Component analysis for grain yield in hybrid rice under *tarai* condition

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ABSTRACT

Correlation and path coefficient were computed to assess the association between direct and indirect influences of different characters on yield in hybrid rice. The grain yield exhibited positive association with total number of spikelets m^{-2}, number of filled spikelets m^{-2}, spikelet sterility, thousand grain (test) weight, grain straw ratio except for number of panicles m^{-2}. The number of filled spikelets m^{-2} was most significantly and positively correlated with grain yield ha^{-1}. The path analysis revealed their highest positive direct effect on biological yield followed by harvest index and crop duration. The contribution of number of filled spikelets m^{-2}, spikelets sterility, thousand grain (test) weight, number of panicle m^{-2}, grain: straw ratio and dry matter production was positive but associated more indirectly to biological yield. Negative direct effect of growing degree days, total number of spikelets m^{-2}, heliothermal units, ripening periods, plant height and days taken to 50% flowering was established.

Key words: *Hybrid rice, grain yield, GDD, heliothermal units and tarai condition*

Although research on the commercial exploitation of heterosis in rice has seen significant achievement, it still requires further strengthening, since high yielding potential in hybrid rice has not fully been tapped. The grain yield in hybrid rice is a complex phenomenon and contributed by a number of attributes. But their influence is highly variable in direction and magnitude and therefore, selection of one character may bring about a simultaneous change in other in negative or positive direction. Due to extremely complex interrelationship among several characters related to dependent variables, correlation coefficient and path coefficient analysis, helps to estimate direct and indirect effects of one variable upon another. The present investigation was undertaken to estimate the correlation coefficient and path analysis to determine the major yield contributing traits in hybrid rice.

MATERIALS AND METHODS

Seven hybrid developed by the public and private sector in India viz., DRRH 1, PHB 71, Pro Agro 6201, KRH 2, ADTHR 1, UPHR 1010 and Pant Sankar Dhan 1 and two commercial inbred varieties viz Pant Dhan 4 and Pant Dhan 12 were grown in randomized block design with four replications during wet season 2000 and 2001 at the Crop Research Centre in Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand. The site is located in *tarai* plains about 30 km south of *Shiwalik* range of Himalayas at 20^0N latitude, 79^0E longitude and an altitude of 243.8 m above mean sea level. It falls under sub humid and subtropical type of climate. Twenty-one days old seedlings were transplanted, single plant $hill^{-1}$ at 20 x 20 cm spacing. Recommended package of practices were followed to raise a normal crop, on silt loam alluvial soil (Acquic Hapludoll), which was rich in organic matter and medium in phosphorus, potassium and was neutral to slightly alkaline in reaction. The data on 16 characters including grain yield were recorded on 156 plants from the plots from all the replications. Growing Degree Days (GDD) were calculated by taking the base threshold temperature of 10^oC, which heliothermal units [$\sum$ (GDD x Bright sunshine hours)] as followed by Singh *et al.* (1990). The mean data of two years was subjected to analysis of variance followed by correlation studies (Al-Jibouri *et al*., 1958) and path coefficient analysis as per method given by Dewey and Lu (1959).

RESULTS AND DISCUSSION

The grain yield is a complex and highly variable character and is a result of cumulative effects of its component characteristics and therefore, direct selection for it may not be effective. These component characters are independent in their action but are inter-linked and in this inter-linked complex genetic system, selection practiced for one individual character might subsequently bring about a simultaneous change in the other. Thus, an understanding of the association between the component characters and their relative contribution of yield is essential to effect a rational improvement in desirable traits. The wide range of variation observed for various traits and the extent of phenotypic variability is presented in (Table 1).

The genotypic and phenotypic correlation coefficients were studied for different traits along with grain yield to understand interrelationship among them. The direction of genotypic and phenotypic correlation was identical but the difference in their magnitude was significant, being larger in case of genotypic correlation. It suggests the larger influence of environment in their inter-relationships. Grain yield showed positive significant correlation (r = 0.68) with the number of filled spikelets m^{-2} (Table 2). Panwar *et al*. (1989) also reported that spikelet number was the main component which influences yield directly. Positive significant correlation between grain yield and number of spikelets m^{-2} was also reported later by Chaudhary and Das (1998). Grain yield showed positive but non-significant correlation with other yield contributing characters except the number of panicles per unit area (negative). Almost similar correlation between yield and yield contributing characters was reported by Sampath *et al*., (1989). Grain yield was negatively associated (non significant) with the number of panicles. Similarly Jiang *et al*. (1983) also reported negative correlation of panicle number with grain number panicle^{-1}, panicle weight and grain weight.

