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Correlation and Path Analysis of Yield Components in Rice (*Oryza sativa* L.) under Irrigated and Reproductive Stage Drought Stress Condition

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Authors' contributions

This work was carried out in collaboration among all authors. Author SP designed the study, wrote the protocol and wrote the first draft of the manuscript. Author Anand Kumar managed the analyses and edited the first draft of the study. Authors FA and JK performed the statistical analysis. Authors PR and Anil Kumar managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aim: The current experiment was conducted to study correlation and path analysis among morphological traits and their contribution towards yield under irrigated and drought stress condition using forty eight diverse rice genotypes.
Study Design: The experiment was studied in three replications using Randomized Block Design.
Place and Duration of Study: The research was carried out during *Kharif* 2018 at Rice Research Farm, Bihar Agricultural University, Sabour (Bhagalpur), India.
Methodology: The experiment was conducted in two different sets; irrigated and drought stress condition. The yield and yield attributes were recorded under both the conditions to conduct the correlation and path analysis.

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Results: The analysis of variance revealed that genotypes significantly varied in yield and yield related traits. In addition, growth and yield attributes such as effective tillers per hill, biological yield, harvest index (%) and number of fertile grains per panicle were significantly and positively correlated with grain yield per plant under irrigated as well as reproductive stage drought stress condition. It was observed that total number of grains per panicle, number of fertile grains per panicle and biological yield had high positive direct effect on grain yield per plant in both irrigated (control) as well stress condition, indicating true relationship of these characters with grain yield and direct selection for these characters will be rewarding. In rest of the characters studied, correlation was mainly due to indirect effects through component characters and hence indirect selection will lead to yield improvement in rice.

Conclusion: The potential for direct and indirect selection for reproductive stage drought stress tolerance using the associated characters may be useful to the breeder to formulate appropriate breeding plans for the selection of the genotype which tolerate high temperature condition.

Keywords: Correlation; path analysis; direct selection; indirect effects.

1. INTRODUCTION

Rice (*Oryza sativa* L.) is the most important food crop and a primary food source for more than one third of the world's population. Globally rice is grown over an area of about 166 million hectares with an annual production of 770 million tons [1]. Rainfed rice accounts for around 45% of the world's rice area and around 40 million hectares of rainfed area is concentrated in South and South East Asia alone [2]. The speculations about increase in the frequency of drought as well as in the global average surface temperature of 1.1- 6.4°C possess serious threat to rice production and thus, food security of Asia [3]. In India, out of the total 20.7 million ha of rainfed rice area, approximately 16.2 million ha in eastern India, of which 6.3 million ha of upland and 7.3 million ha of lowland area are highly drought prone [4]. Grain yield is a complex trait and influenced by many genetic as well as environmental factors. Therefore, use of direct selection for yield could be misleading. A successful selection depends upon the information on the association of grain yield with morpho-agronomic traits. The inter-relationship between important yield components is best estimated by correlation coupled with path coefficient analysis. Correlation is the mutual relationship between the variables; it helps in determination of the most effective procedures for selecting superior genotypes. In the case of positive correlation between major yield components, breeding strategies would be very effective but on the reverse, selection becomes very difficult. The estimates of correlation coefficients alone may be often misleading due to mutual cancellation of component characters. So, study of correlation along with path analysis is more effective in the study of yield contributing characters. Path coefficient analysis is an important statistical tool for dividing the correlation coefficient into direct and indirect effect of the causal components on the complex component. Considering the above points the present research work was undertaken to study the inter-relationship among yield and yield attributing traits under irrigated and reproductive stage drought stress conditions to reveal the associated characters useful to the breeder in formulating appropriate breeding plans for the selection of the genotype which tolerate high temperature condition.

