International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(3): 1886-1891

Received: 14-03-2020
Accepted: 16-04-2020

N Punithavathi
Associate Professor (Seed Science and Technology), Director (Rtd), Tamil Nadu Rice Research Institute, Aduthurai, Tamil Nadu, India

T Jeyaraj
Associate Professor (Seed Science and Technology), Director (Rtd), Tamil Nadu Rice Research Institute, Aduthurai, Tamil Nadu, India

A Sabir Ahamed
Professor (Seed Science and Technology), Horticultural College and Research Institute, (Women), Navalurkuttapattu, Trichy. Tamil Nadu, India

Corresponding Author:
N Punithavathi
Associate Professor (Seed Science and Technology), Director (Rtd), Tamil Nadu Rice Research Institute, Aduthurai, Tamil Nadu, India

Standardization of seed primingon seed quality parameters in rice

N Punithavathi, T Jeyaraj and A Sabir Ahamed

DOI: https://doi.org/10.22271/chemi.2020.v8.i3z.9481

Abstract
Laboratory experiment was conducted to study standardization of seed priming with chemicals, bio control agents as well as plant growth regulators on seed quality parameters of rice. Seed priming, an effective seed invigouration method, has become a common seed treatment to increase the rate and uniformity of emergence and crop establishment in most vegetable and flower crops especially in advanced countries. The seeds of rice were given priming treatments *viz.,* $CaCl_2$, $CaSO_4$,$ZnSO_4$, $FeSO_4$, *Pseudomonas fluorescens, Azophos* and Pungam leaf extract at 0.5 and 1.0% each and with GA_3, IBA at both 10 and 20 ppm concentrations for 12 and 18h soaking durations and sown along with control under laboratory condition. The results revealed that seed priming with *Azophos* 1.0%, $ZnSO_4$ 1.0%, GA_3 20ppm, *Pseudomonas fluorescens* 1.0%, $CaSO_4$ 1.0% and $FeSO_4$ 1.0% for 18h could be recommended as suitable priming treatments for enhancing germination and vigour of rice.

Keywords: Priming, GA_3, $ZnSO_4$, germination, vigour index

Introduction
Rice (*Oryza saiva* L.) is the world's most important staple food-grain grown in over 100 countries, consumed regularly by over two billion people and the primary source of protein for millions. India is the leading rice producing country in terms of area and is the second largest producer next to China. Rice plays an important role in food as well as livelihood security for almost every household, more so in India. To feed this estimated 1.6 billion population of India by 2050 calls for stepping up the current production of 106 mt of milled rice to 140 mt. Higher production and productivity of crop is possible only through use of good quality seeds and proper management practices. Good quality seeds imply vigour, uniformity and structural soundness besides its genetic and physical purity. Seed priming is a controlled hydration process that involves exposing seeds to low water potentials that restrict germination, but permits pre-germinative physiological and biochemical changes to occur (Heydecker and Coolbear, 1977; Bradford, 1986; Khan, 1992). The present study will accentuate on the effect of seed priming with various chemicals, growth regulators and biofertilizers on seed and seedling characteristics of Rice.

Materials and methods
The present study was carried out by using genetically pure seeds of rice varieties TNAU Rice TRY3 and Improved White Ponniobtained from the Department of Plant Breeding and Genetics, ADAC&RI, Trichy formed the basic materials for the study. The laboratory experiments were carried out in Seed Science and Technology laboratory, Department of Plant Breeding and Genetics, ADAC&RI, Trichy, Initially, the rice seeds were dried to bring down the moisture content to less than 13 percent and then cleaned with the help of suitable sieves and winnowed to obtain uniform sized seeds. The seeds were surface sterilized with 10% ethanol and soaked in double the volume of priming agents' solution for 12 and 18h durations. The unprimed seeds formed the control. After soaking, the seeds were removed from respective priming solutions and dried under shade at room temperature to bring back to original moisture content. The primed seeds were evaluated for the following seed and seedling characters along with unprimed seeds. The experiment was carried out with four replications in Factorial Completely Randomised Design (FCRD).

