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EFFECT OF SALINITY STRESS ON GERMINATION AND GROWTH PARAMETERS OF RICE (*ORYZA SATIVA* L.)

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ABSTRACT

Responses of eight varieties of *Oryza sativa* L. ('NERICA 1', 'NERICA 5', 'NERICA 12', 'NERICA 19', 'IR 29', 'IR 20', 'IWA 11', and 'POKKALI', tolerant checks salt) against four levels of salinity (0, 5, 10, and 15 ds m-1) were studied at germination and early growth stages. Germination was not recorded at 20 ds m-1 salt concentration in all cultivars. Salinity decreases FGP, SG, GE% and causes a decrease in shoot and root length and variety dry weight and the amount of reduction increases with increasing salinity stress. The rice varieties 'NERICA 12', 'IR 20', 'IWA 11' and 'NERICA 19' showed greater salt tolerance during germination (germinating at a salinity of 10 ds m-1). However, 'NERICA 1', 'IR 29', and 'IR 20' performed better based on reduced dry matter yield. The results suggest that 'NERICA 1', 'IR 29', and 'IR 20' might be used for further studies on the effects of salinity on the growth process and the physiological consequences in the later stages of growth. The physiological response of rice plants to salinity at various stages of development is essential for identifying salinity tolerance in cultivars.

KEYWORDS: Rice, Stress, Stress, Salinity, Physiological.

INTRODUCTION

Soil salinization is a serious problem worldwide and it has caused substantial losses to crop productivity FAO, 2006.This is a major limitation that limits agricultural productivity to nearly 20% of cultivated and irrigated areas worldwide.[1] Salinity affects nearly every aspect of plant physiology and biochemistry and significantly reduces yield. High concentration of exogenous salts affects seed germination, water deficit, ion imbalance of cellular ions resulting in ionic toxicity and osmotic stress.[2]

Salt stress has been reported to cause inhibition of growth and development, reduced photosynthesis, respiration and protein synthesis in sensitive species.[3] According to the classification of plant tolerance to salinity, rice plants are in sensitive divisions from 0 to 8 ds m-1.[4] The susceptibility of rice to salinity stress varies with the stage of growth. Heenan *et al.*[5] and Lutts *et al.*[5] reported that rice is very sensitive to salinity during germination, young seedlings and early development stages for the most commonly used rice varieties. However, on the other hand, Khan et al.[6] observed that rice was relatively tolerant of salt to germination and in some cases was not significantly affected up to 16.3 ds m-1 salinity. Seed germination, seedling emergence, and their viability are particularly sensitive to substrate salinity.[7]

High soil salinity levels can significantly inhibit seed germination and seedling growth, due to the combined effects of high osmotic potential and ion-specific toxicity.[8] In general, rice becomes very sensitive at the young seedling stage, which has an impact on the density of stands in salt-exposed fields.[9] It is necessary to identify the level of sensitivity and tolerance of a variety at the early nursery stage for successful harvest production in a salt environment. Therefore, this study was carried out to identify salt tolerant rice varieties in the initial seedlings and to determine their salt tolerance level and salinity threshold.

Research Implementation

Seeds of eight different upland rice varieties: 'NERICA 1', 'NERICA 5', 'NERICA 12', 'NERICA 19', 'IR 29', 'IR 20', 'IWA 11' and 'POKKALLI' were used in the experiment. The soil is treated by soaking the sand in 1 N hydrochloric acid for one hour to remove microbes and dissolve trace elements that may be present in it. The acid is dried and the sand is washed with tap water and then distilled water until the pH of the usable water is between 6 and 7, which is optimal for germination and seed growth. The washed sand was dried and transferred to the air seventy-two plastic pots (about 24 cm in diameter and 21 cm deep inside) each with four holes about 4 mm at the bottom to improve drainage during the course of the experiment. Ten seeds were planted in each pot and after germination reduced to five. The plant is exposed to sunlight for up to about eight hours each day. Each bowl was supplied with 200 ml of distilled water in the morning and evening for the first 6 days after planting. After germination and on the 9th day after planting, the pots were divided into three nutrient regimes each containing twenty-four pots, each pot containing five seeds. The experiments were arranged in a completely randomized design and carried out in three replications.

Observation and Analysis of Parameters

Preliminary Soil Analysis

The soil was analyzed at the Department of Soil Science, Faculty of Agriculture, Obafemi Awolowo University, Ile-Ife, Nigeria. The following physical and chemical properties of the soil are determined; particle size distribution (sand, mud and clay) and texture class, pH, organic carbon, organic matter, total nitrogen, available phosphorus, calcium, magnesium, potassium, sodium, exchange acidity and effective cation exchange capacity.

