SEED PRIMING AS A STRATEGY TO MITIGATE SALINITY STRESS IN MULLANKAIMA RICE

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ABSTRACT

Environmental pollutants and abiotic stress influence seed germination, emergence and agricultural output. Salinity can affect agricultural output in dry and semi-arid regions. Underneath salt conditions, seed priming can be used to reduce the consequences of salt stress. Priming has the benefit of displaying steady and faster germination price, seedling vigor and crop development below adverse circumstances, as well as overcoming them from dormancy. As a result, seed priming may be regarded as an advanced solution to germination problems whilst seeds are produced in detrimental. The present study explored numerous seed priming methods with an indigenous rice variety of Wayanad, Mullankaima to standardized suitable seed priming treatment and to examine its effect on increase parameters under salt stress conditions. To systematize an appropriate seed priming treatment for rice, the seeds were primed with different priming methods like hydro priming, osmo priming, chemical priming, redox priming and hormonal priming at different concentrations of salt sress. The results discovered that Mullankaima shows the highest rate of growth under all concentration of Ascorbic acid.

Keywords: *Indigenous variety, Seed priming, Salt tolerance, Mullankaima rice*

INTRODUCTION

Soil and water salinization represent significant abiotic stress that limit rice production worldwide, particularly in coastal and marginal areas. Increased levels of salinity along with osmotic stress disrupt seed germination, early seedling establishment, water absorption, photosynthesis, and ionic balance. These factors ultimately affect grain yield (Vibhuti et.al., 2022). Since rice is especially sensitive to salinity during germination and early growth stages, it is crucial to develop strategies that improve salt tolerance during these important phases to enhance performance in salt-affected soils.

Seed-priming is an effective, low-cost farming practice that involves pre-treating seeds with water, osmotic solutions, chemicals, or growth regulators before planting. This process begins partial hydration, activates metabolic repair and stress-adaptation systems, and allows the seed to dry back to its normal moisture level. Pre-conditioning can shorten average germination time, increase emergence uniformity, and boost early seedling vigour. This leads to better tolerance to later abiotic stresses, including salinity (Singh et.al, 2018). In rice farming, many studies show that halopriming or chemical priming of seeds enhances salinity tolerance by promoting a better Na^+/K^+ balance, increasing antioxidant enzyme activity, maintaining higher relative water content, and improving germination and seedling growth in saline environments (Botanical Studies, 2022; Kappen, Thomas, & Prameela, 2022).

Heritage rice landraces, like Mullankaima, are aromatic, bold-grained, awned varieties grown in the Wayanad hills of Kerala. Mullankaima belongs to the "kaima/kazhama" group of aromatic landraces, prized for their fragrance and creamy texture, and is often used in special dishes by local communities. Historically, its awned feature has protected it against bird damage. Nutritional studies show that Mullankaima has a higher iron content than typical white rice and is considered beneficial for lactating mothers.

Despite its important heritage status and unique benefits, there is a lack of published studies on seed priming or salt tolerance enhancement specifically for Mullankaima. In light of the growing risk of soil salinization in Kerala and the need to preserve and use heritage landraces, it makes sense to investigate priming strategies for Mullankaima. Seed priming could help this landrace adapt better to salty conditions, which could expand its cultivation options, support agro-biodiversity, and combine heritage rice conservation with climate resilience efforts.

MATERIALS AND METHODS

The study was conducted in the Department of Botany, St. Joseph's College (Autonomous), Irinjalakuda, to examine the effect of seed priming on rice under salinity stress. Mature, dried seeds of three rice varieties were collected from Wayanad district, Kerala. Different priming techniques were evaluated to enhance salinity tolerance: hydropriming with sterile distilled water; osmopriming with calcium chloride ($CaCl_2$) at 5, 10, and 15 mM; redox priming with hydrogen peroxide (H_2O_2) at 25%, 50%, and 75%; chemical priming with sodium selenate (Na_2SeO_4) at 100, 150, and 200 µM; and hormonal priming with ascorbic acid at 50, 100, and 200 mg L^{-1}.

