

# Hydro-priming as a Sustainable Approach for Improving Germination and Seedling Growth in Tomato (*Solanum lycopersicum* L.)

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**ABSTRACT:** Uniform and rapid germination of seeds significantly impacts the yield and quality of tomato. Pre-sowing seed hydro-priming emerges as a cost-effective, and easily accessible technique for improving germination rates. Its affordability and effectiveness make it a preferred method for enhancing crop productivity. An experiment was conducted to assess the effect of different hydro-priming durations and seed to water ratio on germination and seedling growth of tomato. The treatments included hydro-priming of tomato seeds of the variety Pusa Rohini at different durations (3, 6, 9, 12, 15, 18, 21, 24, 27, 30, and 33 hours) with 1:1 and 1:2 (w/v) soaking volumes. The results of the study revealed that highest germination percentage (8.2%), shoot length (14.6%), root length (21.1%), total seedling length (19.5%), seedling fresh weight (43.3%), seedling dry weight (58.1%), seedling vigor index I (29.5%) and II (72.7%) were observed in 24 hours of priming duration compare to unprimed seeds. Similarly enhanced seed quality parameters were also observed in 1:2 (w/v) seed to water ratio. Thus, 24 hours of seed hydro-priming with 1:2 water ratio has been found to be effective in enhancing seed quality, including improvements in germination, seedling growth, and vigor in tomato.

**Keywords:** Tomato, hydro-priming, germination and seedling growth

## INTRODUCTION

Tomato, a widely cultivated vegetable crop known for its economic importance and nutritional value. In spite of its extensive cultivation, tomato yields are still low compared to achievable yields. However, the quality of seeds used by farmers has been implicated as a possible cause [1]. Dormancy has been observed in freshly harvested tomato seeds [2]. The main hindrance to germination in tomato seeds is the rupture of the endosperm. In instances where germination is limited by the endosperm, the softening of the micropylar endosperm surrounding the radicle tip is essential for the emergence of the radicle. This process likely involves the breakdown of cell walls through hydrolytic enzymes [3]. Thus, degradation of the endosperm in tomato is essential to initiate the germination [4]. So, it became extremely important in this aspect to increase the seed's physiological status, germination, and seedling development.

Various researchers have innovated new methods known as seed quality enhancement techniques to enhance seed quality. Seed priming, an effective way to revitalize seeds, has become widely adopted in the past two

decades. It is used to improve the speed of seedling emergence and crop establishment, especially in vegetable and flower crops [5]. It is a cost-effective and efficient method for improving crop productivity and it is characterized as a physiological approach that includes hydration followed by drying of seeds to enhance pre-germinative metabolic processes without radicle emergence in water or other priming solutions [6]. It has gained significant attention for its ability to enhance germination and seedling growth in various crops. Among the different priming methods, hydro-priming stands out as a simple and effective approach that involves soaking seeds in water before drying them [7]. This process enables water absorption by the seed and softens the seed coat, facilitating quicker and easier growth of the seed embryo. Additionally, the successful hydro-priming treatment activates metabolic pathways during germination's second step, which are temporarily stopped, leading to improved plant behavior in the field [8]. The early emergence, short germination period and vigorous seedlings were observed in hydro-primed seeds in various crop species.

The duration of hydro-priming has been recognized as a critical factor influencing seed germination and subsequent seedling development in plants, including tomato (*Solanum lycopersicum* L.) and every crop variety has a specific soaking time that is below the safe threshold [9]. Therefore, understanding the suitable priming duration is pre-requisite to achieve the best results. However, there is limited information available regarding the precise hydro-priming duration, particularly for tomato. Therefore, this study was carried out to investigate the optimum hydro-priming duration and also the effect of hydro-priming on enhancing germination and seedling vigour of tomato.

## MATERIAL AND METHODS

### Experimental details

The present research was conducted at the Division of Seed Science and Technology, ICAR- Indian Agricultural Research Institute at New Delhi, India during 2022-23. It involves the study on effect of hydro-priming duration and soaking volume *i.e.*, seed to water ratio on seed quality in tomato. The variety used for study was Pusa Rohini and the treatments involved were control (Unprimed), HP-3h (hydro-priming- 3 hours), HP-6h, HP- 9h, HP- 12h, HP-15h, HP-18h, HP- 21h , HP-24h, HP-27h, HP-30h and HP-33h. As radicle emergence was observed at 36 hours of duration, treatments were considered till 33 hours. The different seed to water ratios used were 1:1 and 1:2 (w/v). A completely randomized design with 50 seeds and 4 replications was employed to set up the experimental treatments.