2. MATERIALS AND METHODS

The present investigation was conducted in *Kharif* season, 2018-19 using forty eight rice genotypes including two checks (Sabour Deep and Sahabagidhan) sown in two environments *i.e.,* irrigated condition and stress condition at rice section, Bihar Agricultural University, Sabour (Bhagalpur), Bihar, India. In the irrigated (control) set of experiment, standing water was maintained from transplanting to 20 days before maturity by supplying water through rain or through supplementary irrigation as and when required. The reproductive stage drought stress experiment was irrigated like the control experiment by allowing standing water up to 28 days after transplanting. Thereafter, the field was drained to enable them to dry for the development of stress. Supplemental irrigation was prohibited in the drought stress experiment. During the reproductive stage stress period soil moisture content was monitored through tensiometer reading. Data were recorded on five randomly and competitive plants of each genotype from each replication for quantitative and physiological characters *viz.,* days to 50% flowering, days to maturity, number of effective tillers per hill, plant height (cm), panicle length (cm), number of fertile grains per panicle, spikelet sterility (%), panicle density index, total number of spikelets per panicle, 1000 grain weight (g), grain yield per plant (g), biological yield (g), harvest index (%), proline content, chlorophyll index, canopy temperature, leaf area, relative water content and root biomass. Data on days to 50 % flowering and days to maturity were recorded on plot basis. The SPAD Chlorophyll Meter Readings (SCMR) was taken at reproductive stage in terms of SPAD value by using SPAD-502 meter (Minolta Konica Co. Ltd., Japan) and chlorophyll index was recorded from the flag leaf in the direction of sun at 1.00 pm. The canopy temperature was recorded at the reproductive stage using infrared thermometer at 1.00 pm in both set of environments.

3. RESULTS

The analysis of variance revealed that there was highly significant variation among the genotypes for the traits studied under both the environments, thus indicated that there was sufficient variability in the material studied under both drought stress and irrigated conditions, which could be utilized in breeding programme. Canopy temperature recorded at the reproductive stage of 48 genotypes in irrigated (control) and stress condition is displayed in Fig. 1.

The phenotypic correlation of different characters in rice genotypes under irrigated and stress conditions are presented in Table 1.

3.1 Correlation Coefficient Analysis under Irrigated Condition

Grain yield per plant showed highly significant and positive association with effective tillers per hill, 1000 grain weight, biological yield, harvest index (%) and significant and positive association with number of fertile grains per panicle, root biomass and chlorophyll index. However, it exhibited highly significant and negative correlation with spikelet sterility (%). Days to 50% flowering showed significant and positive association with days to maturity (0.815**), leaf area (0.175*) and root biomass (0.224**). Days to maturity was found to be significantly and positively associated with leaf area (0.240*), root biomass (0.206*) and chlorophyll index (0.181*). The association of panicle length with proline content (0.169*) and plant height (0.353**) was significant and positive. Number of fertile grains per panicle showed positive and significant association with total number of spikelets per panicle (0.967**), panicle density index (0.885**) and leaf area (0.196*). Number of sterile grains per panicle showed positive and significant association with spikelet sterility % (0.907**), total number of spikelet per panicle (0.377**) and panicle density index (0.290**) whereas significant negative association with root biomass (-0.279**). Total number of spikelets per panicle showed positive and significant association with panicle density index (0.901**) and leaf area (0.202*). Panicle density index showed positive significant association with leaf area (0.228**) and chlorophyll index (0.165*) and negative significant association with root biomass (-0.209*). 1000 grain weight showed positive and significant association with leaf area (0.213*) and root biomass (0.334**), whereas, with proline content (-0.194*), it had negative significant association. Biological yield showed significant and positive association with effective tillers per hill (0.189*), while, significantly negative association with harvest index (-0.353**) and spikelet sterility % (-0.187*). Relative water had positive significant association with proline content (0.280**). Root biomass showed significant positive association with leaf area (0.266**) and significantly negative association with spikelet sterility % (-0.186*).

3.2 Correlation Coefficient Analysis under Drought Stress Condition

Under stress condition, grain yield per plant showed highly significant and positive association with effective tillers per hill, panicle length, biological yield, relative water content, harvest index (%) and significant and positive association with number of fertile grains per panicle, leaf area and proline content. Days to 50% flowering exhibited significant and positive correlation with days to maturity (0.708**) and leaf area (0.184*). Days to maturity showed significant and positive association with leaf area (0.303**) and root biomass (0.186*). Plant height showed significantly positive association (0.246**) with panicle length and significant negative correlation with effective tillers per hill (-0.174*). The association of panicle length was found significant and positive with 1000 grain weight (0.171*), biological yield (0.189*) and relative water content (0.200*), while significant and negative with panicle density index