Healthy, dehusked seeds were surface sterilized with 5% sodium hypochlorite for 15 minutes, rinsed repeatedly with sterile distilled water, soaked for 20 hours at 28°C, and air-dried at 30°C for 24 hours to serve as unprimed controls. For priming treatments, seeds were incubated in the dark at 30°C for 20 hours with gentle agitation at a seed-to-solution ratio of 1:5 (w/v). The seeds were then washed twice with distilled water, surface-dried using blotting paper, and re-dried to their original moisture content at 30°C for 24 hours.

To assess germination under salinity stress, sodium chloride (NaCl) was applied at 100, 150, and 200 mM. Germination tests were performed using the paper towel method, with seeds pre-soaked in NaCl solutions (0–200 mM). The dishes were sealed to maintain humidity. After 14 days, germination percentage was determined according to ISTA (2011) guidelines.

Growth parameters, including root and shoot length, fresh and dry biomass, vigour index, and seed stamina index, were measured. Salinity tolerance was evaluated visually following the Standard Evaluation System (SES) for rice established by the International Rice Research Institute (IRRI) (Gregorio et al., 1997; Bado et al., 2016; Wang et al., 2016; Wangsawang et al., 2018).

Treatments selected for this study were:

T1 indicates No priming + Control temperature,

T2 indicates Hydro priming

T3 indicates Osmo priming using CaCl2: (a:5mM, b:10mM, c:15mM)

T4 indicates Chemical priming using Na2SeO4: (a:100 µM, b: 150 µM, c: 200 µM)

T5 indicates Hormonal priming using Ascorbic acid (a: 50 mg L^{-1}, b: 100 mg L^{-1}, c: 200 mg L^{-1})

T6 indicates Redox priming using H_2O_2: (a:25%, b:50%, c:75%)

i. indicates Salinity stress of 50 mM NaCl

ii. indicates Salinity stress of 100 mM NaCl

iii. indicates Salinity stress of 200 mM NaCl

RESULTS AND DISCUSSION

Table 1: Growth parameters of Mullankaima rice variety

TREATMENT	GERMINATION % (15 TH DAY)	SHOOT LENTH, (15 TH DAY) cm	ROOT LENTH, (15 TH DAY) cm	VIGOUR INDEX	SEED STAMINA INDEX	DRY WIGHT PERCENTAGE	SES SCORE
T1	100	6.5	3.8	1030	10.30	89.5	5
T2.a	100	9.8	3.6	1340	13.40	88.7	1
T2.b	100	9	3.6	1260	12.60	89.0	1
T2.c	100	5.4	2.3	770	7.70	88.1	1
T3.a.i	100	11.6	4	1560	15.60	82.0	1
T3.a.ii	100	8.5	3.9	1240	12.40	89.5	1
T3.a.iii	100	4.8	2	680	6.80	89.0	3
T3.b.i	100	9.9	3.9	1380	13.80	85.5	1
T3.b.ii	100	7.8	3.5	1120	11.20	85.1	1
T3.b.iii	100	4.9	1.8	670	6.70	88.0	1
T3.c.i	100	8	3.8	1180	11.80	89.8	1
T3.c.ii	90	6.2	3	828	8.28	88.2	1
T3.c.iii	100	5	2.9	790	7.90	86.1	1
T4.a.i	30	3.3	0.6	117	1.17	89.8	7
T4.a.ii	35	3	1	147	1.47	85.9	7
T4.a.iii	0	0	0	0	0	80	9
T4.b.i	35	3.5	0.9	154	1.54	87.7	7
T4.b.ii	30	3	1	120	1.20	87.9	7
T4.b.iii	15	0.3	0	4.5	0.045	78.4	9
T4.c.i	40	4.2	1.3	220	2.20	84.7	7
T4.c.ii	20	2.9	1	78	0.78	88.5	7
T4.c.iii	20	0.3	0	6	0.06	87.9	9
T5.a.i	100	13.9	5	1890	18.90	83.5	1
T5.a.ii	100	11	4.2	1520	15.20	87.9	1

