Eco. Env. & Cons. 28 (3) : 2022; pp. (1507-1515)
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ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2022.v28i03.058

Effect of potassium nitrate on germination physiology of magnesium nitrate primed and non-primed rice seeds var. Swarna

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(Received 22 October, 2021; Accepted 13 December, 2021)

ABSTRACT

Present work deals about the influence of graded solution of Potassium Nitrate (KNO_3) on germination physiology and seedling vigor index, using Magnesium Nitrate [$Mg(NO_3)^2$] (4 mM) primed seeds of rice variety Swarna to ensure the importance of seed priming technology vis -a-vis tolerable capacity of seed / seedling towards KNO_3. During experimentation graded solution of KNO_3 was taken into petri dishes, containing $Mg(NO_3)_2$ primed and non-primed seeds of rice for the study of various parameters, included germination percentage and index, speed and mean time for germination, plumule and radicle lengths, root number, fresh and dry weights of seedlings and α-amylase activity. However, time duration of study ranged from 48 h of germination to 8th days of seedling age. Experiment reveals that $Mg(NO_3)_2$ primed seeds performed better as compared to non-primed one even with the introduction of various concentrations of KNO_3 solution. Optimum results were obtained with 10 to 15 mM of KNO_3. Nowadays the seed priming proves itself one of the most viable technologies for field and vegetable crops. But to maintain the sustainability of the soil one has to think also about the absorbing competence of that particular crop in the field condition in presence of various fertilizers, specifically nitrogen containing one while using primed seeds. The present experiment actually reflects the growing capability of $Mg(NO_3)_2$ primed seeds in presence of an important nitrogenous salt's solution, i.e. KNO_3.

Key words: *Germination physiology, Potassium nitrate, Seed priming, Vigor index*

Introduction

Humanity, now a day is standing in front of biggest challenges i.e. to live sustainable and to develop the agricultural system sustainable and remain environment safe, for this world have to implement valuable steps to meet up the food demands of the growing global population (Edmondson *et al*., 2014). The global economic competitiveness, demands some innovative biotech/ molecular tools, treatments or products which are essential to speed-up the consolidation process of the seed industry. Despite contemporary agriculture uses largely chemical compounds, the use of seed invigoration techniques (seed priming is one of them) might represent a good alternative to raise the yield of agricultural

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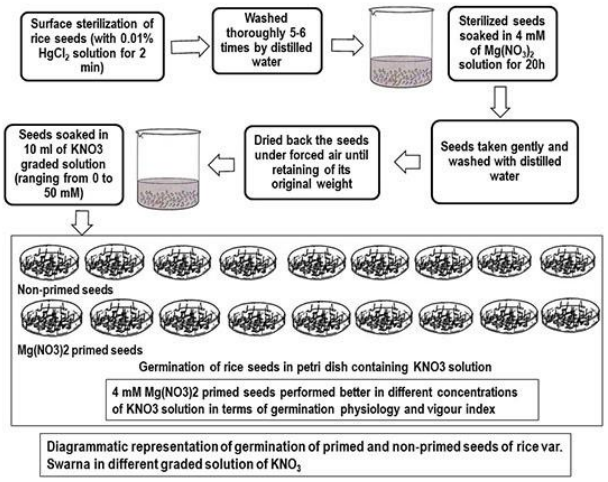

Diagrammatic representation of germination of primed and non-primed seeds of rice var. Swarna in different graded solution of KNO_3

production while improving plant protection and storage (Aladjadjiyan, 2012).

Rice (*Oryza sativa* L.) is a principal cereal crop which serves as a staple food for nearly half of the world's population (Dien *et al*., 2019; Chun *et al*., 2020). By considering the significance of rice, a need-based stability and adequate supply of it is a requirement to maintain the food security, poverty reduction as well as improvement of financial status for any nation (Zheng *et al*., 2016). Different biotic and abiotic stresses affect the emergence and growth of rice seedlings subjecting for colossal losses of yield and finally global rice production is reduced (Quan *et al*., 2016; Dien *et al*., 2019).

