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Impact of hydropriming duration on seed germination and emergence indices of sweet basil

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ABSTRACT: The experiment was conducted in the Department of Horticultural Technology, Enugu State Polytechnic, Iwollo, Enugu state, Nigeria to determine the impact of hydro-priming duration on seed germination and emergence indices of sweet basil (*Ocimum basilicum*) in August, 2018. The treatments were 6, 12, 18, and 24 hours of hydropriming. The control treatment was left un-primed. Twenty seeds from each treatment were plated in Petri dish which contained two layers of filter papers that were wetted with 10 ml of distilled water and was used for the germination studies. Twenty seeds from each of the treatment were sown in 2 kg nursery medium (poly pot) with nursery mixture of soil, well cured poultry manure and sand in the ratio of 3:2:1, respectively and was used for the emergence studies. The experiment was laid in completely randomized design with three replications. Data on germination and emergence indices were collected and analyzed using analysis of variance (ANOVA). The treatment means that were significant were separated using least significant difference at 0.05 probability level. The results showed that hydro-priming significantly ($p<0.05$) increased germination percentage, coefficient of velocity of germination, coefficient of uniformity of germination, emergence percentage and coefficient of velocity of emergence with 18 hour having superior values and the least values were in control. Hydro-priming also significantly decreased mean germination time, mean emergence time, days to 50% germination and days to 50% emergence with the least values obtained in 18 hours and the highest values were in control. It can be concluded that hydro-priming significantly improved germination and emergence of sweet basil (*O. basilicum)*. The optimal hydro-priming duration for sweet basil (*O. basilicum*) was 18 hours, which enhanced seed germination and emergence percentage**,** ensured early germination and seedling emergence, and increased uniformity of emergence.

Keywords: Emergence, germination, hydro-priming, indices, *Ocimum basilicum.*

INTRODUCTION

Basil (*Ocimum basilicum* L.) is a frost sensitive low-growing herb which belongs to the family Lamiaceae (mint family). Basil is native to southern Asia. It has ovate pointed leaves that are simple with pinnate venation, 20 to 60 cm length and white-purple flowers that are normally self-pollinated. Basil is cultivated extensively in France, Egypt, Iran, Hungary, Indonesia, Morocco, Greece and Israel, mostly in Mediterranean countries and in various regions with temperate and hot climates (Özcan and Chalchat, 2002). Commercial cultivation of basil is not common in Nigeria. Its production is restricted to the local farmers who grow it at the back of their compounds. Sweet basil, one of the cultivars of basil, is new in Nigeria. Its adaptation and production requires good stand establishment that will impact on the overall performance.

There are more than 60 cultivars of basil which differ in appearance and taste. Scientific studies *in vitro* have established that bio-actives in basil oil have potent antioxidant, anticancer, antiviral, and antimicrobial properties (de Almeida et al., 2007). Basil is used in traditional Chinese medicine to treat cardiovascular diseases including hypertension (Umar et al., 2010). It is also traditionally used for supplementary treatment of stress, asthma and diabetes in India (Duke, 2008). Other traditional uses are in the treatment of headache, cough, diarrhea, constipation, wart, obesity, worms and kidney diseases (Simon et al., 1999).

One of the major obstacles to high crop yield is lack of synchronized crop establishment due to poor seed quality, poor weather and unfavourable soil conditions (Mwale et al., 2003). Seeds are occasionally been sown in seedbeds at the nursery or at the field having unfavourable moisture probably due to low or high soil water availability which results in poor and unsynchronized seedling emergence. Another major constraint to seed germination is soil salinity, a common problem in irrigated areas (Finch-Savage and Bassel, 2016). Soil salinity may affect the germination of seeds either by creating an osmotic potential external to the seed preventing water uptake, or through the toxic effects of Na^+ and Cl^- ions on the germinating seed (Khajeh-Hosseini et al., 2003). Among these problems, long seed storage leads to poor seed quality especially among small seeds of horticultural crops (Finch-Savage and Bassel, 2016). Generally, seed storage causes a decrease in the protein content which may be related to oxidation of the amino acids due to the increase in the respiratory activity and advance in the deterioration process of the seeds (Mc Donald, 1999).

