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# Character association path analysis studies in *dicoccum* wheat (*Triticum dicoccum* L.)

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**Abstract**
A present investigation was undertaken to estimate the character association and path coefficient in 50 *dicoccum* wheat genotypes grown in randomized block design with two replications at Experimental Farm of Wheat and Maize Research Unit, VNMKV, Parbhani (Maharashtra) during *rabi* season 2023-24. The analysis of variance showed highly significant differences among the genotypes for all the characters. Grain yield per plant had recorded the significant and positive association with number of tillers per plant, spike length and number of grains per spike. Path coefficient analysis revealed that traits such as days to 50 percent heading, plant height, number of productive tillers per plant, spike length and number of grains per spike had positive direct effect on grain yield.

**Keywords:** *Dicoccum* wheat, correlation, path analysis, significant, positive

## Introduction
*Dicoccum*, locally known as Khapli wheat (*Triticum dicoccum* L.), is an annual, predominantly self-pollinated plant with large elongated grains and brittle ears. In the quest for understanding agricultural diversity and exploring nutrient-rich food sources, *Triticum dicoccum* commonly has emerged as a focal point of research. This ancient cereal grain is rich in more than 16% dietary fibre. It contains protein and total carbohydrates ranging from 11.8% to 15.3% and 78.7% to 83.2%, respectively (Singh *et al*. 2015) [1].

The wheat species can be divided into three classes on the basis of the ploidy level as, diploid 2n = 2x = 14 = einkorn wheat; tetraploid 2n = 4x = 28 = *dicoccum* wheat; and hexaploid2n = 6x = 42 = common wheat or bread wheat. *Triticum dicoccum* is a member of the family *Poaceae*, subfamily *Pooideae*, order *Poales*, genus *Triticum* and species *dicoccum*. The two homologous sets of chromosomes in the species are called BBAA (the cytoplasm comes from genome B). This resulted most likely from the selection of favorable morphological traits along with spontaneous interspecific hybridization. It is believed that two wild diploid grass species contributed to develop *dicoccum* wheat. *Triticum urartu* (AA) was considered a pollen donor, whereas the female parent was *Aegilops* in the S genome group, probably *Aegilops speltoides* Tausch, which contributed to the B genome. This hybridization resulted in the tetraploid wild species *Triticumturgidum* ssp. *dicoccoides* (2n = 4x =28) with the hard-rachised form of the cultivated tetraploid wheat. The *dicoccum* wheat is supposed to be originated in Abyssinia and was possibly introduced in India by the Arabian traders in the Western Ghat region. In 2% of India's total wheat region, *dicoccum* wheat is presently grown (Zaharieva *et al*. 2010) [2]. It has historically been grown in the hilly regions of Tamil Nadu, the southern Maharashtra region, the Sourashtra region of coastal Gujarat, the northern Karnataka region, and the Telangana region. (Hanchinal *et al*. 2005) [3].

The global production of *dicoccum* wheat is relatively small compared to modern wheat varieties. According to the Food and Agriculture Organization (FAO), the total production of *dicoccum* wheat is estimated to be in the range of several hundred thousand metric tons annually. This is the fraction of the total global wheat production which exceeds 750 million metric tonnes. *Dicoccum* wheats appear to be more suited to higher temperatures (Yenagi *et al.* 1999) [4]. With respect to its inbuilt genetic makeup and morpho-physiological mechanism, *dicoccum* wheat is more important in this situation than *durum* and *aestivum* because it responds well to high temperature stress and is resistant to rust diseases (leaf and stem) (Tandon and Hanchinal, 1992) [5].

Through successful interspecific hybridization, *dicoccum* wheat's favorable features have been applied to develop *aestivum* and *durum* wheat varieties.

As the demand for nutritious and sustainable food sources rises, *Triticum dicoccum*or *dicoccum* wheat, emerges as a fascinating candidate. By conducting a variability parameter analysis, correlation and path analysis of this ancient crop, we can unlock its hidden potential and promote its cultivation in diverse agro-climatic regions of India.