Seed priming is an easy, cost effective, eco- and farmers friendly technique for the enhancement of seed germination and emergence, growth of seedlings, yields and stress tolerance ability of the crops. It is a restricted hydration technique that activates the pre-germination metabolic processes like increased uptake of water (imbibition), stimulation of reserve mobilization by activating the hydrolyzing enzymes such as amylase, cellulase and xylanase within the seeds but without protrusion of radicle (Mondal *et al*., 2011). Priming has several beneficial effects, it improves the percentage as well as speed and uniformity of germination, faster seedlings stand establishment and vigorous growth of seedlings. Priming causes an increment in the activities of hydrolytic enzymes like amylases, lipases and proteases which break down the reserve foods stored in the nutritive tissue and convert them from their polymeric to monomeric form; and are responsible to enhance the embryonic growth and development of seeds. Priming also minimizes effect of environmental stress during the time of germination and ultimately leads to higher seedling emergence and stand establishment with vigorous growth (Marthandan *et al*., 2020; Ali *et al*., 2021). Such kind of pre-metabolic biological activities of priming are helpful for farmers because it reduces the time of emergence, cost of repeated seeding, fertilization and additional irrigation on treatment with various chemicals or bio-chemicals in different field crops and horticultural crops (Hussain *et al*., 2015; Ruttanaruangboworn *et al*., 2017; Ali *et al*., 2020; Acharya *et al*., 2020; Dhillon *et al*., 2021).

By keeping the views in mind, the present manuscript considered the potentiality of seed priming. The rice seeds was primed with magnesium nitrate [$Mg(NO_3)_2$] and those primed and non-primed seeds were implanted in the graded solution of potassium nitrate (KNO_3). The aim of the present experiment was to study the influence of various concentrations of potassium nitrate salt on the initial phase of germination and seedling growth of primed and non-primed seeds of rice var. Swarna.

Materials and Methods

Rice seeds (*Oryza sativa* L. var. Swarna) were procured from the Department of Genetics and Plant Breeding, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. Healthy and bold seeds were surface sterilized with 0.01% $HgCl_2$ solution for 2 min and then washed 5 to 6 times thoroughly by using distilled water. The experiment was carried out in the Seed Physiology Laboratory, Department of Plant Physiology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (U.P.), India. For priming, the sterilized seeds were soaked in 4mM $Mg(NO_3)_2$ (P) solution for 20h, under 25±2°C and natural light condition. After that the seeds were taken out and gently washed with distilled water once again and then dried back to its initial weight at the room temperature by placing them under fan. Dried primed seeds were then packed in paper bags and were used as per requirement, within one month of priming. The seeds without any treatment referred as control (NP). Both the primed and non primed seeds were sown in the petriplates with 10 ml graded solution of potassium nitrate (KNO_3) (The treatment details were as follows: Non-primed seeds [Control (T_1), 5 mM (T_2), 10mM (T_3), 15 mM (T_4), 20 mM (T_5), 25 mM (T_6), 30mM (T_7), 40 mM (T_8) and 50 mM (T_9) of KNO_3 so-

lutions] and Primed seeds [Control (T_1), 5mM (T_2), 10mM (T_3), 15mM (T_4), 20mM (T_5), 25mM (T_6), 30mM (T_7), 40mM (T_8) and 50mM (T_9) of KNO_3 solutions]) and the germination physiology of rice variety Swarna were studied. The petri dishes were kept in the laboratory to maintain the controlled conditions. These experiments were conducted using completely randomized design (CRD) in factorial arrangement with nine treatments and each treatment was replicated three times.

The parameters considered for germination physiology were germination percentage at 48, 72, 96 and 120h, Germination Index (GI), Speed of Germination (N), Mean Germination Time (MGT), Vigour Index (VI), plumule length, radicle length and root number at 72 and 120 h, fresh and dry weights at 8th DAS. Germination studies were carried out in petri dishes to measure germination percentages.

Germination was observed daily and ***Germination Index (GI)*** was observed by counting the number of seedlings emerging daily from the day of planting till the time of germination was completed. Thereafter GI was computed by using the following formulae:

G.I. = n/d [Where: n = Number of seedlings emerging on day 'd'; of seed.d = Day after planting]

***Speed of germination (N)*:** Number of germinated seeds was counted every day from the first day and the cumulative index was made to compute the speed of germination by using the formula:

Speed of germination = N1/1 + N2/2 + ... + Nx/x = N [Where: N1 = Nx are the no. of seed germinated on day 1 to day x; 1 = X are the no. of days]

***Mean Germination Time (MGT)*:** Mean Germination Time (MGT) was calculated by using the equation of Ellis and Roberts (1981).