One programmatic approach to increase good stand establishment and increase crop production is seed priming (Farooq et al., 2006). It is a controlled hydration process that involves exposing the seed to low water potentials that restrict germination, but permits pre-germinative physiological and chemical changes to occur (Khalid et al., 2019). Furthermore, Hossein (2013) defined seed priming as a controlled hydration process followed by re-drying that allows seed to imbibe water and bring internal biological processes necessary for germination, but which does not allow the seed to actually germinate. Seed priming is a pre-sowing strategy for influencing seedling development by modulating pre-germination metabolic activity prior to emergence of the radicle and generally enhances rapid, uniform emergence and plant performance to achieve high vigour and better yields (Mc Donald, 2000). During priming, seeds are soaked in different solutions with high osmotic potential so that pre-germinative metabolic activities proceed, while radical protrusion is prevented, and then seeds are dried back to the original moisture level. Upon rehydration, primed seeds may exhibit faster rates of germination, more uniform emergence, and greater tolerance to environmental stress and reduced dormancy in many crop species (Finch-Savage and Bassel, 2016). Hydro-priming is the simplest method of seed hydration (Mc Donald, 2000). In some cases, the final seedling emergence percentage of primed and unprimed seeds is equal, but primed seeds emerge more quickly than those of unprimed which may depend on plant *spp*. Demir and Mavi (2004) observed that unprimed watermelon seeds had 4 days delay on emergence as compared with primed seeds. Hydro-priming duration determines how long the seeds are hydrated before they are dried back. Available reports showed that varied hydropriming durations have significant influence in the germination and seedling emergence of some crops. Caseiro et al. (2004) found that hydro-priming was the most effective method for improving seed germination of onion, especially when the seeds were hydrated for 96 hours compared to 48 hours.

O. basilicum belongs to the group of medicinal horticultural crops that has small seeds. Recent adaptation trial on sweet basil, in Enugu state polytechnic, Iwollo, showed that sweet basil has low germination and emergency percentage. Germination and stand establishment of sweet basil (*O. basilicum)* could be affected by long seed storage and poor soil condition (Mwale et al., 2003; Finch-Savage and Bassel, 2016). Approaches towards improving seedling establishment and growth of sweet basil are pertinent in its production for improved yield. Thus, the objective of this study was to determine the impact of hydro-priming duration on seed germination and emergence indices of sweet basil.

MATERIALS AND METHODS

Study area

The experiment was carried out in the laboratory and inside high tunnel in the Department of Horticultural Technology, Enugu State Polytechnic, Iwollo in August, 2018. The study area is located within latitude $06^0 16.834'$ N and longitude $07^0 16.834'$ E (Maplandia, 2019). It is 252 meters above sea level with average annual temperature range of 23 to 27.90°C. The rainfall pattern is often bimodal from April to November with short spell in August. The average annual rainfall is 1726 mm. The precipitation varies from 9 mm in the driest month of December to 301 mm in the wettest month of September. (Uguru, 2011). The area belongs to Group A (Aw – Tropical wet climate) according to Köppen-Geiger climatic classification (Peel et al., 2007).

Source of seed material

Sweet basil (*Ocimum basilicum)* seeds used in the study were bought from Italy.

Sterilization of seed material

Seeds were sterilized to kill the micro organisms that might influence the result. Hand selected seeds were treated with a 1.0% solution of sodium hydrochloride for 5 minutes for surface sterilization. Residual chlorine was eliminated through rinsing of the seeds with distilled water.

Hydro-priming treatments

The seeds were soaked in distilled water in Petri dishes for 6, 12, 18 and 24 hours at 23°C. The primed seeds were dehydrated on a filter paper back to their original state while un-primed seeds served as control.

Experimental design and treatments

The experimental layout was completely randomized design (CRD). The treatments were; 0 (control), 6, 12, 18, and 24 hours hydropriming. The treatments were replicated three times.

Germination studies

Twenty seeds from each treatment were plated in Petri dishes which contained two layers of filter papers that were wetted with 10 ml of distilled water. Germination was considered to have occurred when the radicles were 2 mm long (Moghanibashi et al., 2012). Petri dishes were observed every 24 hours for 14 days and germinated seeds were counted.

Germination indices

Germination percentage (GP)

Data on germination percentage was recorded every 24 hours for 14 days. This was evaluated by counting the number of germinated seeds at the end of the germination test.

$$\mathrm{GP} = \frac{\text{Germinated seeds}}{\text{Total seeds}} x100$$

Mean germination time

Mean germination time was evaluated using the following formula:

$\overline{D} = 100/\{(\sum_{i=1}^{k} ni/\sum_{i=1}^{k} Dini)100\}$ (Bewley and Black, 1994)

where: *ni* = number of germinated seeds on the *i*th day, *Di* = number of days counted from the sowing day to the collection of the datum (*i*), and; *k* = last day of germination.

