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# Selection Parameters and Yield Enhancement of Wheat (*Triticum aestivum* L.) Under Different Moisture Stress Conditions

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**Abstract:** A study was conducted to work out the phenotypic and genotypic variance, heritability, genetic advance, correlation coefficients and path analysis for yield and yield contributing traits. Harvest index and biological yield per meter had direct positive effect both at genotypic and phenotypic level across the entire environment. Higher heritability was observed for plant height and its components. However, the heritability was in general found to lower under moisture stress conditions. Plant height, peduncle length and seedling dry weight showed positive correlation with grain yield at genotypic level. Hence these traits should be given emphasis while selecting high yielding wheat genotypes under moisture stress conditions.

**Key words:** Wheat, heritability, genetic advance, harvest index, biological yields, grain yield, moisture stress

## INTRODUCTION

Bread wheat (*Triticum aestivum* L.) is the most important food crop of the world. It provides food to 36% of the global population contributing 20% of the food calories to it. The area under cultivation of wheat crop in India is 26.6 M ha with the production of 72.1 M tones. A major part of area under wheat cultivation is under moisture stress condition, where productivity has not witnessed any significant increase despite the success of green revolution.

The water is the main abiotic limiting factor in many wheat producing areas of the world. Due to erratic spatial and temporal distribution of rainfall, it is important to have cultivars with superior yield performance under limiting and non limiting soil moisture conditions. The uncertainty of water availability and of temperature conditions during the crop growth period calls for better resilience under fluctuating water and temperature regimes.

The ideal genotype for moisture stress conditions must combine a reasonably high yield potential with specific plant characters which could buffer yield against sever moisture stress (Blum, 1983). The difficulty in breeding for moisture stress is the use of yield as principal selection index because the variability as well as heritability is reduced under drought stress conditions (Roy and Murthy, 1969; Turner, 1986). This causes slow progress in selection under drought stress conditions as compared to environment with optimal rainfall. Hence it is expected that genetic gain could be more rapid and predictable, if desired morpho-physiological attributes for target environment could be identified and selected in the parents and progenies. Grain yield is mainly determined by three major components, namely spikes per unit area, number of grains per spike and kernel weight. Some of these morpho-physiological traits like longer peduncle length with semi dwarf plant height will enhance the physiological efficiency of the wheat plant for synthesis, storage and translocation of photosynthates from source to sink and will also enable it to respond to higher inputs of fertilizer and irrigation. This will also help in identification of stable and superior genotypes in terms of yield suited under target environments of moisture stress and occasionally available input of water and fertilizer conditions.

Yield components and plant trait contributing to grain yield are important for breeding strategies. Simple correlations studies relate grain yield to a single variable and may not provide a complete understanding of the importance of each components in determining grain yield (Dewey and Lu, 1959). Phenotypic and genotypic variance, heritability and genetic advance have been used to assess the magnitude of variance in wheat breeding material (Jhonson *et al*., 1956; Khan, 1990; Zaheer *et al*., 1987). Path coefficient analysis allows an effective means of partitioning correlation coefficient in to unidirectional pathway and alternate pathway. This analysis also permits a critical examination of specific factors and produces a given correlation and can be successfully employed in formulating an effective selection strategy.

The objective of this study were to evaluate degree of association between yield components and plant traits

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with grain yield and to determine direct and indirect effects of yield components and plant traits on grain yield in wheat genotypes grown under moisture stress conditions.

## MATERIALS AND METHODS

Field experiments were conducted at Experimental Farm, Division of Genetics, Indian Agricultural Research Institute, New Delhi, India (28°41' North latitude and 77°13' East latitude, 228 m above mean sea level). The area is semi arid, sub tropical climate with alluvial soil which is slightly alkaline with clay loam texture and low organic matter. The experiment was sown in two planting dates during 2003-04 and 2004-05 crop season.