## Materials and Methods

The presents investigation entitled "Variability and Character Association Studies in *dicoccum* wheat (*Triticum dicoccum* L.)" has been conducted at Experimental Farm of Wheat and Maize Research Scheme, VNMKV Parbhani during *rabi* 2023-24. Fourty six genotypes as the source material for the experiment were provided by NBPGR, New Delhi, were evaluated along with 4 checks including MACS 4049(D), DDK 1056 (dic), DDK 1057 (dic) and MACS 5052 (D), for various morphological traits. The material was evaluated in Randomized Block Design (Fisher, 1925) [6] with two replications. The investigation was carried out for traits *viz*., days to 50 percent heading, days to 50 percent maturity, plant height, number of productive tillers per plant, spike length, number of grains per spike, biological yield per plant, thousand grain weight, harvest index and grain yield per plant. The calculation of genotypic and phenotypic coefficient of variation (PCV and GCV) was estimated by the method suggested by the Burton (1952) [7]. The genetic advance (at 5 percent selection intensity) and correlation was carried out using the formula suggested by Johnson *et al.* (1955) [8].

**Table 1:** List of Forty-Six wheat genotypes along with four checks studied for morpho-physiological and yield contributing traits.

| Sr. No. | Genotypes | Sr. No. | Genotypes |
|---|---|---|---|
| 1 | EC 660576 | 26 | EC 660871 |
| 2 | EC 660651 | 27 | EC 660872 |
| 3 | EC 660654 | 28 | IC 107398 |
| 4 | EC 660655 | 29 | IC 118727 B |
| 5 | EC 660658 | 30 | IC 118772 |
| 6 | EC 660659 | 31 | IC 118774 |
| 7 | EC 660661 | 32 | IC 118796 |
| 8 | EC 660663 | 33 | IC 138845 |
| 9 | EC 660665 | 34 | IC 138883 |
| 10 | EC 660667 | 35 | IC 138896 |
| 11 | EC 660672 | 36 | IC 212164 |
| 12 | EC 660675 | 37 | IC 212165 |
| 13 | EC 660678 | 38 | IC 212167 |
| 14 | EC 660689 | 39 | IC 36780 |
| 15 | EC 660705 | 40 | IC 47040 |
| 16 | EC 660707 | 41 | IC 534811 |
| 17 | EC 660710 | 42 | IC 534856 |
| 18 | EC 660711 | 43 | IC 539261 |
| 19 | EC 660721 | 44 | IC 539287 |
| 20 | EC 660791 | 45 | IC 138849 |
| 21 | EC 660802 | 46 | IC 138900 |
| 22 | EC 660803 | 47 | C. MACS 4049(D) |
| 23 | EC 660820 | 48 | C. DDK 1056 (dic) |
| 24 | EC 660837 | 49 | C. DDK 1057 (dic) |
| 25 | EC 660852 | 50 | C. MACS 5052 (D) |

## Results and Discussion

### Analysis of Variance

Mean squares of days to 50 percent heading, days to 50 percent maturity, plant height, number of productive tillers per plant, spike length, number of grains per spikes, biological yield per plant, thousand grain weight, harvest index and grain yield per plant showed highly significant differences between genotypes (Table 2). ANOVA is in accordance with Koysev & Desheva (2015) [9].

**Table 2:** Analysis of Variance for ten characters of *dicoccum* wheat.

| Source | df | DH | DM | PH | TLP | SPL | GPS | BY | TGW | HI | GY |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Replication | 1 | 15.21 | 4 | 21.492 | 0.063 | 0.16241 | 0.0949 | 0.53261 | 0.848 | 9.132 | 0.3708 |
| Genotype | 49 | 48.447** | 17.101** | 161.133** | 2.90789** | 2.15997** | 17.1004** | 2.02613** | 140.442** | 183.236** | 6.0876** |
| Error | 49 | 4.822 | 2.898 | 30.236 | 0.11098 | 0.37327 | 2.7648 | 1.07724 | 0.269 | 9.235 | 0.2808 |

DH: Days to 50 percent heading, DM: Days to 50 percent maturity, PH: Plant height, TLP: Number of productive tillers per plant, SPL: Spike length, GPS: Number of grains per spike, BY: Biological yield per plant, TGW: Thousand grain weight, HI: Harvest index, GY: Grain yield per plant.

