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Seed priming: A technique to improve seed performance

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Abstract
Seed priming is a method in which seeds are hydrated (control hydration or uncontrolled hydration) and dried to original moisture content but the actual emergence of radicle is prevented. Unqual plant stand and poor germination is a major constraint in seeds under areas which recieve low rainfall. This problem of poor germination can be overcome by sowing primed seeds. Seed Priming improve the germination ability of seed and ultimately improve plant stand in field. It is a seed invigoration treatments and seedlings developed from primed seeds show resistant to abiotic stresses. Seed priming has several benefits to seeds such as rapid, uniform and increased germination, overcome thermo-dormancy in lettuce, primed seeds compete with weeds effectively. Lot of work has been conducted on different priming types and result of these experiments indicate the importance of seed priming in different crops.

Keywords: Hydropriming, halopriming, chemopriming, solid matrix priming, biopriming

Introduction
Stand establishment is of great importance to increase the field production. Absence of synchronized seed germination create obstruction to maximum yield and production of crops (Mwale *et al.* 2003) [36]. Seed Priming activate ‘pre germinative metabolic activity’. The physiological process associated with seed priming take place during early seed imbibition and includes the seed repair response, ensure proper germination and seedling development (Paparella *et al.* 2015) [40]. Seed Priming is the hydration of seeds to initiate pre-germinative metabolic process to occur but the actual germination is inhibited. Low quality seeds required more time for seed germination, this time taken by seeds to germinate can easily decreased by seed priming. Primed seeds have synchronous germination, compete with weeds, release thermodormancy in lettuce (Cantliffe *et al.* 1984) [09], tolerate to abiotic stress (Lal *et al.* 2018) [2]. Seed deterioration is positively associated with decline in protein and nucleic acid synthesis, loss of membrane integrity, change in enzymatic activity (Mc Donald, 1999) [32]. Reversion of effects of aging was done by slowly imbibition of water during seed priming and redrying of seeds to original moisture content (Tilden and West, 1985) [58]. There are following type of seed priming methods:

Hydropriming
It is a seed priming method which involve priming of seed in pure water to initiate pre-germinative physiological activity of seed but without radicle emergence, seeds are dried to original moisture content before sowing. Hydropriming is cost effective beacuse it is without addition of any other priming substance. The main demerit of hydropriming is uncontrolled uptake water by seeds. Water uptake in uncontrolled hydration treatment of seeds depends on affinity of seed tissue toward water (Taylor *et al.*, 1998) [57]. Abbasdokht (2011) [2] found that maximum germination, seedling dry weight, germination index in wheat achieved under high osmotic potential when hydroprimed as compared to halopriming. Same findings given by Abbasdokht *et al.*, (2010) [1]. Maroufi and Farahani (2011) [31] found significant effect of hydropriming on germination percentage, seedling dry weight and seedling vigour. The germination percentage (78%), seedling dry weight (1.32 g) and seedling vigour (102.96) were achieved by 24 h hydropriming. Moreno *et al.* (2017) [35] conducted an experiment to evaluate the effectiveness of seed priming treatments in seeds of *Chenopodium quinoa* and *Amaranthus caudatus* to improve germination under NaCl and found that seed hydropriming and osmopriming cause significant improvements in germination velocity and uniformity, reflected in high final germination percentage (FGP), high germination index (GI) and reduced mean

germination time (MGT) under salinity. *Amaranthus caudatus* performed better when osmoprimed with low water potential while *Chenopodium quinoa* performed better in hydropeiming and osmopring with high water potential. Sharma *et al.* (2014) [50] found that hydropriming for 12 hours and Solid Matrix priming with calcium aluminium silicate (1:0.4:1; Seed: SM: Water) for 24 hours in okra cv. Hisar Unnat significantly increase the seed germination, seedling vigour, mean germination time and marketable fruit yield.

Ibrahim *et al.* (2013) [2] found that hydropriming duration of 12 hours in upland rice variety, NERICA 2 obtained greater establishment and growth performance under Sokoto conditions. Hydrated seeds can be re-dried for four hours without loss of physiological advancement obtained from hydration phase. Jamshidian and Talat (2017) [21] conducted an experiment to improve and modify the uniformity in germination, growth rate and subsequently high performance and production of coriander seeds. The effect of priming on the agronomic performance including fresh weight of plant, plant height, distance of the first branch from ground, number of umbels, number of compound leaves, leaf surface area, total dry weight and seed weight were significant. Saini *et al.* (2017) [48] found that 12 hours osmopriming duration of bitter gourd showed significant high percent of seed germination, seedling length, fresh weight, dry weight, spedd of germination and vigour in comparison to all treatments and control. Less priming time cause decrease in germination and seed vigour.