Screen House Experiment

A warehouse, surrounded by a net of iron. This is to protect the crop from direct rainfall, pest contamination, and to avoid being destroyed by rodents as the crop develops. Daily average temperature, relative humidity and light intensity were also taken and recorded.

Preparation of Salt Solutions

The salinity level using pure NaCl salt was prepared with the following equation: EC = TDS / 640 (Meot-Duros and Magne, 2008); EC = Electrical conductivity; TDS = Dissolved salt concentration in mg / L. Preparation and Salinization of Nutrient Solutions: Nutrient solutions were prepared following this method described by Yoshida et al. (1976) and purified by adding NaCl while stirring until the desired electrical conductivity level (EC).

Experimental design

A factorial trial under a completely randomized design (CRD) with three replications was performed at five different salinity levels (5, 10, 15 and 20 ds m-1) and distilled water (0 ds m-1) served as control.

Nutrient Solution Application

Each pot was supplied with 200 ml of suitable nutrition in the morning and 200 ml of distilled water in the evening until the end of the experiment. The seeds are grown for up to 14 days in a normal nutrient solution to allow for adequate growth prior to salinization. Sampling was carried out four weeks after salinity and at one-week intervals.

Determination of Germination Parameters

The final count (9DAS), germination rate (SG), final germination percent (FGP) and percent germination energy (GE%) were calculated as follows.[10]

$SG = N1 / D1 + N2 / D2 + \ldots .. + Ni / Di$

$FGP = S / T \times 100$

$GE\% = N / T \times 100$

where, S is the number of seeds germinated at the end, T is the total number of seeds, N is the number of seeds germinated in 9 watersheds and Ni is the number of seeds germinated per day (Di).

Variety Classification

Varieties were classified as tolerant (T = 0-20% reduction), moderately tolerant (MT = 21-41% reduction), moderately susceptible (MS = 41-60% reduction) and susceptible (S60% reduction) based on the amount of dry matter they reduced. (roots and shoots) at various levels of salt loading.[11] This experiment was repeated twice to determine the consistency of yield from various varieties against various salt concentration levels.

Measurement of Morphological Parameters

Seedlings and root lengths of five randomly selected seeds from each replication were measured at harvest time (9 days after treatment application) by the meter rule.

Determination of Roots and Dry Weight Shoots

Shoot dry weight and root dry weight of five randomly selected seedlings were recorded after oven drying at 800 C for constant weight.

Statistic Analysis

Data were analyzed using the two-way analysis of variance method (ANOVA) and the means were separated by the Duncan Multiple Range Test (DMRT) using the Statistical Analysis System (SAS, version 9.1) at a significance level of 0.05.

RESULTS AND DISCUSSION

Percentage of final germination (FGP)

At a salinity of 15 ds m-1, germination was completely inhibited for the variety. The germination percentage is inversely related to salt concentration. The germination percentage significantly decreased in all varieties due to increased salinity level (Tab. 1). In the control (0 ds m-1), the germination percentage of all varieties was greater than 90%. At the salinity level of 5 ds m-1, a higher germination percentage of more than 90% was observed for the 'NERICA 5' and 'NERICA 12' varieties, which were statistically similar to the other three varieties, 'NERICA 1', 'IWA 11', and salt tolerant check 'POKKALI'. The other three varieties 'IR 20', 'IR 29' and 'NERICA 19' showed germination efficiencies of between 80 and 90%.

A similar trend with decreased percentage of germination was also observed for salinity levels at 5 ds m 1 (Tab. 1).

Tab. 1: Effect of salinity on germination percentage is different rice varieties.

Varietas	Salinity levels (ds m-1)			
	0	5	10	15
'IR20'	95.0^{a}	88.75^{bc}	82.50^{abc}	45.8^{d}
'POKKALI'	97.00^{a}	95.46^{ab}	92.77^{bc}	64.42^{bc}
'IR29'	94.64^{ab}	84.38^{cd}	76.84^{c}	55.34 ^{b}
'NERICA 1'	93.45^{ab}	90.00^{ab}	80.14^{cd}	64.38^{ab}
'NERICA 5'	96.76^{b}	94.88^{a}	78.63^{b}	60.51^{c}
NERICA 12'	94.34^{a}	91.00^{ab}	58.75^{cd}	37.84^{d}
'NERICA 19'	95.45^{ab}	85.88^{cd}	51.86^{d}	45.16^{cd}
'IWALL'	90.42^{b}	91.25^{ab}	64.23^{c}	40.84^{c}

Means with the same letter in the column are not significantly different (p> 0.05). The values in parentheses represent the percent reduction for each control.