### Correlation between investigated characters

The correlation coefficient at genotypic and phenotypic level between ten characters is presented in the Table 3. Traits like spike length (0.5163, 0.4466), number of grains per spike (0.7820, 0.6871) and harvest index (0.9700, 0.966) showed positive and highly significant correlation with grain yield while, plant height (-0.1792, -0.1284), days to 50 percent heading (-0.0669, -0.0757), days to 50 percent maturity (-0.0684, -0.0984) exhibited negative association with grain yield. Biological yield (0.1818, 0.1030) showed

positive but non-significant correlation with grain yield. The association of structural elements of yield with grain yield and the interrelationships among the components assumes special importance as the basis for selecting high yielding genotypes. In this study, the correlation between grain yield per plant and spike length; number of grains per spike, thousand grain weight and harvest index was positively and significant. These findings are in agreement with those of Kyosev & Desheva (2015) [9], Pachauri *et al.* (2018) [10].

**Table 3:** Genotypic and phenotypic correlation coefficient analysis in fifty genotypes of *dicoccum* wheat.

| Traits | | DH | DM | PH | TLP | SPL | GPS | BY | TGW | HI | GY |
|---|---|---|---|---|---|---|---|---|---|---|---|
| DH | G | 1 ** | 0.2141 | -0.1232 | -0.1247 | 0.1346 | -0.2517 | -0.2694 | -0.4683 ** | -0.0071 | -0.0669 |
| | P | 1 ** | 0.228 * | -0.0735 | -0.1209 | 0.1191 | -0.1534 | -0.2068 * | -0.425 ** | -0.0133 | -0.0757 |
| DM | G | | 1 ** | 0.3285 * | 0.1616 | 0.0446 | -0.045 | -0.0243 | -0.319 * | -0.0301 | -0.0684 |
| | P | | 1 ** | 0.1447 | 0.1129 | -0.0476 | 0.0033 | 0.0614 | -0.2728 ** | -0.0762 | -0.0984 |
| PH | G | | | 1 ** | 0.1288 | -0.1106 | -0.2065 | 0.3902 ** | -0.0847 | -0.226 | -0.1792 |
| | P | | | 1 ** | 0.1119 | -0.0105 | -0.1346 | 0.0971 | -0.0756 | -0.153 | -0.1284 |
| TLP | G | | | | 1 ** | 0.1099 | -0.014 | -0.041 | 0.3904 ** | 0.2353 | 0.2215 |
| | P | | | | 1 ** | 0.1339 | -0.0177 | -0.0586 | 0.3783 ** | 0.2329 * | 0.2167 * |
| SPL | G | | | | | 1 ** | 0.0854 | 0.2773 | 0.124 | 0.4887 ** | 0.5163 ** |
| | P | | | | | 1 ** | 0.0778 | 0.0101 | 0.1032 | 0.4355 ** | 0.4466 ** |
| GPS | G | | | | | | 1 ** | 0.3306 * | 0.2476 | 0.7233 ** | 0.782 ** |
| | P | | | | | | 1 ** | 0.0768 | 0.2161 * | 0.6432 ** | 0.6871 ** |
| BY | G | | | | | | | 1 ** | 0.1706 | -0.0866 | 0.1818 |
| | P | | | | | | | 1 ** | 0.0953 | -0.1315 | 0.103 |
| TGW | G | | | | | | | | 1 ** | 0.2665 | 0.3034 * |
| | P | | | | | | | | 1 ** | 0.2584 ** | 0.2948 ** |
| HI | G | | | | | | | | | 1 ** | 0.97 ** |
| | P | | | | | | | | | 1 ** | 0.966 ** |
| GY | G | | | | | | | | | | 1 ** |
| | P | | | | | | | | | | 1 ** |

*Significant at 5 percent level, **Significant at 1 percent level.

