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## Path Coefficient Analysis for Water Use Efficiency, Evapo-transpiration Efficiency and Some Yield Related Traits in Wheat

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**Abstract:** Correlation and path-coefficient were computed on 10 bread wheat genotypes for plant height, flag leaf area, grains per spike, 100-grain weight, total dry matter of above ground material, total water used, evapo-transpiration efficiency, harvest index, water use efficiency and grain yield per plant. Highly significant differences were observed among the varieties/advanced lines for all the traits except water use efficiency, which was only significant. Grain yield was positively and significantly correlated with total dry matter, evapo-transpiration efficiency, harvest index and water use efficiency but non-significantly with plant height, flag leaf area, grains per spike, 100-grain weight and total water used. Maximum and positive direct effect (1.2956) was produced by water use efficiency and followed by total dry matter (1.286). While minimum negative direct effect was produced by 100-grain weight (-0.7902). Plant height, flag leaf area, 100-grain weight, total water used, evapo-transpiration efficiency and water use efficiency produced maximum positive indirect effects of 0.5313, 0.3390, 0.6495, 0.6985, 0.7382 and 0.4079 on grain yield through total dry matter, respectively. The traits having positive direct effects on grain yield, considered to be a suitable selection criteria for evolving high yielding genotypes. While in case of negative direct effects on grain yield, indirect selection criteria could be practiced through traits with positive indirect effects.

Key words: Path-coefficient, water use efficiency, wheat

### Introduction

Water stress is the most important limitation to wheat (Triticum aestivum L. emend. Fion and Paol) productivity in semi-arid regions of the world. Therefore, the development of wheat cultivars that use available water more efficiently and that are able to tolerate drought is a major goal for increasing productivity in drought prone environments. Water use efficiency is considered an important component of adaptation to drought. Considerable research has been done with bread wheat to characterise and evaluate different traits affecting grain yield in drought environments. Plant height, grains per spike and 1000-grain weight are positively correlated with grain yield (Akhtar et al., 1992; Kumar et al., 1986a; Sheoran et al., 1986; Yadav and Mishra, 1992). Grain yield was significantly and positively correlated with harvest index (Al-Saheal and Gamil, 1982; Adnan et al., 1994). Several studies have shown that grain yield was positively and significantly correlated with biological yield and harvest index (Atale and Zope, 1988; Srivastava et al., 1988; Sharma and Rao, 1989). Grain yield and harvest index increased with increase in evapo-transpiration up to certain level and increase in evapo-transpiration decreased water-use-efficiency but increased the harvest index (Aggarwal et al., 1986). Singh (1987) observed that water use efficiency decreased with increase in irrigation. Similarly Kumar et al. (1986b) found that irrigation increased evapo-transpiration and decreased water use efficiency. While Ehdaie and Waines (1993) recorded a negative correlation was observed between evapo-transpiration and harvest index, whereas there was a positive correlation with plant height. Siddique et al. (1990) reported that improved water use efficiency in modern wheat cultivars was associated with higher harvest index.

#### Materials and Methods

Ten bread wheat varieties/advanced lines were grown in pots under a well-watered treatment during 1998. They included 4 International Maize and Wheat Improvement Centre (CIMMYT) derived varieties grown in Pakistan namely Pak, 81, Kohinoor 83, Faisalabad 85, Pasban 90 and six Pakistani genotypes, viz. LU26S, Inglab 91, 5039, 4770, 4072 and 4943. Five seeds for each variety were planted in a plastic pot containing a polythene bag filled with 10 kg of sandy loam soil with water holding capacity of 21 percent by weight. Pots were arranged in a completely randomized design with 3 replications in a green house at the University of Agriculture, Faisalabad. Each replication contained one pot of each variety. Each pot was brought to water holding capacity by adding 2100 ml of half-strength Hoagland's solution to the soil on 7 November 1998 when seeds were planted in each pot. Throughout the study, the pots were irrigated with the same solution. Pots were weighed every 3-4 days and the amount of solution equal to the loss in weight was added. Fifteen days after sowing, 4 seedlings were removed from each pot keeping the most vigorous one. At this time, 250 g of medium-sized pebbles were added to the top of each pot to reduce surface evaporation. Plants were irrigated as described until the physiological maturity of the plants. Varieties received different amount of water due to genotypic differences in maturity. Plants were harvested after maturity. Shoots were removed from soil surface. The pots were weighed and the total amount of water used was calculated as the difference between final and initial weight and the amount of water supplied to each pot. Thus, the total water used included both transpired and evaporated water. Individual analysis of variance (Steel and Torrie, 1980) was

Individual analysis of variance (Steel and Torrie, 1980) was conducted for each character. The traits measured were plant height, flag leaf area, grains per spike, 100-grain weight, total dry matter of above ground material, total water used, evapotranspiration efficiency, harvest index, water use efficiency and grain yield per plant. Water use efficiency is defined as the ratio of grain yield to total water used. Total water used includes both transpiration and soil evaporation (evapo-transpiration) water. The two primary components of water use efficiency are evapotranspiration efficiency and harvest index, which are defined as follows:

Evapo-transpiration efficiency = Total dry matter/Total water used Harvest index = Grain yield/Total dry matter Thus, Water use efficiency can be expressed as:

- Water use efficiency = Evapo-transpiration × efficiency Harvest index
  - (Total dry matter /Total water used) (Grain yield/ Total dry matter)
  - = Grain yield/Total water used

Genetic and phenotypic correlations were worked out according to the method given by Falconer (1981). The direct and indirect effects of each trait were assessed by path analysis according to the method described by Dewey and Lu (1959).

#### **Results and Discussion**

Analysis of variance showed highly significant differences among varieties/advanced lines for all the traits except water use efficiency, which were only significant (Table 1).

Variety means ranged from 62.59 to 75.07 cm for plant height and from 10.47 to 17.61 g for total dry matter (Table 2). Varieties Pak.81 and Kohinoor 83 (International Maize and Wheat Improvement Centre-derived varieties) showed the highest values while genotypes 4770 and 5039 showed lowest means for plant height and total dry matter, respectively. In general International Maize and Wheat Improvement Centre-derived varieties were intermediate for both traits. In case of flag leaf area mean values ranged from 14.06 to 25.63 cm<sup>2</sup> for Kohinoor 83 and genotype 4943, respectively (Table 2). Highest number of grains was produced by the genotype 4770 closely followed by 4943. Lowest number of grains was produced by LU26S. In case of 100-grain weight variety LU26S and 4770 gave the maximum weight of 4.68 and 4.51 g, respectively. It is obvious from Table 2 that 4943 has the highest values of 6.93 kg, 2.096 g/kg and 8.36 g for total water used, water use efficiency and grain yield, respectively. It means genotype 4943 used maximum water and better water use efficiency ultimately gave the highest yield. But Pasban 90 and LU26S used less water and did not use the water efficiently thus giving low yield. Maximum evapo-transpiration efficiency was noted for 4770. It was followed by 4943 and Faisalabad 85. The highest value of harvest index was recorded by variety Pak.81 followed by genotype 4072. The genotype 4770 showed the minimum value for harvest index.

