

CORRELATION AND PATH COEFFICIENT ANALYSIS OF YIELD COMPONENTS IN AEROBIC RICE (*ORYZA SATIVA* L.)

CHANDAN KUMAR* AND NILANJAYA

Department of Plant Breeding and Genetics, RAU, Pusa, Samastipur - 848125 Bihar, INDIA

e-mail: chandandbg@gmail.com

KEYWORDS

Correlation
Path Analysis
Aerobic Rice

Received on :
08.04.2014

Accepted on :
24.05.2014

*Corresponding
author

ABSTRACT

A study of interrelationship and cause-effect analysis of grain yield and its component traits was carried out using thirty aerobic rice genotypes. The results indicated that relative water content (0.528), chlorophyll content (0.495), root length (0.478), panicle per plant (0.437), 1000 grain weight (0.366), grains per panicle (0.355), spikelet fertility (0.372), root volume (0.256) showed significant and positive association with grain yield per plant. Path analysis revealed that chlorophyll content, tillers per plant, panicles per plant, root volume, grains per panicle and 1000 grain weight were the major contributor of grain yield per plant and these important plant traits must be taken into consideration when any breeding program for higher paddy yield in rice under aerobic condition is to be planned.

INTRODUCTION

Grain yield is a complex character and is controlled by many factors. Selection for desirable types should not only be restricted to grain yield alone but other components related to grain yield should also be considered. The correlation coefficient may also help to identify characters that have little or no importance in the selection programme. The existence of correlation may be attributed to the presence of linkage or pleiotropic effect of genes or physiological and development relationship or environmental effect or in combination of all (Oad *et al.*, 2002). Path coefficient analysis is a statistical technique of partitioning the correlation coefficients into its direct and indirect effects (Dewey and Lu, 1959) so that the contribution of each character to yield could be estimated. It is used in plant breeding programs to determine the nature of the relationships between yield and yield components that are useful as selection criteria to improve the crop yield. The goal of the path analysis is to accept descriptions of the correlation between the traits, based on a model of cause and effect relationship and to estimate the importance of the affecting traits on a specific traits (Milligan *et al.*, 1990). This study was conducted to determine the nature of relationship between grain yield and yield components, direct and indirect contribution of these parameters towards paddy yield and to identify better combination as selection criteria for developing high yielding rice genotypes under aerobic condition.

MATERIALS AND METHODS

The experimental material for the present study comprised of thirty genotypes of rice suitable for aerobic condition procured from directorate of rice research, Hyderabad laid in

randomized block design (RBD) with three replications at the Field Experimentation Centre of Department of Plant Breeding and Genetics, Rajendra Agricultural University, Pusa Samastipur Bihar during *khariif*, 2013. Standard agronomic practices and plant protection measures were taken as per schedule. Each genotype was grown in a plot of 5 x 2 square meters with the spacing 20 x 15 cm row to row and plant to plant respectively. Observations were recorded on five randomly selected plants per replication for different quantitative traits viz. plant height (cm), tillers per plant, panicle length (cm), panicles per plant, spikelet fertility (%), chlorophyll content (SPAD VALUE), relative water content, canopy temperature (°C), critical temperature for reproductive stage (°C), root length (cm), root volume (cm³), grains per panicle, 1000 grain weight (g), and grain yield per plant (g) while traits like seedling vigour, days to 50% flowering and days to physiological maturity were recorded on plot basis. Observations were recorded and the data was subjected to statistical analysis. Statistical analyses for the above characters were done following Singh and Chaudhary (1995) for correlation coefficient and Dewey and Lu (1959) for path analysis.

Trait	Scale	Criteria
Seedling	1 (Extra)	Very fast growing, Plants at 5-leaf stage having 2 or more tillers in majority of population.
Vigor	3 (Vigorous)	Fast growing plants at 4-5 leaf stage have 1-2 tillers in majority of population
	5 (Normal)	Plants at 4 leaf stage
	7 (Weak)	Plants somewhat stunted, 3-4 leaves, thin population, no tiller formation.
	9 (Very weak)	Stunted growth, Yellowing of leaves.

Seedling vigor

Seedling vigor was measured on 1 to 9 scale under standard evaluation system (SES) as proposed by IRRI (1996):

Canopy temperature was measured using a hand-held infrared thermometer (Talebi, 2011).

Critical temperature for reproductive stage was measured by recording accumulated daily temperature till flowering and accumulated daily temperature till maturity and calculated using the equation as proposed Arnold (1960):

$$\text{CRT} = \frac{\text{Accumulated daily temp. till maturity} - \text{Accumulated daily temp. Till flowering}}{\text{Number of days to maturity} - \text{number of days to flowering}}$$

Accumulated daily temp. till maturity = Sum of daily average temperature
× No. of days upto maturity

Accumulated daily temp. till flowering = Sum of daily average temperature
× No. of days upto flowering

Root length and Root volume was measured by digital root scanner using WinRHIZO software (V5.0), Regent Instruments, Quebec, Canada.

Leaf relative water content (RWC) of the flag leaves was determined using the equation given by Barr and Weatherley (1962):

$$\text{RWC} = \frac{\text{F.W} - \text{D.W.}}{\text{T.W.} - \text{D.W.}} \times 100$$

Where,

F.W. = Fresh Weight of flag leaf (g)

D.W. = Dry Weight of flag leaf (g)

T.W. = Turgid Weight of flag leaf (g)

The data were analyzed using WINDOSTAT version 8.6 software for computation of correlation coefficients and path coefficient analysis.

RESULTS AND DISCUSSION

Phenotypic and genotypic correlation coefficients among the seventeen characters were assessed and are presented in Table 1. The present investigation indicated that the genotypic correlation coefficients were higher than the phenotypic correlation coefficients demonstrating that the observed relationships among the various characters were due to genetic causes. This is also in confirmation with the findings of Najeeb and Wani (2004), Radhidevi *et al.* (2002), Sabesan *et al.* (2009) and Sarkar *et al.* (2007).

In present investigation, it is evident that there were significant and positive association of panicles per plant, spikelet fertility, chlorophyll content, relative water content, root length, root volume, grains per panicle and 1000 grain weight with grain yield per plant at both genotypic and phenotypic level. Therefore, these characters should be considered for selection for better performance of genotypes in aerobic condition. These results were in agreement with that of Kato *et al.* (2008)

and Süerk (2003).

Seedling vigor showed significant and negative association with grain yield per plant at both genotypic and phenotypic level. Zhao *et al.* (2006) reported strong association observed between early seedling vigor and yield, which supports the findings of the present investigation.

