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HYDROPRIMING IMPROVES SEED GERMINATION IN HORNED MELON (*CUCUMIS METULIFERUS* E. MEY. EX NAUDIN) LANDRACES

Moses Mutetwa ✉
Department of Agronomy and Horticulture[1]
mosleymtetwa@gmail.com

Paul Chaibva
Department of Agronomy and Horticulture[1]

Ignatius Chagonda
Department of Agronomy and Horticulture[1]

Veronica Makuvaro
Department of Agronomy and Horticulture[1]

Taurira Mtaita
Department of Agricultural Sciences
College of Health, Agriculture and Natural Sciences
P.O. Box 1320, Old Mutare, Zimbabwe

Wonder Ngezimana
Department of Horticulture
Marondera University of Agricultural Sciences and Technology
P.O. Box 35, Marondera, Zimbabwe

Johnson Masaka
Department of Land and Water Resources Management[1]

Pepukai Manjeru
Department of Agronomy and Horticulture[1]

[1]*Midlands State University*
P. Bag 9055, Gweru, Zimbabwe

✉**Corresponding author**

Summary

The global popularity of horned melon highlights the need of sound crop establishment processes, since uniform and quick seed germination has a substantial influence on crop yield and quality. Using a Completely Randomised Design (CRD) with a factorial structure, the effects of hydro priming durations (0, 8, 16, 24, 32, and 40 h) on seeds of two horned melon landrace (*L*1&*L*2) were investigated. Hydro priming had significant ($P>0.05$) influence on several germination indices (germination percentage, relativized percentage, mean germination rate, germination index, synchronization, duration to 50 % germination, mean daily germination, peak value, and germination value). Among the germination indicators tested, landrace (*L*2) exhibited a considerably stronger germination response than *L*1. The findings also reveal a curvilinear relationship between priming length and germination percentage, with 24 hours being greatest proportionately. The mean germination rate, germination index, mean daily germination, peak value of germination, and germination value all rose as the hydro priming duration increased. Primed seeds germinated more quickly than unprimed ones. With increasing priming duration, the synchronization index fell linearly. The interaction between landraces and hydro priming was not significant ($P>0.05$) for final seed germinated, relativized germination, and synchronization indices, but it had a significant impact on all other indices. Because the efficacy of hydro priming tends to lessen with extended soaking, we recommend using it for a maximum of 32 hours. Future study should concentrate on alternative priming chemicals and the applicability of various priming solutions for various agro-ecosystems.

Keywords: Horned melon (*Cucumis metuliferus*), hydro priming, germination, landraces, seeds, commercialization, domestication.

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1. Introduction

Horned melon (*Cucumis metuliferus* E. Mey. Ex Naudin) is endemic to the semi-arid sub-Saharan African region, where the locals eat it as a supplement. In Israel, Kenya, and New Zealand, *C. metuliferus* is grown as an ornamental plant however, its market is expanding as a new vegetable crop [1, 2]. In addition, *C. metuliferus* is nutritionally superior to its *Cucumis* relatives [2] making it a viable candidate for commercialization and the export.

Proper germination environment is key to the successful propagation of plants from seed. For non-dormant seeds, temperature and moisture are crucial environmental factors influencing germination [3]. Single or in combination, these two important factors influence germination percentage and rate. In addition, contemporary agricultural practices rely heavily on technological advances to overcome yield barriers and achieve superior crop productivity [4]. As a result, several seed enhancement techniques have been devised to ensure uniform germination.

Priming is an approach that involves treating seeds with different organic or inorganic chemicals and or with high or low temperatures [5]. Seed priming is also associated with more synchronized germination, seedling growth, and the establishment of multiple crops under various conditions. For improved seed germination and crop yield, various seed pretreatment techniques such as thermopriming, chemopriming, osmopriming, hydro-priming, and biopriming (controlled hydration of seeds via the application of microbes or their biological compounds) have been applied on several crops [6]. Examples include mustard turkey berry [7], eggplant [8, 9], hairy nightshade [10], faba bean [11], chickpea [12], and maize [13]. Seed hydropriming is an effective pre-sowing technique that involves soaking the seeds in water (hydration) and then drying them, resulting in faster germination when the seeds are reimbibed [14, 15]. The process partially hydrate seeds in a monitored environment followed by drying to induce the germination process, but with no radicle emergence [6, 16]. Hydropriming is a popular technique to improve seed germination uniformity, rate, and percentage in most crops with germination challenges [16, 17].