The genotypic and phenotypic correlations coefficients are presented in Table 3. The correlations between plant height and flag leaf area, 100-grain weight, total dry matter, total water used, evapo-transpiration efficiency, harvest index and grain yield were found to be positive but non-significant at genotypic and phenotypic levels (Akhtar *et al.*, 1992). The association between plant height and grains per spike was recorded to be negative. Hence, the lesser the plant height the more the number of grains, it produces. Similarly this trait was negatively and non-significantly correlated with water use efficiency.

A non-significant and negative correlation was observed between flag leaf area and grains per spike, 100-grain weight and harvest index. Flag leaf area was positively and non-significantly associated with total dry matter, total water used, evapo-transpiration efficiency, water use efficiency and grain yield. Flag leaf area is an essential component for better plant growth and productivity as it determines the photosynthetic capacity of plant which ultimately influences final productivity the grain yield (Akhtar *et al.*, 1992). The correlation between grains per spike and 100-grain weight was found to be negative and non-significant. This confirms that more grains per spike lower the 100-grain weight probably due to reduction in the size of grains due to assimilation of available photosynthates to larger number of grains. There was a positive and non-significant association between grains per spike and total dry matter, total water used and grain yield, While positive and significant correlation was observed between grains per spike and water use efficiency (Atale and Zope, 1988; Yadav and Mishra, 1992).

There was a positive and significant correlation between 100-grain weight and total dry matter. Whereas 100-grain weight was positively and non-significantly associated with total water used, evapo-transpiration efficiency, harvest index, water use efficiency and grain yield. Total dry matter was positively and significantly correlated with total water used. This is due to more green surface area associated with higher biomass. Similarly positive and significant correlation was observed between total dry matter and evapo-transpiration efficiency. Henca higher evapo-transpiration efficiency results in the production of more biomass (Ehdaie and Waines, 1993). Total dry matter and water use efficiency, harvest index were positively and non-significantly correlated. Total dry matter includes straw yield and grain yield while water use efficiency is grain yield obtained per unit of water consumed. Hence efficient water users produce more grain yield which augments the total dry matter (Ehdaie and Waines, 1993). The association between total dry matter and grain yield was recorded as positive and significant (Atale and Zope, 1988; Srivastava et al. 1988; Sharma and Rao, 1989). Higher total dry matter contributed to grain yield positively and vice versa. Correlations between total water used and evapo-transpiration efficiency, harvest index, water use efficiency, grain yield were positive and non-significant. A negative and non-significant correlation was observed between evapotranspiration efficiency and harvest index. It means that an increase in evapo-transpiration efficiency will decrease harvest index and vice versa. These results confirm the earlier findings of Ehdaie and Waines (1993) but are in contradiction with those of Aggarwal et al. (1986) who observed increase in harvest index with increase in evapo-transpiration efficiency. Evapo-transpiration efficiency and water use efficiency was positively correlated which indicates that plants which transpire more water are more efficient users of water (Aggarwal et al., 1986; Kumar et al., 1986a; Ehdaie and Waines, 1993). Evapo-transpiration efficiency and grain yield were positively and significantly correlated. Hence it is apparent that evapotranspiration efficiency could be used as selection criterion for improved grain yield (Aggarwal et al., 1986; Ehdaie and Waines, 1993).

A review of Table 3 reveals that a positive correlation was observed between harvest index and water use efficiency. Harvest index and grain yield were found to be positively and significantly associated with each other (Al-Saheal and Gamil, 1982; Sharma and Rao, 1989; Adnan *et al.*, 1994). Higher the harvest index, the higher will be the grain yield and vice versa. High harvest index would be desirable for better conversion of biomass into grain (Ehdaie and Waines, 1993). There was a positive and significant correlation between water use efficiency and grain yield. Hence this desirable positive association is of prime importance in drought tolerance breeding programme (Ehdaie and Waines, 1993).

The direct and indirect effects of various traits are presented in Table 4. Plant height and grain yield was recorded to be positively correlated. The direct effects of plant height on grain yield were also positive. Kumar *et al.* (1986a) confirms these findings. The major indirect positive contributors to grain yield were total dry matter (0.5313), grains per spike (0.3798) and total water used (0.1179). The traits with negative indirect contribution to grain yield were through flag leaf area (-0.1737), 100-grain weight (-0,2181), evapotranspiration efficiency (-0.3130), harvest index (-0.0775) and water use efficiency (-0.2581).

The genotypic correlation between flag leaf area and grain yield was recorded to be positive, although the direct effect of