Grain yield per plant had significant and negative association with days to 50% flowering (genotypic level), days to physiological maturity, plant height, panicle length, canopy temperature, and critical temperature for reproductive stage at both genotypic and phenotypic level. This indicates delay in flowering under stress is caused by a combination of slower floral development and reduced panicle elongation rate, Lafitte *et al.* (2004).

The inter correlation between yield contributing characters may affect the selection for component traits either in favorable or unfavorable direction. Hence, the knowledge of inter relationship between yield component traits may facilitate breeders to decide upon the intensity and direction of selection pressure to be given on related traits for the simultaneous improvement of these traits. Correlation among various yield attributing characters is presented in Table 1.

Seedling vigour exhibited highly significant and positive association with days to 50% flowering, days to physiological maturity, panicles length, canopy temperature and critical temperature for reproductive stage at both genotypic and phenotypic level. It was highly significantly and negatively correlated with tillers per plant, panicles per plant, spikelet fertility, chlorophyll content, relative water content, root length, root volume and grains per panicle at both genotypic and phenotypic level. It exhibited significant and positive association with plant height and significant and negative association with 1000 grain weight at genotypic level only. These results were in accordance with Zhao *et al.* (2006).

Days to 50% flowering showed significant and positive association with days to physiological maturity, plant height, panicle length, canopy temperature and critical temperature for reproductive stage at both genotypic and phenotypic level whereas had significant and negative association with tillers per plant, panicles per plant, spikelet fertility, chlorophyll content, relative water content, root length, root volume, grains per panicle, 1000 grain weight at both genotypic and phenotypic level.

Days to physiological maturity showed significant and positive association with panicle length, canopy temperature and critical temperature for reproductive stage at both genotypic and phenotypic level while it showed significant and negative association with spikelet fertility, relative water content, root length, root volume, grains per panicle and 1000 grain weight at both genotypic and phenotypic level. It had highly significant and positive association with plant height at genotypic level whereas significant and negative association with tillers per plant, panicles per plant and chlorophyll content at genotypic level. These results indicated earliness is a critical trait for performance under reproductive stage stress as was detailed by Jonaliza *et al.* (2004), Manickavelu *et al.* (2006), Pantuwan *et al.* (2001).

Plant height showed significant and positive association with

Table 1: Inter-relationship of different yield attributing characters at Genotypic and Phenotypic levels under Aerobic condition

S/no.	Characters	SV	DF	DPM	PH	TPP	PL	PP	\$F	CC	RWC	CT	CRT	RL	RV	G/PA	TGW	GY/PL	
1.	SV	G	1	0.522**	0.466**	0.650**	-0.977**	0.716**	-0.905**	-0.790**	-0.755**	0.613**	0.841**	-0.930**	-0.823**	-0.688**	-0.684**	-0.845**	
	P	1	0.288*	0.351**	0.097	-0.354**	0.345*	-0.340*	-0.279*	-0.379**	-0.286*	0.411**	0.266*	-0.406**	-0.331*	-0.364**	-0.168	-0.300**	
2.	DF	G	1	0.9861**	0.430**	-0.493**	0.759**	-0.558**	-0.515**	-0.666**	-0.680**	0.726**	0.860**	-0.767**	-0.816**	-0.833**	-0.561**	-0.590**	
	P	1	0.682**	0.269*	0.249*	-0.478**	0.478**	-0.259*	-0.213*	-0.237*	-0.362**	0.328**	0.426**	-0.435**	-0.351**	-0.490**	-0.274*	-0.116	
3.	DPM	G	1	0.226*	-0.857**	0.851**	-0.954**	-0.954**	-0.968**	-0.787**	-0.941**	0.781**	0.966**	-0.945**	-0.801**	-0.997**	-0.736**	-0.790**	
	P	1	0.172	-0.141	0.428**	-0.080	-0.231*	-0.187	-0.381**	-0.313**	0.313**	0.259*	0.925**	-0.394**	-0.266*	-0.324**	-0.306**	-0.228**	
4.	PH	G	1	-0.593**	0.549**	-0.554**	-0.554**	-0.554**	0.006	-0.739**	-0.346**	0.544**	0.614**	-0.845**	-0.844**	-0.707**	0.100	-0.572**	
	P	1	-0.262*	0.405**	-0.096	-0.055	-0.286**	-0.160	0.256*	-0.172	0.256**	0.172	0.172	-0.267*	-0.193	-0.301**	-0.064	-0.269*	
5.	TPP	G	1	-0.802**	0.9568**	0.918**	0.810**	0.717**	-0.859**	-0.892**	0.951**	-0.892**	0.887**	0.951**	0.887**	0.485**	0.877**	0.985**	
	P	1	-0.406**	0.781**	0.347*	0.355**	0.475**	-0.464**	-0.472**	0.536**	0.507**	-0.472**	0.536**	0.507**	0.507**	0.262*	0.393**	-0.556**	
6.	PL	G	1	-0.834**	-0.956**	-0.793**	-0.685**	0.993**	0.948**	0.948**	0.948**	0.948**	0.948**	0.948**	0.948**	-0.977**	-0.798**	-0.912**	
	P	1	-0.354**	0.822**	0.697**	0.715**	-0.844**	-0.844**	-0.844**	-0.844**	-0.844**	-0.844**	-0.844**	-0.844**	-0.844**	-0.610**	-0.301**	-0.576**	
7.	PP	G	1	0.431**	0.348*	0.717**	0.783**	0.783**	0.783**	0.783**	0.783**	0.783**	0.783**	0.783**	0.783**	0.261*	0.409**	0.892**	
	P	1	0.287*	0.287*	0.287*	0.287*	0.287*	0.287*	0.287*	0.287*	0.287*	0.287*	0.287*	0.287*	0.287*	0.287*	0.287*	0.437**	
8.	\$F	G	1	0.988**	-0.928**	-0.928**	-0.928**	-0.928**	-0.928**	-0.928**	-0.928**	-0.928**	-0.928**	-0.928**	-0.928**	-0.928**	-0.928**	-0.928**	0.985**
	P	1	0.827*	0.827*	0.827*	0.827*	0.827*	0.827*	0.827*	0.827*	0.827*	0.827*	0.827*	0.827*	0.827*	0.827*	0.827*	0.827*	0.985**
9.	CC	G	1	0.557**	0.446**	0.446**	0.446**	0.446**	0.446**	0.446**	0.446**	0.446**	0.446**	0.446**	0.446**	0.446**	0.446**	0.446**	0.830**
	P	1	0.408**	0.408**	0.408**	0.408**	0.408**	0.408**	0.408**	0.408**	0.408**	0.408**	0.408**	0.408**	0.408**	0.408**	0.408**	0.408**	0.830**
10.	RWC	G	1	0.731**	0.509**	0.509**	0.509**	0.509**	0.509**	0.509**	0.509**	0.509**	0.509**	0.509**	0.509**	0.509**	0.509**	0.509**	0.702**
	P	1	0.542**	0.542**	0.542**	0.542**	0.542**	0.542**	0.542**	0.542**	0.542**	0.542**	0.542**	0.542**	0.542**	0.542**	0.542**	0.542**	0.702**
11.	CT	G	1	0.905**	-0.893**	-0.893**	-0.893**	-0.893**	-0.893**	-0.893**	-0.893**	-0.893**	-0.893**	-0.893**	-0.893**	-0.893**	-0.893**	-0.893**	0.528**
	P	1	0.625**	0.625**	0.625**	0.625**	0.625**	0.625**	0.625**	0.625**	0.625**	0.625**	0.625**	0.625**	0.625**	0.625**	0.625**	0.625**	0.528**
12.	CRT	G	1	0.950**	-0.950**	-0.950**	-0.950**	-0.950**	-0.950**	-0.950**	-0.950**	-0.950**	-0.950**	-0.950**	-0.950**	-0.950**	-0.950**	-0.950**	-0.954**
	P	1	0.936**	0.936**	0.936**	0.936**	0.936**	0.936**	0.936**	0.936**	0.936**	0.936**	0.936**	0.936**	0.936**	0.936**	0.936**	0.936**	-0.954**
13.	RL	G	1	0.682**	0.450**	0.450**	0.450**	0.450**	0.450**	0.450**	0.450**	0.450**	0.450**	0.450**	0.450**	0.450**	0.450**	0.450**	0.928**
	P	1	0.521**	0.521**	0.521**	0.521**	0.521**	0.521**	0.521**	0.521**	0.521**	0.521**	0.521**	0.521**	0.521**	0.521**	0.521**	0.521**	0.928**
14.	RV	G	1	0.918**	0.918**	0.918**	0.918**	0.918**	0.918**	0.918**	0.918**	0.918**	0.918**	0.918**	0.918**	0.918**	0.918**	0.918**	0.844**
	P	1	0.365**	0.365**	0.365**	0.365**	0.365**	0.365**	0.365**	0.365**	0.365**	0.365**	0.365**	0.365**	0.365**	0.365**	0.365**	0.365**	0.844**
15.	G/PA	G	1	0.714**	0.714**	0.714**	0.714**	0.714**	0.714**	0.714**	0.714**	0.714**	0.714**	0.714**	0.714**	0.714**	0.714**	0.714**	0.256**
	P	1	0.094**	0.094**	0.094**	0.094**	0.094**	0.094**	0.094**	0.094**	0.094**	0.094**	0.094**	0.094**	0.094**	0.094**	0.094**	0.094**	0.256**
16.	TGW	G	1	0.972**	0.972**	0.972**	0.972**	0.972**	0.972**	0.972**	0.972**	0.972**	0.972**	0.972**	0.972**	0.972**	0.972**	0.972**	0.355**
	P	1	0.366**	0.366**	0.366**	0.366**	0.366**	0.366**	0.366**	0.366**	0.366**	0.366**	0.366**	0.366**	0.366**	0.366**	0.366**	0.366**	0.366**

