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Effect of sodicity on growth and yield, of susceptible and tolerant rice varieties under sodic soil

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Abstract
The investigation entitled "Effect of sodicity on growth and yield, of susceptible and tolerant rice varieties under sodic soil " was conducted during the *kharif* season in 2015 at the experimental site of Department of Crop Physiology at Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad-224 229 (U.P.) in randomized block design with three replications and eight varieties, four tolerant (CSR36, CSR43, Narendra Usar 3, NDR 2009) and four susceptible (Swarna sub 1, IR28, IR64, IR29). Evaluate the performance of tolerant varieties and susceptible varieties in sodic soil. Observations were recorded at 60, 90 DAT and maturity. Results indicate the morphological characters such as plant height, numbers of tillers, dry biomass, relative water content and phenology was increased in tolerant varieties and decrease in susceptible varieties. Tolerant varieties showed better grain yield and yield traits as compared to susceptible varieties. CSR36 and CSR43 had a greater tolerance to sodic soil than IR64 and IR29.

Keywords: Rice, salinity, RWC, phenology, test weight, grain yield/plant

Introduction
Rice is the monocarpic annual plant belonging to genus *Oryza* of Poaceae family. The genus *Oryza* has 24 species of which, 22 are wild and two species viz., *Oryza sativa* and *Oryza glaberrima* are cultivated. All varieties found in Asia, America and Europe belonging to *Oryza sativa* and varieties found in West Africa belonging to *Oryza glaberrima*, further *Oryza sativa* rice varieties of the world are commonly grouped into three sub species *viz.*, Indica (India), Japonica (Japan) and Javanica (Indonesia). The largest rice cultivars are available at International Rice Research Institute (IRRI), Philippines, with over 100,000 rice accession held in International Rice Gene Bank. The rice (*Oryza sativa* L.) is one of economically important crops in the world (Bajaj and Mohanty, 2005; Harkamal *et al.*, 2007) [7] which is cultivated in 114 countries (FAO, 2004).In India, it is cultivated under varied situation like from below sea level (in Kerala) to about 2000 m altitude (in Himalayan region), from 8^0N latitude (in Kanyakumari) to 35^0 N latitude (in Kashmir), annual rainfall from 2,818 mm (Assam) to 25 mm (Rajasthan). As for as soil is concerned, it can be grown from sandy loam soil to heavy black cotton soils and from normal to saline alkaline soils.

The global production of rice has been estimated to be at the level of 650 million tonnes and the area under rice cultivation is estimated at 156 million hectare. Asia is the leader in rice production accounting for about 90% of the world's production. Over 75% of the world supply is consumed by people in Asian countries and thus is of immense importance to food security of Asia.Uttar Pradesh state is an important rice growing state in the country. The area and production of rice in this state is about 5.94 million hectare and 15.30 million tonnes respectively with an average productivity of 2.57 tonnes per hectare (Anonymous, 2014). Salt-affected soil is one of the serious abiotic stresses that cause reduced plant growth, development and productivity worldwide (Siringam *et al.*, 2011). In Iran, salinity has already become a major deterrent to crop production, including rice. Addition of salts to water lowers it,s osmotic potential, resulting in decreased availability of water to root cells. Salt stress thus exposes the plant to secondary osmotic stress, which implies that all the physiological responses, which are invoked by drought stress, can also be observed in salt stress (Sairam *et al.*, 2002).

Material and Method

The site has sub-humid climate and falls in the Indo-gangetic plains having an alluvial soil and lies between latitude 26.47^0 North and at a longitude 82.12^0 East with an elevation of about 113 meters from sea levels and is subjected to extremes of weather conditions. The (MES) is situated 42 km away from Faizabad. During *Kharif* season of 2015, in randomized block design with three replications and eight varieties, four tolerant (CSR36, CSR43, Narendra Usar 3, NDR 2009) and four susceptible (Swarna sub 1, IR28, IR64, IR29). Evaluate the performance of tolerant varieties and susceptible varieties in sodic soil. Observations were recorded at 60, 90 DAT and maturity. Results indicate the morphological characters such as plant height, numbers of tillers, dry biomass, relative water content and phenology was increased in tolerant varieties and decrease in susceptible varieties. Tolerant varieties showed better grain yield and yield traits as compared to susceptible varieties. CSR36 and CSR43 had a greater tolerance to sodic soil than IR64 and IR29.