PlantFlag leafGrains per ArietiesVarieties952.26**6.38**188.15**Varieties95.0020.36819.188***Significant at $p < 0.05$ and 0.01, respectively***188.15*****Significant at $p < 0.05$ and 0.01, respectively0.36819.188***Significant at $p < 0.05$ and 0.01, respectively***188.15**Table 2:Mean values of plant heightflag leafGrains per100Varieties/PlantFlag leafGrains per100Varieties/Name17.38851.39543.6Pak 8173.58ab17.98851.39543.6Pak 8173.58ab17.98851.39543.6A07266.20de23.76b52.92bcd3.4A07266.20de14.06g4.64.6Uld10.26565.70de14.06g4.6Uldiab 9173.58ab12.50de52.92bcd3.4A07265.70de15.04fg46.41d4.6Uldiab 9365.70de14.06g4.64.6Uldiab 9473.58ab12.64655.32bcd3.6A07265.30d14.66g4.64.6Uldiab17.36665.33d14.66g4.6Uldiab17.36610.09g65.33d4.6Vithin columns means followed by the same letter are not significantly of single plant of wheat varieties grown 100.97ain weightTaitsFlag leaf70.2330.256Ta	PlantFlag leaHeightFlag leaHeightareaHeightarea05.0920.36805.0920.368at $p < 0.05$ and 0.01, respectivelyvalues of plant heightflag leafPlantFlag leafPlant17.98e70.70bc20.33d66.20de25.63a65.83de14.66g65.70de14.66g65.83de15.04fg65.83de15.04fg65.83de15.04fg65.53de14.06g65.53de15.04fg65.53de14.06g65.53de14.06g65.53de14.06g65.53de15.04fg62.59de25.25ameans followed by the same letterfag leaf07770.30360.30360.30360.29870.298617770.2986170.298617670.2986<	f Grains per Spike, 19.188.15* 19.188 19.188 19.188 19.188 19.188 57.99b 51.33bcd 51.33bcd 51.33bcd 66.24a 66.24a 46.41d 46.41d 46.41d 46.33a are not significa	<ul> <li>r 100-grain weight</li> <li>* 0.85 **</li> <li>* 0.85 **</li> <li>100-grain weight</li> <li>100-grain weight</li> <li>100-grain</li> <li>3.51e</li> <li>100-grain</li> <li>4.61a</li> <li>110 different a</li> </ul>	in Total dry matter 17.97** 0.899 9ht, total dry me experiment Total dry matter (a) 13.11ef 11.43f 13.32de 13.22de 11.72ef 11.43f 11.72ef 11.43f 11.72ef 11.43f 11.72ef 11.43f 11.43f 11.72ef 11.43f 11.72ef 11.43f11.43f 11.43f11.43f 11.43f	Total wat used 2.63** 0.083 0.083 tter, total water trotal water used (Kg) 5.30c 4.79de 6.93a 4.03f 5.20cd 4.60e 4.60e 4.60e 6.97b 6.97b 6.97b 6.97b 6.97b 6.07b	ter Evapo- tanspirati efficiency ( 0.413 * * 0.413 * * 0.413 * * 0.011 Evapo- transpiration efficiency (g/Kg) 1.85bc 1.85bc 1.85bc 1.85bc 1.85bc 1.85bc 1.73c 1.73c 1.73c 1.73c 2.14a 2.23a 1.73c 2.23a 1.73c 2.23a 2.25a 2.25a 2.26a	on index Harvest 0.043** 0.038 0.038 0.038 0.038 Harvest index 0.832a 0.832a 0.627def 0.711bcd 0.711bcd 0.538bcde 0.589cde 0.572efg	Water use efficiency 0.32** 0.0380 0.0380 0.0380 0.0380 0.0380 0.0380 0.0380 0.0380 0.0380 0.0380000000000	G r a in yield 3.78** 0.275 0.275 0.275 0.275 0.275 0.275 0.275 0.275 0.275 0.275 0.205 5.92de 5.92de 5.92de 5.92de 5.92de 5.92de 5.92de 5.92de 5.92de 5.92de 5.92de 5.92de 5.92de 5.92de 5.92de 5.770d
Varieties         9         52.26**         6.38**         188.15**           ***Significant at $p < 0.05$ and 0.01, respectively         0.368         19.188           ***Significant at $p < 0.05$ and 0.01, respectively         Table 2: Mean values of plant height, flag leaf area, grains per pike, 100           efficiency and grain yield of single plant of wheat varieties growers         100           Varieties/         Plant         Flag leaf         Grains per 100           Varieties/         Plant         7.98         5.799b         3.6           Pak 81         7.5.07a         22.49c         57.99b         3.6           Varieties/         Plant         7.98e         51.33bcd         3.6           Pak 81         7.5.07a         22.49c         57.29bc         3.4           4072         70.70bc         23.76b         52.92bcd         3.6           4072         70.70bc         23.76b         4.6         4.6           4072         64.81de         14.50fg         4.6         4	052.26 ** $6.38 *$ 05.0920.368at p < 0.05 and 0.01, respectivelyalues of plant height, flag leaf area.ralues of plant heightregister	188.15*           19.188           grains per pike,           wheat varieties           Grains per spike           57.99b           51.33bcd           55.22bc           66.24a           46.41d           46.41d           46.33a           are not significan	* 0.85 ** 0.030 100-grain wei grown in cot of 100-grain weight (G) 3.51e 3.68cd 3.51e 3.68cd 3.51e 3.68cd 3.51e 3.68cd 3.51e 3.68cd 3.51e 3.68cd 3.51e 3.68cd 3.55cd 4.68a 3.58cd 4.51a anti yifterent a	17.97** 17.97** 0.899 0.899 0.899 matter Total dry matter (a) 13.11ef 11.43f 13.93cd 13.22de 11.72ef 11.72	2.63** 2.63** 0.083 0.083 Total water used (Kg) 5.30c 4.79de 6.61a 6.61a 6.61a 6.61a 6.61a 6.61a 6.61a 6.93a 4.03f 6.93a 4.03f 6.93a 4.03f 6.07b 6.	0.413 * * 0.011 * 0.011 * 0.011 * Evapo- transpiration efficiency (g/Kg) 1.85bc 1.85bc 1.85bc 2.14a 2.23a 1.45d 1.45d 1.73c 1.73c 2.23a 2.23a 1.45d 2.23a 2.23a 2.25a 2.25a	0.043 ** 0.038 0.038 0.038 Harvest index 0.627def 0.832a 0.627def 0.711bcd 0.711bcd 0.586efg 0.586efg 0.572efg 0.572efg	0.32** 0.038 0.038 0.038 0.038 Water use eficiency (g/kg) 1.783ab 1.770bc 1.770bc 1.370bc 1.370bc 1.370bc 1.370bc 1.444bc 1.444bc 1.444bc 2.012a	3.78** 0.275 0.275 6rain vield (g) 7.59abc 7.59abc 5.92de 6.70cd 5.93de 8.36a 5.53e 7.20bc 5.15e 5.15e 5.79de 8.379de 8.07ab
***Significant at p<0.05 and 0.01, respectively Table 2: Mean values of plant height, flag leaf area, grains per pike, 100 efficiency and grain yield of wheat varieties gro Varieties/ Aarieties/ Plant Flag leaf Grains per 10 advance lines Plant of wheat varieties gro ( $Cm$ ) $(cm^2)$ $(G)$ Pak 81 75.07a 22.49c 57.99b 3.6 holds 91 73.58ab 17.986 51.33bcd 3.0 $(Cm)$ $(cm)$ $(cm^2)$ $(G)$ Pak 81 75.07a 22.49c 57.99b 3.6 holds 91 73.58ab 17.986 51.33bcd 3.0 (Cm) $(Cm)$ $(Cm)$ $(Cm)$ $(Cm)$ $(Cm)$ $(Cm)Pak 81 75.07a 22.49c 57.95b 3.6holds 91 73.58ab 17.598 66.24a 3.6(Cm)$ $(Cm)$ $($	at p<0.05 and 0.01, respectively alues of plant height, flag leaf area. alues of plant height, flag leaf Plant Flag leaf Height cm <sup>2</sup> ) 75.07a 22.49c 75.07a 22.49c 75.07a 22.49c 73.58ab 17.98e 70.70bc 20.33d 67.51cd 23.76b 66.20de 25.63a 65.70de 14.60f 65.83de 14.06g 64.81de 15.04fg 65.70de 15.48f 63.85de 15.04fg 62.59de 25.25a means followed by the same letter tes of genotypic and phenotypic cc retes of genotypic and phenotypic cc retes of genotypic and phenotypic cc let plant of wheat varieties grown 1 7 <sup>9</sup> 0.208 -0 7 <sup>6</sup> 0.208 -0	grains per pike, <u>i wheat varieties</u> Grains per spike 57.99b 51.33bcd 55.22bc 52.92bcd 66.24a 66.24a 46.41d 46.41d 46.41d 46.33a 46.33a are not significa	100-grain wei grown in cot of 100-grain weight (G) 3.51e 3.68cd 3.68cd 3.89bc 3.89bc 3.89bc 4.68a 3.58cd 4.68a 3.58cd 4.51a ntly different a	ght, total dry me experiment Total dry matter (a) 11.43f 11.43f 11.43f 13.22de 13.22de 13.22de 11.72ef 11.72ef 11.20f 11.20f 11.20f 10.47f 10.47f 10.47f 10.47f	tter, total water Total water used used (Kg) 5.30c 4.79de 6.61a 5.30c 6.61a 6.61a 6.93a 4.03f 5.20cd 4.06e 4.06e 4.71de 6.07b ability level usir	. used, evapo-tran. Evapo- transpiration efficiency (g/Kg) 1.85bc 1.85bc 2.14a 2.23a 1.45d 1.45d 1.73c 1.73c 1.73c 2.26a	Ispiration efficien Harvest index 0.627def 0.820ab 0.711bcd 0.753abc 0.589cde 0.589cde 0.572efg 0.517fg	icy, harvest index Water use efficiency (g/kg) 1.783ab 1.770bc 1.770bc 1.770bc 1.770bc 1.770bc 1.389c 1.322b 1.428c 1.389cd 1.444bc 1.444bc 2.012a	, water use Grain vield (g) 5.93de 6.70cd 5.93de 8.36a 7.20bc 7.20bc 5.15e 5.15e 5.79de 8.07ab
efficiency and grain yield of single plant of wheat varieties grover Varieties/PlantFlag leafGrains per 100Varieties/PlantFlag leafGrains per 100advance linesHeightareaspikewePak 8175.07a22.49c57.99b3.5Pak 8175.07a23.76b55.22bc3.6A07270.70bc20.33d55.22bc3.6A07270.70bc23.76b55.22bc3.6A07270.70bc23.76b55.22bc3.6A07270.70bc23.76b55.22bc3.6A07270.70bc23.76b55.22bc3.6A07270.70bc23.76b66.24a3.8Kohinoor 8365.70de14.50fg46.41d3.5Kohinoor 8365.70de15.48f45.41d4.6J00565.83de15.04fg46.41d3.5Within columns means followed by the same letter are not significantly47003.6TaitsEstimates of genotypic and phenotypic correlations among pla66.33a4.5TraitsFlag leafGrains per100-grain weight, totTraitsFlag leaf0.3030.2030.276Plant heightrg0.3030.033-0.281Plant heightrg0.3030.033-0.281Plant heightrg0.3030.033-0.281Plant heightrg0.303-0.033-0.281Plant heig	Tex and grain yield of single plant of PlantFlag leaf Flag leafPlantFlag leafPlantFlag leaf(cm)(cm <sup>2</sup> )(cm)(cm <sup>2</sup> )(cm)(cm <sup>2</sup> )(cm)22.49c75.07a22.49c75.07a22.49c75.07a23.76b66.20de25.63a65.83de14.50fg65.83de14.66g65.83de15.04fg65.83de15.04fg65.83de15.04fg65.53de25.25ameans followed by the same lettertes of genotypic and phenotypic ccfg blant of wheat varieties grown 1fg blant of wheat varieties grown 1fg co.303fg co.30	Wheat varieties           Grains per           Spike           57.99b           57.99b           51.33bcd           52.22bc           52.92bcd           66.24a           47.33cd           46.41d           46.41d           46.33a           66.33a	i grown in cot ( 100-grain weight (G) 3.51e 3.51e 3.68cd 3.88cd 3.82bc 4.02b 4.68a 3.58cd 4.02b 4.68a 3.58cd 4.51a mtly different a	experiment Total dry matter (a) 12.11ef 11.43f 11.43f 11.43f 13.93cd 13.22de 13.22de 11.72ef 11.72ef 11.20f 10.47f 10.47f 10.47f 10.47f 10.47f 10.47f	Total water used (Kg) 5.30c 5.30c 6.61a 6.61a 6.93a 4.03f 4.03f 4.03f 4.03f 4.00e 4.60e 4.71de 6.07b ability level usir	Evapo- transpiration <u>efficiency (g/Kg)</u> 1.95b 1.85bc 1.85bc 2.14a 2.23a 1.45d 1.45d 1.46d 1.46d 2.26a 2.26a	Harvest Harvest index 0.822def 0.753def 0.753def 0.753def 0.586efg 0.689cde 0.572efg 0.517fg	Water use eficiency (g/kg) 1.783ab 1.770bc 1.932ab 1.074d 1.428c 1.428c 1.442bc 1.444bc 2.012a	Grain Grain (9) (19) (19) (19) (19) (10) (10) (10) (10) (10) (10) (10) (10