Treatment details

T_0 : Control
T_1 : Hydropriming
T_2 : Halopriming with $CaCl_2$ 0.5%
T_3 : Halopriming with $CaCl_2$ 1.0%
T_4 : $CaSO_4$ 0.5%
T_5 : $CaSO_4$ 1.0%
T_6 : $ZnSO_4$ 0.5%
T_7 : $ZnSO_4$ 1.0%
T_8 : $FeSO_4$ 0.5%
T_9 : $FeSO_4$ 1.0%
T_{10} : GA_3 10 ppm
T_{11} : GA_3 20 ppm
T_{12} : IBA 10 ppm
T_{13} : IBA 20 ppm
T_{14} : *Pseudomonas fluorescens* 0.5%
T_{15} : *Pseudomonas fluorescens*1.0%
T_{16} : *Azophos* 0.5%
T_{17} : *Azophos* 1.0%
T_{18} : Pungam leaf extract 0.5%
T_{19} : Pungam leaf extract 1.0%

Soaking duration : D_1- 12 h D_2- 18 h
Varieties : V_1 – TNAU Rice TRY 3 V_2- I.W.Ponni

The germination test was conducted by following the procedure outlined in ISTA (1999) using paper (Between papers) medium. Four replicates of 100 seeds each were germinated in a seed germinator maintained at 25 ± 2ºC temperature and 95 ± 3% RH. After fourteen day, the seedlings were evaluated and the normal seedlings were counted and expressed in percentage]. Ten normal seedlings of each of the crop/treatment /replication were selected at random and measured using measuring scale for root length (Root length was measured from the point of attachment of seed to the tip of primary root). The mean values were calculated and expressed in centimetre. The seedlings used for measuring root length were also used for measuring shoot length. The shoot length was measured from the point of attachment of seed to tip of the leaf and the mean values were expressed in centimetre. The speed of germination was calculated by using four replicates of twenty-five seeds from different treatments. The seeds showing radicle protrusion were counted daily from third day after sowing until fourteenth day. From the number of seeds germinated on each day, the speed of germination was calculated using the following formula and the results were expressed in number [10].

$$\text{Speed of germination} = \frac{X_1}{Y_1} + \frac{X_2 - X_1}{Y_2} + \ldots\ldots\ldots + \frac{X_n - X_{n-1}}{Y_n}$$

X_1- Number of seeds germinated at first count
X_2- Number of seeds germinated at second count
X_n- Number of seeds germinated on n^{th} day
Y_1- Number of days from sowing to first count
Y_2- Number of days from sowing to second count
Y_n- Number of days from sowing to n^{th} count

After measuring the root and shoot lengths, ten normal seedlings in each replication were shade dried for 24 h and then in hot air oven maintained at 85 ± 1°C for 24 h. Then they were cooled for 30 min in desiccators which contained calcium chloride and then weighed in an electronic balance. The drymatter production was expressed in g seedlings^{-10}. Based on the results obtained, the vigour index values were computed as per [1] and the values were reported as whole number without unit. The data obtained from the experiment was analysed for the 'F' test of significance following the methods described by [15]. Wherever necessary, the per cent values were transformed to angular (Arc-sine) values before analysis. The critical differences (CD) were calculated at 5% probability level. The data were tested for statistical significance. If the F test is non-significant, it was indicated by the letters NS.

Results and discussion

Priming has been developed and used extensively to improve seed germination and seedling vigour in a wide range of crop species and it was identified as an integrated common seed treatment to reduce the time between seed sowing and seedling emergence and the synchronization of emergence. Significant differences were observed due to seed priming treatments and soaking durations in two varieties tested *viz*., TNAU Rice TRY 3 and I.W. Ponni. Between the soaking durations,18h recorded higher germination, early germination, longest root length, shoot length higher seedling drymatter production and vigour index of (90%;8.1;18.8cm;13.7cm; 0.104gseedlings^{-10};2905) whereas 12 h recorded (88%;7.2;18.3cm; 13.0cm; 0.103 g seedlings^{-10}; 2765). Germination percentage was highest for *Azophos*1.0% primed seeds of both varieties and all priming treatments are significantly different and statistically superior from the control and reveals the benefit of priming treatments over control. It is clearly evident from the Table 1 that significantly maximum increase in mean seed germination per cent was registered by T_{17}-*Azophos*1.0% (92.0%) where as control registered T_0 (84%)followed by$ZnSO_4$ 1.0% (T_7) $GA_3$20ppm (T_{11}) *Pseudomonas fluorescens* (T_{15}) registered (91 per cent) and $CaSO_4$ 1.0% (T_5)(90 per cent).Various prehydration or priming treatments have been employed to increase the speed and synchrony of seed germination [3]. Common priming techniques include osmopriming (soaking seeds in osmotic solutions such as polyethylene glycol), halopriming (soaking seeds in salt solutions) and hydropriming (soaking seeds in water).During seed priming the amount of water absorption is controlled so as to allow necessary metabolic activities for germination to take place but prevent radicle emergence by limiting the seed water content, different physiological activities occur within the seed at different moisture levels. [5, 6, 9]; McDonald, 2000;

