total number of seeds used}} \times 100$$

Where, X is the number of normal seedlings produced and Y denotes total number of seeds taken for germination (ISTA 1996).

Germination index (GI)

Germination index (GI) was calculated as described in the Association of Official Seed Analysts (AOSA 1990) as the following formulae :

$$GI = \frac{\text{No. of germinated seeds}}{\text{Day of first count}} + - - - - + \frac{\text{No. of germinated seeds}}{\text{Day of last count}}$$

Germination energy

According to Ruan *et al.* (2002) energy of germination (GE) should be recorded at 4^{th} day after planting. It is the percentage of germinating seeds 4 days after planting relative to the total number of seeds tested.

Seedling parameters

Root lengths and shoot lengths of ten seedlings were measured at 8 days after germination by glass plate method in the laboratory with the help of a scale and graph paper and average was made out, expressed in centimeter (cm). Fresh weight of ten seedlings was measured with the help of a digital balance. Then seedlings were dried at 60-70°C for two hours in hot air oven and weighed in a digital balance. Both seedling fresh weight and dry weight are expressed in gram (g).

Vigour index

Vigour index (VI) was calculated by using the formula suggested by Abdul Baki and Anderson (1973): VI= G × L

Where, 'L' denotes average seedling length (cm) and 'G' indicates germination percentage.

RESULTS AND DISCUSSION

Germination index

Germination index was varied significantly and after counting daily basis of seedling emergence up to eight days, lowest Germination index was observed in control (23.06) preceded by T_4, T_1 and T_{12}. While, T_8 (43.10) showed the highest germination index followed by T_{11}, T_5 and T_9. But, non-significant difference was observed in between T_3 and T_{12}, T_3 and T_7, T_2 and T_{10} (Table 1). Similar type of result was observed by Ray and Bordolui (2022b).

Root length (cm)

During different duration and concentration root length of seedling was varied significantly and after

Table 1. Effect of priming on germination index, root length, shoot length, fresh weight and dry weight of chickpea. Note: T_0= Control, T_1=10 g liter^{-1} for 6 hrs, T_2=10 g liter^{-1} for 8 hrs, T_3=10 g liter^{-1} for 10 hrs, T_4=15 g liter^{-1} for 6 hrs, T_5=15 g liter^{-1} for 8 hrs, T_6=15 g liter^{-1} for 10 hrs, T_7=20 g liter^{-1} for 6 hrs, T_8=20 g liter^{-1} for 8 hrs, T_9=20 g liter^{-1} for 10 hrs, T_{10}=25 g liter^{-1} for 6 hrs, T_{11}= g liter^{-1} for 8 hrs, T_{12}=25 g liter^{-1} for 10 hrs.

Treatment	Germination index	Root length (cm)	Shoot length (cm)	Fresh weight (g)	Dry weight (g)
T_0	23.06	4.00	7.56	0.91	0.09
T_1	27.10	4.70	9.56	0.85	0.10
T_2	30.40	4.50	12.55	0.95	0.08
T_3	27.97	4.52	13.93	1.07	0.11
T_4	26.42	4.97	13.28	1.24	0.13
T_5	36.30	6.11	14.79	1.55	0.14
T_6	29.07	4.52	14.58	1.08	0.09
T_7	28.12	5.44	15.56	1.46	0.12
T_8	43.10	6.57	16.57	1.66	0.14
T_9	31.47	4.16	13.29	1.44	0.13
T_{10}	30.06	2.67	12.45	1.10	0.09
T_{11}	42.40	3.46	12.81	1.12	0.07
T_{12}	27.76	5.40	12.35	1.38	0.13
SEm (±)	**0.14**	**0.154**	**0.142**	**0.038**	**0.009**
LSD (0.05)	**0.41**	**0.449**	**0.414**	**0.112**	**0.027**

Table 2. Effect of priming on germination percentage, vigor index, Time to 50% germination, Mean germination time and germination energy of chickpea. Note : T_0 = Control, T_1=10 g liter^{-1} for 6 hrs, T_2=10 g liter^{-1} for 8 hrs, T_3=10 g liter^{-1} for 10 hrs, T_4=15 g liter^{-1} for 6 hrs, T_5=15 g liter^{-1} for 8 hrs, T_6=15 g liter^{-1} for 10 hrs, T_7=20 g liter^{-1} for 6 hrs, T_8=20 g liter^{-1} for 8 hrs, T_9=20 g liter^{-1} for 10 hrs,T_{10}=25 g liter^{-1} for 6 hrs, T_{11}= g liter^{-1} for 8 hrs, T_{12}=25 g liter^{-1} for 10 hrs.