(-0.455**). Total number of spikelets per panicle (0.928**), panicle density index (0.769**), harvest index % (0.221**), relative water content (0.369**) and proline content (0.236**) had positive significant association with number of fertile grains per panicle. Number of sterile grains per panicle showed significantly positive association with spikelet sterility % (0.901**), total number of spikelet per panicle (0.588**), panicle density index (0.553**) whereas significant negative association with biological yield (-0.208*) and root biomass (-0.311**). Spikelet sterility % showed significantly negative association with 1000 grain weight (-0.184*), biological yield (-0.223**), relative water content (-0.343**), proline content (-0.183*) and root biomass (-0.229**). Total number of spikelets per panicle showed positive significant association with panicle density index (0.854**), harvest index % (0.173*), relative water content (0.243**), and proline content (0.168*). Relative water content (0.379*) and proline content (0.201*) had positive significant association with 1000 grain weight. Biological yield showed significantly negative association with panicle density index (-0.190*) harvest index (-0.375**) and chlorophyll index (-0.228**). Root biomass showed significant positive association with 1000 grain weight (-0.292**) leaf area (0.177*) relative water content (0.176*) and negative significant association with panicle density index (-0.271**).

3.3 Path Coefficient Analysis under Irrigated Condition

Path coefficient analysis (Table 2) revealed that total number of grains per panicle, number of fertile grains per panicle, panicle density index, panicle length, biological yield and harvest index (%) had high positive direct effects on grain yield per plant under irrigated condition. Days to 50% flowering had an indirect positive effect on grain yield per plant via effective tillers per hill, plant height, panicle length, number of fertile grains per panicle, number of sterile grains per panicle, spikelet sterility (%), total number of spikelets per panicle, panicle density index, biological yield and relative water content. Days to maturity, effective tillers per hill, plant height, number of fertile grains per panicle, total number of spikelets per panicle, panicle density index and root biomass had a positive direct effect on grain yield per plant. An indirect positive effect was observed on grain yield per plant by days to maturity via days to 50% flowering, 1000 grain weight, harvest index (%), leaf area, root biomass and chlorophyll index. An indirect positive effect was observed on grain yield per plant by plant height via panicle length, number of fertile grains per panicle, number of sterile grains per panicle, spikelet sterility (%), totalnumber of spikelets per panicle, harvest index (%) and chlorophyll index. An indirect positive effect was observed on grain yield per plant by number of fertile grains per panicle via days to 50% flowering, days to maturity, spikelet sterility (%) and root biomass. An indirect positive effect was observed on grain yield per plant by total number of spikelets per panicle via days to 50% flowering, days to maturity, spikelet sterility (%) and root biomass. An indirect positive effect was observed on grain yield per plant via effective tillers per hill, number of fertile grains per panicle, number of sterile grains per panicle, total number of spikelets per panicle, 1000 grain weight, harvest index%, leaf area, relative water content, proline content and chlorophyll index by panicle density index. An indirect positive effect was observed on grain yield per plant via effective tillers per hill, panicle length, number of fertile grains per panicle, total number of spikelets per panicle, 1000 grain weight, proline content and root biomass by biological yield. An indirect positive effect was imposed by root biomass via days to 50% flowering, days to maturity, effective tillers per hill, 1000 grain weight, biological yield, harvest index (%) and leaf area. Chlorophyll index showed negative direct effect on grain yield per plant. An indirect positive effect was imposed by effective tillers per hill, panicle length, number of sterile grains per panicle, spikelet sterility (%), biological yield, harvest index (%), leaf area and root biomass via chlorophyll index.

3.4 Path Coefficient Analysis under Drought Stress Condition

Total number of grains per panicle, biological yield and number of fertile grains per panicle had high positive direct effects on grain yield per plant in stress condition. Days to maturity, effective tillers per hill, number of fertile grains per panicle, Total number of spikelets per panicle and chlorophyll index had a positive direct effect on grain yield per plant. An indirect positive effect was observed on grain yield per plant by days to maturity via days to 50% flowering, panicle density index, leaf area and root biomass. An indirect positive effect was observed on grain yield per plant via days to 50% flowering, days to maturity, number of sterile grains per panicle, spikelet sterility (%), panicle density index, leaf area, root biomass and chlorophyll index by panicle length. An indirect negative effect was observed by number of fertile grains per panicle via days to 50% flowering, days to maturity, spikelet sterility %, biological yield and chlorophyll index. An indirect positive effect was observed on grain yield per plant by total number of spikelets per panicle via days to 50% flowering, days to maturity, biological yield, root biomass and chlorophyll index. An indirect positive effect on grain yield per plant was observed via days to 50% flowering, plant height, panicle length, 1000 grain weight, biological yield and root biomass by panicle density index. An indirect positive effect on grain yield per plant was observed via effective tillers per hill, panicle length, number of fertile grains per panicle, total number of spikelets per panicle, biological yield, harvest index (%), relative water content, proline content, root biomass and chlorophyll index by 1000 grain weight. Positive indirect effect was observed on grain yield per plant via effective tillers per hill, panicle length, 1000 grain weight, leaf area, relative water content, proline content and root biomass by biological yield. Proline content had indirect positive effect via days to 50% flowering, days to maturity, effective tillers per hill, number of sterile grains per panicle, spikelet sterility (%) and leaf area. Plant height, panicle length, number of fertile grains per panicle, number of sterile grains per panicle, spikelet sterility (%), total number of spikelet per panicle and panicle density index had indirect positive effect on grain yield per plant via root biomass. An indirect positive effect was exhibited by chlorophyll index via effective tillers per hill, number of sterile grains per panicle, spikelet sterility (%), panicle density index, 1000 grain weight, harvest index (%), proline content and root biomass. Plant height and root biomass had a negative direct effect on grain yield per plant in stress condition. An indirect positive effect was observed on grain yield per plant by plant height via days to 50% flowering, days to maturity, effective tillers per hill, panicle density index, 1000 grain weight, biological yield, harvest index, leaf area, relative water content, root biomass and chlorophyll index.