*C. metuliferus i*s a potential domestication and commercialization candidate, and the expanding export market necessitates the development of effective and rapid propagation techniques. *C. metuliferus* is propagated by seed in Zimbabwe and is grown at the subsistence level, and the country has a large number of landrace. Regrettably, most communal farmers face irregular rainfall patterns, which typically result in uneven germination, crop stand patterns, and yield. This is a setback for communal farmers who want to commercially grow this fruit. Furthermore, there is little research on the effects of hydropriming on *C. metuliferus* germination parameters. As a result, the current study aimed to improve the germination parameters of common *C. metuliferus* landraces in Zimbabwe by using hydropriming.

2. Materials and Methods

2. 1. Description of the study site

The experiment was carried out in the Biology Laboratory for the Department of Agronomy and Horticulture at Midlands State University in Gweru, Zimbabwe, situated at coordinates 19°45' S and 29°84' E. The location is in Agro-Ecological Region III, which receives 500–750 mm of rain per year. The average annual temperature range for this location is 18–22 °C. The soils are fersialitic sandy-loam with a high concentration of kaolinite clay minerals [18].

2. 2. Collection and preparation of planting material

C. metuliferus fruits were purchased from a conveniently selected Fruit & VegeTable Market, Sakubva Market in Mutare, put in well-labeled plastic bags, and brought to the laboratory for seed extraction. First, the fruits were left to over-ripen before pulping was done. Then, the seeds were washed, placed on filter paper to dry for 24 hours, and kept in a glass jar with a lid under room temperature.

2. 3. Experimental design and treatments

A Complete Randomized Design (CRD) set up in a 6*2 factorial structure was used in this experiment. The first factor was hydro-priming periods with 6 levels (0, 8, 16, 24, 32, and 40 hours) with no soaking (zero) as a control. The second factor was the landraces with two levels (*L*1 and *L*2), the most common landraces in the country, and treatments were replicated four times.

2. 4. Experimental procedure

The hydro priming periods and incubation temperature were based on previous similar studies and pilot trials. Twenty (20) seeds per treatment were immersed in distilled water for different periods and then air dried for 24 hours under a shaded area. Seeds were placed on two sheets of filter paper in 9 cm Petri dishes and placed in an incubator (Scientific 40 L Digital Incubator Model No. 225, Scientific Manufacturing CC) at 30 °C The filter paper was continuously kept moist by adding to each respective treatment a few drops of distilled water. Seeds were considered as germinated when 1 mm of the radical was protruded. Recording of all germinated seeds was done everyday for 14 days.

2. 5. Methods of calculations of germination parameters

Parameters analyzed included:

a) final germination percentage (*G,* %) [19]:

$$\text{Germination percentage} = \frac{\sum_{i=1}^{l} n_i}{N}, \tag{1}$$

where n_i is the number of seeds germinated on the i^{th} day and N is the total number of seeds used;

b) relativized percentage (*R*) [20]:

$$R\% = \frac{\text{Actual percentage}}{\text{The highest percentage among the group of data}} \times 100; \tag{2}$$

c) mean germination rate (MGR) [21]:

$$MGT = \frac{1}{t}, \tag{3}$$

where:

$$t = \frac{\sum_{i=1}^{l} n_i t_i}{\sum_{i=1}^{l} n_i}, \tag{4}$$

where $n_i t_i$ is the number of seeds germinated at an i^{th} time interval, and n_i is the number of seeds germinated on the i^{th} time;

d) germination index (*GI*) [22]:

$$GI = \frac{\sum_{i=1}^{l} n_i}{t_i}, \tag{5}$$

where n_i – the number of seeds that sprouted in the i^{th} time, t_i – the time taken for seeds to sprout at the i^{th} count;

e) synchronization of Germination (Z) [23]:

$$Z = \frac{\sum_{i=1}^{l} C_{n_i,2}}{C_{\sum n_i,2}}, \tag{6}$$

where; $C_{ni,2}=n_i[n_{i-1}]/2$ combination of seeds germinated in the i^{th} time, two by two, and n_i is the number of seeds germinated on the i^{th} time. When all seeds germinate simultaneously, the number Z equals one. Moreover, at least two seeds can sprout simultaneously when Z is zero.

f) time to 50 % germination (T_{50}) [24]:

$$\text{Time to 50 \% germination} = T_i + \frac{\left[\frac{N+1}{2} - N_i\right]\left[T_j - T_i\right]}{N_J - N_i}, \tag{7}$$

where t_{50} is the median germination time, N is the final number of germinated seeds, and N_i and Nj are the total numbers of seeds germinated in adjacent counts at time T_i and T_j respectively, when:

$$N_i < \frac{N+1}{2} < N_i;$$

g) mean daily germination rate (MDG) [25]:

$$MDG = \frac{\text{Total number of germinated seeds}}{\text{Total number of days}}; \tag{8}$$

h) peak value for germination.