Similarly, the speed of germination also highest in the seeds primed with *Azophos* 1.0%, recorded 9.0 followed by $ZnSO_4$ 1.0% (8.6), GA_3 20 ppm (8.5), *Pseudomonas fluorescens*1.0% (8.0), $CaSO_4$ 1.0% (7.8) and $FeSO_4$ 1.0% (7.7). (Table 2). Similarly the root length and shoot length also highest in seed priming with *Azophos*1.0%(19.3;14.1cm) and $ZnSO_4$ 1.0% (19.1;14.0cm) followed by seed priming with GA_3 20 ppm (19.0 ;13.8cm), *Pseudomonas fluorescens* 1.0% (18.9;13.7cm), $CaSO_4$ 1.0% (18.8;13.7cm) and $FeSO_4$ 1.0% (18.7;13.8cmrespectively) (Table 3&4)The values of interaction for priming treatments and varieties were significant for shoot length.The relative enhancement of germination and seedling vigour might be attributed to the role of phosphorus solubilising bacteria known as phosphobacteria in enhancing the solubilisation of insoluble phosphorus and making it available to the germinating seed with consequent enhancement in the metabolic activity which resulted in higher germination [4]. The results of the present study are in agreement with the findings of [19] (2001) in rice due to seed biofortification with *Azospirillum.* They reported

that it enhanced seedling vigour encompassing speed of germination, seedling length and dry weight of high vigour as well as low vigour seedlots. Similar increase in the seedling growth due to liquid phosphobacteria seed treatments was reported by [7, 11, 20, 23]. Suggested that liquid formulation was an effective method of seed inoculation of biofertilizer.

Higher seedling drymatter production were recorded in the seeds treated with *Azophos*1.0% (0.108 g seedlings^{-10}) followed by $ZnSO_4$ 1.0% (0.106 seedlings^{-10}), GA_3 20 ppm (0.105 g seedlings-^{10}) *Pseudomonas fluorescens* (0.104 g seedlings^{-10}), $CaSO_4$ 1.0% (0.104 g seedlings^{-10}) and $FeSO_4$ 1.0% (0.104 g seedlings^{-10}) (Table 5).In the present study revealed that seed biopriming with *Pseudomonas fluorescens* produced desirable results, both promoting the germination as well as increased the seedling growth and vigour of rice. The results of the present investigation are in agreement with [2, 12, 13, 14, 16, 18, 21, 22]. Similarly higher vigourindex value of 3039was registered by *Azophos*1.0%followed by $ZnSO_4$1.0% (2987), GA_3 20ppm(2983),*Pseudomonas fluorescens*1.0%, (2942), $CaSO_4$ 1.0% (2900) and $FeSO_4$ 1.0% (2842) (Table 6).Whereas control recorded germination, speed of germination, root length, shoot length, drymatter production and vigour index. (84%;6.7;18.0cm;12.2 cm;0.098 g seedlings^{-10}.2550 respectively).

Conclusion

The results revealed that paddy seeds priming with *Azophos* 1.0%, $ZnSO_4$ 1.0%, GA_3 20ppm, *Pseudomonas fluorescens* 1.0%, $CaSO_4$ 1.0% and $FeSO_4$ 1.0% for 18h could be recommended as suitable priming treatments for enhancing germination and vigour of rice.

