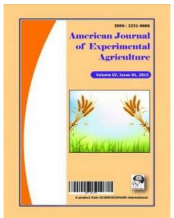

American Journal of Experimental Agriculture
13(1): 1-7, 2016, Article no.AJEA.26810
ISSN: 2231-0606

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Pre-treatment Germination Percentages Affected the Advantage of Priming Treatment in Pepper Seeds

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Authors' contributions

This work was carried out in collaboration between all authors. Authors SE, EO and ESN conducted to work and managed the analysis of study. Author ID designed the study, wrote the protocol and wrote the first draft of the manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJEA/2016/26810
Editor(s):
(1) Dalong Guo, College of Forestry, Henan University of Science and Technology, Luoyang, 471003, Henan, People's Republic of China.
Reviewers:
(1) Thaíse da Silva Tonetto, Federal University of Santa Maria, Brazil.
(2) Ping Leng, China Agricultural University, China.
Complete Peer review History: http://sciencedomain.org/review-history/15124

Original Research Article

Received 3rd May 2016
Accepted 6th June 2016
Published 23rd June 2016

ABSTRACT

This research was conducted to test the benefits of priming treatment and its effects on the pre-treatment germination percentages of pepper (*Capsicum annuum* L.) seed lots. Germination percentages of 12 pepper seed lots which ranged between 66 and 98% before treatment were treated with 2% of KNO_3 solution for 4 days at 20℃. Seed germination percen tages, mean germination time, seedling emergence percentages, mean emergence time and seeds that germinated but were unable to emerge from the soil were determined. The treatment was found to be more successful on germination and emergence of seed lots with low germination percentages than those with high germination percentages. The differences between treated and untreated lots concerning all these criteria were higher in lower quality seed lots compared to those of higher quality. Priming reduced the percentage of seeds that germinated in the soil but unable to emerge. Results showed that priming is more useful for enhancing germination of low quality seed lots than higher quality ones which indicates that repair of ageing is one of the primary advantage of the priming treatments. Priming is therefore a suitable pre-sowing treatment that can be used to enhance the quality of left over and relatively lower quality seeds.

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Keywords: Germination; seedling emergence; mean germination time; mean emergence time.

1. INTRODUCTION

Seed priming technique which involves the controlled hydration and drying-back of seeds before sowing is used on various species of seeds to improve germination and seedling emergence percentages [1-3]. Seed priming improves germination and crop establishment of several types of crop. Seed priming has been widely used to enhance the germination response of agricultural crop species. Numerous factors are responsible for deriving effective and maximal benefits from priming treatments such as priming method, priming medium, treatment temperatures and duration, post treatment seed drying temperatures, plant growth promoters added to solution [2,4]. Moreover performance depends on the crop variety, crop imbibition behavior, priming method, and imbibition time [5].

Initial seed germination percentage can also be a factor that determines the maximum benefit obtained from priming treatment [6]. Germination percentage is the main seed quality parameter that reflects to what extent seed has gone through ageing process. As the ageing progresses seed germination percentage declines. There are some reports that priming treatments are more advantageous in low germinating seeds than that of high germinating ones [5].

Pepper is a warm climate crop and seeds are sensitive to storage conditions and lose germination potential within a short period of time, particularly under adverse storage conditions [7]. Pepper is propagated through transplants and decline in germination potential due to seed ageing may result in low seedling emergence in transplant modules and reduce transplant quality. In some cases left over seeds i.e. slightly low germinating seeds might have to be treated when previous years seed production is excessive and not being sold and had to be stored. The objective of the present study then was to determine how the effect of priming treatment changes according to the pre-treatment germination percentages of seed lots in pepper.

2. MATERIALS AND METHODS

2.1 Seed Material

Twelve seed lots of pepper (*Capsicum annuum* L.), Sera Demre cultivar, roughly about 10 grams of seeds, were obtained from different companies in Turkey and stored at 5℃ about 4 months before use. These lots collected were produced in different production seasons and regions of Turkey. Initial seed moisture content of the seeds was determined using the low temperature oven method [8]; and the moisture content of the lots ranged between 7.2 and 9.4%.

