Table 4. Estimates of correlation coefficients between different characters in rice genotypes under irrigated condition (IC) and reproductive stage drought stress condition (RSS).

Characters	Situation	PH	Biomass	RWC	PC	SPC	LR	LD	ST	SRR	HI	GY
PH	IC		0.311*	0.114	-0.225	0.110	----	----	-0.081	---	0.071	0.159
	RSS		0.218	0.073	-0.187	0.093	0.165	0.208	0.104	0.073	0.038	0.106
Biomass	IC			0.345*	0.289*	0.296*	----	----	-0.059	---	-0.096	0.297*
	RSS			0.419*	0.367**	0.351*	-0.281*	- 0.324*	0.172	0.237	-0.077	0.327*
RWC	IC				0.239	0.303*	----	----	0.104	---	0.187	0.341*
	RSS				0.341*	0.381*	-0.359**	-0.377**	-0.254*	0.261	0.205	0.428**
Proline content	IC					0.219	----	----	-0.134	---	0.057	0.311**
	RSS					0.294*	0. 411*	0. 457*	-0.165	0.197	0.226	0.386**
Soluble protein content	IC						---	---	-0.267	---	0.119	0.274*
	RSS						-0.234	0.176	-0.302*	0.106	0.245	0.337**
LR	IC							---	---	---	---	---
	RSS							0.385*	0.255	0.059	-0.303*	-0.417**
LD	IC								---	---	---	---
	RSS								0.327*	0.117	-0.284*	-0.388*
ST	IC									---	-0.196	-0.142
	RSS									-0.266*	-0.207*	-0.327**
SRR	IC										----	----
	RSS										0.241	0.309*
HI	IC											0.362*
	RSS											0.451**

IC (irrigated condition), RSS (reproductive stage drought stress condition), PH (Plant Height), RWC (relative water content), PC (proline content), SPC (soluble protein content), LR (Leaf rolling), LD (Leaf drying) ST(Sterility %), SRR (Stress recovery rate) HI(Harvest index) and GY(Grain Yield (t ha^{-1}) *- significant at 5%, **- significant at 1%

reported the similar kind of results for proline content in rice under water stress condition.

Relationship between yield and yield attributes under moisture stress (drought) and non-stress (irrigated) condition

In this study, inter-relationship between grain yield and its contributing traits were determined by correlation matrix. Grain yield was significantly and positively correlated with harvest index, biomass and test weight under both drought stress and non-stress irrigated condition (Table 4). Girish *et al.,* (2006) and Murthy et al., (2011) also found significant and positive correlation between grain yield and panicle number and effective tiller number. Grain yield was found to be significantly and negatively correlated with leaf rolling, leaf drying and spikelet sterility under drought stress condition. Drought related parameter leaf rolling and leaf drying is significantly and negative correlated with RWC and plant biomass whereas positively correlated with proline content (Table 4). Stress recovery rate was negatively correlated with spikelet sterility. Significant positive correlations was also observed between proline content, soluble protein content and relative water content with grain yield under reproductive stage water stress condition. Beena *et al.,* (2012) also found significant and positive correlations between proline content, soluble protein content, chlorophyll stability index, stress recovery and relative water content with biomass under drought stress.

From this study, it was concluded that moisture stress imposed during reproductive stage significantly reduced rice yield in all genotypes. The differential responses of genotypes to imposed water stress condition indicate the drought tolerance ability of rice genotypes. This study also indicated that selection based on drought tolerance indices DTE, SSI, STI and TOL will results in the identification of drought tolerant genotypes with significantly superior and stable performance of yield and yield attributes physiological and biochemical traits over current cultivated varieties under water stress condition in rain-fed lowland drought prone ecosystem. IR 84895-B-B-127-CRA-5-1-1, IR83387-B-B-40-1, IR 83376-B-B-24-2, IR83373-B-B-24-3 and IR55419-04 showed high DTE and STI values and low SSI and TOL values, identified as high yielding drought tolerant genotypes. They showed highest yield under normal irrigated condition and good yield under drought condition through better maintenance of desired physiological and biochemical activities under drought stress situation. These drought tolerant rice genotypes can be adopted in large area in rain-fed lowland ecosystem where drought is frequent, particularly during reproductive stage.

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REFERENCES

Ahmad R, Quadir S, Ahmad N, Shah KH (2003). Yield potential and stability of nine wheat varieties under water stress conditions, *Int. J. Agric. Biol*. 5 (1): 7-9.

Ahmad R, Stark JC, Tanveer A, Mustafa T (1999). Yield potential and stability indices as methods to evaluate spring wheat genotypes under drought. *Agric. Sci*. 4: 53–9.