P_{value} is the accumulated number of seeds germinated at the point on the germination curve at which the germination rate starts to decrease. It is computed as the maximum quotient obtained by dividing successive cumulative germination values by the relevant incubation time [25];

i) germination value [26]:

$$Gvalue = MDG \times PV, \tag{9}$$

where MDG is the mean daily germination, and PV is the peak value or largest quotient obtained when all the cumulative germination percentages are divided by the respective time interval.

2. 6. Data analyses

Data recorded were analyzed with a two-way variance analysis (ANOVA) using GenSTAT 18th edition. Also, a simple regression analysis was performed to investigate any significant relationships between priming durations and germination parameters. Interaction effects were compared using the least significant difference (LSD) test at a 5 % probability level. Any treatment means found to be significantly different were separated using Fischer's protected $LSD_{0.05}$.

3. Results

3. 1. Effect of the interaction between landraces ecotype and hydro priming duration on the germination characters of horned melon seeds

There was a significant (P<0.05) interaction between landraces and priming duration for MGR, GI, T50, MDG, P_{value}, and G_{value} germination parameters of horned melons (**Table 1**). The highest and lowest means for MGR, GI, P_{value}, and G_{value} were obtained with $L2$ after 32 hours of priming and *L*1 after 8 hours of priming, respectively. *L*1 had the highest mean for T_{50} (5.715) and *MDG* (6.161) under 8 h and 24 h priming, respectively, while *L*2 had the lowest mean for T_{50} (2.531) and *MDG* (5.268) under 32 h and 8 h priming, respectively. In contrast, the following germination parameters, *G* %, *R* %, and *Z*, were not affected differently ($P>0.05$) with increasing priming duration.

Table 1

Effect of landrace and hydro priming duration on the germination characteristics of horned melon seeds

Treatment	Seed germination parameters								
	G **% (%)**	***R*** **% (%)**	***MGR*** **(day^{-1})**	***GI*** **(day)**	***Z*** **(no units)**	**T_{50} (day)**	***MDG*** **(%)**	**P_{value} (day^{-1})**	**G_{value}**
Landrace (*L*)									
*L*1	78.33^{a}	92.16^{a}	0.2120^{b}	2.286^{b}	0.1663^{b}	4.563^{a}	5.446^{a}	12.24^{b}	69.3^{b}
*L*2	77.08^{a}	85.65^{b}	0.2667^{a}	4.815^{a}	0.1864^{a}	3.291^{b}	5.506^{a}	14.27^{a}	79.0^{a}
P_{value}	0.301	<0.001	<0.001	<0.001	0.005	<0.001	0.645	<0.001	0.020
LSD	2.420	2.738	0.01394	0.2746	0.0137	0.2505	0.2608	1.021	8.04
Hydro priming (*P*)									
0 h (Control)	73.75^{a}	84.35^{a}	0.1855^{a}	2.809^{ab}	0.1972^{b}	5.249^{c}	4.509^{a}	9.16^{a}	44.2^{a}
8 h	75.00^{a}	85.83^{a}	0.1925^{a}	2.720^{a}	0.1758^{ab}	4.879^{c}	5.446^{b}	11.09^{b}	60.6^{b}
16 h	77.50^{ab}	88.60^{ab}	0.2337^{b}	3.224^{bc}	0.1654^{a}	3.852^{b}	5.625^{bc}	13.22^{c}	74.7^{c}
24 h	82.50^{c}	94.40^{c}	0.2430^{b}	3.499^{c}	0.1756^{ab}	3.582^{b}	5.982^{c}	13.94^{cd}	83.4^{c}
32 h	81.25^{bc}	92.97^{bc}	0.2947^{c}	4.695^{d}	0.1899^{b}	3.042^{a}	5.848^{bc}	16.93^{e}	99.1^{d}
40 h	76.25^{a}	87.25^{a}	0.2865^{c}	4.355^{d}	0.1542^{a}	2.958^{a}	5.446^{b}	15.16^{d}	82.9^{c}
G_{rand} Mean	77.71	88.90	0.2393	3.550	0.1764	3.927	5.476	13.25	74.20
P_{value}	<0.001	<0.001	<0.001	<0.001	0.010	<0.001	<0.001	<0.001	<0.001
LSD	4.192	4.743	0.0241	0.4756	0.0237	0.4338	0.4516	1.769	13.93
Interaction (*LP*)**									
P_{value}	0.763	0.729	0.029	<0.001	0.144	<0.001	0.001	0.009	0.018
CV %	5.30	5.20	9.90	13.20	13.20	10.90	8.10	13.10	18.50

