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Path analysis of yield components of some mutants of Basmati rice

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ABSTRACT

Twenty three dwarf mutants, five early flowering mutants and four commercial varieties of Basmati rice were studied for genetic correlations among yield and yield components. Yield per plant showed highly significant positive correlations with number of spikelets per panicle, number of primary and secondary branches per panicle and panicle length. Number of spikelets per panicle recorded highly significant positive correlations with panicle length, number of primary and secondary branches per panicle. Number of secondary branches per panicle showed highly significant positive correlations with number of primary branches per panicle, number of spikelets per panicle and panicle length. Number of primary branches per panicle and panicle length were also significantly correlated. Path-coefficient analysis showed that among all the characters studied, number of spiklets per panicle has the maximum direct effect towards yield. The number of secondary branches per panicle was more important than panicle length and number of primary branches. Therefore the number of spikelets per panicle and the number of secondary branches per panicle are the most important yield components to be considered in Basmati rice breeding.

Keywords: Basmati rice, correlations, *Oryza sativa* L., path coefficients, yield, yield components.

INTRODUCTION

Basmati rice is the premier food grain crop of Pakistan for domestic consumption and export with a production of 4.305 million tons from an estimated area of 2.254 million hectares and an annual foreign exchange return of US$ 338.5 million (Economic Survey of Pakistan 1996-97). The climatic conditions of the province of Punjab are particularly suitable for the cultivation of Basmati varieties. They possess a peculiar aroma, excellent grain and cooking quality characteristics. However, the grain yield of Basmati rice is very low (1912 kg ha^{-1}). Therefore one of the most important problems in Basmati rice breeding is to increase the yielding ability of cultivars.

Yield is a complex character and is collectively influenced by various component characters that are subjected to much environmental variations. The efficiency of selection for yield based on component characters mainly depends upon the direction and magnitude of association between those component characters and yield. The relationship between rice (*Oryza sativa* L.) yield and its components has been studied extensively at the phenotypic level. In general, increased number of panicles per unit area was the single most important yield component associated with rice yield; number of spikelets per panicle and percent filled grains per panicle being of secondary and tertiary importance(Jones and Synder 1987; Miller *et al* 1991). Selection based on correlation without taking into consideration the interactions between the component characters may sometime prove misleading. Path coefficient analysis developed by Wright (1921, 1923) provides an exact picture of the relative importance of direct and indirect effects of each of the component characters towards yield. These relationships are important for better planning of any breeding programme.

The present investigation was, therefore, undertaken to evaluate the direct and indirect effects of yield components on grain yield of promising Basmati rice mutants for developing a selection criterion for increasing efficiency of selection.

MATERIALS AND METHODS

Twenty three dwarf mutants (DM), five early flowering (EF) homozygous mutant lines developed through gamma irradiation and four commercial varieties (Table 1) were chosen for this study. The commercial varieties *viz,* Basmati 370, Basmati -Pak, Kashmir Basmati and Basmati 198 are widely grown and adapted in the province of Punjab. The material was grown at the Experimental Fields of the Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad, (183 m above mean sea level, $31^{0}24'$ N and $730^{0}05'$E), Pakistan, in a randomized complete block design with three replications during the summer season 1994.The crop was harvested in November 1994. Each plot consisted of five rows of four meter length. Thirty-days old seedlings were transplanted keeping a single plant per hill, keeping plant to row distance of 20 cm. Recommended agronomic practices were followed to raise a good crop. At maturity five random plants were taken from the three central rows of each entry and each replication for recording data on panicle length (cm), total number of spikelets per panicle, fertility percentage, 1000 grain weight (g), number of primary and secondary branches per panicle and grain yield per plant (g). The phenotypic and genotypic coefficients of correlation (Miller *et al.* 1958) among these characters were computed. The path coefficients (Dewey and Lu 1959) were also computed to measure the direct and indirect effects of yield components on grain yield and also of panicle length and the number of primary and secondary panicle branches on the number of spikelets per panicle.

