



Effect of Seed Priming with Micro-Nutrients, Botanicals on Seedling Characteristics of Sorghum (*Sorghum bicolor* L. Moench) Var. Paiyur 2

Paidipati Nagakethan Kumar^{1*}, Abhinav Dayal² and Prashant Kumar Rai²

¹*Department of Genetics and Plant Breeding, Sam Higginbottom University of Agriculture, Technology and Sciences, Naini Agricultural Institute, India.*

²*Department of genetics and Plant Breeding, Sam Higginbottom University of Agriculture, Technology and Sciences, Naini Agricultural Institute, India.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2021/v33i2230698

Editor(s):

(1) Dr. Hon H. Ho, State University of New York, USA.

Reviewers:

(1) Maneesha S.R., ICAR-Central Coastal Agricultural Research Institute, India.

(2) Dhia Ahmed Taain, University of Basrah, Iraq.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/75771>

Original Research Article

Received 14 August 2021
Accepted 29 October 2021
Published 05 November 2021

ABSTRACT

The experiment was conducted in Seed Testing Laboratory, Department of Genetics and Plant Breeding, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.) during kharif season 2019-2021, so as to standardize the acceptable seed treatments for sorghum (Paiyur-2). Different seed priming treatments were taken into the study viz., were evaluated T1 – Zinc Sulphate @ 0.5% up to 3 hours, T2 – Zinc Sulfate @ 1% at 4 hours, T3 – Zinc Sulfate @ 1.5% at 6 hours, T4 – Thiourea @ 0.5% at 3 hours, T5 – Thiourea @ 1% at 4 hours, T6 – Thiourea @ 1.5% at 6 hours, T7 – KNO₃ @ 0.5% at 3 hours, T8 – KNO₃ @ 1% at 4 hours, T9 – KNO₃ @ 1.5% at 6 hours, T10 – Moringa Leaf extract @ 3% at 8 hours, T11 – Neem leaf extract @ 3% at 8 hours, T12 – Thiourea @ 0.5% with Zinc Sulphate (ZnSo₄) @ 0.5% at 6 hours. During this study it had been found that maximum germination percent, seedling length and vigour attributes was observed when seed treated with T10- Moringa leaf extract @ 3% followed by T9 – KNO₃ @ 1.5% and minimum observed in Control (Untreated seed). Seed treatment with Moringa leaf extract @ 3% enhances germination on seedling characters and it is a simple method and no requirement for expensive equipment and chemical might be used for overcoming challenges associated with a poor germination and seedling establishment.

*Corresponding author: E-mail: nagkethan@gmail.com;

Keywords: *Sorghum seeds; neem leaf extract; moringa leaf extract; germination; seedling characteristics.*

1. INTRODUCTION

Sorghum (*Sorghum bicolor* (L.) is belonging to the family of graminaceae (Poaceae). It had been first described by Linnaeus in 1753 under the *Holcus* name. Sorghum as an alternate for *Holcus* by Adanson. Later Moench separated from genus *Holcus* (Clayton, 1961). The numerous name sorghum are great millet, Indian millet, milo, durra, orshallu, cereal grain plant of Gramineae family (Poaceae) and its edible starchy seeds. In India sorghum is understood as jowarin Hindi, Jola in kannada, cholam in Tamil, Jonna in Telugu, Sorghu in Urdu and Jwaarie in Panjabi, durra cornin West Africa, and kaoliang in China, Sorgho in French. Sorghum could also be a diploid of $2n = 2x = 20$ i.e., $2n$ is that the somatic chromosome number having two complete chromosomal sets ($2x$) and chromosome number of 20. Johnson grass could also be a tetraploid with $2n = 4x = 40$. In the species of sorghum, the number of chromosomes in each set is ten [1].