G - Genotypic, P-phenotypic/ significant at 1% (**), 5% (*)

Table 2: Genotypic path coefficient analysis of seventeen characters on grain yield of rice under Aerobic condition

S.no.	Characters	SV	DF	DPM	PH	TPP	PL	PP	SF	CC	RWC	CT	CRT	RL	RV	G/PA	TGW
1.	SV	1.251	0.968	0.886	1.120	-1.302	1.101	-1.121	-1.106	-0.996	-0.897	0.812	1.234	-1.234	-0.923	-1.105	-0.865
2.	DF	0.877	0.954	1.143	0.755	-0.956	0.754	-0.845	-0.856	-0.863	-0.776	0.766	0.866	-0.812	-1.234	-0.798	-0.664
3.	DPM	-0.978	-0.913	-0.798	-0.461	0.892	-0.776	0.896	0.955	0.812	0.854	-0.719	-0.812	0.798	0.712	0.812	0.766
4.	PH	-0.895	-0.881	-0.644	-0.877	0.863	-0.564	0.755	-0.318	-0.947	0.987	-0.702	-0.750	0.843	0.816	0.843	-0.285
5.	TPP	-1.070	-1.212	-1.241	-1.211	1.213	-1.031	0.977	2.050	0.788	0.943	-0.966	-1.234	0.812	1.234	0.781	1.230
6.	PL	0.989	1.371	1.465	0.893	-1.295	1.210	-1.667	-1.456	-0.886	-0.962	1.234	1.102	-0.956	-1.340	-0.941	-0.986
7.	PP	-0.901	-0.899	-1.121	-0.755	1.213	-0.898	1.134	0.967	0.688	0.801	-0.899	-0.977	0.766	0.877	0.553	0.962
8.	SF	0.885	0.700	0.808	-0.061	-0.843	0.467	-0.787	-0.866	-0.975	-0.876	0.776	0.778	-0.780	-0.667	-0.724	-0.712
9.	CC	-0.906	-0.529	-1.101	-1.240	0.886	-0.928	0.923	0.866	1.345	0.865	-0.899	-0.864	1.345	1.213	0.876	0.852
10	RWC	-0.014	-0.207	-0.024	-0.009	0.082	-0.196	0.086	0.086	0.014	0.026	-0.078	-0.523	0.025	0.043	0.014	0.202
11	CT	0.560	0.421	0.178	0.624	-0.196	0.526	-0.652	-0.435	-0.788	-0.667	0.728	0.289	-0.804	-0.548	-0.463	-0.597
12	CRT	0.315	0.272	0.452	0.420	-0.319	0.434	-0.595	-0.504	-0.697	-0.722	0.454	0.358	-0.360	-0.608	-0.640	-0.385
13	RL	1.231	2.101	2.101	1.330	-1.251	2.247	-0.946	-1.024	-0.896	-0.965	1.234	2.160	-1.013	-2.050	-0.964	-0.963
14	RV	-0.708	-0.684	-1.070	-0.566	0.788	-0.878	0.777	0.848	0.688	0.715	-0.839	-0.786	0.746	0.941	0.863	0.858
15	G/PA	-0.803	-1.256	-0.966	-0.988	0.703	-1.598	1.086	0.896	0.879	0.790	-1.063	-0.963	0.786	1.567	0.892	0.774
16	TGW	-0.678	-0.796	-0.864	0.454	0.506	-0.783	0.871	0.882	0.778	0.585	-0.825	-0.832	0.766	0.812	0.715	0.785
17	GY/PL	-0.845	-0.590	-0.796	-0.572	0.985	-0.912	0.892	0.985	0.838	0.702	-0.986	-0.954	0.928	0.844	0.714	0.972

canopy temperature at both genotypic and phenotypic level while it showed significant and negative association with tillers per plant, chlorophyll content, root length and grains per panicle at both genotypic and phenotypic level. Critical temperature for reproductive stage and panicle length showed highly significant and positive association with grain yield per plant at genotypic level and phenotypic level respectively whereas panicle per plant, relative water content and root volume showed highly significant and negative association at genotypic level only.