Statistical Analysis

Data recorded on various growth and yield attributes were subjected to statistical analysis by Fisher method of analysis of variance (Fisher and Yates 1949).

Results and Discussion

Plant height

The data regarding plant height are presented in Table-1.The perusal of data reveal that plant height progressively increased with the increase of plant age. All the tolerant varieties attained (CSR36, CSR43, Narendra Usar 3, NDR 2009) higher plant height as compared to susceptible varieties (Swarna *sub 1*, IR28, IR64, IR29) at all the stages of observations. However, the maximum plant height was recorded at maturity in case of CSR36 (109.50 cm) followed by CSR43, Narendra Usar 3 and NDR 2009 and the minimum plant height was recorded in IR28 (86 cm).Tolerant varieties CSR36 and NDR 2009 produced significantly higher plant height as compared to all the susceptible varieties at all the stages of observations. Maximum detrimental effect was found on susceptible varieties IR29 and IR64 while minimum on Swarna *sub 1*.

Table 1: Effect of sodicity on plant height (cm) in different varieties of rice at various growth stages

Name of Variety	60 DAT	90 DAT	Maturity
CSR36	80.25	104.25	109.50
CSR43	68.75	90.75	95.75
Narendra Usar 3	71.42	94.00	98.00
NDR 2009	76.39	98.00	104.25
Swarna *sub 1*	70.27	90.25	95.83
IR28	62.17	82.25	86.00
IR64	72.25	92.50	98.90
IR29	65.60	84.50	88.00
SEm±	1.24	1.10	1.23
CD at 5%	3.75	3.34	3.74

Number of tillers per plant

The number of tillers plant^{-1} of different varieties was recorded at various intervals of crop growth under sodic soil. The average value of number of tillers plant^{-1} presented in Table-2. It is evident from the data that all the tolerant varieties produced higher number of tillers plant^{-1} as compared to susceptible varieties at all the stages of observations. However, the maximum Number of tillers plant^{-1} was recorded at maturity in case of CSR36 (10.25) followed by CSR43, Narendra Usar 3 and NDR 2009 and the minimum in IR29 (5.08). However, tolerant varieties CSR36 and CSR43 produced significantly higher Number of tillers plant^{-1} as compared to all the susceptible varieties at all the stages of observations. Maximum detrimental effect was found on susceptible varieties IR29 and IR64 while minimum on Swarna *sub 1*.

Table 2: Effect of sodicity on number of tillers plant^{-1} in different varieties of rice at various growth stages

Name of Variety	60 DAT	90 DAT	Maturity
CSR36	9.58	10.25	10.25
CSR43	8.17	9.08	9.08
Narendra Usar 3	7.97	8.17	8.17
NDR 2009	7.58	8.00	8.00
Swarna *sub 1*	6.62	7.08	6.75
IR28	6.81	7.00	6.67
IR64	5.50	5.83	5.58
IR29	5.00	5.33	5.08
SEm±	0.50	0.90	0.63
CD at 5%	1.44	2.73	1.86

Biomass plant^{-1} (g)

The data regarding dry bio mass plant^{-1} are presented in Table 3. It is evident from the data presented in Table-3. That the dry biomass plant^{-1} progressively increased at all the crop growth stages. The tolerant varieties produced higher dry biomass plant^{-1} as compared to susceptible varieties. The maximum dry biomass plant^{-1} was recorded at maturity in case of CSR36 (17.25 g) followed by CSR43, Narendra Usar 3 and NDR 2009 and the minimum dry biomass plant^{-1} was recorded in susceptible variety IR29 (10.58).Tolerant varieties CSR36 produced significantly higher dry biomass plant^{-1} as compared to all the susceptible varieties at all the stages of observation while rest of tolerant varieties produced significantly higher dry biomass of the plant as compared to all the susceptible varieties except Swarna *sub 1* at maturity stage. Maximum detrimental effect was recorded on susceptible varieties IR29 and IR64 while minimum on Swarna *sub 1*.

