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Effect of sodic soil on chlorophyll, carbohydrate and starch content in various rice cultivars (*Oryza sativa* L.)

Nikita Nehal, AH Khan, Nitish Sharma, Ankita Singh, Richa Vishwakarma and Anubhuti Singh

Nikita Nehal
Department of Crop Physiology, NDUA&T, Kumarganj, Faizabad, Uttar Pradesh, India

AH Khan
Department of Crop Physiology, NDUA&T, Kumarganj, Faizabad, Uttar Pradesh, India

Nitish Sharma
Department of Crop Physiology, NDUA&T, Kumarganj, Faizabad, Uttar Pradesh, India

Ankita Singh
Department of Plant Physiology, Institute of Agricultural Sciences, BHU, Varanasi, Uttar Pradesh, India

Richa Vishwakarma
KVK, Bharari, Jhansi, Uttar Pradesh, India

Anubhuti Singh
Department of Crop Physiology, NDUA&T, Kumarganj, Faizabad, Uttar Pradesh, India

Abstract
The present investigation was conducted in the net house of Department of Crop Physiology at Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad (U.P.). The experiment was carried out in pot culture in complete randomized block design with three replications and six rice varieties, (Three tolerant varities-CSR 36, CSR 43, Narendra Usar 3) and (Three susceptible-Swarna *Sub* 1, IR 28, IR 29) under sodic soil having pH 8.5-8.6, 9.0-9.1 and 9.5-9.6. Results of the experiments indicated that chlorophyll, carbohydrate and starch content in leaves showed minimum reduction in all the tolerant varieties at pH 9.5 in comparison to susceptible varieties at flowering stage of observation. Tolerant varieties have less accumulation of Na^+ and maintain better level of potassium at higher sodicity levels while, reverse in case of sensitive varieties. CSR 36 and CSR 43 had a greater tolerance to sodic soil than IR 64 and IR 29.

Keywords: Chlorophyll, carbohydrate, starch, rice, salt stress

Introduction
Rice is one of the world's most important cereal crops with exceptional agricultural and economic importance as being a staple food for more than 50% population worldwide and Asian farmers produce more than 90% of the total rice, with two countries India and China, growing more than half of the total crop (IRRI, 2011) [7]. Salinity is one of the most important environmental stress factors limiting plant growth and productivity. Over 20% of the irrigated land and more than 6% of the world's total land are now within the ambit of the salt effects (Mickelbart *et al*., 2015) [10]. In addition, about 1.5 Mha of arable land is lost and $27.5 billion is spent annually due to the salinity problem in the agricultural sector (FAO, 2010; Qadir *et al*., 2014) [5, 16].

Many reports show salt induced reduction in photosynthetic pigments in many plant species such as rice (Cha-um *et al*., 2007). Plants also show the high chlorophyll degradation symptom, chlorosis, as a common morphological and physiological characteristic in response to salt stress (Harinasut *et al*., 2000). Chlorophyll content of salt stressed rice can be described as a function of the leaf sodium content (Yeo & Flowers, 1983) [22]. The response of plants to excess NaCl is complex and involves changes in their morphology, physiology and metabolism (Hilal *et al*., 1998). According to Yeo and Flowers chlorophyll content of salt stressed rice can be described as a function of the leafs sodium content (Yeo and Flowers, 1983) [22]. Sodium chloride accumulation in the leaf laminae reduces net photosynthesis and growth (Yeo *et al*., 1985). Sodium uptake to the rice plant is greater under low than under high air humidity (Asch *et al*., 1997) [2]. The response of transpiration to salt stress under different air humidity levels differs among rice cultivars according to their overall resistance to salinity and their resistance strategy (Asch *et al*., 2000) [3], and also depends on the external salt concentration. The relative leaf chlorophyll content of non stressed field grown rice is lower than moderate salt stressed plants. (Sow *et al*., 1995) [19]. This effect could be due to a reduction in leaf area, which has been discussed as an adaptive strategy of salt-stressed plants to reduce transpiration and thus the uptake of sodium into leaves (Flowers and Yeo, 1989) [6]. The nitrogen concentration per unit leaf area in salt-stressed plants, however, will be higher than in non-stressed plants and thus the net-photosynthesis can also be expected to be higher, at least as long as the sodium accumulation in the leaf blades stays within the limits of the plants tissue tolerance to sodium.

