Journal of Horticultural Science and Technology 6(1): 1-6 (2023)
ISSN: 2617-3220 (Print), 2664-9489 (Online)
https://doi.org/10.46653/jhst2361001

Original Research

Effect of *Different Nutrient Applications on Seed Germination of African Marigold* (*Tagetes erecta* L.)

Ali Raza Jamali*, Tanveer Fatima Miano, Mohsin Ali Buledi, Baber Ali Lashari

Department of Horticulture, Faculty of Crop Production, Sindh Agriculture University, Tandojam, Pakistan

ABSTRACT

Global warming and change in climate triggers to combat the feeding need of the population, seed represent the basic requirement for a quality plant material. The present research was carried out in 2021 at Horticulture Garden Sindh Agriculture University Tandojam to assess the effect of *different nutrients application on seed germination of marigold (Tagetes erecta L.)* The present study was conducted to evaluate effect of different nutrients application on seed germination of marigold (*Tagetes erecta* L.) Therefore, the seeds of marigold were emersed in 1% solution of ammonium sulphate ($(NH_4)_2SO_4$), boric acid (H_3BO_3), and potassium nitrate (KNO_3) to get the accuracy of seed germination. Results revealed that maximum seed germination percentage (85.27%), germination rate of index (83.84), coefficient of velocity germination (2.96), mean germination time (12.73), mean germination rate (44.45), germination index (1.55), final germination percentage (1.23%), first day of germination percentage (74.61), last day of germination (13.23) and time spread germination (14.40) was observed when 1% potassium nitrate was applied and followed by boric acid {seed germination percentage (59.20%), germination rate of index (54.93), coefficient of velocity germination (24.13), mean germination time (8.84), mean germination rate (36.20), germination index (1.04), final germination percentage (3.10), first day of germination percentage (74.36), last day of germination (15.16) and time spread germination (11.90)} while the minimum results were recorded in control with mineral water seed germination percentage (18.28%), germination rate of index (3.26), coefficient of velocity germination (0.73), mean germination time (2.70), mean germination rate (11.00), germination index (0.32), final germination percentage (10.43), first day of germination percentage (37.35), last day of germination (15.06) and time spread germination (4.83) and Pearson correlation (*r*) exhibited a strong positive correlation observed in MGR with CVG=0.4482, FDP=0.3696, G=0.4554, GI=0.4551, GP=0.4499 and GRI=0.3766-). This study showed that seed is directly related with germination and germination-related traits. It has a great positive impact on crop yield.

Keywords: *Marigold, germination, ammonium sulphate, boric acid, potassium nitrate.*

Article History: *Received 15 July 2022; Revised 28 August 2022; Accepted 18 October 2022; Published 31 March 2023.*

INTRODUCTION

Marigold (Tagetes erecta L.) belongs to the family *Asteraceae*. It is an erect annual plant that can grow up to 180 cm tall but is more likely to be around 35 cm, probably native to Mexico, America. This plant produces yellow to orange flowers and germinates within 5-8 days from seeds at 21 to 24 °C (Kadam et al., 2013).

Seeds is one of the most important factors in existence and proliferation of plants and its quality define plants productivity in agricultural ecosystems. Thus, characterization of decreasing factors of seed quality and applying methods to optimize these characteristics are management strategies that can improve productivity of crops. Germination and seedling establishment are critical stages in the plant life cycle. In crop production, stand establishment determines plant density, uniformity, and management options (Cheng et al., 1999).