Table 1: Effect of seed priming treatments and soaking durations on laboratory Germination (%) in rice varieties TNAU Rice TRY 3 and I. W. Ponni

Treatments	Germination (%)						Treatment mean
	TNAU Rice TRY 3 (V_1)			I.W. Ponni (V_2)			
	Soaking duration (D)						
	12h	18h	Mean	12h	18h	Mean	
T_o	84 (66.52)	84 (66.52)	84 (66.52)	84 (66.52)	84 (66.52)	84 (66.52)	84 (66.52)
T_1	86 (68.25)	88 (70.30)	87 (69.46)	85 (67.62)	87 (69.46)	86 (70.30)	87 (69.46)
T_2	88 (69.36)	88 (69.43)	88 (69.44)	86 (68.11)	88 (69.76)	87 (69.46)	88 (69.76)
T_3	89 (70.88)	90 (71.78)	90 (71.34)	89 (70.19)	90 (78.15)	89 (70.67)	90 (78.15)
T_4	86 (68.15)	87 (68.93)	87 (68.55)	86 (67.88)	87 (68.48)	87 (68.18)	87 (68.48)
T_5	90 (71.15)	92 (73.40)	91 (72.28)	88 (69.86)	89 (70.32)	88 (70.09)	90 (71.15)
T_6	89 (70.32)	91 (72.77)	90 (71.55)	87 (68.98)	90 (71.15	89 (70.32)	90 (71.15)
T_7	92 (73.57)	93 (75.25)	93 (74.41)	89 (70.90)	91 (72.67)	90 (71.78)	92 (73.57)
T_8	85 (67.62)	87 (69.46)	86 (70.30)	86 (68.25)	88 (70.30)	87 (69.46)	87 (69.46)
T_9	89 (70.88)	90 (71.78)	90 (71.34)	86 (67.69)	89 (70.27)	87 (68.98)	89 (70.32)
T_{10}	89 (70.88)	89 (70.32)	89 (70.32)	87 (68.98)	90 (71.15	89 (70.32)	89 (70.32)
T_{11}	90 (71.78)	95 (76.58)	93 (74.19)	91 (72.50)	90 (72.04)	90 (72.27)	92 (73.57)
T_{12}	86 (68.15)	87 (68.93)	87 (68.55)	86 (67.88)	87 (68.48)	87 (68.18)	87 (69.46)
T_{13}	85 (67.40)	90 (72.04)	88 (69.73)	86 (67.69)	89 (70.27)	87 (68.98)	88 (69.73)
T_{14}	86 (68.15)	87 (68.93)	87 (68.55)	86 (67.88)	87 (68.48)	87 (68.18)	87 (69.46)
T_{15}	90 (72.04)	94 (76.21)	92 (74.13)	89 (70.82)	90 (71.79)	89 (71.30)	91 (72.83)
T_{16}	89 (70.72)	90 (71.78)	90 (71.26)	87 (68.93)	91 (72.83)	89 (70.88)	90 (71.15)
T_{17}	90 (70.52)	95 (77.43)	93 (74.61)	90 (71.22)	92 (73.84)	91 (72.53)	92 (73.57)
T_{18}	89 (70.32)	87 (68.93)	88 (69.63)	85 (67.45)	85 (67.27)	85 (67.36)	87 (69.46)
T_{19}	89 (70.82)	89 (70.59)	89 (70.71)	88 (69.86)	89 (70.32)	88 (70.09)	89 (70.32)
Mean	88 (69.36)	90 (70.52)	89 (70.71)	88 (69.36)	89 (70.71)	88 (69.63)	89 (70.32)
Soaking duration	12 h			18 h			
Mean	88 (69.63)			90 (71.79)			

(Figures in parentheses indicate arcsine values)

	T	D	V	T x D	DxV	TxV	T x D x V
SEd	1.13	0.358	0.358	1.60	0.50	1.60	2.27
CD (P=0.05)	2.23	0.706	0.706	NS	NS	NS	NS

Table 2: Effect of seed priming treatments and soaking durations on speed of germination in rice varieties TNAU Rice TRY 3 and I. W. Ponni