*Note: * – mean within columns with the same letters is not significantly different at 5 % level; G % – germination percentage; R % – relativized germination; MGR – mean germination rate; GI – germination Index; Z – synchronization index; T_{50} – days to 50 % germination; MDG – mean daily germination; P_{value} – peak value for germination rate; G_{value} – germination value).*

3. 2. Effect of landrace ecotype on the germination of horned melon seeds

Analysis of variance revealed no statistically significant differences ($P>0.05$) between the landraces on final germination percentage (*G* %age) *L*1 had higher (92.16 %) relativized germination percentage (*R* %) than *L*2 (**Table 1**). *L*2 had a higher synchronization index (*Z*) among the germination indices measured ($P<0.05$) than *L*1 (**Table 1**).

3. 3. Effect of hydro priming duration on the germination characteristics of horned melon seeds

Hydro priming duration was significant ($P<0.05$) for *G* % and *R* % at 24 h hydro priming, increasing by 11.86 % and 11.91 %, respectively, compared to the control. Averaged effect of hydro priming on final seed germination percentage was 78.5 % and 73.75 % in primed seeds and control respectively. Relativized germination reached 89.81 % and 84.35 % in primed seeds and control, respectively (**Table 1**). Curvilinear (**Fig. 1**) response to priming duration for *G* %, with hydro priming for 24 h provided the highest percentage (82.50 %) (**Fig. 1**). Except for the control treatment, the lowest figure for *Z* was obtained after 40 hours of hydro priming (0.1542). The synchronization index decreased linearly with priming duration (**Fig. 2**). Germination synchrony was 12.7 % higher in primed seeds than in non-primed seeds.

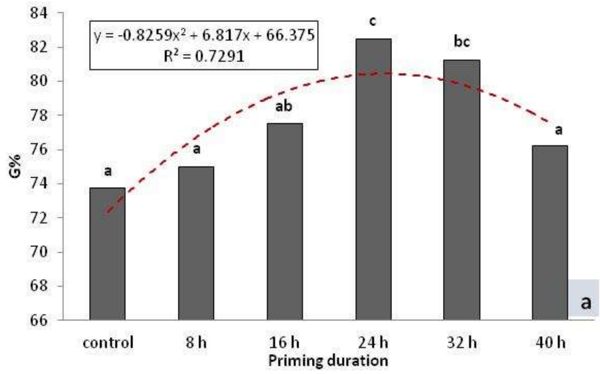

Fig. 1. Regression equations between priming duration and germination percentage (*G* %)

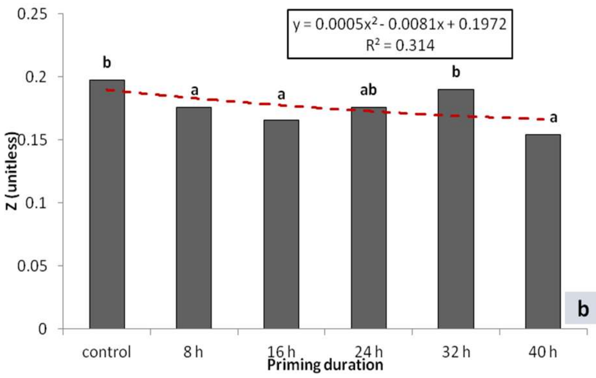

Fig. 2. Regression equations between priming duration and synchronization index

4. Discussion

Seeds are dormant at first because of their low moisture content. Nonetheless, pre-sowing hydro priming increases water imbibition, which leads to enzyme activation, translocation, and usage of stored food materials. This current research provides valuable data about horned melon seed germination under hydro priming conditions. Hydro priming enhanced germination parameters in horned melon seeds, consistent with previous research on other crop species; chickpea [27], sunflower [28], rice [29], cowpea [30], and maize [31].