Days to 50% germination

Days to 50% germination were calculated from the date of sowing to the date up to half of the seeds germinated by counting seeds germinated in each Petri dish daily.

Coefficient of velocity of germination

Coefficient of velocity of germination was evaluated using this formula:

$CVG = (\sum_{i=1}^{k} ni/\sum_{i=1}^{k} Dini)100$ (Bewley and Black, 1994)

Where: *ni* = number of germinated seeds on the *i*th day, *Di* = number of days counted from the sowing day to the collection of the datum (*i*), and; *K* = last day of germination.

Coefficient of uniformity of germination

Coefficient of uniformity of germination was evaluated according to the following formula:

$CUG = \sum_{i=1}^{k} ni/\sum_{i=1}^{k}(\overline{D} - Di)^2\ ni$ (Bewley and Black, 1994)

Where: *ni* = number of germinated seeds on the *i*th day, *Di* = number of days counted from the sowing day to the collection of the datum (*i*), $\overline{D}$ = mean germination time and; *k* = last day of germination.

Emergence studies

Twenty seeds from each of the treatments were sown in 2 kg nursery medium (polypot) with nursery mixture of soil, well cured poultry manure and sand in the ratio of 3:2:1 respectively. The polypots were placed under high tunnel covered with blue polythene film to provide shade and permits transmission of visible light suitable for seedling growth. Each polypot was watered with 50 ml of water daily; morning and evening.

Emergence indices

Emergence percentage (EP)

Data on emergence percentage was recorded every 24 hours for 14 days and was evaluated by counting the number of total seedlings emerged at the end of the emergence test.

$$\mathrm{EP} = \frac{\text{Emerged seeds}}{\text{Total seeds planted}} x100$$

Mean emergence time

Mean emergence time was evaluated using the following formula:

$\overline{D} = 100/\{(\sum_{i=1}^{k} ni/\sum_{i=1}^{k} Dini)100\}$ (Bewley and Black, 1994).

Where: *ni* = number of emerged seeds on the *i*th day, *Di* = number of days counted from the sowing day to the collection of the datum (*i*), and; *k* = last day of emergence.

Days to 50% emergence

Days to 50% emergence were determined by recording the days, starting from the sowing date to the date half of the sown seeds emerged.

Coefficient of velocity of emergence

Coefficient of velocity of emergence was evaluated using the following formula:

$CVE = (\sum_{i=1}^{k} ni / \sum_{i=1}^{k} Dini)100$ (Bewley and Black, 1994)

Where: *ni* = number of emerged seeds on the *i*th day, *Di* = number of days counted from the sowing day to the collection of the datum (*i*), and; *k* = last day of emergence.

Coefficient of uniformity of emergence

Coefficient of uniformity of emergence was evaluated according to the following formula:

$CUE = \sum_{i=1}^{k} ni / \sum_{i=1}^{k} (\overline{D} - Di)^2\, ni$ (Bewley and Black, 1994)

Where: *ni* = number of emerged seeds on the *i*th day, *Di* = number of days counted from the sowing day to the collection of the datum (*i*), $\overline{D}$ = mean emergence time and; *k* = last day of emergence.

Statistical analysis

All the data collected were statistically analyzed using analysis of variance (ANOVA) for completely randomized block design (CRD). Comparison between means was made using least significant difference (LSD) at 0.05 probability level as described by Obi (2002).

RESULTS

Effect of hydro-priming duration on germination of sweet basil (*Ocimum basilicum)* seeds

The results of germination percentage, days to 50% germination, mean germination time, coefficient of velocity of germination and coefficient of uniformity of germination were significantly ($p < 0.05$) influenced by hydro-priming duration (Table 1). The highest value of days to 50% germination (6.00) was obtained in unprimed seeds (control) while the lowest (2.00) was obtained in 18 hours hydro-priming. Similarly, the highest mean germination time (4.24) was obtained in unprimed seeds (control), while the lowest value (2.04) was obtained in 18 hours hydro-priming. On the other hand, the highest coefficient of velocity of germination (49.19) was obtained in 18 hours hydro-priming, while the lowest value (23.58) was obtained in control treatment. All hydro-priming treatments induced higher coefficient of velocity of germination compared to unprimed seeds (control) in this order; 18 hours >24 hours >12 hours >6 hours >control.

