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ASSOCIATION ANALYSIS OF SOME YIELD INFLUENCING TRAITS IN AROMATIC AND NON AROMATIC RICE

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Abstract

Studies on path coefficient analysis for yield and yield components in rice, involving nine genotypes of aromatic group and eight genotypes of non-aromatic group were conducted separately. The study was conducted at the Nuclear Institute for Agriculture and Biology, Faisalabad during 2001-02. *Thirty* days old seedlings were transplanted by maintaining 20 cm plant-to-plant and row-to-row spacing. Analysis of variance reflected significant differences among the genotypes for all the traits studied in both the groups. Broad sense heritability estimates for various traits ranged from 56–89% in the non-aromatic group and 46-99% in the aromatic group. In both the groups, the phenotypic coefficients of variability were higher than their respective genotypic coefficients of variability for all the traits, indicating the effect of the environment on character association.

In the non-aromatic group, productive tillers per hill showed highly significant positive association with grain yield per plant. Whereas in the aromatic group days-to-50% flowering and days-to-maturity exhibited highly significant negative genetic association with grain yield per plant. Association and path analysis suggested that productive tillers per hill, days to maturity and days to 50% flowering may be considered important for the improvement of grain yield in the non-aromatic group whereas productive tillers per hill, spikelets per panicle, fertility %age and plant height may be considered as the selection criteria for the direct improvement of grain yield in the aromatic group.

Introduction

Rice is one of the most important food crops of the world. It is primary staple food for one third of the world population (David, 1991). In Pakistan rice is cultivated over an area of 2.5 million hectares with a production of 5.2 metric tons annually, having an average yield of 2050 kg per hectare (Anony., 2001). The importance of rice for our country is evident as it earns 20% foreign exchange to the national foreign reserves (Anony., 2001). In Pakistan, it is grown at the latitude ranging from 24^o to 36^o N in the south to 25000-meter high altitude in northern upland valleys and terraces in the arid hot zones to the tropical humid. Soils in the rice growing zones range from clay loam to heavy dispersing clays with minimum percolation losses. This type of agro-climate is ideal for bumper rice harvest. Pakistan is the fifth biggest rice exporting country and exports more than one million tons of rice annually, which is 10% of the world’s rice trade. Though the yield of rice per hectare in Pakistan has increased from 970 to 2050 kg per hectare during 1999-2000, due to the introduction of high yielding IRRI varieties, but still it is well below the world’s average.

Economic product of rice is the paddy yield, which exhibits complex genetics as it is influenced by various yield contributing characters and the environment. These yield-contributing characters are interrelated. Therefore, information about the phenotypic and genotypic correlations of these traits is of immense importance to the plant breeders for the development of improved varieties/lines of rice with increased yield potential (Agarwal *et al.*, 1979; Amin, 1979; Ragarathinam *et al.*, 1992), whereas path coefficient analysis is an effort to asses the magnitude of contribution of various agro-morphological characters to yield.

The present studies were undertaken to describe the genetic variability, character association (genotypic and phenotypic) and contribution of various yield-influencing traits to establish appropriate plant attributes for selection to improve the yield in fine and coarse rice varieties.

Materials and Methods

The experiment relating to the genetic correlations and path coefficient analysis consisted of two groups viz., aromatic group (PK5281-1-2-1, 88801, 98401, PB-95, SRI-8, Basmati 15-2, NIAB-2000, Super Basmati and Basmati-2000), and non-aromatic group (KSK-201, KSK-202, PK-3699-43, IR-6-25A, NIAB-Irri-9, L-142, L-143 and KS-282). The material was grown at Nuclear Institute for Agriculture and Biology (183 meter above mean sea level, 31^o to 24^o N and 730^o 05^o E) in a randomized complete block design (RCBD) with three replications during the year 2001-02. The plot size was 3x5 m^2 with 20 cm plant to plant and row-to-row spacing. Thirty day old seedlings were transplanted by maintaining one seedling per hill. To get a good crop, standard agronomic practices were followed. Five plants per replication per entry were harvested randomly to collect the data on plant height, 1000-grain weight, productive tillers per plant, spikelets per panicle, fertility percentage and grain yield per plant.

Analysis of variance and covariance for the data were carried out by using the procedure of Steel & Torrie (1980). The method of Burton & Devane (1953) was used for estimating the heritability as an index of transmissibility associated with various plant performance traits.

