PATH COEFFICIENT ANALYSIS OF YIELD AND YIELD COMPONENTS IN BREAD WHEAT (*TRITICUM AESTIVUM* L.) GENOTYPES

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Abstract

With the trials conducted across two locations and over two years, the correlation coefficients and path analysis were calculated between grain yield and yield components of 20 bread wheat genotypes. Positive and significant correlation was found between yield and plant density, plant height, grain number per spike, grain weight per spike and 1000 kernels weight. Grain yield was negatively and significantly correlated with time to heading. Positive direct effect of plant height and grain weight spike^{-1} and negative direct effect of time to heading associated with significant correlation with grain yield suggested that these yield components may be a good selection criteria to improve yield of wheat genotypes.

Introduction

Yield, as a function of various components, is a complex character. It was suggested that yield depends on the number of spikes per unit area, the number of kernels per spike and the average kernel weight (Poehlman, 1994).

The grain yield and yield components of wheat are affected very much by the genotype and the environment. Therefore, as new cultivars are being produced by breeding, the relationships between yield and its components are studied by the breeders. To increase the yield, study of direct and indirect effects of yield components provides the basis for its successful breeding programme and hence the problem of yield increase can be more effectively tackled on the basis of performance of yield components and selection for closely related characters (Choudhry *et al*., 1986).

The aim of this study was to determine the correlations and path analysis of yield and yield components in bread wheat and evaluate their suitabilities in a breeding program.

Material and Methods

The experiments were conducted in two consecutive growing years (1999-2000 and 2000-2001) at the research plots at Pasinler and Ilica locations of Erzurum Province Center in Turkey (39° 55' North, 41° 16' East), with 1680 m and 1812 m above sea levels, respectively.

In Erzurum long-term average total precipitation is 389,9 mm year^{-1}, mean temperature for the whole year is 4.0^{o}C, and relative humidity is 67%. Precipitation during the experiments growing period for 1999-2000 and 2000-2001 was 238,8 mm and 364,5 mm in Ilica and 279,8 mm and 330,9 mm in Pasinler, respectively.

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Table 1. Bread wheat genotypes used in the experiment.

No.	Cultivars or lines	Pedigree
1.	DOGU-88	Commercial variety
2.	PALANDÖKEN-97	Commercial variety
3.	GEREK-79	Commercial variety
4.	KIRIK	Local variety
5.	TIR	Local variety
6.	BVDB-1	F.12.71/COC/BALL
7.	BVDB-2	WWY860243/3/SPN//63.189.66.7/BEZ
8.	BVDB-3	MLC/4/VPM/MOS951//HILL/3/SPN
9.	BVDB-4	NY242-20A-2USA-NY
10.	BVDB-5	ABN/JUN
11.	KARASU-90	Commercial variety
12.	HAWK	Commercial variety
13.	BVDK-1	KIRAC66/SERI/4/YMH/TUB//MCD/3/LIRA
14.	BVDK-2	PYN/BOW
15.	BVDK-3	GRK79/KAUZ//TXIA374-4/TX71A1039-V
16.	BVDK-4	SPN/VEE//SDY/NAC76
17.	BVDK-5	CLLF/BEZ//SU92/CII3645/3/NAI60/4/EMU/5/DYBR836
18.	BVDK-6	SB-285-2
19.	BVDK-7	KSB2142
20.	BVDK-8	N91L121

Twenty bread wheat genotypes (5 soft winter wheat lines, 8 red winter wheat lines, 2 local and 5 commercial cultivars) were used as genetic material in the trials (Table 1). The experiments were designed in a randomized complete block with three replications. The plot size was 6 m length with 6 rows and row spacing was 20 cm.

Genotypes were sown at the seed rate of 500 seed m^{-2} in November and harvested in the first half of August. Mineral fertilizer was applied at the rate of 60 kg N and 60 kg P_2O_5 per hectare.

In research, direct and indirect effects of traits were evaluated by correlation and path coefficients. Correlation and path coefficients were calculated by using **TARPOPGEN** Statistical Computer Programme.

