Effect of Salt Stress on the Pigment Content and Yield of Different Rice (*Oryza sativa* L.) Genotypes

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Article History

Manuscript No. 384
Received in 8th March, 2013
Received in revised form 5th August, 2013
Accepted in final form 18th August, 2013

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Keywords

Rice, anthocyanin, carotenoid, chlorophyll, salinity, yield

Abstract

A pot experiment was conducted at Institute of Agriculture, Visva-Bharati, Sriniketan during 2009 and 2010 to study the effect of salt stress on the pigment content and yield of different rice (*oryza sativa* L.) genotypes. The effect of induced salinity stress was studied on the pigment content of different rice genotypes like CSR-4, Canning-7, IR-29 and IR-64 under control and two levels of salinity (S_1=40+20+20 mmol l^{-1} and S_2=60+30+30 mmol l^{-1} of NaCl, Na_2SO_4 and $CaCl_2$ respectively) in a pot experiment with complete randomized design. The experimental findings revealed that salinity stress decreased chlorophyll a, chlorophyll b, total chlorophyll and carotenoid content but increased the anthocyanin content in leaves of all the genotypes. The decrease in chlorophyll a, chlorophyll b, total chlorophyll and carotenoid content of leaves were more in IR-29 as compared to more tolerant genotypes CSR-4 and Canning-7. Grain yield also followed a similar trend. The tolerant cultivars Canning-7 and CSR-4 recorded significantly higher chlorophyll and carotenoid content as compared to the sensitive variety IR-29. The result further revealed that the grain yield of different rice genotypes under salt stress condition was positively correlated with chlorophyll and carotenoid content but negatively related to anthocyanin content of leaves.

1. Introduction

Salinity is a major hindrance to crop production in arid and semiarid tropics. Among different abiotic stresses affecting crop yield, salinity is a major cause of yield decline in rice growing areas worldwide. In India about 8.6 mha (Pataki, 2000) is affected by soil salinity. Rice is affected differentially by salinity in almost all growth stages (Akbar,1986). Salt stress is reported to have detrimental effect not only on growth and development but also on physiological processes like photosynthesis, respiration and protein synthesis in sensitive species. Salt stress is also known to affect the pigment composition of the plants like chlorophyll, carotenoids and anthocyanin content. These pigments have significant role in regulating the growth and productivity of different crops (Ali et al., 2004). The present investigation was conducted to study the effect of salt stress on the pigment content and yield of different rice (*Oryza sativa* L.) genotypes of sensitive and tolerant types. An attempt has also been made to correlate the pigment contents of rice with the grain yield of different genotypes of rice under salinity stress.

2. Material and Methods

A pot experiment was conducted at Institute of Agriculture, Visva-Bharati, Sriniketan during *kharif* season of 2009 and 2010 to study the effect of salt stress on the pigment content and yield of different rice (*Oryza sativa* L.) genotypes. The rice genotypes CSR-4, Canning-7, IR-29 and IR-64 were treated with two levels of salinity (S_1=40+20+20 mmol l^{-1} and S_2=60+30+30 mmol l^{-1} of NaCl, Na_2SO_4 and $CaCl_2$ respectively) along with control. The experiment was conducted in pots of 25 cm inner diameter and 30 cm height. The experiment was laid out in CRD design with three replications having 36 pots. Actual salinity levels were determined at three stages (seedling, tillering and flowering) and the mean values were expressed in ECe (dSm^{-1}). Chlorophyll content were measured adopting the method of Hiscox and Israelstam (1979), using Dimethyl sulfoxide (DMSO). Carotenoids content of leaves was calculated according to the method of Lichtenthaler and Wellburn (1983). The chlorophyll as well as carotenoids content were estimated by using the formula given by Arnon (1949) and expressed as mg g^{-1} of fresh leaf. Anthocyanin contents were determined using the method of Mancinelli et al. (1975) and was determined using the formula, $A=A_{530}-(1/3A_{657})$.