Correspondence
Nikita Nehal
Department of Crop Physiology, NDUA&T, Kumarganj, Faizabad, Uttar Pradesh, India

The accumulation of soluble carbohydrates in plants has been widely reported as a response to salinity or drought, despite a significant decrease in net CO_2 assimilation rate (Murakezy *et al*., 2003). When glycophytes are exposed to high salinity, the increase in soluble sugars contributes up to 50% increase in osmotic potential (Parvaiz and Satyawati, 2008) [13]. Parida *et al*., (2002) [12] reported that carbohydrates such as mono and disaccharides (glucose, fructose, sucrose, fructans) and polysaccharides like starch accumulate under salt stress and play a major role in osmoprotection, osmotic adjustment, carbon storage, and radical scavenging. Parida *et al*., (2002) [12] found that salinity reduced starch and increased reducing and non-reducing sugars in leaves of *Bruguiera parviflora.* In corroboration, Khavari-Nejad and Mostofi (1998) [8] indicated that the contents of soluble sugars and total saccharides are increased significantly, but the starch content was not affected in leaves of tomato.

Starch accumulates in leaves as a temporary reserve form of carbon and is the principal component of dry mass accumulated in mature leaves, whereas sucrose is transported to different organs where it is used by plants. The last step in the photosynthetic production of sucrose is catalysed by the sucrose phosphate synthase (SPS) (Stitt *et al*., 1987 and Krause *et al*., 1998) [20, 9] which converts hexose phosphates to sucrose. Prolonged water stress which limited photosynthesis led also to loss of SPS activity (Vassey *et al*., 1991) [21], whereas in rapidly stressed spinach leaves a stimulation in SPS activity was observed (Quick *et al*., 1989) [17]. Sucrose breakdown inside the tissues is accomplished by acid invertase or sucrose synthase (Pfeiffer and Kutschera, 1996) [14]. Metabolism of sugars is adversely affected in plants growing under saline conditions (Dubey, 1997) [4].

Materials and Methods

The pot experiment was carried out in the net house of Department of Crop Physiology, Narendra Deva University of Agriculture & Technology, Kumarganj, Faizabad (U.P.) during *Kharif* (wet season) 2015 and 2016 under sodic soil, with six different rice varieties *viz*., CSR 36, CSR 43, Narendra Usar Dhan 3 (salt tolerant), IR 28, IR 29 and Swarna *Sub*1 (salt susceptible). The experiment was conducted in earthen pots at 3 pH levels of soil (8.5-8.6, 9.0-9.1, 9.5-9.6). The experiment consisted a total of 18 treatment combinations. The whole experiment was planned under complete randomized block design with three replications. Soils were collected and tested various field of the university and soil having pH 8.5, 9.0 as well as 9.5 were collected upto 15 cm depth (surface soil) and brought to net house of the Department of Crop Physiology. Soils were mashed and sieved to get it well pulverized before filling the pots. Uniform earthen pots of 12 cm diameter and 20 cm depth were used for this study. A small piece of stone along with cotton was put at the hole of the pot in the base for retaining of water in sufficient amount. After that each pot was filled with 8 kg of well pulverized dry soil. Before transplanting of seedling, soil pH of each pot was tested to confirm the pH of the soil.

Thirty five days old seedlings of all the 6 rice varieties were transplanted in earthen pots at 10 places. Ten days after transplanting five plants were maintained in each pot, two seedlings were used for transplanting. Six pots constituted a set for each variety at each pH value. In this way, each replication having 108 pots and treatments were replicated three times. Each pot was irrigated with 1 liter of water at an interval of one day to maintain the proper soil moisture for good growth. Number of panicles plant^{-1} was counted on three tagged plants per replication and their average was taken to express number of panicles plant^{-1}. 1000 grains were counted from the samples of each treatment. These counted grains were weighed and recorded as test weight at 15% moisture level. Chlorophyll content of leaf was directly measured from intact leaves microprocessor based plant efficiency analyzer model: X55/M-PEA. The total soluble sugar content in shoot was estimated by the method of Yemm and Wills (1954). Starch was estimated through following anthrone reagent method, described by Mc Cardy *et al.* (1950).

Results and Discussion

The data regarding total chlorophyll content in leaves are presented in Table 1. The total chlorophyll content increased upto flowering after that it decreased in all the varieties at all the pH levels. At stages of observations, maximum chlorophyll content was found in CSR 36 followed by CSR 43 and Narendra Usar Dhan 3 while IR 29 showed minimum chlorophyll content followed by IR 28 Swarna *Sub* 1. The mean effect of variety and treatment was significant at all the growth stages of observation, whereas, interaction effect was found non-significant at all the growth stages of observations. The reduction in chlorophyll content under sodic soil might be due to the loosened binding between chlorophyll and chloroplast protein (Afria and Normolia, 1999). The results indicate that chlorophyll is highly sensitive to sodicity in susceptible genotypes. Pal *et al.* (2004) stated that salinity could affect chlorophyll concentration in leaves through inhibition of synthesis of chlorophyll or an acceleration of its degradation. Reduction in chlorophyll concentrations may be probably due to inhibitory effect of the accumulated ions of various salts on the biosynthesis of the different chlorophyll fractions. These results are corraborated with findings of Singh and Shrama (2010); Razzaque *et al.*, (2010) and Jamil *et al.*, (2012) in rice.