4. DISCUSSION

The present studies suggested the presence of variation among the genotypes for grain yield and yield associated traits which showed differential response to drought stress at reproductive stage. Drought stress at reproductive stage caused significant reduction in plant height, grain yield, relative water content and increase in proline and spikelet sterility percentage in rice genotypes; however, the responses varied among genotypes. The positive correlation of grain yield per plant with 1000 grain weight, number of fertile grains per panicle, effective tillers per hill and chlorophyll index under irrigated condition is in agreement with earlier reports of Kishore et al. [5] Chakravarty and Ghosh [6],

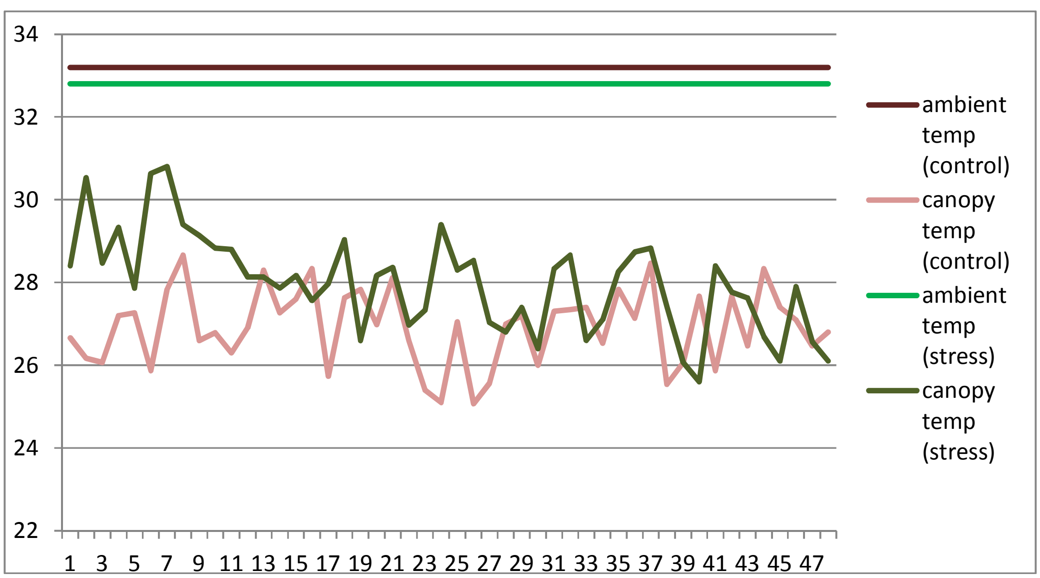

Fig. 1. Analysis of the 48 genotypes of rice under control and reproductive stress drought condition using canopy temperature

Table 1. Phenotypic correlation of different characters in rice genotypes under irrigated (c) and stress (s) conditions