In order to determine the extent of character association at phenotypic and genotypic levels, correlation coefficients were computed by using the technique given by Kwon & Torrie (1964). Genetic correlations were tested for their statistical significance by using the methodology given by Lothrop *et al.*, (1985). Standard error for heritability was computed according to the method proposed by Reeve (1955) and Robertson (1959). The methodology proposed by Dewey & Lu (1959) was used to perform the path analysis for grain yield and its components keeping grain yield as resultant variable and its components as causal variables.

Results and Discussions

A. Genetic variability

Mean squares, heritability, genotypic and phenotypic coefficients of variability for various traits are presented in Table 1a and 2a. Results showed that the genotypic differences for all the traits were highly significant in both the groups (aromatic and non-aromatic), so these genotypes were highly diversified and selection can be made for various morphogenetic traits (Kaw *et al.*, 1999) also studied significant variations for fertility %age and flowering duration.

Table 1a. Genetic parameters for various morphological traits in non-aromatic genotypes of rice.

cter	Mean squares		δ^2g	δ^2p	GCV	PCV	h^2	G.A (%of mean)
	Treatment	Error						
ɔ 50% flowering	54.42**	8.31	15.37	23.68	3.70	4.59	64.89	6.52
ɔ maturity	50.71**	8.96	13.91	22.87	2.68	3.43	60.84	6.00
ieight	205.40**	7.86	65.84	73.71	7.48	7.92	89.33	15.73
tive tillers per hill	16.29**	2.12	04.72	6.84	14.57	17.54	69.04	3.71
ets per panicle	1250.19**	259.18	330.34	589.52	10.68	14.27	56.03	28.00
;rain weight	4.85**	0.175	1.56	1.73	4.85	5.11	89.89	2.43
y %age	30.14**	4.51	8.54	13.05	3.17	3.92	65.42	4.83
yield per plant	129.66**	7.62	40.67	48.30	15.62	17.03	84.21	12.03

* at 1% and 5% level of significance h^2: Heritability δ^2p: Phenotypic variance G.A. Genetic advance δ^2g: Genetic variance, GCV:Genotypic ent of variability PCV: Phenotypic coefficient of variability.

Table 1b. Phenotypic and genotypic correlations among morphological characters in non-aromatic genotypes of rice.

racter	Correlation	Days to 50% flowering	Days to maturity	Plant height	Productive tillers per hill	Spikelets per panicle	1000-grain weight	fertility %age
to maturity	G	0.998**						
	P	0.989**						
height	G	-0.707*	-0.736*					
	P	-0.492	-0.503					
uctive tillers/ Hill	G	0.565	0.562	-0.321				
	P	0.394	0.379	-0.255				
elets/Panicle	G	-0.839**	-0.878**	0.687	-0.390			
	P	-0.694	-0.746*	0.513	-0.103			
-grain weight	G	-0.063	-0.091	0.125	-0.070	-0.194		
	P	-0.138	-0.152	0.104	-0.071	-0.071		
lity %age	G	0.638	0.688	-0.077	0.091	-0.735*	-0.349	
	P	0.467	0.506	-0.055	0.152	-0.579	-0.283	
ı yield per plant	G	0.517	0.496	-0.158	0.992**	-0.382	0.162	0.182
	P	0.404	0.389	-0.079	0.841**	-0.237	0.152	0.262

d *: significant at 1% and 5% levels of significance respectively **G**: Genotypic Correlation **P**: Phenotypic correlation **n**: 8 (No. of data points)

Data presented in Table 1a (Non-aromatic group) showed maximum genetic variability (15.62) for grain yield per plant followed by productive tillers per hill (14.57). The most consistent performance was observed with respect to days-to-maturity (2.68). In the aromatic group (Table 2a), maximum genetic variability was observed for total spikelets per panicle (22.64) followed by productive tillers per hill (18.08). The most consistent performance was observed for fertility %age (2.06). In both the groups (Table 1a and 2a) generally the phenotypic coefficients of variability were higher than genotypic coefficients of variability for all the traits, which reflects the effect of the environment on character association at the genetic level (Buu & Tuan, 1991).