Panicles per plant showed significant and positive association with spikelet fertility, chlorophyll content, relative water content, root length, root volume, grains per panicle and 1000 grain weight at both genotypic level and phenotypic level whereas it was significantly and negatively correlated with canopy temperature and critical temperature for reproductive stage at both genotypic and phenotypic level. These results for plant height and panicles per plant were in accordance with Ganesan *et al.* (1997), Janardhanam *et al.* (2001) Lalitha and Sreedhar (1996), Kavitha and Reddi (2001), Sharma and Sharma (2007) and Yogameenakshi *et al.* (2004).

Tillers per plant showed significant and positive association with panicles per plant, spikelet fertility, chlorophyll content, relative water content, root length, root volume, grains per panicle and 1000 grain weight at both genotypic and phenotypic level while it showed highly significant and negative association with panicle length, canopy temperature, critical temperature for reproductive stage at both genotypic and phenotypic level. The results were in unison with Reddy *et al.* (1995), Roy *et al.* (1995) and Reddy *et al.* (1997). It indicated that grain yield can be increased whenever there is an increase in characters that showed positive and significant association with grain yield. Hence, these characters can be considered as criteria for selection for higher yield as these were mutually and directly associated with yield.

Spikelet fertility showed significant and positive association with chlorophyll content, relative water content, root length, root volume, grains per panicle and 1000 grain weight at both genotypic and phenotypic level whereas it was significantly and negatively correlated with canopy temperature and critical temperature for reproductive stage at both genotypic and phenotypic level. This was in accordance with the findings of D. Malath *et al.* (2013).

Chlorophyll content showed highly significant and positive association with relative water content, root length, root volume, grains per panicle and 1000 grain weight at both genotypic and phenotypic level whereas it was highly significantly and negatively correlated with canopy temperature and critical temperature for reproductive stage at both genotypic and phenotypic level. Chlorophyll content, which indicates the nitrogen status of the plant is very important during the grain filling stage. The nitrogen content indicates the sink strength of plants, so high chlorophyll content indicates high sink strength of the plants higher sink strength would produce higher and rice yields. This was in conformity with the findings of Wankhade and Sanz, (2013) who observed total chlorophyll content was very important in determining rice yield in *Oryza sativa* L.

Relative water content showed significant and positive

Table 3: Genotypic Path coefficient (direct and indirect effects) of the estimated yield attributes of grain yield of rice under Aerobic condition

Characters	Direct effect	Indirect effect	Correlation with yield
Seedling vigour	1.250	-2.096	-0.845
Days to 50% flowering	0.954	-1.544	-0.590
Days to physiological maturity	-0.798	0.002	-0.796
Plant height	-0.877	0.305	-0.572
Tillers per plant	1.213	-0.299	0.985
Panicle length	1.210	-2.123	-0.912
Panicle per plant	1.134	-0.242	0.892
Spikelet fertility	-0.866	1.851	0.985
Chlorophyll content	1.345	-0.033	0.838
Relative water content	0.026	0.675	0.702
Canopy temperature	0.728	-1.174	-0.986
Critical temperature	0.358	-1.312	-0.954
Root length	-1.013	1.941	0.928
Root volume	0.941	-0.096	0.844
Grain per panicle	0.892	-0.178	0.714
1000-grain weight	0.785	0.187	0.972

ABBREVIATIONS:-

SV-seedling vigor, DF- days to 50% flowering, DPM-days to physiological maturity, PH- plant height, PL-panicle length, TPP- tillers per plant, PP- panicles per plant, SF-spikelet fertility, CC- chlorophyll content, RWC- relative water content, CT- canopy temperature, CRT- critical temperature for reproductive stage, RL-root length, RV-root volume, G/PA- grains per panicle, TGW-1000 grain weight GY/PL-grain yield per plant

association with root length, root volume, grains per panicle and 1000 grain weight (Zarei *et al.*, 2012) at both genotypic level and phenotypic level whereas it was significantly and negatively correlated with canopy temperature and critical temperature for reproductive stage at both genotypic and phenotypic level. It revealed that relative water content is a measure of carbon assimilation by photosynthesis per unit of water transpired. Turgor of cells is determined in part by osmotic potential. Plants can adjust osmotic potential (i.e., osmotic adjustment) to maintain turgor under stress conditions. This becomes possible through varieties having higher RWC under stress condition are more drought tolerant and gave higher yield than others. This was in conformity with the findings of Thangaraj and Siva Subramanian (1990).

Canopy temperature showed highly significant and positive association with critical temperature for reproductive stage at both genotypic level and phenotypic level whereas it was highly significantly and negatively correlated with root length, root volume, grains per panicle and 1000 grain weight at both genotypic and phenotypic level. This was in accordance with the findings of Liu *et al.* (2004).

Critical temperature for reproductive stage showed highly significant and negative association with root length, root volume, grains per panicle and 1000 grain weight at both genotypic level and phenotypic level. Booting and flowering are the stages most sensitive to high temperature, which may sometimes lead to complete sterility. Matsui *et al.* (2001) found variation of temperatures causing sterility between the most tolerant and most susceptible cultivars among japonica cultivars.

Root length showed highly significant and positive association with root volume, grains per panicle and 1000 grain weight at both genotypic level and phenotypic level. Root volume

showed highly significant and positive correlation with grains per panicle and 1000 grain weight at both genotypic level and phenotypic level. This was in conformity with the findings of Michael Gomez and Rangasamy (2002), Sinha *et al.* (2000) and Yogameenakshi (2002). Results shows that a well-developed root system will help the plant in maintaining high plant water status (Kato *et al.*, 2007). Maintaining higher leaf water status under receding soil moisture conditions during grain filling is crucial for better grain yield.

