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ENHANCING SODICITY RESISTANCE IN RICE (ORYZA SATIVA) THROUGH PLANT GROWTH REGULATORS: MECHANISMS, STRATEGIES, AND SUSTAINABLE RICE PRODUCTION.

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ABSTRACT:

Effect of seed soaking of three plant growth regulators viz; GA_3 (100, 200 and 300 ppm), Kinetin (100, 150 and 200ppm) and putrescine (30, 60 and 90 ppm) were studied on a direct seeded rice (c.v. sarjoo-52), under normal and sodic soil. Total soluble carbohydrate in Culm at different stages was significantly decreased in sodic condition over normal. Among growth regulators, putrescine 30ppm proved most effective and improved carbohydrate contents in sodic condition. Reverse trend was noted in catalase and peroxidase activity under sodicity. However, kinetin 100 ppm favored catalase activity and putrescine 30 ppm favored peroxidase activity at 120 DAS stage showed lower values compared to other growth regulators tried. Na content in plants increased significantly with a concomitant decrease in K and Ca content in sodic soil. Of the three regulators, kinetin 150 ppm and putrescine 60 ppm retained higher Na K, and Ca under sodic condition. Grain yield and its attributes also declined significantly in sodic soil. Seed soaking with putrescine 30 ppm appeared most effective, followed by GA_3 300 ppm which increased yield and panicle length under sodic condition.

Keywords: Rice, GA3, kinetin, mineral content, peroxidase, putrescine, salinity.

1. Introduction

Rice is the most prominent crop of India as it is the staple food for most of the people of the country. This crop is the backbone of livelihood for millions of rural households and plays vital role in the country's food security, so the term "rice is life" is most appropriate in Indian context. India occupies an important position both in area and production of rice. By the adoption of improved production technologies such as high-yielding varieties/hybrids, expansion of irrigation potential, and use of chemical fertilizer, supply of rice in the country has kept pace with the increase in demand. Rice is generally cultivated by transplanting method. Transplanting of rice requires huge quantity of water as well as a greater number of labors. Direct seeding of rice offers an option to address the issue of lowering cost of cultivation and labour problems. But under direct seeded condition, germination and seedling establishment is major issue to be addressed due to presence of excessive salt. Salinity reduces stomatal frequency and to stomata opening and transpiration. Salt stress is one of the major wide spread environmental stresses that limits growth and development of plant (Greenway & Munns, 1980). There are a small number of hormones with the capacity to regulate plant physiological processes (Ferguson and Grafton-Cardwell, 2014) that have been studied since the 1930's for improving crop development and production (Rademacher, 2015). These hormones exist in low concentrations within plant tissue, resulting in large challenges in isolation, identification and extraction of suitable quantities for laboratory testing (Rademacher, 2015). Sodicity adversely affects plant growth through osmotic and ion toxicity. Though reclamation of these problem soils is the common practice but it is expensive in many cases. A possible approach to increase the productivity of such areas is to improve tolerance in plants. Plant growth regulators have been used to reverse the salt induced deleterious effects. Therefore, the present investigation was carried out to study the deleterious effects of sodicity and their amelioration by the application of PGR on yield, enzyme activity and quality of produce in direct seeded rice.

2. Materials and Methods

The experiment was conducted during the Kharif season in the year 2009 in earthen pot filled with 8kg of natural normal sodic soil having the pH value 8.0, 9.8 the 0.18ds/m, 0.97/dsm, ESP 12%, 80% and organic carbon 0.38%, 27% respectively at N.D. university of Agriculture & Tech. Kumarganj Faizabad. The experiment was laid out in complete randomized block design with three replications. At the commencement of the experiment ten pots were ear marked for each treatment, five pots were used for periodic sampling and the remaining five were maintained up to maturity. Both types of soils were sprayed on separate polythene sheets and major nutrients nitrogen, phosphorus and potassium @ 120:60: 60 kg/ha were added through urea single super phosphate and muriate of potash. Seeds of sarjoo –52 were soaked for 12 hrs in aqueous solutions of conc. GA_3 (100, 200 and 300 ppm). Kinetin (100, 150 and 200 ppm) putrescine and (30, 60 and 90 ppm) along with distilled water treated as control. After soaking, the seeds were removed from the solution and dried under the shade for 48 hours. Direct sowing of soaked seeds was done in earthen pots containing normal and sodic soils. Each pot was supplied with NPK, DAP and MOP @ of 120: 60:60 respectively. After germination thinning was done and four healthy and uniform plants were maintained in each pot. Observations were recorded on sodic and normal plants at 30^{th}, 60^{th} 90th DAS and at maturity. Total chlorophyll content estimated by Arnon (1949). Total soluble sugar was determined by anthrone reagent. The catalase activity was determined by Sinha (1972) and peroxidase was assayed by the methods of Galaston. At the end of the experiment three plants were randomly selected which was used for recording seed yield.