Broad sense heritability estimates in both the groups (Table 1a and 2a) were generally high for all the traits except grain yield per plant (45.88%) in the aromatic group. Iftikhar *et al.,* (2001) also reported high heritability estimates for plant height, days to maturity, 1000-grain weight and spikelets per panicle, which support the present findings. Although high heritability estimates have been found to be effective in performing selection of superior genotypes on the basis of phenotypic performance, Johnson *et al.,* (1955) suggested that heritability estimates along with genetic advance (% of mean) were more useful in predicting the effect for selecting the best individual. High heritability along with high genetic advance was recorded for spikelets per panicle and plant height in both the groups (Table 1a & 2a) and similar findings have been reported by Ali *et al.,* (2000) in *Oryza sativa L.*

B. Genotypic and phenotypic correlation

The genotypic and phenotypic correlation coefficients are given in Tables 1b (Non-aromatic group) and 2b (Aromatic group).

Non-aromatic group: Days- to-50% flowering showed positive and highly significant genotypic and phenotypic correlations with days to maturity, significant but negative association with plant height, negative and highly significant correlation with spikelets per panicle and positive significant correlation with fertility %age at the genotypic level. Prasad *et al.,* (2001) observed that days to flowering are negatively correlated with plant height. Days to flowering showed positive genotypic and phenotypic correlations with yield per plant, which is in agreement with the findings of Manvel & Palananisamy (1989) who observed positive correlation of days to flowering with grain yield.

Days to maturity showed negative and significant association with plant height at genotypic level, negative and highly significant at genotypic and negatively significant correlations with total spikelts per panicle whereas negative and non-significant genotypic and phenotypic correlations with 1000-grain weight. But this trait exhibited positive and non-significant correlation with productive tillers per plant; fertility %age and grain yield per plant at both levels. Prasad *et al.,* (2001) also reported positive association of days to maturity with productive tillers per plant; fertility %age and grain yield per plant but negative correlation with plant height at both levels. Iftikhar *et al.,* (2001) also reported negative correlation between days to maturity and spikelets per panicle. Plant height exhibited negative and non-significant correlations both at genotypic and phenotypic levels with productive tillers, fertility %age and grain yield per plant, but positive and non-significant correlation with total spikelets per panicle and 1000 grain weight, Prasad *et al.,* (2001) also reported negative association of plant height with grain yield per plant and productive tillers per plant at both levels whereas Rasheed *et al.,* (2002) reported positive association of plant height with fertility index which is not in line with present finding which might be due to the differences of the genetic constitution of the material used.

Table 1c. Direct and indirect effects in non-aromatic genotypes of rice.

Characters	Days to 50% flowering	Days to maturity	Plant height	Productive tillers per hill	Spikelets per panicle	1000-grain weight	Fertility %age	Grain yield per plant (r_g)
Days to 50% flowering	**(-0.407)**	0.709	-0.332	0.526	0.145	-0.007	-0.117	0.517
Days to maturity	-0.406	**(0.710)**	-0.345	0.524	0.152	-0.010	-0.127	0.496
Plant height	0.288	-0.523	**(0.469)**	-0.302	-0.119	0.014	0.014	-0.158
Productive tiller/Hill	-0.230	0.399	-0.152	**(0.932)**	0.067	-0.008	-0.017	0.992
Spikelets per panicle	0.341	-0.624	0.323	-0.364	**(-0.173)**	-0.021	0.135	-0.382
1000-grain weight	0.026	-0.064	0.058	-0.065	0.034	**(0.109)**	0.064	0.162
Fertility %age	-0.260	0.488	-0.036	0.085	0.127	-0.038	**(-0.184)**	0.182

Figures in parentheses indicate direct effects $\mathbf{r_g}$: Genotypic correlation

Table 2a. Estimates of genetic parameters for various characters in aromatic genotypes of rice.

Character	Mean squares		δ^2g	δ^2p	GCV	PCV	h^2	G.A (%of mean)
	Treatment	Error						
Days to 50% flowering	357.82**	1.58	118.75	120.32	10.45	10.52	98.69	10.97
Days to maturity	355.76**	1.50	118.08	119.59	7.85	7.90	98.73	10.93
Plant height	691.85**	13.29	226.18	239.48	10.97	11.29	94.45	15.47
Productive tillers per hill	21.95**	01.12	6.94	8.06	18.08	19.49	86.10	2.83
Spikelets per panicle	4210.69**	121.46	1363.08	1484.54	22.64	23.62	91.81	38.53
1000-grain weight	7.79**	0.45	2.45	2.89	7.18	7.80	84.58	2.94
Fertility %age	12.20**	1.36	3.61	4.97	2.06	2.41	72.62	3.35
Grain yield per plant	11.25*	3.17	2.69	5.87	5.45	8.05	45.88	2.29

