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Research Article

Association analysis of native rice (*Oryza sativa* L.) of Bastar

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Abstract
The present investigation was carried out at S.G. College of Agriculture and Research Station, Jagdalpur, Chhattisgarh**.** The experimental materials used were 94 local landraces of rice and three popular standard checks. The experiment was conducted during *kharif* 2016 in RBD. Observations were recorded for 16 qualitative and 20 qualitative characters and analysis of variance for characters showed differences for various characters. Correlation analysis revealed positive and highly significant correlation of total number of filled grains per panicle, total number of grains per panicle, plant height and number of effective tiller per plant, harvest index, test weight, flag leaf length and days to maturity had positive highly significant correlation with grain yield per plant. According to the direct effects on grain yield, the order of yield components was direct selection for characters *viz.* flag leaf length, days to maturity, plant height, number of effective tillers per plant, harvest index, and total number of grains per panicle will be very effective for increasing grain yield.

Key words
Rice, correlation, path analysis, grain yield

Introduction

Rice is one of the most essential staple foods for more than half of the world's population and having impacts on the livelihoods and economics of several billion people. Rice is life for most of the people living in Asia. Indigenous varieties are rapidly being lost due to changes in land use and agricultural practices, which help agronomically improved varieties. Some indigenous rice genotypes of Bastar contain special quality characters like iron and zinc content and some rice genotypes contain delicious scent, exportable grain texture or size, cooking quality or rich in vitamins. The diversity among land races of any crop is required for improvement of the crop. This investigation may be helpful for researchers to identify the gene which may be helpful in the near future to achieve food security. According used by the traditional healers, many traditional cultivars like Safari, Gurmatia, Bhata Mokdo, Chudi Dhan, Kalimoonch, Laicha are used by the in traditional medicine system for treatment of rheumatism, skin infections, paralysis, diabetes etc. (Das and Oudhia, 2001). For the development of economically high-yielding varieties with all of the desirable agronomic traits it is also important to consider other characteristics when selecting the parental material such as aspects related to difference in grain type and shape, plant height, and other yield related traits. Yield is a complex trait being governed by a large number of cumulative, duplicate and dominant genes and directly or indirectly influenced by environment as well as responds poorly to the direct selection. Keeping these points in view, to find out suitable genotypes or donor to meet any current or future demand for improvement of the rice crop, various indigenous rice genotypes were for the current study.

Material and Methods

The experiment was carried out at Research cum Instructional Farm, S.G. College of Agriculture and Research Station, Kumhrawand, Jagdalpur, Bastar, Chhattisgarh, India. The experimental materials comprised of ninety four local landraces of rice and three popular standard checks. The experimental materials were received from rice breeding section of S.G. College of Agriculture and Research Station, Jagdalpur, Bastar, Chhattisgarh. The experiment was conducted during *Kharif* 2016 in an RBD Design to assess the agromorphological characterization, genetic variability, association analysis and genetic divergence among the ninety four local landraces of rice (*Oryza sativa* L.) and three popular standard checks namely MTU-1010, Danteshwari,

and CR-40 (Table 1). The observations on various agro-morphological characters including qualitative and quantitative characters and incidence of major insect and disease of rice were recorded *viz.*, harvest index, grain yield/plant, days to 50% flowering, days to maturity, flag leaf length, flag leaf width, plant height, panicle length, number of effective tillers/plant, total number of grain /panicle, spikelet fertility, test weight, total number of filled grains/panicle, days to first heading, grain breadth, grain length, grain length breadth ratio, kernel breadth, kernel length, kernel length breadth ratio, grain shape, and kernel shape. The list of characters along with descriptor is mentioned in (Table 2.) The data recorded on 94 local landraces of rice and three popular standard checks for different quantitative characters and quality characters were subjected to the statistical analysis *viz.*, analysis of variance, correlation coefficient analysis and path analysis,.

Results and Discussion

The results of analysis of variance indicated that the mean sum of squares due to the genotypes were highly significant for various quantitative and quality characters studied *i.e*. days to 50% flowering, days to maturity, days to first heading, number of effective tillers per plant, plant height (cm), flag leaf length, flag leaf width, panicle length (cm), total number of grains per panicle, number of filled spikelets per panicle, spikelet fertility percentage (%), test weight (g), grain yield per plant (g), harvest index (%), grain length (mm), grain breadth (mm), grain length: breadth ratio, kernel length (mm), kernel breadth (mm), kernel length: breadth ratio. The analysis of variance for quality and quantitative character is presented in (Table 3 and Table 4) respectively.