Sorghum may be a crop which is truly versatile and can be grown as a grain and forage or sweet crop. It is one among the major millet crops within the world. Sorghum may be a genus of flowering plants in Gramineae family (Poaceae), which includes about 25 species. Among these, few species have grown as cereals for human consumption and a few in pastures for animals [2-7]. One species, great millet, was originally domesticated in Africa and later has since spread throughout the world. Seventeen out of the 25 species are native to Australia, with the range of some extending to Africa, Asia, Mesoamerica, and certain islands within the Indian and Pacific Oceans [8,9,10,11]. Sorghum is among the foremost efficient crops in conversion of solar power and use of water and is understood as a high-energy, drought tolerant crop which is eco-friendly. Due to sorghum's wide uses and adaptation, "sorghum is one among the really indispensable crops" required for the survivable human (Jack Harlan, 1971).

Sorghum could even be a versatile cereal grain used for human consumption also as livestock feed, alcoholic beverages, and biofuel production. When sorghum is consumed with its outer hull intact, it's an honest source of dietary fiber and antioxidants. Sorghum crop is taken into account as camel crop because of immune

to drought [12,13]. It has earned this name because of its ability to grow in arid soils and withstand prolonged droughts. sort of those species is grown as cereals for human consumption and a few of in pastures for animals.

Pre-sowing seed treatment such as seed coating and seed priming could improve the seed germination and seedling vigor particularly under unfavourable environmental conditions. Seed priming is the some of the pre-sowing seed treatments that have widely applied for many crops around the world. Applications with fungicides, botanicals and different kinds of priming methods acclimate to seed prior to planting to provide effective protection against many seed and soil-born plant pathogens. Micro-nutrient treatment guards against the various seed rots and seedling blights that occur during storage or after planting [14-17].

Seed priming is widely used now a days for betterment of seed performance in terms of upper rate of germination and uniformity of multinational. Also, it causes the reduction in emergence time, accomplishment of uniform emergence and betterment of crop substitute many crops. More recently priming with a spread of agents like hormones, botanicals, bio agents and growth regulators is under practise to urge the required benefits during seed germination and afterward good performance of the crop (Jan Mohammadi et al., 2008).

Seed priming is technique which involves uptake of water by the seed followed by drying to initiate the primary events of germination up to the aim of radical emergence. Its benefits include rapid, uniform and increased germination, improved seedling vigour and growth under a broad range of environment resulting in better stand establishment and alleviation of phytochrome –induced dormancy [18-20]. Seed priming could also be a pre-sowing strategy for influencing seedling development by modulating pre-germination metabolic activity before emergence of radical and typically enhance germination rate and plant performance (Bradford, 1986; Tailor and Harman, 1990).

During priming, seeds are partially hydrated so as that pre-germination metabolic activities proceed, while, radical protrusion is

prevented, then are dried back to original moisture level [21]. Germination percentages due to the effects of interaction between priming media and duration were significant 92 to 97.4%. Zinc and N primed seeds for the duration of 10h had the highest germination percentage compared to other hydro-primed seeds.

2. MATERIALS AND METHODS

The experiment was conducted in Seed testing laboratory of Seed Science and Technology within the Department of Genetics and Plant Breeding, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj (U.P).sorghum (var.paiyur2) T0 – Control, T1 – Zinc Sulphate (ZnSo4) @ 0.5% up to 3hours, T2 – Zinc Sulphate@1% at 4 hours, T3 – Zinc Sulfate@1.5% at 6 hours, T4 – Thiourea @ 0.5% at 3 hours, T5 – Thiourea @ 1% at 4 hours, T6 – Thiourea @ 1.5% at 6 hours, T7 – Potassium Nitrate @ 0.5% at 3 hours, T8 – Potassium Nitrate @ 1% at 4 hours, T9 – Potassium Nitrate @ 1.5% at 6 hours, T10 – Moringa Leaf extract @ 3% at 8 hours, T11 – Neem leaf extract @ 3% at 8 hours, T12 – Thiourea @0.5% with Zinc Sulphate (ZnSo4) @ 0.5% at 6 hours. After cleaning and grading, the seeds were soaked in respective priming solutions at different volume of seeds for accurate hours. Then the seeds were air dried under the shade to bring back to their original moisture content and used for Laboratory experiment.