Strategies for improving the growth and development of crop species have been investigated for many years. Seed priming is a pre-sowing strategy for influencing seedling development by modulating pre-germination metabolic activity prior to emergence of the radicle and generally enhances germination rate and plant performance (Ashraf et al., 2001; Taylor et al., 1990). During priming, seeds are partially hydrated so that pre-germination metabolic activities proceed, while radicle protrusion is prevented, then are dried back to the original moisture level (McDonald, 2000). Various priming treatments have been employed to increase the speed and synchrony of seed germination (Bradford, 1986). Common priming

* Corresponding author
Emails: alijamali752@gmail.com (A.R. Jamali), tfmiano@sau.edu.pk (T.F. Miano), nawabbaloch740@gmail.com (M.A. Buledi), baberali8210@gmail.com (B.A. Lashari)

techniques include comprising (soaking seeds in osmotic solutions such as polyethylene glycol), halopriming (soaking seeds in salt solutions) and hydropriming (soaking seeds in water). Comprising contributes to significant improvement in seed germination and seedling growth in different plant species. Seeds of tomato and asparagus (*Asparagus offcinalis*) osmo conditioned in -0.8 MPa PEG-8000 showed increased germination under saline media (Pill, 1991). Osmotic priming to improve seed germination performance may also enhance general crop performance. Osmo conditioning of Italian ryegrass (*Lolium multiflorum)* and sorghum (*Sorghum bicolor*) seeds with 20 % PEG-8000 for 2 d at 10 °C increased the percentage of germination formation of seedling and production of dry matter under conditions of water stress, water logging, cold stress, and saline conditions (Hur, 1991).

In the present scenario, marigold is not only important for social, political, historical occasions, birthdays, wedding and marriage greetings, and religious offerings but are also used in the pharmaceutical industry to cure diseases (Manisha et al., 2013). The extract of the plant has been used against rheumatism, colds and bronchitis, earache, leaves, florets, and decoction used as a diuretic, treatment of eye diseases, skin wash, ulcers, abdominal pain, muscular, bone pain and, ulcers due to, enriched antimalarial, antioxidant, and carminative properties (Manisha et al., 2013; Dixit et al., 2013; Khulbe et al., 2013; Rasoanaivo et al., 1992). Besides medicinal importance, it is also used as a flavouring in food, a popular dye plant, effective repellent i.e., mosquitocidal, insecticidal, and caterpillar repellent (Marcia et al., 2011; Nikkon et al., 2011; Patrick et al., 2011).

Seed quality has always been an issue in present day for a quality plant material, and to get vigorous seedlings for high yield per unit area, therefore, to get precise and healthy seedlings, seed quality must be characterized and analysed through various seed quality parameters to confirm its viability and germinating capacity. Therefore, the present study was conducted to analyse the seed germination of as affected by through various quality dimensions.

MATERIALS AND METHODS

Imbibition treatment

In present study, seeds of marigold were purchased from The SAU Nursery at Sindh Agriculture University, imbibed in 1% solution of potassium nitrate (KNO_3), boric acid (H_3BO_3), ammonium sulphate ($(NH_4)_2SO_4$), and (mineral water (H_2O). The 36 seeds in each treatment were immersed into the solution for 24 hours, the seedling tray filled with canal silt used for seed sowing. Date of seed sowing was noted and, seed quality attributes were also recorded.

Seed quality based on imbibition

Good quality seed is the feature of good plant yield, therefore, a thorough understanding about seed quality attributes seed germination percentage (SGP), germination rate of index (GRI), coefficient of velocity germination (CVG), mean germination time (MGT), mean germination rate (MGR), germination index (GI), final germination percentage (FGP), first day of germination percentage (FDG), last day of germination (LDG) and time spread germination (TSG) was observed to have a good seed quality. Further, formulas were applied to check its quality index Seed germination represents the base for seed viability and vitality (Table 1).

Statistical analysis

The data were statistically analysed using computer software Statistix 8.1. Significant differences were determined by using ANOVA in combination with the least significance difference (LSD) test. The significance of differences was evaluated at $p<0.05$. Tables and figures report the means and standard errors means are based on the three replicates per treatment. The Pearson correlation coefficients were used for the dependence between the parameters.

RESULTS

Seed germination percentage

The SGP showed a statistically signification results (Table 2), for all the imbibition treatments. Maximum germination was observed in seeds imbibed with 1% potassium nitrate (85.27%), followed by imbibition in boric acid (59.20%). Whereas less seed germination (18.27%) was noted in seeds imbibed only in mineral water (pH 7.0).