Grains per panicle showed highly significant and positive association with 1000 grain weight at both genotypic level and phenotypic level. This was earlier found by Deepa Sankar *et al.* (2006).

The correlation coefficient of causal variable on the dependent variable may include in it the direct and indirect influences of component traits. Therefore, splitting the total correlation into direct and indirect effects of cause through path coefficient analysis, a statistical device developed by Wright, (1934) would give more meaningful interpretation to the cause of association between the variable like yield and independent variables like yield attributing traits.

Genotypic path coefficients among the seventeen characters were assessed and are presented in Table 2. From the table it is evident that strong positive direct effect exhibited by chlorophyll content followed by seedling vigour, tillers per plant, panicle length, panicles per plant, root volume, grains per panicle, 1000 grain weight, canopy temperature and critical temperature for reproductive stage. Positive direct effects of these traits on grain yield indicated their importance in determining this complex character and therefore, should be kept in mind while practicing selection aimed at the improvement of grain yield. These findings were also corroborated by Kole *et al.* (2008) and Sarawgi *et al.* (2000). Strong negative direct effect showed by root length, plant height, spikelet fertility and days to physiological maturity. Selection of plants on the basis of these traits would certainly lead to improvement in grain yield. Similar results had been reported by Ekka *et al.* (2011).

Among all the characters (Table 3) Seedling vigor, days to 50 % flowering, panicle length, canopy temperature, critical temperature for reproductive stage expresses significant and negative association with grain yield is mainly due to its indirect effect. Days to physiological maturity and plant height expresses negative association with grain yield mainly due to its high direct effect. Tillers per plant, panicles per plant, chlorophyll content, root volume and grains per panicle expresses positive association with grain yield mainly due to its high direct effect. Spikelet fertility and root length expresses positive association with grain yield mainly due to its indirect effect. Relative water content and 1000 grain weight expresses positive association with grain yield due to contribution of both direct and indirect effect.

Hence, selection based on these characters would be more effective for yield improvement under aerobic rice. The characters which have high direct effect and significant association with grain yield indicating that these traits were more contribute towards grain yield in these rice lines, therefore selection for these characters is likely to bring about

an overall improvement in plant yield directly. This was similar to previous reports by, Ezeaku and Mohammed (2006), Mehetre *et al.* (1994), Samonte *et al.* (1998), Sundaram and Palanisamy (1994).

Seedling vigour, days to 50 % flowering, days to physiological maturity, panicle length, canopy temperature and critical temperature for reproductive stage expresses high indirect and negative effect on grain yield *via.* days to physiological maturity, plant height, tillers per plant, panicles per plant, chlorophyll content, relative water content, root volume, grains per panicle and 1000 grain weight. The indirect expression of panicle length on grain yield through all the foresaid characters were negative except spikelet fertility. Tillers per plant, panicles per plant, chlorophyll content, relative water content, root length, root volume, grains per panicle expresses high and positive indirect effect on grain yield *via.* days to physiological maturity, plant height, tillers per plant, panicles per plant, chlorophyll content, relative water content, root volume, grains per panicle and 1000 grain weight. The indirect effect expression of spikelet fertility and 1000 grain weight on grain yield through all the foresaid characters were negative except plant height. Similar results have been reported by Reddy *et al.* (2013), Reuben and Katouli (1989) Sarawagi *et al.* (2000) and Zahid *et al.* (2006).

Based on the studies on correlation and path-coefficient analysis, it may be concluded that days to physiological maturity, plant height, tillers per plant, panicles per plant, chlorophyll content, root volume, grains per panicle, 1000 grain weight exhibited significant association with grain yield due to its high direct effect seems to be primary yield contributing characters and could be relied upon for selection of genotypes to improve genetic yield potential of rice under aerobic condition. Hence, utmost importance should be given to these characters during selection for single plant yield improvement.

ACKNOWLEDGEMENT

Authors are thankful to Directorate of Rice Research, Hyderabad, for providing genotypes of rice suitable for aerobic condition and all the members of Department of Plant Breeding and Genetics for their encouragement, support and providing necessary facilities.