The biochemical parameters like chlorophyll, carotenoids and anthocyanin content in leaves were measured at tillering (30 DAT) and flowering (60 DAT), whereas yield of the crop was recorded at maturity.

3. Result and Discussion

The experimental findings (Table 1 and 2; Figure. 1 ,2 and 3) revealed that salinity stress decreased chlorophyll a, chlorophyll b, total chlorophyll and carotenoid content but increased the anthocyanin content in leaves of all the genotypes in both the seasons. Salt stress induced decrease in chlorophyll and carotenoids content was also reported by Sairam et al. (2002). Increase in anthocyanin content of leaves under salt stress was also reported by Chutipaijit et al. (2011). Anthocyanin is known to play important role in amelioration of environmental stresses (Chalker-Scott,1999). The pigment content of different

Table 1: Effect of salt stress on pigment content (chlorophyll, carotenoids and anthocyanin) and yield of different rice genotypes in *kharif* season of 2009

Treatments	Pigment content						Yield hill^{-1} (g)
Variety	Total Chlorophyll (mg g^{-1} fresh wt.)		Carotenoids (mg g^{-1})		Anthocyanin (ΔOD)		
	30 DAT	60 DAT	30 DAT	60 DAT	30 DAT	60 DAT	
Canning-7	2.345	2.570	0.284	0.352	0.022	0.024	14.7
CSR-4	2.483	2.726	0.301	0.380	0.027	0.028	16.6
IR 64	2.241	2.471	0.260	0.322	0.016	0.020	16.8
IR 29	2.087	2.294	0.233	0.301	0.013	0.016	14.4
SEm±	0.042	0.042	0.008	0.007	0.001	0.0007	0.349
CD*	0.122	0.124	0.024	0.021	0.003	0.002	1.02
Salinity level							
S_0	2.593	2.880	0.301	0.387	0.012	0.015	22.3
S_1	2.241	2.484	0.256	0.336	0.019	0.022	14.5
S_2	2.032	2.181	0.251	0.294	0.027	0.029	10.0
SEm±	0.036	0.037	0.007	0.006	0.001	0.0006	0.302
CD (p=0.05)	0.106	0.107	0.021	0.018	0.003	0.002	0.88

Table 2: Effect of salt stress on pigment content (chlorophyll, carotenoids and anthocyanin) and yield of different rice genotypes in *kharif* season of 2010

Treatments	Pigment content						Yield hill (g)
Variety	Total Chlorophyll (mg g^{-1} fresh wt.)		Carotenoids (mg g^{-1})		Anthocyanin (ΔOD)		
	30 DAT	60 DAT	30 DAT	60 DAT	30 DAT	60 DAT	
Canning-7	1.969	2.309	0.252	0.332	0.022	0.023	13.6
CSR-4	2.106	2.418	0.269	0.357	0.025	0.027	15.0
IR 64	1.779	2.166	0.235	0.308	0.018	0.019	15.0
IR 29	1.663	2.087	0.211	0.288	0.015	0.017	12.9
SEm±	0.036	0.036	0.008	0.009	0.0004	0.0005	0.239
CD	0.105	0.104	0.022	0.025	0.0012	0.0016	0.70
Salinity level							
S_0	2.144	2.548	0.277	0.369	0.013	0.015	21.2
S_1	1.813	2.229	0.230	0.312	0.020	0.022	12.7
S_2	1.681	1.957	0.218	0.282	0.026	0.029	8.4
SEm±	0.031	0.031	0.007	0.008	0.0003	0.0004	0.207
CD (p=0.05)	0.091	0.090	0.020	0.022	0.0009	0.0012	0.60