		DFF	DM	EBT	PHT	PL	NFGPP	NSGPP	SS%	TNSPP	PDI	1000 GR WT	BY	H.I %	LA	RWC	PROLINE	RB	CI	GYPP
DFF	c																			-0.03
	s																			-0.003
DM	c	0.815**																		-0.042
	s	0.708**																		-0.02
EBT	c	-0.063	-0.114																	0.418**
	s	-0.123	-0.185*																	0.238**
PHT	c	-0.077	-0.006	-0.325**																-0.069
	s	-0.106	-0.154	-0.174*																-0.141
PL	c	-0.117	-0.071	0.063	0.353**															0.149
	s	-0.169*	-0.219**	0.083	0.246**															0.238**
NFGPP	c	-0.046	-0.054	0.157	0.078	0.029														0.187*
	s	-0.037	-0.037	0.026	0.039	0.103														0.208*
NSGPP	c	-0.188*	-0.155	-0.009	0.092	0.13	0.129													-0.137
	s	-0.201*	-0.147	0.191*	0.034	-0.051	0.245**													-0.187*
SS%	c	-0.145	-0.11	-0.075	0.054	0.1	-0.276**	0.907**												-0.219**
	s	-0.171*	-0.124	0.191*	0.008	-0.111	-0.181*	0.901**												-0.303**
TNSPP	c	-0.091	-0.09	0.144	0.097	0.06	0.967**	0.377**	-0.025											0.139
	s	-0.108	-0.088	0.095	0.045	0.066	0.928**	0.588**	0.194*											0.102
PDI	c	-0.048	-0.065	0.099	-0.052	-0.372**	0.885**	0.290**	-0.067	0.901**										0.069
	s	-0.017	0.032	0.025	-0.071	-0.455**	0.769**	0.553**	0.235**	0.854**										-0.049
1000 GR WT	c	0.004	0.023	0.022	-0.108	-0.180*	0.079	-0.11	-0.126	0.046	0.125									0.230**
	s	-0.02	-0.07	0.151	-0.092	0.171*	0.114	-0.123	-0.184*	0.048	-0.048									0.107
BY	c	-0.0001	-0.103	0.189*	-0.023	0.153	0.106	-0.134	-0.187*	0.064	-0.007	0.046								0.513**
	s	-0.021	-0.053	0.149	-0.023	0.189*	-0.016	-0.208*	-0.223**	-0.093	-0.190*	0.059								0.376**
H.I %	c	0.004	0.027	0.1	0.014	0.003	0.072	-0.01	-0.033	0.065	0.057	0.153	-0.353**							0.340**
	s	0.003	0.001	0.125	-0.115	0.095	0.221**	-0.03	-0.132	0.173*	0.096	0.056	-0.375**							0.712**
LA	c	0.175*	0.240**	0.043	-0.102	-0.109	0.196*	0.07	-0.019	0.202*	0.228**	0.213*	-0.037	0.035						0.1
	s	0.184*	0.303**	-0.041	-0.082	-0.096	0.12	0.075	0.031	0.129	0.16	-0.087	0.046	0.12						0.164*
RWC	c	-0.088	-0.037	0.045	-0.117	0.049	0.078	-0.162	-0.193*	0.031	0.018	0.012	-0.122	0.115	0.161					0.054
	s	-0.023	-0.037	0.028	-0.064	0.200*	0.369**	-0.169*	-0.343**	0.243**	0.111	0.379**	0.158	0.103	0.105					0.228**
PROLINE	c	0.058	-0.04	0.101	-0.193*	0.169*	0.148	-0.102	-0.189*	0.112	0.025	-0.194*	0.085	-0.04	0.034	0.280**				0.062
	s	-0.025	-0.089	-0.003	0.143	0.088	0.236**	-0.077	-0.183*	0.168*	0.092	0.201*	0.053	0.154	-0.066	0.065				0.177*
RB	c	0.224**	0.206*	0.148	-0.256**	-0.052	-0.196*	-0.279**	-0.186*	-0.255**	-0.209*	0.334**	0.013	0.045	0.266**	-0.051	-0.065			0.197*
	s	0.07	0.186*	0.049	-0.162	-0.008	-0.229**	-0.311**	-0.229**	-0.310**	-0.271**	0.292**	0.134	0.013	0.177*	0.176*	-0.002			0.119
CI	c	0.119	0.181*	-0.13	0.062	-0.194*	0.096	-0.024	-0.047	0.084	0.165*	0.016	-0.135	-0.074	-0.009	0.041	0.009	-0.027		0.181*
	s	-0.022	-0.013	0.101	-0.035	-0.158	-0.067	0.033	0.075	-0.043	0.045	0.096	-0.228**	0.023	-0.115	-0.077	0.074	0.07		-0.136