Varieties/         Plant         Hag leaf         Grains per         To           Varieties/         Plant         Haight         area         spike         we           advance lines         Height         area         spike         we           Pak 81         75.07a         22.49c         57.99b         3.6           Pak 81         73.58ab         17.98e         51.33bcd         3.6           A072         70.70bc         20.33d         55.22bcd         3.4           A943         66.20de         23.76b         52.92bcd         3.4           A943         66.20de         23.76b         40.4c         4.c           A943         66.20de         23.76b         47.33cd         3.8           Rohinoor 83         65.70de         14.50fg         46.41d         4.c           A102         66.28de         15.04fg         46.41d         3.5           Kohinoor 83         65.70de         14.50fg         46.41d         3.5           A700         62.35de         15.04fg         46.41d         3.5           A700         62.59de         15.04fg         46.41d         3.5           Vithin columns means followed by the same letter are not significan	Plant         Flag leaf           Height         rag leaf           (cm)         (cm <sup>2</sup> )           75.07a         22.49c           73.58ab         17.98e           70.70bc         23.76b           65.51cd         23.76b           65.51cd         23.76b           65.70de         14.50fg           65.83de         14.50fg           65.83de         14.606g           65.70de         15.64fg           65.83de         15.48f           65.83de         15.64g           65.83de         15.64g           65.83de         15.48f           65.59de         25.25a           means followed by the same letter         G           fs         0.303           62.59de         25.25a           fs         0.303           6.         0.303           fs         0.303           fs         0.303           fs         0.303           fs         0.303	Grains per spike 57.99b 51.33bcd 55.22bc 52.22bc 66.24a 47.33cd 47.33cd 46.41d 46.41d 46.41d 46.33a 66.33a ere not significa	100-grain weight (G) 3.51e 3.51e 3.68cd 3.47d 3.82bc 4.02b 4.68a 3.58cd 4.51a ntly different a	lotal dry matter (a) 11.43f 11.43f 11.43f 16.60ab 13.93cd 13.22de 11.72ef 11.72ef 11.20f 11.20f 15.37bc 15.37bc	l otal water used 5.300 5.300 6.61a 6.61a 6.93a 6.93a 4.03f 5.20cd 4.00e 4.00e 6.07b 6.07b	Evapo- transpiration 1.95b 1.67c 1.67c 2.14a 2.23a 1.45d 1.73c 1.73c 1.73c 2.25a 2.23a 2.23a 2.23a 2.23a 2.26a	Harvest index 0.832a 0.627def 0.820ab 0.711bcd 0.753abc 0.53abc 0.586efg 0.589cde 0.572efg 0.517fg	Water use eficiency (g/kg) 1.783ab 1.770bc 1.932ab 2.096a 1.074d 1.428c 1.389cd 1.444bc 2.012a	Grain (g) 7.59abc 5.92de 6.70cd 6.70cd 5.936 8.36a 7.20bc 7.156 5.79de 8.07ab
(cm)         (cm <sup>2</sup> )         (cm <sup>2</sup> )         (cm <sup>2</sup> )         (c)           Pak 81         75.07a         22.49c         57.99b         3.5           Incilab 91         73.58ab         17.98e         51.33bcd         3.0           4072         70.70bc         20.33d         55.22bc         3.4           4072         70.70bc         23.76b         52.92bcd         3.4           493         65.20de         25.63a         65.24a         3.8           Pasban 90         65.83de         14.50fg         47.33cd         3.8           Kohinoor 83         65.70de         14.06g         47.6         4.6           UU26S         64.81de         15.04fg         45.09d         4.6           5039         65.59de         15.04fg         45.09d         4.6           5039         65.59de         15.04fg         45.09d         4.6           5039         65.59de         15.04fg         46.41d         4.0           Ultin columns means followed by the same letter are not significantly         4770         0.276           Traits         9.559de         25.25a         66.33a         4.5           Traits         0.516         0.303         0.276	$\begin{array}{c cccc} (cm) & (cm^2) & (cm^2) \\ 75.07a & 22.49c \\ 73.58ab & 17.98e \\ 70.70bc & 22.376b \\ 67.51cd & 23.76b \\ 67.51cd & 23.76b \\ 65.70de & 14.06g \\ 65.70de & 14.06g \\ 64.81de & 15.48f \\ 63.85de & 15.48f \\ 63.85de & 15.04fg \\ 62.59de & 25.25a \\ e2.59de & 15.04fg \\ 62.59de & 15.04fg \\ 62.59de & 15.000 \\ 15.04fg \\ 62.59de & 15.000 \\ 16.000 & 1000 \\$	57.99b 51.33bcd 55.23bcd 55.22bc 65.24a 47.33cd 47.33cd 46.41d 46.41d 46.41d 46.33a 66.33a are not significa	(G) 3.51e 3.51e 3.68cd 3.88bc 3.82bc 4.02b 4.02b 4.68a 3.58cd 4.51a ntly different a	(a) 12.11ef 11.43f 11.43f 16.60ab 13.23de 13.22de 11.72ef 11.72ef 11.20f 11.20f 11.20f 11.20f 11.20f 11.20f 11.20f 11.20f 11.20f 11.20f 11.20f	(Kg) 5.30c 4.79de 6.61a 6.61a 6.933 4.03f 5.20cd 4.60e 6.71de 6.71de 6.71de	efficiency (g/Kg) 1.95b 1.67c 2.14a 2.14a 2.23a 2.23a 1.45d 1.73c 1.14e 1.14e 1.14e 1.26a	0.832a 0.827def 0.820ab 0.711bcd 0.753abc 0.588cfg 0.689cde 0.572efg 0.517fg	(g/kg) 1.783ab 1.783ab 1.770bc 1.932ab 2.996a 1.428c 1.389cd 1.444bc 1.444bc 2.012a	(g) 7.59abc 6.70cd 5.92de 5.92de 5.90de 8.36a 5.156 5.156 5.156 5.156 5.156 5.156
Park 81 $r_{5}.07$ a $22.490$ $51.395$ ab $3.5$ Incitab 91       73.58ab       17.98e       51.33bcd       3.6         4072       70.70bc       23.76b       55.22bcd       3.4         4943       66.20de       25.63a       66.24a       3.8         Reisalabad 85       67.51cd       23.76b       55.22bcd       3.8         Rohinoor 83       66.20de       25.63a       66.24a       3.8         Rohinoor 83       65.70de       14.50fg       47.33cd       3.8         Kohinoor 83       65.70de       14.50fg       47.33cd       3.8         Kohinoor 83       65.23de       14.50fg       47.33cd       3.8         Kohinoor 83       65.29de       15.48f       46.41d       4.6         Jord       63.85de       15.48f       46.41d       3.5         Within columns means followed by the same letter are not significantly       4700       3.5         Within columns means followed by the same letter are not significantly       405       405         Table 3:       Estimates of genotypic and phenotypic correlations among pla       470       475         Traits       Elag leaf       Grains per       405       46.41d       405<	75.07/a 22.49c 70.70bc 217.98e 70.70bc 201 67.51cd 23.76b 66.20de 25.63a 65.70de 14.50fg 65.70de 14.60g 65.70de 15.04fg 65.70de 15.04fg 63.85de 25.25a means followed by the same letter thes of genotypic and phenotypic cc lle plant of wheat varieties grown 1 rg 0.303 - 0 rg rg 0.303 - 0	9.7.39b 51.33bcd 55.22bc 55.22bc 66.24a 47.33cd 46.41d 46.41d 46.41d 66.33a 66.33a are not significa	3.51e 3.03e 3.468cd 3.47d 3.89bc 3.82bc 4.02b 4.68a 3.58cd 4.51a ntly different a	12.1.1eT 11.4.3f 11.4.3f 13.93cd 13.22de 11.72ef 11.72ef 11.20f 10.47f 10.47f 10.47f 10.47f 10.47f 10.47f 10.47f 10.47f 10.47f	9.30c 6.79de 6.61a 5.87b 6.93a 4.03f 4.03f 4.03f 4.60e 4.71de 6.07b ability level usir	1.955 1.67c 2.147 2.143 2.23a 1.45d 1.73c 1.73c 2.26d 2.26d	0.627def 0.627def 0.820ab 0.753abc 0.7536efg 0.586efg 0.689cde 0.572efg 0.517fg	1.783ab 1.539bc 1.932ab 2.096a 1.074d 1.428c 1.389cd 1.444bc 2.012a	7.59abc 6.70cd 6.70cd 5.99de 8.36a 5.53e 7.20bc 5.15e 5.79de 8.07ab
4072       7.0.70bc       20.33d       55.22bc       3.6         4072       70.70bc       23.76b       55.22bc       3.6         743       66.20de       25.63a       66.24a       3.8         843       66.20de       25.63a       66.24a       3.8         82ban 90       65.83de       14.50fg       47.33cd       3.8         82binoor 83       65.70de       14.60g       46.41d       4.6         82binoor 83       65.50de       15.48f       45.09d       4.6         82binoor 83       65.50de       15.48f       45.09d       4.6         82039       65.33d       65.23a       46.31d       3.5         87039       65.59de       15.04fg       46.41d       3.5         9770       63.85de       15.04fg       46.41d       3.5         9730       62.59de       25.25d       66.33a       4.5         9770       63.85de       15.04fg       46.41d       3.5         9333       62.59de       25.25d       66.33a       4.5         9333       62.59de       15.48f       40.41d       4.6         7010       76       75.25a       66.33a       4.5 <t< td=""><td>70.2000 67.51cd 23.76b 67.51cd 23.76b 65.83de 14.50fg 65.70de 14.60g 65.70de 14.06g 65.70de 15.48f 63.85de 15.04fg 63.85de 25.53d 62.59de 25.25a means followed by the same letter tes of genotypic and phenotypic cc lle plant of wheat varieties grown 1 7 fa 0.303 -0</td><td>55.22bc 52.92bcd 66.24a 47.33cd 46.41d 46.41d 46.41d 66.33a 66.33a are not significa</td><td>3.500 3.47d 3.47d 3.89bc 3.82bc 4.02b 4.68a 3.58cd 4.51a ntly different a</td><td>11.201 16.60ab 13.93cd 13.22de 11.72ef 11.72ef 11.20f 10.47f 10.47f 10.47f 10.47f 10.47f 10.47f</td><td>4. 20ue 6. 61a 6. 93a 6. 93a 4. 03f 4. 03f 4. 60e 4. 71 de 6. 07b ability level usir</td><td>1.620 2.147 2.143 1.45d 1.45d 1.146 2.26 2.26</td><td>0.0270ab 0.7110ab 0.753abc 0.586efg 0.689cde 0.572efg 0.577fg</td><td>1.770bc 1.932ab 2.096a 1.074d 1.428c 1.389cd 1.444bc 2.012a</td><td>6.70cd 5.99de 8.36a 5.53e 7.20bc 5.15e 5.79de 8.07ab</td></t<>	70.2000 67.51cd 23.76b 67.51cd 23.76b 65.83de 14.50fg 65.70de 14.60g 65.70de 14.06g 65.70de 15.48f 63.85de 15.04fg 63.85de 25.53d 62.59de 25.25a means followed by the same letter tes of genotypic and phenotypic cc lle plant of wheat varieties grown 1 7 fa 0.303 -0	55.22bc 52.92bcd 66.24a 47.33cd 46.41d 46.41d 46.41d 66.33a 66.33a are not significa	3.500 3.47d 3.47d 3.89bc 3.82bc 4.02b 4.68a 3.58cd 4.51a ntly different a	11.201 16.60ab 13.93cd 13.22de 11.72ef 11.72ef 11.20f 10.47f 10.47f 10.47f 10.47f 10.47f 10.47f	4. 20ue 6. 61a 6. 93a 6. 93a 4. 03f 4. 03f 4. 60e 4. 71 de 6. 07b ability level usir	1.620 2.147 2.143 1.45d 1.45d 1.146 2.26 2.26	0.0270ab 0.7110ab 0.753abc 0.586efg 0.689cde 0.572efg 0.577fg	1.770bc 1.932ab 2.096a 1.074d 1.428c 1.389cd 1.444bc 2.012a	6.70cd 5.99de 8.36a 5.53e 7.20bc 5.15e 5.79de 8.07ab
Faisalabad 85 $67.51cd$ $23.76b$ $52.92bcd$ $3.4$ 4943 $66.20de$ $25.63a$ $66.24a$ $3.8$ Pasban 90 $65.83de$ $14.50fg$ $47.33cd$ $3.8$ Kohinoor 83 $65.70de$ $14.50fg$ $47.33cd$ $3.8$ Kohinoor 83 $65.70de$ $14.66g$ $46.41d$ $4.6$ Kohinoor 83 $65.70de$ $15.48f$ $46.41d$ $4.6$ LU26S $63.85de$ $15.04fg$ $46.41d$ $4.6$ Sold $50.39$ $63.385de$ $15.04fg$ $46.41d$ $3.5$ Within columns means followed by the same letter are not significantly $3.5$ $45.515de$ $45.33a$ $4.5$ Within columns means followed by the same letter are not significantly $100-grain weight, tot       100-grain weight, tot         Traits       Estimates of genotypic and phenotypic correlations among pla       9.5255a 65.33a 4.56         Traits       Desingle plant of wheat varieties grown 100-grain weight, tot       100-grain weight, tot       100-grain weight, tot         Traits       Elag leaf       Grains per       100-grain weight, tot       100-grain $	67.51cd 23.76b 66.20de 25.63a 65.83de 14.50f9 65.81de 15.48f 63.85de 15.04f9 64.81de 15.04f9 62.59de 25.25a means followed by the same letter tess of genotypic and phenotypic cc lie plant of wheat varieties grown 1 7 fn 0.303 -0	52.92bcd 66.24a 47.33cd 46.41d 45.09d 46.41d 66.33a 66.33a are not significa	3.47d 3.89bc 3.82bc 4.02b 4.68a 3.58cd 4.51a ntly different a	13.93cd 13.22de 11.72ef 17.61a 11.20f 10.47f 10.47f 10.47f 15.37bc	5.87b 6.93a 4.03f 5.20cd 4.60e 4.71de 6.07b ability level usir	2.14a 2.23a 1.45d 1.73c 1.14e 2.26a 2.26a	0.711bcd 0.753abc 0.586efg 0.689cde 0.572efg 0.517fg	1.932ab 2.096a 1.074d 1.428c 1.389cd 1.444bc 2.012a	5.99de 8.36a 5.53e 7.20bc 5.15e 5.79de 8.07ab