2.2 Priming Treatment

Priming was carried out by placing seeds (3 g) in 9 cm petri dishes containing two Whatman filter papers moistened with 8 ml of 2% KNO_3 solution (2 grams/100 ml) and kept at 20℃ for 4 days in the dark. Thiram (0.2%, w/v) was added to the salt solution to inhibit fungal development, and the petri dishes were covered with plastic film to prevent excessive loss of liquid during the treatment. At the end of the treatment seeds were rinsed under tap water and dried to 8±0.3% moisture content on top of filter paper at room temperature inside the laboratory (20±3℃) for about 24 hours. Seed germination and seedling emergence commenced 5 days after the treatment. During this period, seeds were kept at 5℃ in glass jars.

2.3 Germination, Emergence and Mean Germination/Emergence Times

Germination test of treated and untreated seeds in each lot was carried out in petri dishes (9 cm diameter) containing two Whatman no:1 filter papers imbibed with 5 ml of distilled water. Four replicates of fifty seeds were set up for each treatment. The germination test was conducted at 25℃ in the dark for 14 days [8]. Germination percentages (germination defined as two mm radicle protrusion) were recorded daily during the 14 days period.

Seedling emergence was determined by sowing treated (T) and control (C) seeds (four replicates of 50 seeds/lot) 2 cm deep in peat moss (Plantaflour, Humus–Verkaufs GmbH, Germany) in large plastic boxes (32 x 16 x 6 cm). The seed trays were placed in a growing cabinet maintained at 20±2℃. Cool fluorescent lamps (72 $\mu Mm^{-2}s^{-1}$) were used to supply light to the seedling throughout the test period. The seedling trays were watered with the same amount of water as and when necessary. Seedlings (cotyledons appeared on the surface) emerged above the soil surface were counted daily and the experiment was terminated 25 days after sowing. Emerged seedlings were expressed as percentages. At the end of the emergence test, the peat moss was dug out and those seeds that germinated under the soil but were unable to emerge above the surface were counted and expressed as percentages as well.

The mean germination/ emergence times were calculated according to [9] as follows:

$$MGT/MET: \sum (n \times D) / \sum n$$

Where, MGT/MET is the mean germination/ emergence time, n, is the number of seeds germinated/emerged at D days, D, is the number of days from the start of germination/emergence test.

Duncan multiple range test was performed using SPSS packet programme ($p<0.05$) in order to compare the means of control and treatment in Table 1. Regressions (R^2) were performed to find out the relationship between pre-treatment seed germination percentages and various seed quality parameters in figures.

3. RESULTS

Pre-treatment seed germination percentages of 12 seed lots ranged between 66 and 98% in control and 73 and 97% in treated seed lots (Table 1). The seed lots that have lower germination percentages had longer mean germination time. Treatment reduced mean germination time in all seed lots. Mean germination time ranged between 4.4 and 7.4 days in control, 2.9 and 5.6 days in treated seed lots, respectively. Seedling emergence percentages of the lots were slightly lower than radicle emergence percentages. With a few exceptions all seed lots had higher emergence percentages after treatment (Table 1). The difference between emergence percentages of control and treated seeds was highest in lot 8 as 43%, none as 0% in lot 2 and slightly lower (3%) than the control in lot 3. Treatment was positively influential in enhancing germination in nine seed lots out of twelve. Mean seedling emergence time values were also lower in treated seed lots than those of the control. The percentages of seeds that germinated but unable to emerge were higher at pre-treatment low germinating seed lots. The percentage of seeds that germinated but unable to protrude was over 30% in lots 8, 9, 11 and 12 (Table 1).

The priming treatment was pivotal in inducing the germination percentages. This was more prominent in seed lots with lower pre-treatment germination percentages (Lots 8 and 12). Pre-treatment seed germination percentages were highly related to seedling emergence in control (R^2=0.71, $p<0.01$), and treated seed lots (R^2=0.87, $p<0.001$) (Fig. 1).

The difference in germination of treated and control seeds between the lots that have high pre-treatment germination percentages are less compared to those of low pre-treatment germination percentages. The advantage of the treatment was more prominent in seed lots with low germination percentages compared to higher germination percentages (Fig. 2).