### Seed quality parameters

#### Germination percentage (%)

The germination test was conducted using the method as per ISTA (2022) [10], with minor modifications. A fifty seeds in four replications were placed on moist germination paper and then rolled towels were incubated at  $25 \pm 1$  °C and  $90 \pm 2\%$  relative humidity. The final count was taken on 14th day. The normal and abnormal seedlings were classified as per criteria given in Chapter “The Germination Test” of ISTA (International Rules for Seed Testing). The germination percentage was expressed based on normal seedlings observed and calculated using the following formula.

$$\text{Germination (\%)} = \frac{\text{Number of normal seedlings observed}}{\text{Total number of seeds}} \times 100$$

#### Shoot, root and total seedling length (cm)

On the day of the final count (14th day), ten normal seedlings were chosen randomly from each replication at the end of the germination test, then root, shoot and total length of seedlings were measured. The means for these measurements were calculated and expressed in cm.

#### Seedling fresh and dry weight (g)

At the end of the germination test, fresh weight of the 10 seedlings was taken and the mean was calculated. Then the seedlings were kept for drying in hot air oven at 72°C for 24hrs, after that weight was taken and mean was calculated.

#### Seedling vigour index I and II

At the end of the germination test, lengths of 10 normal seedlings were taken and the mean was calculated. Then mean seedling length was multiplied with germination percentage to get seedling vigour index I and dry weight of the 10 normal seedlings was taken, this was multiplied with germination percentage to get seedling vigour index II. Formula proposed by Abdul Baki and Anderson (1973) [11] was used for calculation as mentioned below;

$$\text{Seedling vigour index I (SVI I)} = \text{Germination (\%)} \times \text{Mean seedling length (cm)}$$

$$\text{Seedling vigour index II (SVI II)} = \text{Germination (\%)} \times \text{Seedling dry weight (g)}$$

