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Sustainable Hydropriming Strategies to Enhance Seed Germination and Seedling Vigour in Lentil (*Lens culinaris* Medik)

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ABSTRACT The quality and yield of an agriculture crop are highly dependent on uniform and rapid germination of the seeds. Pre-sowing hydropriming is one of the most suitable, reasonable, easily available, and highly cost-effective environment friendly techniques for improving seed quality and enhanced seedling growth. Henceforth, a laboratory experiment was conducted to assess the effect of hydro-priming duration on germination and seedling growth of lentil. The experiment was laid out in two factor Completely Randomized Design (CRD) with three replications and five treatments including different hydro-priming durations (Control, Hydropriming for 12 hours,14 hours, 16 hours and 18 hours) in two varieties namely PDL 1 and IPL 316. Hydropriming seeds for 16 hours significantly improved their performance compared to non-primed seeds in both of these varieties tested. The results showed an increase in speed of germination by 53% and 69%, a boost in germination rate by 12.6% and 8.2%, and enhancements in Vigour Index I by 36% and 12%. Additionally, Vigour Index II increased by 27.8% and 7.4%.In both of these varieties, the highest seed quality parameters were recorded in the 16 hours of hydro-primed seeds whereas the lowest seed quality parameters were observed in non-primed seeds. Overall, from this experiment it was concluded that 16 hours of seed hydro-priming duration proved to be an effective method for enhancing seed germination and vigour.

Keywords: Seed priming, Lentil, Hydro priming, seed quality, seed germination and seedling vigour

INTRODUCTION

Lentil (*Lens culinaris* Medik.), an herbaceous annual plant with a diploid (2n=14) chromosome count, is a self-pollinated seed legume within the Fabaceae family. In India, it is considered as second most important winter season legume crop [1]. It covers an area of 1.46 million hectare with a production of 1.49 million tonnes and productivity of 1,017 kg ha^{-1} [2]. Seed priming is a simple, cost-effective, and efficient method for improving crop performance. This approach, described as a physiological technique, involves hydrating and subsequently drying seeds to enhance their pre-germinative metabolic processes [3]. In hydropriming, seeds are soaked in water, with or without aeration, at an optimal temperature, generally between 5°C and 20°C. This occurs without the emergence of the radicle, using either water or other priming agents. Hydropriming involves soaking seeds in water before planting for a specified period of time. Following hydropriming, seeds are typically surface dried until they regain their original weight. Achieving high yields, both in terms of quantity and quality, in annual crops relies heavily on rapid and uniform emergence in the field. The success of seed priming is significantly influenced by the duration of priming. Controlled imbibition of water that forms the basis of seed priming technology is fundamentally affected by soaking duration. Duration of priming is a crucial factor that influences germination success and seedling establishment [4]. Seed priming before radicle emergence can definitely offer benefits. However, prolonged priming durations may lead to adverse effects on seed germination, such as the risk of seedling death upon drying out. Hydropriming beyond optimal limits can negatively impact seedling length and dry weight in black gram [5]. Henceforth, the study aimed to optimize the duration of hydropriming for enhancing the seed quality performance in PDL 1and IPL 316 varieties of lentil based on several seedling parameters.

MATERIALS AND METHODS

A laboratory experiment on optimization and enhancement of seed quality parameters through hydropriming in lentil seeds was conducted in the Division of Seed Science and Technology, IARI, New Delhi. Genetically pure lentil seeds of variety PDL 1 and IPL 316 were obtained from the Division of Genetics, ICAR-IARI, New Delhi was used. Seeds of lentil were hydroprimed for different soaking durations of 12, 14, 16, and 18 hours at 20°C. The seed-to-water ratio was 1:2 (w/v). After different hours of soaking durations, water was drained out and the seeds were shade dried to bring back to the original seed weight. Seeds were subjected to germination test for evaluating seed quality parameters along with unprimed control. The experiment was carried out with three replications in Completely Randomized Design (CRD).

Germination (%)

Germination test was conducted in three replications by between paper (roll towel) method as described by ISTA [6]. Three replicates of 25 seeds each were randomly selected from each treatment and evenly spaced on wet germination paper. The rolled papers were subsequently incubated in a walk-in germinator at a constant temperature of 20°C, with 90% relative humidity maintained during the germination test. At the end of tenth day after germination test, seeds were evaluated based on number of normal seedlings and expressed in percentage.

