

## Original Research Article

# ENHANCEMENT OF VIGOUR STATUS THROUGH HYDRO AND LEAF EXTRACT PRIMING AND HUMID INVIGORATION IN RIBBED GOURD (COH 1) AND BITTER GOURD (CO 1)

## ABSTRACT

The present study focused on the evaluation of priming with water and various botanical leaf extract and followed by humid invigoration as a means to improve seed germination and seedling vigour of ribbed gourd (COH 1) and bitter gourd (CO 1). The seeds of these gourds were primed with water and various leaf extracts at 2% concentration viz., Pongam (*Pongamia pinnata* L.), Neem (*Azadirachta indica*), Moringa (*Moringa oleifera*), Curry leaf (*Murraya koenigii*), Notchi (*Vitex negundo*), Coconut (*Cocos nucifera*), Hena (*Lawsonia inermis*) and Guava (*Psidium guajava*). Unprimed seeds taken as a control. Hydro and leaf extract priming with humid invigoration process significantly influence the germination and seedling vigour of both crops viz., ribbed gourd (COH 1) and bitter gourd (CO 1). The study revealed that highest seed and seedling quality characters like germination percentage, speed of germination, seedling length, dry matter production, vigour index I and vigour index II were recorded in hydro primed with humid invigoration. Among the leaf extracts moringa shows better seedling growth of above parameters. Minimum value of this parameter was recorded in henna leaf extract priming with humid invigoration in both ribbed gourd (COH 1) and bitter gourd (CO 1).

**Keywords :** Botanical leaf extract, Seed priming, Humid invigoration, Bitter gourd, Ribbed gourd

## INTRODUCTION

Gourds are a remarkable crop in the world that comes under the Cucurbitaceae family which originated in Africa's tropical and subtropical areas. Gourds are highly adaptive in both tropical and subtropical regions. 83% of the production area was covered by Asia, 3% by Africa, and 2% by Central America (Dhillon *et al.*, 2020). In 2022, the bitter gourd was cultivated on about 0.109 M ha with a productivity of 12 t/ha and ribbed gourd was cultivated on about 0.01 M ha with average production and productivity of 0.12 M MT and 12.5 T, respectively (India Stat 2022). Bitter gourd often known as bitter melon or bitter apple. Bitter gourd referred to as a "gold mine of functional bioactive components" due to the presence of approximately 228 distinct bioactive substances (Nagarani *et al.*, 2014). The ridged gourd is also referred to as Chinese okra, ribbed gourd, silk squash. Ridged gourd seeds have purgative, emetic, and anthelmintic properties, while the fruits have demulcent and diuretic qualities (Nadkarni *et al.*, 1996).

Seed priming is a physiological seed quality enhancement treatment. During priming, imbibitions take place in a controlled manner (Harris *et al.*, 1999) (phase I). This controlled imbibition activates the hydrolytic enzymes, which lead to the breakage of complex stored products like

starch, carbohydrate, and proteins into simple, easily available products (*i.e.*, glucose and amino acids) (phase II). Then, before the radical protrusion stage, seeds were brought to their original moisture content (phase III) by shade drying for long-term safe storage. Priming activates pre germinative physiological and biochemical processes in advance of field establishment which leads to early emergence during field establishment even under low moisture levels. Some commonly used priming methods are hydro priming, osmo priming, bio priming, chemical priming, matrix priming, nutrient priming, halo priming, thermo priming.

Inclusion of antioxidants, chemicals, PGR, and nutrients during priming improves seed performance and early plant growth and development, especially in harsh environments such as extreme temperatures or salty conditions. (Pill and FINCH-SAVAGE *et al.*, 1988; Taylor and Harman *et al.*, 1990; Afzal *et al.*, 2011; Bakht *et al.*, 2011) However, the use of chemical components in seed priming is costly for resource-limited farmers, and large-scale utilization is also not possible. Seed priming with specific phytochemicals can be a cost-effective and environmentally conscious alternative to such chemicals. Some tree and crop water extracts have been found to have beneficial functions for crop growth and yield (Chung and Miller *et al.*, 1995; Ahmed and Nimer *et al.*, 2002; Farooq *et al.*, 2008). These leaf extracts have more than hundreds of bioactive compounds which mainly include secondary metabolites *viz.*, alkaloids, phenols, glycosides, and essential oils *viz.*, terpenes, tannins, eugenol, cineol, kaempferol. These bio active compounds possess various activity in plant system *viz.*, antioxidant, antibacterial, antifungal, larvicidal, anticarcinogenic, hypoglycemic, anti-lipid peroxidative, hypolipidemic and antihypertensive activity (Goutam and Purohit *et al.*, 1974; Chowdhury *et al.*, 2008). Several studies have been proved that this leaf extract treatment significantly improved the germination and seedling growth of various crops like ragi (Prakash *et al.*, 2020), black gram (Tamilmani *et al.*, 2012), rice (Prakash *et al.*, 2013).

