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RELATIONSHIP OF MORPHOLOGICAL TRAITS AND GRAIN YIELD IN RECOMBINANT INBRED WHEAT LINES GROWN UNDER DROUGHT CONDITIONS

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Abstract

Interrelationship among yield and different yield related traits in 16 wheat recombinant inbred lines (RILS) / varieties were determined by correlation and path coefficient analysis under moisture stress conditions using randomized complete block design with three replications. Grain yield was positively correlated with days to maturity, tillers m^{-2} and number of grains $spike^{-1}$. Negative correlation of grain yield was observed with plant height, spike length, peduncle length, peduncle extrusion, sheath length and 1000-grain weight. So far the relationship between different parameters is concerned, 55.55 % genotypic and 57.77 % phenotypic correlations were positive while the remaining were negative. Path analysis indicated that peduncle length had the highest direct effect on grain yield followed by tillers m^{-2}, grains $spike^{-1}$, spike length and days to maturity whereas peduncle extrusion, sheath length, 1000 grain weight and plant height had negative direct effect on the same parameter. The characters such as days to maturity, tillers m^{-2} and grains $spike^{-1}$ having positive direct effect along with positive genotypic correlation on grain yield are considered to be suitable selection criteria for the development of high yielding genotypes.

Introduction

Drought is the most serious constraint for crop production. The problem of drought is acute in the developing countries of the world where about 37% of the wheat growing areas are semi-arid having low moisture as a limiting factor for higher yield (Rajaram, 2001). In Pakistan, nearly 80% of agricultural land is irrigated, while the rest 20% is rainfed. But the situation is totally different in NWFP where 68.5 % wheat is grown on rainfed areas and 31.5 % on irrigated areas. The wheat yield in irrigated areas ranges from 2.5 to 2.8 tones per hectare whereas in rainfed areas it ranges from 0.5 to 1.3 tones per hectare.

The wheat yield under rainfed areas suffers a serious moisture stress throughout its life cycle beginning from seedling stage to maturity. According to Kramer (1980), the world wide losses in yield caused by water shortage and salinity are greater than those caused by all other factors together. Areas where wheat is grown under supplemental irrigation are also hit by drought during the late stages of plant growth causing considerable reduction in yield. Enhancement of irrigation water supplies to the barani areas is not only un-economical but most often practically difficult. Moreover, geographical location of our wheat belts receives less winter rains. In such a situation it is a dire need to evolve new genotypes that could not only tolerate serious soil and atmosphere moisture stress at various stages of plant development but also can produce economical seed yield.

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For improvement in yield, study of yield contributing components in respect of their genetic mechanism is very important. Information regarding genotypic and phenotypic correlations between quantitatively inherited plant characters and their direct and indirect effects on grain yield as a result of varietal response proved to be a useful tool for increasing the yield per unit area through selection. Simple correlation analysis indicates the degree of association between traits but it cannot provide reasons of association. Therefore, simple correlation coefficients are not always effective in determining the real relationship among traits. Hence there is a need for component analysis (Hardwick & Andrews, 1980).

Path coefficient analysis is simply a standardized partial regression coefficient and as such measures the direct and indirect effect for one variable upon another and permits the separation of the correlation coefficient into components of direct and indirect effect (Dewey & Lu, 1959). Using path coefficient analysis, it is easy to determine which yield component is influencing the yield substantially. Having this information, selection can then be based on that criterion thus making possible great progress through selection in limited time. Path analysis was used by several researchers with the objective to determine the effects of important yield components (Maria *et al*., 1984; Stafford & Seiler 1986; Turan 1989; Ball *et al*., 1993; Costa & Krostand 1994; Akanda & Mundt 1996; Dogney *et al*., 1998; Mehetre *et al*., 1997; Yağdı 2001; Naazar *et al*., 2003, Ahmed *et al*., 2003). The objectives of the present study were to get scientific information on yield and yield components in bread wheat through the determination of relationships among various traits along with path analysis technique.

Materials and Methods

The studies were carried out at the experimental field of Nuclear Institute for Food and Agriculture (NIFA), Tarnab, Peshawar Pakistan during 2007-08. Fourteen recombinant inbred wheat lines (NRL-0702, NRL-0704, NRL-0707, NRL-0709, NRL-0710, NRL-0711, NRL-0712, NRL-0715, NRL-0716, NRL-0717, NRL-0720, NRL-0721, NRL-0722, RAS-I) and two standard varieties (Inqilab and Tatara) were grown in randomized complete block design (RCBD) with three replications. Six rows of 5 m length per entry were sown keeping rows 30 cm apart. Recommended doses of fertilizers were applied at the time of sowing. No irrigation was applied during the growing season (precipitation 204.10 mm). Data were recorded on plant height, days to maturity, tillers m^{-2}, spike length, peduncle length, peduncle extrusion, sheath length, grains $spike^{-1}$, thousand grain weight and grain yield.