Correlation analysis revealed positive and highly significant correlation of grain yield per plant with total number of filled grains per panicle, total number of grains per panicle, plant height number of effective tiller per plant, harvest index, test weight, flag leaf length and days to maturity. Grain yield per plant had positive and highly significant correlation with harvest index and total number of grains per panicle as in agreement with the findings of (Ambili and Radhakrishnan, 2011; Vanisree *et al*., 2013; Sohgaura *et al.,* 2014; Allam *et al.,* 2015; Moosavi 2015; Solomon and Wegary, 2016). Highly significant and positive correlation between total number of filled grains per panicle and grain yield per plant was in agreement with the results of Chakraborty *et al*. (2010), Ekka *et al*. (2011), Vanisree *et al*. (2013), Sohgaura *et al*. (2014) and Allam *et al.* (2015). Highly significant and positive correlation between days to 50% flowering and plant height with grain yield per plant was in agreement with the results of Nandan *et al*. (2010), Ekka *et al*. (2011), and Vanisree *et al*. (2013). However, days to maturity was highly significantly and positively correlated to grain yield per plant was in agreement with the findings of previous researchers (Rashid *et al*., 2014; Sarawgi *et al*., 2015; Sritama *et al.,* 2015). A significant and positive correlation of number of effective tillers per plant with grain yield per plant was in confirmation with the findings advocated by Chakraborty *et al*. (2010), Ambili and Radhakrishnan (2011), Rashid *et al*. (2014) and Sarawgi *et al*. (2015).

In the present investigation total number of filled grains per panicle, total number of grains per panicle, plant height and number of effective tillers per plant, harvest index, test weight, flag leaf length and days to maturity had positive and highly significant correlation with grain yield per plant. It indicated strong correlation of these traits with grain yield per plant and selection for these traits will be useful in improving the grain yield. Positive correlation between desirable traits is favourable because it helps in the simultaneous improvement of both characters. On the other hand, negative correlation will hinder the simultaneous expression of both characters with high values. In such situation some economic compromise has to be made (Table 5).

During path coefficient analysis the residual effect was high (0.33271) as per the scale given by (Lenka and Mishra, 1973). In the present study, flag leaf length, days to maturity, plant height, number of effective tillers per plant, harvest index, and total number of grains per panicle had highly significant positive correlation with grain yield per plant as well as positive direct effect on grain yield per plant. The positive direct effect of plant height on grain yield per plant is in confirmation with the findings of (Nandan *et al.,* 2010; Ambili and Radhakrishnan, 2011; Selvaraj *et al*., 2011; Babu *et al*., 2012; Naseem *et al*., 2014; Rai *et al.,* 2014; Islam *et al.,* 2015; Sarawgi *et al*., 2015) flag leaf length had positive direct effect on grain yield per plant corroborates with the findings of (Sarawgi *et al*., 2015) days to maturity had positive direct effect on grain yield per plant supports with the findings of (Naseem *et al*., 2014; Islam *et al.,* 2015; Sarawgi *et al*., 2015) number of effective tillers per plant had positive direct effect on grain yield per plant confirms with the findings of (Nandan *et al.,* 2010; Ambili and Radhakrishnan, 2011; Naseem *et al*., 2014;

Sarawgi *et al*., 2015) harvest index had positive direct effect on grain yield per plant confirms with the findings of (Nandan *et al.*, 2010; Ambili and

Radhakrishnan 2011; Rai *et al.*, 2014) total number of grains per panicle had positive direct effect on grain yield per plant supports with the findings of (Nandan *et al.*, 2010; Naseem *et al*., 2014). Significant positive correlation as well as positive direct effect on grain yield indicates true relationship between them and direct selection for these traits will be rewarding for yield improvement.The total number of filled grains per panicle had significant positive correlation with grain yield per plant but exhibited very high negative direct effect on grain yield. In this situation correlation is mainly due to indirect effects of the character through another component trait, so indirect causal factors are to be considered simultaneously for selection. On the basis of above findings it can be concluded that the direct selection for characters *viz.*, flag leaf length, days to maturity, plant height, number of effective tillers per plant, harvest index, and total number of grains per panicle will be very effective for increasing the grain yield, hence they should be given consideration in the selection criteria (Table 6).