Ghasemi *et al.* (2014) [17] found that highest seedling characters and enzymatic activity obtained from hydro-priming treatment under non-aged condition. Hydro-priming improved quality of aged wheat seeds and increase enzymes activity. Mahmoudi *et al.* (2012) [28] found that under NaCl supplemented hydroponic culture, the dry weight was higher in plants derived from hydroprimed seeds when compared to non-primed, osmoprimed (KNO_3) and hormonal primed (GA_3) lettuce seeds. Under control and 100 mM NaCl treatment, malondialdehyde (MDA) content and electrolyte leakage did not show any correlation with activities of gaiacol peroxidase (GPX) and catalase (CAT), but did with the increase in reduce dascorbate (AsA) and total ascorbate contents.

Dastanpoor *et al.* (2013) [12] found that final germination percentage (FGP), mean germination time (MGT) and synchronization of seed germination improved by hydropriming at 10 °C, 20 °C, 30 °C. Hydropriming (12h at 30 °C) was most effective in improving seed germination and final germination percentage was increased by 25.5% as compared to non-primed seeds. Ahammad *et al.* (2014) [3] found that hydropriming significantly influenced germination percentage, germination index and mean germination time in maize seeds. Same finding was given by Eskandari and Kazemi (2011) [15]. Hydopriming of Bitter gourd (*Momordica charantia* L.) for 72 hours were found to increase speed of germination, total per cent germination, seedling length, seedling dry weight, vigour index-I and vigour index-II (Mehta *et al.* 2014) [33].

Saglam *et al.*, (2010) [47] found that lentil seeds were able to germinate at all concentrations of PEG-6000 (At 0.0, -0.3 and -0.6 MPa water potential). Cultivar 'Pul 11' with the lightest seed weight gave better performance. Whereas enhanced germination percentage with hydro priming under increased water stress shown by cv. 'Sultan 1'. Djebali, N. (2012) [13] found better seedling fresh weight in hydropriming of *Triticum durum* (Durum wheat) and *Hordeum vulgare* (Barley) at 25 ºC temperature than 35 ºC. Hydeoprimed seeds of cv. Karim inoculated with *Fusarium culmorum* showed an increase in seedling growth and reduction in percentage of infection in comparison to non-hydroprimed seeds. Fabunmi *et al.* (2012} [16] found that Oloyin (Cowpea variety) primed for 4 hours had higher dry matter than Drum (Cowpea variety) at 6 weeks after planting under moisture stress. Plants showing reduction in growth characters developed from unprimed seeds under moisture stress.

Mamun *et al.* (2018) [29] conducted an experiment to study the effect of seed priming on seed germination and seedling growth of modern rice (*Oryza sativa* L.) varieties and found that priming treatments, Vitamin C priming and Osmo-hardening were superior in performance. In interaction, germination and seedling vigour index was increased with osmopriming and vitamin C priming in Nerica variety. Bijanzadeh *et al. (*2010) [7] found that solid matrix priming with compost in rapeseed cv. Hyola 401 was effective in improving seed germination. Hydropriming for 24 hours and solid matrix priming with compost for 12 hours and 24 hours were found to reduce mean getmination time. Lowest electrical conductivity observed in hydroprimed and solid matrix priming treatments after 12 and 24 hours. Highest root and shoot length recorded in hydropriming after 24 hours. Improvement in germination and seedling emergence of rapeseed was found in Solid matrix priming for 12 hours and 24 hours.

Chemopriming

Chemopriming involve the use of various chemicals to invigour the seeds. This priming method improve seedling characters e.g germination, root length, seedling dry weight, vigour index-I and vigour index-II, field emergence and survival in various abiotic stress. Lakkundi and Channaveerswami (2013) [26] studied the influence of chemopriming treatment on seed quality in okra (*Abelmoschus esculentus*). Among the different inorganic salts used for priming in this study, KI @1% and seed drying after priming (D_1) showed significantly highest germination, root length, shoot length, seedling dry weight, seedling vigour index-I, seedling vigour index-II, field emergence and lowest electrical conductivity.