Table 1: Seed germination parameters, their symbols, and formulae.

S. No.	Germination parameter	Symbol	Formula for calculation	Reference
1.	Seed Germination Percentage	SGP	Germinated seed×100/total seed	Bench et al., 1991
2.	Germination rate of index	GRI	GRI = G1/1+G2/2+…+Gx/x	Esechi, 1994
3.	Coefficient velocity germination	CVG	CVG = $N_1+N_2+…+Nx/100×N_1T_1+…+N_x/T_x$	Jones and Sanders, 1987
4.	Mean germination time	MGT	MGT = ∑f.x/∑f	Orchard et al., 1977
5.	Mean germination rate	MGR	MGR = G1/1+G2/2+…Gx/x	
6.	Germination index	GI	GI = (10×n1)+(9×n2)….(1×n10)	
7.	Final germination percentage	FGP	FGP = Final number of seeds germination in a seed lot × 100	Scott et al., 1984
8.	First day of germination	FDG	FDG=Day on which the first germination event occurred	Kader, 1998
9.	Last day of germination	LDG	LDG = Day on which the last germination event occurred	Kader et al., 1998
10.	Time spread germination	TSG	TSG = The time in days between the first and last germination events occurring in a seed lot	Kader and Jutzi, 2002

Table 2: Effect of imbibition on germination, germination rate of index and coefficient of velocity germination in marigold seeds.

Imbibition	Germination (%)	Germination rate of index	Coefficient of velocity germination
Control	18.28 D	3.26 D	0.73 D
1% H_3BO_3	59.20 B	4.59 B	2.41 B
1% KNO_3	85.27 A	83.84 A	2.96 A
1% $(NH_4)_2SO_4$	29.36 C	4.37 C	1.22 C
LSD	0.34	0.64	0.04
SE	0.14	0.2791	0.01
P-Value	0.00	0.00	0.00
F-Value	8.16	4.08	6.61
CV	0.03	1.24	1.2

Table 3: Mean germination time, mean germination rate and germination index in marigold seed under imbibition treatments.

Imbibition	Mean germination time	Mean germination rate	Germination index
Control	2.70 D	11.00 D	0.32 D
1% H_3BO_3	8.84 B	36.20 B	1.04 B
1% KNO_3	12.73 A	44.45 A	1.55 A
1% $(NH_4)_2SO_4$	4.43 C	33.60 C	0.52 C
LSD	0.07	24.58	0.03
SE	0.03	10.66	0.01
P-Value	0.00	0.06	0.00
F-Value	3.41	3.60	3.11
CV	0.59	41.7	1.99

Germination rate of index

The GRI showed a statistically signification (*$p<0.05$*) results (Table 2), for all the imbibition treatments, Maximum germination rate of index was observed in seed imbibed with 1% potassium nitrate (83.84), followed by imbibition in ammonium sulphate (4.37). Whereas less germination rate of index (3.26) was noted in seeds imbibed in mineral water (pH 7.0).

Coefficient of velocity germination

The CVG showed a statistically signification results (Table 2), for all the imbibition treatments. Maximum coefficient of velocity germination was observed in seed imbibed with 1% potassium nitrate (2.96), followed by imbibition in boric acid (1.22) Whereas, less coefficient of velocity germination (0.75) was observed in seeds imbibed in mineral water (pH 7.0).

Mean germination time

The MGT showed a statistically signification results (Table 3), for all the imbibition treatments, Maximum mean germination time was observed in seed imbibed with 1% potassium nitrate (12.73), followed by boric acid (8.84). Whereas less mean germination time (2.70) was noted in seeds imbibed in mineral water (pH 7.0).

Mean germination rate

The MGR showed a statistically signification results (Table 3), for all the imbibition treatments, Maximum mean germination rate was observed in seed imbibed with 1% potassium nitrate (44.45), followed by boric acid (36.20). Whereas less mean germination rate (11.00) was noted in seeds imbibed in mineral water (pH 7.0).