RESULTS AND DISCUSSION

Mean values pertaining to panicle length, total number of spikelets panicle^{-1}, fertility percentage, 1000 grain weight, number of primary branches, number of secondary branches and yield per plant revealed significant differences (Table 1). Several mutants significantly out-yielded the commercial varieties. Phenotypic and genotypic correlation coefficients for all possible combinations of the seven characters are presented in Table 2. For each combination, phenotypic and genotypic correlation coefficients were very close. Hence only genotypic correlations were used for further analysis.

Grain yield showed highly positive correlation with panicle length, number of primary and secondary branches per panicle and number of spikelets per panicle. These results are in agreement with those of Ramalingam *et al* (1993) and Chau and Bharagava (1993). Number of spikelets per panicle also showed highly significant correlations with panicle length and the number of primary and secondary branches per panicle. Rangel (1979) and Kato and Takeda (1996) also reported similar

Table 1. Mean values of yield and yield components in induced dwarf (DM) and early flowering (EF) mutants compared with four commercial Basmati varieties.

Varieties	Panicle length, cm	Number of spikelets panicle^{-1}	Fertility percentage	Thousand grain weight, g	No. of primary branches panicle^{-1}	Number of secondary branches panicle^{-1}	Yield plant^{-1}, g
DM-1	30.1	150.6	92.87	19.4	10.9	26.1	27.25
DM-2	29.2	172.3	92.21	19.0	12.6	26.7	28.42
DM-3	30.4	165.0	94.39	19.0	11.3	28.0	28.98
DM-4	29.6	154.5	93.41	19.4	11.3	27.1	27.31
DM-9	29.8	114.3	78.52	19.9	9.9	17.3	26.39
DM-12	30.1	158.5	93.37	18.8	11.5	28.3	31.87
DM-21	27.4	147.4	83.22	20.2	12.1	27.9	20.31
DM-24	29.4	141.0	95.16	16.8	10.9	23.3	24.23
DM-25	29.3	139.9	95.19	19.9	10.4	25.5	23.29
DM-28	29.5	141.7	95.01	17.7	11.0	23.8	24.93
DM-38	29.3	154.7	95.48	17.9	10.9	26.7	20.64
DM-15-1	23.0	64.2	95.05	17.0	8.3	6.7	10.70
DM-15-4	26.4	87.2	90.94	17.0	9.6	13.8	12.94
DM-15-5	29.3	158.5	92.40	20.4	11.2	30.5	22.12
DM-15-11	23.0	63.6	92.25	16.6	8.3	7.2	11.03
DM-16-5-1	30.0	161.9	96.83	18.6	11.4	28.5	27.54
DM-25-18-88	29.7	142.8	95.34	20.2	10.9	25.4	22.49
DM-25-26-88	26.9	123.5	96.00	17.5	10.2	21.2	17.05
DM-107-4	29.4	111.9	75.16	17.3	10.0	18.2	12.73
DM-178-1	30.7	167.6	93.78	19.1	11.1	30.4	26.97
DM-179-1	29.3	143.4	92.91	18.2	11.2	25.4	21.15
Short culm 5-3	29.6	133.7	94.86	19.4	11.7	22.7	18.18
EF-4	30.6	154.3	93.36	22.7	10.9	27.1	25.45
DM-15-13-1	29.0	154.9	92.76	19.3	10.5	28.6	19.19
EF-6	29.5	134.8	96.34	20.4	11.7	21.4	22.20
EF-15-13	28.3	106.2	89.74	18.5	9.7	16.3	12.87
EF-25-4-2	26.4	96.9	87.13	22.0	9.8	11.4	13.81
EF-76-1	27.4	113.5	94.46	17.9	10.0	17.6	18.76
Kashmir Basmati	29.0	114.6	92.25	19.7	8.6	22.1	17.83
Basmati 198	28.9	156.1	92.40	19.7	10.9	29.9	18.61
Basmati Pak	25.0	85.5	88.10	21.6	10.2	8.9	11.26
Basmati 370	31.2	151.2	95.15	19.9	11.0	27.1	22.51
L.S.D. 5%	0.788	5.95	2.687	0.562	0.661	1.332	1.588
1%	1.048	7.92	3.573	0.747	0.878	1.770	2.112

Table 2. Phenotypic and genotypic correlation coefficinets among grain yield, yield components and panicle characteristics.