2.1 Preparation of Solution

For the preparation of saturated salt solution KNO₃ at 10g are going to be taken during a beaker. The chemicals are going to be added in 1000 ml. of water with constant stirring. The quantity of solution will finally constitute to at least one litre, then it became 1% stock solution of KNO₃ as in perspective prepare the answer at accurate concentrations are 0.1%,0.5%,1.5%. And repeat the tactic for ZnSO₄ and Thiourea. The flasks containing chemicals are going to be covered with muslin cloth to avoid any contamination. For the Preparation of solution of the botanicals, to organize 3% solution of neem and moringa leaf extract, 30g of neem and moringa leaf extracts are going to be taken beaker add in 1000 ml of water with constant stirring the quantity of solution will finally constitute at least on litre, then it became 3% stock solution of neem and moringa leaf extract

then on. The flasks containing chemicals are going to be covered with muslin cloth to avoid contamination.

2.2 Soaking in the Solution

After preparing the ZnSO₄, KNO₃, Thiourea, neem leaf extract and moringa leaf extract solution, the sorghum seeds are soaked in the required solution for 3 hours and 8 hours. The untreated seed is called the control. After 8 hours of soaking, the solution will drain from the beaker and previously soaked, it is airdried to its original weight and then germinated under controlled conditions in the laboratory.

The observation on characters viz., speed of germination, germination per cent (ISTA, 2011), Root length (cm), shoot length (cm), Seedling length (cm), Seedling Fresh weight (g), Seedling dry weight (g), Seedling Vigour index I, Seedling Vigour index II [22] were recorded. The experimental data recorded were subjected to statistical analysis for calculating analysis of variance, range, mean, critical difference and coefficient of variation (R.A.Fisher, 1936).

3. RESULTS AND DISCUSSION

According to the results, seedling characters viz. Germination per cent, Root length (cm), Shoot length (cm), Seedling length (cm), seedling fresh weight (g), seedling dry weight (g), SVI-1, SVI-2 were suffering from Moringa leaf extract (3%) concentration significantly recorded maximum were minimum found on top of things (Table- 2).

Mean performance of Germination percent ranged from 95.5% to 92% Significantly maximum was reported T10 – Moringa leaf extract (3%) – 8hours in followed by (95.25%) KNO₃ (1.5%) – 6hours and minimum (92%) was recorded by T0 - control. These results were consonant with Shehzad et al [23] who indicated that priming sorghum seed with KNO₃ solution increase germination %. In contrast, Moringa leaf extracts found to possess no significant effects on seed germination of sorghum (Mubarak et al.,2009: [24].

The mean performance of Root length ranged from 14.16cm to 9.66cm significantly maximum was reported T₁₀- Moringa leaf extract (3%)-8hours in followed by (14.04cm) T₁₁. Neem leaf extract (3%) – 8hours and minimum(9.66cm) was recorded by T₀ - Control. The mean performance of Shoot length ranged from 18.76cm to 14.83cm

significantly maximum was reported in T₁₀ - Neem leaf extract (3%) -8 hours followed by (17.78cm) in T₃ -ZnSo₄(1.5%) -6hours and minimum(14.83cm) was recorded by T₀ - Control.

The mean performance of Seedling length ranged from 31.06cm to 25.74 Significantly maximum was reported T₁₀-Moringa leaf extract (3%) - 8hours in followed by (31.05) T₆- Thiourea (1.5%) -6hours and minimum (25.74) was recorded by T₀ - Control. Abasdokhtef et al., [25] reported similar leads to wheat. Abebe et al., [26] found similar leads to dry beans where soaking of seeds water (hydropriming) resulted increased seedling length. Caserio [27] reported that the Halopriming effects on seedling length of onion.