Root and Shoot length

At the end of the germination test, ten normal seedlings were taken at random and for the root length, from the point of attachment of seed cotyledon to the tip of primary root, length of root was measured and for the shoot length, from the point of attachment of seed cotyledon to the tip of primary shoot length of shoot was measured. The mean values of root and shoot length were recorded in centimetre.

Seedling dry weight

The seedlings used for measuring root and shoot length were put in butter paper cover and dried in hot air oven at 55° C for 48 hours. Dried seedlings were weighed and expressed in g per 10 seedlings.

Vigour index I & II

Vigour index was calculated using the following formula as suggested by Abdul-Baki and Anderson [7].

Vigour index I = Germination percentage x seedling length

Vigour index II = Germination percentage x seedling dry weight

Speed of germination

Three replications with twenty-five seeds for each replication were used to test the speed of germination. Every day from the second day after initiating germination until the final count, the seeds with protruding radicles were counted and the speed of germination was calculated and the results were expressed in number using the following formula as suggested by Maguire [8].

$$\text{Speed of germination} = \frac{X_1}{Y_1} + \frac{X_2 - X_1}{Y_2} + \ldots\ldots\ldots\ldots + \frac{X_n - X_{n-1}}{Y_n}$$

X_1- Number of seeds germinated at first count

X_2- Number of seeds germinated at second count

X_n- Number of seeds germinated on n^{th} count

Y_1- Number of days from the start of the test to the first count

Y_2- Number of days from the start of the test to the second count

Y_n- Number of days from the start of the test to the n^{th} count

Mean germination time

Three replicates of 25 seeds each were randomly selected from each treatment and arranged equidistantly in a petri dish for the germination test. Daily observations were made to record seed germination, with seeds showing a radicle emergence of more than 2 mm considered as germinated. The Mean Germination Time (MGT) was then calculated using the following formula Ellis and Roberts [9].

$$\text{Mean germination time (MGT)} = \frac{\Sigma\,(Dn)}{\Sigma\,n}$$

Where, n is number of seeds newly germinated at time 'd'

D is days from putting the seeds for germination

Statistical analysis

The experiment was carried out with three replications in Completely Randomized Design (CRD). The results were expressed as the mean of 3 biological replicates. Variations among different treatments were analysed using the general linear model procedure of IBM SPSS Statistics for Windows 24.0 (IBM Corp., Armonk, NY, USA) and the means were compared using the Tukeys' at 5% probability ($p \leq 0.05$).

RESULTS AND DISCUSSION

The ANOVA of the laboratory data revealed significant effect of hydropriming duration on seed quality parameters, which are discussed below.

Germination (%): Germination was statistically significant due to hydro-priming in PDL 1 and IPL 316 variety of lentil seeds. In both the varieties; PDL 1 and IPL 316, seeds hydro primed with 16 hours duration registered higher germination(98 % and 92 %)compared to other treatments and lowest per cent of germination were registered in unprimed seeds (87 and 85 per cent) respectively (Fig.1). The optimization of duration of hydropriming revealed that seeds hydro-primed with 16 h duration increased the germination by 12.6 and 8.2 percent in PDL 1 (Fig. 4a) and IPL 316 varieties (Fig. 4b) respectively. The findings align with previous research indicating that hydropriming for 16 hours significantly enhances seed germination and seedling emergence in lentils. In contrast, longer hydropriming durations of 24, 36, and 48 hours were found to be less effective than the 16hours treatment [10].The results of the present study are also in agreement with reports on rice, seed hydropriming with 24 hours showed improved seed germination and seedling growth[11]. The observed enhancement in seed germination following hydro-priming is believed to be due to the activation of the seed's metabolic processes, which leads to quicker and more uniform germination. This process may involve the mobilization of reserves and the enhancement of enzymatic activities that facilitate germination [12]. Seed priming essentially improves seed performance, leading to earlier and more consistent germination through a range of physiological, biochemical, molecular, and cellular alterations [13].