MGT = Σ Dn /Σ n [Where n is the number of seeds that had germinated on day D and D is the number of days counted from the beginning of germination.]

***Seed Vigour Index (SVI)*:** Seed vigour index is calculated by multiplying germination (%) and seedling length at 120 h after seed plating. The seed lot showing the higher seed vigour index is considered to be more vigorous (Akazawa and Hara-Mishimura, 1985).

Radicle and plumule lengths of germinated seeds were measured using graph papers and they were calculated per seed basis using the following formula.

The number of roots of plants was also counted by placing the root part on a glass plate and by using a needle. The dry weight of seedlings was obtained by keeping the sample for an hour in an oven pre-set at 100 - 110 ^oC. Thereafter it was placed in another oven, which was set at 60 to 70 ^oC till to get the constant weight (5 seedlings were taken into consideration for each treatment and per replication).

The α-amylase activity was measured in the endosperm, obtained from 72, 120 and 192h germinated rice seeds using the method of Bernfeld (1955). 100 mg endosperm was taken out aseptically from the germinated seeds and homogenized in 5 mL of phosphate buffer (pH 6.9) in a pre chilled mortar and pestle. The homogenate was centrifuged (Model: C-24 Remi revolutionary table top high speed cooling centrifuge) at 5,000 g at 4 ^0C for 10 minutes. Supernatant represented the enzyme (α-amylase) extract. Then supernatant was collected and volume was maintained up to 5 ml by adding phosphate buffer. In a test tube 1 ml of starch solution (1%) prepared in phosphate buffer pH 6.9 was taken and 1ml of enzyme extract was added to it. The same was kept for incubation at 20 ^0C for 10 minutes. After proper incubation 2 ml of DNS (3, 5-dinitrosalicylic acid) solution was added for the suppression of enzyme activity. Test tube containing reaction mixture was kept in boiling water bath for 5 minutes then cooled with the help of running tap water and final volume raised up to 50 ml by adding distilled water. For blank in a place of enzyme extract 1 ml of distilled water was used. Absorbance was read at 510 nm and standard curve of maltose was used for calculating the activity of α-amylase in rice endosperm.

Mean values were taken from each treatment of three independent replications; and Statistical Package for Social Science (SPSS Version 23.0) was used for the analysis of variance. Significant differences among various treatments were determined using Duncan's Multiple Range Test (DMRT).

Results and Discussion

Results showed in Table 1 represented that 4 mM $Mg(NO_3)_2$ primed seed while placed in graded solution of KNO_3 significantly increased the germination percentage as compared to the non-primed one; the germination percentage was recorded from 48 to 120h. At 48h in the graded solution of KNO_3 treat-

ment T_1 to T_4 (87.50, 90.33, 90.67 and 90.33%) showed better germination percentage and showed statistically significant result with other treatments in case of 4mM $Mg(NO_3)_2$ primed seeds. Whereas, the treatment T_4 (51.67%) showed highest and statistically significant results with other treatment in non-primed seeds. However, the results obtained from 72, 96 and 120h study periods, showed similar kind of pattern like 48h after germination; among the treatments including non-primed and primed seeds treatment T_4 showed highest germination percentage and the values were 58.00, 98.17% at 72h; 58.17, 98.17% at 96h and 58.17, 98.17% at 120h in non-primed and primed one respectively. But the treatment T_3 recorded statistically at par value of germination percentage with T_4 in all the studied hours in primed seeds.

Whereas, the data depicted in Table 2 represents the Speed of germination (N), Germination Index (GI), Mean Germination Time (MGT) and Seed Vigour Index (SVI) of non-primed and primed seeds. The non-primed seeds case in different graded solution of KNO_3, the treatment T_4 (40.99, 97.34 and 279.78 respectively) recorded highest value of N, GI and SVI likewise, this treatment showed lowest MGT (0.28) followed by other treatments. Whereas, in primed seeds the treatment T_3 (88.11) in Speed of Germination, T_3 (202.71) and T_4 (202.06) in Germination Index, T_2 (0.16), T_3 (0.16) and T_4 (0.16) in Mean Germination Time and T_4 (919.82) in Seed Vigour Index observed to have best result as compared to other treatment. As per the recorded result of primed and non-primed seeds in graded solution of KNO_3, over all the primed seeds performed better as compared to non-primed seeds.