Germination less than 90% mainly occurred at and above a salt concentration of 10 ds m-1 for all rice varieties except 'POKKALI'. However, different variations are seen at the 10 ds m-1 salinity levels. Significantly, the highest germination percentage was found in 'POKKALI', which was identical to the range 'NERICA 1'.

Among the varieties tested, 'NERICA 1', 'NERICA 19', 'IR 29' and 'IR 20' were superior in germination under salt conditions at 10 ds m-1 compared to the salt tolerant cultivar 'POKKALI'. Variability of salinity tolerance among rice varieties on germination has been reported.[12] The salinity yield at poor stands due to a decrease in the germination rate of seeds. Presumably, the osmotic effect of salinity maturity was the main inhibiting factor which reduced germination as demonstrated by Akbar and Ponnamperuma.[13] Salinity reduces plant growth due to osmotic and ionic effects on soil solutions.[14] High levels of soil salinity can significantly inhibit seed germination and seedling growth, due to the combined effects of high osmotic potential and specific ion toxicity.[8] The accumulation of Na + is high in Salt soil causes a decrease in water potential and hence makes plants unable to extract water from osmotic stressed soils.[15]

Germination Speed (SG)

The average SG values of rice varieties with different salinity levels are presented in Tab. 2. The rate of germination decreases as the salinity level increases. Regardless of the variety, the highest mean SG was found in the control and at least 15 ds m-1. At lower electrical conductivity (EC) 5 ds m-1, the variations 'POKKALI', 'NERICA 12', and 'IWA 11' showed better germination rate (SG) followed by IR 20, and SG was the least observed of other varieties. At 5 ds m-1, the 'IR 20', 'NERICA 12', 'NERICA 19', and 'IWA 11' varieties were higher SG compared to controls. With an increase in salinity up to 10 ds m-1, several

Tab. 2: Effect of Salinity on Germination Rate (SG) of different rice varieties.

Varietas	Salinity levels (ds m-1)			
	0	5	10	15
'IR20'	19.45^{b}	17.87^{bc}	12.48^{adc}	2.78^{c}
'POKKALI'	24.76^{a}	21.28^{a}	14.64^{ab}	7.14^{b}
'IR29'	21.17^{a}	17.13^{bc}	8.48^{b}	0.25^{c}
'NERICA 1'	21.45^{a}	15.81^{a}	7.39^{a}	0.13^{c}
'NERICA 5'	19.87^{ab}	14.74^{ab}	8.64^{c}	2.63^{c}
NERICA 12'	26.46^{ab}	23.76^{bc}	17.14^{dc}	1.58^{cd}
'NERICA 19'	26.68^{bc}	21.17^{ab}	14.48^{cd}	2.92^{bc}
'IWALL'	24.55^{a}	20.48^{bc}	17.41^{ab}	2.53^{b}

Berarti dengan huruf yang sama di kolom tidak berbeda secara signifikan (p> 0,05). Nilai dalam kurung menunjukkan pengurangan persen masing-masing kontrol. the number of varieties 'IR 20', 'NERICA 19', 'NERICA 12' and 'IWA 11' showed higher SG values compared to controls. At the EC level of 15 ds m-1, although 'IR 20' maintained a higher germination rate compared to other varieties, it reduced 75% of SG compared to control (Tab. 2).

The trend of decreasing SG due to increasing salinity is in accordance with the reports of others.[16] The reduction in germination rate at high salt levels may be mainly due to osmotic stress.[17]

Energy Germination (GE%)
Germination energy was observed on the 9th day after seed germination and a difference in variation was observed in relation to GE% under saline conditions. With increasing NaCl concentration, germination energy was significantly reduced (Tab. 3). At the salinity level of 5 ds m-1 varieties 'IWA 11', 'NERICA 19', and 'NERICA 12' showed a higher or identical% GE compared to examining the various 'POKKALI'. While the salinity level increased to 10 ds m-1, only four varieties; 'IWA 11', 'NERICA 19', 'NERICA 12' and 'IR 29' showed a% better GE than the variation check. However, at EC from 15 ds m-1 seed germination did not occur for most of the varieties except 'IR 20', 'POKKALI' and 'IWA 11'. The results agree with the work of Karim et al.,[18] Khan et al.[18] that salinity delays the germination process. Hakim et al.[19] reported that seed germination did not occur at 15 ds-1. Folkard and Wopereis.[20] reported that salinity germination was delayed in rice by increasing salt stress. In this study, several varieties had high FGP but low% GE, which means most of the seeds of this variety probably germinated after 4 days. Varieties with a high% GE value at a certain salinity level will clearly have a higher competitive advantage than Varieties having a lower% GE value to catch.