REFERENCES

- Anbanandan, V., Saravanan, K. and Sabesan, T. 2009.** Variability heritability and genetic advance in rice. (*Oryza sativa* L.). *Int. J. Plant Science*. **3(2)**: 61-63.
- Arnold, C. Y. 1960.** Maximum-minimum temperatures as a basic for computing heat units. *Proc. Amer. Soc. Hort. Sci.* **76**: 682-692.
- Barr, H. D. and Weatherley, P. E. 1962.** A re-examination of the relative turgidity technique for estimating water deficit in leaves. *Australian J. Biological Science*. **15**: 413-428.
- Barker, R., Dawe, D., Tuong, T. P., Bhuiyan, S. I. and Guerra, L. C. 1999.** The outlook for water resources in the year 2020: challenges for research on water management in rice production. In: Assessment and Orientation Towards the 21st Century, *Proceedings of 19th Session of the International Rice Commission, Cairo, Egypt, 7-9 September 1998*. FAO, Rome. pp. 96-109.
- Deepa Sankar, P., Sheeba, A. and Anbumalaramathi, J. 2006.** Variability and character association studies in rice (*Oryza sativa* L.). *Agri Sci. Digest*. **26(3)**:182-184.
- Dewey, J. R. and Lu, K. H. 1959.** Correlation and path coefficient analysis of components of crested wheat grass seed production. *Agronomy J.* **51**: 515-518.
- Ekka, R. E., Sarawagi, A. K. and Kanwar, R. R. 2011.** Correlation and Path Analysis in Traditional Rice Accessions of Chhattisgarh. *J. Rice Research*. **4(2)**: 11-18.
- Ezeaku, I. E. and Mohammed, S. C. 2006.** Character association and path analysis in grain sorghum. *Afric. J. Biotechnology*. **5**: 1337-1340.
- Ganesan, K., Wilfred Manuel, W., Vivekanandan, P. and Arumugam Pillai. 1997.** Character association and path analysis in rice. *Madras Agricultural J.* **84(10)**: 614-615.
- IRRI. 1996.** International network for genetic evaluation of rice: Standard Evaluation System for Rice. *International Rice Research Institute, Philippines*.
- Janardhanam, V., Nadarajan, N. and Jebaraj, S. 2001.** Correlation and path analysis in rice (*Oryza sativa* L.). *Madras Agricultural J.* **88**: 719-720.
- Jonaliza, C., Lanceras, P., Pantuwan, G., Boonrat, J. and Theerayut, T. 2004.** Quantitative trait loci associated with drought tolerance at reproductive stage in rice. *Plant Physiol*. **135**: 1-16.
- Jongdee, B., Pantuwan, G., Fukai, S. and Fischer K. 2006.** Improving drought tolerance in rainfed lowland rice: An example from Thailand. *Agric. Water Manag.* **80**: 225-240.
- Kato, Y., Kamoshita, A. and Yamagishi, J. 2008.** Preflowering abortion reduces spikelet number in upland rice (*Oryza sativa* L.) under water stress. *Crop. Science*. **48**: 2389-2395.
- Kavitha, S. and Reddi, S. R. N. 2001.** Correlation and path analysis of yield components in Rice. *The Andhra Agricultural J.* **48(3-4)**: 311-314.
- Kole, P. C., Chakraborty, N. R. and Bhat, J. S. 2008.** Analysis of variability, correlation and path coefficient in induced mutants of aromatic nonbasmati rice. *Tropical Agric. Res. and Ext.* p. 11.
- Kumar, R., Atlin, G. and Lafitte, R. 2004.** Evaluation of rapid drought stress protocol to predict field performance of rice under drought stress condition. In: *Proc. Workshop on resilient crops for water limited environments, Cuernavaca, Mexico*. pp. 167-168.
- Lalitha, S. P. V. and Sreedhar, N. 1996.** Heritability and correlation studies in rice. *The Andhra Agricultural J.* **43(2-4)**: 158-161.
- Liu, H. Y., Mei, H. W., Zou, G. H., Hu, S. P., Liu, G. L., Yu, X. Q., Li, J., Long, P. and Lijun, L. 2004.** Studies on phenotype of Zhenchan 97B IRTA 109 RIL population in field screen facility. In: *Proc. Workshop on resilient crops for water limited environments, Cuernavaca, Mexico*. pp.171-172.
- Malath, D. and Gomathinayagam, P. 2013.** Correlation Analysis for Yield and Yield contributing Characters involving in aerobic rice *International J. Scientific Research*. **2(10)**: 2277-8179.
- Manickavelu, A., Gnamalar, R. P., Nadarajan, N. and Ganesh, S. K. 2006.** Identification of important traits in rice (*Oryza sativa* L.) For lowland drought situation by association analysis. *Int. J. Agricultural Res.* **1(6)**: 509-521.
- Matsui, T., Kobayasi, K., Kagata, H. and Horie, T. 2005.** Correlation between viability of pollination and length of basal dehiscence of the theca in rice under a hot and humid condition. *Plant Production Science*. **8**:109-114.
- Mehetre, S. S., Mahajan, C. R., Patil, P. A., Lad, S. K. and Dhumal, P. M. 1994.** Variability, heritability, correlation, path analysis and genetic divergence studies in upland rice. *Int. Rice. Res. Notes*. **19**: 8-9.

- Michael Gomez, S. and Rangasamy, P. 2002.** Correlation and path analysis of yield and physiological characters in drought resistant rice (*Oryza sativa* L.). *Int. J. Mendel.* **19(1-2)**: 33-34.
- Milligan, S. B., Gravois, K. A., Bischoff, K. P. and Martin, F. A. 1990.** Crop effects on genetic relationships among sugarcane traits. *Crop Sci.* **30**: 927-931.
- Najeeb, S. and Wani, S. A. 2004.** Correlation and path analysis studies in barley. *Natl. J. Plant Improv.* **6(2)**: 124-125.
- Oad, F. C., Samo, M. A., Hassan, Z. U., Pompe, S. C. and Oad N. L. 2002.** Correlation and Path Analysis of Quantitative Characters of Rice Ratoon Cultivars and Advance Lines, *Int. J. Agri. Biol.* **4(2)**: 204-207.
- Pantuwan, G., Fukai, S., Cooper, M., Rajatasereekul, S., O'Toole, J. C. 2002.** Yield response of rice (*Oryza sativa* L.) genotypes to different types of drought under rainfed lowlands: Part Grain yield and yield components. *Field Crops Res.* **73**: 153-168.
- Radhidevi, R. P., Nagarajan, P., Shanmugasundram, P., Chandrababu, R., Jayanthi, S. and Subramani, S. 2002.** Combining ability analysis in three line and two line rice hybrids. *Plant Arch.* **(2)**: 99-102
- Ramakrishnan, S. H., Amandakumar, C. R., Saravanan, S. and Malini N. 2006.** Association Analysis of some Yield traits in Rice (*Oryza sativa* L.).
- Reddy, G. E., Suresh, B. G., Sravan, T. and Reddy, P. A. 2013.** Interrelationship and cause-effect analysis of rice genotypes in north east plain zone. *The Bioscan.* **8(4)**: 1141-1144.
- Reddy, J. N., De, R. N. and Suriya Rao, A. V. 1997.** Correlation and path analysis in low land rice under intermediate (0-50 cm) water depth. *Oryza.* **34(3)**: 187-190.
- Reddy, N. Y. A., Prasad, T. G. and Udaya Kumar, M. 1995.** Genetic variation in yield, yield attributes and yield of rice. *Madras Agricultural J.* **82(4)**: 310-313.
- Reuben, S. O. W. M. and Katuli, S. D. 1989.** Path analysis of yield components and selected agronomic traits of upland rice breedin lines. *I.R.R.N.* **14**: 11-12.
- Roy, A., Panwar, D. V. S. and Sarma, R. N. 1995.** Genetic variability and causal relationships in rice. *Madras Agricultural J.* **82(4)**: 251-255.
- Sabesan, T., Suresh, R. and Saravanan, K. 2009.** Genetic variability and correlation for yield and grain quality characters of rice grown in coastal saline low land of Tamilnadu. *Electronic J. Plant Breed.* **(1)**: 56- 59.
- Samonte, S. O., Wilson, L. T. and McClung, A. 1998.** Path analysis of yield and yield-related traits of fifteen diverse rice genotypes. *Crop Sci.* **38**: 1130-1136.
- Sarawgi, A. K., Rastogi, N. K. and Sani, D. K. 2000.** Studies on some quality parameters of indigenous rice in Madhya Pradesh. *Ann. Agric. Res.* **21**: 2, 258-261.
- Sarkar, K. K., Bhatia, K. S., Senapathi, B. K. and Roy, S. K. 2007.** Genetic variability and character association of quality traits in Rice (*Oryza sativa* L.). *Oryza.* **44(1)**: 64-67.
- Sharma, A. K. and Sharma, R. N. 2007.** Genetic variability and character association in early maturing rice. *Oryza.* **44(4)**: 30003-303.
- Singh, R. K. and Chaudhary, B. D. 1995.** Biometrical methods in quantitative genetic analysis. *Kalyani Publishers New Delhi.* pp. 215-218.
- Sinha, P. K., Prasad, K. and Mishra, G. N. 2000.** Studies on root characters related to drought Resistance and their association in selected upland rice genotypes. *Orzo.* **37(1)**: 29-31.
- Sundaram, T. and Palanisamy, S. 1994.** Path analysis in early rice (*Oryza sativa* L.). *Madras. Agric. J.* **81**: 28-29.
- Sürek, H. and Beser, N. 2003.** Correlation and path coefficient analysis for some yield related traits in rice (*Oryza sativa* L.) under Thrace. *Turk. J. Agric. Sci.* **27**: 77-83.
- Talebi, R. 2011.** Evaluation of chlorophyll content and canopy temperature as indicator for drought tolerance in durum wheat (*T. durum* Desf.). *Australian J. Basic and Applied Science.* **5(11)**: 1457-1462.
- Thangaraj, M. and Sivasubramanian, V. 1990.** Effects of low light intensity on growth and productivity of irrigated rice. *Madras Agric. J.* **77(5/6)**: 220-224.
- Wankhade, S. D. and Sanz, A. 2013.** Chronic mild salinity affects source leaves physiology and productivity parameters of rice plants (*Oryza sativa* L., cv. Taipei 309). *Plant Soil.* **36(7)**: 663-672.
- Wright, S. 1921.** Correlation and causation. *Journal of Agricultural Research.* **20**: 557-85.
- Wright, S. 1934.** The method of path coefficient. *Annals of Mathematical Statistics.* **5**: 161-215.
- Yogameenakshi, P. 2002.** Genetic analysis and in vitro studies for drought tolerance in rice (*Oryza sativa* L.). *M.Sc (Ag.) Thesis. TNAU, Coimbatore.*
- Yogameenakshi, P., Nadarajan, N. and Anbumalarnathi, J. 2004.** Correlation and path analysis on yield and drought tolerant attributes in rice (*Oryza sativa* L.) under drought stress. *Oryza.* **41(3 & 4)**: 68-7.
- Zahid, M. A., Akhter, M., Sabar, M., Manzoor, Z. and Awan, T. 2006.** Correlation and path analysis studies of yield and economic traits in Basmati Rice (*Oryza sativa* L.). *Asian J. Pl. Sci.* **5(4)**: 643-645.
- Zarei, B., Kahrizi, D., Pour, Aboughadareh, A. R. and Sadeghi, F. 2012.** Correlation and path analysis for determining interrelationships among grain yield and related characters in corn hybrids (*Zea mays* L.). *International J. Agriculture and Crop Sciences.* **4(20)**: 1519-1522.
- Zhao, X., Qin, Y. and Sohn, J. K. 2010.** Identification of main effects, epistatic effects and their Environmental interactions of QTLs for yield traits in rice. *Genes and Genomics.* **32**: 37-45.