Among all the KNO_3 solutions in both the primed and non-primed seeds the treatment T_4 (0.55cm and 1.50cm) showed the highest plumule length as compared to other treatments and statistically significant also (Table 3). In different concentrations of KNO_3 solutions i.e., T_1 to T_9 presented in Table 4, where treatment T_4 (0.58 cm and 3.93 cm at 72h; 2.05cm and 4.93cm at 120h respectively) represented highest value of radicle length and statistically significant in both non-primed and primed seeds followed by other treatments like T_3 and T_4. The adventitious roots were formed in the primed rice seedlings in all the graded solutions of KNO_3 but any adventitious roots were not formed in non-primed seedlings. The Figure 1 represents root number of the primed rice seedlings in the graded solution of KNO_3; among all the treatments T_4 form the highest number of roots and showed statistically significant result from the other treatments.

Among all the solutions of KNO_3 treatment T_4 (0.11g, 0.31g and 0.025g, 0.032g fresh and dry weight respectively) accumulated highest amount of fresh and dry weights and showed statistically significant results as compared to other treatment of the non-primed and primed seeds (Table 5).

Table 1. Effect of different concentrations of KNO_3 on germination percentage of $Mg(NO_3)_2$ primed and non-primed seeds of rice var. Swarna at different time intervals

Treatments	Germination percentage							
	48 h		72 h		96 h		120h	
	NP	P	NP	P	NP	P	NP	P
T1	26.00±0.58^{d}	87.50±0.29^{a,b}	40.67±1.20^{c}	90.50±0.29^{c}	46.84±0.44^{b}	90.67±0.33^{b,c}	46.83±0.44^{b}	90.67±0.33^{b,c}
T2	31.33±0.88^{c}	90.33±0.33^{a}	43.17±0.44^{c}	92.50±0.29^{b}	47.50±0.29^{b}	92.50±0.29^{b}	47.50±0.29^{b}	92.50±0.29^{b}
T3	39.83±1.30^{b}	90.67±0.67^{a}	48.33±0.60^{b}	97.50±0.29^{a}	48.34±0.83^{b}	97.50±0.29^{a}	48.33±0.83^{b}	97.50±0.29^{a}
T4	51.67±1.20^{a}	90.33±2.73^{a}	58.00±1.61^{a}	98.17±0.17^{a}	58.17±1.74^{a}	98.17±0.17^{a}	58.17±1.74^{a}	98.17±0.17^{a}
T5	33.17±0.93^{c}	84.33±1.01^{b,c}	43.67±0.73^{c}	90.17±0.73^{c}	44.00±1.04^{c}	91.00±1.04^{b,c}	44.00±1.04^{c}	91.00±1.04^{b,c}
T6	31.50±1.26^{c}	81.17±0.73^{c,d}	39.67±1.09^{c}	86.50±0.76^{d}	40.00±1.26^{d}	89.84±1.59^{c}	40.00±1.26^{d}	89.83±1.59^{c}
T7	25.17±0.44^{d}	80.83±0.44^{d}	34.17±2.32^{d}	82.00±0.50^{e}	36.34±0.73^{e}	84.50±1.04^{d}	36.33±0.73^{e}	84.50±1.04^{d}
T8	21.67±0.60^{e}	73.83±0.73^{e}	30.50±2.08^{d}	80.17±0.44^{f}	33.17±0.44^{f}	80.17±0.44^{e}	33.17±0.44^{f}	80.17±0.44^{e}
T9	17.50±0.29^{f}	66.17±0.73^{f}	21.00±0.58^{e}	71.17±0.60^{g}	21.17±0.73^{g}	71.17±0.60^{f}	21.17±0.73^{g}	71.17±0.60^{f}

Data presented in the table are means values of the three replicates with standard errors. Different letters indicate the significant differences among the treatments and same letters depicted the at par results; tested by Duncan's multiples range test at $p < 0.05$