Kumari *et al.* (2017) [24] found that maize seed primed with salycylic acid and $CaCl_2$ increase seedling characters. All studied seedling characters performed good in seeds primed with GA_3 for 12 hours, among all priming methods. Hamidi *et al.* (2013) [19] conducted an experiment and found both halo primed and hydro primed wheat seeds performed good in respect of seedling characters such as germination percentage, seedling and radicle length, plant height and leaf area. Increase in KNO_3 and KH_2PO_4 and decrease in N+P were associated with positive effect. A study of Kumar *et al.* (2017) [23] revealed that haloprimed seed of tomato with 1% KNO_3 for 48 hours performed in seedling survival, fresh and dry weight of seedlings whereas 2% KNO_3 for 24 and 48 hours invigourate tomato seedlings.

Halopriming

In Halopriming, seeds are dipped in various salt solution e.g. Nacl. It also work on same process as hydropriming but in this salt solutions are involved and which have different positive effects on seedling parameters like reduction of time to take 50% emergence and mean imergence time. Tamimi (2016) [55] found a significant increase in accumulation of proline, total soluble sugars, soluble proteins and H_2O_2 was also observed in response to salinity although variations axist among landraces of Jordanian wheat. Seed priming with $CaCl_2$ can be utilized for enhancing the salt tolerant potential of wheat and could contribute to promote its cultivation in salt affected soils. Golezanik and Esmaeilpour (2008) [18] conducted an experiment to study the effect of salt primingon performance of differentially matured Cucumber (*Cucumis sativus*) and found that seed germination, seedling emergence and growth were significantly affected by seed maturity and priming. In all treatments, priming with KNO_3 was more effective than NaCl priming.

Nawaz *et al.* (2011) [37] found that halopriming of tomato cv. 'Nagina' and 'Pakit' with 25 mM KNO_3 for 24 hours resulted in reduction of time taken to 50% emergence and mean emergence but increase in final seedling emergence percentage and seedling growth. Halopriming with different concentration of KNO_3 improve germination potential and seedling establishment in 'Nagina' and 'Pakit' cultivar. Maiti *et al.* (2013) [29] found that early flowering and increased plant height was observed in halopriming of tomato and chill. Halopriming caused an increase in yield per 20 plants. Patel *et al.* (2018) [43] conducted an experiment to assess different priming treatments on seedling characters of two tomato varieties (Navodya and S-22) and found that haloprimimg of tomato varieties (Navodya and S-22) with NaCl (1% solution for 36 hours) was superior among all duration of priming treatments.

Solid matrix priming

Solid matrix priming is a type of seed priming in which seeds are mixed with solid materials and water. This priming method also have positive effect on seed germination and seedling growth under stress conditions. Kanwar and Mehta (2017) [22] found that solid matrix priming of low and high vigour seeds with perlite for 72 hours performed better in respect to field emergence and fruit yield than other priming methods. A study of Ozden *et al.* (2018) [39] revealed highest germination, lowest mean germination time, lowest electrical conductivity and highest catalase activity in low vigoured seed lot, solid matrix primed seeds of leek among all treatments and lots. Solid matrix priming with air was found better as compared to solid matrix priming with nitrogen and vacuum.

Solid matrix primed seeds of eggplant with *Trichoderma harzianum* showed increased seed germination, germination index, seedling emergence, photosynthetic characters and decreased mean germination time. These findings indicate that solid matrix priming with *Trichoderma harzianum* is effective way to enhance seed germination and seedling emergence (Lingyun *et al.*, 2017) [27].

Conway *et al.* (2001) [11] found that mean emergence of chemoprimed okra seeds than untreated okra seeds. Chemoprimed seeds had maximum vigour at location Stillwater and Bixby. Taylor *et al.* (1988) [56] conducted an experiment entitled as "Solid matrix priming of seeds" and found that decreased time for 50% seedling emergence and increased plant dry weight in all priming treatments for each crop i.e. carrot, tomato and onion seeds. Seedling emergence characteristics of solid matrix primed seeds were superior or equal to conventional priming methods.

Osmopriming

Osmopriming is one of the type of seed priming in which seeds are mixed with osmotic agents of high molecular weight (Poly Ethylene Elycol) with different osmotic potential and have control on level of hydration i.e. controlled hydration. Generally used osmotic agent is PEG 6000 and PEG 8000. Osmopriming also have positive effects on speed of seed germination and seedling characters. Arif *et al.* (2010) [6] found an increase in Absolute Growth Rate and Crop Growth Rate boost with PEG concentration from 0 to 300g PEG per litre water and thereafter decrease. Primed seed plots of soybean showed higher Absolute Growth Rate and Crop Growth Rate as compared with non-primed seed plots. Yuan *et al.* (2010) [61] found that seed priming accelerated the process of glucose metabolism, enhanced the activities of Phenyl Alanineammonia Lyase, Super Oxide Dismutase, Catalase, and Peroxidase in the stressed seeds of all studied cultivars of Rice. Priming of Gangyou 527 (indica hybrid rice) seeds with PEG @ 20% and priming of Nongken 57 (conventional japonica rice) seeds with PEG @10-15% showed positive effect on seed germination and seedling growth under drought stress.