The rice accessions used in the study revealed significant variability for most of the morphological traits. Correlation studies revealed that selection criteria based on positive and highly significant correlation of grain yield per plant *viz*., total number of filled grains per panicle, total number of grains per panicle, plant height and number of effective tillers per plant, harvest index, test weight, flag leaf length, and days to maturity would be quite useful for further improvement. On the basis of above findings it can be concluded that the direct selection for characters *viz.*, flag leaf length, days to maturity, plant height, number of effective tillers per plant, harvest index, and total number of grains per panicle will be very effective for increasing the grain yield, hence they should be given consideration in the selection criteria.

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Table 1. List of ninety four local landraces of rice and three popular standard checks used in the present study

Entry No.	**Accession Name**	Entry No.	**Accession Name**
1	Rago vati	20	Narial
2	Hiran bako	21	Noni dhan
3	Band kari	22	Kal tut masilo
4	Bakti chudi	23	Kari chudi
5	Ram jeera	24	Bghal mijo
6	Bans koria	25	Bhuku kuda
7	Baria dhan	26	Koog dhan
8	Mayur funda	27	Kapoor sai
9	Lokti machhi	28	Baku dhan
10	Pat dhan	29	Bhata dubraj
11	Surmatia	30	Sagi pareta
12	Sendur senga	31	Haldi ghati
13	Tiki chudi	32	Tama koni
14	Anjani	33	Bhasam patti
15	Kadam phool	34	Dumar phool
16	Sona sari	35	Bode bargi
17	Chepti gurmutiya	36	Kava padi
18	Bhata mokdo	37	Koorlu mundi
19	Kukda mor	38	Anga dhan

Table 1. Contd….

Entry No.	Accession Name	Entry No.	Accession Name
39	Lankeshri	67	Hisya dhan
40	Rami gali	68	Chagdi kaj
41	Bhata gada khuta	69	Dokra mecha
42	Rai kera	70	Barha sal
43	Kurli kabri	71	Kala umari
44	Alti mijo	72	Kakda kdo
45	Alam dhan	73	Bargi dhan
46	Ghaghar dhan	74	Koosum jhopa
47	Mudria	75	Bas koriya
48	Kari khuji	76	Manki dhan
49	Dumar phool	77	Bhata kanai
50	Pharsa phool	78	Bhalu dubraj
51	Hathi panjra	79	Baso mati
52	Karmari bhog	80	Rang gada khuta
53	Godavari	81	Ghdva phool
54	Kari gudi	82	Son pari
55	Dogar kanri	83	Mundra chudi
56	Bhanvar gedi	84	Mehar dhan
57	Machi dhan	85	Kormel
58	Dhabda dhan	86	Gogal sathka
59	Kura dhan	87	Dogar kabri
60	Bhans path	88	Lal makdo
61	Barangi	89	Moha dhan
62	Goyadi	90	Laycha
63	Ram bhog	91	Godandi
64	Aajan dhan	92	Hare krishna
65	Masur lochia	93	Tagan dhan
66	Aasan chudi	94	Machhali poti
CH1	MTU1010	CH3	CR40
CH2	Danteshwari		

Note: CH=check variety.

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Table 2. Description of agro-morphological characters

S. No.	Characters	Growth stage	Categories or type	Symbols
1	Basal leaf sheath	Vegetative	Green	1
	Colour		Light purple	2
			Purple lines	3
			Uniform purple	4
2	Auricle colour	Late	Absent (no auricles)	1
		vegetative	Whitish	2
			Yellowish green	3
			Purple	4
			Light purple	5
			Purple lines	6
3	Leaf blade	Late	Pale green	1
	Colour	vegetative	Green	2
			Dark green	3
			Purple tips	4
			Purple margin	5
			Purple blotch	6
			Purple	7
4	Ligule shape	Late	Acute to acuminate	1
		vegetative	2-cleft	2
			Truncate	3
5	Flag leaf angle	Reproductive	Erect	1
			Semi-erect	3
			Horizontal	5
			Drooping	7
6	Plant height	Reproductive	Very short (<91 cm)	1
	(cm)		Short (91-110 cm)	3
			Medium(111-130 cm)	5
			Long (131-150 cm)	7
			Very long (>150 cm)	9
7	Flag leaf length	Reproductive	Short (<30 cm)	3
	(cm)		Med. (30-45 cm)	5
			Long (>45 cm)	7
8	Flag leaf width	Reproductive	Narrow (<1 cm)	3
	(cm)		blade Medium (1-2 cm)	5
			Broad (>2 cm)	7
9	Date to 50%	Reproductive	Very early (<71 days)	1
	Flowering		Early (71-90 days)	3
			Medium (91-110 days)	5
			Late (111-130 days)	7
			Very late (> 131 days)	9

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Table 2. Continued…….