The grain yield had positive and significant correlation with days to 50% flowering and crop duration (Table 2). Chaudhary and Das (1998) also reported significant positive correlation for days to 50% flowering, days to maturity and plant height with grain yield. Grain yield also showed highly significant positive correlation with biological yield, GDD and heliothermal units (Table 2).

The dependent but variable grain yield was a result of interaction between component traits, which are either positively or negatively associated with each other. The path coefficient analysis indicated that biological yield had the maximum direct contribution to grain yield (t ha^{-1}) and it was followed by harvest index, crop duration, GDD, number of filled spikelets m^{-2} and the percent spikelet sterility (Table 3). The direct contribution of 1000 grain weight, number of panicle m^{-2}, grain straw ratio and dry matter production was positive but of low magnitude. Maximum negative direct effect was observed for the heliothermal units and total number of spikelets m^{-2} during ripening period, plant height and days taken to 50% flowering.

The direct contribution of crop duration on grain yield was supported by indirect positive effect through

Table 1. Descriptive statistics of hybrid rice for different agronomic traits under *tarai* condition

Traits	Mean	SE±	Max.	Min.	Range	CV (%)
Days to 50% flowering	96	1.46	102	83	19	3.10
Crop duration	128	1.38	130	113	17	2.20
Plant height	112	1.50	120	101	19	2.70
No. of panicle m^{2}	210	15.20	234	158	76	14.5
Total no of spikelets (000/m^{2})	34	2.10	42	26	16	12.4
No. of filled spikelets panicle^{1}	122	7.00	146	100	46	11.5
Spikelet sterility (%)	25	2.30	35	16	19	18.4
1000 grain weight(g)	24	0.65	27.9	21.8	6.1	5.5
Harvest Index	0.52	0.01	0.58	0.50	0.08	5.27
Dry matter production (gm^{2})	1377.8	82.0	1646.2	1150.4	495.8	12.0
Grain yield (t ha^{1})	6.39	0.17	7.2	5.7	1.5	5.56
GDD	1639	13.5	1689	1525	164	1.70
Heliothermal units	9468	181.9	10018	8447	1571	3.80

Table 2. Phenotypic (r_p) and genotypic (r_g) correlation coefficients between grain yield and agronomic traits in hybrid rice