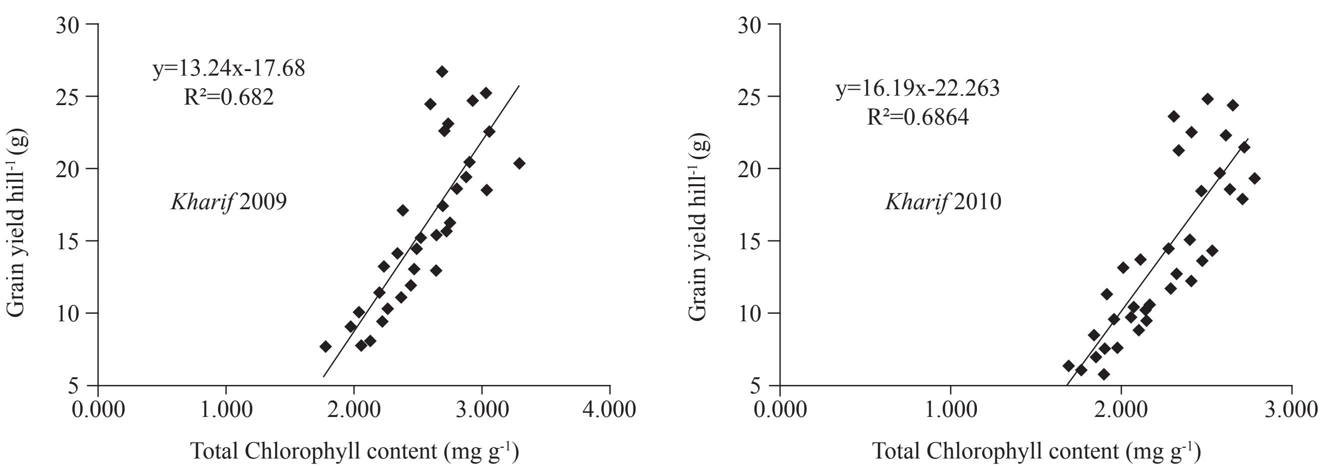

Figure 1: Correlation between total chlorophyll content of leaves (mg g^{-1} fresh wt.) and grain yield hill^{-1} (g) of different genotypes of rice in the *kharif* season of 2009 and 2010, respectively

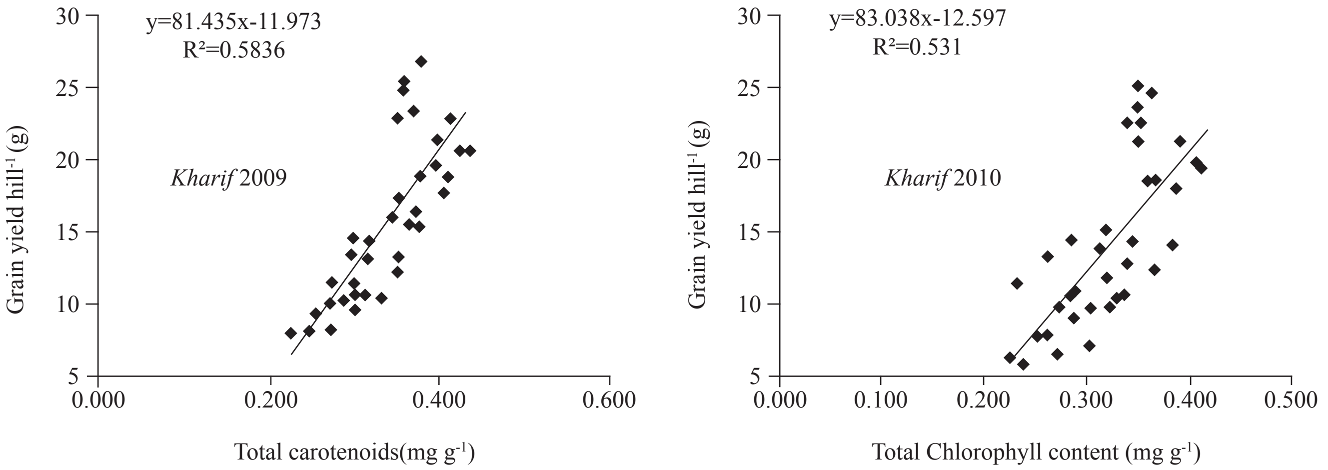

Figure 2: Correlation between total carotenoid content of leaves (mg g^{-1} fresh wt.) and grain yield hill^{-1} (g) of different genotypes of rice in the *kharif* season of 2009 and 2010, respectively