Germination index

The GI showed a statistically signification results (Table 3), for all the imbibition treatments, Maximum germination index was observed in seed imbibed with 1% potassium nitrate (1.55), followed by boric acid (1.04). Whereas less germination index (0.32) was noted in seeds imbibed in mineral water (pH 7.0).

Final germination percentage

The FGP showed a statistically signification results (Table 4), for all the imbibition treatments, Maximum germination index was observed in seed imbibed with Control (10.43), followed by ammonium sulphate (4.10). Whereas less final germination percentage (1.32) was noted in seeds imbibed in mineral water (pH 7.0).

First day of germination

The FDG percentage showed a statistically signification results (Table 4), for all the imbibition treatments, Maximum first day of germination was observed in seed imbibed with potassium nitrate (740.61), followed by boric acid (740.36). Whereas less first day of germination (370.14) was noted in seeds imbibed in mineral water (pH 7.0).

Last day of germination

The LDG showed a statistically signification results (Table 4), for

Table 4: Seed related quality metamorphous final germination percentage, first day of germination, last day of germination and time spread germination of marigold during germination.

Imbibition	Final germination percentage	First day of germination	Last day of germination	Time spread germination
Control	10.43 A	37.35 C	15.06 C	4.83 D
1% H_3BO_3	3.10 C	74.36 B	15.16 A	11.90 B
1% KNO_3	1.23 D	74.61 A	13.23 D	14.40 A
1% $(NH_4)_2SO_4$	4.10 B	37.14 D	15.10 B	10.90 C
LSD	0.53	0.36	0.42	0.93
SE	0.23	0.15	0.18	0.40
P-Value	0.00	0.00	0.00	0.00
F-Value	1.70	1.30	5.30	2.01
CV	0.05	4.06	1.53	4.72

Table 5: Pearson correlation coefficients (*r*) for the total seed related quality metamorphous of marigold during germination. weighting seed related variables.

	CVG	FDG	FDP	G	GI	GP	GRI	LDG	MGR	MGT
FDG	-0.8098									
	0.0014									
FDP	0.9599	-0.6633								
	0.0000	0.0187								
G	0.9904	-0.7905	0.9283							
	0.0000	0.0022	0.0000							
GI	0.9859	-0.7899	0.9177	0.9992						
	0.0000	0.0022	0.0000	0.0000						
GP	0.9900	-0.7884	0.9279	0.9999	0.9992					
	0.0000	0.0023	0.0000	0.0000	0.0000					
GRI	0.8032	-0.6331	0.6584	0.8765	0.8886	0.8777				
	0.0017	0.0271	0.0199	0.0002	0.0001	0.0002				
LDG	-0.7653	0.6039	-0.6200	-0.8420	-0.8526	-0.8428	-0.9823			
	0.0037	0.0376	0.0315	0.0006	0.0004	0.0006	0.0000			
MGR	0.4482	-0.5784	0.3696	0.4554	0.4551	0.4499	0.3766	-0.4003		
	0.1440	0.0488	0.2371	0.1368	0.1372	0.1423	0.2276	0.1972		
MGT	0.9907	-0.7946	0.9272	0.9999	0.9992	0.9999	0.8762	-0.8418	0.4543	
	0.0000	0.0020	0.0000	0.0000	0.0000	0.0000	0.0002	0.0006	0.1378	
TSG	0.8357	-0.9831	0.6853	0.8262	0.8295	0.8237	0.6960	-0.6592	0.5851	0.8296
	0.0007	0.0000	0.0139	0.0009	0.0008	0.0010	0.0119	0.0197	0.0456	0.0008

all the imbibition treatments, Maximum last day of germination was observed in seed imbibed with boric acid (15.16), followed by control (15.06). Whereas less last day of germination (13.23) was noted in seeds imbibed in mineral water (pH 7.0).