Results and Discussion

Average values: The genotypes differed significantly for all traits indicating the presence of sufficient genetic variability for selection to identify the superior genotypes (Table 2). Data belong to investigated traits, as average of two years, two locations and 20 genotypes are shown in Table 3. Among these genotypes, grain yield ranged from 1030 to 7560 kg per hectare.

Correlation coefficients: Simple correlation coefficients calculated in every location and year and over locations and years are given in Table 4. Simple coefficient showed that there was a very strong (r=0,719) positive correlation between plant number and grain yield. Previous authors had reported similar results between grain yield and spike number (Hadjichristodoulou, 1989; Sharma & Rao, 1989; Mohan *et al*., 1993; Akanda & Mundt, 1996; Dokuyucu & Akkaya, 1999; Mondal *et al*., 2001). Grain yield was positively and

Table 2. The results of analysis of variance for yield and yield-related traits belonging to the bread wheat genotypes.

Source of variation	D.F.	Components						
		Spike numbers M^{-2}	Plant height	Grain numbers $spike^{-1}$	Grain weight $spike^{-1}$	1000 kernels weight	Time to heading	Grain yield
Years (Y)	1	3114709.5**	15424.0**	15.5**	0.047*	160.8**	3096.0**	4113139.8**
Locations (L)	1	1458444.5**	53521.0**	3.5	0.929**	41.5**	633.7**	2574874.5**
Y x L	1	512358.0**	340.8**	17.6**	1.157**	2.0	395.2	750513.5
Blocs	8	6291.4	64.1*	1.5	0.008	2.3	1.1	261.4
Genotypes (G)	19	27862.6*	337.9**	9.7**	0.027**	8.3**	9.4**	8781.0**
Y x G	19	19044.3	92.1**	2.8**	0.014*	5.5**	0.9	4927.5**
L x G	19	21368.9	38.9	2.1*	0.008	1.6	1.3	6618.0**
Y x L x G	19	19371.9	111.1**	1.7	0.010	3.8**	0.9	3599.1**
Error	152	14783.6	29.5	1.1	0.008	1.6	0.8	1157.1

Table 3. Data belong to SN, PH, GN, GW, 1000 KW, TH and GY by the average of locations, years and genotypes.

Traits	Range	Mean
Spike number M^{-2}	344-1613	719
Plant height (cm)	50.0-120.0	83.6
Grain number spike^{-1}	35.0-44.0	40.2
Grain weight spike^{-1} (g)	0.75-1.39	1.15
1000 kernel weight (g)	33.0-43.1	38.3
Time to heading (days)	152-168	162
Grain yield hectare^{-1} (kg)	1030-7560	3030

significantly correlated with plant height (r=0,731). Some authors also reported positive and significant correlations between yield and plant height (Subhani & Khaliq, 1994; Chaturvedi & Gupta, 1995; Sharma *et al*., 1995; Khan *et al*., 1999). Simple correlation coefficient was positive and significant between grain yield and grain number per spike (r=0,250). In most of the previous studies, similar results have been reported between grain yield and grain number per spike (Sharma & Rao, 1989; Mohan *et al*., 1993; Singh & Sharma, 1994; Subhani & Khaliq, 1994; Sharma *et al*., 1995; Aruna & Raghavaiah, 1997; Dokuyucu & Akkaya 1999; Narwal *et al*., 1999; Khan *et al*., 1999; Mondal & Khadjura, 2001; Mohammad *et al*., 2002). Grain yield was positively and significantly correlated with grain weight per spike (r=0,488). Mohan *et al*., (1993), Aruna & Raghavaiah, (1997), Moghaddam *et al*., (1998), Dokuyucu & Akaya (1999) and Ismail (2001) had reported similar results between grain yield and grain weight. 1000 kernels weight showed significant positive association with grain yield (r=0,518). This result is in agreement with the results of Sarkar *et al*., (1988), Hadjichristodoulou, (1989), El-Marakby *et al*., (1994), Subhani & Khaliq (1994), Mondal *et al*., (1997), Dokuyucu & Akaya, (1999), Mondal & Khajuria (2001) and Sarkar *et al*., (2002). In the study highly negative correlation of time to heading and grain yield was observed (r=0,899). Yildirm *et al*., (1996), Mondal *et al*., (1997), Narwal *et al*., (1999) and Ismail (2001) found similar results in their studies. On the other hand, in some studies, negative correlations between grain yield and plant height (Mondal *et al*., 1997; Mohammad *et al*., 2002) and grain weight (Esmail, 2001; Mohammad *et al*., 2002) and positive correlations between grain yield and time to heading (Chaturvedi & Gupta, 1995; Aruna & Raghavaiah, 1997) had been found.