In order to extend the beneficial effect of seed priming and also to stimulate various physiological changes in soaked seeds, the seeds after priming were subjected to humid invigoration treatment. During humid invigoration primed seeds are placed in a loosely knotted wet cloth bag and placed in a closed container on an elevated platform where humid, dark conditions may be created to aid the invigoration process. Higher relative humidity (>80% RH) during the priming process improves the physiological and physiochemical properties of the seeds, such as increased germination, speed of emergence, dry matter production, seedling length, decline in seed leachates and elevation in amylase activity and sugar content (L. Anilkumar *et al.*, 2019) (Powell AA *et al.*, 2000), (Nath S *et al.*, 1991).

## MATERIALS AND METHOD

Bitter gourd (CO1) and ribbed gourd (COH1) seeds were collected from the Department of Vegetable Science, HC & RI, TNAU Coimbatore, and subjected to seed priming treatment with water (hydropriming), and different leaf extracts, *viz.*, pongam (*Pongamia pinnata*), neem (*Azadirachta indica*), coconut (*Cocos nucifera*), henna (*Lawsonia inermis*), guava (*Psidium guajava*), curry leaf (*Murraya koenigii*), Moringa (*Moringa oleifera*), and Notchi (*Vitex negundo*) at 2% w/v concentration. Unprimed seeds are taken as control. Ribbed gourd and bitter gourd seeds were soaked in the above-mentioned solution for 24 hours. The seed-to-solution ratio for

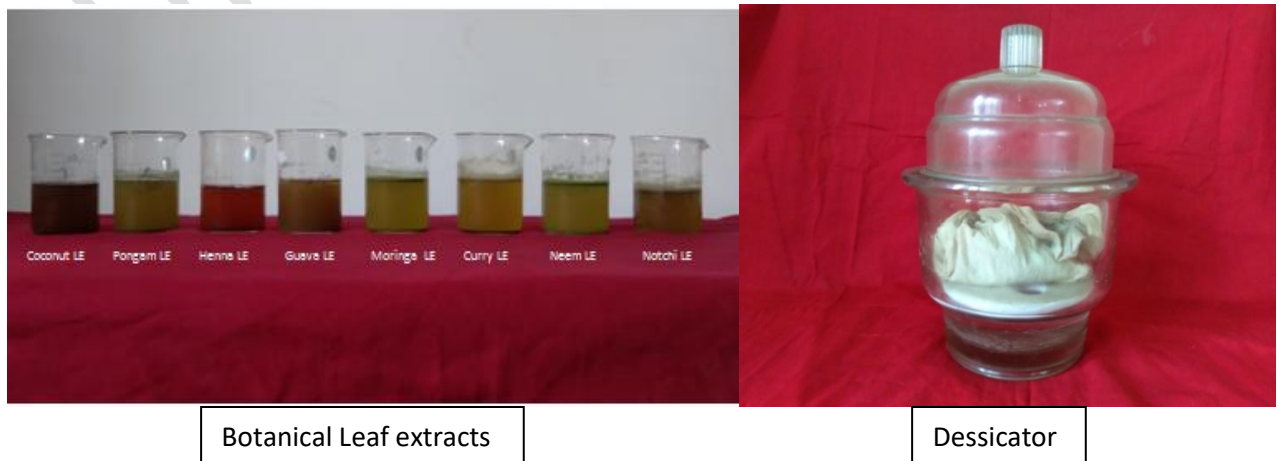
soaking was 1:2 on a volume-by-volume basis. After 24 hours of soaking, the soaking solution was drained, and seeds were placed for about 12 hours in a loosely knotted wet cloth bag that was kept under a closed container on an elevated platform (dessicator) where humid and dark conditions may be created to aid the invigoration process. To create humid condition dessicator was placed under dark and elevated room temperature (30°C). After completing the humid invigoration process, seeds were dried under shade conditions for about 12 hours to bring them back to their original moisture content.