** and * at 1% and 5% level of significance **h^2**:Heritability **δ^2p:** Phenotypic variance **G.A**. Genetic advance **δ^2g:** Genetic variance, **GCV**: Genotypic coefficient of variability **PCV**: Phenotypic coefficient of variability

Productive tillers per plant exhibited positive and highly significant correlation with grain yield per plant both at genotypic and phenotypic levels, negative but non-significant association with total spikelets per panicle and 1000-grain weight, positive and non-significant association with fertility %age. Kalaimani & Kadambavanasundram (1988) reported positive and significant correlation of grain yield with productive tillers per plant. Total spikelets per panicle exhibited negative and significant correlation with fertility %age at genotypic level, negative and non-significant correlation with 1000-grain weight and grain yield per plant. Thousand grain weight was negatively and non-significantly correlated with fertility %age but positively and non-significantly correlated with grain yield per plant. Positive correlation of 1000-grain weight with grain yield per plant was also recorded by Tsuzuki & Umeki (1990) and Mirza *et al.,* (1992). Kennedy & Rangasamy (1998) reported highly significant correlation between grain yield and 1000-grain weight at the phenotypic level. Total spikelets per panicle showed negative but non significant correlation with 1000 grain weight, fertility %age and grain yield per plant. Ifithkar *et al.,* (2001) also observed negative correlation between spikelets per panicle, 1000-grain weight and grain yield per plant. Fertility %age revealed positive but non-significant correlation with grain yield per plant both at the genotypic and phenotypic levels.

Aromatic group: Days-to-50% flowering exhibited highly significant positive genotypic and phenotypic correlations with days to maturity, which means that the genotypes, which flower vigorously, will mature earlier whereas this trait showed negative and highly significant correlation with 1000-grain weight and grain yield per plant at genotypic level and negative significant phenotypic correlation with 1000-grain weight. For plant height, productive tillers per plant and fertility %age, and days to flowering showed non-significant negative correlations at both levels. Exactly the same trend was observed with respect to days to maturity. Plant height was positively correlated with total spikelets per panicle and grain yield per plant but negatively correlated with productive tillers per plant, 1000 grain weight and fertility %age. Positive correlation of plant height with yield per plant has also been reported by Sharma & Reddy (1991). Khan *et al.,* (1991) reported negative correlation between plant height and productive tillers per plant. Productive tillers per plant showed negative but non-significant correlation with total spikelets per panicle but positive correlation with grain yield per plant both at the genotypic and phenotypic levels. Ganesan & Subramanian (1990), Deshmukh & Chau (1992) reported positive and significant association between productive tillers per plant and grain yield per plant. Total spikelets per panicle showed negative and non-significant correlation with 1000-grain weight. Iftikhar *et al.,* (2001) also noted similar kind of results. Total spikelets per panicle showed negative and significant correlation with fertility %age but positive and non-significant correlation with grain yield per plant.

1000-grain weight exhibited positive but non-significant correlation with fertility %age and grain yield per plant at both levels. Cheema *et al.,* (1998) also found positive and significant correlation between 1000-grain weight and grain yield per plant at the genotypic and phenotypic levels. Fertility %age showed positive but non-significant correlation with grain yield per plant and same results were deduced by Cheema *et al.,* (1998). Rasheed *et al.,* (2002) reported a positive association between fertility index and grain yield per plant.

In both the experiments generally most of the genotypic and phenotypic correlation coefficients were non significant, this might be attributed to the difference in genetic constitution of the breeding material used. Similar findings have also been reported by Rasheed *et al.,* (2002).

C. Path coefficient analysis

Table 1c (Non-aromatic group) and 2c (Aromatic group) revealed the results of direct and indirect effects of various traits on grain yield per plant.