Hydro priming has been demonstrated to promote germination and growth parameters, including germination percentage [32, 33], germination time [28], germination speed [33], time to 50 % germination [32], synchronization index [11]. Similarly, hydro priming seeds have been shown to improve germination under unfavorable environments [15, 34–36]. In this study, hydro priming induced germination to varying degrees in the horned melon landraces. The two landraces did not significantly vary in their response to germination percentage and mean daily germination. An assessment of the relativized germination means shows that L1 has better germination than *L*2. The variables, MGR and *T*50 can then be used to compare the dispersion of germination between these horned melon landraces. The significantly lower MGR for *L*2 compared to *L*1 implies that when both landraces are planted in the soil at the same time, *L*1 may germinate before *L*2, which has the shortest time to achieve 50 % of maximum germination (*T*50). *L*1 had more homogeneous germination over time, as evidenced by a lower synchronization index than *L*2 probably genetically influenced. In this study, the germination index (GI) was used to determine the speed and percentage of germination, and the results show that there were major differences in the responses of the landraces to germination (**Table 1**). A greater value for such a measure shows a better germination rate [37], implying that *L*2 has a higher germination rate than *L*1. Greater G_{value} and P_{value} values indicate that *L*2 is superior to *L*1.

The importance of hydro priming in the germination of horned melon is evidenced by the index values (**Fig. 1** and **Table 1**). *G* %, *R* %, *MGR*, *GI*, *Z*, *MDG*, *T*50, P_{value} and G_{value} were statistically influenced by both long and short periods. An increase in values with a corresponding increase in the priming period indicates improved germination. Hydro priming increases *G* %, *R* %, and *MDG* germination up to a peak (24 h), after which it begins to decline, indicating that prolonged priming has a detrimental impact on germination. Prolonged priming results in excess water inside the seed embryo and this causes a substantial decrease in oxygen availability in the embryo [38]. A decrease in *Z* values and T_{50} values in hydro primed treatments indicates faster and even more uniform germination. Higher mean values for P_{value} and G_{value}, on the other hand, indicated faster cumulative germination. Lower days to 50 % germination and mean germination time values obtained in hydro-primed seeds indicated more uniform and rapid germination.

As seed germination is divided into three stages:

I) imbibition;

II) lag phase;

III) radicle growth and emergence [39], priming is used to extend the lag phase, which permits some pre-germinative biochemical and physiological processes to occur and yet precludes germination [40].

In our germination tests, the outcomes for the interaction effect of soaking duration and horned melon landrace (**Table 1**) revealed significant distinctions between the treatment means. Other researchers have found that seed priming treatment increases seed germination [41, 42]. Enhanced germination indices for treated seeds may be related to their rapid utilization in synthesizing numerous amino acids and amides [43], which may cause an increased germination rate. The higher the germination index, the quicker a seed lot germinated, as the germination index is an attribute that integrates the germination percentage and time of germination. Several of the distinction obtained among priming treatments have been marginal. However, suppose germination indices for germination rate and lag time were faster and shorter, respectively, these advantages become relevant for nursery practices [44] because even minor changes in germination parameters may shorten seedling permanence in the seedbed, greenhouse, or shade house [45]. The mean values for P_{value} and G_{value}, representing cumulative germination, were highest after 36 hours of priming and then declined, reducing germination. The decrease in germination due to longer priming duration might be believed to be due to excess water inside the seeds, which causes a substantial decrease in O_2 availability towards the embryo.

5. Conclusions

Each landrace responded differently to hydro priming, with *L*2 appearing to have a better response to germination than *L*1, registering a higher germination rate together with higher values for germination and peak germination values. As both landraces germinated better than in the control treatment, hydro priming appears important at long and short time scales. On average, hydro priming enhanced germination index values across priming duration treatments. As the influence of hydro priming seems to be more likely to decline with prolonged soaking, it is recommended that hydro priming be implemented for 32 hours in light of the results of the current study. Because hydro priming is a simple technique, evaluating its efficacy in various environmental conditions is critical for optimizing this hydro priming technique. While seed priming is a viable technology for increasing crop yield, future research should focus on other priming agents and the suitability of various priming options for different agroecosystems. The effect of germinating media and seedling vigor of these species deserves further investigation too.

Conflict of interest

The authors declare that there is no conflict of interest in relation to this paper, as well as the published research results, including the financial aspects of conducting the research, obtaining and using its results, as well as any non-financial personal relationships.

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Data availability

Data will be made available on reasonable request

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References

[1] Benzioni, A., Mendlinger, A., Ventura, M., Huyskens, S. (1993). Germination, fruit development, yield and postharvest characteristics of Cucumis metuliferus. New crops. Proceedings of the Second National Symposium: New crops, exploration, research and commercialization, 553–557.