The mean performance of Seedling fresh weight ranged from 1.81gms to 0.98gms Significantly maximum was reported T₁₀ - Moringa leaf extract (3%) - 8hours in followed by (1.79) T₁₂- Thiourea+ZnSo₄ (0.5%+0.5%) - 6hours and minimum (0.98) was recorded by T₀ - Control. Similarly, Chivasa et al., [28] obtained a higher seedling weight for 10 h hydro-primed sorghum seeds than unprimed. Abdelhady and Aly, [29] also reported to the results regarding root and shoot fresh weights are in agreement with those of who reporte that fresh and dry weights of seedlings from primed seeds were significantly higher, as compared to other unprimed seeds. similar results of weight of seedling were observed by Caseiro et al., [27] Sarikurkcu et al. [30] dursun and Ekinci [31] and Okoh et al., [32].

The mean performance of Seedling dry weight ranged from 0.06gms to 0.03gms Significantly maximum was reported T₁₀- Moringa leaf extract

(3%) -8hours and minimum (0.03) was recorded by T₁ - ZnSo₄ (0.5%)-3hours & T₇ - KNO₃ (0.5%)-6hours. Mekonnen [33] also found the very best shoot and root dry matter weight for 10 and 13 h hydro primed sorghum seeds and observed variation among varieties.

The mean performance of SVI-1 ranged from 2943.63 to 2373.31 Significantly maximum was reported T₁₀- Moringa leaf extract (3%) - 8hours in followed by (2942.12)-T₆-Thiourea (1.5%)-6hours and minimum (2373.31) was recorded by - T₀ - Control. From the findings of Ashraf and Razmjoo [34] that has been reported that primed seeds showed better germination pattern and higher vigour level than non-primed seeds.

The mean performance of SVI-2 ranged from 5.77 to 3.51 Significantly maximum was reported T₁₀ - Moringa leaf extract (3%) - 8hours in followed by (5.35) T₁₂ - Thiourea+ZnSo₄(0.5%+0.5%) - 6hours and minimum (3.51) was recorded by - T₀ - Control. From the [21] findings seed priming improved seedling vigour indices of sorghum varieties as indicated by increased emergence percentage, seedling length, and seedling dry weight. It is apparent that primed seeds can rapidly imbibe and revive the seeds metabolism, enhancing germination rate that can lead to the production of large and uniform seedlings. The improvement in vigour of normal/lowvigour seed might be due to reserve mobilization of food material, activation and re-synthesis of some enzymes DNA and RNA synthesis start during priming. Similar results of Seed vigour index-II were observed by Afzal et al., [35] Okoh et al [32] AhangerFaroz Ahmad et al., [36] and Daniel, [37]

Table 1. Analysis of variance for 8 seedling characters in sorghum (*Sorghum bicolor* L. Moench)

S.no	Seedling Characters	Mean Sum of Squares	
		Treatments (df=12)	Error (df=36)
1.	Germination Percentage	3.53*	4.73
2.	Root Length	7.9*	2.75
3.	Shoot Length	4.68*	2.96
4.	Seedling length	14.45*	6.97
5.	Seedling Fresh weight	0.24*	0.01
6.	Seedling Dry weight	0.00016*	0.00041
7.	a. Vigour Index I	131488.9*	58154.08
	b. Vigour Index II	1.47*	1.05

*Significance at 5% level of significance

Table 2. Mean performance of 8 seedling characters in sorghum (*Sorghum bicolor* L. Moench)

