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Influence of seed priming cum foliar spray on seed yield of rice under sodicity condition

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Abstract
The world population is increasing rapidly, while the cultivable area is decreasing gradually by 1-2% per year. In India, approximately 8.6 million hectares of agricultural land is affected by varying degrees of salt related problems. The problems of soil sodicity, salinity and of poor quality water are likely to increase in near future. Salt affected soils have gained global concern. Cereals contribute mainly to food production and growing grain crops on sodic soils require adoption of different strategies for sustainable crop production. Based on the above view an experiment was undertaken at Anbil Dharmalingam Agricultural College and Research Institute, Trichy District, Tamil Nadu to study the Influence of seed priming cum foliar spray on yield of rice in alleviating sodicity stress. The paddy varieties *viz*., TNAU Rice TRY 3 and Improved White Ponni were primed with chemicals, biofertilizer, bio control agents as well as plant growth regulator *viz*., Seed priming with 1% mixture of $CaSO_4$+$ZnSO_4$+$FeSO_4$, Seed priming with 1% mixture of $CaSO_4$+$ZnSO_4$+$FeSO_4$ + GA_3 20 ppm +*Azophos* 1.0%, Seed priming with 1% mixture of KCl + $CaSO_4$+ $ZnSO_4$+ $FeSO_4$ + GA_3 20 ppm + *Azophos* 1.0% Followed by foliar spray of 0.5% $FeSO_4$, 0.5% $ZnSO_4$, 2% DAP and 2% cowpea pulse sprout extract were given at active tillering and panicle initiation stage. Among the different combination of priming treatments tried, Seed priming with 1% mixture of $CaSO_4$+$ZnSO_4$+$FeSO_4$+$GA_3$20ppm+*Azophos*1% along with foliar spray of 0.5% $ZnSO_4$ under sodicity condition effectively enhanced the overall efficiency of the crop and improved the yield in both tolerant and sensitive varieties of rice grown under salt stress condition.

Keywords: Seed priming, sodicity, GA_3, $ZnSO_4$, cowpea pulse sprout extract

Introduction

Rice is grown in more than 154 million hectares in the world in a wide range of ecosystems under varying temperatures and water regimes in India and it occupies an area of 44 million hectares. While the population of rice consumers is increasing at a rate of 1.8 per cent annually, the population grow at a rate of 1.5 per cent every year. Hence, the rice requirement by the year 2025 would be about 125 million tons [12]. Increasing salinity had significant impact on food production and more agricultural lands are expected to become salt affected due to climate change effect [16]. Cereals contribute mainly to food production and growing grain crops on sodic soils require adoption of different strategies for sustainable crop production. Rice is susceptible to salt stress [13] particularly during the early seedling stage [11]. Salinity affects the seed germination by creating osmotic stress due to reduced water uptake or through ionic imbalance due to toxic effects of sodium (Na^+) and chloride (Cl^-) ions [8]. Efficient strategies are required for effective utilization of saline lands for crop growth. Improvement of salinity tolerance in crop species is one potential strategy in overcoming salinity problems in agriculture [6, 22]. Development of salt tolerant plants through conventional breeding programs is very slow due to the complexity of salt tolerance and lack of reliable traits for selection [22]. Nonetheless, exogenous application of Osmolytes, Osmoprotectants or plant hormones through foliar or seed is a good option to alleviate the adverse effects of salinity stress on crops [1]. 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 [3, 7, 9]. Upon rehydration, primed seeds may exhibit faster rate of germination, more uniform emergence, greater tolerance to environmental stresses, and reduced dormancy in many species [9].

Availability of seed technological research work under sodic soil condition is very negligible. Based on the above view an experiment was conducted in sodic soil condition.

Materials and Methods

A field trial was laid out at Anbil Dharmalingam Agricultural College and Research Institute, Trichy District, Tamil Nadu. It is located at 10^0 N latitude and 78^0E longitude at an altitude of 85 m above MSL. Soil type of experimental field is s naturally sodic clay loam in condition with mechanical compositions of coarse sand 4.04% Fine sand 5.03%, Silt 21.00% and Clay 68.50 (%) and Chemical composition of the soil with pH 9.5, EC (dSm^{-1}) 0.45, ESP (%)20.31, Exc. Ca+Mg (c mol kg^{-1}) 14.12, Exc. Na(c mol kg^{-1}) 10.14 Available nitrogen189 kg ha^{-1} Available phosphorus 15.33kg ha^{-1} and Available potassium 364kg ha^{-1}.