[2] Lim, T. K. (2011). Cucumis metuliferus. Edible Medicinal And Non-Medicinal Plants, 235–238. doi: https://doi.org/10.1007/978-94-007-1764-0_37

[3] Bradford, K. J. (2002). Applications of hydrothermal time to quantifying and modeling seed germination and dormancy. Weed Science, 50 (2), 248–260. doi: https://doi.org/10.1614/0043-1745(2002)050[0248:aohttq]2.0.co;2

[4] Levidow, L., Zaccaria, D., Maia, R., Vivas, E., Todorovic, M., Scardigno, A. (2014). Improving water-efficient irrigation: Prospects and difficulties of innovative practices. Agricultural Water Management, 146, 84–94. doi: https://doi.org/10.1016/j.agwat.2014.07.012

[5] Kamithi, K. D., Wachira, F., Kibe, A. M. (2016). Effects of different priming methods and priming durations on enzyme activities in germinating chickpea (Cicerarietinum L.). American Journal of Natural and Applied Sciences, 1, A1–A9.

[6] Paparella, S., Araújo, S. S., Rossi, G., Wijayasinghe, M., Carbonera, D., Balestrazzi, A. (2015). Seed priming: state of the art and new perspectives. Plant Cell Reports, 34 (8), 1281–1293. doi: https://doi.org/10.1007/s00299-015-1784-y

[7] Sarathkumar, A., Malarkodi, K., Ananthi, M. (2017). Evaluation of Physiological Seed Treatments on Seedling Quality parameters in Turkey Berry (Solanum torvum Sw.). International Journal of Current Microbiology and Applied Sciences, 6 (6), 212–219. doi: https://doi.org/10.20546/ijcmas.2017.606.025

[8] Neto, F. J. D., Dalanhol, S. J., Machry, M., Junior, A. P., Rodrigues, J. D., Ono, E. O. (2017). Effects of plant growth regulators on eggplant seed germination and seedling growth. Australian Journal of Crop Science, 11 (10), 1277–1282. doi: https://doi.org/10.21475/ajcs.17.11.10.pne542

[9] Ali, M., Hayat, S., Ahmad, H., Ghani, M. I., Amin, B., Atif, M. J., Cheng, Z. (2019). Priming of Solanum melongena L. Seeds Enhances Germination, Alters Antioxidant Enzymes, Modulates ROS, and Improves Early Seedling Growth: Indicating Aqueous Garlic Extract as Seed-Priming Bio-Stimulant for Eggplant Production. Applied Sciences, 9 (11), 2203. doi: https://doi.org/10.3390/app9112203

[10] Forti, C., Ottobrino, V., Doria, E., Bassolino, L., Toppino, L., Rotino, G. L. et al. (2021). Hydropriming Applied on Fast Germinating Solanum villosum Miller Seeds: Impact on Pre-germinative Metabolism. Frontiers in Plant Science, 12. doi: https://doi.org/10.3389/fpls.2021.639336

[11] Damalas, C. A., Koutroubas, S. D., Fotiadis, S. (2019). Hydro-priming Effects on Seed Germination and Field Performance of Faba Bean in Spring Sowing. Agriculture, 9 (9), 201. doi: https://doi.org/10.3390/agriculture9090201

[12] Patil, K., Ravat Anilkumar, L., Trivedi, V., Hirpara, A., Sasidharan, N. (2018). Effect of seed priming treatment in chickpea (Cicer arietinum L.). IJCS, 6, 1064–1069. Available at: https://www.researchgate.net/publication/327052826

[13] Mutetwa, M., Nyaera, K., Masaka, T., Mtaita, T. A. (2020). Effect of bio priming seeds with microbial based bio fertilizers on growth of maize seedlings. International Journal of Research and Review, 6 (10), 281–288. Available at: https://www.ijrrjournal.com/IJRR_Vol.6_Issue.10_Oct2019/IJRR0040.pdf

[14] Adhikari, B., Dhital, P. R., Ranabhat, S., Poudel, H. (2021). Effect of seed hydro-priming durations on germination and seedling growth of bitter gourd (Momordica charantia). PLOS ONE, 16 (8), e0255258. doi: https://doi.org/10.1371/journal.pone.0255258

[15] Devika, O. S., Singh, S., Sarkar, D., Barnwal, P., Suman, J., Rakshit, A. (2021). Seed Priming: A Potential Supplement in Integrated Resource Management Under Fragile Intensive Ecosystems. Frontiers in Sustainable Food Systems, 5. doi: https://doi.org/10.3389/fsufs.2021.654001

[16] Farooq, M., Basra, S. M. A., Afzal, I., Khaliq, A. (2006). Optimization of hydropriming techniques for rice seed invigoration. Seed Science and Technology, 34 (2), 507–512. doi: https://doi.org/10.15258/sst.2006.34.2.25