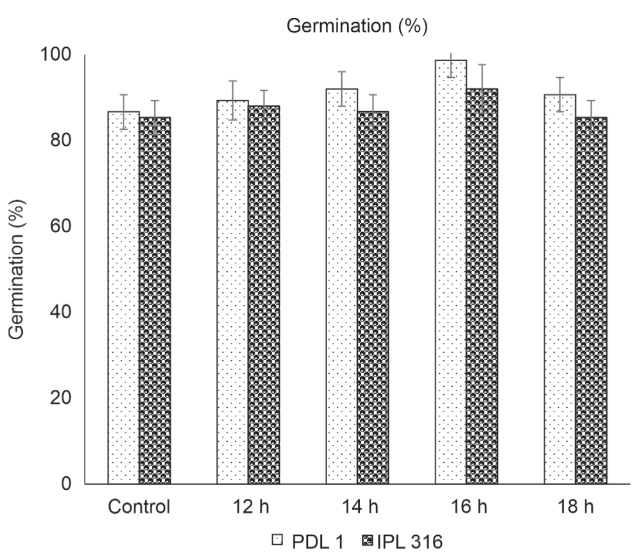

Figure 1. Effect of duration of hydro priming on germination percentage in PDL 1 and IPL 316 of lentil seeds

Mean germination time and Speed of germination: Significant differences were observed for speed of germination and mean germination time due to hydropriming with different durations in PDL 1 and IPL 316 of lentil seeds. Seeds hydro primed with 18 h duration which registered higher speed of germination (22.33) in PDL 1 and seeds hydro primed with 16 h duration which registered higher speed of germination (18.67) in IPL 316, whereas lower speed of germination was recorded (13.83) and (11.00) in non-primed seeds, respectively (Fig. 2a). The increase in germination speed was 54% for PDL 1 and 69% for IPL 316 compared to non - primed seeds. Research indicates that hydropriming significantly increases the speed of germination in both of these varieties. For instance, seeds that undergo hydropriming exhibit a rapid initial hydration phase, which facilitates quicker metabolic activation compared to dry seeds [14]. In a study on wheat, seeds primed for 12 hours demonstrated a notable increase in germination speed, germinating faster than unprimed seeds due to the immediate availability of moisture, which allows them to initiate the germination process earlier. Hydropriming significantly influenced mean germination time. Seeds hydro primed with 16 hours of duration revealed that the rapid germination was recorded for primed seeds with least MGT value of 1.15 days and 1.25 days in PDL 1 and IPL 316 respectively, whereas the higher MGT values were recorded in unprimed seeds of 2.0 days and 1.96 days in PDL 1 and IPL 316 respectively which depicts the delayed seed germination (Fig.2b). These findings align with previous research, whereas 12-hour hydroprimed wheat seeds reached 50% germination (G50) faster than unprimed seeds, which had longer MGT. The findings of this study align with previous research, where hydropriming for durations of 12, 24, and 36 hours consistently improved germination characteristics compared to non-primed seeds. Notably, the 24-hour hydropriming duration was particularly effective in reducing the mean germination time [15]. The present study demonstrated that hydropriming significantly reduced Mean Germination Time (MGT), a key indicator of faster germination. A lower MGT reflects quicker