Treatment	Germination percentage (transform value)	Vigor index	Time to 50% germination (days)	Mean germination time (days)	Germination energy (%)
T_0	85.83 (67.86)	992.18	3.55	4.40	51.57 (45.88)
T_1	89.80 (71.37)	1265.44	2.74	3.83	65.64 (54.09)
T_2	88.60 (70.26)	1660.46	2.40	3.53	76.78 (61.18)
T_3	87.90 (69.64)	1609.60	2.72	3.33	65.49 (54.00)
T_4	87.87 (69.61)	1601.85	2.59	3.89	65.20 (53.83)
T_5	91.53 (73.08)	1553.85	2.53	3.69	71.66 (57.82)
T_6	87.37 (69.18)	1844.48	2.88	3.85	59.67 (50.56)
T_7	87.70 (69.46)	1858.32	2.72	3.42	67.46 (55.20)
T_8	93.77 (75.56)	2137.07	2.33	3.34	77.82 (61.89)
T_9	93.60 (75.35)	1611.46	2.43	3.56	71.59 (57.77)
T_{10}	87.27 (69.08)	1295.91	2.50	3.25	69.47 (56.44)
T_{11}	93.63 (75.38)	1515.20	2.95	3.05	71.97 (58.02)
T_{12}	90.93 (72.48)	1611.66	2.96	4.04	59.61 (50.52)
SEm (±)	**0.700**	**28.650**	**0.086**	**0.129**	**0.422**
LSD (0.05)	**2.046**	**83.743**	**0.250**	**0.376**	**1.235**

eight days of final count maximum seedling root length was observed for T_8 (6.57 cm) followed by T_5 and T_7 respectively, while it was minimum for T_{10} (2.67 cm) (Table 1). Although T_1, T_2, T_3 and T_6,T_3 and T_4, T_4 and T_{12}, T_0 and T_9, T_7 and T_{12}, T_2, T_3, T_6 and T_9 showed non-significant difference among themselves (Table 1). Root and shoot lengths increased in seeds due to priming as compared to non-primed seeds reported by Kaur *et al.* (2000), Choudhury and Bordolui (2022a).

Shoot length (cm)

Significant variation was observed for seedling shoot length, when average was taken over treatments; Considering shoot length, the longest seedling shoot length was recorded for T_8 (14.57 cm) followed by T_7 and T_5 while shortest shoot length was observed in Control (7.56 cm) preceded by T_1 and T_{12}. Significant difference was noted for shoot length in overall though non-significant difference was observed in between T_2, T_{10} and T_{12}, T_2, T_{10} and T_{11}, T_4 and T_9, T_6 and T_8 (Table 1). The result corroborates the findings of Farooq *et al.* (2008), Choudhury and Bordolui (2022b).

Fresh weight (g)

Fresh weight of five seedlings was recorded ant it was significantly difference varied in fresh weight after PEG 6000 solution. Highest seedling fresh weight was observed for T_8 (1.66 g) followed by T_5 and T_7 while lowest was noted in T_1 (0.85 g) preceded by T_0 and T_2 respectively. But non-significant difference was noticed in between T_5 and T_8, T_3, T_6, T_{10} and T_{11}, T_5, T_7 and T_9, T_5 and T_8, T_7, T_9 and T_{12}, T_0, T_1 and T_2 (Table 1).