Basnayake J, Ouk M, Thun V, Kang S, Pith KH, Fukai S, Men S, Fisher K (2004). Measurement and management of genotype-environment interaction (GXE) for the improvement of rain-fed lowland rice yield in Cambodia. In Proceeding for the 4th International Crop Science Congress, Brisbane, Australia, 26 September-1 October, p. 239. http://www.cropscience.org.au.

Bates LS, Waldren RP, Teak TD (1973). Rapid determination of free proline for water stress studies. *Plant Soil,* 39:205-207.

Beena R, Thandapani, Chandrababu R (2012). Physio-morphological and biochemical characterization of selected recombinant inbred lines of rice for drought resistance. *Indian J. Plant Physiol*. 17(2): 189-193.

Blum A (1989). Osmotic adjustment and growth of barley cultivars under drought stress. *Crop Sci.* 29: 230-233.

Blum A (2002). Drought tolerance-is a complex trait. In: Field screening for drought tolerance in

crop plants with emphasis of rice. Saxena, N.P. and O'Toole, J.C. (ed.), pp. 17-22. ICRISAT, Patancheru, India.

Blum A, Mayer J, Golan G, Sinmera B (1999). Drought tolerance of a doubled- haploid line population of rice in the field. In: Genetic improvement of rice for water limited environment. Ito, P., O'Toole, J.C. and Hardy, B. (ed.). IRRI, pp. 319-330.

Chauhan JS, Tyagi MK, Kumar A, Nashaat NI, Singh M, Singh NB, Jakhar ML, Welham SJ (2007). Drought effects on yield and its components in Indian mustard (*Brassica juncea* L.). *Plant Breeding* 126: 399-402

Fernandez GCJ (1992). Effective selection criteria for assessing plant stress tolerance. In: Kus EG (ed) Adaptation of Food Crop Temperature and Water Stress. Proceeding of 4th International Symposium, Asian Vegetable and Research and Development Center, Shantana, Taiwan, pp 257–270.

Fischer KS, Wood G (1981). Breeding and selection for drought tolerance in tropical maize. In: Proc. Symp. on Principles and Methods in Crop Improvement for Drought Resistance with Emphasis on Rice, IRRI, Philippines.

Fischer RA, Maurer R (1978). Drought resistance in spring wheat cultivars. I. Grain yield responses in spring wheat. *Australian. J. Agric. Sci*. 29: 892-912.

Garrity DP, Toole J**C (**1994). Screening rice for drought resistance at the reproductive phase. *Field Crop Res*. 39:99-110.

Girish TN, Gireesha TM, Vaishali MG, Hanamareddy BG, Hittalmani S (2006). Response of a new IR50/Moroberekan recombinant inbred population of rice (Oryzasativa L.) from an indica x japonica cross for growth and yield traits under aerobic situations. *Euphytica* 152: 149-161.

Gloria CS, Ito O, Alejar AA (2002). Physiological evaluation of responses of rice (*Oryza sativa* L.) to water deficit. *Plant Sci*. 163:815-827.

Gowri S (2005). Physiological studies on aerobic rice (*Oryza sativa* L.). M.Sc., thesis submitted to Tamil Nadu Agricultural University, Coimbatore, India.

Gupta R, Guhey A (2011). Responses of rice genotypes to water stress imposed at early seedling stage. *Oryza* 48(4), 366-369

Hirasawa T, Ozawa S, Tayraran RD, and Ookawa T (2010). Varietal differences in photosynthetic rates in rice plants with special reference to the nitrogen content of leaves. *Plant Prod. Sci.* 13: 53-57.

Hiscox JD, Israelstam GF (1979). A method for the extraction of chlorophyll from leaf tissue without maceration. *Can. J. Bot*. 57: 1332-1334.

Hossain ABS, Sears AG, Cox TS, Paulsen GM (1999). Desiccation tolerance and its relationship to assimilate partitioning in winter wheat. *Crop Sci* 30: 622–627

Huke RE, Huke EH (1997). Rice Area by Type of Culture: South, Southeast and East Asia. International Rice Research Institute, Los Banos, Philippines.

International Rice Rrsearch Institute (1996). Standard Evaluation System for Rice, International Rice Research Institute, Los Banos, The Philippines, 4th Edn.

IRRI (2009). Rough rice production by country and geographical region-USDA. Trend in the rice economy. In: world rice statistics. www.irri.org/science/ricestat

Jha BN, Singh RA (1997). Physiological responses of rice varieties to different levels of moisture stress. *Indian J. Plant Physiol*. 2: 81-84.

Jiang MY, Jing JM, Wang ST (1992). Effect of osmotic stress on membrane lipid peroxidation and endogenous protective systems in rice seedlings. *Acta Phtophysiol. Sinica*. 17: 80-84.