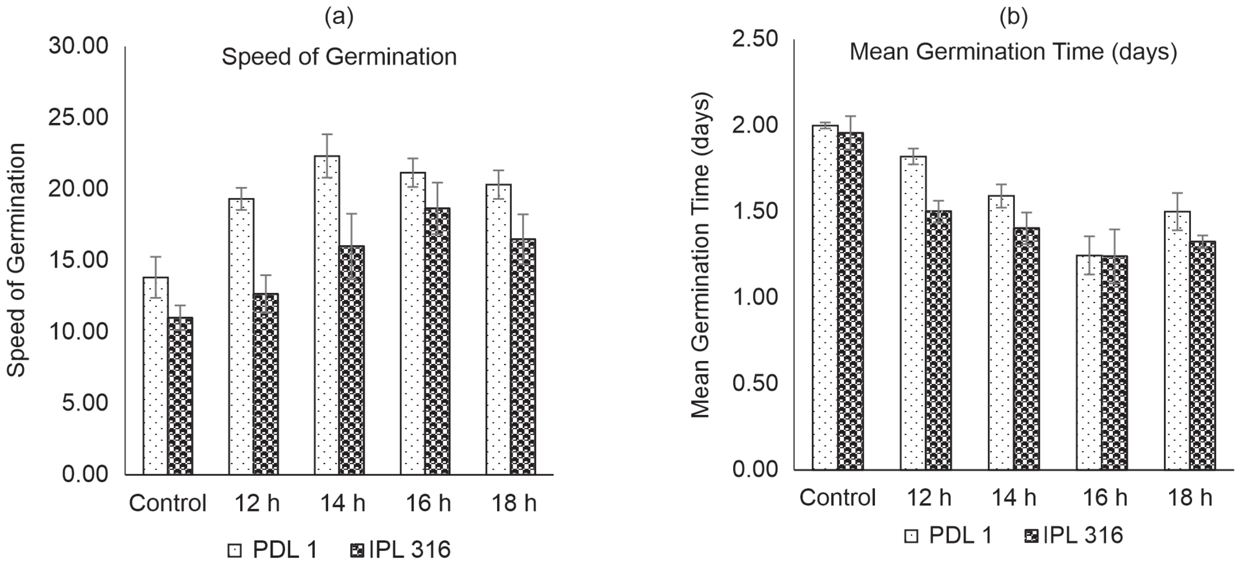

Figure 2. Effect of different durations of hydropriming treatments on (a) - Speed of Germination and (b)- Mean Germination Time in PDL 1 and IPL 316 lentil seeds

germination initiation, which is beneficial for seedling establishment. These results underscore hydropriming's effectiveness in accelerating germination and improving seedling emergence.

Vigour index I: Significant differences were observed in vigour index I of PDL 1 and IPL 316 variety of lentil seeds due to hydropriming. Seeds hydro primed with 16 hours duration registered higher value of 2668.53 in PDL 1 and 3167.23 in IPL 316 compared to other hydropriming treatments whereas lowest vigour index I was recorded in unprimed seeds. The increase over sunprimed seed of vigour index I was 36% and 22% in PDL 1 and IPL 316 varieties, respectively (Fig. 3a).

Vigour index II: Vigour index II values were significantly influenced by different durations of hydropriming treatment in PDL 1 and IPL 316 of lentil seeds. In PDL 1 variety, highest vigour index values of 8.41 was observed in hydropriming with 14 hours and in IPL 316 variety, highest vigour index values of 11.15 was observed in hydropriming with 16 hours compared to other

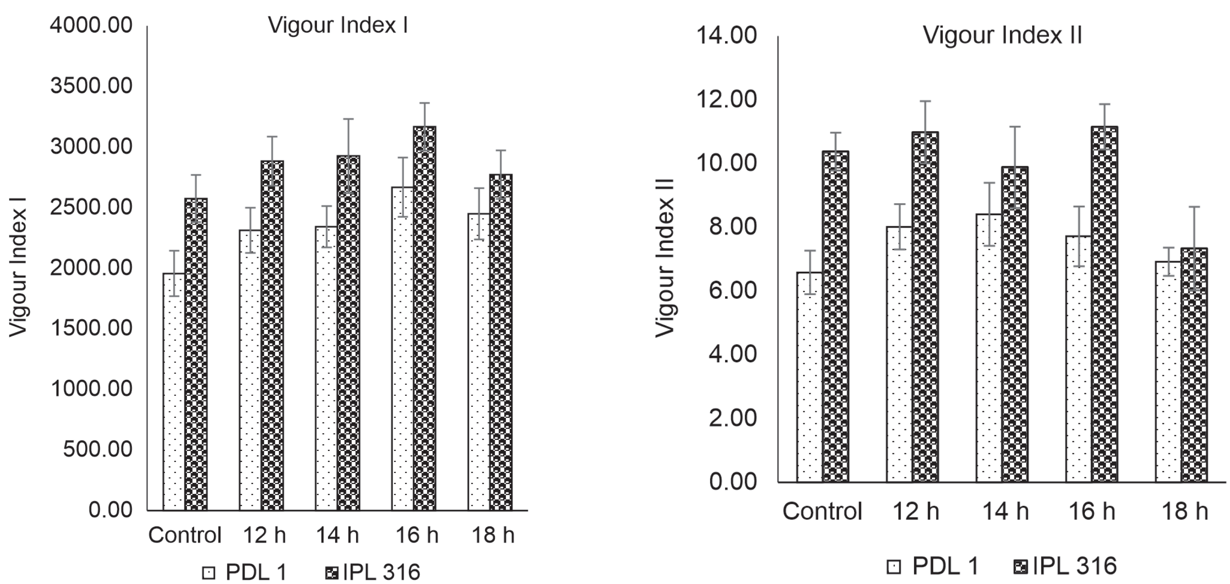

Figure 3. Effect of different durations of hydropriming treatments on (a) Vigour Index I and (b) Vigour Index II in PDL 1 and IPL 316 lentil seeds