After the completion of drying process, primed seeds and control seeds were subjected to seed germination tests through the sand method under controlled environmental conditions in a germination room. Daily observations made up the final count (14 days). At the final count, seedlings that emerged were counted, recorded, and evaluated for their seedling characteristics. The experiment was statistically analysed by Completely Randomized Block Design (CRD) in three replications

**Table 1. Treatment details.**

T <sub>1</sub>	Control	Humid Invigoration for 12 hrs followed by shade drying for 12 hrs
T <sub>2</sub>	Hydro priming	
T <sub>3</sub>	Coconut leaf extract @2 %	
T <sub>4</sub>	Pongam leaf extract @2 %	
T <sub>5</sub>	Henna leaf extract @2 %	
T <sub>6</sub>	Guava leaf extract @2 %	
T <sub>7</sub>	Moringa leaf extract @2 %	
T <sub>8</sub>	Curry leaf leaf extract @2 %	
T <sub>9</sub>	Neem leaf extract @2 %	
T <sub>10</sub>	Notchi leaf extract @2 %	

**Fig 1. Treatment details**



## Leaf extract preparation

Leaves of pongam (*Pongamia pinnata* L.), neem (*Azadirachta indica*), coconut (*Cocos nucifera*), henna (*Lawsonia inermis*), guava (*Psidium guajava*), curry leaf (*Murraya koenigii*), moringa (*Moringa oleifera*), and notchi (*Vitex negundo*) will be collected and washed with water. The washed leaves will be shade dried for 2-3 days, followed by sun-drying for 3-4 days. Then the dried leaves will be powdered with help of ball mill. 2% of extracts will be prepared with distilled water in a ratio of 2 g per 100 ml of water as weight per volume (Parry *et al.*, 2006).

## RESULTS

The results showed that among different treatments, seeds of bitter gourd soaked in water (hydro priming) for 24 h followed by 12 hrs humid invigoration recorded the better seedling performance. Hydro priming with humid invigoration shows maximum germination per cent (94 %) followed by moringa leaf extract priming with humid invigoration (90 %), while the control (unprimed seeds) recorded 86 % germination. The lower germination % (78 %) was recorded in henna leaf extract priming with humid invigoration. All parameters viz., germination per cent, speed of germination, root length (cm), shoot length (cm), dry matter production (g seedlings-10), total seedling length (cm), and vigour index I and vigour index II was found to be higher in hydro priming and lower in henna leaf extract priming. The percentage increase recorded over control was 45, 13, 5, 34, 8, 18, 46, respectively and over the henna LE extract was 21, 58, 25, 15, 29, 18, 43,57, respectively

Similar to bitter gourd, ribbed gourd also had greater seedling performance under hydro priming with humid invigoration condition. Hydro priming with humid invigoration shows maximum germination (92 %) followed by moringa leaf extract priming with humid invigoration (90 %). While the control (unprimed seeds) recorded only 82 % germination. Lowest germination per cent (76 %) recorded in henna LE priming followed by guava LE (80 %). Hydro priming with humid invigoration shows higher germination percentage, with an increase of 12 % over the control and an increase of 21 % over the henna leaf extract. Speed of germination, root length (cm), shoot length (cm), dry matter production (g seedlings-10), total seedling length (cm), and vigour index I and vigour index II was also found to be higher in hydro priming and lower in henna leaf extract priming. The percentage increase recorded over control was 32, 46, 14, 12, 28, 37, 21, respectively and over the henna LE priming was 32, 46, 14, 12, 28, 37, 21 respectively. Other leaf extract also had some promotional effects on physiological parameters viz., germination percent, The root length (cm), shoot length (cm), total seedling length (cm), dry matter production (g seedlings-10) and vigor index over the control in both crops. Among the leaf extracts, moringa LE showed higher germination percent (88 %) in both crops which was on par with notchi and pungam LE in ribbed gourd. Other parameters like the speed of germination, dry matter production (g seedlings-10), total seedling length (cm), and vigour index I and vigour index II was also found to be highest in moringa LE in both ribbed gourd (3.13,1.127, 26.9, 2367, 99 receptively) and bitter gourd (3.21, 1.524, 36.15, 3254, 137 respectively)