Path coefficient analysis: In this research, the response variable grain yield (GY) and six predictor variables, spike number meter^{-2} (SN), plant height (PH), grain number spike^{-1} (GN), grain weight spike^{-1} (GW), 1000 kernel weight (1000 KW) and time to heading (TH), were studied for path coefficient (Table 5).

The direct effect of spike number M^{-2} (SN) on grain yield (GN) was too small (0.0627). The indirect effects of SN via GN, GW and 1000 KW were also small (0.0040, 0.0422 and 0.0183 respectively), via PH was moderate (0.1208) and via TH was high (0.4706). In most of the previous studies, SN had positive direct effect on the GY (Gebeyehou *et al*., 1982; Sharma & Rao, 1989; Garcia *et al*., 1991; Dofing & Knight, 1992; Chaturvedi & Gupta, 1995; Akanda & Mundt, 1996; Dokuyucu & Akaya, 1992; Mohammed *et al*., 2002).

Table 4. Simple correlation coefficient belonging to traits.

Locations and years	Components	Components					
		Spike numbers M^{-2}	Plant height	Grain numbers spike^{-1}	Grain weight spike^{-1}	1000 kernels weight	Time to heading
Ilica-00	Yeild	0.571**	0.069 ns	-0.144 ns	0.73 ns	0.746**	0.240 ns
Ilica-01		-0.002 ns	0.169 ns	0.283*	0.391**	0.148 ns	0.107 ns
Pasinler-00		0.068 ns	-0.170 ns	0.211 ns	0.193 ns	0.176 ns	-0.237 ns
Pasinler-01		0.026 ns	0.048 ns	0.040 ns	0.394**	0.498**	-0.040 ns
Combined		0.719**	0.721**	0.250**	0.488**	0.518**	0.899**
Ilica-00	Spike numbers M^{-2}		0.105 ns	0.059 ns	-0.040 ns	0.743**	-0.194 ns
Ilica-01			-0.041 ns	0.172 ns	-0.014 ns	0.059 ns	-0.242 ns
Pasinler-00			-0.239 ns	0.154 ns	0.100 ns	0.591**	-0.135 ns
Pasinler-01			-0.110 ns	-0.065 ns	-0.036 ns	0.224 ns	-0.160 ns
Combined			0.536**	0.202**	0.320**	0.468**	-0.735**
Ilica-00	Plant height			-0.061 ns	-0.099 ns	0.183 ns	-0.266 ns
Ilica-01				0.145 ns	0.103 ns	-0.005 ns	0.077 ns
Pasinler-00				-0.209 ns	-0.267*	-0.312*	0.134 ns
Pasinler-01				-0.169 ns	0.131 ns	0.074 ns	-0.031 ns
Combined				0.098 ns	0.423**	0.344**	-0.626**
Ilica-00	Grain numbers spike^{-1}				0.244 ns	-0.151 ns	-0.152 ns
Ilica-01					0.041 ns	0.119 ns	-0.098 ns
Pasinler-00					0.050 ns	0.068 ns	-0.207 ns
Pasinler-01					0.153 ns	-0.017 ns	0.015 ns
Combined					0.212**	0.140**	-0.253**
Ilica-00	Grain weight spike^{-1}					0.097 ns	-0.010 ns
Ilica-01						0.276*	0.090 ns
Pasinler-00						0.149 ns	-0.042 ns
Pasinler-01						0.461**	0.072 ns
Combined						0.345**	-0.348**
Ilica-00	1000 kernels weight						-0.015 ns
Ilica-01							-0.373**
Pasinler-00							-0.121 ns
Pasinler-01							0.063 ns
Combined							-0.506**

Table 5. Path coefficients and indirect effects of SN, PH, GN, GW, 1000 KW and TH on grain yield.