S.No.	Treatments	Germination %	Root length (cm)	Shoot length (cm)	Seedling length (cm)	Fresh weight (g)	Dry weight (g)	Vigour index I	Vigour index II
1	T0(Control) (- -) (- -)	92	9.66	14.83	25.74	0.98	0.05	2373	3.51
2	T1(ZnSo4)(0.5%)(3 hrs)	94.25	10.95	15	25.95	1.21	0.03	2444	4.81
3	T2(ZnSo4)(1%)(4 hrs)	93.75	11.48	16.08	26.31	1.27	0.04	2719	4.38
4	T3(ZnSo4)(1.5%)(6 hrs)	94.75	13.43	17.78	27.58	1.31	0.05	2633	5.05
5	T4(Thiourea) (0.5%)(3 hrs)	94.5	10.73	16.57	27.3	1.43	0.05	2578	5.27
6	T5(Thiourea)(1%)(4 hrs)	93.25	10.6	16.15	29.36	1.39	0.05	2739	4.92
7	T6(Thiourea)(1.5%)(6hrs)	94.75	11.43	16.88	31.05	1.69	0.05	2942	5.31
8	T7(KNO3)(0.5%)(3 hrs)	94.5	13.15	16.39	29.54	1.41	0.03	2796	4.01
9	T8(KNO3)(1%)(4 hrs)	94.5	12.14	15.34	27.48	1.54	0.05	2595	5.23
10	T9(KNO3) (1.5%)(6 hrs)	95.25	12.66	16.74	29.4	1.72	0.05	2803	4.72
11	T10(Moringa Leaf Extract) (3%)(8 hrs)	95.5	14.16	18.76	31.06	1.81	0.06	2943	5.77
12	T11(Neem Leaf Extract) (3%)(8 hrs)	93.5	11.04	16.74	30.56	1.38	0.04	2878	4.72
13	T12(Thiourea+ZnSo4) (0.5%+0.5%) (6 hrs)	93.5	11.48	15.8	27.29	1.79	0.05	2552	5.35
	Grand Mean	94.15	11.99	16.39	28.36	1.46	0.05	2692	4.85
	Minimum	92	9.66	14.83	25.74	0.98	0.03	2373.31	3.51
	Maximum	95.5	14.16	18.76	31.06	1.81	0.06	2943.63	5.77
	SE(m)	1.08	0.83	0.86	1.32	0.05	0.01	120.57	0.51
	SE(d)	1.53	1.17	1.22	1.86	0.07	0.01	170.52	0.72
	C.D at 5%	2.12	1.38	2.45	3.79	0.15	0.02	246.21	1.47
	C.V.	2.31	13.83	10.49	9.31	7.36	22.36	8.95	21.2

4. CONCLUSION

In the present investigation, priming with different treatments exhibited significant effect on various seed quality characteristics. The seed pre-soaking seed treatment increases the germination and vigour of sorghum seeds, significantly all data in laboratory condition. Zinc sulphate, Thiourea and Potassium nitrite @ 0.5%,1%,1.5% and Neem Leaf Extract @ 3% (8hrs) significantly increase the germination and vigour parameters in sorghum. Moringa Leaf Extract @ 3% (8 hrs) showed maximum increase in germination and vigour parameters sorghum. Here compared to control all treatments shows high values. Thus, application of T10 (Moringa Leaf Extract) (3%) (8 hrs) is useful for getting higher yield in sorghum. These conclusions are based on the results of present investigation and therefore further investigation is needed to arrive at valid recommendations.

ACKNOWLEDGEMENT

The authors are thankful to the, University official, HOD of the Department of Genetics and Plant Breeding, Dr. Suresh B.G(late), (Professor and Head) Dept. of Genetics and Plant Breeding for his continuous support during covid pandemic. NAI, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, U.P., and for government of Uttar Pradesh for providing all necessary facilities and support.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