## DISCUSSION

Among the various treatment treatments hydro priming with humid invigoration recorded higher **seed germination (%) and seedling vigour in both crops viz., ribbed gourd (COH 1) and bitter gourd (COH 2)**. Hydropriming is a physiological seed quality enhancement technique which significantly improve the seed and seedling quality of several crops which was supported by findings of Wardah *et al.* (2019) in wheat, Mohammadi *et al.* (2014) in maize, Beata *et al.* (2018) in sugar beetroot, Langeroodi and Noora (2017) *et al.*, (2017) in soybean and Lekić *et al.* (2015) in sunflower. Hydro-priming improves seed performance under the favorable condition which leads to higher germination percentages, speed of germination and dry matter production in Brassica sp (Alias *et al.*, 2016) and rice (Farooq *et al.*, 2006) (Forti *et al.*, 2020). Even under unfavorable condition also hydropriming promote germination in different crops viz., green gram (Jisha and Puthur *et al.*, 2018), maize (Jayesh and Meeta, 2015), rice (Jisha and Puthur, 2014), melon (Casenave and Toselli *et al.*, 2010), lentil (SAĞLAM *et al.*, 2010). Hydro priming facilitates faster water uptake (imbibition) due to high water potential of pure water leading to early enzyme activation, translocation, and fast utilization of reserved food materials in seed and hydration makes seed coat soft enough for enhanced easy and fast growth of seed embryo (Pandita *et al.*, 2007; Devika *et al.*, 2021). Hydro priming maintain the water content of the tissue leading to activation of hydrolytic enzyme like amylase, lipase for pre-germinative metabolism (Saleem *et al.*, 2014) and leaching out of toxic metabolite effects (Basu *et al.*, 1994). According Forti *et al.* (2020) faster germination due to hydropriming was associated with limited lipid peroxidation and significant tocopherols enhancement which provides protection against membrane oxidative damage. Humid invigoration stops germination and allows for the healing of cell membrane damage, which may have increased the germination percentage and vigour of seedlings (Basra and colleagues *et al.*, 2002). Seed humidification has been shown to increase seed germination in sesame (Vijayalakshmi *et al.*, 2018), *B. juncea* and *B. campestris* (Thornton *et al.*, 1993) and cockscomb (Khan *et al.*, 2003) RH is a important abiotic factor which influence the production of several plant growth hormone like gibberellins, auxins, cytokine, ethylene. Under higher pH , plant growth hormones like gibberellins, auxins, cytokine were significantly elevated, these lead to improved pollen viability and pollen which have been reported by few authors in plants like lily (Simons *et al.*, 1972), avocado (Loupassaki *et al.*, 1997), aglaonema (Henny *et al.*, 1998) papaya (Cohen *et al.*, 1980), walnut (Luza *et al.*, 1903), Humidity increases ethylene synthesis during priming, which may stimulate endo-mannase activity and aid in endosperm weakening and post-priming germination (Chen and Arora *et al.*, 2011).

Among the leaf extracts, moringa LE priming with humid invigoration showing better seed and seedling quality than other leaf extracts. This might be due to presence antioxidants like ascorbic acid, flavonoids, phenolics and carotenoids (Sinha *et al.*, 2011) as well as the growth-promoting substance such as vitamins C, K, and Ca, cytokinin, and others (Foidl *et al.*, 2001). Zeatin, a type of cytokinin found in moringa leaves that could speed up cell division (Foidl *et al.*, 2001) and Calcium act as enzyme cofactor which trigger the protein synthesis during germination process (Christiansen and Foy *et al.*, 1979) phenols has major role in activation of root growth of several crops viz maize, barnyard millet, forage sorghum (Nandhakumar *et al.*, 2010; Shehzad *et al.*, 2012; Suguna *et al.*, 2012) During priming the embryo of the seed appeared to receive the majority of the mineral nutrients provided by moringa LE, which facilitated the emergence of seedlings and eventually, the growth and development of plants. Increase in dry weight might be

due to enhanced lipid and enzyme utilization which was activated by bioactive substances like auxin and gibberellins present in moringa leaf extract.

Compare than other leaf extracts henna, guava and coconut leaf extracts, irrespectively showing lower values in seedling parameters viz., speed of germination, root length (cm), shoot length (cm), dry matter production (g seedlings-10), total seedling length (cm), and vigour index I and vigour index II in both bitter gourd and ribbed gourd. Henna's negative effect on seed germination and seedling growth was previously documented by Kaveriammal *et al.* (2013) in various crops viz., *V. radiate* (L), *V. mungo* (L), and *A. hypogaea*. Germination of *C. occidentalis* was significantly affected by guava leaf extracts (Namkeleja *et al.*, 2014). It might be due to presence of allelochemicals which led to negative allelopathy effect on seedling growth. Henna and guava leaf contains several allelochemicals such as terpenoids, flavonoids, coumarins, and cyanogenic acids (Chapla and Campos *et al.*, 2010; Khan *et al.*, 2014) According to (Khan *et al.*, 2014) presence of these allelochemicals significantly lower the germination as well as seedling growth by affecting the hydrolysis of food reserves and cell division during the process of germination. In some instances, they alter membrane permeability, interfere with the production of chlorophyll and synthesis of protein, and deactivate the activity of specific hormones and enzymes (Namkeleja *et al.*, 2014). Terpenoids and other allelochemicals have been shown to disturb the balance of growth hormones viz., auxin gibberellins (Namkeleja *et al.*, 2014). This interruption in normal auxin levels results in the stimulation of lateral shoot growth and the subsequent suppression of vertical growth (Brunn *et al.*, 1992).