T5.a.iii	100	9.3	4	1130	11.30	88.8	1
T5.b.i	100	13.5	4.9	1840	18.40	89.6	1
T5.b.ii	100	10.5	4.3	1480	14.80	89.8	1
T5.b.iii	100	8.6	3.9	1250	12.50	87.7	1
T5.c.i	100	12.9	4.5	1740	17.40	88.3	1
T5.c.ii	100	9.9	4.3	1420	14.20	89.9	1
T5.c.iii	100	7.5	3.4	1260	12.60	87.0	1
T6.a.i	100	9.2	3.6	1280	12.80	88.7	1
T6.a.ii	100	9.1	3.5	1260	12.60	88.3	1
T6.a.iii	100	9.9	3.3	1330	13.30	88.8	1
T6.b.i	70	8.3	3.5	826	8.26	89.4	1
T6.b.ii	65	7.3	2.9	663	6.63	85.7	5
T6.b.iii	50	5.2	2.3	37	0.37	86.9	5
T6.c.i	65	6.8	3.4	663	6.63	88.2	5
T6.c.ii	45	5.5	2.3	351	3.51	85.4	7
T6.c.iii	20	3.4	1.6	100	1	83.6	7

Mullankaima displayed moderate germination rates in all treatments but treatments with highest salinity had reduced germination.Vigour Index, which measures the seedling quality in terms of both shoot and root growth, correlated well with germination. In most cases, rice demonstrated the highest vigour index in treatments such as T5ai (1890) and T5bi (1840), suggesting high seedling vigor and adaptability under optimal conditions.Dry weight percentage is an important indicator of the nutrient content and robustness of seedlings. Mullankaima showed consistently high dry weight percentages (around 88-89%) in most treatments (T2a, T3bi, T5ai), signifying strong overall growth and development under optimal conditions.The Seed Stamina Index, which measures the resilience of seedlings to environmental stress, was highest in treatments like T5ai (18.90) for Mullankaima. These high values suggest that these treatments produced the most resilient seedlings capable of thriving under variable conditions. In contrast, the SES score revealed poor performance in certain treatments with low vigour and reduced seedling survival, particularly in T4 and T6 treatments. The SES score was lowest (9) for treatments exhibiting minimal germination or growth, confirming that these seedlings failed to develop adequately.

The highest vigour is observed in treatments like T2a, T3ai, and T5ai, with vigor indices exceeding 1500 and SES scores of 1. These treatments also exhibit high germination (100%) and substantial shoot/root lengths. Conversely, treatments like T4aiii and T4biii show poor germination (0-15%) and poor seedling development, with corresponding high SES scores (7-9), suggesting reduced seed viability. Its resilience, as indicated by the Seed Stamina Index, was also relatively


T1a
T2a
T2b
T2c
T3a1
T3a2
T3a3
T3b1
T3b2
T3b3
T3c1
T3c2
T3c3
T4a1
T4a2
T4a3
T4b1
T4b2
T4b3
T4c1
T4c2
T4c3
T5a1
T5a2
T5a3
T5b1
T5b2
T5b3
T5c1
T5c2
T5c3
T6a1
T6a2
T6a3
T6b1
T6b2
T6b3
T6c1
T6c2
T6c3

high.

SUMMARY AND CONCLUSION

Mullankaima germinated under NaCl 100mM shows highest (100%) germination in hydropriming, osmo-priming, hormonal priming and Redox priming. Highest shoot and root length is observed (13.9,5) in hormonal priming with ascorbic acid. Vigour index and seed stamina index is higher (1890,18.90 respectively) in hormonal priming. Dry weight percentage is more (89.8%) in both osmo-priming and chemical priming.

Mullankaima germinated under NaCl 150mM shows highest (100%) germination in hydropriming and hormonal priming. The highest shoot length and root length is observed (11,4.2) in hormonal priming. Vigour index and seed stamina index (1480,14.80) is more in priming with ascorbic acid. Dry weight percentage (89.9%) is higher in hormonal priming.

Mullankaima germinated under NaCl 200mM shows highest (100%) in hydropriming

osmopriming and hormonal priming. Shoot length and root length is more (9.3,4) in hormonal priming. Vigour index and seed stamina index (1330,13.30) are highest in Redox priming. Dry weight percentage is maximum (89.0%) in osmo-priming.

ACKNOWLEDGEMENTS

We thank all the faculty and staff of Department of Botany, St. Joseph's College (Autonomous), Irinjalakuda, for their cooperation and kind support throughout the research.

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