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Effect of seed priming on germination and phenology of rice under anaerobic condition

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Abstract
Present investigation was carried out to study the "Effect of seed priming on germination and phenology of rice under anaerobic condition" during wet season, 2016-17. Experiment was laid out in randomized block design with three replication and two varieties Sambha Mahsuri and Sambha Mahsuri *Sub1* in cemented pond (size; 20×20×1.25 meter). Primed seeds were direct seeded and field was completely submerged/ flooded, upto 25-30 cm water depth was maintained for one month. Recommended dose of N, P and K @ 120:40:40 Kg ha^{-1} was reframed with time schedule. Treatments comprised of (T_1) Seed priming with GA_3 @ 25 ppm, (T_2) Seed priming with GA_3 @ 50 ppm, (T_3) Seed priming with JLE @ 2%, (T_4) Seed priming with KNO_3@ 0.5%, (T_5) Seed priming with KCl @ 0.2%, (T_6) Seed priming with NaCl @ 0. 5 %, (T_7) Seed priming with IAA @ 0.2 %, (T_8) Seed priming with $CaCl_2$ @ 0.1 %, (T_9) Control with distilled water. Results indicated that all the priming treatments increased the germination percent, speed of germination, days to 50% flowering and days to physiological maturity however, effect of GA_3 @ 50 ppm was found more pronounced on various parameters in both the variety but Sambha Mahsuri *Sub1* showed more response of seed priming as compared to that of Sambha Mahsuri. Seed priming with various chemicals and its concentration may be used as a tool to mitigate the adverse effect caused by anaerobic condition in rice or direct seeded rice early flooding in recurrent phenomena.

Keywords: rice, GA_3, IAA, KNO_3, biochemical

Introduction
Rice (*Oryza sativa* L., 2n= 24), belongs to the family Poaceae (Graminae). Rice farming is about 10,000 year old and largest single use of land for producing food. Rice fields covers 11% of Earth's entire aerable land. Two rice species are important cereals for human nutrition *i.e. Oryza sativa* grown worldwide and *Oryza glaberrima* grown in parts of West Africa. Varieties of growth duration ranging from 70 to 160 days exist in diverse environments. Rice is the most important cereal food crop of India. It occupies about 23.3% of gross cropped area of the country and plays vital role in the national food grain supply.

Submergence stress is a major constraint to rice production during the monsoon flooding season in the rainfed lowlands in South and Southeast Asia, which causes annual losses of over US$1 billion and affects disproportionately the poorest farmers in the world (Xu *et al.*, 2006) [10]. Excessive flooding poses risks to human life and is a major contributor to the poverty and vulnerability of marginalized communities especially women and children in poor families (Douglas *et al.* 2009) [2]. It is estimated that the flood-affected area has more than doubled in size from about 5% (19 million hectares) to about 12% (40 million hectares) of India's geographic area. Adding to these already high risk areas, the climate projections suggest that temperatures, precipitation and flooding and sea level rise are likely to increase, with adverse impacts on crop yield and farm income in Southeast Asia (Unnikrishnan *et al.*, 2006) [9] By flooding during submergence, plant germination is greatly affected by depth of water and by its physico-chemical characteristics (oxygen and carbon dioxide concentration, pH, turbidity, temperature etc.

Seed priming is a simple and low cost hydration technique in which seeds are partially hydrated to a point where pre-germination metabolic activities start without actual germination and then re-dried until close to the original dry weight. Seed priming is employed for better crop stand and higher yields in a range of crops including rice (Farooq *et al.*, 2009; Kaymak *et al.*, 2009) [3, 5].

Primed seeds when seeded usually emerge faster with better, uniform and vigorous crop stand persistent under less than optimum field conditions. Crop stands from primed seeds lead to earlier flowering and higher grain yield than non-primed seeds. In some other studies, Farooq *et al.* (2006) [4] reported that early emergence and seedling growth, better crop stand, allometric response, increased kernel yield, harvest index, and improved quality from seeds primed with KCl and $CaCl_2$ in coarse and fine rice, respectively.