DH: Days to 50 percent heading, DM: Days to 50 percent maturity, PH: Plant height, TLP: Number of productive tillers per plant, SPL: Spike length, GPS: Number of grains per spike, BY: Biological yield per plant, TGW: Thousand grain weight, HI: Harvest index, GY: Grain yield per plant.

**Path Coefficeint analysis**

The result obtained in the investigation indicated that number of grains per spike had the greatest positive direct effect (1.4397) on yield per plant(Table 4).Among the ten characters studied three characters showed negative direct effect on grain yield *viz*., days to 50 percent maturity (-0.2876), harvest index (-0.5217) and biological yield per plant (-0.7237). Days to 50 percent heading, plant height, number of productive tillers per plant, thousand grain weight exhibited positive effect on yield (0.1385, 0.4619, 0.2353, 0.0227) respectively. Phenotypic path coefficient analysis revealed that biological yield per plant (0.2233) has highest positive effect on grain yield. Except for the characters days to 50 percent maturity (-0.0435) and thousand grain weight (-0.0018) showed positive direct effect on grain yield per plant.

In present investigation, path analysis was done according the procedure given by Dewey and Lu (1959) to know the direct and indirect effects of various characters. Path coefficient analysis helps to determine the contribution of various components of yield to overall grain yields in the genotypes under study. It provides an effective way of working out direct and indirect sources of correlation. Kumar *et al.* (2009) [11], Saleh *et al.* (2018) [12], Tarkeshwaretal *et al.* (2020) [13] all obtained similar results.

**Table 4:** Direct (bold values) and indirect effects at Genotypic level of yield components on grain yield per plant in *dicoccum* wheat.

| Traits | DH | DM | PH | TLP | SPL | GPS | BY | TGW | HI | GY |
|---|---|---|---|---|---|---|---|---|---|---|
| DH | 0.1385 | 0.0296 | -0.0171 | -0.0173 | 0.0186 | -0.0349 | -0.0373 | -0.0648 | -0.001 | -0.0669 |
| DM | -0.0616 | -0.2876 | -0.0944 | -0.0465 | -0.013 | 0.0129 | 0.007 | 0.0917 | 0.0086 | -0.0684 |
| PH | -0.057 | 0.1517 | 0.4619 | 0.0595 | -0.051 | -0.0954 | 0.1803 | -0.0391 | -0.1043 | -0.1792 |
| TLP | -0.0293 | 0.038 | 0.0303 | 0.2353 | 0.0259 | -0.0033 | -0.0096 | 0.0919 | 0.0554 | 0.2215 |
| SPL | 0.1165 | 0.0386 | -0.0957 | 0.0951 | 0.8655 | 0.074 | 0.2401 | 0.1074 | 0.423 | 0.5163 ** |
| TLP | -0.3624 | -0.0647 | -0.2973 | -0.0201 | 0.123 | 1.4397 | 0.4761 | 0.3565 | 1.0413 | 0.782 ** |
| BY | 0.1952 | 0.0177 | -0.2824 | 0.0295 | -0.201 | -0.2393 | -0.7237 | -0.1236 | 0.0626 | 0.1818 |
| TGW | -0.0106 | -0.0072 | -0.0019 | 0.0089 | 0.0028 | 0.0056 | 0.0039 | 0.0227 | 0.006 | 0.3034 * |
| HI | 0.0037 | 0.0157 | 0.1179 | -0.1228 | -0.255 | -0.3773 | 0.0451 | -0.139 | -0.5217 | 0.9700 ** |

*Significant at 5 percent level, **Significant at 1 percent level Residual Effect = 0.2797

DH: Days to 50 percent heading, DM: Days to 50 percent maturity, PH: Plant height, TLP: Number of productive tillers per plant, SPL: Spike length, GPS: Number of grains per spike, BY: Biological yield per plant, TGW: Thousand grain weight, HI: Harvest index, GY: Grain yield per plant.