Elkoca *et al.* (2007) [14] found that hydropriming and osmopriming induced faster and synchronous germination at all tested temperatures and decrease thermal time requirements. Highest germination speed was observed in seeds treated with water for 12 hours. Among all osmopriming treatments, seeds osmoprimed with PEG for 24 hours at -0.5MPa performed better. Yu-jie *et al.* (2007) [62] that osmopriming at 10 °C and 30 °C, improve uniformity of germination and accelerate seed germination. Maximum speed of germination was found in seed hydroprimed in 500 µL of water per 1 gram of seeds for 48 hours at 15 °C. This treatment increased seed germination at 10 °C. Salehzade *et al.* (2009) [49] found an improvement in germination and seedling vigour in seeds of wheat cv. Zarin osmoprimed with PEG 8000 (Polyethylene Glycol) and KNO_3 solutions for 12 hours.

Yari *et al.* (2010) [59] found maximum stem length and radicle length in seeds primed with Poly Ethylene Glycol 10% and 20% for 24 hours, respectively. Seedling vigour index was found in Azar-2 (bread wheat cultivar) seed primed with KH_2PO_4 @ 0.5%. Seeds performed better in germination percent, vigour index and speed of germination, when primed upto 12 hours of priming duration. Treatment temperature 20 °C had good effects on germination attributes and seedling parameters of wheat. Sadeghi *et al.* (2011) [46] found that -1.2Mpa osmotic pressure caused an increase in germination percentage, germination index and seed vigor while decreased in mean germination time, time to get 50% germination and electrical conductivity of soybean seeds. Priming duration of 12 hours has effect on germination percentage, mean germination time, germination index, and the time to get 50% germination, seed vigor and electrical conductivity as -1.2Mpa osmotic pressure treatment.

Papastylianou and Karamanos (2012) [41] found that osmopriming of cotton seeds with mannitol at osmotic potential of -0.5MPa tend to increase germination rate and uniformity in germination as well as osmopriming resulted in lowering of thermal time requirement for germination. Priming duration of 6 hours or 12 hours was considered better for seed performance than 18 hours priming duration. Higher germination uniformity was found in priming temperature of 19 °C and 22 °C. Singh *et al.* (2012) [52] conducted an experiment to study the effect of osmopriming duration on germination, emergence and seedling growth of sorghum seeds and found higher seed germination, emergence, plant height and dry matter accumulation in osmoprimed and hydroprimed sorghum seeds. Better field establishment and seedling growth was found in sorghum seeds osmoprimed in KNO_3 for 6 hours.

Capron *et al.* (2000) [10] found that osmopriming of sugarbeet seeds for longer than 2 days decrease in germination of treated seeds. Seeds osmoprimed at 25 °C for 14 days, 60% of the pre-treated seeds failed to germinate when transfered to water. This loss in germination is closely associated with degradation of LEA (Late Embryogenesis Abundant) proteins. Temperatures and concentrations of oygen which were in seed priming were similar to those which allowed solubilization of B-subunit of 11-S globulin, supporting the robustness of protein marker for optimization of sugarbeet seed priming. A study of Probert *et al.* (1991) [44] revealed that priming followed by drying did not increase seed longevity in the related species *Ranunculus sceleratus* L. The promotive effects of priming on seed survival appear to be species specific and may be related to ecological factors.

Youngqing *et al.* (1996) [60] found that fresh PEG-primed seeds maintained more positive effects gained from priming while normal PEG-primed tomato seeds had lost promoting effects on germination. Normal PEG-primed tomato seeds were much more susceptible to controlled deterioration than fresh PEG-primed tomato seeds. Bruggink *et al.* (1999) [8] found that desired longevity could be obtained by keeping the seeds, after a priming treatment, under a mild water and temperature stress for a period of several hours to days. Optimal duration and degree of water stress were strongly temperature dependent. The methods applied to obtain primed seeds without loss of longevity are very similar to those used to induce dessication tolerance in germinated seeds.