Tab. 3: Effect of salinity on Energy Germination (GE%) of various rice varieties.

Varietas	Salinity levels (ds m-1)			
	0	5	10	15
'IR20'	67.84bc	54.78c	19.8c	76.2a
'POKKALI'	68.01c	53.41d	15.60d	0.0
'IR29'	62.16d	48.64c	23.50b	0.0
'NERICA 1'	60.0cd	37.81b	11.8a	0.0
'NERICA 5'	44.75c	31.89ef	56.4c	0.0
NERICA 12'	64.36cd	58.61bc	22.5b	0.0
'NERICA 19'	74.75a	68.01a	29.84c	5.4c

Means with the same letter in the column are not significantly different (p> 0.05). The values in parentheses represent the percent reduction for each control.

environmental and educational resources. Although salinity delays germination, a higher salt concentration will ultimately reduce the percentage of seeds germinating.[21]

Long Shoots and Roots
The shoot length of all rice varieties decreased in all salt treatments relative to controls and with increasing salinity (Fig. 1). However, the reduction in image length was less than 5% at a salt concentration of 5 ds m-1 except for the 'NERICA' variation (25% reduction).

At the salinity level of 10 ds m-1, the various checks ("POKKALI") showed better performance followed by "IR 20" and "IWAII" and the lowest performance was observed "NERICA 12". At this salt concentration level, take a length reduction of about 16-38% for the variety. With a further increase in salinity at 15 ds m-1, a reduction the percentage is 29-60%. Although the 'IR 20' and 'POKKALI' varieties had resulted in much higher long shots at this salt concentration level compared to the others, it had only 29 and 35% control. At 15 ds m-1, the difference in shoot length of the varieties was not pronounced because serious weight loss included control for variation except 'IR 20'. Decreasing seed height is a common phenomenon of many crops grown in saline conditions.[22] Likewise, root length also decreased with increasing salinity (Fig. 2). The root length is more depressed than shooting with salinity at any given salt concentration level. At all salinity levels, varieties "POKKALI", "IR 29", and "IR 20" produced significantly higher root lengths compared to other varieties and "IWAII" produced the lowest root length. The gradual decrease in root length with an increase in salinity as observed may be due to more inhibitory effect of NaCl salt for root growth compared to shoot growth.[23]

Dry Weight of Roots and Shoots
Shoot dry weight was inversely related to salt concentration, it decreased with increasing salt concentration (Tab. 4). It is relatively less sensitive to salt than dry weight roots especially at higher salt concentrations. On average, at salinity concentrations of 5, 10 and 15 ds m-1, the shoot dry weight was reduced to about 27, 62 and 80%, respectively, of the control, while the dry weight of the roots showed a greater reduction of about 34, 70 and 86%, respectively, of controls (Tab. 4 and 5). The cultivars also differed and showed variability in the response of shoot dry weight to salt concentration.

At the lowest salt concentration (5 ds m-1), the greatest reduction in shoot dry weight was observed at 'IR 29' (50%), whereas in other varieties, the reduction range was 13-29% relative to the control. At 10 ds m-1, the variance is clear; 'IWA 11', 'NERICA 5', 'NERICA 12', and 'IR 20' had a reduction of about 52-65%, only three varieties 'IR 29', 'NERICA 1' and 'NERICA 19' had 70-74% . At 10 ds the m-1 reduction in shoot dry weight ranged from 50-74%. The smallest reduction was observed in 'NERICA 12' (50%) and the largest was at 'IR 29' (approx. 75%). At 15 ds m-1, the reduction was much higher (67-92%) and all rice varieties were salt susceptible. In this study, at all salinity levels, shoot dry weight of all varieties was significantly affected, whereas the 'NERICA 19' variation showed the highest salt sensitivity in all salinity treatments (Tab. 6).

Root dry weight decreases with increasing salinity level. The difference in varietal differences is pronounced in this character. At high salinity levels (10 and 15 ds m-1), dry matter reduction in all varieties was serious. The lowest salt concentration (5 ds m-1), the root dry weight of all varieties was reduced to about 20-57% of the control, while 'POKKALI' and 'NERICA 5' were reduced by a large amount of 50 and 57%, respectively.