Materials and Methods

The present investigation was carried out in Kharif season, during 2015-2016 at the Research Farm of Department of Crop Physiology, Narendra Deva University of Agriculture and Technology, Kumarganj, 224229, Faizabad (U.P.) India. Direct seeding was done in constructed cemented submergence pond (*size: 20x10x1.25m; ground surface was cemented*) Seeding was done at the spacing of 20×5 cm. Seeds of two genotypes were collected from C.R.S Masodha Farm and primed with different chemicals *viz* GA_3 @ 25 & 50 ppm, JLE @ 2%, KNO_3 @ 0.5 %., KCl @ 0.2%, NaCl @ 0.5%, IAA @ 0.2%, $CaCl_2$ @ 0.1 %, and control treated with distilled Seeds were sterilized 2% NaCl solution and soaked in different chemical. Treated seeds dried in shade at room temperature. Water was sown by direct seeding method in field. Experiment was conducted in randomized block design with three replications in submergence pond (pond size; 20x10x1.25 M). Field was prepared and 20 seeds of each genotype treated with different chemicals were (row length 2 meter) direct seeded in row. Submerged Pond was filled up with fresh water up to the height in 20-25 cm to create anaerobic condition and water depth was maintained for one month.

Seed germination was recorded as rate as well as percentage during successive period of germination. It was recorded daily up to 15 days. The germination percentage was calculated using the following formula:

$$\text{Germination per cent} = \frac{\text{Number of seed germinated}}{\text{Total number of seeds}} \times 100$$

The germination test was conducted by following the procedure outlined by ISTA (1999) using liquid medium. Speed of germination was calculated based on the following formula of Maguire (1962).

$$\textbf{Speed of Germination} = \frac{X_1}{Y_1} + \frac{X_2 - X_1}{Y_2} + \frac{X_3 - X_2}{Y_3} + \cdots + \frac{X_n - X_{n-1}}{y_n}$$

Results and Discussions

Data pertaining to germination percentage as affected by different seed priming treatments under anaerobic condition in two rice varieties *i.e.* Sambha mahsuri *Sub 1* and Sambha Mahsuri were recorded at different time intervals have been presented in Table-1(a) & (b). In general, germination percent increases with increase in time intervals. Germination starts from 2nd day of seed priming and increases with time. Variation in the effectiveness of seed priming with various chemicals and its concentrations were visualized from 3rd day of germination and all seed priming treatments significantly increases the germination percent and maximum germination percent was found at 15 days after seed priming. Among both the variety Sambha Mahsuri *Sub 1* showed higher response of seed priming treatments than Sambha Mahsuri and registered maximum germination percentage in GA_3 @ 50 ppm (93.33, 88.33 respectively) followed by GA_3 @ 25 ppm (88.33, 83.33 respectively) and KCl @ 0.2% (83.33, 80.00 respectively) while minimum was noted in IAA @ 0.2% (71.66, 68.33) as compared to other seed priming treatments. Amylases are the key enzymes for starch degradation in germinating seeds and rice varieties that have greater ability to degrade starch even under oxygen degradation through successful production of alpha amylase are more likely to vigorously germinate and survive the stress (Loreti *et al.*, 2003) [6]. Key enzyme in the alcoholic fermentation pathway, alcohol dehydrogenase (ADH) and pyruvate decorboxylase (PDC) are induced by anoxia stress (Recard *et al.*, 1986) [7]. This result corroborates with the findings of Harmeet Singh *et al.*, (2015) [8] reported that germination and seedling emergence are the critical stages in the life cycle of rice.

Data with respect to effect of seed priming on speed of germination in two rice varieties *i.e.* Sambha Mahsuri *Sub 1* and Sambha Mahsuri under anaerobic condition have been presented in Table-2 and show that priming with different chemicals and its concentration increases the speed of germination in both the varieties (Sambha mahsuri *Sub 1* and Sambha mahsuri) but the effect was higher in Sambha Mahsuri *Sub 1* than Sambha Mahsuri. Among various seed priming treatments in both the varieties (Sambha Mahsuri *Sub 1* and Sambha Mahsuri) maximum speed of germination was found in GA_3 @ 50 ppm (2.78, 2.48) followed by GA_3 @ 25 ppm (2.49, 2.06) while the minimum speed of germination was noticed in IAA @ 0.2 % (1.87,1.54) as compared to other seed priming treatments. This result corroborates with the findings of Harmeet Singh *et al.*, (2015) [8] reported that germination and seedling emergence are the critical stages in the life cycle of rice.