Designated paddy crop varieties TNAU Rice TRY 3 (M_1) Improved White Ponni (M_2) to main plot and seed priming cum foliar spray to sub plot Control (S_1),: Seed priming with 1% mixture of $CaSO_4$+$ZnSO_4$+$FeSO_4$ (S_2),: Seed priming with 1% mixture of $CaSO_4$+$ZnSO_4$+$FeSO_4$ + GA_3 20 ppm +*Azophos* 1.0% (S_3): Seed priming with 1% mixture of KCl + $CaSO_4$+ $ZnSO_4$+ $FeSO_4$ + GA_3 20 ppm + *Azophos* 1.0% (S4) Seed priming with 1% mixture of KCl + $CaSO_4$+ $ZnSO_4$+ $FeSO_4$ + GA_3 20 ppm + *Azophos* 1.0% + *Pseudomonas fluorescens* 1.0% (S5): Seed priming with 1% mixture of $CaSO_4$ + $ZnSO_4$ + $FeSO_4$ + foliar spray of 0.5% $FeSO_4$ (S6), +: Seed priming with 1% mixture of $CaSO_4$ + $ZnSO_4$ + $FeSO_4$ + GA_3 20ppm+A*zophos*1% + foliar spray of 0.5% $ZnSO_4$ (S7): Seed priming with 1% mixture of KCl + $CaSO_4$ + $ZnSO_4$ + $FeSO_4$ + $GA_3$20 ppm + *Azophos* 1% + foliar spray of 2% DAP (S8),: Seed priming with1% mixture of KCl + $CaSO_4$ + $ZnSO_4$ + $FeSO_4$ +$GA_3$20ppm+*Azophos* 1% +*Pseudomonas fluorescens* 1% foliar spray of 2% cowpea pulse sprout extract (S9), The field trial was laid out in Split plot design with three replication in a plot size of 3 x 3m. Foliar spray was given at active tillering and panicle initiation stages. All the recommended package of practices was followed during crop growth period to raise a good healthy crop under sodic soil condition. The biometric characters were recorded at maturity stage by selecting five representative samples at random from each replication under sodicity. The methods followed in recording the observations are described below.

Growth and Yield Attributes

Days to first and 50 per cent flowering: The number of days taken from the date of sowing to first flowering and 50 per cent was counted and the mean values were expressed in days.

Number of total tillers: The total number of tillers in each hill was counted and the mean was expressed in number of tillers plant $^{-1}$.

Number of productive tillers: The number of ear bearing tillers in each hill at the time of maturity was counted and recorded.

Plant height: Plant height was measured from the ground level to the tip of the matured panicle was measured and expressed in cm.

Panicle length: The distance between the base to the tip of the randomly selected panicles measured with linear scale and the mean was expressed in cm.

Number of seeds panicle^{-1}: The numbers of fully developed and well filled seeds in each randomly selected panicle were counted and mean number of seeds panicle $^{-1}$ was recorded.

Seed set (%)

The matured seeds and unfilled –chaffy seeds from randomly selected panicles were separated and counted individually. The mean seed set per cent was calculated using the following formula.

$$\text{Seed setting (\%)} = \frac{\text{Total number of filled spikelets per panicle}}{\text{Total number of spikelets per panicle}} \times 100$$

Seed yield plant^{-1}: All the seeds extracted from selected single plants were cleaned, dried, processed, weighed at 13 per cent moisture content and expressed in grams.

Seed yield ha^{-1}: The seeds were harvested separately plot wise, weighed and computed for unit area and expressed in kg ha^{-1}.

100 seed weight: From each selected plant, one hundred well filled seeds selected at random were weighed and expressed in grams.

Results and Discussion

The priming cum foliar spray treatments advanced early days to first and 50 per cent flowering by 1-3 days in seed priming with 1% mixture of KCl + $CaSO_4$+ $ZnSO_4$ + $FeSO_4$ + GA_3 20ppm + *Azophos*1% along with 0.5% foliar spray of ZnSO4 under sodicity. The results are in conformity with the findings of [21] in rice. Comparing the varieties TNAU Rice TRY 3 promoted early flowering by 3 days than I.W. Ponni (Table 1). The possible reasons for early flowering could be due to induction of early emergence and physiological activation of growth by priming treatments. Seed priming with 1% mixture of KCl + $CaSO_4$+ $ZnSO_4$ + $FeSO_4$ + GA_3 20ppm + *Azophos* 1% along with 0.5% foliar spray of ZnSO4 showed maximum total tillers and productive tillers (20.1 and 18.3) than other treatment as well as untreated control (Table 2). This might be due to the various micronutrients present in the treatment allowing effective absorption by the plant at respective subsequent stages which might have increased the activity of enzymes and hormones resulting in better growth and production of productive tillers [15, 18]. Comparing varieties, TNAU Rice TRY 3 excelled than I.W. Ponni in terms of recording productive tillers (16.1, 14.3).