However, a similar trend was not observed for EC 10 ds m-1 but from a statistical point of view, 'NERICA 5' displayed the highest root dry weight at 5 ds m-1 compared to all other varieties. At the level of 10 ds m-1 EC 'NERICA 19' showed the highest and lowest root dry weight observed by 'IR 20' at that salinity level. A similar trend was observed for EC 15 ds m-1 because 'NERICA 19' was completely reduced (100%) followed by 'NERICA 5' (about 97%) while other varieties were reduced to about 76-88% of the control. Hence, varietal differences and high levels of salt sensitivity are pronounced at this level. Similarly, Jamil and Rha,[24] observed that shoot length, root length and dry weight decreased with increasing salt stress.

This confirms previous reports that suggested that salt stress reduces the biomass of tomatoes,[25] beans,[25] and rice,[25] although shoot dry weight is more sensitive to salinity than roots. dry weight.[25] The reduction in root and shoot development may be due to the toxic effects of NaCl as well as the unbalanced nutrient uptake by the seedlings. This also confirms the findings of Hussain and Rehman.[26] High salinity can inhibit roots and shoot elongation because it slows down water uptake by plants.[27] Neumann.[28] indicated that salinity can rapidly inhibit root growth and its capacity to absorb water and essential mineral nutrients from the soil.[19]

Variety Classification

All varieties showed inconsistency in salt treatment further increasing salt concentration. At the electrical conductivity of 5 ds m-1, three varieties 'IR 20', 'IR 29' and 'NERICA 1' were salt tolerant (T) and the other five varieties were moderately tolerant (MT). However, as the salinity level increased to 10, most of the varieties showed gradual deviations from the previous salt tolerant ratings of T to MT, MT to MS and MS to S respectively while sharp deviations.

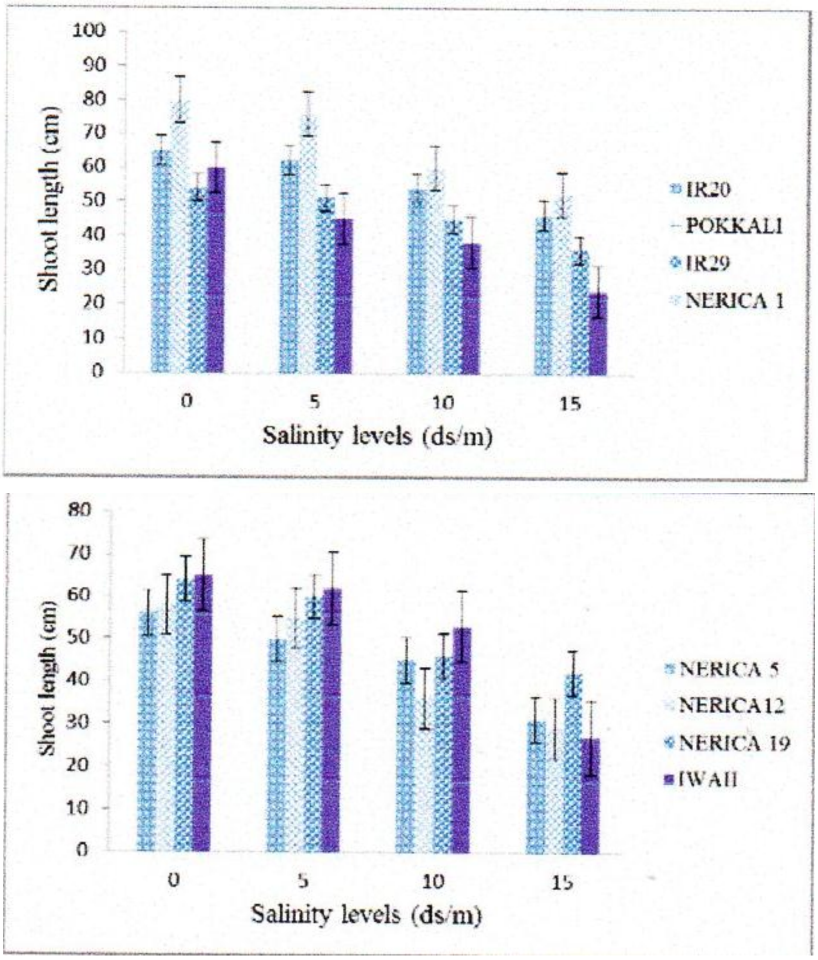

Figure 1: Effect of salinity on shoot length (cm) of different rice varieties.