**Table 5:** Direct (bold values) and Indirect effects Phenotypic levels of yield components on grain yield per plant in *dicoccum* wheat.

| Traits | DH | DM | PH | TLP | SPL | GPS | BY | TGW | HI | GY |
|---|---|---|---|---|---|---|---|---|---|---|
| DH | 0.0016 | 0.0004 | -0.0001 | -0.0002 | 0.0002 | -0.0002 | -0.0003 | -0.0007 | 0 | -0.0757 |
| DM | -0.0099 | -0.0435 | -0.0063 | -0.0049 | 0.0021 | -0.0001 | -0.0027 | 0.0119 | 0.0033 | -0.0984 |
| PH | -0.0005 | 0.001 | 0.0069 | 0.0008 | -0.0001 | -0.0009 | 0.0007 | -0.0005 | -0.0011 | -0.1284 |
| TLP | -0.0018 | 0.0017 | 0.0017 | 0.0151 | 0.002 | -0.0003 | -0.0009 | 0.0057 | 0.0035 | 0.2167 * |
| SPL | 0.0034 | -0.0014 | -0.0003 | 0.0038 | 0.0287 | 0.0022 | 0.0003 | 0.003 | 0.0125 | 0.4466 ** |
| GPS | -0.0107 | 0.0002 | -0.0094 | -0.0012 | 0.0054 | 0.07 | 0.0054 | 0.0151 | 0.045 | 0.6871 ** |
| BY | -0.0462 | 0.0137 | 0.0217 | -0.013 | 0.0023 | 0.0172 | 0.2233 | 0.0213 | -0.0293 | 0.103 |
| TGW | 0.0008 | 0.0005 | 0.0001 | -0.0007 | -0.0002 | -0.0004 | -0.0002 | -0.0018 | -0.0005 | 0.2948 ** |
| HI | -0.0124 | -0.071 | -0.1426 | 0.2171 | 0.4061 | 0.5997 | -0.1224 | 0.2409 | 0.9325 | 0.9660 ** |

*Significant at 5 percent level, **Significant at 1 percent level Residual Effect = 0.096

DH: Days to 50 percent heading, DM: Days to 50 percent maturity, PH: Plant height, TLP: Number of productive tillers per plant, SPL: Spike length, GPS: Number of grains per spike, BY: Biological yield per plant, TGW: Thousand grain weight, HI: Harvest index, GY: Grain yield per plant.