3. Result and discussion

Germination

Perusals of data indicate that salinity reduced growth of crop under normal soil condition, all the doses of GA3 and 200 ppm showed significant increase in germination percentage over control. Among various growth regulators showed the response of GA3 was best in germination percentage of pearl millet in salinity (Khuhad *et al.* 1987).

Table 1: Effect of growth regulators on germination (%) of direct seeded rice under normal and sodic soil conditions.

Growth regulators (ppm)	Normal	Sodic
Control	51.71	18.41
GA_3 100	62.50	30.83
GA_3 200	63.51	31.73
GA_3 300	64.00	36.21
Kinetin 100	52.21	27.55
Kinetin 150	55.72	27.51
Kinetin 200	56.91	29.01
Putrescine 30	50.00	29.21
Putrescine 60	51.71	27.52
Putrescine 90	53.40	28.01
Mean	56.17	28.60
CD at 5 %	GR= 3.51 S= 1.61, GR x S = 5.09	

Phenological stages

The days taken to 50% flowering were less than normal condition in all growth regulator treatments except putrescine. Maximum number of days for 50% flowering was recorded highest in kinetin (150 and 200 ppm) and putrescine 30 ppm under normal and sodic condition. (Ndayiragije and Lutts 2007) emphasized the role of putrescine in flowering that cause and improvement in floral morphogenesis and pollen viability in salt treated plants. Days to maturity was found that in kinetin 200ppm followed by its lower doses (150 and 100ppm) and GA3 300ppm under normal condition, however under sodic condition, maturity duration was highest in all putrescine treatments followed by kinetin treatments.

Table 2: Effect of growth regulators on phenology of direct seeded rice under normal and sodic soil conditions.

Growth regulators (ppm)	50 % flowering		Days to Maturity	
	Normal	Sodic	Normal	Sodic
Control	80	74	128	115
GA3 100	80	78	128	119
GA3 200	81	78	130	119

GA3 300	81	78	130	119
Kinetin 100	82	78	132	121
Kinetin 150	83	80	132	123
Kinetin 200	83	80	135	123
Putrescine 30	80	82	129	125
Putrescine 60	80	80	128	125
Putrescine 90	80	80	128	125
Mean	81.00	78.8	130.00	121.4
CD at 5 %	GR= NS S= 2.19 GR x S = NS		GR = NS S = 4.34 GR x S= NS	

Plant Height

Growth regulators (ppm)	30 DAS		60 DAS		90 DAS		120 DAS	
	Normal	Sodic	Normal	Sodic	Normal	Sodic	Normal	Sodic
Control	34.70	18.62	54.81	27.90	66.41	34.41	67.51	35.20
GA3 – 100	39.51	23.91	61.04	32.31	74.72	40.70	75.32	41.00
GA3 – 200	40.62	25.72	64.21	36.62	76.27	42.81	78.12	43.50
GA3 – 300	40.12	28.63	63.71	38.81	76.80	47.51	77.80	48.71
Kinetin 100	35.10(S)	20.14	55.72	31.51	69.87	39.01	71.20	40.30
Kinetin 150	35.26(S)	21.76	56.20	32.98	68.50	40.51	70.50	41.140
Kinetin 200	35.02(S)	23.51	55.40	33.71	68.72	43.12	70.71	44.07
Putrescine 30	34.91(S)	25.42	54.00	42.62	63.10	49.71	65.61	50.51
Putrescine 60	34.70	25.63	52.60	40.10	61.72	47.41	62.82	48.12
Putrescine 90	34.60	24.60	52.05	39.00	62.51	47.00)	63.02	47.41
Mean	36.46	23.79	56.97	35.56	68.86	43.22	70.26	44.00
CD at 5 %	GR= 1.66 S= 0.74 GR x S =2.35		GR= 2.46 S=1.10 GR x S = 3.48		GR= 5.27 S= 2.36 GR x S = 7.45		GR= 3.86 S= 1.73 GR x S =5.46	

Plant height was found maximum in all the doses of GA3 treatments under normal condition and kinetin 100 ppm found highest plant height under sodic soil and maximum biomass showed under normal soil in GA3 200ppm and kinetin 150ppm growth regulators treatments and under sodic soil putrescine 30ppm recorded maximum biomass but higher doses of putrescine (60, 90 ppm) showed comparatively less biomass, (Sinha et *al.*1986) reported that sodicity interferes various enzymatic processes and also creates hormonal imbalances.

Table 3: Effect of growth regulators on plant height (cm) of direct seeded rice under normal and sodic soil conditions. Tillers

Tiller number per plant was showed highest in putrescine. similar to our results several workers have sown that exogenous application of putrescine is more effective in overcoming the harmful effects of salts on seedlings (Krishnamurthy,1991; Prakash and Prathapasenan 1988).

Table 4: Effect of growth regulators on tillers/ plant of direct seeded rice under normal and sodic soil conditions.