Kamoshita A, Babu RC, Boopathi NM, Fukai S (2008). Phenotypic and genotypic analysis of drought-resistance traits for development of rice cultivars adapted to rain-fed environments. *Field Crop Res*. 109: 1-23

Kumar A, Verulkar S, Dixit S, Chauhan B, Bernier J, Venuprasad R, Zhao D, Shrivastava MN (2009). Yield and yield-attributing traits of rice (*Oryza sativa* L.) under lowland drought and suitability of early vigour as a selection criterion. *Field Crop Res.* 114: 99-107.

Lowry OH, Rosenbergh NH, Farr AL, Randall RJ (1951). Protein measurement with folin-phenol reagent. *J. Biol. Chem.* 193:263-275.

Maclean JL, Dawe DC, Hardy B, Hettel GP (eds.) (2002). *Rice almanac* (third Edition), Philippines, IRRI, WARDS, CIAT and FAO.

Madhusudan KV, Giridharakumar S, Ranganayakulu GS, Reddy PC, Sudhakar C (2002). Effect of water stress on some physiological responses in two groundnut (*Arachis hypogea* L.) cultivars with contrasting drought tolerance. *J. Plant Biol*. 29: 199-202.

Maibangasa S (1998). Morpho-physiological, biochemical and molecular mechanisms of water stress tolerance in rice (*Oryza sativa* L.). Ph.D. Thesis, Tamil Nadu Agricultural University, Coimbatore, India.

Mohan MM, Laxmi NS, Ibrahim SM (2000). Chlorophyll stability index (CSI): its impact on salt tolerance in rice. *International Rice Research Notes***,** 25: 38-39.

Murthy KBC, Kumar A, Hittalmani S (2011). Response of rice (*Oryza sativa* L.) genotypes under aerobic situations. *Electronic Journal of Plant Breeding.* 2(2): 194-199.

Ouk M, Basnayake J, Tsubo M, Fukai S, Fischer KS, Cooper M, Nesbitt H (2006). Use of drought response index for identification of drought tolerant genotypes in rain-fed lowland rice. *Field Crop Res.* 99: 48-58.

Pandey S, Bhandari H (2008). Drought: economic costs and research implications. In: Seeraj, R. Bennet, J, Hardy,B.(eds.), Drought frontiers in rice: crop improvement for increased rain-fed production. World Scientific publishing, Singapore, p.3-17.

Pinter Jr PJG, Zipoli RJ, Reginato RD, Jackson, Idso SB Idso (1990). Canopy temperature as an indicator of differential water use and yield performance among wheat cultivars. *Agric. Water Manag*. 18: 35– 48.

Praba ML, Cairns JE, Babu RC, Lafitee HR (2009). Identification of physiological traits underlying cultivar differences in drought tolerance in rice and wheat. *J. Biol. Sci.* **7**: 841-847.

Prakash V (2007). Screening of wheat (*Triticum aestivum* L.) genotypes under limited moisture and heat stress environments. *Indian J. Genet*. 67 (1): 31-33.

Puri RR, Khadka K, Paudyal A (2010). Separating climate resilient crops through screening of drought tolerant rice land races in Nepal. *Agronomy Journal of Nepal. 1: 80*-84.

Raman A, Verulkar S, Mandal NP, Varrier M, Shukla VD, Dwivedi JL, Singh BN, Singh ON, Swain P, Mall AK, Robin S, Chandrababu R, Jain A, Ram TR, Hittalmani S, Haefele S, Piepho HS, Kumar A (2012). Drought yield index to select high yielding rice lines under different drought stress severities. *Rice*: 5(31): 1-12.

Rosielle AA, Hamblin J (1981). Theoretical aspects of selection for yield in stress and non-stress environment. *Crop Sci.* 21: 943–946

Singh BU, Rao KV, Sharma HC (2011). Comparison of selection indices to identify sorghum genotypes resistant to the spotted stemborer Chilo partellus (Lepidoptera: Noctuidae). *Int. J. Trop. Insect Sci*. 31:38–51.

Singh S, Singh TN (2000). Morphological, chemical and environmental factor affecting leaf rolling in rice during water stress. Indian J Plant Physiol., 5: 136-141.

Slafer GA, Araus JL, Roya C, Del Moral LFG (2005). Promising eco-physiological traits for genetic improvement of cereals in Mediterranean environments. *Ann. App. Biol*. 146: 61-70.

Talebi R, Fayaz F, Naji AM (2009). Effective selection criteria for assessing drought stress tolerance in durum wheat (Triticum Durum Desf.). *Gen. Appl. Plant. Physiol*. 35: 64-74.

Weatherley PE (1950). Studies in water relation of cotton plants. The field measurement of water deficit in leaves. *New Phytology,* 49: 81-87.

Zaharieva M, Gaulin E, Havaux M, Acevedo E, Monneveux P (2001). Drought and heat responses in the wild wheat relative. Aegilops geniculata Roth. *Crop Sci*. 41: 1321-1329.