Locations and years	Components	Spike number M^{-2}		Plant height		Number of grains spike^{-1}		Weight of grains spike^{-1}		1000 kernels weight		Time to heading	
Ilica-00		*0.1694**	*24.74*	0.0003	0.03	-0.0015	0.22	-0.0012	0.17	0.4585	66.94	-0.0541	7.89
Ilica-01		*-0.0148*	*14.72*	-0.0035	3.53	0.0451	44.93	-0.0049	4.84	0.0039	3.91	-0.0282	28.07
Pasinler-00	Spike number M^{-2}	*-0.1085*	*38.12*	0.0107	3.75	0.0248	8.72	0.0150	5.28	0.1006	35.33	0.0251	8.80
Pasinler-01		*-0.1392*	*52.15*	0.0031	1.14	-0.0004	0.16	-0.0069	2.58	0.1005	37.65	0.0168	6.31
Combined		*0.0627*	*8.72*	0.1208	16.82	0.0040	0.56	0.0422	5.87	0.0183	2.55	0.4706	65.48
Ilica-00		0.0177	8.84	*0.0025*	*1.22*	0.0015	0.76	-0.0029	1.45	0.1128	56.26	-0.0631	31.47
Ilica-01		0.0006	0.36	*0.0866*	*50.98*	0.0381	22.43	0.0353	20.77	-0.0003	0.19	0.0090	5.27
Pasinler-00	Plant height	0.0260	11.67	*-0.0446*	*20.04*	-0.0337	15.14	-0.0402	18.08	-0.0531	23.89	-0.0249	11.18
Pasinler-01		0.0153	14.44	*-0.0278*	*26.28*	-0.0011	1.03	0.0251	23.71	0.0333	31.48	0.0032	3.06
Combined		0.0336	4.59	*0.2255*	*30.84*	0.0020	0.27	0.0559	7.64	0.0135	1.84	0.4008	54.81
Ilica-00		0.0101	5.65	-0.0001	0.08	*-0.0249*	*13.99*	0.0072	4.02	-0.0934	52.46	-0.0423	23.78
Ilica-01		-0.0025	0.82	0.0126	4.03	*0.2626*	*84.41*	0.0140	4.50	0.0079	2.55	-0.0114	3.68
Pasinler-00	Number of grains spike^{-1}	-0.0167	6.82	0.0093	3.80	*0.1612*	*65.89*	0.0075	3.07	0.0115	4.71	0.0384	15.70
Pasinler-01		0.0091	15.46	0.0047	8.04	*0.0064*	*10.97*	0.0293	49.98	-0.0076	12.88	-0.0016	2.65
Combined		0.0127	5.07	0.0222	8.86	*0.0199*	*7.94*	0.0280	11.18	0.0055	2.18	0.1622	64.77
Ilica-00		-0.0068	6.44	-0.0002	0.23	-0.0061	5.79	*0.0293*	*27.86*	0.0600	57.07	-0.0027	2.61
Ilica-01		0.0002	0.05	0.0089	2.28	0.0107	2.75	*0.3424*	*87.53*	0.0184	4.71	0.0105	2.68
Pasinler-00	Weight of grains spike^{-1}	-0.0108	5.06	0.0119	5.55	0.0080	3.75	*0.1505*	*70.18*	0.0253	11.81	0.0079	3.66
Pasinler-01		0.0050	1.20	-0.0036	0.88	0.0010	0.24	*0.1917*	*46.05*	0.2073	49.80	-0.0076	1.83
Combined		0.0200	4.10	0.0955	19.56	0.0042	0.86	*0.1320*	*27.03*	0.0135	2.76	0.2229	45.67
Ilica-00		0.1258	16.68	0.0004	0.05	0.0038	0.50	0.0280	0.38	*0.6172*	*81.83*	-0.0041	0.55
Ilica-01		-0.0009	0.37	-0.0004	0.18	0.0312	13.16	0.0945	39.84	*0.0668*	*28.18*	-0.0433	18.28
Pasinler-00	1000 kernels weight	-0.0642	21.10	0.0139	4.58	0.0109	3.60	0.0224	7.37	*0.1701*	*55.95*	0.0225	7.39
Pasinler-01		-0.0311	5.38	-0.0021	0.36	-0.0001	0.02	0.0884	15.29	*0.4497*	*77.81*	-0.0066	1.14
Combined		0.0293	5.65	0.0777	14.98	0.0028	0.53	0.0455	8.77	*0.0382*	*7.55*	0.3240	62.50
Ilica-00		-0.0328	10.07	-0.0006	0.17	0.0038	1.16	-0.0003	0.09	-0.0091	2.79	*0.2792*	*85.71*
Ilica-01		0.0036	1.72	0.0067	3.20	-0.0258	12.41	0.0309	14.84	-0.0249	11.96	*0.1163*	*55.87*
Pasinler-00	Time to heading	0.0146	5.49	-0.0060	2.23	-0.0334	12.51	-0.0064	2.39	-0.0206	7.72	*-0.1857*	*69.65*
Pasinler-01		0.0223	13.07	0.0009	0.50	0.0001	0.06	0.0139	8.4	0.0282	16.55	*-0.1052*	*61.69*
Combined		-0.0461	5.12	-0.1411	15.70	-0.0050	0.56	-0.0459	5.11	-0.0198	2.20	*-0.6406*	*71.29*