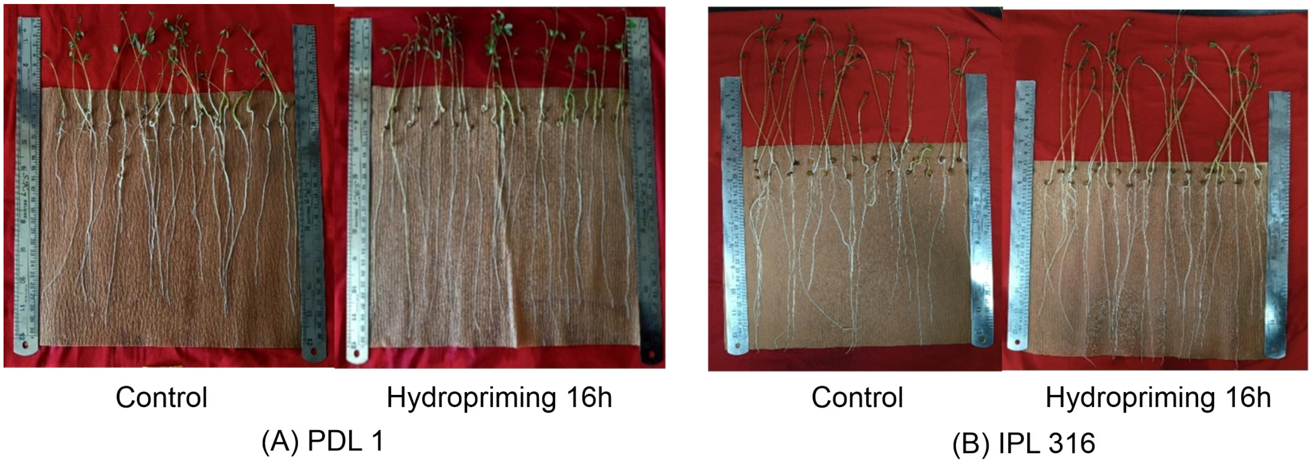

Figure 4. Influence on lentil seed hydropriming on germination percentage and seedling vigour in (A) PDL 1 and (B) IPL 316 seeds compared to control

hydropriming treatments whereas lowest vigour index values were recorded in unprimed seeds. The increase over control seeds of vigour index II was 27.8 % and 7.4 % in PDL 1 and IPL 316 varieties, respectively (Fig. 3b & Fig. 4).This study aligns with previous research, where 36 and 48-hour hydropriming in bitter gourd seeds significantly enhanced water imbibition, resulting in higher germination percentage, and improved seedling vigour index [16]. Similar outcomes were noted in studies on the germination and seedling performance of various crops, including faba bean [17], black gram [18], cucumber [19], and tomato [20].The observed increase in germination and seedling vigour can be attributed to hydropriming, which enhances water absorption and activates crucial metabolic processes. This hydro-priming treatment ensures more uniform and quicker germination, improves overall seed quality performance and ultimately leads to vigorous seedlings and better plant establishment [21].

Conclusion

The results of the present study demonstrated that hydropriming duration has a significant impact on seed germination and seedling growth in lentils. Hydropriming for 16 hours significantly enhanced the seed germination percentage, speed of germination, reduced mean germination time, and improved seedling vigour index in both PDL 1 and IPL 316 varieties. This duration of hydropriming effectively optimizes seed quality, leading to better germination and robust seedling development. Additionally, hydropriming can minimize the need for additional treatments during early growth stages by enhancing germination speed, reducing mean germination time, and improving uniformity of germination. This study also supports sustainable agricultural practices. Thus, hydropriming is a practical and cost-effective technique that enhances seed quality, overall seedling performance, and provides a promising alternative for seed quality enhancement in lentil.

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