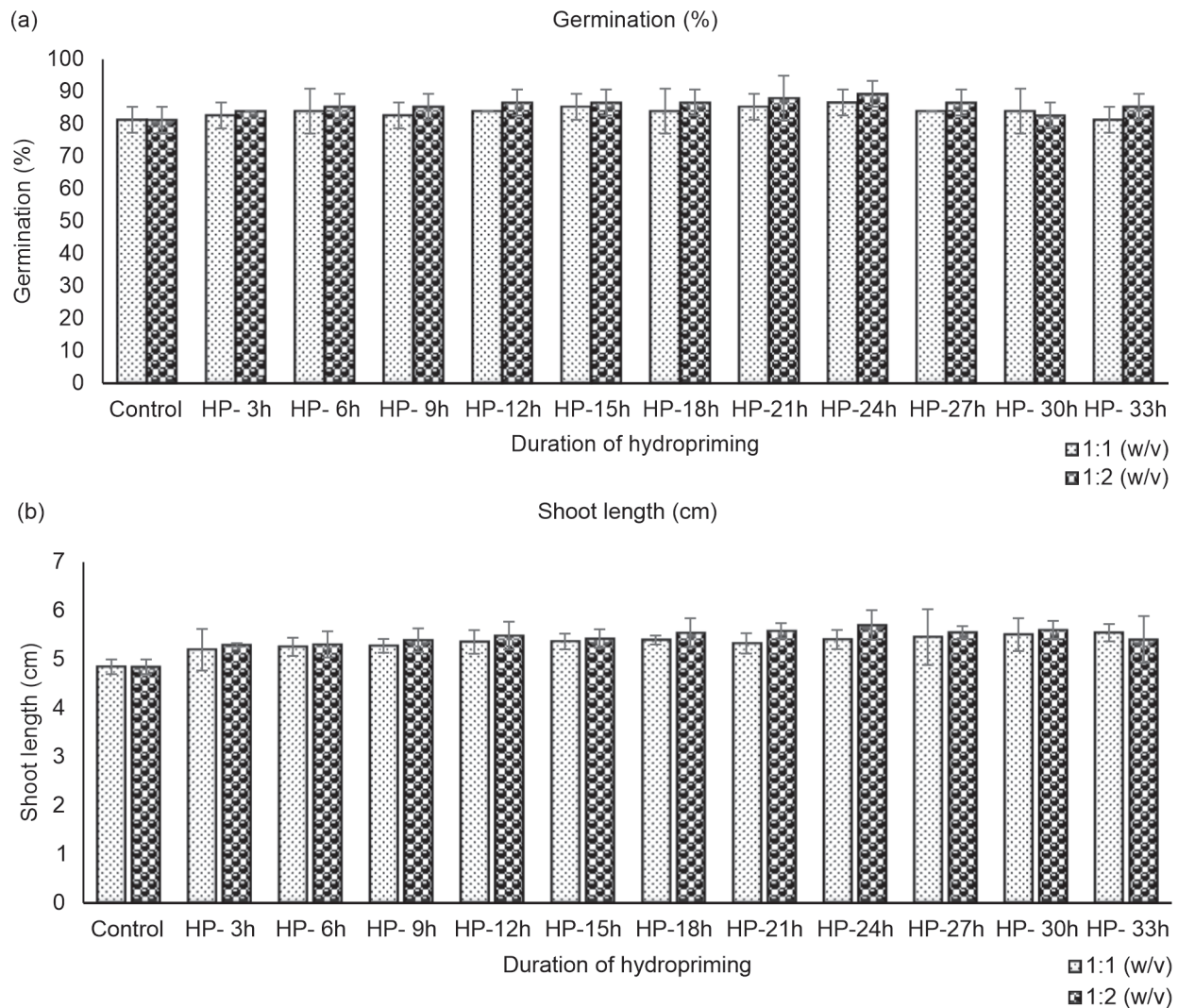
#### Statistical analysis of data

The mean values from all treatments were calculated across three replications, and these mean values were used for data analysis. The data analysis was conducted using a completely randomized design (CRD) with SPSS version 17 software, and significant differences among the means were determined at a significance level of P d” 0.05.

## RESULTS AND DISCUSSION

The results obtained from the study of effect of durations of hydro-priming and soaking volume on seed quality parameters are discussed hereunder:

**Seed germination:** The results determined that there were significant differences in germination percentage among different durations of hydro-priming and seed to water ratios (Fig.1a). Among the different durations of hydro-priming, significantly higher germination percentage was observed in 24h and 21h of hydro-priming and among the different seed to water ratio it