Table 3: Effect of sodicity on dry biomass plant^{-1} (g) in different varieties of rice at various growth stages

Name of Variety	60 DAT	90 DAT	Maturity
CSR36	8.00	12.33	17.25
CSR43	7.28	11.25	16.36
Narendra Usar 3	7.17	11.00	16.00
NDR 2009	6.69	9.25	15.25
Swarna *sub 1*	5.41	9.00	14.17
IR28	5.25	8.00	12.83
IR64	4.83	7.86	12.08
IR29	4.00	6.00	10.58
SEm±	0.33	0.69	0.57
CD at 5%	1.00	2.09	1.74

Relative water content (RWC)

The data pertaining relative water content are presented in Table 4. It is clear from the data that relative water content progressively decreased with the increasing plant age. The tolerant varieties produced higher relative water content as compared to susceptible varieties. The maximum relative water content was recorded at 60 DAT in case of CSR36 (78.33%) followed by CSR43, Narendra Usar 3 and NDR 2009 and the minimum relative water content was recorded in susceptible variety IR29 (76.31%). Tolerant variety CSR36

produced significantly higher relative water content as compared to all the susceptible varieties at all the stages of observations. Among all the susceptible varieties IR29 produced lowest relative water content while highest in Swarna *sub 1*.

Table 4: Effect of sodicity on relative water content (%) in leaves of different varieties of rice at various growth stages

Name of Variety	60 DAT	90 DAT
CSR36	87.00	78.33
CSR43	85.90	77.21
Narendra Usar 3	84.80	76.23
NDR 2009	83.70	75.13
Swarna *sub 1*	79.20	72.20
IR28	77.51	69.20
IR64	76.33	68.17
IR29	76.31	66.36
SEm±	0.87	1.26
CD at 5%	2.64	3.82

Phenology

Days to 50% flowering

Data pertaining to days to 50% flowering in tolerant and susceptible varieties are presented in Table-5. It is clear from the table that all tolerant varieties takes more number of day for 50% flowering, which was noted maximum in CSR36 (110 days) followed by CSR43, Narendra Usar 3 and NDR 2009. However, minimum days to 50% flowering were recorded in all the susceptible varieties. Among susceptible varieties, IR29 has flowered very early (93 days) followed by Swarna *sub 1*, IR28, and IR64.

Table 5: Effect of sodicity on days to 50% flowering and days to maturity in different varieties of rice

Name of Variety	Days to 50 % flowering	Days to maturity
CSR36	110	139
CSR43	93	125
Narendra Usar 3	94	124
NDR 2009	97	127
Swarna *sub 1*	88	119
IR28	97	125
IR64	91	121
IR29	93	121

Days taken to maturity

Crop maturity data are presented in Table-11. The perusal of data reveal that all tolerant varieties took maximum days for maturity than the susceptible varieties. Among the tolerant varieties, CSR36 has taken maximum days (139) to mature while minimum in NDR 2009.Among susceptible varieties, maximum duration for maturity was recorded in IR28 and minimum in Swarna *sub 1*.

Panicle length

The data pertaining to panicle length are presented in Table-6. It is evident from the data that sodicity drastically influenced the panicle length of susceptible varieties. All the tolerant rice varieties showed significantly higher panicle length as compared to all the susceptible varieties. However, among the tolerant varieties (CSR36, CSR43, Narendra Usar 3, NDR 2009), maximum panicle length (27.66 cm) was recorded in CSR36 and minimum (23.23 cm) in NDR 2009.Among susceptible varieties (Swarna *sub 1*, IR28, IR64 and IR29) maximum (23.23 cm) panicle length was recorded in Swarna *sub 1*and minimum (20.33) in IR29.