Growth regulators (ppm)	30 DAS		60 DAS		90 DAS		120 DAS	
	Normal	Sodic	Normal	Sodic	Normal	Sodic	Normal	Sodic
Control	2.82	1.31	4.11	2.38	5.38	2.96	5.20	2.81
GA3 100	3.08	1.46	4.36	2.61	5.46	3.22	5.39	3.28
GA3 200	3.00	1.50	4.29	2.65	5.64	3.35	5.47	3.32
GA3 300	2.78	1.61	4.15	2.76	5.51	3.42	5.34	3.38
Kinetin 100	3.14	1.4	4.29	2.58	5.2	3.10	5.32	3.14
Kinetin 150	3.2	1.42	4.41	2.72	5.51	3.24	5.67	3.25
Kinetin 200	3.17	1.58	4.46	2.76	5.3	3.29	5.56	3.32
Putrescine 30	2.8	1.64	4.15	2.81	5.42	3.74	5.33	3.64
Putrescine 60	2.8	1.61	4.15	2.77	5.31	3.47	5.23	3.44
Putrescine 90	2.78	1.58	4.00	2.77	5.26	3.4	5.21	3.42
Mean	2.96	1.51		4.24	2.68		5.40	3.31
CD at 5 %	GR= 0.13 S= 0.058 GR x S =0.18		GR= NS S= 0.15 GR x S =NS		GR= 0.37 S= 0.16 GR x S =NS		GR= NS S= 0.19 GR x S = NS	

Yield and Yield Attributes

It is also clear that higher doses of putrescine recorded lower grain weight/ panicle as compared to putrescine. (Ndayiragije and Lutts 2007) **grain yield** increase in salt treated rice crop exposed to putrescine is related to an improvement in floral morphogenesis which leads to a higher number of spikelet's per panicle. The **sterility percentage** under different treatments varied from 18% to 33% and 43% to 56% in normal and sodic condition respectively. In normal condition, all doses of kinetin and GA3 200 recorded significant decrease in sterility percent over control. While, under sodic condition, all the doses of putrescine, GA3 300 had significant decrease. In sodic condition **grain yield** was found maximum in all the doses of putrescine than other growth regulators. The higher doses of putrescine (60.90 ppm). In normal soil, maximum **grain yield** was observed with kinetin 200 followed by kinetin 150 and GA3 300. (Balki and Padole 1982) observed that grain yield in wheat by application of GA3 under salinity.

Table 5: Effect of growth regulators on panicle length (cm) and grain weight (g) per panicle of direct seeded rice under normal and sodic soil conditions.

Growth Regulators (ppm)	Length of panicle (cm)		Grain weight per panicle (g)	
	Normal	Sodic	Normal	Sodic
Control	15.81	8.97	2.28	1.02
GA3 100	17.00	10.30	2.31	1.21
GA3 200	19.36	10.28	2.40	1.40
GA3 300	19.12	11.96	2.42	1.55
Kinetin 100	17.54	10.50	2.59	1.10
Kinetin 150	17.37	11.70	2.63	1.22
Kinetin 200	17.83	11.13	2.58	1.40
Putrescine 30	16.20	13.10	2.33	1.78
Putrescine 60	15.86	12.30	2.29	1.65
Putrescine 90	15.61	11.70	2.28	1.50
Mean	17.07	11.19	2.41	1.38
CD at 5 %	GR= 1.24 S= 0.56 GR x S=1.75		GR= 0.10 S= 0.04 GR x S= 0.14	

Table:6 **Effect of growth regulators on grain yield, biological yield and harvest index of direct seeded rice under normal and sodic soil conditions.**

Growth regulators (ppm)	Grain yield (g)/ plant		Biological yield (g)/ plant		Harvest index (%)	
	Normal	Sodic	Normal	Sodic	Normal	Sodic
Control	7.48	2.81	17.47	7.77	42.80	36.12
GA3 100	8.30	3.14	19.50	8.44	42.60	37.16
GA3 200	8.46	3.58	20.05	8.95	41.20	40.00
GA3 300	8.50	4.30	19.54	11.05	43.62	39.00
Kinetin 100	8.10	2.90	18.49	7.91	43.80	36.62
Kinetin 150	8.90	3.29	19.95	8.56	44.60	38.43
Kinetin 200	8.92	4.19	19.82	10.31	44.86	40.62
Putrescine 30	7.71	5.06	18.09	12.09	42.62	41.85
Putrescine 60	7.67	4.89	18.78	11.73	40.78	41.69
Putrescine 90	7.52	4.50	17.48	11.02	43.09	40.83
Mean	8.16	3.87	18.92	9.78	43.00	39.23
CD at 5 %	GR = 0.72 S = 0.32 GR x S = 1.02		GR = 1.32 S = 0.59 GR x S = 1.86		GR = NS S = 1.26 GR x S = NS	

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