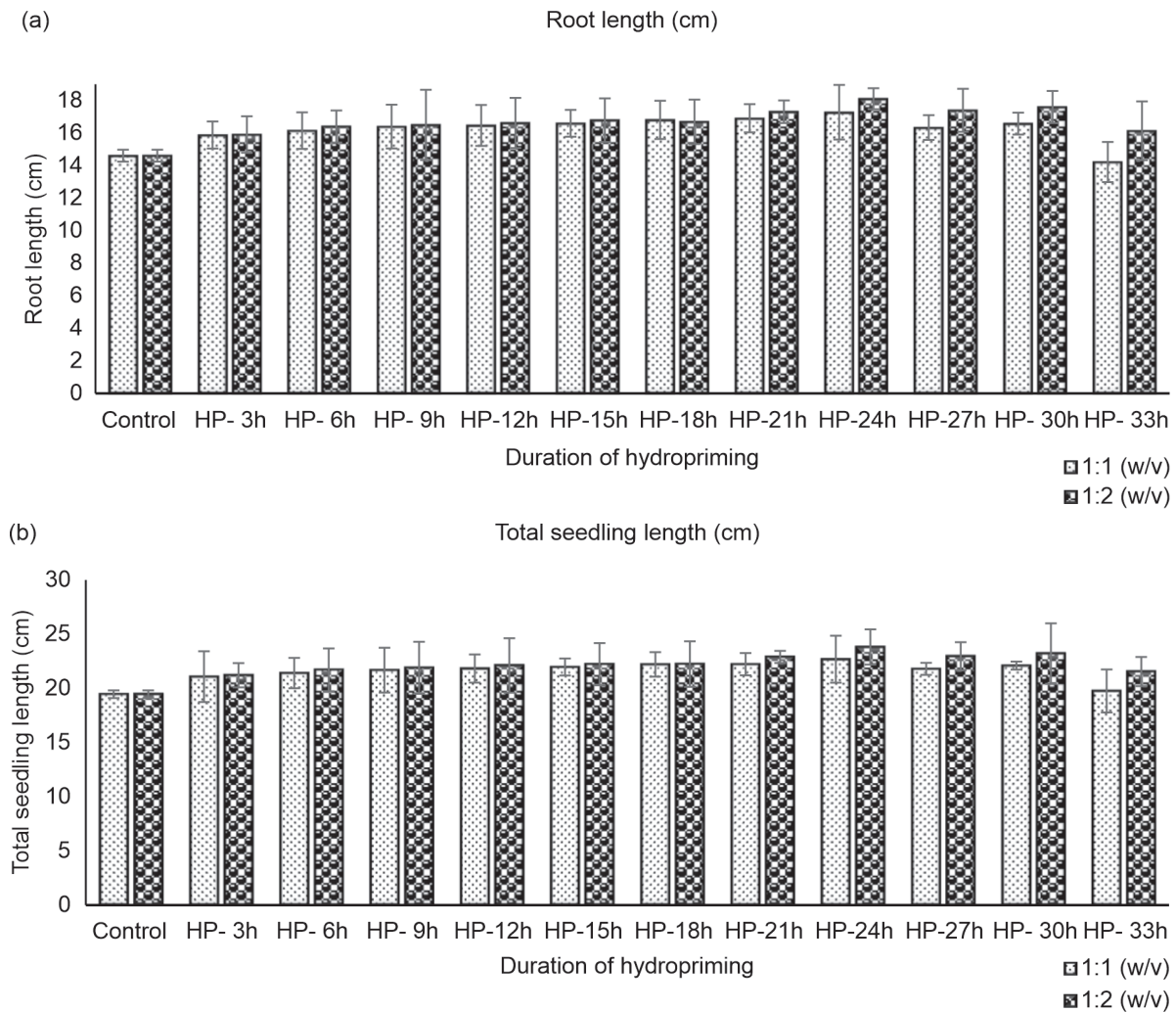


**Figure 1.** Effect of hydro-priming duration and seed to water ratio on a) germination percentage and b) shoot length

was observed in 1:2 (w/v) ratio. The germination percentage was reported to be increased by 8.2% and 6.56% in 24h and 21h of hydro-priming respectively compare to unprimed or control. Similarly, germination (%) was increased by 2.26% in 1:2 (w/v) seed to water ratio compare to 1:1 ratio. As, hydro-priming of seeds before sowing softens the seed coat and supports the metabolic processes necessary for germination, it leads to an early germination [12]. The enhanced germination may be attributed to the stimulation of significant biochemical and physiological changes that prepare seeds for radicle protrusion, including dormancy breakdown, hydrolysis, metabolism of growth inhibitors, enzyme activation [13], nucleic acid repair and synthesis (DNA and mRNA), protein synthesis, membrane repair [3, 14, 15]. Also, the outcome our study aligns with results observed in various other crops [16, 17, 18]. Similarly,

with regard to the soaking volume it was found that cowpea [19] and vegetable pea [20] seeds, using a volume twice the seed weight yielded superior results compared to half or equal volumes. The results indicate that water absorption differs among crop species and should be standardized across various priming conditions.

**Shoot, root and total seedling length:** Hydro-priming of tomato seeds in different durations and seed to water ratios had significant effect on shoot (Fig. 1b), root (Fig. 2a) and total seedling length (Fig. 2b). Among the different durations of hydro-priming, significantly higher shoot length was observed in 24h and 30h of hydro-priming and 1:2 seed to water ratio. It was observed that the shoot length was increased by 14.63% in 24h and 30h of hydro-primed seeds as compared to un-primed seeds and