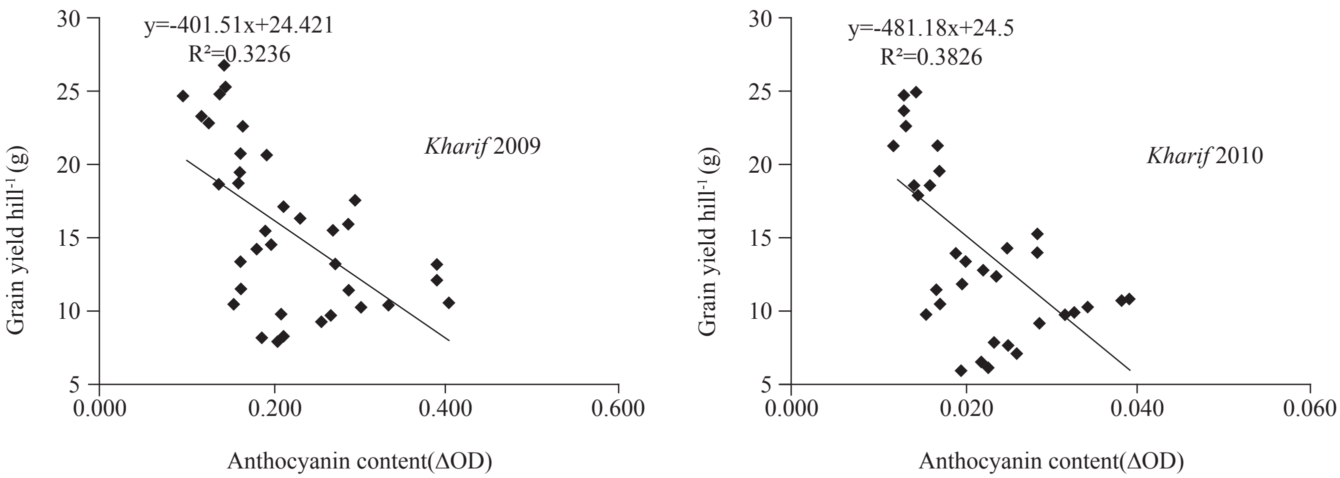

Figure 3: Correlation between anthocyanin content of leaves (ΔOD) and grain yield hill^{-1} (g) of different genotypes of rice in the *kharif* season of 2009 and 2010, respectively

genotypes of rice varied significantly. The tolerant genotypes viz. Canning-7 and CSR-4 recorded significantly higher chlorophyll, carotenoid and anthocyanin content as compared to the sensitive variety IR-29. The interaction effect of salt stress and genotypes on grain yield was significant (Figure 4). Canning7 and CSR-4 genotypes performed better in terms of grain yield hill^{-1} as compared IR29 under different levels of induced salinity.