Number of panicles per plant

The data regarding number of panicle plant^{-1} are presented in Table-6. It is evident from the data that there is great variation in number of panicle plant^{-1} among tolerant and susceptible varieties. Tolerant varieties CSR36 and CSR43 produced significantly higher number of panicle plant^{-1} as compared to all the susceptible varieties. The maximum number of panicle plant^{-1} was observed in tolerant variety CSR36 (10.25) and minimum (5.08) in susceptibility variety IR29.

Table 6: Effect of sodicity on panicle length and no. of panicles plant^{-1} in different varieties of rice

Name of Variety	Panicle length (cm)	No. of panicles plant^{-1}
CSR36	27.66	10.25
CSR43	26.52	9.08
Narendra Usar 3	23.81	8.17
NDR 2009	23.23	8.00
Swarna *sub 1*	22.64	6.75
IR28	21.71	6.67
IR64	20.82	5.58
IR29	20.33	5.08
SEm±	0.04	0.63
CD at 5%	0.13	1.86

Number of grains per panicle

The data regarding no. of fertile and sterile grains panicle^{-1} are presented in Table-7.The perusal of table reveal that clear that tolerant varieties (CSR36, CSR43,Narendra Usar 3 and NDR 2009) significantly produced higher no. fertile grains panicle^{-1} as compared to all the susceptible varieties (Swarna *sub 1*, IR28, IR64 and IR29). Maximum number of fertile grains panicle^{-1} was recorded in CSR36 (141) and minimum (70.67) in IR29. However reverse trend was observed in case of no. of sterile grains panicle^{-1} and all the susceptible varieties have significantly higher no. of sterile grain panicle^{-1} in comparison to all the tolerant varieties. Among susceptible varieties, maximum no. of sterile grain panicle^{-1} (46.3) was found in IR64 and minimum (31.7) in IR29.

Table 7: Effect of sodicity on number of fertile, sterile grains panicle^{-1} and grain yield plant^{-1} in different varieties of rice

Name of variety	No. of fertile grains	No. of sterile grains	Grain yield plant^{-1}(g)
CSR36	141.00	21.33	8.17
CSR43	138.63	19.00	7.60
Narendra Usar 3	111.33	10.67	7.22
NDR 2009	90.00	22.00	6.67
Swarna *sub 1*	82.33	33.67	6.08
IR28	86.33	39.50	5.42
IR64	82.27	46.33	5.25
IR29	70.67	31.75	4.08
SEm±	1.48	1.65	0.48
CD at 5%	4.49	5.01	1.16

Grain yield per plant

Data pertaining to grain yield plant^{-1} are presented in Table-7. Tolerant varieties CSR36 and CSR43 showed significantly higher grain yield plant^{-1} as compared to all the susceptible varieties. Maximum grain yield was observed in variety CSR36 (8.17 g) and minimum (4.08 g) grain yield plant^{-1} was recorded in susceptible variety IR29.

Test weight (1000 grain weight)

It is clear from the test weight data presented in Table-8. Highest test weight was recorded in CSR43 (26.23) followed

by CSR36, Narendra usar 3, NDR 2009, Swarna *sub 1*, IR28, IR64 and IR29.

Harvest index (%)

Data pertaining to Harvest index are presented in Table-8. The maximum harvest index was observed in CSR36 (43.92) followed by CSR43, Narendra Usar 3 and NDR 2009. However, less harvest index was recorded in all the susceptible varieties and very minimum harvest index (40.13) was recorded with IR29 followed by IR 64, IR28 and Swarna *sub 1*. Susceptible varieties showed reduction in harvest index than their normal harvest index which they attain in normal soil.

Table 8: Effect of sodicity on test weight and harvest index (%) in different varieties of rice

Name of Variety	Test weight (g)	Harvest index (%)
CSR36	24.30	43.92
CSR43	26.23	43.34
Narendra Usar 3	23.26	43.16
NDR 2009	24.82	43.13
Swarna *sub 1*	24.13	42.29
IR28	25.16	41.20
IR64	25.19	40.67
IR29	24.63	40.13
SEm±	0.08	
CD at 5%	0.23	

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