Table 1. The effect of treament (2%, KNO_3, 4 days, 20℃) on radicle emergence (%), mean germination time (MGT), seedling emergence (%), mean emergence time (day), germinated but unable to emerge seedling percentage of control (C) and treated (T) of 12 pepper seed lots

Lot	Radicle emergence (%)		MGT (days)		Seedling emergence		MET(days)		Germ. but unable to emergence (%)	
	C	T	C	T	C	T	C	T	C	T
1	98 a	97 a	6.4 ef	4.5 b	85 a	90 a	13.4 d	10.8c	5 fg	2 f
2	98 a	95 ab	5.6 c	4.2 b	85 a	85 b	11.9 b	10.3 b	7 f	5 ef
3	95 ab	93 bc	7.0 g	4.4 b	88 a	85 b	12.5 c	11.6 fg	0 i	7 e
4	95 ab	92 bc	6.0 d	5.0 c	85 a	93 a	12.4 c	9.6 a	5 fg	3 f
5	92 b	92 bc	4.4 a	2.9 a	77 b	82 b	11.4 a	9.5 a	2 hi	8 e
6	92 b	90 cd	4.7 b	2.9 a	73c	78 c	12.3 bc	9.5 a	3 gh	5 ef
7	87 c	90 cd	6.5 f	4.4b	63 d	70 d	13.8 d	10.1 b	7 f	12 d
8	87 c	87 d	6.8 g	5.4 de	35 h	78 c	13.8 d	10.9 cd	30 d	7 e
9	73 d	78 e	6.2 de	5.3 cde	38 gh	55 e	12.5 c	11.2 de	40 a	22 b
10	70 d	77 e	6.2 de	5.4 de	53 e	67 d	13.4 d	11.4 ef	17 e	20 b
11	70 d	78 e	6.8 g	5.2 cd	45 f	55 e	12.8 c	11.9 g	33 c	15 c
12	66 e	73 f	7.4 h	5.6 e	40 g	55 e	13.9 d	11.9 g	36 b	25 a

Means with the different letter (s) in the same line in each cultivar and run are significant ($p<0.05$), C: Control T: Treated, 2%, KNO_3, 4 days, 20℃

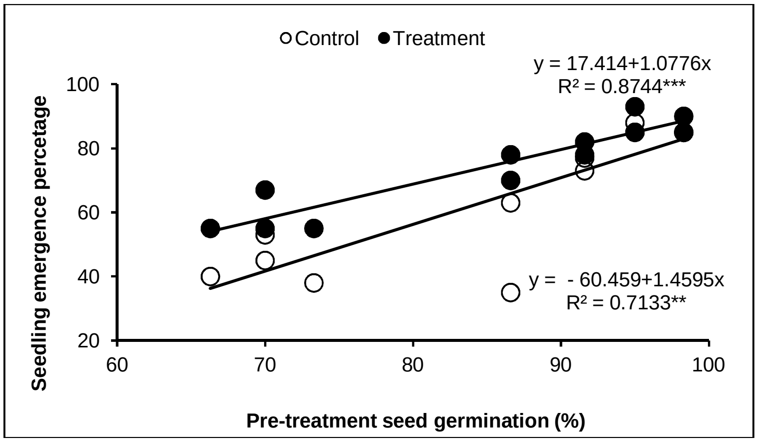
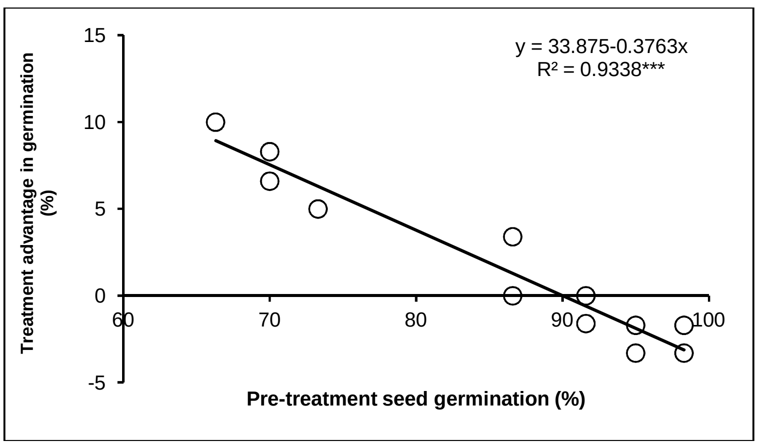