Effect of hydro-priming duration on emergence of sweet basil (*Ocimum basilicum)* seeds

The results showed significant differences ($p<0.05$) in emergence percentage, days to 50% emergence, mean emergence time and coefficient of velocity of emergence as influenced by different hydropriming duration (Table 2). There was non-significant difference ($p>0.05$) in coefficient of uniformity of emergence among the treatments. All hydro-priming treatments induced higher emergence percentage, and coefficient of velocity of emergence compared to the control. The highest emergence percentage (73.33) was obtained in 18 hours which differed significantly with the other hydro-priming durations (63.33, 61. 67, 58.33 and 53.33% in 12, 24, 6 hours and control, respectively). All hydro-priming durations had statistically at par influence in terms of coefficient of velocity of emergence. Consequently, all hydro-priming durations induced lower days to 50% emergence and mean emergence time compared to un-primed treatment. The lowest days to 50% emergence (5.00) was obtained in 18 hours which differed significantly with the other hydro-priming durations. All hydro-priming durations were statistically at par in terms of mean emergence time.

DISCUSSION

The findings of this study suggest an important role of hydro-priming on germination and seedling emergence of sweet basil (*Ocimum basilicum)*. Seed hydro-priming significantly improved days to 50% germination and emergence; emergence percentage; mean germination and emergence time; coefficient of velocity of germination and emergence; and coefficient of uniformity of emergence as shown in Table 1 and Table 2. Lower values of days to 50% germination and mean germination time obtained in hydro-primed seeds were indications of more uniform and speedy germination. On the other hand, higher coefficient of velocity of germination expressed higher power of germination and seed vigour.

The findings were in agreement with Ahmadi et al. (2007) who found that hydro-priming of wheat (*Triticum aestivum*) seeds improved speed of emergence, vigour index and seedling dry weight. Other beneficial effects of hydro-priming were reported in maize (Murungu et al., 2004), sunflower (Hussain et al., 2006), bean (Abebe and Modi, 2009), lentil (Salglam et al., 2010) and cowpea (Singh et al., 2011). Rapid and uniform field emergences of seedlings are two essential pre-requisites to increase yield, quality and ultimately profit in annual crops. Rapid emergence of seedlings could lead to the production of

Table 1. Effect of hydro-priming on germination percentage, days to 50% germination, mean germination time, coefficient of velocity of germination and coefficient of uniformity of germination of sweet basil (*Ocimumbasilicum*).

Hydro-priming treatments	D50G (day)	G.P (%)	MGT (day)	CVG	CUG (day^{-2})
6hrs	4.67[b]	66.67[c]	3.537[b]	28.54[b]	0.504[b]
12hrs	3.67[b]	73.33[b]	3.137[bc]	31.94[b]	0.463[b]
18hrs	2.00[c]	83.33[a]	2.040[d]	49.19[a]	1.5o9[a]
24hrs	4.00[b]	68.33[bc]	2.957[c]	33.20[b]	0.467[b]
Control	6.00[a]	60.00[d]	4.243[a]	23.58[c]	0.412[b]
$LSD_{0.05}$	1.050	6.214	0.5111	4.847	0.2512
CV (%)	14.2	4.9	8.8	8.0	20.6
S.E.	0.577	3.416	0.2809	2.664	0.1381
Grand mean	0.7	70.33	3.537	33.29	0.671

$LSD_{0.05}$ = Least significant difference at 5% probability level; CV = Coefficient of variation; S.E. = Standard error; G.P (Germination Percentage), D50G (Days to 50% germination), MGT (Mean Germination Time), CVG (Coefficient of Velocity of germination), CUG (Coefficient of uniformity of germination). Mean values within each column with the same letter are significantly different ($p<0.05$).

Table 2. Effect of hydro-priming duration on emergence percentage, days to 50% emergence, mean emergence time, coefficient of velocity of emergence and coefficient of uniformity of emergence of sweet basil (*Ocimumbasilicum*).