Time spread germination

The TSG showed a statistically signification results (Table 4), for all the imbibition treatments, Maximum time spread germination was observed in seed imbibed with potassium nitrate (14.40), followed by boric acid (11.90). Whereas less time spread germination (4.83) was noted in seeds imbibed in mineral water (pH 7.0).

Pearson correlation coefficients

Correlation depicts a very deep insights into various positive and negative relationship among various parameters related to seed germination viability and vigour characteristics (Table 5). The FGP showed a positive correlation with Coefficient of Velocity germination (CVG), G (0.9904, 0.9283) had a positive correlation with CVG (0.9904) and FDP (0.9283). Strong positive correlation was observed in MGR with CVG=0.4482, FDP=0.3696, G=0.4554, GI=0.4551, GP=0.4499 and GRI=0.3766) and TSG (CVG=0.8375, FDP=0.6853, G=0.8262, GI=0.8295, GP=0.8237, GRI=0.9660) with all the variable expect FDG (-0.5784) followed by GRI which indicated a negative correlation only with FDG (-0.6331) as far as strong negative correlation is concerned, it was noted in LDG that showed only positive correlation with FDG (0.6039). So, from this result it can be depicted that most of the seed parameters are in positive correlation with each other.

DISCUSSION

The discussion revolves around the seed quality of the marigold to have an extraordinary result by confirming its viability and germination power through germination metamorphosis techniques. The imbibition treatment on seeds were given to have a significant and beneficial result, in this method seeds were imbibed in different solutions and were subsequently tested using ANOVA with combined LSD test, at the end a positive change was observed in germination, germination rate index, coefficient of velocity germination, mean germination time, mean germination rate, germination index, final germination percentage, first day of germination, last day of germination and time spread germination. Which were further analysed by the before and after treatment results. Treatment of seeds with potassium nitrate and boron, had a beneficial effect on seed germination in laboratory conditions. The beneficial effect of seeds on the appearance of seedlings is consistent with the ideas of farmers about their effects on some other medicinal plants, such as cumin and pot marigold (*Calendula officinalis* L.). Tabrizan KNO_3 + B seed priming in this study resulted in an overall germination of 98 %. In station trigger experiments, Harris et al. (1999) reported that soaking seeds in the primer solution for 12 hours reduced germination time by about 50 %. Concentrations above 1.5% NO_3 and 1% B in initial solutions adversely affected germination. Ajouri et al. (2004), similarly studying the effects of seed priming on germination, showed that concentrations greater than 0.04 m of boric acid significantly reduced the germination rate of barley. Low germination was also recorded during the processing of sweet pepper when higher doses of micronutrients were used in seed preparation (Diniz et al., 2009). Tabrizian and Osarkh (2007) emphasized the importance of seedling power for creating a rapid vector and early growth of medicinal plants to compete for water, light and nutrients. In this study, it was observed that priming of Face 4 and 3PO3 seeds led to a higher dill SPF. Radpoor and Rimaz (2007), in their study of the preparation of fennel seeds with a solution of iron, molybdenum and boron, came to the same conclusion. In addition, Louzada and Vieira (2005) confirmed that the application of very high doses of micronutrients to bean seeds due to their toxic effects led to an increase in the number of abnormal seedlings and death. Significant differences were observed in dry matter accumulation and sphagnum of the red periwinkle (*Catharanthus roseus* L.) between primed and non-primed seeds (Kartikian et al., 2007).

CONCLUSION

The seeds imbibed in 1 % KNO_3 induced maximum seed-related attributes as compared to other imbibition treatments. The imbibition really triggered seed germination rapidly and enhanced other seed germination related attributes. The seed germination metamorphic are directly related to seed vigour. The imbibition was directly in correlation to seed improving parameters except final days to germination.

Declaration of competing interests

The authors declare that they have no known competing financial interests or personal relationships that seem to affect the work reported in this article. We declare that we have no human participants, human data, or human tissues.