The data of total soluble sugar in plant is presented in Table-2. The data reveal that total soluble sugar decreased with increase of pH levels at each stage of observation. Under higher pH levels (9.5 and 9.0 pH) less amount of soluble sugar was noted as compared to lower soil pH 8.5 in all the varieties at all the stages of observation. At all the growth stages, maximum soluble sugar in plant was recorded in CSR 36 followed by CSR 43 and Narendra Usar Dhan 3 while minimum was recorded in case of IR 29 followed by IR 28 and Swarna *Sub* 1 at all the growth stages. The mean effect of variety and treatment was significant at each stage of observations, whereas, interaction was found non-significant at all the stages of observations. Reduction in total soluble sugar under sodicity may be due to reduced hydrolysis of reserve polysaccharides or rapid utilization of total soluble sugars. Decrease in sugar content under salt stress has been also reported by Singh *et al.*, (1990) [18]; Prasad (1990) [15], Amer (1999) [1] and Murakeozy *et al*., (2003) [11] in rice.

Data pertaining to starch content of 6 rice cultivars grown at different levels of pH were recorded at various growth stages are presented in Table 3. The critical observations of data reveal that starch content progressively increases with the age of the plant at all the pH levels. However, soil with higher pH significantly reduced starch content in shoot as compared to lower pH value at all the stages in all the varieties. Tolerant varieties show less reduction in starch content in comparison to susceptible varieties. The maximum starch content was found in CSR 36 at all the stages of observation followed by CSR 43 and Narendra Usar Dhan 3, while IR 29 showed a minimum starch content than tolerant varieties followed by IR 28 and Swarna *Sub* 1. The mean effect of variety and treatments as well as the interaction was found significant at all the growth stages. Starch may not play a crucial role in a salt -tolerance mechanism, it was suggested that the ability of plants to partition sugars into starch may help to avoid metabolic alterations by lowering feedback inhibition caused by excess amount of sucrose in cytoplasm (Krapp *et al.*,1995, Pattangul and Thitisaksakul, 2008). Another reason for reduction in starch concentration in plant tissue is the direct effects of decreased CO_2 assimilation caused by reduction in stomatal conductance and chlorophyll contents in plant tissues under salt stress (Moradi and Ismail, 2007). Reduction of starch can be decomposed into smaller units that cause the accumulation of soluble sugars in plant cells (Ashraf and Harris, 2004).

Table 1: Effect of sodicity on chlorophyll content (SPAD value) in leaves of different varieties of rice at flowering stage

pH Variety	8.5	9.0	9.5	Mean
Narendra Usar Dhan 3	14.48	14.10	13.41	14.00
CSR 36	15.38	15.14	14.63	15.05
CSR 43	14.94	14.64	14.05	14.54
Swarna *Sub* 1	13.72	13.22	12.42	13.12
IR 28	13.32	12.71	11.76	12.60
IR 29	12.98	12.23	11.15	12.12
Mean	14.14	13.67	12.90	-
SEm±	V=1.20, T=0.64, V×T =0.55			
CD at 5%	V=2.78, T=0.61, V×T =NS			

Table 2: Effect of sodicity on total soluble sugar (mg g^{-1} dry weight) in shoot of different varieties of rice at flowering stage

pH Variety	8.5	9.0	9.5	Mean
Narendra Usar Dhan 3	123.50	117.77	105.52	115.60
CSR 36	132.32	127.52	118.35	126.06
CSR 43	128.45	122.65	111.68	120.93
Swarna *Sub* 1	117.48	109.54	97.34	108.12
IR 28	110.65	100.62	86.30	99.19
IR 29	107.57	96.40	80.64	94.87
Mean	119.20	112.42	99.97	-
SEm±	V=4.51, T=2.36, V×T =6.88			
CD at 5%	V=13.47, T=8.04, V×T =NS			

Table 3: Effect of sodicity on starch content (mg g^{-1} dry weight) in shoot of different varieties of rice at flowering stage

pH Variety	8.5	9.0	9.5	Mean
Narendra Usar Dhan 3	229.53	221.33	209.54	220.13
CSR 36	242.81	236.38	226.29	235.16
CSR 43	235.34	228.46	217.39	227.06
Swarna *Sub* 1	211.80	202.34	187.44	200.53
IR 28	201.25	190.60	174.48	188.78
IR 29	197.47	185.60	168.45	183.84
Mean	219.70	210.84	197.21	-
SEm±	V=8.47, T=4.33, V×T =11.82			
CD at 5%	V=23.36, T=13.96, V×T =32.35			