The Bioscan

An International Quarterly Journal of Life Sciences

ISSN : 0973-7049

Volume 9, Number 2 : 2014

Published as an official organ by

NATIONAL ENVIRONMENTALISTS ASSOCIATION

CONTENTS

	Page
A. RESEARCH PAPER	
1. Redescription of some Indian <i>Lepidocyrtus</i> sp. (Collembola-Entomobryidae) M. Raghuraman, Santeshwari and J. Singh	455 - 460
2. Host specific molecular variations in <i>Bemisia tabaci</i> (G.) as revealed by using mitochondrial and ribosomal marker R. Ellango, R. Asokan and Riaz Mahmood	461 - 466
3. Foraging behavior of black drongo (<i>Dicrurus macrocercus</i>) in Nalgonda district of Andhra Pradesh, India B. Laxmi Narayana, V. Vasudeva Rao and V. Venkateswara Reddy	467 - 471
4. Assessment of relationships and variability of morpho-physiological characters in bread wheat (<i>Triticum aestivum</i> L.) under drought stress and irrigated conditions Akhilesh Kumar Singh, Satish Kumar Singh, Himanshu Shekhar Garg, Rajesh Kumar and Rakesh Choudhary	473 - 484
5. Effect of foliar application of GA ₃ , ethrel and copper sulphate on flowering behaviour and yield of <i>Jatropha curcas</i> L. Paresh Gayakwad, D. B. Jadeja, M. B. Tandel, M. R. Parmar, Shailendra Bhalawe and D. Nayak	485 - 490
6. Impact of zinc application on its translocation into various plant parts of wheat in a vertisol K. S. Keram, B. L. Sharma, G. D. Sharma and R. K. Thakur	491 - 495
7. A dwarf determinate plant type for achieving higher and stable yield in blackgram (<i>Vigna mungo</i> L. Hepper) R. B. Raman and S. P. Sinhamahapatra	497 - 500
8. Importance of growth regulatore and cold storage treatments for breaking of gladiolus (<i>Gladiolus grandiflorus</i> L.) corm dormancy G. B. Bhujbal, N. G. Chavan and S. S. Mehetre	501 - 505
9. Glycerinization of foliages for dry flower products making K. Vishnupriya and M. Jawaharlal	507 - 511
10. Growth, yield and quality of french bean (<i>Phaseolus vulgaris</i> L.) as influenced by sulphur and boron application on inceptisols of Kashmir Mumtaz A. Ganie, Farida Akhter, M. A. Bhat and G. R. Najar	513 - 518
11. Impact of delayed crush on post-harvest deterioration of promoting early maturing sugarcane clones Y. Sharath Kumar Reddy and K. V. Naga Madhuri	519 - 523
12. Influences of organic manures and ammendements in soil physiochemical properties and their impact on growth, yield and nutrient uptake of banana K. Vanilarasu and G. Balakrishnamurthy	525 - 529
13. Fertilizer recommendation based on soil testing for the targeted yield of rice in eastern plain zone of Utter Pradesh Kanhaiya Lal Regar and Y. V. Singh	531 - 534
14. Effect of nitrogen and weed management on nutrient uptake by weeds under direct seeded aerobic rice Seema, Maya Krishna and M. Thoi Thoi Devi	535 - 537
15. Performance of transplanted scented rice (<i>Oryza sativa</i> L.) under seri based cultivation practices: A sustainable method for crop production Damini Thawait, Amit K. Patel, Samaptika Kar, Manish Kumar Sharma and Mayur R. Meshram	539 - 542
16. Effect of dietary beta-glucan on growth and body compisition of <i>Macrobrachium rosenbergii</i> S. J. Meshram, H. Shivananda Murthy, H. S. Swain, H. Ali, T. D. Jagadeesh and H. B. Dhamgaye	543 - 546
17. Effect of growth regulators on clusterbean [<i>Cyamopsis tetragonologa</i> (L.)] growth under aravali hills environment in Rajashthan V. K. Meena, M. K. Kaushik, R. S. Meena, V. S. Meena and B. P. Meena	547 - 550
18. <i>In vitro</i> shoot regeneration and plantlet development in safflower (<i>Carthamus tinctorius</i> L.) Mohite Nikhil, M. S. Dudhare, P. V. Jadhav, M. P. Moharil and A. G. Deshmukh	551 - 555
19. Response of <i>Rhizobium</i> inoculation and phosphorus levels on mungbean (<i>Vigna radiata</i>) under guava-based agri-horti system S. K. Prasad, M. K. Singh and Jay Singh	557 - 560