Author contribution statement

Ali Raza Jamali; Methodology, Software, Validation, Original Draft, Writing, **Tanveer Fatima Miano;** Supervision, Project administration, Formal analysis, Writing – Review & Editing, **Mohsin Ali Buledi;** Investigation, Resources, Data curation, **Baber Ali Lashari;** Visualization, Funding acquisition.

Acknowledgments

Authors thank Department of Horticulture, Faculty of Crop Production, Sindh Agriculture University, Tandojam, Pakistan for providing funds to conduct research reported in this paper.

REFERENCES

Ajouri, A., Asgedom, H. and Becker, M. 2004. Seed priming enhances germination and seedling growth of barley under conditions of P and Zn deficiency. *Journal of Plant Nutrients and Soil Science,* 167(3): 630-636. https://doi.org/10.1002/jpln.200420425

Ashraf, M. and Rauf, H. 2001. Inducing salt tolerance in maize (*Zea mays* L.) through seed priming with chloride salts, growth, and ion transport at early growth stages. *Acta Physiologiae Plantarum*, 23: 407-414. https://doi.org/10.1007/s11738-001-0050-9

Bench, A.R., Fenner, M. and Edwards, P. 1991. Changes in germinability, ABA content and ABA embryonic sensitivity in developing seeds of *Sorghum bicolor* (L.) Moench induced by water stress during grain filling. *New Phytologist,* 118: 339-347. https://doi.org/10.1111/j.1469-8137.1991.tb00986.x

Bradford, K.J. 1986. Manipulation of seed water relations via osmotic priming to improve germination under stress conditions. *Journal of Horticulture Science,* 21: 1105-1112. https://doi.org/10.21273/HORTSCI.21.5.1105

Cheng, Z., Bradford, K.J. 1999. Hydrothermal time analysis of tomato seed germination responses to priming treatments. *Journal of Experimental Botany*, 33: 89-99. https://doi.org/10.1093/jxb/50.330.89

Diniz, K., Silva, P., Oliveira, J. and Evangelista, J. 2009. Sweet pepper seed responses to inoculation with microorganisms and coating with micronutrients, amino acids and plant growth regulators. *Journal of Science Agriculture,* 66: 293-297.

Dixit, P., Tripathi, S. and Verma, N.K. 2013. A brief study on marigold. *International Research Journal of Pharmacy,* 4: 43-48.

Esechie, H. 1994. Interaction of salinity and temperature on the germination of sorghum. *Journal of Agronomy and Crop Science*, 172: 194–199. https://doi.org/10.1111/j.1439-037X.1994.tb00166.x

Harris, D., Joshi, A., Khan, P., Gothkar, P. and Sodhi, P. 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: 15-29. https://doi.org/10.1017/S0014479799001027

Hur, S.N. 1991. Effect of osmo-conditioning on the productivity of Italian ryegrass and sorghum under suboptimal conditions. *Korean Journal of Animal Sciences*, 33(1): 101-105.

Jones, K. and Sanders, D. 1987. The influence of soaking pepper seed in water or potassium salt solutions on germination at three temperatures. *Journal of Seed Technology*, 11: 97-102.

Kadam, C.L., Bhingare, R., Sumbe, R., Nikam, A. and Patil, G. 2013. Physicochemical and phytochemical investigation of *Tagetes erecta* Linn flowers (*Asteraceae*). *Journal of Biology Science Open,* 1(1): 21-24.

Kader, M.A. 1998. Notes on various parameters recording the speed of seed germination. *Journal of Agriculture in the Tropics and Subtropics,* 99: 47-154.

Kader, M.A, Omari, M. and Hattar, B. 1998. Maximizing germination percentage and speed of four Australian indigenous tree species. *Dirasat Agricultural Sciences,* 25: 157-169.

Kader, M. and Jutzi, S. 2002. Time-course changes in high temperature stress and water deficit during the first three days after sowing in hydro-primed seed: Germinative behavior in sorghum. *Journal of Agriculture and Rural Development in the Tropics and Subtropics,* 103:157-168.