Observations made on yield attributing factors also revealed that, seed priming with 1% mixture of KCl + $CaSO_4$+ $ZnSO_4$ + $FeSO_4$ + GA_3 20ppm + *Azophos*1% along with 0.5% foliar spray of ZnSO4 at active tillering and panicle initiation stages showed maximum values for panicle length, number of seeds panicle^{-1}, seed set per cent characters with15.4, 9.1, 9.0 and 9.8 per cent higher than control, respectively. Similar findings was reported by [21] in rice (Table 3, 4, 5& 6). Seed yield was significantly increased due to seed priming cum foliar spray. The seed yield was enhanced by 15.4 per cent over control in seed priming with 1% mixture of $CaSO_4$ + $ZnSO_4$ + $FeSO_4$ +

GA_3 20 ppm + *Azophos*1% along with 0.5% foliar spray of $ZnSO_4$ at active tillering and panicle initiation stages under sodic condition. This might be due to the foliar application of higher concentration of the micronutrients at critical growth stage which increased the growth and yield parameters. This result is corroborating with the findings of [17, 23]. Comparing two varieties, TNAU Rice TRY 3 recorded higher yield of 5743 and 5660 kg ha^{-1} than I.W. Ponni under sodic soil condition.

The positive effect of micro nutrients such as $CaSO_4$, $ZnSO_4$ and $FeSO_4$ attributed to the various metabolic activities of plant and higher production of auxin, an important growth promoter regulating the cell elongation and cell enlargement. This is in accordance with the findings of [5, 15] in rice. Supply of different micronutrients *viz*., Zn, Cu, Fe, Mn, and B through foliar spraying resulted in better absorption of nutrients and in turn helping in the photosynthetic activities and effective translocation to storage organs which has contributed for the increased yield. This is in accordance with the findings of [5, 20].

The positive effect of GA_3 might be mainly due to its activation to ά-amylase for breakdown of starch stored in the seeds that will be used by the growing embryo during germination, enhancing IAA exertion, promoting cell elongation and division particularly mesocotyle length and internodes of rice seedlings, reducing Na and Cl uptake, increasing N, P and K uptake and enhanced chlorophyll content of rice seedling resulted from seeds soaked in GA_3 leading to high seedling vigour, reasonable plant growth at both early and later stages, improving source-sink relation resulted in high yield contributing components and grain yield under salt stress [2, 4, 10, 14, 19].

Table 1: Effect of seed priming and foliar spray on days to first flowering and 50 per cent flowering in rice varieties of TNAU Rice TRY 3 and I. W. Ponni under Sodicity condition

Treatments	Days to first flowering				Days to 50 per cent flowering			
	M_1		M_2	Mean	M_1		M_2	Mean
S_1	102.0		105.0	103.5	109.3		111.3	110.3
S_2	102.0		104.7	102.7	108.7		111.7	110.2
S_3	100.3		104.3	102.3	107.7		108.7	108.2
S_4	103.3		104.3	103.8	107.3		111.3	109.3
S_5	98.7		103.0	100.8	105.3		110.7	108.0
S_6	101.7		103.7	102.7	107.0		111.0	109.0
S_7	97.3		102.3	99.8	103.3		110.0	106.7
S_8	98.3		103.0	100.7	105.0		110.3	107.7
S_9	98.0		102.0	100.0	105.7		109.3	107.5
Mean	100.2		103.6		106.6		110.5	
	M	S	M x S	S x M	M	S	M x S	S x M
S.Ed	1.45	0.80	1.79	0.97	1.67	0.54	1.82	0.66
CD (P=0.05)	6.22	1.62	NS	NS	7.20	1.11	7.40	1.56

Table 2: Effect of seed priming and foliar spray on total tillers and productive tillers in rice varieties TNAU Rice TRY 3 and I.W. Ponni under sodicity condition

Treatments	Total tillers				Productive tillers			
	M_1		M_2	Mean	M_1		M_2	Mean
S_1	15.3		13.8	14.6	13.4		11.8	12.6
S_2	16.7		14.8	15.7	14.5		12.7	13.6
S_3	18.1		16.4	17.2	16.3		14.9	15.6
S_4	17.4		15.6	16.5	15.4		13.9	14.6
S_5	18.3		16.8	17.5	16.5		14.5	15.5
S_6	17.6		16.0	16.8	15.5		14.1	14.8
S_7	20.1		18.3	19.2	18.2		16.2	17.2
S_8	19.1		17.2	18.2	17.1		15.1	16.1
S_9	19.3		17.8	18.6	17.6		15.4	16.5
Mean	18.0		16.3		16.1		14.3	
	M	S	M x S	S x M	M	S	M x S	S x M
S.Ed	0.28	0.32	0.51	0.39	0.22	0.23	0.38	0.37
CD (P=0.05)	1.21	0.65	NS	NS	0.93	0.47	1.25	0.86