The data were statistically analyzed using MStat-C. Genotypic and phenotypic variances and analysis of covariance was carried out for all the characters (Singh & Chaudhary, 1979). Genotypic and phenotypic correlations were determined and tested for significance (Gomez & Gomez, 1984). Path coefficient analysis was carried out with genotypic correlation considering grain yield as dependent variable and other traits as independent variables (Dewey & Lu, 1959).

Results

Correlation: Genotypic correlation coefficients were higher than the respective phenotypic correlation coefficients indicating that the latter were slightly influenced by environment (Table 1). The phenotypic / genotypic association of plant height was almost positive and highly significant with spike length, peduncle length, peduncle extrusion, sheath length and 1000-grain weight whereas it expressed negative correlation with tillers m^{-2}, grains $spike^{-1}$ and grain yield.

Days to maturity showed positive and significant correlation with spike length, peduncle length, and grains spike^{-1} at both genotypic and phenotypic levels. Its association with sheath length was positive and negligible at genotypic level but negative at phenotypic level.

Tillers m^{-2} was negatively correlated with almost all the traits except with grains spike^{-1} and grain yield. Peduncle length and peduncle extrusion exhibited positive and significant correlation with sheath length and 1000-grain weight at both genotypic and phenotypic levels. Furthermore both the traits were negatively correlated with grain spike^{-1} and grain yield. Spike length was strongly and positively correlated phenotypically and genotypically with peduncle length, peduncle extrusion, sheath length, 1000-grain weight and negatively with grains spike^{-1}. Its relation with grain yield was highly significant but negative. Number of grains spike^{-1} had positive correlation with grain yield at both levels. The trait further displayed negative but highly significant correlation with 1000-grain weight. The association between 1000-grain weight and grain yield was negative and non significant at both levels.

Overall only grains spike^{-1} showed positive and highly significant phenotypic correlation with seed yield, however genotypic correlation of this character was only positive and non significant. Another character which showed only positive phenotypic and genotypic correlation with seed yield was tillers m^{-2}.

Path analysis

Plant height vs grain yield: Plant height showed negative direct effect on grain yield by displaying a value of -0.176 (Table 2). It has positive indirect effect through days to maturity (0.037), spike length (0.147) and peduncle length (40.687) while negative indirect effect *via*. tillers m^{-2} (-0.675), peduncle extrusion (-29.753), sheath length (-8.841), grains spike^{-1} (-0.175) and 1000-grain weight (-1.254).

Days to maturity vs grain yield: Days to maturity had positive direct effect (0.160) on grain yield (Table 2). Similar positive values were obtained from indirect effects through spike length (0.130), peduncle length (13.491), grains spike^{-1} (0.183) and 1000-grain weight (0.007); whereas, plant height, tillers m^{-2}, peduncle extrusion and sheath length had negative indirect effects on grain yield.

Tiller m^{-2} vs grain yield: Tillers m^{-2} had positive direct affect on grain yield with a value of 1.259. Similar positive values were obtained from the indirect effects through plant height (0.094), spike length (0.281), peduncle extrusion (21.956), sheath length (3.553), grains spike^{-1} (0.073) and 1000-grain weight (0.488) whereas, days to maturity and peduncle length had negative indirect effects on grain yield (Table 2).

Spike length vs grain yield: The path analysis indicated that spike length had a positive direct effect (0.241) on grain yield. Indirect effects *via* days to maturity and peduncle length were observed showing 0.087 and 44.510 values respectively. However, characters like plant height (-0.107), tillers m^{-2} (-1.471), peduncle extrusion (-39.406), sheath length (-3.032) grains spike^{-1} (-0.193) and 1000-grain weight (-1.302) had negative indirect effects (Table 2).

Peduncle length vs grain yield: Peduncle length had positive direct effect on grain yield possessing maximum value of direct effect (43.828). Positive values were obtained from indirect effects *via* days to maturity (0.049) and spike length (0.245) and negative values from indirect effects *via* plant height (-0.163), tillers m^{-2} (-0.773), peduncle extrusion (-33.986), sheath length (-7.637) grains $spike^{-1}$ (-0.226) and 1000-grain weight (-1.585).