S.no	Characters	Growth stage	Categories or type	Symbols
10	Stigma Colour	Reproductive	White	1
			Light green	2
			Yellow	3
			Light purple	4
			Purple	5
11	Apiculus Colour	At dough stage	White	1
			Straw	2
			Brown	3
			Red	4
			Red apex	5
			Purple	6
			Purple apex	7
12	Awning	Flowering to maturity	Absent	0
			Present	1
13	Awn Colour	At maturity	Straw	1
			Gold	2
			Brown	3
			Red	4
			Purple	5
			Black	6
14	Awn length	At maturity	None (awnless)	0
			Very short (<5 mm)	1
			Short (~8 mm)	3
			Intermediate (~15 mm)	5
			Long (~30 mm)	7
			Very long (>40 mm)	9
15	Date to maturity (days)	Maturity	Very early (<100 days)	1
			Early (101-120 days)	3
			Medium (121-140 days)	5
			Late (141-160 days)	7
			Very late (>160 days)	9
16	Panicle length (cm)	Maturity	Very short (<16cm)	1
			Short (16-20 cm)	3
			Medium (21-25cm)	5
			Long (26-30 cm)	7
			Very long (>30 cm)	9

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Table 3. Analysis of variance for quality traits related to yield

Source of variation	Degree of freedom	Mean squares					
		GB	GL	GLBR	KB	KL	KLBR
RSS	1	164.42	614.24	148.09	98.04	392.66	102.95
TMSS	96	0.28	2.11	0.58	0.20	1.54	0.55
ErSS	96	0.10	0.07	0.13	0.07	0.02	0.10
F cal.		2.82**	32.07**	4.36**	2.81**	77.62**	5.38**

* Significant at 5%,
** Significant at 1%
p value of 0.1 level of significance DFn 96 and DFd 96 p=1.0000
p value of 0.5 level of significance DFn 96 and DFd 96 p=0.9996
GB=grain breadth,
GL= grain length,
GLBR=grain length breadth ratio,
KB=kernel breadth,
KL=kernel length,
KLBR= kernel length breadth ratio.

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Table 4. Analysis of variance for quantitative traits

Source of variation	Degree of freedom	Mean squares						
		TNFGP	TNGP	SF	PH	NETH	PL	GYP
RSS	2-1=1	5041.86	23289.56	14163.08	9.93	0.4250	9.84	7.56
TMSS	97-1=96	1212.23	1536.46	38.61	487.63	4.86	8.26	55.13
Er.SS	(2-1)(97-1)=96	344.12	1.17	0.69	13.82	0.35	1.57	8.43
F calculated		3.52**	1308.13**	56.19**	35.28**	13.74**	5.25**	6.54**

Table: 4 continued……

Source of variation	Degree of freedom	Mean squares						
		HI	TW	FLL	FLW	DTF	DTFH	DTM
RSS	2-1=1	6203.14	6931.30	3.54	0.003	424.58	19002.06	0.05
TMSS	97-1=96	120.20	60.11	52.74	0.871	175.09	113.42	177.03
ErSS	(2-1)(97-1)=96	1.91	1.74	7.22	0.006	52.14	2.61	13.46
F cal.		63.03**	34.50**	7.30**	153.594**	3.36**	43.43**	13.15**

*= significant at 5%, **= significant at 1%

p value of 0.1 level of significance DFn 96 and DFd 96 p=1.0000
p value of 0.5 level of significance DFn 96 and DFd 96 p=0.9996

HI=Harvest Index, GYP=grain yield/plant, DTF= days to 50% flowering, DTM =days to maturity, FLL=flag leaf length, FLW=flag leaf width, PH= plant height, PL=panicle length, NETH= number of effective tillers/plant, TNGP= total number of grain /panicle, SF spikelet fertility, TW=test weight, TNFGP=total number of filled grains/panicle, DTFH=days to first heading

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Table 5. Correlation for different quantitative traits