Non-aromatic group: Productive tillers per plant exhibited the highest positive direct effect followed by days to maturity and plant height. Direct effect of days to 50% flowering, total spikelets per panicle and fertility %age were negative. The direct effect of days to 50% flowering with grain yield per plant was negative but the correlation coefficient was positive and it was mostly due to the positive indirect effects via days to maturity and productive tillers per plant. The highest positive indirect effect was observed via days to maturity. The negative indirect effect via 1000-grain weight was almost negligible. Days to maturity exhibited a positive direct effect as well as the correlation coefficient that indicates the true relationship and direct selection through this trait can be effective. However, the indirect effect via days to 50% flowering, plant height, 1000-grain weight and fertility %age were negative. The indirect effect via productive tillers per plant and total spikelets per panicle were positive. The direct effect of plant height on grain yield was positive but the correlation coefficient was negative, therefore a restricted simultaneous selection model is recommended to nullify undesirable indirect effects in order to make use of direct effect. The indirect effects via productive tillers per plant and total spikelets per panicle were also negative but the indirect effect via 1000-grain weight and fertility %age were positive and low. The highest positive direct effect and highly significant positive correlation coefficient was recorded between productive tillers per plant and grain yield per plant, which is in accordance with the finding of Gupta *et al.,* (1999). Most of the positive associations shown by this trait were due to the high positive direct effect of productive tillers per plant on grain yield. The indirect effects via days to 50% flowering, plant height, 1000-grain weight and fertility %age were negative but low as compared to the direct effect. The indirect effects via days to maturity and total spikelets per panicle were low but positive.

Direct effect and correlation coefficient between total spikelets per panicle and grain yield per plant were negative but very low. The indirect effect via days to maturity, productive tillers per plant and 1000-grain weight were negative but the indirect effect via days to 50% flowering, plant height, and fertility %age were positive. Since the direct effect and correlation coefficient both were negative, so the direct selection for this trait to improve the yield will not be desirable, However, improvement in panicle fertility along with desirable plant height and flowering period may help to compensate the negative effect of spikelets per panicle which is negligible.

Direct effect and correlation coefficient of 1000-grain weight with grain yield were positive but the indirect effect of 1000-grain weight via days to maturity and productive tillers per plant was negative. It shows that any selection for 1000-grain weight will not have significant effect in improving the grain yield. Cheng *et al.,* (1999) also reported positive direct effect of 1000-grain weight on grain yield in upland rice genotypes. Bagali *et al.,* (1999) reported positive association of 1000-grain weight with grain yield and

Table 2b. Phenotypic and genotypic correlations among morphological characters in aromatic genotypes of rice.

Character	Correlation	Days to 50% flowering	Days to maturity	Plant height	Productive Tillers per hill	Spikelets per panicle	1000-grain weight	Fertility %age
Days to maturity	G	0.999**						
	P	0.996**						
Plant Height	G	-0.118	-0.111					
	P	-0.111	-0.102					
Productive Tillers/ Hill	G	-0.215	-0.239	-0.425				
	P	-0.194	-0.229	-0.398				
Spikelets/Panicle	G	0.133	0.164	0.473	-0.547			
	P	0.134	0.168	0.446	-0.505			
1000-grain weight	G	-0.821**	-0.841**	-0.203	0.337	-0.629		
	P	-0.738*	-0.757*	-0.189	0.250	-0.539		
Fertility %age	G	-0.070	-0.083	-0.611	0.029	-0.754*	0.605	
	P	-0.087	-0.103	-0.523	0.021	-0.729*	0.486	
Grain yield per plant	G	-0.832**	-0.816**	0.459	0.255	0.509	0.272	0.390
	P	-0.550	-0.524	0.322	-0.233	0.426	0.202	-0.271

** and *: significant at 1% and 5% levels of significance respectively **G:** Genotypic Correlation **P:** Phenotypic Correlation **n**: 9 (No. of data points)

Table 2c. Direct and indirect effects in aromatic genotypes of rice.

Characters	Days to 50 % flowering	Days to maturity	Plant height	Productive tillers per hill	Spikelets per panicle	1000-grain weight	Fertility %age	Grain yield per plant (r_g)
Days to 50% flowering	**(-139.11)**	141.81	-1.32	-2.90	1.27	0.55	-1.13	-0.83
Days to maturity	-139.04	**(141.89**	-1.24	-3.22	1.57	0.56	-1.34	-0.82
Plant height	16.49	-15.77	**(11.17)**	-5.71	4.53	0.13	-10.38	0.46
Productive tiller/Hill	29.99	-33.94	-4.74	**(13.44)**	-5.23	0.22	0.46	0.25
Spikelets per panicle	-18.53	23.28	5.28	-7.35	**(9.57)**	0.42	-12.15	0.51
1000-grain weight	114.26	-119.32	-2.27	4.53	-6.02	**(0.66)**	9.76	0.27
Fertility %age	9.77	-11.84	-7.20	0.38	-7.22	0.40	**(16.11)**	0.39

Figures in parentheses indicate direct effects **r_g**: Genotypic correlation these findings support the present results. Fertility %age revealed positive association with grain yield but the direct effect is negative. The highest positive indirect effect of this trait was observed via days to maturity but the indirect effect via days to 50% flowering, plant height and 1000-grain weight was negative. Whereas indirect effects via days to maturity, productive tillers per plant and total spikelets per panicle were positive. In general most of the direct and indirect effects of this trait on grain yield were low.