	Page
20. Effect of different organic mulching materials on soil properties of NA '7' aonla (<i>Emblica officinalis</i> Gaertn) under rainfed condition of Shiwalik foothills of Himalayas, India Vijay Kumar	561 - 564
21. Bael preserve-syrup as booster of human health as a health drink Amit Kumar Singh, A. K. Chaurasiya and I. Chakraborty	565 - 569
22. A survey of infestation of coconut eriophyid mite, <i>Aceria guerreronis</i> Keifer in Konkan region of Maharashtra (India) A. S. Bagde and V. V. Pashte	571 - 576
23. Evaluating the efficacy of novel molecules against soybean defoliators Meena U. Patil, A. V. Kulkarni and Omkar Gavkare	577 - 580
24. Effect of herbicides on weed control and yield of wet seeded rice (<i>Oryza sativa</i> L.) Mallikarjun, A. S. Channabasavanna, Sudheendra Saunshi and C. S. Shrinivas	581 - 583
25. Ecological occurrence of Himalyan poplar (<i>Populus ciliata</i> Wallich Ex Royle) and its nursery evaluation under temperate conditions of Kashmir T. H. Masoodi, Hillal Ahmad, S. A. Gangoo, P. A. Sofi, M. A. Bhat and M. A. Islam	585 - 588
26. Influence of irrigation regimes and fertigation levels on yield and physiological parameters in cauliflower S. D. Yanglem and A. D. Tumbare	589 - 594
27. Effect of organic and inorganic sources of nutrient on yield, yield attributes and nutrient uptake of rice cv. PRH-10 Arun Kumar, R. N. Meena, Lalji Yadav and Y. K. Gilotia	595 - 597
28. High frequency regeneration protocol for callus cultures of peanut leaves using ethylene modulators as culture medium additive T. Radhakrishnan, O. Jithesh and J. R. Dobaría	599 - 604
29. Phytoecdysteroid changes amino acid content in the larvae of <i>Bombyx mori</i> K. Srivastava and V. B Upadhyay	605 - 608
30. Biochemicals study on the host plant "Asan" (<i>Terminalia tomentosa</i>) leaves of tasar silkworm <i>Antheraea mylittad</i> collected from eco-pockets of Similipal biosphere reserve, Mayurbhanj, Odisha D. S. Hota, G. C. Patra, P. K. Satapathy and S. Satapathy	609 - 611
31. Influence of enriched bio-digester liquid manure on growth and yield of finger millet Sudhendra Saunshi, V. C. Reddy, Mallikarjun, Rajesh Rawal	613 - 616
32. Yield and quality of pomegranate as influenced by organic and inorganic nutrients S. K. Dutta Ray, P. V. Takawale, R. Chatterjee and V. Hnamte	617 - 620
33. Studies on crop performance of tropical tasar silkworm <i>Antheraea mylitta</i> (Drury) in <i>Ziziphus mauritiana</i> Lam. (Ber), an available secondary food plant in Similipal biosphere reserve, Odisha for commercial exploitation Sarojinee Baskey, Subrat Satapathy and Akhaya Kumar Bastia	621 - 623
34. Phagostimulant activity of some botanicals to <i>Bombyx mori</i> Linn Priyanka Bhatt, Nitin Thodsare and R. P. Srivastava	625 - 628
35. Population dynamics and monitoring of sucking pests and bollworms on BT cotton in humid zone of southern Rajasthan S. Ramesh Babu and Madan Lal Meghwal	629 - 632
36. Screening for antifeedant activity of <i>Gymnema sylvestre</i> leaf extracts against <i>Spodoptera litura</i> F. (Lepidoptera: Noctuidae) Jaipal Singh Choudhary, Chitra Srivastava and Suresh Walia	633 - 638
37. Migration behaviours of mango hoppers, <i>Idioscopus</i> spp. in relation to host plant flowering phenology: A synchronous shift P. D. Gundappa, Kamala Jayanthi and Abraham Verghese	639 - 641
38. Pre-sowing seed bio-priming in okra: response for seed production A. K. Rai and A. K. Basu	643 - 647
39. Response of mustard (<i>Brassica juncea</i> L.) Czernj. & Cosson) to potassium with other nutrients on yield and quality Aruna Paliwal and J. P. Singh	649 - 652
40. Effect of coal ash on physio-morphological and bio-chemical characters of okra (<i>Abelmoschus esculentus</i> L. Moench) S. C. Swain, S. K. Padhi and D. Sahoo	653 - 657
41. Effect of <i>Alcaligenes faecalis</i> supplementation to different casing mixtures on its physico-chemical properties and yield stimulation of <i>Agaricus bisporus</i> Neelam, Vinod Upadhyay and K. P. S. Kushwaha	659 - 661
42. Effect of LCC and spad based nitrogen management on growth and yield of lowland rice (<i>Oryza sativa</i> L.) Shantappa Duttarganvi, A. S. Channabasavanna, Satyanarayan Rao and A. S. Halepyati	663 - 665
43. Effect of vermicompost and sulphur on growth, yield and nutrient uptake of fenugreek (<i>Trigonella foenum-graecum</i> L.) S. R. Verma, A. C. Shivran, R. Bhanwaria and M. Singh	667 - 670
44. Effect of salicylic acid in soybean (<i>Glycine max</i> L. Meril) under salinity stress Akanksha Jaiswal, V. Pandurangam and S. K. Sharma	671 - 676
45. Physico-chemical and microbial status of Malkhed lake at Chandur railway, district: Amravati C. K. Deshmukh and R. N. Urkude	677 - 682