Dry weight (g)

In case of dry weight, it was significantly varied due to priming with different duration and concentration of PEG. Maximum seedling dry weight was noticed for T_5 (0.14 g) followed by T_9 and T_7 respectively while minimum was noticed for T_{11} (0.07 g) preceded by T_2 and T_6 respectively. Although non-significant difference was observed in between T_0, T_1 and T_2, T_0, T_1 and T_3, T_3, T_4, T_7, T_9 and T_{12},T_2, T_6, T_{10} and T_{11}, T_4, T_5, T_7, T_8, T_9 and T_{12} (Table 1). Mohammadi (2009) reported similar kind of experiment in soybean (*Glycine max* L.).

Germination percentage

Significant difference was observed in germination percentage. Among the priming treatments, with

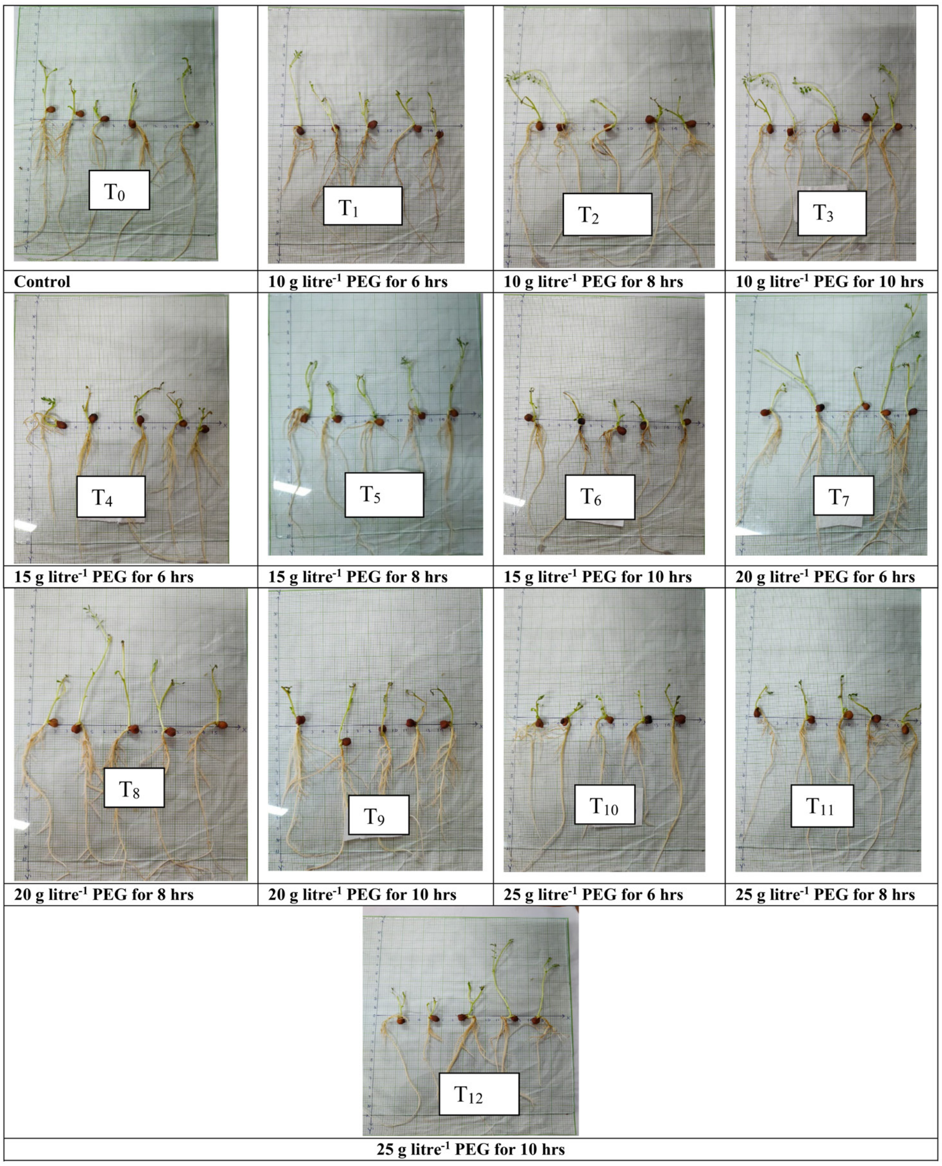

Fig 1. Evaluation of seedling vigour under laboratory condition.