Treatments	Speed of germination						Treatment mean
	TNAU Rice TRY 3 (V_1)			I. W. Ponni (V_2)			
	Soaking duration (D)						
	12h	18h	Mean	12h	18h	Mean	
T_o	6.1	7.2	6.7	6.0	7.2	6.6	6.7
T_1	6.6	7.6	7.1	6.4	7.2	6.8	7.0
T_2	6.5	7.6	7.1	6.6	7.6	7.1	7.1
T_3	7.2	8.0	7.6	7.2	8.0	7.6	7.6
T_4	6.7	7.8	7.3	6.8	7.8	7.3	7.3
T_5	7.6	8.4	8.0	7.2	8.0	7.6	7.8
T_6	7.9	9.0	8.5	7.9	8.9	8.4	8.5
T_7	8.4	9.2	8.8	7.8	9.0	8.4	8.6
T_8	6.6	7.6	7.1	6.1	7.2	6.7	6.9
T_9	7.6	8.4	8.0	7.0	7.8	7.4	7.7

T_{10}	7.7	8.7	8.2	7.5	8.6	8.1	8.2
T_{11}	8.1	8.9	8.5	7.6	9.2	8.4	8.5
T_{12}	6.5	7.5	7.0	6.1	7.2	6.7	6.9
T_{13}	7.2	8.1	7.7	6.7	7.6	7.1	7.4
T_{14}	6.7	7.8	7.3	6.8	7.8	7.3	7.3
T_{15}	7.8	8.3	8.1	7.4	8.3	7.8	8.0
T_{16}	8.2	9.2	8.7	7.7	8.8	8.3	8.5
T_{17}	8.6	9.4	9.0	8.6	9.4	9.0	9.0
T_{18}	7.1	8.1	7.6	6.8	7.9	7.4	7.5
T_{19}	7.4	8.3	7.8	7.4	8.3	7.8	7.8
Mean	7.2	8.2	7.8	7.1	8.0	8.0	7.7

Soaking duration	12 h	18 h
Mean	7.2	8.1

	T	**D**	**V**	**T x D**	**DxV**	**TxV**	**T x D x V**
SEd	0.13	0.04	0.04	0.19	0.06	0.19	0.27
CD (P=0.05)	0.27	0.08	0.08	NS	NS	0.38	NS

Table 3: Effect of seed priming treatments and soaking durations on root length (cm) in rice varieties TNAU Rice TRY 3 and I. W. Ponni

Treatments	**Root length (cm)**						**Treatment mean**
	TNAU Rice TRY 3 (V_1)			**I. W. Ponni (V_2)**			
	Soaking duration (D)						
	12h	**18h**	**Mean**	**12h**	**18h**	**Mean**	
T_o	18.5	18.3	18.2	17.9	17.6	17.7	18.0
T_1	18.0	18.8	18.4	18.0	17.9	17.9	18.2
T_2	18.1	18.8	18.5	18.1	17.9	17.9	18.2
T_3	18.2	19.7	18.9	18.4	18.1	18.2	18.6
T_4	18.2	18.9	18.6	18.4	18.1	18.2	18.4
T_5	18.6	19.8	19.2	18.3	18.5	18.4	18.8
T_6	18.5	19.2	18.8	18.4	18.4	18.4	18.6
T_7	18.6	20.4	19.5	18.6	18.6	18.6	19.1
T_8	18.4	18.6	18.5	18.0	18.3	18.2	18.4
T_9	18.5	19.7	19.1	18.1	18.4	18.2	18.7
T_{10}	18.5	18.9	18.7	18.1	18.5	18.3	18.5
T_{11}	18.7	20.1	19.4	18.5	18.5	18.5	19.0
T_{12}	18.3	18.4	18.4	18.1	18.0	18.1	18.3
T_{13}	18.5	19.6	19.0	18.1	18.4	18.2	18.6
T_{14}	18.5	18.9	18.7	18.1	18.5	18.3	18.5
T_{15}	18.5	20.3	19.3	18.1	18.8	18.4	18.9
T_{16}	18.5	19.3	18.9	18.4	18.7	18.5	18.7
T_{17}	18.7	20.4	19.5	18.7	19.2	19.0	19.3
T_{18}	18.1	18.4	18.2	18.0	18.2	18.1	18.2
T_{19}	18.4	18.5	18.4	18.1	18.0	18.0	18.2
Mean	18.4	19.2	18.8	18.2	18.4	18.3	18.5
Soaking duration	12 h			18 h			
Mean	18.3			18.8			