Fig. 1. The relationship between pre-treatment seed germination and seedling emergence percentages in relation to priming treatment (●, 2%, KNO_3, 4 days, 20°C) and control (○) seeds of 12 pepper seed lots

(: p=0.05, **:p=0.01, ***: p=0.001)*



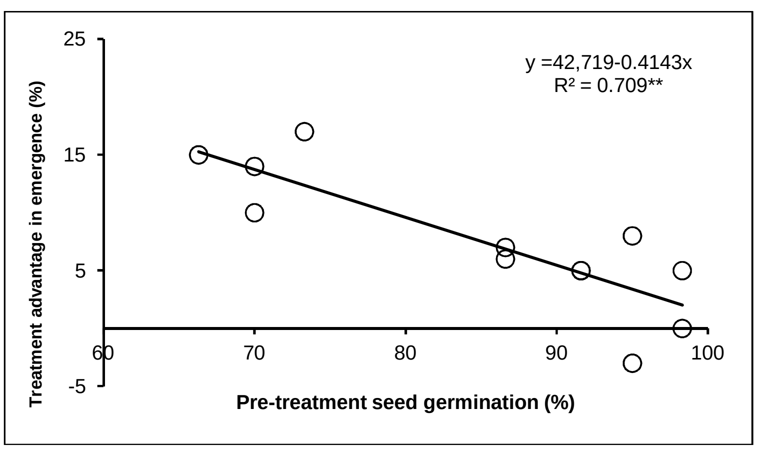


Fig. 2. The relationship between pre-treatment seed germination and the advantage obtained by the priming treatment on seed germination and seedling emergence percentages of 12 pepper seed lots. The advantages were calculated by substracting control (C) from treated seed (T) percentages in each lot in Table 1

(: p=0.05, **:p=0.01, ***: p=0.001)*

Mean emergence time differences between treated and control seed lots were very similar in relation to pre-treatment germination percentages. The difference in the mean germination time is about 2 days. The R^2 value (0.66, $p<0.05$) was higher in treated seed lots than that of the control (0.56) (Fig. 3).

The treatment reduced the percentage of germinated but unable to emerge seeds and highly related to pre-treated germination percentages (R^2=0.88, $p<0.001$) (Fig. 4).

4. DISCUSSION

The results of the present work indicated that the pre-treatment germination percentages of pepper seed lots affect the advantage obtained from priming (Table 1 and Figs. 1 and 4). The lower the pre-treatment germination percentages the more the advantages were obtained from the priming treatment (Figs. 1 and 3). This is similar for both seed germination and seedling emergence percentages. The most significant reason of positive influence influences of priming on seed lots with low germination percentages can be attributed to the repair mechanism induced by priming treatment [10]. It was reported that priming may trigger reinvigoration; repair of ageing and in turn outcome of the priming is more prominent on aged seeds and stressful environments [5,11]. The pre-treatment range of seed germination in our work is much wider between 66 and 98% (Table 1). The triggering repair of ageing by the priming treatments has biochemical effects that are significant for upgrading the quality of left over seeds from the previous year's production. Seeds are stored over a year when excess produce is realized or when all the produce is not sold in the same year. In some cases the storage is done without a hermetic packaging therefore seeds are subjected to ageing depending on the storage environment. Such seeds can be treated to maintain viability and the good quality for sale in subsequent the year. The potential of priming in repair of seed ageing was also considered to be fundamental in extending the longevity of seed accessions in seed gene bank material [12].

The priming was found to be more influential on low germinating seed lots but the mean germination time and emergence times were equally influenced in all seed lots. The most significant influences of priming on the seeds under study is the shortening seed germination time (reducing mean time to germination). There are number of papers on that issue [1,2,13,14]. The major reason is that primed seeds complete the first two stages of imbibition during the priming process. Upon sowing, treated seeds tend to complete the third stage of imbibition and therefore emerge faster [1]. It was also observed that treated seeds produced larger seedlings and better stands in the field or greenhouse compared to untreated [5]. Pepper seeds are known to be short lived and depending on the storage conditions a fast decline in germination potential and viability of seeds may occur especially under adverse conditions [7,12]. Peppers are produced by transplants modules in glasshouse in which early emergence is an important physiological process that is significant