Characters	TNFGP	TNGP	SF	PH	NETH	PL	HI	TW	FLL	FLW
TNFGP	**1**	**0.697****	-0.099	0.08	0.031	0.181*	-0.053	-0.176*	0.096	0.088
TNGP		1	**0.270****	0.053	0.006	0.141*	0.231**	0.215**	0.115	0.101
SF			1	**0.051**	0.069	-0.076	0.591**	0.665**	-0.033	0.079
PH				1	**-0.074**	0.327**	-0.104	0.190**	0.179*	0.074
NETH					1	**-0.116**	0.039	-0.172*	0.156*	-0.038
PL						1	**-0.131**	-0.035	0.043	-0.032
HI							1	**0.464****	0.001	0.053
TW								1	**-0.052**	0.211**
FLL									1	**-0.094**
FLW										1
DTF										
DTFH										
DTM										
GB										
GL										
GLBR										
KB										
KL										
KLBR										
GYP										

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Characters	DTF	DTFH	DTM	GB	GL	GLBR	KB	KL	KLBR	GYP
TNFGP	0.034	-0.101	0.179*	-0.157*	-0.238**	-0.203**	-0.131	-0.217**	-0.213**	0.344**
TNGP	0.051	0.362**	0.230**	0.353**	0.220**	0.219**	0.364**	0.249**	0.209**	0.336**
SF	-0.201**	0.659**	-0.056	0.783**	0.778**	0.764**	0.770**	0.756**	0.719**	-0.011
PH	0.223**	0.123	0.082	-0.01	0.149*	0.077	-0.032	0.1	0.072	0.257**
NETH	-0.072	-0.035	0.055	-0.084	-0.014	0.113	-0.102	-0.056	0.077	0.276**
PL	0.099	0.002	-0.083	-0.095	-0.043	-0.041	-0.109	-0.059	-0.029	0.12
HI	-0.225**	0.401**	-0.091	0.511**	0.524**	0.509**	0.503**	0.582**	0.536**	0.297**
TW	0.054	0.688**	0.019	0.830**	0.832**	0.569**	0.800**	0.803**	0.560**	0.142*
FLL	-0.064	-0.051	0.014	-0.024	-0.052	-0.033	-0.015	-0.069	-0.064	0.200**
FLW	**-0.041**	0.028	-0.057	0.108	0.118	0.038	0.172*	0.121	0.025	0.133
DTF	1	**0.373****	0.574**	-0.1	0.003	-0.062	-0.147*	-0.039	-0.065	0.078
DTFH		1	**0.345****	0.737**	0.765**	0.686**	0.702**	0.726**	0.658**	0.036
DTM			1	**-0.012**	0.074	0.073	-0.023	0.052	0.059	0.191**
GB				1	**0.771****	0.572**	0.949**	0.761**	0.566**	0.007
GL					1	**0.893****	0.741**	0.939**	0.853**	0.087
GLBR						1	**0.570****	0.846**	0.926**	-0.008
KB							1	**0.725****	0.514**	0.002
KL								1	**0.897****	0.099
KLBR									1	**0.027**
GYP										**1**

*= significant at 0.05, **= significant at 0.01

HI=Harvest Index, GYP=grain yield/plant, DTF= days to 50%flowering, DTM =days to maturity, FLL=flag leaf length, FLW=flag leaf width, PH= plant height, PL=panicle length, NETH= no. of effective tillers/plant, TNGP= total no. of grain /panicle, SF spikelet fertility, TW=test weight, TNFGP=total number of filled grains/panicle, DTFH=date of first heading, GB=grain breadth, GL= grain length, GLGR=grain length breadth ratio, KB=kernel breadth, KL=kernel length, KLBR= kernel length breadth ratio.

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Table 6. Path coefficients showing direct and indirect effects of different characters on grain yield per plant