Seed priming with KNO_3 significantly increased germination and emergence percentages, radicle and plumule length, seedling dry weight, plant height, plant leaf area and plant dry weight. Also at the salinity stress, mean germination and emergence time of primed seeds were less than non-primed seeds, significantly. At the salinity stress, specific highest salinity level, final germination percentage, radicle and plumule length, plant height, plant leaf area and plant dry weight of primed seeds were more than non-primed seeds, significantly. Positive effects of priming with potassium nitrate on seeds of Gorgan-3 cv. were greater than those of Sahar cv. (Ahmadvand *et al.*, 2012) [4].

Biopriming

Biopriming is also a type of priming in which seeds are primed in a solution containing bio-control agents like *Trichoderma harzianum, Trichoderma viride and Pseudomonas flourescens etc*. Biopriming has biological and physiological (seed priming) aspects of disease control. Except improvement in germination percent, uniformity of emergence and decrease the time to emergence like other priming methods, it also control disease in plant.

Raj *et al.* (2004) [45] conducted an experiment to study the effect of seed biopriming with *Pseudomonas fluorescens* isolates on growth of pearl millet plants and induction of resistance against downy mildew and found that seed biopriming with *Pseudomonas flourescens* resulted in vigour and yield related parameters. Isolate UOM SAR 14 induce resistence against downy mildew with the range 20% to 75% but control of disease was best achieved by systemic fungicide Apron. Ananthi *et al.* (2014) [5] found that biopriming with *Trichoderma viride* and *Pseudomonas fluorescens* at 60% (w/v) for 3 hours and 12 hours, respectively, gave the highest values for all parameters measured, including rate of germination, the germination percentage, mean root length, mean shoot length, biomass production, and seedling vigour index. Sharma *et al.* (2018) [51] found that soybean seeds primed with *Pseudomonas inflorescence* strain Psf-173 had highest field emergence, minimum days to 50% flowering while maximum plant height was obtained in seeds primed with *Trichoderma harzianum* strain Th-14. This suggest that biopriming enhances yield contributing traits.

Singh *et al.* (2016) [53] conducted an experiment to study the evaluate effectiveness of biopriming of pea seeds with *Trichoderma asperellum* BHUT8 for plant growth promotion. An increase in shoot length, root length, number of leaves, shoot fresh weight, root fresh weight, shoot dry weight and root dry weight than unprimed seeds. Sivakalai and Krishnaveni (2017) [54] found that pumpkin cv. CO2 bioprimed wit and qualityh seed Azospirillium 10% + Phosphobacteria 20% + *Pseudomonas fluorescence* 20% for 12 hours have maximize seed yield, growth & development and quality of resultant seed, under field condition. Monalisa *et al.* (2017) [34] found that bioprimed seeds of common bean with *Trichoderma harzianum* @40% concentration for 4 hours performed better in germination, shoot length, root length, seedling dry weight, seedling vigour index-I (SVI-I), Seedling vigour index-II (SVI-II) and speed of germination over unprimed seeds. Common bean seeds bioprimed with *Pseudomonas fluorescence*@ 40% for 4 hours was found at par with other best biopriming treatments.

Nithya and Geetha (2017) [38] conducted an experiment to study comparative effects of biopriming and hydropriming and found that bioprimed seeds with *Pseudomonas flourescence*has free from insect and pathogen attack during storage period. Biopriming with *Pseudomonas flourescence* @20% for rice cv PMK 4 was established as best method of priming which was capable of improving seed vigour as well as viability. Patel *et al.* (2017) [42] found that different parameters of tomato and brinjal seeds such as germination, germination index, mean germination time, seedling length, radicle length, plumule length, SVI (Seedling vigour index) and seed stamina index was found to be positively effected by priming. Biopriming of seed was found better in comparison to hydropriming.

Conclusion

Seeds having poor quality in terms of seed germination and seedling characters ultimately affect the yield and performance of plant under various abiotic stress but seed primed with different seed priming methods perform good under abiotic stress and give synchronous seedling emergence. Now a days, different priming methods are being used in different crops for invigouration. So, these different priming methods should be used in low vigour seed to get better results. Seed biopriming also control disease in plants developed from bioprimed seeds.

References

1. Abbasdokht H, Edalatpishe MR, Gholami A. The effect of hydropriming nad halopriming on germination and early growth stage of wheat (*Triticum aestivum* L.). International Journal of Agricultural and Biosystems Engineering. 2010; 4(8):551-555.
2. Abbasdokht H. The effect of hydropriming and halopriming on germination and early growth stage of wheat (*Triticum aestivum* L.). Desert. 2011; 16:61-68.
3. Ahammad KU, Rahman MM, Ali MR. Effect of hydropriming on maize (*Zea mays*) seedling emergence.