Where, (1) NP and P are non-primed and 4mM $Mg(NO_3)_2$ primed seeds, respectively. (2) T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_9 are different concentrations (0, 5, 10, 15, 20, 25, 30, 40, and 50 mM) of KNO_3

Table 2. Effect of different concentrations of KNO_3 on Speed of Germination, Germination Index, Mean Germination Time and Vigour Index of $Mg(NO_3)_2$ primed and non-primed seeds of rice var. Swarna

Treatments (KNO_3)	Speed of germination (N)	Germination Index (GI)	Mean Germination Time (MGT)	Vigour Index (VI)
		Non-Primed (NP)		
T1	26.93	62.63	0.41	132.07
T2	29.44	68.93	0.38	139.18
T3	33.25	78.78	0.35	159.82
T4	40.99	97.34	0.28	279.78
T5	29.67	69.94	0.39	122.32
T6	27.56	64.97	0.42	93.07
T7	24.13	56.32	0.48	77.15
T8	21.74	50.53	0.53	63.35
T9	15.46	36.28	0.77	35.63
		Primed (P)		
T1	77.79	180.72	0.17	517.10
T2	85.39	196.63	0.16	647.19
T3	88.11	202.71	0.16	752.38
T4	87.78	202.06	0.16	919.82
T5	83.32	191.17	0.17	745.59
T6	77.69	178.84	0.17	591.70
T7	73.43	169.78	0.18	525.03
T8	67.53	156.71	0.19	484.74
T9	59.25	137.83	0.22	400.43

Table 3. Effect of different concentrations of KNO_3 on plumule length (cm) of $Mg(NO_3)_2$ primed and non-primed seeds of rice var. Swarna at 72 and 120h study period

Treatments	Plumule length (cm)			
	72 h		120 h	
	NP	P	NP	P
T1	0.14 ± 0.02^{f}	$1.13\pm0.09^{b,c}$	1.30 ± 0.06^{c}	3.01 ± 0.10^{f}
T2	0.40 ± 0.01^{c}	$1.19\pm0.04^{b,c}$	1.39 ± 0.02^{c}	3.78 ± 0.05^{c}
T3	0.46 ± 0.03^{b}	$1.37\pm0.01^{a,b}$	1.55 ± 0.05^{b}	4.07 ± 0.02^{b}
T4	0.55 ± 0.03^{a}	1.50 ± 0.03^{a}	2.76 ± 0.08^{a}	4.44 ± 0.06^{a}
T5	0.37 ± 0.02^{c}	$1.36\pm0.03^{a,b}$	1.26 ± 0.04^{c}	4.14 ± 0.04^{b}
T6	0.31 ± 0.02^{d}	$1.27\pm0.22^{a,b,c}$	1.06 ± 0.06^{d}	3.26 ± 0.06^{e}
T7	0.19 ± 0.01^{d}	$1.14\pm0.03^{b,c}$	1.08 ± 0.05^{d}	3.48 ± 0.07^{d}
T8	$0.18\pm0.01^{d,e}$	$1.14\pm0.00^{b,c}$	0.82 ± 0.05^{e}	$3.66\pm0.04^{c,d}$
T9	0.09 ± 0.01^{e}	1.00 ± 0.03^{c}	0.86 ± 0.04^{e}	3.26 ± 0.06^{e}

Data presented in the table are means values of the three replicates with standard errors. Different letters indicate the significant differences among the treatments and same letters depicted the at par results; tested by Duncan's multiples range test at $p < 0.05$

Where, (1) NP and P are non-primed and 4mM $Mg(NO_3)_2$ primed seeds, respectively. (2) T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_9 are different concentrations (0, 5, 10, 15, 20, 25, 30, 40, and 50 mM) of KNO_3

Among the different solutions of KNO_3 presented in table 6 represented the α-amylase enzyme's activity where the endosperm of different studied hours (72. 120 and 196h) obtained from treatment T_4 (representing 15 mM KNO_3) (0.391 and 0.537 at 72h; 0.516 and 0.647 at 120h and 0.380, and 0.363 mg maltose g^{-1} h^{-1} fresh weight of endosperm at 192h for non-primed and primed one respectively) showed highest α-amylase activity in both non-primed and primed case, which was followed by T_5 (representing 20 mM KNO_3). At 192h the α-amylase activity of rice endosperm depicted at par values from treat-