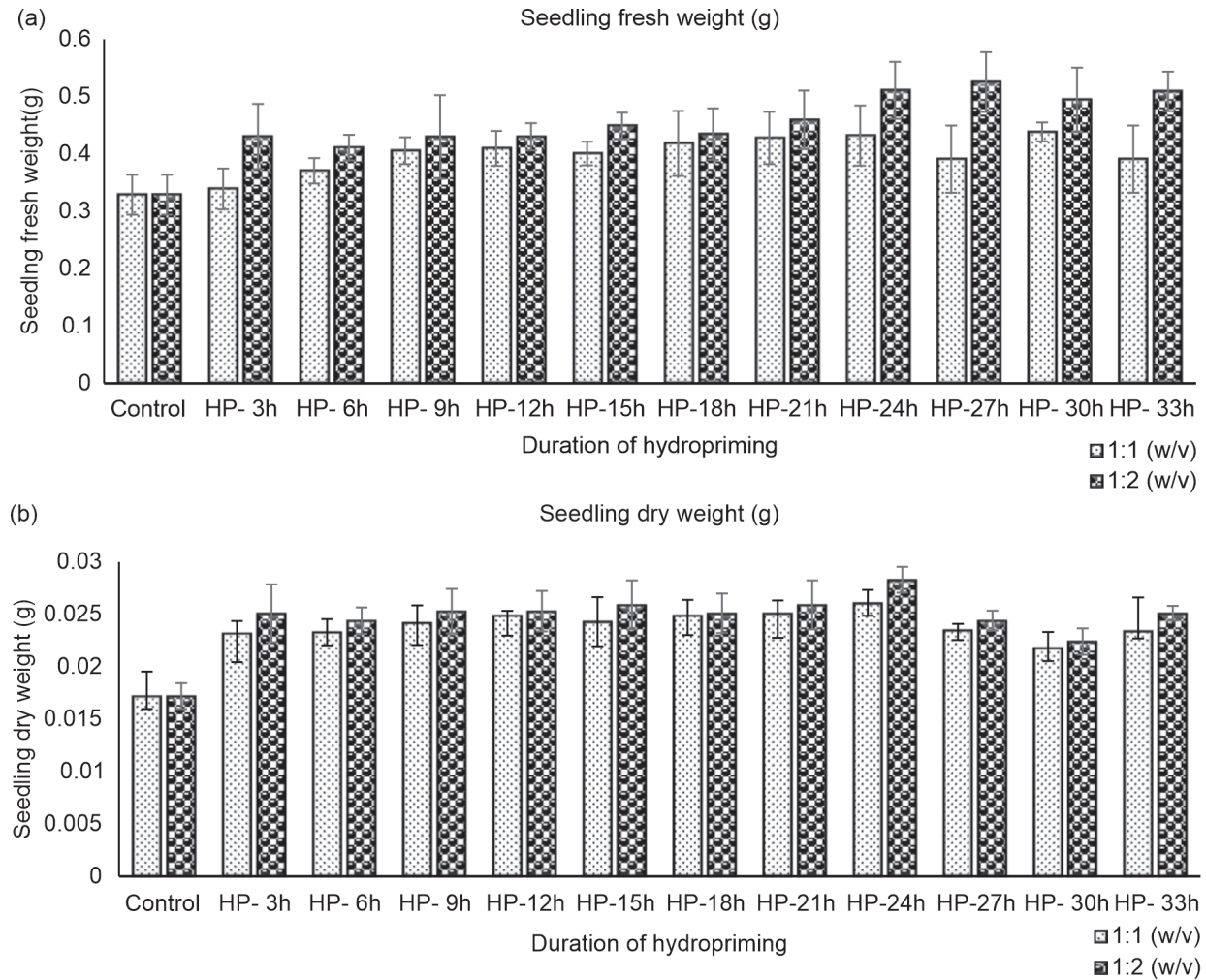
**Figure 2.** Effect of hydro-priming duration and seed to water ratio on a) root length and b) total seedling length