	T	**D**	**V**	**T x D**	**DxV**	**TxV**	**T x D x V**
SEd	0.15	0.04	0.05	0.21	0.06	0.21	0.30
CD (P=0.05)	0.29	0.09	0.09	0.42	0.13	0.41	0.59

Table 4: Effect of seed priming treatments and soaking durations on shoot length (cm) in rice varieties TNAU Rice TRY 3 and I. W. Ponni

Treatments	**Shoot length (cm)**						**Treatment mean**
	TNAU Rice TRY 3 (V_1)			**I. W. Ponni (V_2)**			
	Soaking duration (D)						
	12h	**18h**	**Mean**	**12h**	**18h**	**Mean**	
T_o	12.1	12.5	12.3	12.3	12.0	12.1	12.2
T_1	12.5	13.3	12.9	12.1	12.8	12.5	12.7
T_2	12.3	13.6	13.0	12.4	12.8	12.6	12.8
T_3	13.0	14.2	13.6	12.7	13.4	13.1	13.4
T_4	13.0	13.8	13.4	12.8	13.3	13.0	13.2
T_5	13.4	14.1	13.8	13.4	13.7	13.5	13.7
T_6	13.4	13.9	13.7	13.0	13.6	13.3	13.5
T_7	14.0	14.3	14.2	13.2	14.1	13.7	14.0
T_8	12.7	13.3	13.0	12.7	13.1	12.9	13.0
T_9	13.4	14.1	13.7	13.2	13.6	13.4	13.6

T_{10}	13.1	14.0	13.6	12.9	13.4	13.2	13.4
T_{11}	13.5	14.5	14.0	13.4	13.8	13.6	13.8
T_{12}	13.1	14.0	13.6	12.7	13.1	12.9	13.3
T_{13}	13.0	14.4	13.7	13.0	13.8	13.4	13.6
T_{14}	13.3	13.8	13.5	12.8	13.5	13.1	13.3
T_{15}	13.6	14.2	13.9	13.3	13.8	13.5	13.7
T_{16}	13.5	14.2	13.8	13.1	13.7	13.4	13.6
T_{17}	14.0	14.8	14.4	13.5	14.0	13.8	14.1
T_{18}	12.3	13.0	12.6	12.2	12.5	12.4	12.5
T_{19}	12.9	13.5	13.2	12.4	13.3	12.9	13.1
Mean	13.1	13.9	13.5	12.9	13.4	13.1	13.3
Soaking duration	12 h			18 h			
Mean	13.0			13.7			

	T	D	V	T x D	D x V	T x V	T x D x V
SEd	0.20	0.06	0.06	0.30	0.09	0.28	0.41
CD (P=0.05)	0.40	0.13	0.13	0.57	NS	NS	NS

Table 5: Effect of seed priming treatments and soaking duration son drymatter production (g seedlings^{-10}) in rice varieties TNAU Rice TRY 3 and I.W. Ponni

Treatments	Dry matter Production (g seedlings^{-10})						Treatment mean
	TNAU Rice TRY 3 (V_1)			I. W. Ponni (V_2)			
	Soaking duration (D)						
	12h	18h	Mean	12h	18h	Mean	
T_o	0.120	0.112	0.116	0.080	0.080	0.080	0.098
T_1	0.118	0.118	0.118	0.080	0.084	0.082	0.100
T_2	0.119	0.121	0.120	0.080	0.084	0.082	0.101
T_3	0.122	0.120	0.121	0.084	0.083	0.084	0.103
T_4	0.121	0.121	0.121	0.082	0.083	0.083	0.102
T_5	0.122	0.123	0.123	0.084	0.085	0.085	0.104
T_6	0.122	0.123	0.122	0.084	0.086	0.085	0.104
T_7	0.122	0.126	0.124	0.086	0.090	0.088	0.106
T_8	0.120	0.122	0.121	0.082	0.083	0.083	0.102
T_9	0.121	0.122	0.122	0.084	0.085	0.085	0.104
T_{10}	0.122	0.123	0.122	0.083	0.084	0.084	0.103
T_{11}	0.122	0.123	0.123	0.088	0.084	0.086	0.105
T_{12}	0.120	0.120	0.120	0.084	0.084	0.084	0.102
T_{13}	0.120	0.121	0.121	0.084	0.084	0.084	0.103
T_{14}	0.121	0.123	0.122	0.083	0.084	0.084	0.103
T_{15}	0.123	0.124	0.123	0.083	0.087	0.085	0.104
T_{16}	0.128	0.123	0.125	0.087	0.093	0.090	0.108
T_{17}	0.124	0.125	0.125	0.095	0.084	0.090	0.108
T_{18}	0.121	0.121	0.121	0.083	0.084	0.084	0.103
T_{19}	0.120	0.120	0.120	0.084	0.085	0.085	0.103
Mean	0.121	0.122	0.122	0.084	0.085	0.085	0.103
Soaking duration	12 h			18 h			
Mean	0.103			0.104			