*DFF= days to 50% flowering; DM=days to maturity; EBT= number of effective tillers per hill; PHT= plant height; PL= panicle length; NFGPP= number of fertile grains per panicle; NSGPP= number of sterile grains per panicle; SS%= spikelet sterility %; TNSPP= total number of spikelets per panicle; PDI= panicle density index; GR WT= grain weight; BY= biological yield; HI= harvest index; LA= leaf area; RWC= relative water content; RB= root biomass; CI= chlorophyll index; GYPP= grain yield per plant; * and ** significant at 5% and 1% probability level*

Table 2. Direct (diagonal) and indirect (off diagonal) effects of contributing characters on grain yield of rice under irrigated (c) and stress (s) conditions

		DFF	DM	EBT	PHT	PL	NFGPP	NSGPP	SS%	TNSPP	PDI	1000 GR WT	BY	H.I %	LA	RWC	PROLINE	RB	CI
DFF	c	**-0.1273**	-0.1037	0.008	0.0098	0.0149	0.0059	0.0239	0.0184	0.0116	0.0061	-0.0005	0.0001	-0.0005	-0.0223	0.0112	-0.0074	-0.0285	-0.0151
	s	**-0.0032**	-0.0022	0.0004	0.0003	0.0005	0.0001	0.0006	0.0005	0.0003	0.0001	0.0001	0.0001	0	-0.0006	0.0001	0.0001	-0.0002	0.0001
DM	c	0.1159	**0.1422**	-0.0162	-0.0008	-0.01	-0.0076	-0.022	-0.0157	-0.0128	-0.0092	0.0032	-0.0147	0.0039	0.0342	-0.0052	-0.0057	0.0293	0.0257
	s	0.0154	**0.0217**	-0.004	-0.0033	-0.0048	-0.0008	-0.0032	-0.0027	-0.0019	0.0007	-0.0015	-0.0012	0	0.0066	-0.0008	-0.0019	0.004	-0.0003
EBT	c	-0.0146	-0.0266	**0.233**	-0.0757	0.0148	0.0365	-0.0021	-0.0176	0.0336	0.0231	0.0052	0.0441	0.0233	0.0101	0.0104	0.0235	0.0344	-0.0304
	s	-0.0006	-0.001	**0.0052**	-0.0009	0.0004	0.0001	0.001	0.001	0.0005	0.0001	0.0008	0.0008	0.0007	-0.0002	0.0001	0	0.0003	0.0005
PHT	c	-0.0022	-0.0002	-0.0095	**0.0292**	0.0103	0.0023	0.0027	0.0016	0.0028	-0.0015	-0.0032	-0.0007	0.0004	-0.003	-0.0034	-0.0056	-0.0075	0.0018
	s	0.0008	0.0011	0.0013	**-0.0072**	-0.0018	-0.0003	-0.0002	-0.0001	-0.0003	0.0005	0.0007	0.0002	0.0008	0.0006	0.0005	-0.001	0.0012	0.0002
PL	c	-0.0765	-0.046	0.0413	0.2301	**0.6516**	0.0186	0.0844	0.065	0.039	-0.2424	-0.1174	0.0994	0.0017	-0.0709	0.032	0.1103	-0.034	-0.1264
	s	0.0065	0.0084	-0.0032	-0.0094	**-0.0383**	-0.0039	0.002	0.0043	-0.0025	0.0174	-0.0066	-0.0072	-0.0036	0.0037	-0.0076	-0.0034	0.0003	0.0061
NFGPP	c	0.0167	0.0194	-0.0567	-0.0283	-0.0103	**0.362**	-0.0467	0.0997	-0.3501	-0.3205	-0.0286	-0.0383	-0.0262	-0.0711	-0.0283	-0.0538	0.0709	-0.0348
	s	-0.0338	-0.0347	0.024	0.0361	0.0953	**0.9268**	0.2268	-0.168	0.8604	0.713	0.1052	-0.0149	0.2047	0.111	0.342	0.2188	-0.2118	-0.0619
NSGPP	c	-0.041	-0.0338	-0.0019	0.02	0.0283	0.0281	**0.2183**	0.198	0.0823	0.0634	-0.0239	-0.0292	-0.0021	0.0154	-0.0354	-0.0223	-0.0608	-0.0052
	s	-0.1353	-0.0988	0.1285	0.0227	-0.0344	0.1645	**0.6722**	0.6057	0.395	0.372	-0.0824	-0.1397	-0.0203	0.0501	-0.1139	-0.0518	-0.2089	0.0225
SS%	c	0.0462	0.0352	0.0241	-0.0172	-0.0319	0.088	-0.2898	**-0.3195**	0.0078	0.0213	0.0404	0.0597	0.0107	0.006	0.0618	0.0604	0.0596	0.0149
	s	0.0361	0.0262	-0.0403	-0.0017	0.0235	0.0382	-0.1899	**-0.2108**	-0.0409	-0.0496	0.0389	0.0471	0.0278	-0.0065	0.0723	0.0385	0.0483	-0.0158