The experimental material comprised of 90 wheat lines which were screened initially for characters as total plant height, peduncle length and peduncle length/plant height ratio and 40 desirable genotypes were selected for further studies. The selected material represents a range of phenotypic variation in maturity, date to heading, adaptation zone, yield potential etc. The material was planted in Randomized Complete Block Design (RCBD) with three replications. Six, 5 m row were planted by keeping a distance of 23 cms between the row. Normal cultural practices were followed. The data were recorded for plant height (cm), days to heading, peduncle length PL (cm), ear length EL (cm), lower plant height LPH (cm) (LPH = PH-PL-EL), PL/PH index (PL/PH x 100), LPH/PH index (LPH/PH X 100), PL/LPB index (PL/LPH X 100), tillers per meter, tillers per plant, grain number per spike, grain weight per spike, 1000 kernel weight, biological yield per meter, biological yield per plant, grain yield per plant, grain yield per meter and harvest index. Variance analysis was done as per Panse and Sukhatme, 1967; coefficients of variability (Burton and Devane, 1953); heritability in broad sense (Allard, 1960); genetic advance (Robinson *et al*., 1951); phenotypic and genotypic correlation (Al-Jibouri et al., 1958); and path coefficient analysis (Dewey and Lu, 1959) were carried out.

## RESULTS AND DISCUSSION

**Variability studies:** The pooled analysis of variance showed highly significant differences among genotypes for all the traits (Table 1). The highest PCV was observed for character tillers/m (23.21%) followed by grain weight per spike (22.34%), biological yield (22.14%), PL/LPH index (21.4%), lower plant height (20.83%), harvest index (20.75%) and grain weight/spike (17.82%). The high value of GCV was obtained for character lower plant height (19.92%) followed by PL/LPH index, tillers/m, biological yield, harvest index. This may be due to different parentage background of the genotypes. In some cases like those of phenotypic and genotypic coefficient of variation were almost similar in most of the cases and indicative for presence of very low environmental effects.

High value of heritability in broad sense was observed for plant height and its component which is more than 70%, while for yield traits like tillers/m, grain weight/spike, biological yield and harvest index, it is ranging between 50-65%. The comparison of heritability for all the traits was done under moisture stress, limited irrigation and irrigated high fertility conditions. This indicates that except for plant height, biological yield/m, grain yield/m and harvest index, heritability increases with better input condition environment. This may be due to influence of environment on genotypes under moisture stress environment.

Higher genetic advance was observed for biological yield (87.71%) and for plant height, PL/PH index, tillers/m, moderate genetic advance was found in the range of 25-30%. This indicates that in respect of these traits, selection is effective and the material present may be

Table 1: Estimation of selection parameters for different quantitative traits in wheat

| | Heritability | | | | | |
|---|---|---|---|---|---|---|
| Characters | Envt 1 | Envt 2 | Envt 3 | Genetic Advance | GCV (%) | PCV (%) |
| Days to flowering | 75.9 | 89.5 | 91.1 | 8.40 | 4.89 | 5.17 |
| Plant height | 91.6 | 96.4 | 96.1 | 25.79 | 12.24 | 12.46 |
| Peduncle length | 58.7 | 65.3 | 88.1 | 6.12 | 9.26 | 11.46 |
| Lower plant height | 56.2 | 91.4 | 93.6 | 21.26 | 19.92 | 20.83 |
| Ear length | 59.3 | 74.8 | 77.7 | 1.82 | 9.94 | 11.50 |
| PL/PH index | 60.3 | 68.1 | 85.0 | 6.29 | 9.64 | 11.68 |
| LPH/PH index | 66.3 | 77.2 | 85.9 | 8.52 | 9.14 | 10.40 |
| PL/LPH index | 54.9 | 72.1 | 83.2 | 24.21 | 18.17 | 21.40 |
| Tillers/meter | 52.9 | 55.6 | 89.8 | 28.19 | 17.68 | 23.21 |
| Grain weight per spike | 44.4 | 54.8 | 59.6 | 0.55 | 16.54 | 22.34 |
| 1000 kernel weight | 44.4 | 54.8 | 58.2 | 8.18 | 12.63 | 15.72 |
| Biological yield | 45.7 | 64.6 | 59.4 | 87.71 | 17.29 | 22.14 |
| Grain yield per meter | 72.1 | 31.6 | 44.0 | 11.62 | 10.01 | 17.82 |
| Harvest index | 66.2 | 65.1 | 69.2 | 9.11 | 16.74 | 20.75 |