	T	D	V	T x D	D x V	T x V	T x D x V
SEd	0.001	0.0004	0.0004	0.02	0.0006	0.002	0.003
CD (P=0.05)	0.002	0.0009	0.0008	NS	NS	NS	NS

Table 6: Effect of seed priming treatments and soaking durations on vigour index in rice varieties TNAU Rice TRY 3 and I.W. Ponni

Treatments	Vigour index						Treatment Mean
	TNAU Rice TRY 3(V_1)			I. W. Ponni (V_2)			
	Soaking duration (D)						
	12h	18h	Mean	12h	18h	Mean	
T_o	2587	2570	2579	2520	2520	2520	2550
T_1	2601	2793	2697	2623	2702	2663	2680
T_2	2710	2807	2759	2614	2702	2658	2709
T_3	2777	3051	2914	2795	2835	2815	2865
T_4	2683	2845	2764	2700	2732	2716	2740
T_5	2880	3064	2972	2790	2866	2828	2900
T_6	2839	3012	2926	2767	2880	2823	2875
T_7	2999	3143	3071	2830	2976	2903	2987
T_8	2643	2775	2709	2640	2763	2702	2706
T_9	2839	2988	2914	2692	2848	2770	2842
T_{10}	2812	2928	2870	2714	2871	2793	2832

T_{11}	2898	3221	3060	2903	2907	2905	2983
T_{12}	2700	2819	2760	2683	2706	2695	2728
T_{13}	2678	3006	2842	2675	2866	2771	2807
T_{14}	2735	2845	2790	2700	2784	2742	2766
T_{15}	2889	3149	3019	2795	2934	2865	2942
T_{16}	2848	3015	2932	2775	2948	2862	2897
T_{17}	2943	3259	3101	2898	3054	2976	3039
T_{18}	2706	2732	2719	2575	2610	2593	2656
T_{19}	2786	2839	2813	2684	2786	2735	2774
Mean	2772	2979	2861	2754	2830	2767	2814
Soaking duration	12 h			18 h			
Mean	2765			2905			

	T	**D**	**V**	**T x D**	**D x V**	**T x V**	**T x D x V**
SEd	46.96	14.85	14.85	66.41	21.00	66.41	93.92
CD (P=0.05)	92.51	29.25	29.25	NS	41.40	NS	NS