## Conclusion

From this study, it could be concluded that Hydro priming (24 hrs) followed by humid invigoration (12 hrs) significantly improve the seed germination and seedling vigour of ribbed gourd (COH 1) and bitter gourd (CO 1). This prove that water mediated priming is sufficient for activate the bio chemical change of the seeds which positively influence the seedling growth. There is no influential effect was recorded in seeds primed with varies leaf extract except moringa leaf extract. Instead of promoting they suppressed the seedling growth parameter particularly henna, guava and coconut leaf extract highly inhibit the growth of the seedling. mineral nutrient and anti oxidant substance of moringa leaf support the growth of the seedlings mean while allelochemicals of henna, guava, coconut might create negative allelopathy effect on ribbed gourd and bitter gourd seedling growth.

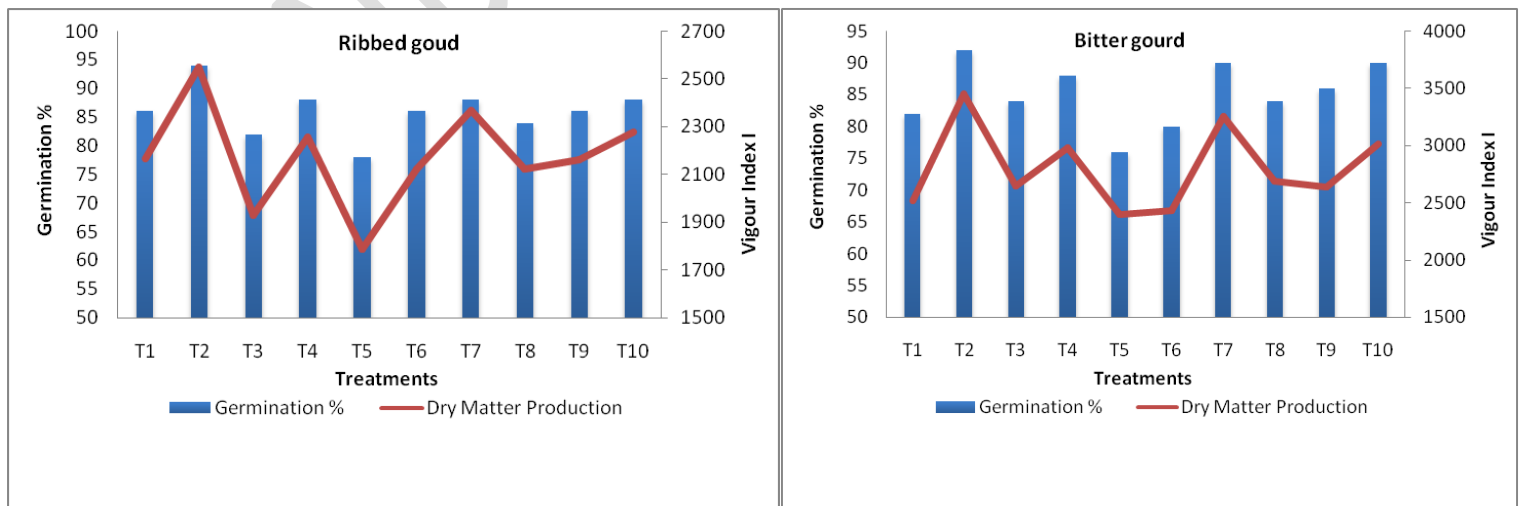
**Table 2: Effect of leaf extract priming on seedling quality parameters of Ribbed gourd (COH 1)**

Treatments	Germination (%)	Speed of germination	Root length (cm)	Shoot length (cm)	DMP (g/10 seedings)	Seedling length	Vigour index I	Vigour index II
T1	86 (68.0)	2.67	8.14	17.03	0.862	25.17	2165	74
T2	94 (75.8)	3.87	9.21	17.9	1.156	27.11	2548	108
T3	82 (64.9)	2.9	7.23	16.3	0.882	23.53	1929	72
T4	88 (69.7)	2.98	8.7	16.95	0.957	25.65	2257	84
T5	78 (62.0)	2.45	7.34	15.57	0.895	22.91	1787	69
T6	86 (68.0)	2.84	8.15	16.51	0.993	24.66	2121	85
T7	88 (69.7)	3.13	9.17	17.73	1.127	26.9	2367	99
T8	84 (66.4)	2.76	8.55	16.7	1.102	25.25	2121	92
T9	86 (68.0)	2.89	8.4	16.75	1.089	25.15	2162	93
T10	88 (69.7)	2.84	8.85	17.05	1.115	25.9	2279	98
Mean	<b>68.3340</b>	<b>2.9330</b>	<b>8.3740</b>	<b>16.8490</b>	<b>1.0178</b>	<b>25.225</b>	<b>2173.6</b>	<b>87.400</b>
SEd	<b>2.9748 *</b>	<b>0.1271 **</b>	<b>0.356**</b>	<b>0.72 (NS)</b>	<b>0.043 **</b>	<b>1.076 *</b>	<b>92.51 **</b>	<b>3.74 **</b>
CD(P=0.05)	<b>6.6284</b>	<b>0.2832</b>	<b>0.7952</b>	<b>1.6214</b>	<b>0.0965</b>	<b>2.3993</b>	<b>206.127</b>	<b>8.3370</b>