Table 2a: Genotypic path coefficient analysis showing direct (diagonal) and indirect effect on grain yield under timely sown moisture stress condition

| Characters | Days to flowering | Plant height | Peduncle length | Lower plant height | Ear length | PL/PH index | LPH/PH index | PL/LPH index | Tillers per meter | Grain weight/ spike | 1000-grain weight | Biological yield | Harvest index |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Days to flowering | **0.121** | 0.829 | 0.116 | -1.198 | -0.197 | 1.6552 | -1.810 | 0.446 | -0.008 | -0.005 | -0.011 | -0.044 | -0.133 |
| Plant height | 0.037 | **2.670** | -0.150 | -2.236 | 0.024 | 1.268 | -2.092 | 0.446 | 0.006 | 0.001 | 0.031 | 0.110 | 0.342 |
| Peduncle length | -0.051 | 1.468 | **-0.272** | -0.609 | 0.154 | -0.826 | 0.312 | -0.145 | 0.008 | 0.004 | 0.048 | 0.181 | 0.360 |
| Lower plant height | 0.061 | 2.524 | -0.070 | **-2.365** | 0.027 | 1.762 | -2.557 | 0.593 | 0.005 | 0.000 | 0.020 | 0.072 | 0.242 |
| Ear length | -0.036 | -0.099 | 0.064 | 0.095 | **-0.659** | -0.525 | 0.035 | -0.085 | -0.021 | -0.009 | -0.031 | -0.187 | 0.116 |
| PL/PH index | 0.089 | -1.153 | -0.100 | 1.861 | 0.155 | **-2.239** | 2.632 | -0.671 | 0.003 | 0.003 | 0.012 | 0.057 | -0.029 |
| LPH/PH index | 0.079 | 2.015 | 0.031 | -2.182 | -0.008 | 2.126 | **-2.772** | 0.676 | 0.002 | -0.001 | 0.005 | 0.012 | 0.089 |
| PL/LPH index | -0.078 | -1.811 | -0.058 | 2.042 | 0.085 | -2.196 | 2.729 | **-0.686** | 0.002 | 0.001 | 0.004 | 0.032 | -0.062 |
| Tillers per meter | -0.016 | 0.258 | -0.039 | -0.207 | 0.236 | -0.119 | -0.109 | -0.021 | **0.059** | 0.007 | -0.025 | 0.068 | 0.013 |
| Grain weight/spike | 0.617 | -0.073 | 0.030 | 0.632 | -0.193 | 0.216 | -0.070 | 0.029 | -0.013 | **-0.032** | 0.058 | 0.184 | -0.043 |
| -1000-grain weight | -0.013 | 0.810 | -0.128 | -0.451 | 0.196 | -0.269 | -0.122 | -0.026 | -0.614 | -0.018 | **0.103** | 0.251 | 0.056 |
| Biological yield | -0.009 | 0.522 | -0.088 | -0.302 | 0.220 | -0.228 | -0.062 | -0.039 | 0.007 | -0.010 | 0.046 | **0.561** | -0.272 |
| Harvest index | -0.017 | 0.952 | -0.012 | -0.597 | -0.079 | 0.067 | -0.257 | 0.044 | 0.001 | 0.001 | 0.006 | -0.159 | **0.959** |