[17] Srivastava, A. K., Lokhande, V. H., Patade, V. Y., Suprasanna, P., Sjahril, R., D'Souza, S. F. (2010). Comparative evaluation of hydro-, chemo- , and hormonal-priming methods for imparting salt and PEG stress tolerance in Indian mustard (Brassica juncea L.). Acta Physiologiae Plantarum, 32 (6), 1135–1144. doi: https://doi.org/10.1007/s11738-010-0505-y

[18] Nyamapfene, K. (1991). Soils of Zimbabwe. Harare: Nehanda Publishers, 179.

[19] Pérez-Pizá, M. C., Prevosto, L., Grijalba, P. E., Zilli, C. G., Cejas, E., Mancinelli, B., Balestrasse, K. B. (2019). Improvement of growth and yield of soybean plants through the application of non-thermal plasmas to seeds with different health status. Heliyon, 5 (4), e01495. doi: https://doi.org/10.1016/j.heliyon.2019.e01495

[20] Fitch, E. A., Walck, J. L., Hidayati, S. N. (2007). Temporal fulfilment of the light requirement for seed germination: an example of its use in management of rare species. Seeds: Biology, Development and Ecology. Proceedings of the Eighth International Workshop on Seeds, Brisbane, Australia, May 2005, 365–373. doi: https://doi.org/10.1079/9781845931971.0365

[21] Ranal, M. A., Santana, D. G. de, Ferreira, W. R., Mendes-Rodrigues, C. (2009). Calculating germination measurements and organizing spreadsheets. Revista Brasileira de Botânica, 32 (4), 849–855. doi: https://doi.org/10.1590/s0100-84042009000400022

[22] Rules for Testing Seeds (1993). Journal of Seed Technology, 16.

[23] Labouriau, L. G. (1978). On the frequency of isothermal germination in seeds of Dolichos biflorus L. Plant and Cell Physiology, 19 (3), 507–512. doi: https://doi.org/10.1093/oxfordjournals.pcp.a075620

[24] Coolbear, P., Francis, A., Grierson, D. (1984). The Effect of Low Temperature Pre-Sowing Treatment on the Germination Performance and Membrane Integrity of Artificially Aged Tomato Seeds. Journal of Experimental Botany, 35 (11), 1609–1617. doi: https://doi.org/10.1093/jxb/35.11.1609

[25] Adams, J. C., Farrish, K. W. (1992). Seedcoat Removal Increases Speed and Completeness of Germination of Water Oak. Tree Planters' Notes, 43 (2).

[26] Czabator, F. J. (1962). Germination value: an index combining speed and completeness of pine seed germination. Forest science, 8 (4), 386–396.

[27] Sharma, R., Pandey, S. T., Verma, O. (2021). Response to pre-sowing seed treatment on germination indices, seeding growth and enzymatic activities of chickpea (Cicer arietinum L.) seed. International Journal of Ecology and Environmental Sciences, 3 (1), 405–410. Available at: https://www.researchgate.net/publication/350048437_Response_to_pre-sowing_seed_treatment_on_germination_indices_seedling_growth_and_enzymatic_activities_of_chickpea_Cicer_arietinum_L_seed

[28] Catiempo, R. L., Photchanachai, S., Bayogan, E. R. V., Wongs-Aree, C. (2021). Impact of hydropriming on germination and seedling establishment of sunflower seeds at elevated temperature. Plant, Soil and Environment, 67 (9), 491–498. doi: https://doi.org/10.17221/163/2021-pse

[29] Amruta, N., Prasanna Kumar, M. K., Kandikattu, H. K., Sarika, G., Puneeth, M. E., Ranjitha, H. P. et al. (2019). Bio-priming of rice seeds with novel bacterial strains, for management of seedborne Magnaporthe oryzae L. Plant Physiology Reports, 24 (4), 507–520. doi: https://doi.org/10.1007/s40502-019-00492-6

[30] Arun, M. N., Hebbar, S. S., Bhanuprakas, K., Senthivel, T. (2017). Seed priming improves irrigation water use efficiency, yield and yield components of summer cowpea under limited water conditions. LEGUME RESEARCH - AN INTERNATIONAL JOURNAL. doi: https://doi.org/10.18805/lr-3785

[31] Rozier, C., Hamzaoui, J., Lemoine, D., Czarnes, S., Legendre, L. (2017). Field-based assessment of the mechanism of maize yield enhancement by Azospirillum lipoferum CRT1. Scientific Reports, 7 (1). doi: https://doi.org/10.1038/s41598-017-07929-8