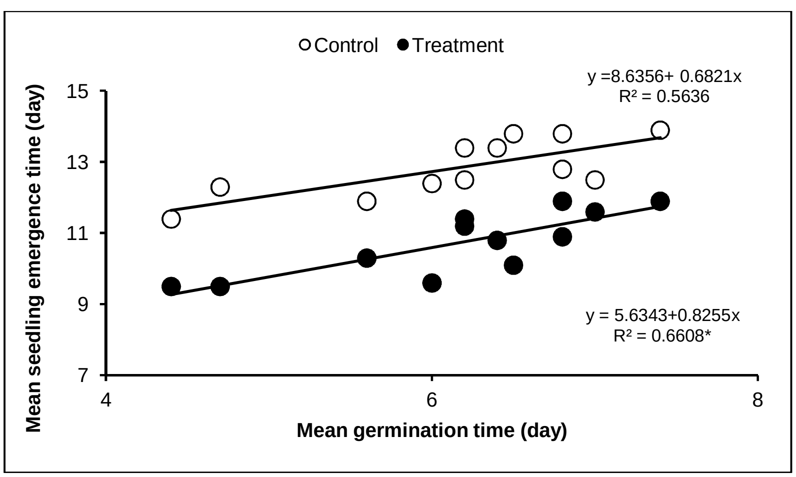


Fig. 3. The relationship between mean germination time (day) and mean emergence time (day) in relation to control (○) and treated (●) 12 pepper seed lots
(: p=0.05, **: p=0.01, ***: p=0.001)*

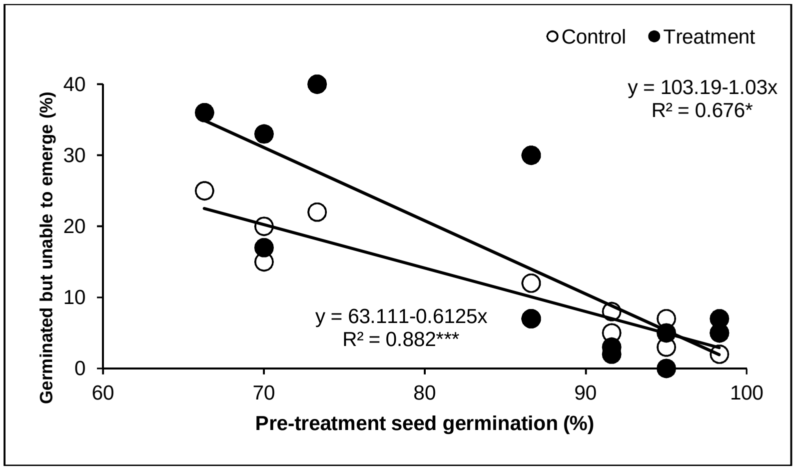


Fig. 4. The relationship between pre-treatment seed germination and germinated but unable to emerge seedling percentages in relation to treatment in 12 pepper seed lots. The values were compiled from Table 1

(: p=0.05, **:p=0.01, ***: p=0.001)*

for producing uniform and well developed transplants. The results obtained from this research indicate that early seedling emergence in various seed lots with different germinability Priming may have a potential to get better transplant production in low quality seed lots. The priming treatment is a useful tool for seed companies to produce high quality transplants because priming invigorates seed quality and enhances the vigour of seedlings produced from low quality or aged seeds. Increase in seedling vigour through priming also enhances the ability of the seedlings to penetrate the soil surface and emerge faster. There are number of papers that priming enhance germinability under adverse conditions such as abiotic stresses as salt [11,14,15]. This result indicated that treatment enhanced not only germination potentials but also protrusion of the seedlings to the surface. This is a good sign of post radicle emergence enhancement in the soil by the priming. This conclusion was also in line with previous findings in watermelon seeds [16].

5. CONCLUSION

In conclusion, priming can be a useful tool for enhancing seed germination of low germinating pepper seed lots. In turn this can be well reflected on the transplant size and quality which is an important physiological property that is valuable for transplant producing companies.

ACKNOWLEDGEMENT

We express our sincere thanks to Tübitak (The Scientific and Technological Research Council of Turkey) and Ankara University (BAP Scientific Research Project Office) for financial support.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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