Table 2b: Genotypic path coefficient analysis showing direct (diagonal) and indirect effect on grain yield under timely sown irrigated high fertility condition

| Characters | Days to flowering | Plant height | Peduncle length | Lower plant height | Ear length | PL/PH index | LPH/PH index | PL/LPH index | Tillers per meter | Grain weight/ spike | 1000-grain weight | Biological yield | Harvest index |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Days to flowering | **-0.017** | -3.825 | -0.040 | 5.771 | 0.635 | -8.159 | 1.729 | 4.011 | -0.255 | -0.727 | 0.686 | 0.894 | -0.834 |
| Plant height | -0.009 | **-7.160** | -0.847 | 9.258 | 0.345 | -8.817 | 2.265 | 4.886 | -0.120 | -0.245 | 0.262 | 1.051 | -0.536 |
| Peduncle length | 0.000 | -4.437 | **-1.367** | 3.603 | 0.419 | 1.946 | -0.021 | -0.341 | 0.073 | 0.236 | -0.174 | 0.618 | -0.077 |
| Lower plant height | -0.010 | -6.841 | -0.508 | **9.691** | 0.055 | -11.097 | 2.733 | 5.949 | -0.160 | -0.360 | 0.353 | 1.023 | -0.623 |
| Ear length | -0.005 | -1.110 | -0.257 | 0.240 | **2.227** | -0.012 | -0.499 | -0.566 | -0.077 | -0.141 | 0.220 | 0.115 | 0.137 |
| PL/PH index | 0.010 | 4.865 | -0.205 | -8.286 | -0.002 | **12.978** | -2.894 | -6.546 | 0.220 | 0.520 | -0.486 | -0.771 | 0.600 |
| LPH/PH index | -0.010 | -5.432 | 0.010 | 8.872 | -0.373 | -12.584 | **2.985** | 6.576 | -0.196 | -0.471 | 0.422 | 0.871 | -0.658 |
| PL/LPH index | 0.010 | 5.275 | -0.070 | -8.692 | 0.190 | 12.809 | -2.959 | **-6.633** | 0.214 | 0.524 | -0.476 | -0.857 | 0.653 |
| Tillers per meter | -0.008 | -1.699 | 0.198 | 3.062 | 0.341 | -5.659 | 1.160 | 2.815 | **-0.505** | -0.580 | 0.413 | 1.512 | -0.888 |
| Grain weight/spike | 0.006 | 0.920 | -0.169 | -1.828 | -0.165 | 3.541 | -0.738 | -1.822 | 0.154 | **1.960** | -0.976 | -0.045 | 0.084 |
| 1000-grain weight | 0.009 | 1.415 | -0.180 | -2.580 | -0.369 | 4.747 | -0.948 | -2.378 | 0.157 | 1.402 | **-1.327** | -0.609 | 0.695 |
| Biological yield | -0.006 | -3.627 | -0.367 | 4.304 | 0.111 | -4.341 | 1.128 | 2.469 | -0.331 | -0.037 | 0.351 | **2.304** | -1.496 |
| Harvest index | 0.007 | 1.983 | 0.054 | -3.120 | 0.157 | 4.026 | -1.016 | -2.241 | 0.232 | 0.083 | -0.477 | -1.782 | **1.934** |

Table 2c: Genotypic path coefficient analysis showing direct (diagonal) and indirect effect on grain yield under late sown high fertility condition