Table 3: Effect of seed priming and foliar spray on plant height (cm) and panicle length (cm) in rice varieties TNAU Rice TRY 3 and I. W. Ponni under sodicity condition

Treatments	Plant height (cm)			Panicle length (cm)		
	M_1	M_2	Mean	M_1	M_2	Mean
S_1	132.2	136.9	134.5	26.2	21.8	24.0
S_2	132.9	144.2	138.6	27.8	21.4	24.6
S_3	138.5	151.7	145.1	28.3	23.4	25.8
S_4	134.4	143.3	138.9	27.8	22.9	25.3
S_5	139.3	154.0	146.6	29.0	23.0	25.9
S_6	134.5	150.4	142.4	28.4	22.5	25.5
S_7	146.6	157.4	152.0	31.0	24.4	27.7

S_8	141.6		154.6	148.1	29.5		23.8	26.6
S_9	143.1		155.3	149.2	30.3		23.7	27.0
Mean	138.2		150.4		28.7		23.8	
	M	S	M x S	S x M	M	S	M x S	S x M
S.Ed	3.03	1.54	3.66	1.88	0.74	0.58	1.06	0.706
CD (P=0.05)	13.0	3.13	13.9	4.42	3.20	1.17	NS	NS

Table 4: Effect of seed priming and foliar spray on Total number of seeds panicle^{-1} and seed set per cent and in rice varieties TNAU Rice TRY 3 and I. W. Ponni under sodicity condition

Treatments	**Sodicity**				**Salinity**			
	M_1		**M_2**	**Mean**	**M_1**		**M_2**	**Mean**
S_1	141.5		131.1	136.3	84.9		82.5	84.0
S_2	143.2		132.0	137.6	85.4		84.8	85.1
S_3	146.3		135.6	141.0	88.9		86.4	87.7
S_4	143.8		133.8	138.8	87.0		85.6	86.3
S_5	148.7		136.3	142.5	90.7		85.4	88.0
S_6	144.8		134.5	139.6	88.9		86.2	87.2
S_7	156.5		141.1	148.8	92.4		90.5	91.5
S_8	149.7		137.3	143.5	91.6		88.2	90.0
S_9	153.8		139.6	146.7	93.2		89.5	91.4
Mean	147.6		135.7		89.1		86.6	
	M	S	M x S	S x M	M	S	M x S	S x M
S.Ed	1.93	2.25	3.56	2.75	1.23	0.77	1.60	0.94
CD (P=0.05)	8.29	4.60	NS	NS	5.30	1.57	NS	NS

Table 5: Effect of seed priming and foliar spray on Seed yield plant^{-1} (g) and Seed yield (kg ha^{-1}) in rice varieties TNAU Rice TRY 3 and I. W. Ponni under sodicity condition

Treatments	**Seed yield plant^{-1} (g)**				**Seed yield (kg ha^{-1})**			
	M_1		**M_2**	**Mean**	**M_1**		**M_2**	**Mean**
S_1	26.8		24.6	25.7	5396		4580	4988
S_2	27.1		25.1	26.1	5447		4650	5048
S_3	29.0		28.1	28.5	5667		4899	5283
S_4	28.4		26.7	27.5	5513		4779	5146
S_5	29.7		28.7	29.2	5783		5054	5419
S_6	28.7		27.5	28.1	5586		4905	5245
S_7	35.0		30.8	33.0	6253		5263	5758
S_8	30.5		29.4	30.0	5930		5083	5506
S_9	31.7		30.3	31.0	6102		5136	5619
Mean	29.6		28.0		5743		4928	
	M	S	M x S	S x M	M	S	M x S	S x M
S.Ed	0.61	0.94	1.39	1.15	95.9	68.80	132.7	84.2
CD (P=0.05)	2.63	1.91	4.58	2.70	413.1	140.10	443.2	197.8

Conclusion

The paddy seeds primed with 1% mixture of $CaSO_4$ + $ZnSO_4$ + $FeSO_4$ + GA_3 20 ppm +*Azophos* 1% along with 0.5% foliar spray of $ZnSO_4$ at active tillering and panicle initiation stages under sodic condition effectively enhanced the overall efficiency of the crop and improved the yield in both tolerant and sensitive varieties of rice grown under salt stress condition.

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