TNSPP	c	0.0964	0.0949	-0.1521	-0.1021	-0.0632	-1.0212	-0.3981	0.0259	**1.056**	-0.9519	-0.0483	-0.068	-0.0689	-0.2128	-0.0331	-0.1188	0.2688	-0.0883
	s	0.1217	0.099	-0.1073	-0.0514	-0.0748	-1.0496	-0.6643	-0.2195	**1.1306**	-0.9657	-0.054	0.1052	-0.1953	-0.1453	-0.2747	-0.1894	0.3503	0.0485
PDI	c	-0.07	-0.0949	0.1454	-0.0766	-0.5457	1.2988	0.4261	-0.098	1.3225	**1.4671**	0.1827	-0.0109	0.084	0.3344	0.0261	0.0366	-0.3073	0.2416
	s	0.0016	-0.003	-0.0023	0.0066	0.0427	-0.0721	-0.0519	-0.0221	-0.0801	**-0.0937**	0.0045	0.0178	-0.009	-0.015	-0.0104	-0.0086	0.0254	-0.0042
1000 GR WT	c	0.0003	0.0016	0.0016	-0.0078	-0.0129	0.0057	-0.0079	-0.0091	0.0033	0.0089	**0.0719**	0.0033	0.011	0.0153	0.0008	-0.014	0.024	0.0012
	s	-0.0001	-0.0004	0.0008	-0.0005	0.0009	0.0006	-0.0007	-0.001	0.0003	-0.0003	**0.0054**	0.0003	0.0003	-0.0005	0.002	0.0011	0.0016	0.0005
BY	c	-0.0003	-0.0669	0.1226	-0.0149	0.0989	0.0685	-0.0866	-0.1211	0.0417	-0.0048	0.0295	**0.6479**	-0.2285	-0.0237	-0.0787	0.0549	0.0081	-0.0877
	s	-0.0159	-0.0394	0.1102	-0.017	0.1399	-0.0119	-0.1542	-0.1657	-0.069	-0.1411	0.0441	**0.7419**	-0.2784	0.0341	0.1173	0.0391	0.0991	-0.1692
H.I %	c	0.0021	0.0143	0.0518	0.0072	0.0014	0.0376	-0.005	-0.0173	0.0339	0.0297	0.0796	-0.1831	**0.5192**	0.018	0.0597	-0.021	0.0236	-0.0382
	s	0.0028	0.0001	0.1233	-0.1129	0.0937	0.2175	-0.0298	-0.13	0.1701	0.095	0.0552	-0.3696	**0.9849**	0.118	0.1017	0.1516	0.0133	0.0223
LA	c	0.0062	0.0086	0.0015	-0.0036	-0.0039	0.007	0.0025	-0.0007	0.0072	0.0081	0.0076	-0.0013	0.0012	**0.0356**	0.0057	0.0012	0.0095	-0.0003
	s	0.0018	0.0029	-0.0004	-0.0008	-0.0009	0.0012	0.0007	0.0003	0.0012	0.0016	-0.0008	0.0004	0.0012	**0.0097**	0.001	-0.0006	0.0017	-0.0011
RWC	c	-0.0027	-0.0011	0.0014	-0.0036	0.0015	0.0024	-0.0051	-0.006	0.001	0.0006	0.0004	-0.0038	0.0036	0.005	**0.0312**	0.0087	-0.0016	0.0013
	s	-0.0001	-0.0001	0.0001	-0.0001	0.0005	0.0008	-0.0004	-0.0008	0.0006	0.0003	0.0009	0.0004	0.0002	0.0002	**0.0023**	0.0001	0.0004	-0.0002
PROLINE	c	0.0013	-0.0009	0.0022	-0.0043	0.0038	0.0033	-0.0023	-0.0042	0.0025	0.0006	-0.0043	0.0019	-0.0009	0.0008	0.0063	**0.0223**	-0.0014	0.0002
	s	0.0004	0.0015	0.0001	-0.0023	-0.0014	-0.0039	0.0013	0.003	-0.0027	-0.0015	-0.0033	-0.0009	-0.0025	0.0011	-0.0011	**-0.0164**	0	-0.0012
RB	c	0.0244	0.0224	0.0161	-0.0279	-0.0057	-0.0213	-0.0303	-0.0203	-0.0277	-0.0228	0.0364	0.0014	0.0049	0.029	-0.0056	-0.007	**0.1089**	-0.0029
	s	-0.0005	-0.0013	-0.0003	0.0011	0.0001	0.0015	0.0021	0.0015	0.0021	0.0018	-0.002	-0.0009	-0.0001	-0.0012	-0.0012	0	**-0.0067**	-0.0005
CI	c	-0.0046	-0.007	0.005	-0.0024	0.0075	-0.0037	0.0009	0.0018	-0.0032	-0.0064	-0.0006	0.0052	0.0028	0.0004	-0.0016	-0.0003	0.001	**-0.0386**
	s	-0.0004	-0.0002	0.0018	-0.0006	-0.0027	-0.0012	0.0006	0.0013	-0.0007	0.0008	0.0017	-0.004	0.0004	-0.002	-0.0013	0.0013	0.0012	**0.0173**
GYPP	c	-0.0296	-0.0425	0.4177	-0.069	0.1492	0.1869	-0.137	-0.2189	0.1394	0.0695	0.2299	0.5131	0.3396	0.1003	0.0539	0.0622	0.1969	-0.1813
	s	-0.0028	-0.0202	0.2377	-0.1414	0.2383	0.2079	-0.1873	-0.303	0.1017	-0.0486	0.1067	0.376	0.7117	0.1637	0.2283	0.1774	0.1193	-0.1363