| Characters | Days to flowering | Plant height | Peduncle length | Lower plant height | Ear length | PL/PH index | LPH/PH index | PL/LPH index | Tillers per meter | Grain weight/ spike | 1000-grain weight | Biological yield | Harvest index |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Days to flowering | **0.147** | -8.765 | 2.412 | 5.433 | 0.439 | 0.795 | -0.241 | -0.160 | 0.006 | 0.381 | -0.087 | 0.175 | -0.170 |
| Plant height | 0.069 | **-18.705** | 5.586 | 12.880 | -0.258 | 1.688 | -0.758 | -0.489 | 0.007 | 0.898 | -0.406 | 0.442 | -3.87 |
| Peduncle length | 0.035 | -10.314 | **10.131** | 2.030 | -1.207 | -2.442 | 0.403 | 0.0378 | -0.025 | 0.085 | 0.074 | 0.273 | -0.384 |
| Lower plant height | 0.056 | -16.815 | 1.435 | **14.328** | -0.325 | 3.226 | -1.125 | -0.783 | 0.020 | 1.031 | -0.499 | 0.340 | -0.219 |
| Ear length | 0.054 | 4.044 | -1.760 | -0.908 | **1.192** | -0.135 | 0.341 | 0.177 | 0.013 | -0.296 | -0.084 | 0.276 | -0.283 |
| PL/PH index | -0.027 | 7.179 | 5.626 | -10.545 | 0.037 | **-4.397** | 1.206 | 0.918 | -0.033 | -0.827 | 0.504 | -0.168 | -0.008 |
| LPH/PH index | 0.028 | -11.105 | -3.209 | 12.686 | -0.320 | 4.173 | **-1.271** | -0.933 | 0.027 | 0.959 | -0.41 | 0.206 | -0.029 |
| PL/LPH index | -0.025 | 9.675 | 4.046 | -11.857 | 0.223 | -4.267 | 1.253 | **0.946** | -0.029 | -0.959 | 0.495 | -0.258 | 0.089 |
| Tillers per meter | 0.012 | -1.144 | -2.161 | 2.425 | 0.128 | 1.235 | -0.291 | -0.233 | **0.117** | 0.213 | -0.196 | 0.215 | -0.249 |
| Grain weight/spike | -0.029 | 8.586 | -0.442 | -0.549 | 0.181 | -1.860 | 0.623 | 0.464 | -0.013 | **-1.956** | 0.989 | -0.118 | 0.315 |
| 1000-grain weight | -0.008 | 4.786 | 0.470 | -4.511 | -0.063 | -1.399 | 0.386 | 0.295 | -0.014 | -1.221 | **1.585** | 0.303 | -0.069 |
| Biological yield | -0.024 | -7.362 | 2.553 | 4.505 | 0.360 | 0.681 | -0.241 | -0.225 | 0.023 | 0.212 | 0.443 | **1.083** | -1.358 |
| Harvest index | -0.015 | 4.342 | -2.333 | -1.879 | -0.203 | 0.022 | 0.022 | 0.050 | -0.007 | -0.369 | -0.065 | -0.882 | **1.667** |

useful for enhancing the productivity in wheat under different moisture regimes. Higher genetic advance for some traits also indicates for additive gene action and hence these can be effectively used for selection of better genotypes. Deviation this trend is observed for grain weight/spike which is having very low genetic advance (0.55) with moderate heritability (54.8%), peduncle length ($h^2$ = 65.3 and GA = 6.12), ear length ($h^2$ = 74.8 and GA = 1.82). The genetic advance expected from selection can be explained best if estimate of heritability and genotypic coefficient of variation were considered together.

**Path coefficient analysis:** The path coefficient were studied for all the traits under three environments viz., moisture stress (rainfed), limited irrigation timely sown high fertility, and late sown irrigated high fertility conditions. A close perusal of Table 2a-c showing direct effects of on grain yield reflects that harvest index and biological yield per meter had direct positive effect on yield both at genotypic and phenotypic levels across the three environments. This result is similar to the findings of Shamsuddin (1987) and Singh and Sharma (1994). This indicates that selection for harvest index and biological yield can be practiced under all the environments for improving yield.

Plant height has shown direct positive effect under moisture stress conditions whereas on increasing inputs (under irrigated conditions), it has shown direct negative effects at genotypic level. This indicates that selection of semi dwarf plant height is good under irrigated condition but under stress environment selection for medium tall plant height is effective for increasing the grain yield.

Under moisture stress conditions most of the components of plant height namely peduncle length, PL/PH index, PL/LPH index and lower plant height is having direct negative effect on yield both at genotypic and phenotypic level, but value of direct negative effect of plant height components are very small as compared to value of positive direct effect of other traits towards yield. The findings of present study with regard to peduncle length are not in conformity with observations of Nachit and Jorrah (1986) who reported peduncle length responding positively under drought conditions.