different duration and concentration of PEG 6000, T_8 (93.77 %) recorded highest germination percentage followed by T_{11} and T_9. While lowest germination percentage was recorded for T_0 (85.83 %) preceded by T_4, and T_3 respectively. But, non-significant difference was observed in between T_1, T_2, T_3 and T_4, T_2, T_3, T_4, T_6, T_7 and T_{10}, T_0, T_4, T_6, T_7 and T_{10}, T_1 and T_8 (Table 2). This result is in agreement with Singh and Rao (1993).

Vigour index

Considering vigour index, it was varied significantly when average was made over the treatments. Maximum value was calculated for T_8 (2013.08) followed by T_1 and T_8 respectively, minimum vigour index was noted for T_0 (992.18) preceded by T_{10} and T_3. Although, vigour index was significantly varied, but some non-significant difference was also noticed in between T_1 and T_5, T_3, T_7, T_{10} and T_{12}, T_2, T_4 and T_9, T_6, T_8 and T_{11} (Table 2, Fig. 1). Iqbal (2015) conducted similar kind of experiment in cowpea (*Vigna unguiculata* L.), Chakraborty and Bordolui (2021) observed similar kind of experiment in green gram.

Time to 50% germination (days)

Significant responses were noticed in the priming treatment with different duration and concentration of PEG-6000 solution under laboratory condition. Minimum time to 50% germination was recorded in T_8 (2.33 days) followed by T_2 and T_9. While, maximum time to 50% germination was observed for T_0 (3.55 days) preceded by T_{12} and T_{11}. Although, time to 50% germination was significantly varied, but some non-significant difference was also noticed in between T_1, T_3, T_4, T_5, T_7 and T_{10}, T_2, T_4, T_5, T_9 and T_{10}, T_2, T_5, T_8, T_9 and T_{10} (Table 2). The result corroborates the findings of Dezfuli *et al.* (2008).

Mean germination time (days)

Considering mean germination time T_{11} (3.05 days) had the shortest mean germination time preceded by T_8 and T_2. While maximum mean germination time was noticed in T_0 (4.40 days) followed by T_{12}. Though significant difference was observed in mean germination time but some non-significant difference was also noticed in between T_1, T_4, T_5, T_6 and T_{12}, T_1, T_4, T_5, T_6 and T_9, T_2, T_7, T_8 and T_{10}, T_3, T_7, T_8, T_{10} and T_{11}, T_0 and T_{12} (Table 2). Similar kind of experiment was noted by Ray and Bordolui (2022a).

Germination energy

Among the priming treatments, with different duration and concentration of PEG-6000, significant difference was observed in germination energy. The maximum energy of germination was recorded in T_8 (77.82) followed by T_2 and T_{11} while it was minimum for T_0 (51.57) preceded by T_{12} and T_6. Seed priming treatments enhanced the energy of germination over that of untreated seeds and maximum energy of germination was recorded with hydro-priming in rice (Mahajan *et al*. 2011). Some non-significant difference was also observed in between T_1, T_3 and T_4, T_5, T_9 and T_{11}, T_6 and T_{12} and T_2 and T_8 (Table 2). Sohail *et al.* (2018) observed similar type of experiment in Kabuli chickpea.

CONCLUSION

Seeds of chickpea were treated with various concentration and duration of Polyethylene Glycol recorded higher seed quality parameters compared to control. For soaking duration 8 hrs and concentration 20 g liter^{-1} of PEG 6000 showed significant performance for seed quality parameter like germination percentage (93.77), seedling fresh weight (1.66 g), seedling dry weight (0.14 g), seedling vigour index I (2137.07), time to 50% germination (2.33 days) and germination index (43.10). Therefore, pre-sowing treatment with PEG 6000 @20 g liter^{-1} with duration of 8 hrs is recommended for treating chickpea seed for better seedling establishment.

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