Aromatic group: Days-to-maturity had the highest positive direct effect on grain yield followed by fertility %age, productive tillers per plant and plant height. The direct effect of days to 50% flowering was negative and very high. The genotypic correlation and indirect effects via plant height, productive tillers per plant, fertility %age were also negative. Negative direct effect of days to flowering but positive indirect effect via days to maturity on grain yield was reported by Prasad *et al.,* (2001), which is in accordance with the present finding. Thaware *et al.,* (1999) reported positive direct effect of days to 50% flowering, which is not in line with present finding. The direct effect of days to maturity was positive and very high but the genotypic correlation coefficient and indirect effect via days to 50% flowering, plant height, productive tillers per plant and fertility %age were negative. The indirect effects via total spikelets per panicle and 1000-grain weight were positive but low as compared to other traits. Since the genotypic correlation coefficient is negative and highly significant but the direct effect is positive, under such conditions, a restricted simultaneous selection model is to be followed i.e. Restrictions are to be imposed to nullify undesirable indirect effects in order to make use of the direct effects (Singh & Kakar, 1977). Thaware *et al.,* (1999) reported the positive direct effect of days to maturity on grain yield, which is in accordance with the present findings. Plant height exhibited a positive direct effect and genotypic correlation coefficient with grain yield per plant although correlation coefficient was low and non significant. The indirect effect via days to maturity, productive tillers per plant and fertility %age is negative and high. Maximum positive indirect effect was observed via days to 50% flowering followed by total spikelets per plant and 1000-grain weight. Positive direct effect of plant height on grain yield is supported by Baba *et al.,* (2002). Productive tillers per plant exhibited a positive direct effect on grain yield per plant. The indirect effect via days to maturity was negative and the highest one. The correlation coefficient was positive as most of the negative indirect effects were nullified by positive indirect effect via days to 50% flowering. Indirect effects via plant height and total spikelets per panicle were almost equal and negative. Positive association of grain yield with productive tillers per plant was also studied by Meenakshi *et al.,* (1999). Total spikelets per panicle also exhibited a positive direct effect and correlation coefficient with grain yield per plant. Correlation coefficient was high due to the high positive indirect effect via days to maturity. Indirect effect via days to 50% flowering was also high but negative followed by fertility %age and productive tillers per plant. Since the direct effect and correlation coefficient between total spikelets per panicle and grain yield are positive, so it is an indication of true relationship among these traits. It suggests that the direct selection for total spikelets per panicle would likely to be effective in improving the grain yield. Kim *et al*., (1999) reported positive contribution of total spikelets towards grain yield, which supports the present finding.

Thousand grain weight exhibited a low negative direct effect on grain yield but correlation coefficient was positive. The indirect effect via days to 50% flowering, productive tillers per plant and fertility %age were positive but most of the positive indirect effects were neutralized by the negative indirect effect via days to maturity. Indirect effect via plant height and total spikelets per panicle were also negative but very low as compared to the negative indirect effect via days to maturity. Mohan & Narayanswami (1973) and Thaware *et al.,* (1999); also reported negative direct effect of 1000-grain weight on grain yield. The fertility %age revealed a high positive direct effect but the correlation coefficient is positive and low as most of the positive direct effect is nullified due to the negative indirect effects via days to maturity, plant height and total spikelets per panicle. The indirect effect via days to 50% flowering and productive tillers per plant are positive but later has small effect as compared to the former. Cheng *et al*., (1999) also reported positive contribution of fertility %age towards grain yield.

Conclusion

It is obvious from the results that in the non-aromatic group, the highest positive direct and indirect effects were observed for productive tillers per hill and days to maturity while days to 50% flowering showed the highest positive indirect effect. These parameters also showed positive genotypic association with grain yield and therefore, may be considered as the selection criteria for the improvement of grain yield. In the aromatic group, days to maturity showed the highest positive direct effect and days to 50% flowering exhibited the highest positive indirect effect but these parameters have highly significant negative genetic association. The traits such as productive tiller per hill, spikelets per panicle, fertility %age and plant height do have high positive direct effect and positive genotypic association as well with grain yield. So these parameters may be given prime importance for the direct improvement of grain yield in this group.

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