Peduncle length had positive direct effect under irrigated high fertility conditions which indicated that plant with long peduncle yielded significantly higher under timely sown limited irrigation. However, long peduncle contributed to yield through harvest index, biological yield per meter and 1000 kernel weight because they also have direct positive effect on yield under irrigated high fertility conditions.

Most of the components of plant height have shown negative direct effect on grain yield whereas, most of the yield traits showed positive direct effect under irrigated high fertility late sown condition. This indicate that yield and its component like tillers per meter, 1000 grain weight, biological yield per meter and harvest index can be better utilized as selection criteria both for moisture stress and irrigated environment, whereas plant height component have little use particularly for irrigated environments.

## DISCUSSION

The yield components related traits like plant height and its component and seedling traits are not independent in their action and are interlinked likely to bring simultaneous change for other characters. So it is necessary to find out the direct association between the two at phenotypic and genotypic level. Correlation among the seedling traits, grain yield per meter and related traits like plant height and its components were studied and are presented in Table 3.

Coleoptile length showed significant positive correlation with seedling fresh weight. Plant height, seedling dry weight (seedling vigor), peduncle length and seedling weight index showed positive correlation with grain yield both at phenotypic and genotypic level. These characters can be effectively used as selection criteria for grain yield under limited moisture regime. Seedling weight index was found to have significant positive correlation with yield, but this association is at phenotypic level while at genotypic level, significant positive correlation is not found, indicating thereby that either seedling dry weight index has no significance for yield improvement or this character needs further elaborate study to confirm the findings of the present investigation.

Plant breeder also argues that selection for yield components is more effective than that for yield per se (Graffius, 1956). So, it can be concluded that factors show

Table 3: Phenotypic and genotypic correlation coefficients between different seedling traits and plant yield

| Characters | Seminal roots | Seedling fresh weight | Seedling dry weight | Seedling weight index | Plant height | Peduncle length | PL/PH index | Grain yield per meter |
|---|---|---|---|---|---|---|---|---|
| Coleoptile length | -0.210 | 0.340* | 0.148 | 0.043 | 0.700** | 0.378* | -0.341* | 0.030 |
| | (-0.250) | (0.382*) | (0.956**) | (0.151) | (0.723**) | (0.476) | (-0.382*) | (0.011) |
| Seminal roots | | 0.343* | 0.041 | -0.078 | -0.294 | -0.240 | -0.336* | -0.115 |
| | | (0.339*) | (0.187) | (-0.148) | (-0.342*) | (-0.334*) | (-0.333*) | (-0.221) |
| Seedling fresh weight | | | 0.204 | -0.124 | 0.053 | 0.016 | -0.985** | -0.091 |
| | | | (0.251) | (-0.969**) | (0.070) | (0.015) | (-0.987**) | (-0.240) |
| Seedling dry weight | | | | 0.943** | 0.045 | -0.115 | -0.214 | 0.057 |
| | | | | (-0.015) | (0.220) | (-0.351*) | (-0.273) | (0.660**) |
| Seedling weight index | | | | | 0.031 | -0.111 | 0.113 | 0.097 |
| | | | | | (0.095) | (-0.554**) | (0.225) | (0.938**) |
| Plant height | | | | | | 0.509** | -0.061 | 0.189 |
| | | | | | | (0.623**) | (-0.079) | (0.650*) |
| Peduncle length | | | | | | | 0.011 | 0.260 |
| | | | | | | | (0.011) | (0.425**) |
| PL/PH index | | | | | | | | 0.102 |
| | | | | | | | | (0.252) |

Figure in parenthesis is phenotypic correlation, *, ** Significant at 1% and 5% level of probability significant positive correlation with grain yield should be given priority especially where breeding for varietal improvement for moisture stress condition is concerned.

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