It is clear from the data presented in Table-3 that all the seed priming treatments increase the days to 50% flowering in both the varieties *i.e.* Sambha Mahsuri *Sub 1* and Sambha Mahsuri under anaerobic condition however Sambha Mahsuri *Sub1* showed more effect of seed priming as compared to that of Sambha Mahsuri. Among all the seed priming treatments more delay in days to 50% flowering in both the varieties (Sambha Mahsuri *Sub 1*, Sambha Mahsuri) was found in of GA_3 @ 50 ppm (128, 126 respectively) and GA_3 @ 25 ppm (128, 126 respectively) followed by KNO_3 @ 0.5% (127, 125 respectively) and KCl @0.2% (127, 125 respectively) while the minimum days to 50% flowering was noticed in IAA @ 0.2 % (123,122 respectively) as compared to all other priming treatments. W.B. Binang**,** (2012) [1] found that seed priming causes an increase in number of days to 50 % flowering in rice as compared to non primed seeds.

Data with respect to days to physiological maturity are presented in Table 4 showed that all the seed priming treatments increases the days to physiological maturity in both the varieties *i.e.* Sambha Mahsuri *Sub 1* and Sambha Mahsuri under anaerobic condition. Days to physiological maturity delayed with different seed priming treatments in both the varieties (Sambha mahsuri *Sub 1*and Sambha mahsuri). However, Sambha Mahsuri *Sub 1* show more delay in physiological maturity as compared to that of Sambha Mahsuri in all the treatments. The results are in accordance with the findings of J.D. Ntia (2012) [1] reported the effect of seed priming on growth and yield of rice and found that primed seeds causes delay in physiological maturity as well as days to 50% flowering which might be helpful in increasing biomass of plants under stress condition. Similar results were also noticed by J.O. Shiyam (2012) [1] reported that that delay in physiological maturity in primed seeds which causes higher biomass of plants under stress condition.

Table 1(a): Effect of seed priming on germination (%) under anaerobic condition on rice seedling

Samba Mahsurisub-1															
Treatments / Days	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
T_1GA_3@25ppm	0.00	0.00	5.00	15.00	20.00	31.60	36.66	46.66	51.66	55.00	60.00	66.66	73.33	81.66	88.33
T_2GA_3@50ppm	0.00	1.66	8.33	20.00	25.00	36.66	40.00	43.33	46.66	50.00	55.00	61.66	71.66	81.66	93.33
T_3JLE@2%	0.00	1.66	5.00	13.33	18.33	23.33	26.66	38.33	41.66	43.33	46.66	50.00	53.33	65.00	73.33
T_4KNO_3@0.5%	0.00	0.00	3.33	10.00	15.00	25.00	30.00	38.33	41.66	45.00	50.00	56.66	63.33	78.33	80.00
T_5KCL@0.2%	0.00	0.00	5.00	6.66	11.66	20.00	25.00	33.33	36.66	40.00	45.00	51.66	63.33	76.66	83.33
T_6NaCL@0.5%	0.00	0.00	3.33	6.66	11.66	15.00	20.00	28.33	31.66	35.00	40.00	46.66	60.00	76.66	78.33
T_7IAA@0.2%	0.00	1.66	10.00	18.33	23.33	28.33	31.66	43.33	46.66	48.33	50.00	55.00	58.33	70.00	71.66
T_8CaCL_2@0.1%	0.00	0.00	8.33	11.66	16.66	20.00	25.00	33.33	36.66	40.00	43.33	48.33	55.00	71.66	78.33
T_9Control	0.00	1.66	1.66	8.33	13.33	18.33	23.33	33.33	36.66	38.33	41.66	45.00	48.33	60.00	68.33
SEm±	-	1.66	2.01	1.83	3.17	1.82	2.30	2.96	2.50	2.20	2.58	1.72	3.31	1.69	2.41
CD or LSD	-	3.48	6.03	5.49	9.51	5.46	6.89	8.87	7.49	6.61	7.74	5.17	9.92	5.06	7.21