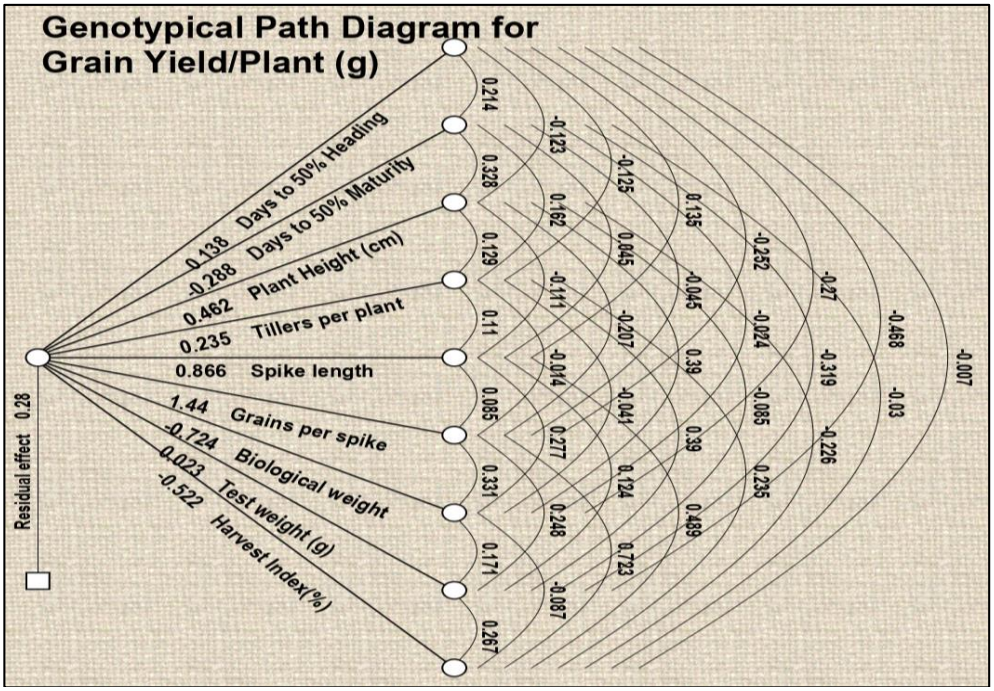


**Fig 1:** Genotypical path diagram for ten characters in *dicoccum* wheat

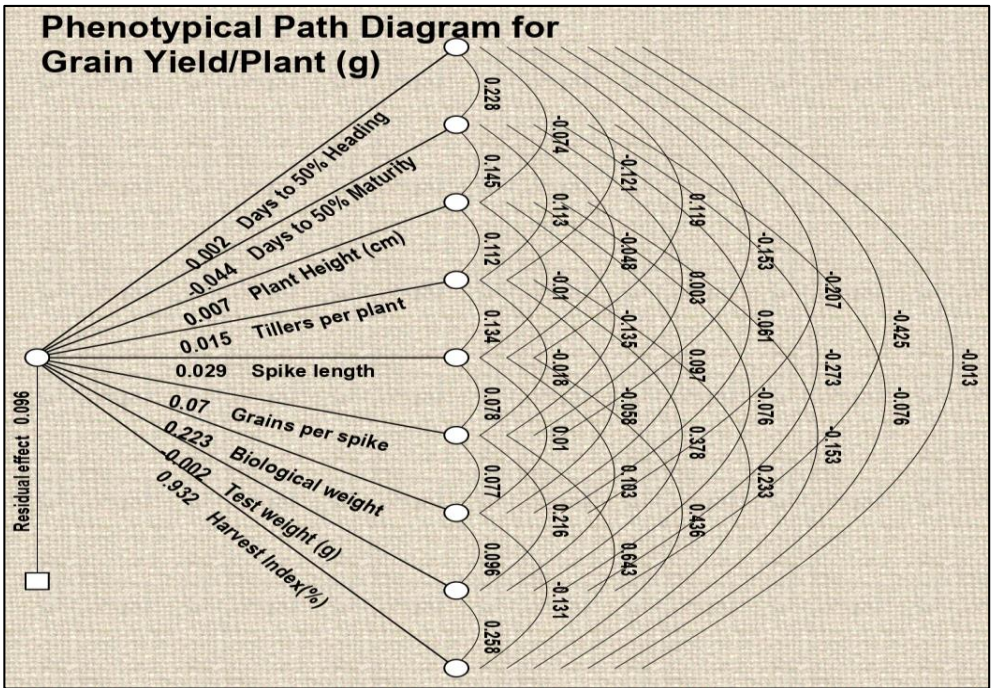


**Fig 2:** Phenotypical path diagram for ten characters in *dicoccum* wheat

## Conclusion

From the present study it is concluded that the analysis of variance showed highly significant differences among the genotypes for all the characters studied. Grain yield had significant positive association with characters *viz*., number of tillers per plant, spike length and number of grains per spike and plant height has negative association with grain yield. Path coefficient analysis revealed that number of grains per spike had greatest direct positive effect on grain yield.

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