Tab. 4: Effect of salinity on shoot dry weight (g / 5 plants) of different rice varieties.

Variety	Salinity levels (ds m-1)			
	0	5	10	15
'IR20'	0.030^{c}	0.025^{de} (16.7)	0.014^{c} (53.33)	0.008^{c} (73.33)
'POKKALI'	0.067^{a}	0.058^{b} (13.43)	0.032^{a} (52.23)	0.022^{b} (67.16)
'IR29'	0.070^{c}	0.035^{bc} (50)	0.018^{b} (74.28)	0.007^{bc} (90)
'NERICA 1'	0.042^{d}	0.032^{cd} (23.81)	0.012^{cf} (71.42)	0.004^{d} (90.48)
'NERICA 5'	0.038^{a}	0.027^{c} (28.95)	0.016^{de} (57.89)	0.010^{b} (73.68)
NERICA 12'	0.046^{bc}	0034^{b} (26.08)	0.023^{c} (50)	0.012^{a} (69.56)
'NERICA 19'	0.027^{bc}	0.019^{d} (29.63)	0.007^{a}(74.07)	0.002^{bc}(92.6)
'IWALL'	0.045^{b}	0.034^{c} (24.44)	0.016^{de} (64.44)	0.010^{b} (77.78)

Tab. 5: Effect of salinity on root dry weight (g / 5 plant) of different rice varieties.

Variety	Salinity levels (ds m-1)			
	0	5	10	15
'IR20'	0.034^{b}	0.024^{a} (29.41)	0.018^{a} (47.06)	0.008^{c} (76.47)
'POKKALI'	0.076^{a}	0.038^{bc} (50)	0.013^{b} (82.89)	0.009^{b} (88.15)
'IR29'	0.030^{c}	0.024^{c} (20)	0.011^{bc} (63.3)	0.006^{c} (80)
'NERICA 1'	0.027^{b}	0.019^{d} (29.63)	0.009^{d} (66.7)	0.005^{d} (81.5)
'NERICA 5'	0.065^{b}	0.028^{bc} (56.92)	0.008^{b} (87.7)	0.002^{d} (96.9)
NERICA 12'	0.034^{bc}	00.20^{b} (35.48)	0.012b^{c} (61.29)	0.005^{ab} (83.87)
'NERICA 19'	0.018^{bc}	0.014^{bc} (22.22)	0.001^{b}(94.4)	0.00^{d}(100)
'IWALL'	0.034^{b}	0.023^{d} (32.35)	0.014^{bc} (58.83)	0.008^{c} (76.47)

Tab. 6: Effect of salinity on total dry matter production (g / 5 plants) of various rice varieties and their classification on salinity tolerance.

Variety	Salinity levels (ds m^{-1})						
	0	5	10	15	5	10	15
'IR20'	0.034^{b}	0.054^{a}	0.031^{a}	0.010^{c}	T	S	S
'POKKALI'	0.14^{a}	0.09^{b}	0.043^{b}	0.023^{b}	MT	S	S
'IR29'	0.068^{c}	0.05^{bc}	0.028^{bc}	0.038^{d}	T	S	S
'NERICA 1'	0.084^{c}	0.057^{d}	0.052^{d}	0.008^{c}	T	MS	S
'NERICA 5'	0.066^{b}	0.05^{bc}	0.027^{b}	0.012^{d}	MT	MT	S
NERICA 12'	0.106^{bc}	0.057^{b}	0.019^{bc}	0.005^{ab}	MS	MS	S
'NERICA 19'	0.079^{b}	0.06^{bc}	0.036^{b}	0.01^{d}	MT	S	S
'IWALL'	0.08^{b}	0.056^{bc}	0.028^{bc}	0.015^{c}	MT	MS	MS

Look at 'IR 20' and 'IR 29'. At 15 ds m-1, all varieties except 'NERICA 1' are susceptible to salinity. Hakim *et al*.[19] had previously reported all varieties to be susceptible at 16ds m-1. Fageria.[30] classified rice cultivars based on their percentage decrease in yield, they observed that at the salinity level of 5 ds m-1, almost all eight cultivars were tolerant, while at 15 ds m-1, all varieties were susceptible and at 10 ds m-1, the cultivars were show between tolerances.

CONCLUSION

Increasing salt concentration can inhibit the growth of several rice varieties, both in germination and in nurseries because of the presence of salinity in the soil.

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