Hydro-priming Treatments	EP (%)	D50E (day)	MET (day)	CVE	CUE (day^{-2})
6hrs	58.33[b]	6.67[b]	5.49[b]	18.29[a]	0.484
12hrs	63.33[b]	6.00[b]	5.14[b]	19.51[a]	0.594
18hrs	73.33[a]	5.00[c]	4.99[b]	20.15[a]	0.915
24hrs	61.67[b]	6.67[b]	5.55[b]	18.16[a]	0.542
Control	53.33[c]	10.33[a]	7.43[a]	13.47[b]	0.304
$LSD_{0.05}$	5.252	0.814	0.788	2.619	NS
CV (%)	4.7	6.5	7.6	8.0	43.3
S.E	2.887	0.447	0.433	1.44	0.2461
Grand mean	62.00	6.93	5.77	17.91	0.568

NS: Non Significant; $LSD_{0.05}$ = Least significant difference at 5% probability level; CV = Coefficient of variation; S.E. = Standard error; G.P (Germination Percentage), D50G (Days to 50% germination), MGT (Mean Germination Time), CVG (Coefficient of Velocity of germination), CUG (Coefficient of uniformity of germination). Mean values within each column with the same letter are significantly different ($p<0.05$).

vigorous plants. The efficiency of seed hydro-priming for better seedling emergence is also formerly reported (Abdulrahmani et al., 2007; Rinku et al., 2017; Damalas et al., 2019).

The stimulatory effects of hydropriming on the early stage of germination process could be the reason for the positive effects recorded. When dry seed is soaked in water, the uptake of water involves three stages which include; the initial stage of imbibitions (Stage I), a slow increase (Stage II) and a substantial increase (Stage III) (Varier et al., 2010). According to Bewley (1997), rapid uptake of water occurs in the first stage due to seed low water potential and in the last stage where the process of germination is completed by the radicle emergence while, the second stage involves biochemical activities. The effect of priming in improving seed performance could be attributable to the completion of pre-germination process such as DNA replication, increased RNA and protein synthesis, greater ATP availability (Ahmadi et al., 2007), faster embryo growth (Chang et al., 2000), repair of deteriorated seed parts (Finch-Savage and Bassel, 2016), reduced leakage of metabolites, decrease in lipid peroxidation and increase in the antioxidant activities (Issam et al., 2012). Furthermore, hydro-priming reduces the inhibitory activities of trypsin and chymotrypsin and promote germination and seedling emergence (Bewley and Black, 1994).

The optimal hydro-priming duration for sweet basil (*O. basilicum)* as shown in this study was 18 hours, which enhanced the germination and emergence percentage, ensured early germination and seedling emergence, increased uniformity of emergence, and increased seed vigour. When seeds imbibe, the water content reaches a plateau and changes little until radicle emergence (Finch-Savage and Bassel, 2016). Priming up to this point can have a positive effect, while extended priming duration may negatively affect germination. In other words, duration of seed priming, especially hydro-priming, affects seed germination properties. Longer hydro-priming duration does not always have more positive effect on seeds germination properties. Ghassemi-Golezani et al. (2010) reported that the lowest mean germination time and the highest germination percentage and seedling dry weight of pinto bean were achieved with 7 and 14 hours priming duration which was significantly different from 21 hours of hydro-priming.

Seed germination is very sensitive to hydration process. Water uptake rate in priming is always slow. At 18 hours, seeds probably had enough time to complete the pre-germination process (Varier et al., 2010), but not enough to cause suffocation and death of embryo due to lack of oxygen (Finch-Savage et al., 2004). This could explain why optimal germination and seedling emergence of sweet basil were observed at 18 hours hydro-priming compared to other hydro-priming durations. The improved seedling emergence in hydro-primed seeds could be an induction of improved germination indices. These findings support the earlier studies on rice (Farooq et al., 2006; Ibrahim et al., 2013), wheat (Ahmadi et al., 2007; Meena et al., 2015), bean (Abebe and Modi, 2009; Ghassemi-Golezani et al., 2010), tomato (Amooaghaie et al., 2010), lentil (Saglam et al., 2010), basil (Aliabadi and Maroufi, 2011), bromus (Tavili et al., 2011), cowpea (Singh et al., 2011), Mexican fir tree (Zulueta-Rodríguez et al., 2015) and mung bean (Shukla et al., 2018).

Conclusion

Hydro-priming has been considered as a simple and cost-effective strategy for improving germination and emergence of some crops. The findings of this study showed that hydro-priming is an effective technique for improving seed germination and emergence of sweet basil (*Ocimum basilicum).* All the hydro-primed *O. basilicum* seeds performed better than the unprimed ones. Also, hydro-priming duration influenced germination and seedling emergence of sweet basil. Hydro-priming for 18 hours was the most effective treatment as compared with 6 hours which was the least effective treatment. Therefore, for optimal germination and emergence of sweet basil (*O. basilicum)* hydro-priming for 18 hours is recommended.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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