Variables		No. of primary branches	No. of secondary branches	1000 grain weight	Fertility percentage	No. of spikelets	Grain yield per plant
Panicle length	G	0.673**	0.841**	0.287	0.153	0.854**	0.781**
	P	0.632**	0.822**	0.268	0.130	0.834**	0.763**
No. of primary branches	G		0.768**	0.300	0.230	0.858**	0.717**
	P		0.727**	0.261	0.185	0.811**	0.656**
No. of secondary Branches	G			0.224	0.329	0.971**	0.774**
	P			0.215	0.301	0.968**	0.763**
1000 grain weight	G				-0.093	0.260	0.200
	P				-0.095	0.251	0.190
Fertility percentage	G					0.336	0.307
	P					0.312	0.289
No. of spikelets per panicle	G						0.841**
	P						0.825**

G= Genotypic correlation P= Phenotypic correlation ** = Significant at 1% probability level

results. Number of secondary branches per panicle was significantly and positively correlated with the panicle length and the number of primary branches per panicle. Number of primary branches per panicle also showed a highly significant and positive correlation with panicle length. These results are in agreement with Ramalingam *et al.* (1993) and Chau and Bharagava (1993).

Path diagram showing cause and effect relationships of grain yield and its components and number of spikelets per panicle and its components is presented in Fig 1. The estimates of the direct, indirect and total effects of yield components on grain yield and also panicle components on number of spikelets per panicle are presented in Table 3.

Grain yield vs. Number of spikelets per panicle

Genotypic correlation between these two characters was positive and significant (r=0.841) indicating thereby 71% contribution towards grain yield. The direct effect of this character was positive and extremely high (0.837) whereas indirect effects via fertility percentage and 1000 grain weight were negligible. Our results are in agreement with those

Table 3. Estimation of direct, indirect and total effects of yield components on grain yield and panicle components on number of spikelets per panicle.

Cause and effect relationship components	Effect			
Grain yield and components	**Direct**	**Indirect**		**Total**
Number of spikelets (1) and yield	0.837	via 2 via 3	=0.008 =0.004	0.841
Fertility percentage (2) and yield	0.024	via 1 via 3	=0.282 =0.001	0.307
1000 grain weight (3) and yield	-0.015	via 1 via 2	=0.218 =-0.002	0.200
Number of spikelets and components				
Panicle length (4)	0.101	via 5 via 6	=0.179 =0.574	0.854
Primary branches panicle^{-1}(5)	0.266	via 4 via 6	=0.068 =0.524	0.858
Secondary branches panicle^{-1}(6)	0.682	via 4 via 5	=0.085 =0.204	0.971