Karthikeyan, B., Jaleel, C., Gopi, R. and Deiveeka, M. 2007. Alterations in seedling vigor and antioxidant enzyme activities in *Catharanthus roseus* under seed priming with native diazotrophs. *Journal of Zhejiang University Science B,* 8: 453-457. https://doi.org/10.1631/jzus.2007.B0453

Khulbe, A., Pandey, S. and Parkash, S. 2010. Antidepressant like action of the hydromethanolic flower extract of Tagetes erecta in mice and its possible mechanism of action. *Indian Journal of Pharmacology*, 45 (4): 386-390. https://doi.org/10.4103/0253-7613.115026

Louzada, S. and Vieira, N. 2005. Effect of application of micronutrients on germination of marigold. In *Congresso Nacional de Pesquisa de Feijão,* 8: 732-734.

Manisha, R. L., Shaik, R. and Satyanarayana, A. 2013. Evaluation of anxiolytic activity of flowers of *Tagetes erecta* Linn (*Asteraceae*) in rats. *Journal of Applied Pharmaceutical Science,* 39(12): 75-85. http://dx.doi.org/10.7324/JAPS.2013.31214

Marcia, M., Marques, M. and Selene, M. 2011. Larvicidal activity of *Tagetes erecta* against *Aedes aegypti*. *Journal of American Mosquito Control Association,* 27(2): 156-158. https://doi.org/10.2987/10-6056.1

McDonald, M. C. 2000. Seed priming, Black, M., J. D. Bewley, (Eds.), Seed Technology and its Biological Basis. Sheffield Academic Press, Sheffield, UK, 2: 287–325.

Nikkon, F.M., Habib, M.R. and Saud, Z. A. 2011. *Tagetes erecta* Linn and its mosquitocidal potency against *Culex quinquefasciatus*. *Asian Pacific Journal of Tropical Biomedicine*, 1691(11): 186-188. https://doi.org/10.1016/s2221-1691(11)60024-5

Orchard, T. 1977. Estimating the parameters of plant seedling emergence. *Journal Seed Science and Technology*, 5: 61-69.

Patrick, R. S., Marijo, S. and Sandra, R. 2011. Antimicrobial Activity of flavonoids from *Piper lanceaefolium* and other Colombian medicinal plants against antibiotic susceptible and resistant strains of Neisseria gonorrhoeae. *Sexually Transmitted Diseases*, 38(2): 81-88. https://doi.org/10.1097/olq.0b013e3181f0bdbd

Pill, W., Frett, G. and Morneau, A. 1991. Germination and seedling emergence of primed tomato and asparagus seeds under adverse conditions. *Horticulture Science*, 26: 1160-1162. https://doi.org/10.21273/HORTSCI.26.9.1160

Radpoor, R. and Rimaz, A. 2007. Rapid germination and higher vigor in seedlings of fennel (*Foeniculum vulgare*) due to seed priming with microelements. *Iran Journal of Crop Science,* 7: 237-248.

Rasoanaivo, P., Petitjean, P. M., Ratsimamanga-Urverg, S. and Rakoto, A. 1992. Medicinal plants used to treatment malaria in Madagascar. *Journal of Ethnopharmacology,* 37: 117-127. https://doi.org/10.1016/0378-8741(92)90070-8

Scott, S., Jones, R. and Williams, W. 1984. Review of data analysis methods for seed germination. *Journal of Crop Science,* 24: 1192-1199. https://doi.org/10.2135/cropsci1984.0011183X002400060043x

Tabrizian, F. and Osareh A. 2007. Improved seed emergence and yield related traits of marigold (*Calendula officinalis* L.) by on-farm seed micronutrient treatment trials. *Iranian Journal of Crop Science*, 9: 124-141.

Taylor, A.G., Harman, G. H. 1990. Concepts and technologies of selected seed treatments. *Annual Review of Phytopathology*, 28: 321-339. https://doi.org/10.1146/annurev.py.28.090190.001541