1.88% in 1:2 seed to water ratio as compared to 1:1 ratio. Whereas, significantly highest root length was observed in 24h, 21h and 30h duration of hydro-priming and 1:2 seed to water ratio. It was reported that the root length was increased by 21.08%, 17.11% and 16.97% in 24h, 21h and 30h duration of hydro-priming respectively as compared to unprimed seeds. However, the percent increase of root length was 2.96% in 1:2 seed to water ratio than 1:1 ratio. Similarly, highest seedling length was observed in 24h of hydro-primed seeds and 1:2 seed to water ratio. The total seedling

length was increased by 19.52% in 24h of hydro-primed seeds as compared to unprimed seeds. However, the percent increase of total seedling length was 2.74% in 1:2 as compared to 1:1 ratio. The quick germination and emergence of seeds lead to rapid seedling growth, resulting in taller seedlings. Seedlings from primed seeds

grow faster than those from non-primed seeds, leading to increased seedling height [18]. The observed improvement in seedling growth in this research can be linked to the stimulation and synthesis of plant growth regulators like gibberellins, cytokinins, and indole acetic acid. Additionally, primed seeds showed enhanced availability of minerals, ions, and increased water uptake compared to non-primed seeds [21]. The increased seedling growth from primed seeds may also be attributed to the pretreatment's direct impact on regulating the cell cycle and mechanisms involved in cell elongation [22]. Comparable results with our study were reported in rice [23] and bitter gourd [24].

**Seedling fresh and dry weight:** The result revealed that there were significant difference in seedling fresh weight (Fig. 3a) in different duration of priming and seed to water ratio but not in seedling dry weight (Fig. 3b). Significantly