Bangladesh Journal of Agriculture Research. 2014; 39(1):143-150.
4. Ahmadvand G, Soleimani F, Saadatian B, Pouy M. Effect of seed priming with potassium nitrate on germination and Emergence Traits of two soybean cultivars under salinity stress conditions. American Eurasian Journal of Agriculture & Environmental science. 2012; 12(6):769-774.
5. Ananthi M, Selvaraju P, Sundaralingam K. Effect of biopriming using biocontrol agents on seed germination and seedling vigour in chilli (*Capsicum annum* L.) 'PKM 1'. The Journal of Horticultural Science and Biotechnology. 2014; 89(5):564-568.
6. Arif M, Jan MT, Khan NU, Khan A, Khan MJ, Munir I. Effect of seed priming on growth parameters of soybean. Pak. J. Bot. 2010; 42(4):2803-2812.
7. Bijanzadeh E, Nosrati K, Egan T. Influence of seed priming techniques on germination and emergence of rapeseed (*Brassica napus*). Seed Science & Technology. 2010; 38(1):242-247.
8. Bruggink GT, Ooms JJJ, Van der Toorn P. Induction of longevity in primed seeds. Seed Science Research. 1999; 9(1):49-53.
9. Cantliffe DJ, Fischer JM, Nell TA. Mechanism of seed priming in circumventing thermodormancy in lettuce. Plant Physiology. 1984; 75(2):290-294.
10. Capron I, Corbineau F, Dacher F, Job C, Come D, Job D. Sugarbeet seed priming: effects of priming conditions on germination, solubilization of 11-S globulin and accumulation of LEA proteins. Seed Science Research. 2000; 10:243-254.
11. Conway KE, Mereddy R, Kahn BA, Wu Y, Hallgren SW, Wu L. Beneficial Effects of Solid Matrix Chemo-priming in okra. Plant Disease. 2001; 85(5):535-537.
12. Dastanpoor N, Fahimi H, Shariati M, Davazdahemami S, Hashemi SMM. Effects of hydropriming on seed germination and seedling growth in sage (*Salvia officinalis* L.). African Journal of Biotechnology. 2013; 12(11):1223-1228.
13. Djebali N. Seed hydropriming effect on *Triticum durum* and *Hordeum vulgare* Germination, seedling growth and resistance to *Fusarium culmorum.* Plant Pathology Journal. 2012; 11(3):77-86.
14. Elkoca E, Haliloglu K, Esitken A, Ercisli S. Hydro and osmopriming improve chickpea germination. Acta Agriculturae Scandinavica Section B-soil and Plant Science. 2007; 57:193-200.
15. Eskandari H, Kazem K. Effect of seed priming on germination properties and seedling establishment of cowpea (*Vigna sinensis*). Natulae Scientia Biologicae. 2011; 3(4):113-116.
16. Fabunmi TO, Gbadamosi BK, Adigbo SO. Seed hydropriming and Early moisture stress impact on biomass production and grain yield of cowpea. International Journal of Applied Science & Technology. 2012; 2(10):112-122.
17. Ghasemi E, Ghahfarokhi MG, Darvishi B, Kazafi ZH. The effect of hydro-priming on germination characteristics, seedling growth and antioxidant activity of accelerated aging wheat seeds. Cercetari Agronomice in Moldova. 2014; XLVII(4):41-48.
18. Golezanik G, Esmaeilpour B. The effect of salt priming on performance of differentially matured Cucumber (*Cucumis sativus*) seeds. Notulae Botanicae Horti Agrobotanici Cluj-Napoca. 2008; 36(2):67-70.