Traits		Days to 50 % flowering	Ripening period	Crop duration	Plant height	No. of panicle m 2	Total no. of spikelet m 2	No. of filled spikelet m 2	Spikelet sterility (g)	1000 grain weight	Harvest index	Grain: straw ratio	Dry matter production	Biological yield	GDD	Helio thermal units	Grain yield t ha^{-1}
Days to 50% Flowering	r_p		-0.08	0.86**	0.44	-0.02	0.18	0.11	0.20	0.24	-0.09	-0.25	0.36	0.53*	0.86**	0.81**	0.61*
	r_g		-0.14	0.97**	0.47	0.01	0.25	0.13	0.24	0.38	-0.13	-0.35	0.61*	0.71*	0.96**	0.94**	0.80**
Ripening Period	r_p			0.16	0.29	0.24	0.61*	0.16	0.41	-0.53	-0.28	-0.21	0.29	0.26	0.17	0.21	0.13
	r_g			0.26	0.33	0.29	0.75*	0.27	0.53*	-076*	-0.32	-0.23	0.28	0.30	0.27	0.33	0.15
Crop duration	r_p				0.51	-0.02	0.31	0.14	0.38	0.05	-0.14	-0.28	0.29	0.61*	1.00**	0.97**	0.66*
	r_g				0.57*	0.19	0.55*	0.21	0.43	0.09	-0.25	-0.43	0.76*	0.78*	1.00**	0.98**	0.81**
Plant height	r_p					0.32	0.38	0.09	0.02	-0.17	-0.52	-0.52	0.68*	0.80**	0.50	0.48	0.60*
	r_g					0.52	0.48	0.18	-0.07	-0.26	-0.75	-0.77*	1.10**	0.99**	0.59*	0.58*	0.69*
No. of panicle m^{-2}	r_p						0.51	-0.60*	0.42	-0.31	-0.65*	-0.63	0.51*	0.29	-0.02	-0.09	-0.09
	r_g						0.49	-0.62*	0.54*	-0.68*	-0.96**	-0.84**	0.24	0.23	0.19	0.15	-0.30
Total no. of spokelets m^2	r_p							0.21	0.62*	-0.64*	-0.32	-0.30	0.62*	0.39	0.30	-0.31	0.27
	r_g							0.27	0.76*	-0.91**	-0.43	-0.36	0.45	0.54*	0.56*	0.65*	0.35
Spikelet sterility (%)	r_p								-0.35	-0.32	0.46	0.49	0.18	0.06	0.14	0.24	0.38
	r_g								-0.24	-0.08	0.47	0.50	0.39	0.35	0.21	0.45	0.68*
1000 grain weight	r_p									-0.31	-0.27	-0.32	0.03	0.13	0.37	0.35	-0.01
	r_g									-0.61*	-0.28	-0.31	-0.07	0.06	0.43	0.39	-0.08
Harvest Index	r_p										0.32	0.22	-0.18	-0.14	0.04	-0.02	0.10
	r_g										0.43	0.25	-0.31	-0.14	0.09	0.01	0.11
Grain: straw ratio	r_p											0.94**	-0.54	-0.58*	-0.14	0.08	0.004
	r_g											0.98**	-0.66*	-0.52	-0.25	-0.12	-0.01
Dry matter production	r_p												-0.56	-0.63*	-0.28	-0.20	-0.10
	r_g												-0.65*	-0.59*	-0.44	-0.28	-0.11
Biological yield	r_p													0.68*	0.28	0.27	0.46
	r_g													1.02**	0.76*	0.81**	0.79**
GDD	r_p														0.61*	0.60*	0.80**
	r_g														0.79**	0.80**	0.86**
Heliothermal units	r_p															0.97**	0.65*
	r_g															0.98**	0.81**
																	0.69*
																	0.91**

* and ** significant at P 0.05 and 0.01 levels, respectively.

Table 3. Plant coefficient analysis showing direct and indirect effect (bold) at genotypic level in hybrid

Traits	Days to 50 % flowering	Ripening period	Crop duration	Plant height	No. of panicle m^2	Total no. of spikelet	No. of filled spikelet m^2	Spikelet sterility (g) m^2	1000 grain weight	Harvest index	Grain: straw ratio	Dry matter production	Biological yield	GDD	Helio thermal units	R
Days to 50% flowering	**0.00**	0.00	0.30	-0.01	0.00	-0.02	0.02	0.03	0.03	-0.06	-0.03	0.04	0.74	-0.16	-0.08	0.80**
Ripening period	0.00	**-0.02**	0.08	-0.01	0.02	-0.07	0.04	0.06	-0.06	-0.05	-0.02	0.02	0.31	-0.05	-0.03	0.15
Crop duration	0.00	-0.00	**0.31**	-0.01	0.01	-0.05	0.03	0.05	0.01	-0.11	-0.03	0.06	0.81	-0.17	-0.09	0.81**
Plant height	0.00	-0.01	0.02	**-0.02**	0.04	-0.05	0.03	-0.01	-0.02	-0.35	-0.06	0.08	1.02	-0.10	-0.05	0.69*
No. of panicle m^2	0.00	-0.01	0.06	-0.01	**0.08**	-0.05	-0.10	0.07	-0.05	-0.04	-0.06	0.02	0.24	-0.03	-0.01	-0.30
Total no. of spikelets m^2	0.00	-0.01	0.17	-0.01	0.04	**-0.10**	0.04	0.09	-0.07	-0.20	-0.03	0.03	0.54	0.09	-0.06	0.35
No. of filled spikelets m^2	0.00	-0.00	0.06	0.00	-0.05	-0.03	**0.16**	-0.03	-0.01	0.22	0.04	0.03	0.36	0.03	-0.04	0.68*
Spikelet sterility (%)	0.00	-0.01	0.13	0.00	0.04	-0.07	-0.04	**0.12**	-0.05	-0.13	-0.02	-0.01	0.06	-0.07	-0.03	-0.08
1000 grain weight	0.00	-0.01	0.03	0.00	-0.05	0.09	-0.01	-0.07	**0.08**	0.20	0.02	-0.02	-0.14	-0.02	-0.00	0.11
Harvest index	0.00	0.01	-0.08	0.01	-0.07	0.04	0.08	-0.03	0.03	**0.46**	0.07	-0.05	-0.54	0.04	0.01	-0.01
Grain : straw ratio	0.00	0.00	-0.13	0.01	-0.06	0.04	0.08	-0.04	0.02	0.46	**0.08**	-0.05	-0.61	0.07	0.02	-0.11
Dry matter production	0.00	-0.00	0.23	-0.02	-0.02	-0.04	0.06	0.01	-0.02	-0.31	-0.05	**0.07**	1.05	-0.13	-0.07	079**
Biological yield	0.00	-0.01	0.24	-0.02	0.02	-0.05	0.06	0.01	-0.01	-0.24	-0.05	0.07	**1.03**	-0.13	-0.07	0.86**
GDD	0.00	-0.00	0.31	-0.01	0.01	-0.05	0.03	0.05	0.01	-0.11	-0.03	0.06	0.81	**0.17**	-0.09	0.81**
Heliothermal units	0.00	-0.01	0.30	-0.01	0.00	-0.06	0.07	0.05	0.00	-0.05	-0.02	0.06	0.83	-0.16	**-0.09**	0.91**