- Odnett GL, Ohadi S, Pugh NA. Sorghum bicolor XS. halepense interspecific hybridization is influenced by the frequency of 2n gametes in S. bicolor. Sci Rep. 2019;9:17901.
- Ahmed M, El Naim, et al. Impact of Salinity on Seed Germination and Early Seedling Growth of three Sorghum (*Sorghum bicolor L. Moench*) cultivars. Science and Technology. 2012;2(2):16-20.
- Abdul Wahid SMA, Basra M, Farooq, Thiourea: A Molecule with Immense Biological Significance for Plants. International Journal of Agriculture & Biology. 2017;19:911-920.
- Amarnath BH. Effect of Priming with Botanicals and Animal Waste on Germination and Seedling Length of Sorghum (*Sorghum bicolor L.*) Seeds. International Journal of Current Microbiology and Applied Sciences. 2018;7:2917-2923.
- Basra SMA, Farooq M, Tabassum R, Ahmad N. Physiological and biochemical aspects of pre-sowing seed treatment in fine rice (*Oryza sativa L.*). Seed Science Technology. 2000;33:623-628.
- David Harris QA, Hamdi AC, Terryoda., Germination and emergence of sorghum bicolor: Genotypic and environmentally induced variation in the response to temperature and depth of sowing. plant, cell and environment. 1987;(10):501-508.
- Hamza Badamasi. Impacts of citric acid on the Phytoextraction of Zinc (Micronutrient) using Sorghum (*Sorghum bicolor L. Moench*) plants. Malaysian Journal of Analytical Sciences. 2020;587-598.
- Almodares A, Hadi MR, Dosti B. Effect of Salt Stress on Germination Percentage and Seedling Growth in Sweet Sorghum Cultivars. Journal of biological sciences. 2007;7(8):1492-1495.
- Ali S, Hossein RR. Effect of hydro priming morphological and physiological performance of aged groundnut (*Arachis hypogaea L.*) seeds. Iranian Journal of Field Crops and Sciences. 2016;(43-53).
- Inayat- Ur- Rahman. Effect of seed priming on germination performance and yield of okra (*Abelmoschus esculentus L.*); 2016.
- Nirmala.K, and Umarani Ranganathan Evaluation of seed priming methods to improve seed vigour of okra (*Abelmoschus esculentus*) and beetroot (*Beta vulgaris*); 2008.
- Vikram Limba. Effect of Seed Priming and Urea Foliar Application on the Performance of Soyabean (*Glycine max L. Merrill*). Journal of Pharmacognosy and Phytochemistry. 2020;9(6):1270-1274.
- Wondimu Teshome, Tamado Tana, Nigussie Dechassa, Singh TN. Effect of Seed Priming on Germination and Seedling Growth of Grain Sorghum (*Sorghum bicolor L. Moench*) Varieties. East African Journal of Sciences. 2018;12(1):51-60.
- Narendra B UN. Effect of seed priming and seed treatments on seed germination and