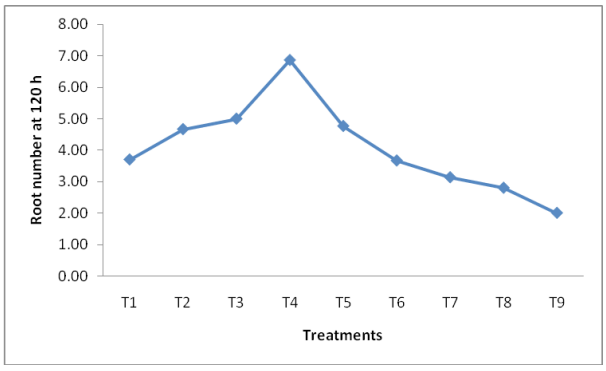

Fig. 1. Effect of different concentrations of KNO_3 on root number of $Mg(NO_3)_2$ primed seeds of rice var. Swarna at 120h

ment T_1 to T_6 in primed sets; moreover, in non-primed seeds treatment T_1 (control) showed highest α-amylase activity followed by other treatment in different graded solution of KNO_3. In all the three studied hours (72, 120 and 192h) the peak values of α-amylase activity was observed at 120h in all the treatments and the activity of the enzyme was exhausted in 192h in all the treatments except T_1 (control); it showed peaked at 192h because the process of solubulization of carbohydrates in the endosperm starts in a slow process during the early hours of germination in non primed one in comparison to primed seeds. In cereals, at the time of germination α-amylases present in the aleurone layer play a very important role in the starch metabolism by hydrolyzing the starch of endosperm into metabolizable sugars which provides energy for the growth of germinating seedlings (Beck and Ziegler, 1989). These highly expressed enzymes are synthesized under the influence of plant growth hormones such as gibberellic acid (GA_3) and exist in multiple forms (Mitchell, 1972; MacGregor, 1977). In the present case while considering the seed priming process, it improves the speed and synchronization of the germination process by activating the α-amylase activity in rice seeds. Rajjou *et al*. (2012) and Bose *et al*. (2018) reported that if a graph is plotted between seed water content (imbibition/osmosis) and time for both primed and non-primed seed germination process, then the representation of three phases is in a likewise manner; phase I depicts the entry of water into the seed by the process of imbibition which is similar for both the cases. Phase II reveals hydration process for non-primed seeds, whereas in primed seeds hydration process allows in a restricted manner where radicle emergence is pre-

Table 4. Effect of different concentrations of KNO_3 on radicle length (cm) of $Mg(NO_3)_2$ primed and non-primed seeds of rice var. Swarna at 72 and 120h study period

Treatments	Radicle length (cm)			
	72 h		120 h	
	NP	P	NP	P
T1	0.22±0.01^{d,e}	2.31±0.05^{e}	1.52±0.05^{c}	2.69±0.07^{e}
T2	0.31±0.02^{c}	2.58±0.05^{d}	1.54±0.08^{c}	3.21±0.06^{d}
T3	0.46±0.01^{b}	3.04±0.08^{b}	1.76±0.02^{b}	3.64±0.06^{c}
T4	0.58±0.02^{a}	3.93±0.10^{a}	2.05±0.06^{a}	4.93±0.07^{a}
T5	0.42±0.02^{b}	2.81±0.04^{c}	1.52±0.03^{c}	4.06±0.09^{b}
T6	0.26±0.03^{c,d}	1.95±0.08^{f}	1.27±0.04^{d}	3.33±0.10^{d}
T7	0.23±0.01^{d}	1.40±0.09^{g}	1.05±0.04^{e}	2.73±0.04^{e}
T8	0.17±0.01^{e}	1.32±0.06^{g}	1.09±0.09^{e}	2.39±0.06^{f}
T9	0.12±0.01^{f}	1.06±0.08^{h}	0.82±0.04^{f}	2.37±0.04^{f}

Data presented in the table are means values of the three replicates with standard errors. Different letters indicate the significant differences among the treatments and same letters depicted the at par results; tested by Duncan's multiples range test at $p < 0.05$