Peduncle extrusion vs grain yield: Peduncle extrusion showed negative direct effect (-34.476) on grain yield (Table 2). Similar negative values were obtained from indirect effects *via* plant height (-0.151), tillers m^{-2} (-0.802), sheath length (-6.632) grains $spike^{-1}$ (-0.195) and 1000-grain weight (-1.542), only three traits indicated positive indirect effects via days to maturity (0.060), spike length (0.275) and peduncle length (43.204).

Sheath length vs grain yield: The direct effect of sheath length on grain yield was negative (-9.303). The indirect effects through days to maturity (0.001), spike length (0.078) and peduncle length (35.978) were positive. Traits like plant height (-0.167), tillers m^{-2} (-0.481), peduncle extrusion (-24.576), grains $spike^{-1}$ (-0.283) and 1000-grain weight (-1.338) were the indirect negative contributors (Table 2).

Grains $spike^{-1}$ vs grain yield: Grains $spike^{-1}$ had positive direct effect (0.370) on grain yield (Table 2). The indirect effects through plant height, days to maturity, tillers m^{-2}, peduncle extrusion, sheath length and 1000-grain weight were positive with path coefficient values of 0.083, 0.079, 0.249, 18.184, 7.118 and 1.581 respectively, while indirect effects through spike length (-0.126) and peduncle length (-26.834) were negative.

1000-grain weight vs grain yield: Negative direct effect in case of 1000-grain weight on grain yield was estimated by displaying a value of -1.674. Similar negative values were obtained from indirect effects via. plant height (-0.131), days to maturity (-0.001), tillers m^{-2} (-0.367), peduncle extrusion (-31.759), sheath length (-7.438) and grains $spike^{-1}$ (-0.349), only two traits indicated positive indirect effects via spike length (0.187) and peduncle length (41.483).

Discussion

Correlation between plant height and grain yield was negative and non significant. The results are in agreement with Ahmad *et al*., (1980), Shahid *et al*., (2002), Okuyama *et al*., (2004), Khaliq *et al*., (2004) and Akram *et al*., (2008). This may be due to lodging in taller plants. Furthermore this trait shows negative direct effect on grain yield. Similar results were reported by Chowdhry *et al*., (1986) and Khan *et al*., (2005). It might be due to high percentage of dry matter accumulation in vegetative parts of taller plants thereby affecting the grain yield.

The genotypic correlation between days to maturity and grain yield was positive but non significant. Similar findings have been reported by Asif *et al*., (2004). This trait further showed positive direct effect on grain yield. As the direct effect and genotypic correlation between the two characters is positive thus it indicates true relationship and signifies the direct selection of this character in breeding program. Relationship of tillers m^{-2} with grain yield was positive but non significant. These results are in agreement with the work of Saleem *et al*., (2006). Data regarding the path coefficient analysis revealed that tillers m^{-2} had positive direct effect on grain yield. Shamsuddin (1987) and Simane (1998) also reported similar findings. This trait also showed positive relationship with grain yield and thus direct selection for higher number of tillers would be helpful to increase yield.

Spike length showed negative correlation with grain yield. The result contradicted the findings of Shahid *et al*., (2002) and Saleem *et al*., (2006). This may be due to different environmental conditions and genetic background of breeding materials used. It is evident from the data that this character showed positive direct effect on grain yield. The results can be confirmed from the findings of Kashif & Khaliq (2004) which stated that grain yield can be enhanced through spike length selection.

Genotypic correlation between peduncle length and grain yield was negative and highly significant. The direct effect of peduncle length on grain yield was recorded to be positive and high. Under this condition, restrictions are to be imposed to nullify the undesirable indirect effects in order to make use of direct effect (Singh & Kakar, 1977).

Peduncle extrusion and sheath length had negative genotypic correlation with grain yield. The direct effect of peduncle extrusion and sheath length is also negative which is in conformity with the results obtained by Okuyama *et al*., (2005) which stated that peduncle extrusion and sheath length has inconsistent and low total correlation with grain yield.

Relationship between grains $spike^{-1}$ and grain yield was positive and highly significant. Quite identical results were obtained by Shahid *et al*., (2002), Ashfaq *et al*., (2003) Nabi *et al*., (1998) and Aycicek & Yildirim (2006). This character also showed positive direct effect on grain yield. Similar results were reported by Ashfaq *et al*., (2003) and Kashif & Khaliq (2004). As the direct effect as well as the genotypic correlation is positive, therefore, direct selection of this trait is recommended for obtaining higher yield.

Genotypic correlation between 1000-grain weight was negative and non significant which is in contradiction with the observations of Khan *et al*., (2005). The difference may be due to variation in genotypes used in this study and prevailing environmental conditions. The direct effect of 1000-grain weight on yield was also negative which is in agreement with the results obtained by Ashfaq *et al*., (2003) and Kashif & Khaliq (2004).

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