4943       66.20de       25.63a       66.24a       3.8         Pasban 90       65.83de       14.50fg       47.33cd       3.8         Kohinoor 83       65.70de       14.50fg       46.41d       4.6         LU26S       64.81de       15.04fg       46.41d       3.5         470       62.59de       15.04fg       46.41d       3.5         4770       62.59de       25.25a       66.33a       4.6         770       62.59de       25.25a       66.33a       4.6         770       62.59de       25.25a       66.33a       4.6         770       62.59de       25.25a       66.33a       4.6         7100-grain weight. tot       7.90       7.90       7.6         7       7 single plant of wheat varieties grown 100-grain weight. tot       7.6       0.298       0.450       0.216         7       7       7       3.33       -0.500       0.216       7.6       0.236         7       7       7       0.303       -0.500       0.216       7.6       0.236         7       7       0.303       -0.033       -0.031       -0.281       100-grain weight. tot         7       7       6	66.20de 25.63a 65.83de 14.50fg 65.70de 14.06g 64.81de 15.48f 63.85de 15.04fg 62.59de 25.25a means followed by the same letter tes of genotypic and phenotypic cc le plant of wheat varieties grown 1 6 Flag leaf 6 7 area s area s	66.24a 47.33cd 46.41d 45.09d 46.41d 66.33a 66.33a are not significa	3.89bc 3.82bc 4.02b 4.68a 3.58cd 4.51a ntly different a	13.22de 11.72ef 17.61a 11.20f 10.47f 15.37bc 15.37bc	6.93a 4.03f 5.20cd 4.60e 4.71de 6.07b ability level usir	2.23a 1.45d 1.73c 1.14e 1.46d 2.26a	0.753abc 0.586efg 0.689cde 0.572efg 0.517fg	2.096a 1.074d 1.428c 1.389cd 1.444bc 2.012a	8.36a 5.53e 7.20bc 5.15e 5.79de 8.07ab
Pasban 90       65.83de       14.50fg       433dd       3.8         Kohinoor 83       65.70de       14.50fg       46.41d       4.6         LU26S       64.81de       15.04fg       46.41d       3.5         4720       62.59de       25.25a       63.33       4.5         Within columns means followed by the same letter are not significantly       46.41d       3.5         Within columns means followed by the same letter are not significantly       62.59de       25.25a       66.33a       4.6         Table 3:       Estimates of genotypic and phenotypic correlations among pla       0.00-grain weight, tot       0.00-grain weight, tot         Traits       Flag leaf       Grains per       100-grain weight, tot         Traits       Flag leaf       0.303       -0.500       0.276         Flag leaf       r       0.303       -0.6003       -0.281         Flag leaf       r       0.303       -0.031       -0.281         Flag leaf       r       0.303       -0.630       0.276         Flag leaf       r       0.303       -0.033       -0.281         Tout height       r       0       -0.033       -0.281         Flag leaf       r       0.033       -0.033	65.3de 14.50rg 65.7de 14.069 64.81de 15.48f 63.85de 15.04f9 62.59de 25.25a means followed by the same letter tes of genotypic and phenotypic cc le plant of wheat varieties grown 1 G Flag leaf G Flag leaf G area s area s	47.33d 46.41d 45.09d 46.41d 66.33a 66.33a are not significa	3.82bc 4.02b 4.68a 3.58cd 4.51a ntly different a	11.72ef 17.61a 11.20f 10.47f 15.37bc 15.37bc	4.03f 5.20cd 4.60e 4.71de <u>6.07b</u> ability level usir	1.45d 1.73c 1.146 1.46d 2.26a	0.586etg 0.689cde 0.572efg 0.517fg	1.0/4d 1.428c 1.389cd 1.444bc 2.012a	5.53e 7.20bc 5.15e 5.79de 8.07ab
Normicol of control $r_{0}$ LU26S       64.81de       15.48f       45.09d       4.5         503       63.85de       15.04fg       46.41d       3.5         4770       62.59de       25.25a       66.33a       4.5         Within columns means followed by the same letter are not significantly       4.5       4.1d       3.5         Within columns means followed by the same letter are not significantly       0.0-gr       4.5       4.5         Table 3: Estimates of genotypic and phenotypic correlations among pla       0.6       0.33       4.5         Traits       of single plant of wheat varieties grown 100-grain weight, tot       100-grain weight, tot       100-grain weight, tot         Traits       Flag leaf       0.303       0.500       0.216         Plant height $r_{9}^{1}$ 0.303       -0.600       0.216         Flag leaf area $r_{9}^{1}$ 0.298       -0.450       0.236         Io0-grain weight $r_{9}^{1}$ 0.033       -0.231       -0.231         Io0-grain weight $r_{9}^{1}$ 0.033       -0.333       -0.342         Io0-grain weight $r_{9}^{1}$ 0.033       -0.342       -0.342         Io0-grain weight $r_{9}^{1}$	rs. 14.000 64.8.1de 15.04f 63.85de 15.04f 62.59de 25.25a means followed by the same letter tes of genotypic and phenotypic co lie plant of wheat varieties grown 1 Flag leaf G area s area s area	45.09d 45.09d 66.33a are not significal	4.020 4.68a 3.58cd 4.51a ntly different a	11.20f 11.20f 10.47f 15.37bc rt n = 0.05 prob	9.2000 4.60e 4.71de 6.07b ability level usir	1.14e 1.46d 2.26a	0.572efg 0.517fg	1.4200 1.389cd 1.444bc 2.012a	5.15e 5.79de 8.07ab
503963.85de15.04fg46.41d3.5 $4.770$ $62.59de$ $25.25a$ $66.33a$ $4.5$ Within columns means followed by the same letter are not significantlyTable 3: Estimates of genotypic and phenotypic correlations among pla $0f$ single plant of wheat varieties grown 100-grain weight, totTraits $0f$ single plant of wheat varieties grown 100-grain weight, totTraits $0f$ single plant of wheat varieties grown 100-grain weight, totTraits $0f$ single plant of wheat varieties grown 100-grain weight, totTraits $0f$ single plant of wheat varieties grown 100-grain weight, totFlag leaf $0.303$ Plant height $r_g^p$ Plant height $r_g^p$ Rag leaf area $r_g^p$ $r_g^p$ $0.298$ Grains per $r_g^p$ $0.031$ $0.031$ $0.2316$ Flag leaf area $r_g^p$ $r_g^p$ $0.033$ $r_g$	63.85de 15.04fg 62.59de 25.25a means followed by the same letter tes of genotypic and phenotypic cc lie plant of wheat varieties grown 1 Flag leaf G area s area s area -f	46.41d 66.33a are not significa	3.58cd 4.51a ntly different a	10.47f 15.37bc ht n = 0.05 prob	4.71de 6.07b ability level usir	1.46d 2.26a	0.517fg	1.444bc 2.012a	5.79de 8.07ab
477062.59de25.25a66.33a4.5Within columns means followed by the same letter are not significantlyTable 3: Estimates of genotypic and phenotypic correlations among plaTraitsof single plant of wheat varieties grown 100-grain weight, totTraitsFlag leafGrains perTraitsFlag leafGrains perPlant height $r_g^{\rm p}$ 0.3030.276Plant height $r_g^{\rm p}$ 0.2980.4500.216Flag leaf $r_g^{\rm p}$ 0.298-0.6000.276Flag leaf $r_g^{\rm p}$ 0.298-0.033-0.236Grains per $r_g^{\rm p}$ 0.298-0.033-0.236Flag leaf $r_g^{\rm p}$ 0.298-0.033-0.236Grains per spike $r_g^{\rm p}$ -0.033-0.236Tool-grain weight $r_g^{\rm p}$ -0.033-0.335Total dry matter $r_g^{\rm p}$ -0.033-0.342	62.59de     25.25a       means followed by the same letter       tes of genotypic and phenotypic co       fle plant of wheat varieties grown 1       rg     0.303       rg     0.298       rg     0.298	66.33a are not significa	4.51a ntly different a	15.37bc rt n = 0.05 prob	6.07b ability level usir	2.26a		2.012a	8.07ab
Table 3: Estimates of genotypic and phenotypic correlations among plaTraitsof single plant of wheat varieties grown 100-grain weight, totTraitsFlag leafGrains perTraits0.3030.276Plant height $r_g$ 0.3030.276Plant height $r_g$ 0.3030.276Plant height $r_g$ 0.3030.276Plant height $r_g$ 0.3030.276Flag leaf area $r_g$ 0.2980.033Flag leaf area $r_g$ 0.2980.033Tool-grain weight $r_g$ 0.2980.033Tool-grain weight $r_g$ 0.0330.275Total dry matter $r_g$ 0.2980.033Total dry matter $r_g$ 0.0330.345	rtes of genotypic and phenotypic cc lie plant of wheat varieties grown 1 Flag leaf G area s r <sub>g</sub> 0.303					nd I SD test	0.484g		
Traits     Flag leaf     Grains per     100-gi       Plant height     rg     area     spike     weight       Plant height     rg     0.303     -0.500     0.276       Plant height     rg     0.303     -0.216     0.216       Flag leaf area     rg     0.298     -0.450     0.216       Flag leaf area     rg     -0.033     -0.231       Frains per spike     rg     -0.033     -0.367       100-grain weight     rg     -0.033     -0.375       Total dry matter     rg     -0.342     -0.342	Flag leaf area area area s area s 0.303 0.298 0.298 0.298 0.298	orrelations among 00-arain weight.	g plant height, . total drv matt	flag leaf area, g ter, total water u	rains per spike, sed. evapo-tran	efficiency, harves spiration in pot ex	st index, water u xperiment	use efficiency and	grain yield
area         spike         weight           Plant height         rg         0.303         -0.500         0.276           Flag leaf area         rg         0.303         -0.500         0.216           Flag leaf area         rg         0.298         -0.450         0.216           Flag leaf area         rg         0.298         -0.031         -0.281           Grains per spike         rg         -0.033         -0.231         -0.231           100-grain weight         rg         -0.033         -0.342         -0.345           Total dry matter         rg         -0.033         -0.342         -0.342	area area c.298 a.2 1, , , , , , , , , , , , , , , , , , ,	irains per 10	00-grain	Total dry	otal water	Evapo-	Harves	Water use	Grain
Plant height     rg     0.303     -0.500     0.276       Flag leaf area     rg     0.298     -0.450     0.216       Flag leaf area     rg     -0.281     -0.281       Frains per spike     rg     -0.033     -0.275       Grains per spike     rg     -0.033     -0.275       100-grain weight     rg     -0.033     -0.345       Total dry matter     rg     -0.341	ر م م م م م م م م م م م م م م م م م م م	pike we	eight	matter	lsed	transpiration efficiency	index	eficiency	yield
r         0.298         -0.450         0.216           Flag leaf area         r         -0.281         -0.281           Frains per spike         r         -0.033         -0.275           Grains per spike         r         -0.033         -0.275           100-grain weight         r         -0.367         -0.367           100-grain weight         r         -0.345         -0.367           Total dry matter         r         -0.345         -0.345	، ب ب ب ب م ع م م	0.500 0.	276	0.413 (	.365	0.422	0.286	-0.199	0.450
rlag lear area r r Grains per spike r 100-grain weight r Total dry matter r r r	5 <u>-</u>	0.450 0.	216 201	0.358	).358	0.417	0.320	-0.181	0.367
Grains per spike $r_{g}^{P}$ -0.365 100-grain weight $r_{g}^{P}$ Total dry matter $r_{g}^{P}$	<u>-</u>	0.033 -0 -033 -0	275	0.204	0.122 0.105	0.137	-0.246 -0 225	0.215	0.435 0.418
r <sup>6</sup> 100-grain weight r 5 Total dry matter r 5		0 0 0 0	.367	0.312	0.113	-0.124	-0.232	0.547*	0.617
rou-grain weight r <sub>i</sub> Fr Total dry matter r <sub>i</sub>	° <b>-</b>	Ŷ	.342	0.309	0.101	-0.110	-0.224	0.535*	0.608
Total dry matter r <sub>g</sub>				0.497*	1.237	0.146	0.243	0.237	0.462
	d. 5				0.543*	0.574*	0.203	0.317	0.795*
	، <b>ر</b> م			0	.503*	0.562*	-0.240	0.301	0.698*
Total water used r <sub>g</sub>	ی ت <sub>ا</sub>					0.436 0.428	0.492 0.481	0.214	0.619 0.599
Evapo-transpiration r <sub>g</sub>	tion r						-0.396	0.275	0.688*
efficiency r <sub>p</sub> Harvest index r	<u>م</u> ک						-0.355	0.257 0.187	0.654 * 0.814 *
۲ <sup>م</sup> Water use efficiency ۲ <sub>9</sub>	ency r <sub>g</sub>							0.171	0.633*
r <sub>s</sub> *Significant at 0.05 level of probability	r,								0.644*