References

1. Amer AF. Effect of salinity stress, increasing gradually and suddenly treatments on plant nutrient uptake and content of some carbohydrate practices. Egyptian Journal of Soil Sci. 1999; 1:39 & 14:111-128.
2. Asch F, Dingkuhn M, Dorffling K. Physiological stresses of irrigated rice caused by soil salinity in the Sahel, in In Irrigated Rice in the Sahel*:* Prospects for sustainable development, Miezan KM *et al*., Editors. Côte d'Ivoire, 1997, 247-273.
3. Asch F, Dingkuhn M, Dorffling K. Salinity increases CO_2 assimilation but reduces growth in field-grown, irrigated rice. Plant and Soil 2000; 218:1-10.
4. Dubey RS. Protein synthesis by plants under stressful conditions, in Handbook of Plant and Crop Stress, M. Pessarakli, Editor. Marcel Dekker New York. 1997, 859-875.
5. FAO. Land and Plant Nutrition Management Service. Available at: www.fao.org, 2010.
6. Flowers TJ, Yeo AR. Effects of salinity on plant growth and crop yield, in Environmental Stress in Plants, Cherry JH, Editor. Springer Verlag: Berlin. 1989, 101-119.
7. IRRI. International Rice Research Institute, Philippines. Available from the website: http://www.irri.org. 2011.
8. Khavari-Nejad R, Mostofi Y. Effects of NaCl on photosynthetic pigments saccharides, and chloroplast ultra-structure in leaves of tomato cultivars. Photosynthetica 1998; 35:151-154.
9. Krause KP. Sucrose metabolism in end-stored potato tubers ·with decreased expression of sucrose phosphate synthase. Plant Cell Environ. 1998; 21:285-299.
10. Mickelbart MV, Hasegawa PM, Bailey-Serres J. Genetic mechanisms of abiotic stress tolerance that translate to crop yield stability. Nat. Rev. Genet. 2015; 16:237-251. doi: 10.1038/nrg3901.
11. Murakeozy EP, Nagy Z, Duhaze C, Bouchereau A, Tuba Z. Seasonal changes in the levels of compatible osmolytes in three halophytic saline vegetation in Hungary. J Plant Physiol. 2003; 160:395-401.
12. Parida A, Das A, Das P. NaCl stress causes changes in photosynthetic pigments, proteins, and other metabolic components in the leaves of a true mangrove, *Bruguiera parviflora*, in hydroponic cultures. Journal of Plant Biology. 2002; 45:28-36.
13. Parvaiz A, Satyawati S. Salt stress and phyto-biochemical responses of plants-a review. Plant Soil and Environment. 2008; 54:89-96.
14. Pfeiffer L, Kutschera U. Sucrose metabolism and lipid mobilisation during light induced expansion of sunflower leaves. J Plant Physiol. 1996; 147:553-558.
15. Prasad B. Sodicity induced changes in some of the enzymes of carbohydrate and nitrogen metabolism in rice (*Oryza sativa* L.) genotypes. Thesis Submitted to N.D.U.A.T., Kumarganj, Faizabad (U.P.), 1990.
16. Qadir M, Quillerou E, Nangia V, Murtaza G, Singh M, Thomas RJ *et al.* Economics of salt-induced land degradation and restoration. Nat. Resour. Forum 2014; 38:282-295. doi: 10.1111/1477-8947.12054.
17. Quick P. Short tenn water stress leads to stimulation of sucrose synthesis by activating sucrose phosphate synthase. Planta. 1989; 177:535-546.
18. Singh M, Singh BB, Ram PC. Effect of iso-osmotic levels of salt anf PEG-6000 on sugars, free proline and nitrogen content during early seedling growth of pea (*Pisum sativum* L.). Biology Plant. 1990; 32(3):232-237.
19. Sow T, Asch F, Dingkuhn M. Field-testing of rice plants regenerated from salt- stressed callus cultures, in West Africa Rice Development Association, Annual Report, Côte d'Ivoire, 1995.
20. Stitt M, Huber S, Kerr P. Control of photosynthetic sucrose fonnation, in The Biochemistry of Plants. A

Comprehensive Treatise, Stumpf PK and Conn FE, Editors. Academic Press NewYork. 1987, 327-409.

21. Vassey TL. Water stress carbon dioxide and light effects on sucrose-phosphate synthase activity in *Phaseolus vulgaris*. Physiologia plantarum. 1991; 81(1):37-44.
22. Yeo AR, Flowers TJ. Varietal differences of sodium ions in rice leaves. Physiol. Plant 1983; 59:189-195.
23. Yeo AR, Caporn JM, Flowers TJ. The effect of salinity on photosynthesis in rice (*Oryza sativa* L.): Gas exchange of individual leaves in relation to their salt content. J Exp. Bot. 1985; 36:1240-1248.