Characters	TNFGP	TNGP	SF	PH	NETH	PL	HI	TW	FLL	FLW
TNFGP	**-1.45**	1.68	0.07	0.02	0.01	0.02	0.03	0.01	0.01	0.01
TNGP	-1.38	**1.77**	-0.06	0.01	0.00	0.02	0.01	0.01	0.01	0.01
SF	-0.24	-0.24	**0.42**	0.03	0.04	0.00	0.08	0.00	0.00	0.00
PH	-0.14	0.11	0.06	**0.21**	-0.03	0.03	-0.05	-0.02	0.02	0.01
NETH	-0.04	-0.01	0.04	-0.02	**0.38**	-0.01	0.01	0.02	0.01	0.00
PL	-0.31	0.38	0.01	0.07	-0.05	**0.08**	-0.04	0.00	0.01	0.00
HI	-0.11	0.03	0.08	-0.03	0.01	-0.01	**0.43**	0.00	0.00	0.00
TW	0.12	-0.16	0.02	0.06	-0.11	0.00	0.03	**-0.07**	-0.01	0.02
FLL	-0.20	0.25	-0.01	0.04	0.06	0.00	0.01	0.00	**0.10**	-0.01
FLW	-0.17	0.17	0.02	0.02	-0.02	0.00	0.00	-0.02	-0.01	**0.08**
DTF	-0.09	0.22	-0.09	0.05	-0.03	0.01	-0.09	-0.02	-0.01	0.00
DTFH	-0.11	0.22	-0.07	0.05	-0.04	0.01	-0.06	-0.02	-0.01	0.00
DTM	-0.30	0.45	-0.05	0.02	0.02	-0.01	-0.05	0.00	0.00	-0.01
GB	-0.02	0.10	-0.05	0.00	-0.11	0.00	-0.03	-0.04	0.00	0.01
GL	0.29	-0.38	0.02	0.07	-0.03	0.01	0.02	-0.04	-0.01	0.01
GLBR	0.21	-0.32	0.05	0.04	0.06	0.01	0.02	0.01	0.00	0.00
KB	-0.10	0.18	-0.04	-0.01	-0.13	0.00	-0.02	-0.04	0.00	0.02
KL	0.21	-0.24	0.00	0.05	-0.06	0.00	0.08	-0.03	-0.01	0.01
KLBR	0.20	-0.27	0.02	0.03	0.04	0.01	0.06	0.00	-0.01	0.00

Table 6. Contd……..

Characters	DTF	DTFH	DTM	GB	GL	GLBR	KB	KL	KLBR	Correlation with GYP
TNFGP	0.00	0.00	0.03	-0.01	-0.19	0.16	0.05	0.05	-0.10	0.344**
TNGP	-0.01	0.00	0.04	-0.04	-0.19	0.20	0.07	0.05	-0.12	0.336**
SF	0.01	0.00	-0.02	0.09	0.04	-0.13	-0.07	0.00	0.04	-0.011
PH	-0.01	0.01	0.01	-0.01	0.30	-0.20	-0.03	-0.08	0.11	0.257**
NETH	0.00	0.00	0.01	0.22	-0.08	-0.17	-0.24	0.06	0.07	0.276**
PL	0.00	0.00	-0.02	-0.01	0.09	-0.07	-0.03	-0.02	0.06	0.120
HI	0.01	0.00	-0.02	0.05	0.04	-0.06	-0.04	-0.07	0.11	0.297**
TW	-0.01	0.01	0.00	-0.48	0.53	0.12	0.42	-0.19	-0.03	0.142*
FLL	0.00	0.00	0.00	0.01	-0.06	0.03	0.00	0.04	-0.06	0.200**
FLW	0.00	0.00	-0.01	-0.14	0.14	0.05	0.17	-0.06	-0.04	0.133
DTF	**-0.06**	0.02	0.10	-0.06	0.26	-0.12	0.01	-0.06	0.06	0.078
DTFH	-0.05	**0.02**	0.09	-0.06	0.24	-0.11	0.00	-0.06	0.07	0.036
DTM	-0.04	0.01	**0.16**	0.05	0.14	-0.18	-0.06	-0.04	0.09	0.191**
GB	0.00	0.00	-0.01	**-0.76**	-0.05	0.85	0.65	0.02	-0.45	0.007
GL	-0.02	0.01	0.02	0.04	**0.91**	-0.74	-0.09	-0.29	0.44	0.087
GLBR	-0.01	0.00	0.02	0.58	0.61	**-1.11**	-0.53	-0.20	0.61	-0.008
KB	0.00	0.00	-0.01	-0.66	-0.11	0.79	**0.75**	0.05	-0.56	0.002
KL	-0.01	0.00	0.02	0.04	0.71	-0.58	-0.10	**-0.38**	0.56	0.099
KLBR	0.00	0.00	0.02	0.46	0.53	-0.91	-0.56	-0.28	**0.75**	0.027

Note -: Residual factor =0.33271**, Figures in bold are direct effects.**
**Significant at 1% level, * Significant at 5% level.
HI=Harvest Index, GYP=grain yield/plant, DTF= days to 50%flowering, DTM =days to maturity, FLL=flag leaf length, FLW=flag leaf width, PH= plant height, PL=panicle length, NETH= no. of effective tillers/plant, TNGP= total no. of grain /panicle, SF spikelet fertility, TW=test weight, TNFGP=total no. of filled grains/panicle, DTFH=date of first heading, GB=grain breadth, GL= grain length, GLGR=grain length breadth ratio, KB=kernel breadth, KL=kernel length, KLBR= kernel length breadth ratio.