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	Plant	Flag leaf	Grain per	100-grain	Total dry	Total water	Evapo-	Harvest	Water use	Grain
	Height	area	spike	weight	matter	used	transpiration	index	efficiency	yield
							efficiency			
Plant height	(0.4614)	-0.1737	0.3798	-0.2181	0.5313	0.1179	-0.3130	-0.0775	-0.2581	0.450
Flag leaf area	0.1400	(-0.5724)	0.0236	0.2223	0.3390	0.0394	-0.1016	0.0668	0.2782	0.4351
Grain per spike	-0.2305	0.0177	(-0.7604)	0.2900	0.4008	0.0365	0.0918	0.0629	0.7083	0.6172
100-grain weight	0.1273	0.1610	0.2791	(-0.7902)	0.6495	0.0961	-0.1146	-0.1094	0.3126	0.6114
Total dry matter	0.1907	-0.1509	-0.2370	-0.3991	(1.2856)	0.1755	-0.4263	-0.557	0.411	0.7947
Total water used	0.1684	-0.0698	-0.0859	-0.2350	0.6985	(0.3231)	-0.3240	-0.1333	0.2776	0.6197
Evapo-transpiration	0.1945	-0.0784	0.0941	-0.1219	0.7382	0.141	(-0.7425)	0.1073	0.3556	0.6879
efficiency										
Harvest index	0.1320	0.1410	0.1763	-0.3189	0.2607	0.1589	0.2938	(-0.2711)	0.2418	0.8143
Water use	-0.0919	-0.1229	-0.4157	-0.1907	0.4079	0.0692	-0.2038	-0.0506	(1.2956)	0.6971
efficiency										