DFF= days to 50% flowering; DM=days to maturity; EBT= number of effective tillers per hill; PHT= plant height; PL= panicle length; NFGPP= number of fertile grains per panicle; NSGPP= number of sterile grains per panicle; SS%= spikelet sterility %; TNSPP= total number of spikelets per panicle; PDI= panicle density index; GR WT= grain weight; BY= biological yield; HI= harvest index; LA= leaf area; RWC= relative water content; RB= root biomass; CI= chlorophyll index; GYPP= grain yield per plant

Krishnaveni et al. [7] and Sathya and Jebaraj [8], respectively. Reddy et al. [9] and Bhutta et al. [10] also found the positive correlation of effective tillers/hill, Haider et al. [11] for number of fertile grains per panicle, with grain yield/plant under drought stress condition. Therefore, it is suggested that these traits should be used as selection criteria for yield improvement in rice under control and drought stress condition. Further yield improvements in drought stress situation can be achieved by identifying morpho-physiological traits contributing for tolerance against water stress. Similar results were reported by Satheesh kumar and Saravanan [12] Bhatt et al. [13], Premkumar et al. [14] and Priya et al. [15] for correlation coefficient analysis of different traits with grain yield per plant.

It was observed that total number of grains per panicle, number of fertile grains per panicle and biological yield had high positive direct effect on grain yield per plant in both irrigated as well stress condition, indicating true relationship of these characters with grain yield and direct selection for these characters will be rewarding. In rest of the characters correlation was mainly due to indirect effects through component characters and hence indirect selection will lead to yield improvement in rice. The potential for indirect selection for drought stress tolerance using these associated characters may be useful to the breeder to formulate appropriate breeding plans for the selection of the genotype which tolerate high temperature condition. These findings are in accordance with the result of Nandan et al. [16] and Katiyar et al. [17].

5. CONCLUSION

Drought stress had influence on yield and yield contributing traits in rice. Growth and yield attributes such as effective tillers per hill, biological yield, harvest index (%) and number of fertile grains per panicle were significantly and positively correlated with grain yield per plant under irrigated as well as reproductive stage drought stress condition. Total number of grains per panicle, number of fertile grains per panicle and biological yield had high positive direct effect on grain yield per plant in both irrigated (control) as well stress condition. The potential for indirect selection for drought stress tolerance using the associated characters may be useful to the breeder to formulate appropriate breeding plans for the selection of the genotype which tolerate high temperature condition. Positive direct effect as well as significant positive correlation coefficients of number of fertile grains per panicle and biological yield in both irrigated as well as reproductive stage drought stress condition indicated true relationship of these characters with grain yield, thus, selection exercised for these traits would be highly rewarding for yield improvement.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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