Where, (1) NP and P are non-primed and 4mM $Mg(NO_3)_2$ primed seeds, respectively. (2) T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_9 are different concentrations (0, 5, 10, 15, 20, 25, 30, 40, and 50 mM) of KNO_3

Table 5. Effect of different concentrations of KNO_3 on fresh and dry weights (g) of $Mg(NO_3)_2$ primed and non-primed seeds of rice var. Swarna at 8 days after sowing

	Fresh weight (g)		Dry weight (g)	
	NP	P	NP	P
T1	0.05±0.00^{d}	0.23±0.01^{d}	0.010±0.00^{c}	0.024±0.00^{c}
T2	0.06±0.00^{c,d}	0.25±0.01^{c}	0.010±0.00^{c}	0.025±0.00^{c}
T3	0.09±0.00^{b}	0.28±0.01^{b}	0.015±0.00^{c}	0.031±0.00^{a,b}
T4	0.11±0.01^{a}	0.31±0.01^{a}	0.025±0.00^{a}	0.032±0.01^{a}
T5	0.08±0.01^{b,c}	0.25±0.00^{c}	0.011±0.00^{b,c}	0.030±0.00^{b}
T6	0.08±0.01^{b,c}	0.25±0.00^{c}	0.010±0.00^{c}	0.025±0.00^{c}
T7	0.07±0.01^{b,c}	0.24±0.01^{c,d}	0.010±0.00^{c}	0.020±0.00^{d}
T8	0.07±0.01^{b,c}	0.20±0.00^{e}	0.010±0.00^{c}	0.020±0.00^{d}
T9	0.05±0.01^{d}	0.17±0.00^{f}	0.010±0.00^{c}	0.020±0.00^{d}

Data presented in the table are means values of the three replicates with standard errors. Different letters indicate the significant differences among the treatments and same letters depicted the at par results; tested by Duncan's multiples range test at $p < 0.05$

Where, (1) NP and P are non-primed and 4mM $Mg(NO_3)_2$ primed seeds, respectively. (2) T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_9 are different concentrations (0, 5, 10, 15, 20, 25, 30, 40, and 50 mM) of KNO_3

vented. Phase III includes both the germination and post-germination phase which is similar for primed and non-primed seeds. The present experiment is based upon the germination process of primed and non-primed seeds, where primed seeds performed better as compared to non-primed one and the reason behind these is due to prefabrication of the rice seeds by giving low dose magnesium seed priming treatment in the laboratory condition for 20h. Moreover, the non-primed control seeds cannot able to meet up these time gap and act as a poor performer.

In another sense, the present experiment was conducted in graded solution of potassium nitrate (KNO_3) to identify the tolerability of KNO_3 by the primed and non-primed seeds. From the data set of the experiment it has been realized that 4 mM of $Mg(NO_3)_2$ primed seeds performed better in presence of 10 and 15 mM concentrations range of KNO_3 solution in respect to nonprime seeds placed in presence of various concentration of KNO_3 and absence of the same as regard to various studied parameters of germination physiology in rice variety Swarna. This represents the inquisitive effect of seed priming and application of KNO_3 at a time. It was observed that priming of the seeds of maize, mustard and rice with $Mg(NO_3)_2$ in range of 4 to 7.5 mM were found more beneficial in improving all the phases of plant's life as well as yield (Bose and Tandon, 1991; Bose and Mishra, 1999; Mondal *et al*., 2011) in one hand whereas, 20 mM of KNO_3 was found best for the germination and seedling growth of maize while used in the range of the concentration of 0 to 30 mM **(**Bose and Misra, 1994**)**. There was a report where Bose and Srivastava (1979) showed that while detached petiole of cowpea leaf immersed in the solution of various salts of nitrogen, the nitrate salt KNO_3 was able to induce more rooting through petiole in one hand and in the other side it also delays the senescence of leaf. Further they observed that nitrate salt has the capacity to induce the protein synthesis in the detached cowpea leaves floated in KNO_3 solution. In addition, Ali *et al*. (2021) reported that there was a significant increase in final emergence (%), mean emergence time, and physiological attributes were observed in tomato while primed with 0.75% KNO_3. Moreover, Dhillon *et al*. (2021) noted that halo-priming with 2.0% KNO_3 in dry direct seeded rice were attributed to higher and rapid germination/crop emergence, better root growth, and improvement in yield parameters. In the present study it has also been realized that no rooting was observed except radicle in the non primed seedlings during study periods whereas, the seedlings from primed seeds generate more number of roots from the crown region. It can be predicted that during the time of seed germination root formation may starts by up taking of KNO_3 while supplied to the seeds. However, the result showed that the primed seeds can improve the seedling growth by generating more number of root initials of rice