- vigour in groundnut seeds. M.Sc. (Ag.) Thesis Junagadh agricultural university. Junagadh; 2014.
15. RK Yadav. Techniques of seed priming in field crops. International Journal of Chemical Studies. 2018;6(3):1588-1594.
 16. Kharadi RR. Influence of Various Zinc and Iron treatments on Yield and Yield Attributes of Pearl millet. International Journal of Chemicals Studies. 2020;8(4); 2192-2194.
 17. Umair A, Ali S, Muhammad S, Kashif B., Muhammad JT, Muhammad AM. Assessment of Some Priming Techniques in Mungbean (*Vigna radiata*: a Green House Study. Pakistan Journal of Agricultural Research. 2015;26(4):265-274.
 18. MV. R Murthy, P. Singh SP Wani, K. Srinivas. Yield Gap Analysis of Sorghum and Pearl millet in India Using Simulation Modeling. Research Gate. 2007; 237105801.
 19. Mohammed M, Hassan, Hussaien M. Daffalla. Allelopathic effects on some botanical extracts on germination and seedling growth of Sorghum bicolor L. Journal of Agriculture Technology. 2012;8(4):1423-1469.
 20. Muhammad Usman. Effect of Zinc Sulphate as Soil Application and Seed treatment on greengram (*Vigna radiata* L.). Pakistan Journal of Life and Sciences. 2014;12(2):87-91.
 21. McDonald MB. Seed priming. In: M. Black JD. Bewley (eds.) Seed Technology and Its Biological Basis. Sheffield Academic Press, Sheffield, UK. 2000;287-325.
 22. Abdul-baki AA, Anderson JD. Vigour determination in soybean by multiple criteria. Crop Sciences. 1973;13: 630-633.
 23. Shehzad MM, Ayub AUH, Ahmad M. Yaseen. Influence of priming techniques on emergence and seedling growth of forage sorghum (*Sorghum bicolor* L.). J. Anim.Plant Sci. 2012;22(1):154-158.
 24. Phiri C. Influence of moringa oliefera leaf extracts on germination and early seedling development in major cereals. Agriculture and Biology Journal of North America. 2010;1(15):774-777.
 25. Abbasdokht H, Edalatpish MR, Gholami A. The effect of hydropriming and halopriming on germination and early growth stage of wheat (*Triticum aestivum* L.), World Academy of Science Engineering and Technology. 2010;68
 26. Abebe TA, Modi AT. Hydro priming in dry beans (*Phaseolus vulgaris*). Research J. Seed Sci. 2009;2(2):23-31.
 27. Caseiro B, Bennett MA, Marcos Filho. Comparison of three priming techniques for onion seed lots differing in initial seed quality. Seed Science and Technology. 2004;32:365-375.
 28. Chivasa W, Harris D, Chiduza C, Mashingaidze AB, Nyamudeza P. Determination of optimum on-farm seed priming time for maize (*Zea mays* L.) and sorghum (*Sorghum bicolor* L. Moench) for use to improve stand establishment in semi-arid agriculture. Tanzanian J. Agr. Sci. 2000;3(2):103-112.
 29. Abdelhady MI, Aly HAH. Antioxidant antimicrobial activities of Callistemon comboynensis essential oil. Free Radic Antioxidants. 2012;2:37-41.
 30. Sarikurkcü C, Arisoy K, Tepe B, Cakir A, Abali G, Mete E. Studies on the antioxidant activity of essential oil and different solvent extracts of *Vitexagnuscastus* L. fruits from Turkey. Food Chem Toxicol. 2009;47: 2479- 83.
 31. Dursun A, Ekinci M. Effects of different priming treatments and priming durations on germination percentage of parsley (*Petroselinum crispum* L.) seeds. Agricultural Science. 2010;010;1:17-23.
 32. Okoh OO, Sadimenko AP, Afolayan AJ. Comparative evaluation of the antibacterial activities of the essential oils of *Rosmarinus officinalis* L. obtained by hydrodistillation and solvent free microwave extraction methods. Food Chem. 2010;120:308-12.
 33. Mekonnen HG. Effects of hydro priming sorghum (*Sorghum bicolor* L. Moench) seeds on germination, seedling emergence, and stand establishment. M. Sc. Thesis, Haramaya University, Ethiopia; 2005.
 34. Ashraf E, Razmjoo K. Effects of priming on seed germination and field emergence of safflower (*Carthamus tinctorius* L.). Seed Science and Technology. 2010;38(3):675-681.
 35. Afzal I, Ashraf S, Qasim M, Basra SMA, Shahid.M, Hussain.B, Mannitol. priming induces biochemical changes and enhances germination capacity and seedling vigor in marigold (*Tagetes spp.*). Acta Horticulturae. 2011;898:25-29.
 36. AhangerFaroz Ahmad, Rao R J., and Mamta K. Effect of Aqueous extracts of

- Neem (*Azadirachta indica*) and Eucalyptus citroides on the growth and germination of wheat (*Triticum aestivum* var. *desi*) Journal of environmental science. 2013;4(2):169-172.
37. Daniel IO. Hydropriming and organic improved germination and vigor of Kenaf (*Hibiscus cannabinus* L.) seeds. Journal of Food, Agriculture and Environment. 2012;10(2):760-763.

© 2021 Kumar et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:

The peer review history for this paper can be accessed here:
<http://www.sdiarticle4.com/review-history/75771>