*Italic numbers show the direct effects on the grain yield

Plant height (PH) had a strong positive direct effect on grain yield (GY) (0.2255). Some authors also indicated the positive direct effect of PH on GY (Chaturvedi & Gupta, 1995; Khan *et al*., 1999; Moghaddam *et al*., 1998). On the other hand some authors pointed that PH had negative direct effect on GY (Subhani & Khaliq, 1994; Mondal *et al*., 1997; Mohammed *et al*., 2002). The indirect effect of PH via SN, GN, GW and 1000 KW were small, via TH was great.

The direct effect of grain number spike^{-1} (GN) on GY was positive but small (0.0199). Similarly, there are reports indicating the positive effect of GW on GY (Sarkar *et al*., 1988; Sharma & Rao, 1989; Singh & Sharma, 1994; Subhani & Khaliq, 1994; Moghaddam *et al*., 1998; Narwal *et al*., 1999; Khan *et al*., 1999; Mohammed *et al*., 2002). The indirect effect of GN due to SN and 1000 KW was small, due to PH, GW and TH were great.

Grain weight spike^{-1} (GW) had a positive direct effect on GY (0.1320). Similar results had been reported by some authors (Mohan *et al*., 1993; Aruna & Raghavaiah, 1997; Moghaddam *et al*., 1998; Dokuyucu & Akaya, 1999; Ismail, 2001). The indirect effects of GW via all components were positive. These indirect positive effects were small via SN, GN and 1000 KW and great via PH and TH.

The direct effect of 1000 kernel weight (1000 KW) on GY was positive and small (0.0392). In some of the previous studies this positively direct effect had been found (Sharma & Rao, 1989; El-Marakby *et al*., 1994; Mohammed *et al*., 2002). The indirect effects of 1000 KW via SN, PH, GN and GW were positive and small, but via TH was also positive but great.

The only character having negative direct effect on GY in the trial was time to heading (TH). The negative direct effect of TH on GY was highly great (0.6406). Some authors also indicated the negative effect of TH on GY (Yildirim *et al*., 1996; Narwal *et al*., 1999). The indirect effect of TH due to, SN, GN, GW and 1000 KW was negative and small, due to PH was negative moderate.

Conclusion

Our results obtained from 20 bread wheat genotypes and combined 2 years and 2 locations showed that grain yield was significantly and positively correlated with all the characters, except time to heading. Grain yield was significantly and negatively related with time to heading.

Path coefficient analysis indicated that the direct effects of spike number meter^{-2}, grain number spike^{-1} and 1000 kernel weight on grain yield were weakly positive, the direct effects of plant height and grain weight spike^{-1} were strongly positive, time to heading was strongly negative. Therefore, the characteristics of plant height, grain weight spike^{-1} and time to heading can be used as selection criteria to increase grain yield in bread wheat in the region.

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