Reference

1. Abdul Baki AA, Anderson JD. Vigour determination in soybean seed by multiple criteria. Crop. Sci. 1973; 13:630-633.
2. Begum MM, Sariah M, Puteh AB, Zainal Abidin MA, Rahman MA, Siddiqui Y. Field performance of bioprimed seeds to suppress *Colletotrichum truncatum* causing damping-off and seedling stand of soybean. Biological Control. 2010; 53:18-23.
3. Bradford KJ. Manipulation of seed water relations via osmotic priming to improve germination under stress conditions. Hort. Sci. 1986; 21:1105-1112.
4. Cooper R. Bacterial fertilizers in the Soviet Union. Soil Fert. 1979; 22:327-333.
5. Dell Aquila A, Tritto V. Germination and biochemical activities in wheat seeds following delayed harvesting, ageing and osmotic priming. Seed Sci. & Technol. 1991; 19:73-82.
6. Giri GS, Schillinger WF. Seed priming winter wheat for germination, emergence and yield. Crop Sci. 2003; 43:2135-2141.
7. Gomathy M, Thangaraju M, Gopal NO, Sarathambal C. Comparative performance of liquid formulation of phosphobacteria with carrier-based inoculants on the growth and yield of maize (CO 1). J. Soil Biol. 2007; 27(1-2):7-12.
8. ISTA. International rules for seed testing. Seed Sci. Technol., (Supplement rules). 1999; 27:25-3.
9. Kaur S, Gupta AK, Kaur N. Effect of osmo-and hydropriming of chickpea seeds on the performance of crop in the field. Int. Chickpea Pigeonpea Newslett. 2002; 9:15-17.
10. Maguire JD. Speed of germination - Aid in selection and evaluation of seedling emergence and vigour. Crop. Sci. 1962; 2:176-177.
11. Mahfouz SA, Sharaf-Eldin MA. Effect of mineral vs. biofertilizer on growth, yield, and essential oil content of fennel (*Foeniculum vulgare* Mill.). Int. Agrophysics. 2007; 21:361-366.
12. Niranjan Raj S, Chaluvaraju G, Amruthesh KN, Shetty HS, Reddy MS, Kloepper JW. a. Induction of growth promotion and resistance against downy mildew on pearl millet (*Pennisetumglaucum*) by rhizobacteria. Plant Dis. 2003; 87:380-384.
13. Niranjan Raj S, Shetty NP, Shetty HS. Seed biopriming with *Pseudomonas fluorescens* isolates enhances growth of pearl millet plants and induces resistance against downy mildew. Inter. J. of Pest Management. 2004; 50(1):41-48.
14. Niranjan Raj S, Deepak SA, Basavaraju P, Shetty HS, Reddy MS, Kloepper JW. b. Comparative performance of formulations of plant growth promoting rhizobacteria in growth promotion and suppression of downy mildew in pearl millet. Crop Protection. 2003; 22:579-588.
15. Panse VG, Sukhatme PV. Statistical methods for Agricultural workers. ICAR, Publication, New Delhi, 1985, 327-340.
16. Praveen Kumar L, Niranjana SR, Prakash HS, Shetty HS. Improvement of seed quality and field emergence of rice seeds using an antagonistic strain of *Pseudomonas fluorescens*. Asian Journal of Microbiology, Biotechnology and Environmental Sciences. 2001; 3:11-15.
17. Praveen Kumar L, Niranjana SR, Prakash HS, Shetty HS. Effect of *Pseudomonas fluorescens* formulation against *Pyriculariagrisea* in rice. Crop Improvement. 2000; 27:193-200.
18. Raju NS, Niranjana SR, Janaradhana GR, Prakash HS, Reddy HS, Mathur SB. Improvement of seed quality and filed emergence of *Fusarium moniliforme* infected sorghum seeds using biological agents. Journal of the Science of Food and Agriculture. 1999; 79:206-212.
19. Ramamoorthy V, Viswanathan R, Raghuchander T, Prakasam T, Samiyappan R. Induction of systemic resistance by plant growth promoting rhizobacteria in crop plants against pests and diseases. Crop Protection. 2001; 20:1-11.
20. Rice WA, Olsen PE. Effect of inoculation method and size of *Rhizobium meliloti* population in the soil on nodulation of alfalfa. Can. J. Soil. Sci. 1992; 72:57-67.
21. Sunil Kumar M, Arya C, Ranjit Singh. Efficiency of *Pseudomonas fluorescens* and *Trichoderma harzianum*as bio-enhancers in tomato at high altitude in central Himalayas. Indian J. Crop Sci. 2007; 2(1):79-82.
22. Umesha S, Dharmesh SM, Shetty A, Krishnappa M, Shetty HS. Biocontrol of downy mildew disease of pearl millet using *Pseudomonas fluorescens*. Crop Protect. 1998; 17(5):387-390.
23. Yousry S, Kabesh OM, Saber MS. Managanese availability in a calcareous soil as a result of phosphate fertilization and inoculation with phosphor bacteria. African J. Agric. Sci. 1978; 5(2):75-80.