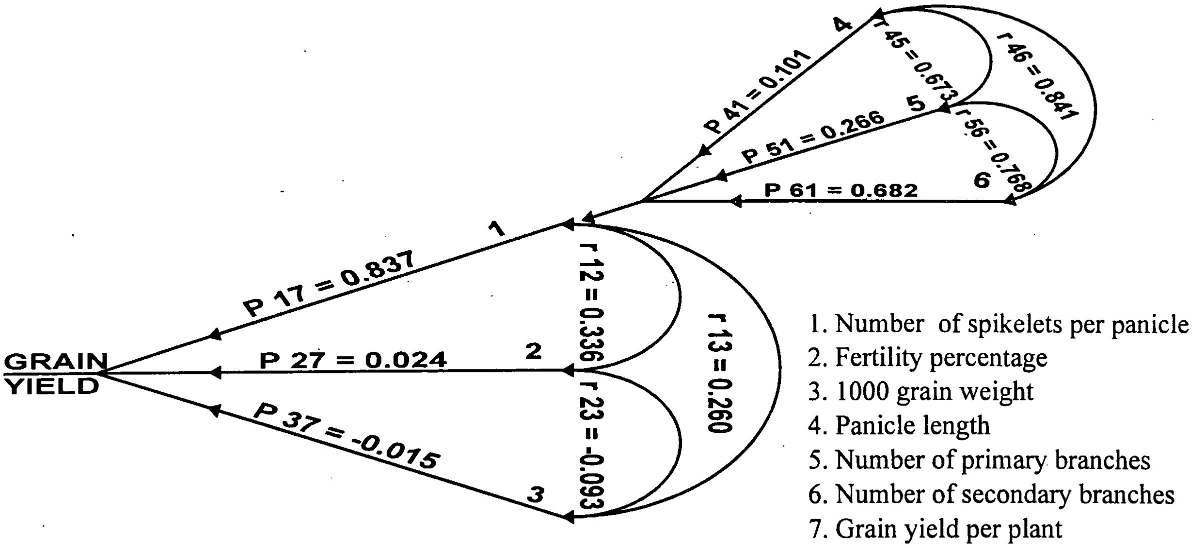

Fig. 1. Path diagram superimposed on cause and effect relationship of grain yield and yield components and number of spikelets per panicle and it's components.

of Ramalingam *et al.* (1993) and Chau and Bharagava (1993). The direct and indirect effects of panicle characteristics on number of spikelets panicle^{-1} are therefore important for increasing grain yield. Therefore the panicle length, number of primary and secondary branches were considered as components of number of spikelets per panicle and analyzed separately.

Number of spikelets per panicle vs panicle length

The coefficient of correlation of number of spikelets per panicle with panicle length was (r=0.854). The direct effect of panicle length was negligible (0.01), while indirect effect via primary branches and via secondary branches were relatively high (0.179 and 0.574 respectively). This indicates that the number of rachis branches is more important than panicle length for number of spikelets per panicle. The high correlation of number of spikelets with panicle length is due to the indirect effects of the rachis branches.

Number of spikelets per panicle vs primary branches per panicle

The correlation between these two traits was positive and high (r=0.858). The indirect effect on number of spikelets per panicle via panicle length was positive (0.068) and via secondary branches was high and positive (0.534). Thus the number of secondary branches has a high indirect effect through panicle length and primary branches.

Number of spikelets per panicle vs secondary branches per panicle

The correlation between these two traits was positive and extremely high (r=0.971) and a large proportion of this relationship is direct (direct effect = 0.682). A relatively small proportion of the correlation was due to the positive and indirect effects via panicle length (0.085) and via primary branches (0.204). Therefore it is evident that the number of secondary rachis branches is important for increasing the number of spikelets per panicle, which in turn has a high correlation and a direct effect on grain yield.

Grain yield vs fertility percentage

The coefficient of correlation of grain yield with fertility percentage was non significant (0.307). The direct effect of this character was also non-significant (0.024) and indirect effects via spikelets per panicle and 1000 grain weight was (0.282 and 0.001 respectively) also negligible. Buu and Troung (1988) have also reported similar results. The fertility percentage of the commercial varieties used as parents in the mutation breeding programme of Basmati rice was high (Table 1). As a result, all the mutants recorded high fertility percentages. Only two dwarf mutants recorded fertility percentages of less than 80% (Table 1).

Grain yield vs 1000 grain weight

The coefficient of correlation of grain yield with 1000 grain weight was positive but not significant (0.200). The direct effect was negative and non-significant while the indirect effects via number of spikelets per panicle and fertility percentage were also low (0.218 and -0.002 respectively). Our results are quite similar to the findings of Buu and Troung (1988). Therefore, 1000 grain weight does not seem to have a major contribution to yield in Basmati rice breeding.

The present study on the correlation and path analysis suggested that while selecting the high yielding genotypes in the Basmati rice, prime importance should be given to the number of spikelets per panicle which has great direct and indirect influence on the grain yield. The other characters were of secondary importance and exerted relatively low influence on grain yield. The number of secondary branches of the panicle exert the highest influence on this character. It may be concluded therefore that the number of spikelets per panicle and the number of secondary rachis branches per panicle are the most important yield components to be considered in Basmati rice breeding.

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