**Table 3: Effect of leaf extract priming on seedling quality parameters of Bitter gourd (CO 1)**

Treatments	Germination (%)	Speed of germination	Root length (cm)	Shoot length (cm)	DMP (g/10 seedings)	seedling length	Vigour index I	Vigour index II
T1	82 (64.9)	2.69	13.2	16.05	1.517	29.25	2516	130
T2	92 (73.6)	3.54	19.3	18.25	1.704	37.55	3455	157
T3	84 (66.4)	2.96	14.65	16.83	1.351	31.48	2644	113
T4	88 (69.7)	3.02	15.49	18.35	1.487	33.84	2978	131
T5	76 (60.7)	2.53	14.85	16.7	1.367	31.55	2398	104
T6	80 (63.4)	2.61	14.53	15.89	1.345	30.42	2434	108
T7	90 (71.6)	3.21	18.25	17.9	1.524	36.15	3254	137
T8	84 (66.4)	2.85	16.03	16.01	1.325	32.04	2691	111
T9	86 (68.0)	2.89	14.9	15.81	1.356	30.71	2641	117
T10	90 (71.6)	2.96	16.01	17.5	1.367	33.51	3016	123
mean	<b>67.7130</b>	<b>2.9260</b>	<b>15.7210</b>	<b>16.9295</b>	<b>1.4344</b>	<b>32.6500</b>	<b>2802.70</b>	<b>123.1000</b>
SEd	<b>3.00 *</b>	<b>0.12 **</b>	<b>0.67 **</b>	<b>0.736 *</b>	<b>0.062 **</b>	<b>1.40 **</b>	<b>118.76**</b>	<b>5.25 **</b>
CD(P=0.05)	<b>6.6912</b>	<b>0.2803</b>	<b>1.5000</b>	<b>1.6407</b>	<b>0.1387</b>	<b>3.1372</b>	<b>264.6325</b>	<b>11.7057</b>