Residual factor 0.01

biological yield. The indirect effects through dry matter production, spikelet sterility, number of filled spikelets m^{-2}, 1000 grain weight and number of panicles m^{-2} were positive but of very low magnitude. Similarly, the number of filled spikelets m^{-2} also contributed to higher grain yield substantially via biological yield and harvest index while the effect via crop duration, grain straw ratio and dry matter production was only meager. Spikelet sterility had shown positive direct effect, however, its indirect effect via total number of spikelets m^{-2}, number of filled spikelets, 1000 grain weight, harvest index, GDD, heliothermal units, grain straw ratio and dry matter production was negative in direction. Harvest index exhibited the second highest direct contribution for yield. However, its indirect and positive effects through grain straw ratio, number of filled spikelet, total number of spikelets m^{-2}, GDD,1000 grain weight, plant height and ripening period were of insignificant magnitude. Its indirect effect through biological yield was much larger and negative in its direction. Similarly, the biological yield plant^{-1} with the higher direct positive effects on yield was also accompanied by very high indirect effect through crop duration. Its indirect contribution through dry matter production, number of filled spikelet m^{-2}, number of panicle m^{-2} and spikelet sterility were positive but of low magnitude. GDD showed direct negative effect accompanied by indirect negative effect with harvest index, heliothermal units, total number of spikelet m^2, grain straw ratio and plant height. However, indirect effect on spikelet via crop duration, number of panicles m^{-2}, number of filled spikelets m^2, spikelet sterility percent, dry matter production and biological yield was positive. These explicitly revealed the importance of biological yield, harvest index and crop duration followed by GDD, number of filled spikelets m^{-2} and percent spikelet sterility in determining the grain yield of hybrid rice. The indirect contribution was recorded for dry matter production and plant height followed by heliothermal units, crop duration, the maturity, days taken to 50% flowering, total number of spikelets m^{-2}, number of filled spikelets m^{-2}, ripening period and number of panicle m^{-2}. These findings are in agreement with the results obtained by Chaudhary and Das (1998) in respect of plant height Luzi Kihupi (1998) for 1000-grain weight. Shanthakumar *et al*., (1998) for percent spikelet fertility, Bagali *et al.* (1999) for harvest index and Satpute (1996) for the number of spikelet panicle^{-1}. The magnitudes of the direct and indirect effects in the other cases were very meager. The value of residual effects was very low (0.01) suggesting that the characters studied in path analysis had accounted for most of the genetic variability for grain yield.

Results of this study suggested that the characters namely biological yield, harvest index, crop duration, number of filled spikelets m^2, spikelets sterility,1000 grain weight, number of panicle m^2, grain straw ratio and dry matter production influenced the grain yield (t ha^{-1}) either directly or indirectly. Thus, a selected line with these characters would be ideal hybrid rice possessing higher grain yield potential. Therefore, these characters could be used for improving grain yield in hybrid rice.

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