Table 1(b): Effect of seed priming on germination (%) under anaerobic condition on rice seedling

Samba Mahsuri															
Treatments / Days	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
T_1GA_3@25ppm	0.00	0.00	1.66	10.00	15.00	26.66	31.66	41.66	46.66	50.00	55.00	61.66	70.00	76.66	83.33
T_2GA_3@50ppm	0.00	1.66	5.00	15.00	20.00	30.00	35.00	38.33	41.66	45.00	50.00	56.66	66.66	76.66	88.33
T_3JLE@2%	0.00	1.66	3.33	8.33	13.33	18.33	21.66	33.33	36.33	38.33	41.66	45.00	48.33	60.00	71.66
T_4KNO_3@0.5%	0.00	0.00	3.33	6.66	11.66	20.00	25.00	33.33	36.66	40.00	45.00	51.66	63.33	73.33	76.66
T_5KCL@0.2%	0.00	0.00	5.00	6.66	13.33	16.66	20.00	28.33	31.66	35.00	40.00	50.00	58.33	71.66	80.00
T_6NaCL@0.5%	0.00	0.00	5.00	5.00	8.33	10.00	15.00	23.33	26.66	30.00	35.00	41.66	55.00	71.66	75.00
T_7IAA@0.2%	0.00	0.00	6.66	13.33	18.33	23.33	26.66	40.00	41.66	43.33	45.00	50.00	53.33	65.00	68.33
T_8CaCL_2@0.1%	0.00	0.00	5.00	8.33	11.66	15.00	20.00	28.33	31.66	35.00	38.33	43.33	50.00	66.66	75.00
T_9Control	0.00	0.00	1.66	5.00	8.33	13.33	18.33	28.33	31.66	33.33	36.66	40.00	43.33	55.00	66.66
SEm±	-	0.73	1.21	1.55	2.89	1.82	2.40	2.76	2.50	2.20	2.42	1.32	3.12	1.69	1.92
CD or LSD	-	2.20	3.63	4.64	8.65	5.46	7.19	8.28	7.49	6.61	7.26	3.95	9.35	5.06	5.77

Table 2: Effect of seed priming on Speed of germination under anaerobic condition on rice seedling

Treatments / Variety's	**Samba Mahsuri Sub-1**	**Samba Mahsuri**
T_1GA_3@25ppm	2.49	2.06
T_2GA_3@50ppm	2.78	2.48
T_3JLE@2%	2.06	1.79
T_4KNO_3@0.5%	2.12	1.67
T_5KCL@0.2%	1.98	1.87
T_6NaCL@0.5%	2.03	1.85
T_7IAA@0.2%	1.87	1.52
T_8CaCL_2@0.1%	2.04	1.78
T_9Control	1.72	1.52
SEm±	0.13	0.12
CD or LSD	0.38	0.35

Table 3: Effect of seed priming on days of 50% flowering under anaerobic condition on rice seedling

Treatments / Varieties	**Samba Mahsuri Sub-1**	**Samba Mahsuri**
T_1GA_3@25ppm	128	126
T_2GA_3@50ppm	128	126
T_3JLE@2%	124	123
T_4KNO_3@0.5%	127	125
T_5KCl@0.2%	127	125
T_6NaCl@0.5%	125	124
T_7IAA@0.2%	123	122
T_8CaCl_2@0.1%	125	123
T_9Control	121	119
SEm±	2.76	4.57
CD or LSD	8.27	13.70

Table 4: Effect of seed priming on days to physiological maturity under anaerobic condition on rice seedling

Treatments / Varieties	Samba Mahsuri Sub-1	Samba Mahsuri
T_1GA_3@25ppm	147	145
T_2GA_3@50ppm	148	145
T_3JLE@2%	141	140
T_4KNO_3@0.5%	146	144
T_5KCl@0.2%	146	144
T_6NaCl@0.5%	145	143
T_7IAA@0.2%	141	140
T_8CaCl_2@0.1%	145	142
T_9Control	138	136
SEm±	5.85	5.24
CD or LSD	17.53	15.71

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