[32] Adinde, J., Omeje, E., Uche, O., Agu, C. (2020). Impact of hydropriming duration on seed germination and emergence indices of sweet basil. J. Agric. Sci. Pract. Available at: https://www.researchgate.net/publication/340021229_Impact_of_hydropriming_duration_on_seed_germination_and_emergence_indices_of_sweet_basil

[33] Shakuntala, N. M., Kavya, K. P., Macha, S. I., Kurnalliker, V., Patil, M. (2020). Studies on standardization of water soaking duration on seed quality in cucumber (Cucumis sativus L.) seeds. Journal of Pharmacognosy and Phytochemistry, 9 (4), 1400–1404. Available at: https://www.phytojournal.com/archives/2020/vol9issue4/PartS/9-4-168-895.pdf

[34] Zulfiqar, F. (2021). Effect of seed priming on horticultural crops. Scientia Horticulturae, 286, 110197. doi: https://doi.org/10.1016/j.scienta.2021.110197

[35] Chatterjee, N., Sarkar, D., Sankar, A., Pal, S., Singh, H. B., Singh, R. K. et al. (2018). On-farm seed priming interventions in agronomic crops. Acta Agriculturae Slovenica, 111 (3). doi: https://doi.org/10.14720/aas.2018.111.3.19

[36] Jisha, K. C., Puthur, J. T. (2018). Seed Hydropriming Enhances Osmotic Stress Tolerance Potential in Vigna radiata. Agricultural Research, 7 (2), 145–151. doi: https://doi.org/10.1007/s40003-018-0306-x

[37] Javaid, M. M., Florentine, S., Ali, H. H., Weller, S. (2018). Effect of environmental factors on the germination and emergence of Salvia verbenaca L. cultivars (verbenaca and vernalis): An invasive species in semi-arid and arid rangeland regions. PLOS ONE, 13 (3), e0194319. doi: https://doi.org/10.1371/journal.pone.0194319

[38] Nagabhushan Arun, M., Shankara Hebbar, S., Bhanuprakash, Senthivel, T., Kumar Nair, A., Padmavathi, G. et al. (2022). Seed Priming: The Way Forward to Mitigate Abiotic Stress in Crops. Physiology. doi: https://doi.org/10.5772/intechopen.102033

[39] Ali, A. S., Elozeiri, A. A. (2017). Metabolic Processes During Seed Germination. Advances in Seed Biology. doi: https://doi.org/10.5772/intechopen.70653

[40] Tian, Y., Guan, B., Zhou, D., Yu, J., Li, G., Lou, Y. (2014). Responses of Seed Germination, Seedling Growth, and Seed Yield Traits to Seed Pretreatment in Maize (Zea maysL.). The Scientific World Journal, 2014, 1–8. doi: https://doi.org/10.1155/2014/834630

[41] Shrestha, A., Pradhan, S., Shrestha, J., Subedi, M. (2019). Role of seed priming in improving seed germination and seedling growth of maize (Zea mays L.) under rain fed condition. Journal of Agriculture and Natural Resources, 2 (1), 265–273. doi: https://doi.org/10.3126/janr.v2i1.26088

[42] Ahammad, K., Rahman, M., Ali, M. (2014). Effect of hydropriming method on maize (Zea mays) seedling emergence. Bangladesh Journal of Agricultural Research, 39 (1), 143–150. doi: https://doi.org/10.3329/bjar.v39i1.20164

[43] Onomo, P. E., Niemenak, N., Ndoumou, D. O., Lieberei, R. (2010). Change in amino acids content during germination and seedling growth of Cola sp. African Journal of Biotechnology, 9 (35), 5632–5642. Available at: https://www.researchgate.net/publication/228980055_Change_in_amino_acids_content_during_germination_and_seedling_growth_of_Cola_sp

[44] Schmidt, L. H. (2000). Guide to handling of tropical and subtropical forest seed. Copenhagen: University of Copenhagen, Danida Forest Seed Centre.

[45] Peraza-Villarreal, H., Sánchez-Coronado, M. E., Lindig-Cisneros, R., Tinoco-Ojanguren, C., Velázquez-Rosas, N., Cámara-Cabrales, L., Orozco-Segovia, A. (2018). Seed Priming Effects on Germination and Seedling Establishment of Useful Tropical Trees for Ecological Restoration. Tropical Conservation Science, 11, 194008291881788. doi: https://doi.org/10.1177/1940082918817886

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