flag leaf area on grain yield was negative. The positive indirect effects were noted through total dry matter (0.3390), water use efficiency (0.2782), 100-grain weight (0.2223), plant height (0.140), harvest index (0.0668) and grains/spike (0.0236). Evapotranspiration efficiency contributed negative indirect effect on grain yield through flag leaf area (-0.1016). Due to the negative direct effect and positive correlation between flag leaf area and grain yield, the indirect selection can be made for high yielding wheat genotypes through most of the traits having positive indirect effects. The correlation between grains per spike and grain yield was found to be positive, whereas the direct effect of grains per spike was recorded to be negative (Kumar et al., 1986a). Only plant height had negative indirect effect on grain yield with grains per spike. Water use efficiency and total dry matter contributed the maximum positive indirect effects 0.7083 and 0.4008, respectively. Due to the negative direct effect of grains per spike on grain yield, indirect selection should be made via traits having positive indirect effects. The genotypic correlation between 100-grain weight and grain yield was also positive. Although negative direct effects (-0.7902) be produced by 100-grain weight (Kumar et al., 1986a). Maximum positive indirect effect was contributed by total dry matter followed by water use efficiency.

The positive and significant correlation was found between total dry matter and grain yield. Positive direct effect was also recorded by total dry matter on grain yield (Atale and Zope, 1988; Srivastava *et al.*, 1988). Water use efficiency had maximum indirect effect followed by plant height. Most of the traits have negative indirect effect on grain yield. Due to positive direct effect of total dry matter on grain yield and positive and significant correlation between these two traits, it Was considered suitable selection criterion for evolving high yielding wheat varieties.