Table 6. Effect of different concentrations of KNO_3 on α-amylase activity (mg maltose g^{-1} h^{-1} fresh weight of endosperm) of $Mg(NO_3)_2$ primed and non-primed seeds of rice var. Swarna at 72, 120 and 192h study period

Treatments	α-amylase activity					
	72 h		120 h		192 h	
	NP	P	NP	P	NP	P
T1	0.342±0.04^{d}	0.410±0.01^{f}	0.389±0.03^{f}	0.514±0.20^{b,c}	0.412±0.01^{a}	0.347±0.00^{a}
T2	0.352±0.02^{d}	0.487±0.02^{c,d}	0.481±0.05^{b}	0.556±0.06^{b}	0.347±0.02^{b,c}	0.314±0.01^{a,b}
T3	0.368±0.06^{b}	0.492±0.02^{c}	0.488±0.04^{b}	0.585±0.08^{b}	0.348±0.06^{b,c}	0.317±0.01^{a,b}
T4	0.391±0.04^{a}	0.537±0.05^{a}	0.516±0.02^{a}	0.647±0.20^{a}	0.380±0.01^{b}	0.363±0.01^{a}
T5	0.389±0.01^{a}	0.514±0.01^{b}	0.478±0.01^{b,c}	0.603±0.15^{a}	0.379±0.01^{b}	0.335±0.01^{a}
T6	0.372±0.02^{b}	0.505±0.02^{b}	0.467±0.02^{c,d}	0.565±0.04^{b}	0.334±0.10^{c}	0.325±0.02^{a,b}
T7	0.366±0.02^{b}	0.476±0.02^{d}	0.456±0.01^{d}	0.518±0.45^{b,c}	0.335±0.01^{c}	0.288±0.06^{c}
T8	0.348±0.05^{c,d}	0.452±0.04^{e}	0.435±0.02^{e}	0.472±0.06^{e}	0.359±0.01^{b,c}	0.251±0.02^{c,d}
T9	0.331±0.02^{e}	0.413±0.01^{f}	0.395±0.02^{f}	0.454±0.00^{f}	0.350±0.01^{b,c}	0.241±0.01^{c,d}

Data presented in the table are means values of the three replicates with standard errors. Different letters indicate the significant differences among the treatments and same letters depicted the at par results; tested by Duncan's multiples range test at $p < 0.05$

Where, (1) NP and P are non-primed and 4mM $Mg(NO_3)_2$ primed seeds, respectively. (2) T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_9 are different concentrations (0, 5, 10, 15, 20, 25, 30, 40, and 50 mM) of KNO_3

variety Swarna in respect to nonprime one by speeding up the rate of utilization of nitrate salt, but consuming of higher concentration i.e., more than 15 mM of KNO_3 uptake by the roots is not possible that might be directly related to the genetic makeup of the species itself. During the phase of germination, the development of more number of roots is an important indication of better growth and development of the plants in future for stand establishment of seedlings and vigor, which leads to improve the productivity; by using the seed priming technology along with farmers package and practices. The work gives an insight that before using any chemical we have to know about the utilization level of every crop to retain the sustainability of soil as well as crop growing therein.

Conclusion

Present experiment deals with sustainable agriculture in context of the use of primed seeds in farming soil. In context to farming soil and farmers point of view, 4mM magnesium nitrate primed rice seeds can show optimum germination and seedling growth in the range of 10 to 15 mM potassium nitrate containing solution and more than this concentration suppresses the growth of the crop; also it depends upon the genetic construction of the species itself. It unveils that before using primed seeds in crop fields one has to be very cautious for management of nitrogenous fertilizer for particular crop species.

Conflict of Interest: No conflict of interest was reported by the authors.

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