**Fig 2. Graphical distribution of Effect on leaf extract priming on seedling quality parameters.**



**Fig 3. Effect of leaf extract priming on bitter gourd (CO 1)**



**Fig 4. Effect of leaf extract priming on ribbed gourd (COH 1)**



## REFERENCE

- Afzal, I., S. Basra, and N. Ahmad. 2011. "Hormonal priming induces salt tolerance in wheat through enhanced antioxidant defence system." *Cereal Res. Commun* 39:334-342.
- Ahmed, D.M., and A.M. Nimer. 2002. "Effects of acacia senegal (L., Willd.) on sandy soils: A case study of El damokeya forest, Northern Kordofan State." *University of khartoum journal of agricultural sciences* 10 (1):106-118.
- Bakht, J., M. Shafi, Y. Jamal, and H. Sher. 2011. "Response of maize (*Zea mays* L.) to seed priming with NaCl and salinity stress." *Spanish Journal of Agricultural Research* 9 (1):252-261.
- Chowdhury, J.U., M.N.I. Bhuiyan, and M. Yusuf. 2008. "Chemical composition of the leaf essential oils of *Murraya koenigii* (L.) Spreng and *Murraya paniculata* (L.) Jack." */// Bangladesh Journal of Pharmacology* 3 (2):59-63.
- Chung, I.M., and D.A. Miller. 1995. "Effect of alfalfa plant and soil extracts on germination and growth of alfalfa." *Agronomy Journal* 87 (4):762-767.
- Dhillon, N.P., S. Laenoi, S. Srimat, S. Pruangwitayakun, A. Mallappa, A. Kapur, K.K. Yadav, G. Hegde, R. Schafleitner, and P. Schreinemachers. 2020. "Sustainable cucurbit breeding and production in Asia using public-private partnerships by the world vegetable center." *Agronomy* 10 (8):1171.
- Farooq, M., T. Aziz, S. Basra, M. Cheema, and H. Rehman. 2008. "Chilling tolerance in hybrid maize induced by seed priming with salicylic acid." *Journal of Agronomy and Crop Science* 194 (2):161-168..
- Goutam, M., and R. Purohit. 1974. "Antimicrobial activity of the essential oil of the leaves of *Murraya koenigii* (Linn) Spreng (Indian Curry leaf)." *Indian J. Pharm* 36 (1):11-12.
- Harris, D., A. Joshi, P. Khan, P. Gothkar, and P. Sodhi. 1999. "On-farm seed priming in semi-arid agriculture: development and evaluation in maize, rice and chickpea in India using participatory methods." *Experimental Agriculture* 35 (1):15-29.
- Nadkarni, K. 1996. "Dr. KM Nadkarni's Indian materia medica: with ayurvedic, unani-tibbi, siddha, allopathic, homeopathic, naturopathic & home remedies, appendices & indexes. 1." *Pop. Prakashan* 1:751-752.
- Nagarani, G., A. Abirami, and P. Siddhuraju. 2014. "Food prospects and nutraceutical attributes of *Momordica* species: A potential tropical bioresources-A review." *Food Science and Human Wellness* 3 (3-4):117-126.
- Pill, W., and W.E. FINCH-SAVAGE. 1988. "Effects of combining priming and plant growth regulator treatments on the synchronisation of carrot seed germination." *Annals of Applied Biology* 113 (2):383-389.
- Prakash, M., G.S. Narayanan, B.S. Kumar, and A. Kamaraj. 2013. "Effect of seed hardening and pelleting on seed quality and physiology of rice in aerobic condition." *Agricultural Science Digest-A Research Journal* 33 (3):172-177.
- Tamilmani, U. 2012. Studies on effect of various seed management practices on quality seed production in greengram (*Vigna radiata* L.) cv. ADT.
- Taylor, A., and G. Harman. 1990. "Concepts and technologies of selected seed treatments." *Annual review of phytopathology* 28 (1):321-339.
- Alias, N., L. Billa, A. Muhammad, and A. Singh. 2016. "Priming and temperature effects on germination and early seedling growth of some Brassica spp." III All Africa Horticultural Congress 1225.
- Beata, M.-K., Z. Wyszynski, V. Pačuta, M. Rašovský, and A. Róžańska. 2018. "The effect of seed priming on field emergence and root yield of sugar beet." *Plant, Soil and Environment* 64 (5):227-232.

- Casenave, E., and M. Toselli. 2010. "Germination of melon seeds under water and heat stress: Hydropriming and the hydrotime model." *Seed Science and Technology* 38 (2):409-420.
- Chapla, T.E., and J.B. Campos. 2010. "Allelopathic evidence in exotic guava (*Psidium guajava* L.)." *Brazilian Archives of Biology and Technology* 53:1359-1362.
- Christiansen, M., and C. Foy. 1979. "Fate and function of calcium in tissue." *Communications in Soil Science and Plant Analysis* 10 (1-2):427-442.
- Devika, O.S., S. Singh, D. Sarkar, P. Barnwal, J. Suman, and A. Rakshit. 2021. "Seed priming: a potential supplement in integrated resource management under fragile intensive ecosystems." *Frontiers in Sustainable Food Systems* 5:654001.
- Farooq, M., S.M. Barsa, and A. Wahid. 2006. "Priming of field-sown rice seed enhances germination, seedling establishment, allometry and yield." *Plant Growth Regulation* 49:285-294.
- Foidl, N., H. Makkar, and K. Becker. 2001. "What development potential for Moringa products." A conference on the potential of *Moringa oleifera* for Agricultural and industrial uses. October 20th–November 2nd.
- Forti, C., A. Shankar, A. Singh, A. Balestrazzi, V. Prasad, and A. Macovei. 2020. "Hydropriming and bioprimering improve *Medicago truncatula* seed germination and upregulate DNA repair and antioxidant genes." *Genes* 11 (3):242.
- Henny RJ. Pollen germination in aglaonema flowers of different ages. HortScience (USA). 1988.
- Jayesh, V., and J. Meeta. 2015. "Influence of halopriming and hydropriming on seed germination and growth characteristics of *Zea mays* L. cv. GSF-2 under salt stress." *Research Journal of Chemistry and Environment* \_\_\_\_\_ Vol 19:10.
- Jisha, K., and J.T. Puthur. 2018. "Seed hydropriming enhances osmotic stress tolerance potential in *Vigna radiata*." *Agricultural research* 7:145-151.
- Jisha, K.C., and J.T. Puthur. 2014. "Seed halopriming outdo hydropriming in enhancing seedling vigor and osmotic stress tolerance potential of rice varieties." *Journal of Crop Science and Biotechnology* 17:209-219.
- Kaveriammal, S., S. Geethambigai, and A. Subramani. 2013. "Phytotoxicity effects of *Lawsonia inermis* L. on the seed germination and growth performance of selected pulses." *International Journal of Research in Botany* 3 (1):23-26.
- Khan MM, Qasim M, Iqbal MJ, Naeem AF, Abbas M. Effect of seed humidification on germinability, vigour and leakage in cockscomb (*Celosia argentea* var. *crispata* L.). *International Journal of Agriculture and Biology*. 2003;5:499-503.
- Khan, A.R., M.J. Khan, M. Anwar, P. Gull, and M. Fatima. 2014. "Allelopathic effect of different concentrations of leaf extract of *Lawsonia inermis* L., seed germination of *Sterea italica*, *Pennisetum americanum* and *Lectuca sativa*." *Int. J. Pharma. and Phytochem. Res* 6:766-773.
- Langeroodi, A., and R. Noora. 2017. "Seed priming improves the germination and field performance of soybean under drought stress." *Journal of animal and plant sciences* 27 (5):1611-1620.
- Lekić, S., I. Draganić, M. Milivojević, and G. Todorović. 2015. "Germination and seedling growth response on sunflower seeds to priming and temperature stress." *Helia* 38 (63):241-252
- Luza JG, Polito VS, Weinbaum SA. Staminate bloom date and temperature responses of pollen germination and tube growth in two walnut (*Juglans*) species. *American Journal of Botany*.
- Loupassaki M, Vasilakakis M, Androulakis I. Effect of pre-incubation humidity and temperature treatment on the in vitro germination of avocado pollen grains. *Euphytica*. 1997;94:247-251..