19. Hamidi R, Anosheh HP, Izadi M. Effect of seed halo priming compared with hydropriming on wheat germination and growth. International Journal of Agronomy and Plant Production. 2013; 4(7):1611-1615.
20. Ibrahim ND, Bhadmus Z, Singh A. Hydropriming and re-drying effects on germination, emergence and growth of upland rice (*Oryza sativa* L.). Nigerian Journal of Basic and Applied Science. 2013; 21(2):157-164.
21. Jamshidian Z, Talat F. Effects of seed priming on morphological phonological characteristics of the coriander (*Coriandrum sativum* L.). Advances in Plants & Agriculture Research. 2017; 7(6):411-415.
22. Kanwar R, Mehta DK. Studies on solid matrix priming of seeds in bitter gourd (*Momordica charantia*). Journal of Applied and Natural Science. 2017; 9(1):395-401.
23. Kumar CK, Kumar S, Singh D. Effect of halo-priming on growth, nutrient and enzyme parameters of tomato seedlings under different levels of salinity. The Bioscan. 2017; 12(3):1497-1501.
24. Kumari N, Rai PK, Bara BM, Singh I. Effect of halo priming and hormonal priming on seed germination and seedling vigour in maize (*Zea mays* L) seeds. Journal of Pharmacognosy and Phytochemistry. 2017; 6(4):27-30.
25. Lal SK, Kumar S, Sheri V, Mehta S, Varakumar P, Ram B, *et al*. Seed Priming: An Emerging Technology to Impart Abiotic Stress Tolerance in Crop Plants. Rakshit A, Singh HB (eds.). Advances in Seed Priming, 2018, pp41.
26. Lakkundi K, Channaveerswami AS. Studies on influence of chemopriming treatment on seed quality in okra (*Abelmoschus esculentus*). International Journal of Plant Sciences. 2013; 8(2):414-418.
27. Lingyun WU, Dongwei YAO, Ming LI. Effects of solid matrix priming with *Trichoderma harzianum* on seed germination, seedling emergence and photosynthetic capacity of eggplant. African Journal of Biotechnology. 2017; 16(14):699-703.
28. Mahmoudi H, Massoud RB, Baatour O, Tarchoune I, Salah IB, Nasri N *et al*. Influence of different seed priming methods for improving salt stress tolerance in lettuce plants. Journal of Plant Nutrition. 2013; 35:1910-1922.
29. Maiti R, Rajkumar D, Jagan M, Pramanik K, Vidyasagar P. Effect of seed priming on seedling vigour and yield of tomato and chilli. International Journal of Bio-resource and Stress Management. 2013; 4(2):119-125.
30. Mamun AA, Naher UA, Ali MY. Effect of seed priming on seed germination and Seedling growth of modern Rice (*Oryza Sativa* L.) varieties. The Agriculturists. 2018; 16(1):34-43.
31. Maroufi K, Farahani HA. Increasing of germination percentage by hydropeiming method in soybean (*Glycine max* L.). Advances in Environmental Biology. 2011; 5(7):1663-1667.
32. McDonald MB. Seed deterioration: physiology, repair and assessment. Seed Science & Technology. 1999; 27:177-237.
33. Mehta DK, Kanwar HS, Thakur AK, Thakur S, Thakur KS. Standerdization of seed Hydro-priming duration in bitter gourd, *Momordica charantia* L. International journal of bio-resource and stress management. 2014; 5(1):98-101.
34. Monalisa SP, Beura JK, Tarai RK, Naik M. Seed quality enhancement through biopriming in common bean