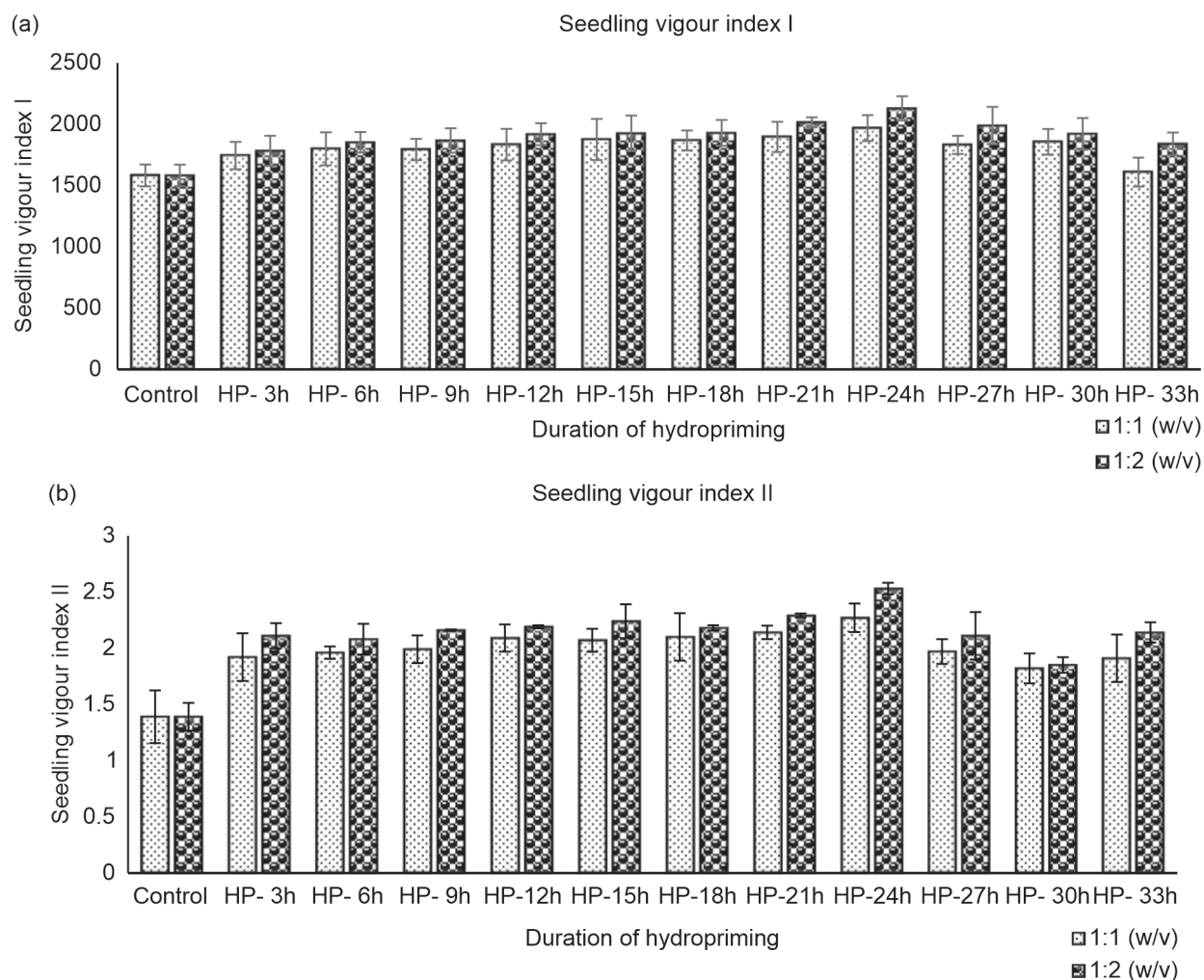


**Figure 3.** Effect of hydro-priming duration and seed to water ratio on a) seedling fresh weight and b) seedling dry weight

highest seedling fresh weight was observed in 12, 15, 18, 21, 24, 27, 30 and 33h duration of hydro-priming and 1:2 seed to water ratio. The seedling fresh weight was reported to increase by 27.7%, 29.2%, 29.7%, 34.9%, 43.3%, 39.3%, 41.9% and 36.9% in 12, 15, 18, 21, 24, 27, 30 and 33h duration of hydro-priming respectively as compared to unprimed seeds and 13.89% increase in 1:2 as compared to 1:1 ratio. Whereas numerically higher seedling dry weight was observed in 24h of hydro-priming duration and it was reported to increase by 58.1% as compared to unprimed seeds. Whereas in seed to water ratio the percent increase was 4.26% as compared to 1:1 ratio. Hydro-priming enhances the development of the plant's root system, leading to faster growth and better nutrient uptake. This ultimately results in taller plants with increased accumulation of dry matter. The higher fresh and dry matter from primed seed indicates that most of

the energy intake was used for relative growth of seedlings [25]. Similar results were also reported in groundnut [26].

Seedling vigour index I and II: Hydro-priming of tomato seeds in different durations and seed to water ratios had significantly affected seedling vigour index I (Fig. 4a) and II (Fig. 4b). Among the different durations of hydro-priming, significantly higher seedling vigour index I was observed in 24h duration of hydro-primed seeds and it was reported to increase by 29.5% as compared to unprimed seeds. Whereas, in seed to water ratio significantly higher seedling vigour index I was observed in 1:2 and it was increased by 5.1% compare to 1:1 ratio. Then significantly higher seedling vigour index II was reported in 24, 21, 15, 12 and 18h duration of hydro-priming, but there was no significant difference in seed to water ratios. However, the percent increase in seedling



**Figure 4.** Effect of hydro-priming duration and seed to water ratio on a) seedling vigour index I and b) seedling vigour index II

vigour index II was 72.66%, 59.71%, 54.38%, 53.96% and 53.96% respectively in 24, 21, 15, 12 and 18h of duration of hydro-priming as compared to unprimed seeds and 7.11% in 1:2 seed to water ratio as compared to 1:1 ratio. Similar outcomes were noted in studies involving the germination and field performance of various crops like faba bean [16], bitter melon [7], cucumber [27], and other food crops [9]. The seedling vigor index has been increasing due to the shortened imbibition lag time in priming treatments. Priming induces physiological and biochemical modifications in seeds, including increased amylase production, which enhances metabolic functions and boosts seed vigor [28]. Hydro-priming contributes to a more robust establishment of the plant's root system, indirectly promoting rapid growth, improved nutrient absorption, taller plants, and increased dry matter accumulation [16].

## CONCLUSION

In conclusion, since imbibition is primarily a passive process that triggers metabolic activity, the priming duration should be adequate to ensure that germination processes are sufficiently initiated for pre-germinative effects to occur. However, the timing of these events varies depending on the cultivar, seed quality, and priming parameters. Therefore from the present study it was found that seeds primed with hydro-priming for 24 hours in double the volume of water (w/v) shown significantly higher germination, seedling height, and seedling vigor indices compared to other priming durations in tomato. This improvement in seed germination and seedling growth is attributed to the better establishment of the plant root system, which is indirectly related to fast growth and improved nutrient absorption. Therefore, hydro-priming can be recommended as a simple and cost-effective

procedure to improve seed germination and seedling quality under various agro-climatic conditions.

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