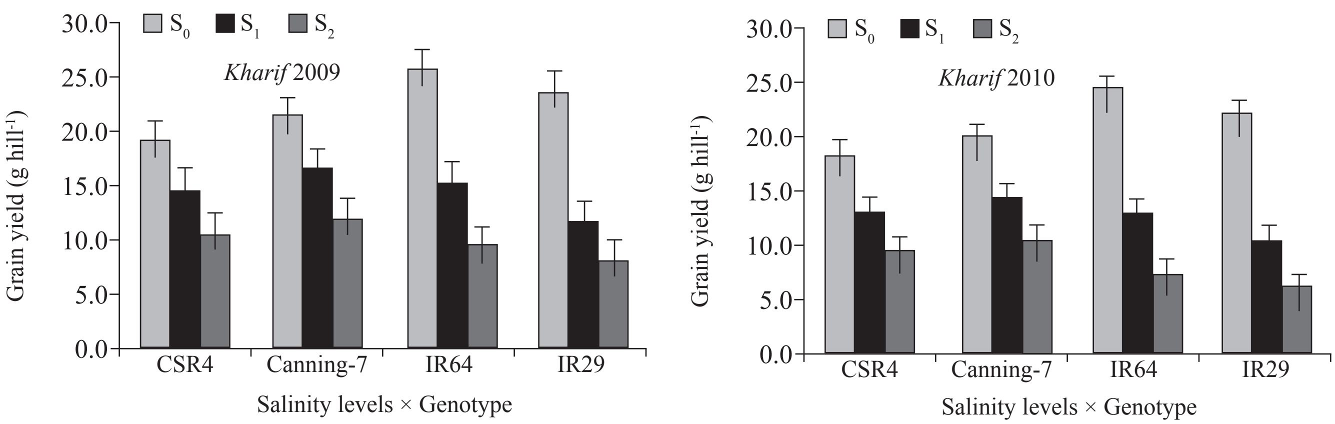

Figure 4: Interaction effect of salt stress and genotypes on the grain yield of rice in *kharif* 2009 and 2010, respectively

The correlation between grain yield and chlorophyll and carotenoids content of leaves was found to be significant in both the seasons. The yield showed a strong positive correlation with total chlorophyll and carotenoid content in leaves of rice genotypes. This shows a very vital role of these pigments in photosynthesis and grain yield. Decrease in yield could be attributed to decrease in assimilation of dry matter by lower rate of photosynthesis under salt stress. The salinity tolerance of different genotypes of rice as manifested by higher grain yield in tolerant genotypes under salt stress condition was found to be positively correlated with chlorophyll and carotenoid content and negatively correlated with anthocyanin content of leaves.

4. Conclusion

The foregoing discussion established that the tolerant genotypes viz. Canning-7 and CSR-4 recorded significantly higher chlorophyll, carotenoid and anthocyanin content besides recording higher grain yield as compared IR-29 under different levels of induced salinity. Strong positive correlation was observed between yield and total chlorophyll and carotenoid content in leaves of rice genotypes.

5. References

Akbar, M., 1986. Breeding for salinity resistance in rice. In: Ahmed, R.A.S., Pietro (Eds.), Prospects for bio-saline research, Department of Botany, University of Karachi, Pakistan, 37-55.

Ali, Y., Aslam, Z., Ashraf, M.Y., Tahir, G.R., 2004. Effect of salinity on chlorophyll concentration, leaf area, yield and yield components of rice genotypes grown under saline environment. International Journal of Environmental Science and Technology 1(3), 221-225

Arnon, D.L., 1949. A copper enzyme is isolated chloroplast polyphenol oxidase in *Beta vulgaris*. Plant Physiology 24,1-15.

Chalker-Scott, L., 1999. Environmental significance of anthocyanins in plant stress responses. Photochemical Photobiology 70, 1-9.

Chutipaijit, S., Cha-um, S., Sompornpailin, K., 2011. High contents of proline and anthocyanin increase protective response to salinity in *Oryza sativa* L. indica. Australian Journal of Crop Science 5(10), 1191-1198.

Hiscox, J.D., Isrealstam, G.F., 1979. A method for the extraction of chlorophyll from leaf tissue without maceration. Canadian Journal of Botany 57, 1332-1334.

Linchtenthaler, H.K., Wellburn, W.R., 1983. Determination of carotenoids and chlorophylls 'a' and 'b' of leaf extracts in different solvents. Biochemical Society Transactions 11, 591-592.

Mancinelli, A.L.,Yang, C.H., Lindquist, P., Anderson, O.R., Rabino, I., 1975. Photocontrol of Anthocyanin Synthesis III. The Action of Streptomycin on the Synthesis of Chlorophyll and Anthocyanin. Plant Physiology 55(2), 251-257.

Pathak, P.S., 2000. Agroforestry: A tool for arresting land degradation. Indian Farming 49, 15-19.

Sairam, R.K., Veerabhadra Rao, K., Srivastava, G.C., 2002. Differential response of wheat genotypes to long term salinity stress in relation to oxidative stress, antioxidant activity and osmolyte concentration. Plant Science 163, 1037-1046.