(*Phaseolus vulgaris* L.). Journal of Applied and Natural Science. 2017; 9(3):1740-1743.
35. Moreno C, Seal CE, Paperbrock J. Seed Priming improve germination in saline conditions for *Chenopodium quinoa* and *Amaranthus caudatus*. Journal of Agronomy and Crop Science, 2017, 1-9.
36. Mwale SS, Hamusimbi C, Mwansa K. Germination, emergence and growth of sunflower (*Helianthus annus* L.) in response to osmotic seed priming. Seed Science Research. 2003; 31:199-206.
37. Nawaz A, Amjad M, Pervez MA, Afzal I. Effect of halopriming on germination and seedling vigor of tomato. African Journal of Agricultural Research. 2011; 6(15):3551-3559.
38. Nithya N, Geetha R. Storability evaluation of primed seeds of rice (*Oryza sativa*) cv. PMK-4. Journal of Pharmacognosy and Phytochemistry. 2017; SP1:61-63.
39. Ozden E, Ermis S, Sahin O, Taskin MB, Demir I. Solid matrix priming treatment with O_2 enhanced quality of leek seed lots. Not Bot Horti Agrobo. 2018; 46(2):371-375.
40. Paparella S, Araujo SS, Rossi G, Wijayasinghe M, Carbonera D, Balestrazzii A. Seed Priming: state of the art and new perspectives. Palnt Cell Rep. 2015; 34(8):1281-1293.
41. Papastylianou PT, Karamanos AJ. Effect of osmopriming treatments with mannitol on cotton seed germination performance under suboptimal conditions. Seed Science & Technology. 2012; 40(2):248-258.
42. Patel RV, Pandya KY, Jasrai RT, Brahmbhatt N. Effect of hydropriming and biopriming on seed germination of Brinjal and Tomato seeds. Research Journal of Agriculture and Forestry Sciences. 2017; 5(6):1-14.
43. Patel YK, Rai PK. Effect of seed priming on seed quality of tomato (*Solanum lycopersicum* L.). The Pharma Inovation. 2018; 7(2):264-267.
44. Probert RJ, Bogh SV, Smith AJ, Wechsberg GE. The effect of priming on seed longevity in *Ranunculus sceleratus* L. Seed Science Research. 1991; 1:243-249.
45. Raj SN, Shetty NP, Shetty HS. Seed biopriming with *Pseudomonas fluorescence* isolates enhances growth of pearl millet plants and induces resistance against downy mildew. International Journal of Pest Management. 2004; 50(1):41-48.
46. Sadeghi H, Khazaei F, Yari L, Sheidaei S. Effect of seed osmopriming on seed germination behaviour and vigor of soybean (*Glycine max*). Journal of Agricultural and Biological Science. 2011; 6(1):39-43.
47. Saglam S, Day S, Kaya G, Gurbuz A. Hydropriming increases germination of Lentil (*Lena culinaris* Medilk.). Not Sci Biol. 2010; 2(2):103-106.
48. Saini R, Rai PK, Bara BM, Sahu P, Anjer T, Kumar R. Effect of seed priming treatments and its duration on seedling characters of bitter gourd (*Momordica charantia* L.). Journal of Pharmacognosy and Phytochemistry. 2017; 6(5):848-850.
49. Salehzade H, Shishvan MI, Ghiyasi M, Forouzin F, Siyahjani AA. Effect of seed priming on germination and seedling growth of wheat (*Triticum aestivum* L.). Research Journal of Biological Sciences. 2009; 4(5):629-631.
50. Sharma AD, Rathore SVS, Srinivasan K, Tyagi RK. Comparison of various seed priming methods for seed germination, seedling vigour and fruit yield in okra (*Abelmoschus esculentus* L. Moench). Scientia Horticulture. 2014; 165:75-81.
51. Sharma P, Bhatt A, Jyoti B. Effect of seed biopriming with microbial inoculants on plant growth, yield and yield contributing characters in soybean [*Glycine max* (L.) Merrill]. International Journal of Economic Plants. 2018; 5(2):53-58.
52. Singh A, Dahiru R, Musa M. Osmopriming duration influence on germination, emergence and seedling growth of sorghum. Seed Technology. 2012; 34(1):111-118.
53. Singh V, Upadhyay RS, Sharma BK, Singh HB. Seed biopriming with *Trichoderma asperellum* effectively modulate plant growth promotion on pea. International Journal of Agriculture, Environment and Biotechnology. 2016; 9(3):361-365.
54. Sivakalai R, Krishnaveni K. Effect of biopriming on seed yield and quality in pumpkin cv. CO2. International Journal of Current Microbiology and Applied Sciences. 2017; 6(12):85-90.
55. Tamimi SM. Effect of seed priming on growth and physiological traits of five Jordanian wheat [*Triticum estivum* L.] landraces under salt stress. Journal of Bioscience and Agriculture Research. 2016; 11(1):906-922.
56. Taylor AG, Klein DE, Whitlow TH. SMP: Solid Matrix Priming of Seeds. Scientia Horticulturae. 1988; 37:1-11.
57. Taylor AG, Allen PS, Bennett MA, Bradford KJ, Burris and Mishra MK. Seed Enhancements. Seed Science Research. 1998; 8(2):245-256.
58. Tilden RL, West SH. Reversal of effect of aging in soybean seeds. Plant Physiology. 1985; 77(3):584-586.
59. Yari L, Aghaalikani M, Khazaaei F. Effect of seed priming duration and temperature on seed germination behaviour of bread wheat (*Triticum aestivum* L.). Journal of Agricultural and Biological Sciences. 2010; 5(1):1-6.
60. Youngqing L, Bino RJ, Van der Burg WJ, Groot SPC, Hilhorst HWM. Effects of osmotic priming on dormancy and storability of tomato (*Lycopersicon esculentum* Mill.) seeds. Seed Science Research. 1996; 6(2):49-55.
61. Yuan SY, Jian SY, Tian WM, Yil LX, Xiang G, Rong H, *et al*. Effects of seed priming on germination and seedling growth under water stress in Rice. Acta Agronomica Sinica. 2010; 36(11):1931-1940.
62. Yu-jie Li, Dorna H, Su-juan G, Ming-pu Z. Effects of osmopriming and hydropriming on vigour and germination of china aster (*Callistephus chinensis* (L.) Nees.) seeds. Forestry Studies in China. 2009; 11(2):111-117.