- Mohammadi, G., Y. Koochi, M. Ghobadi, and A. Najaphy. 2014. "Effects of seed priming, planting density and row spacing on seedling emergence and some phenological indices of corn (*Zea mays* L.)." *Philippine Agricultural Scientist* 97 (3):300-306.
- Nath S, Coolbear P, Hampton JG. Hydration-dehydration treatments to protect or repair stored 'Karamu' wheat seeds. *Crop Science*.1991;31:822-826.
- Namkeleja, H.S., M.T. Tarimo, and P.A. Ndakidemi. 2014. "Allelopathic effects of *Argemone mexicana* to growth of native plant species." *American journal of plant sciences* 2014.
- Nandhakumar, M. 2010. "Utilization of leaves and leaf extracts of tropical trees for eco-friendly Vrکشayurvedic farming in maize (*Zea mays* L.)." *MSc (Agric) thesis, Tamil Nadu Agricultural University, Coimbatore, TN, India*.
- Powell AA, Yule LJ, Jing HC, Groot SP, Bino RJ, Pritchard HW. The influence of aerated hydration seed treatment on seed longevity as assessed by the viability equations. *Journal of Experimental Botany*. 2000;51:2031-2043.
- Pandita, V., A. Anand, and S. Nagarajan. 2007. "Enhancement of seed germination in hot pepper following presowing treatments." *Seed Science and Technology* 35 (2):282-290.
- SAĞLAM, S., D. Sibel, K. Gamze, and A. Gürbüz. 2010. "Hydropriming increases germination of lentil (*Lens culinaris* Medik.) under water stress." *Notulae Scientia Biologicae* 2 (2):103-106.
- Saleem, M.S., M. Sajid, Z. Ahmed, S. Ahmed, N. Ahmed, and S. Islam. 2014. "Effect of seed soaking on seed germination and growth of bitter gourd cultivars." *J Agric Vet Sci* 6 (6):7-11.
- Shehzad, M., M. Ayub, A. Ahmad, and M. Yaseen. 2012. "Influence of priming techniques on emergence and seedling growth of forage sorghum (*Sorghum bicolor* L.)." *J Anim Plant Sci* 22 (1):154-158.
- Sinha, M., D.K. Das, S. Bhattacharjee, S. Majumdar, and S. Dey. 2011. "Leaf extract of *Moringa oleifera* prevents ionizing radiation-induced oxidative stress in mice." *Journal of medicinal food* 14 (10):1167-1172.
- Suguna, A. 2012. "Scientific study on Vrکشayurvedic farming in barnyard millet (*Echinochloa frumentacea* L.)." *M. Sc.(Agriculture) Thesis*.
- Simons DH, Sfakiotakis E, Dilley DR. Enhancement of in vitro pollen germination of lily with increased pre-inoculation humidity. *HortScience*. 1972.
- Thornton JM, Collins AR, Powell AA. The effect of aerated hydration on DNA synthesis in embryos of *Brassica oleracea* L. *Seed Science Research*. 1993;3:195-199.
- Vijayalakshmi K, Sundaralingam K. Enhancement of Vigour Status through Micronutrient Priming and Humid Invigouration in Sesame. *Madras Agricultural Journal*. 2018;105:40-43.