The correlation between total water used and grain yield was found to be positive. This trait had also a positive direct effect on grain yield. Maximum indirect effect was produced by total dry matter and followed by water use efficiency. Most of the traits have negative indirect effects. The association between evapotranspiration efficiency and grain yield was noted to be positive and significant but direct effect of evapo-transpiration efficiency was negative on grain yield. Positive indirect effects, ie 0.7382, 0.3556, 0.1945, 0.141, 0.1073 and 0.0941 were contributed by total dry matter, water use efficiency, plant height, total water used, harvest index and grains per spike, respectively. Therefore, indirect selection could be practiced to evolve high yielding wheat genotypes through those traits having positive indirect effects.

There was a positive and significant relationship between harvest index and grain yield but direct effect of harvest index on grain yield was found to be negative. Maximum indirect effect was produced through evapo-transpiration efficiency and followed by total dry matter. The correlation was found to be positive and significant between water use efficiency and grain yield. The positive direct effect was also found for water use efficiency, maximum positive indirect effect was noted for total dry matter and followed by total water used. The water use efficiency has a positive direct effect on grain yield and a significant correlation existed between these two traits.

It is concluded that dwarf and semi dwarf varieties are more efficient users of available water than tall ones. It is also concluded that those genotypes, which use more water, give greater harvest index value and produce more grain yields. These important points should be given due consideration while selection is made for drought resistance where efficient use of limited available water is a prerequisite. Due to the positive direct effect of total dry matter on grain yield and positive and significant correlation between these two traits, it was considered suitable selection criterion for evolving high yielding wheat varieties.

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