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J. Coll. Sci., King Saud Univ., 13 (2), pp. 237 - 248 (1982)

Heritabilities and Interrelationships of Yield and Yield Components in a Diallel Cross of Wheat(*)

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Parents and 10 F1 hybrids of wheat were grown together in a randomized complete block field experiment in 1980 season.

Traits under investigation were; grain yield per plant, number of spikes per plant, number of kernels per spike, plant weight, harvesting index, 100 - kernel weight, days to heading, plant height, spike length, number of spikelets per spike, and spike density.

Heritability was high in both broad and narrow sense for grain yield per plant, number of spikes per plant and plant weight. Values for spike length, number of kernels per spike, harvesting index and spike density were high in the broad sense and relatively high or intermediate in the corresponding narrow sense ones. Whereas, 100 kernel weight, days to heading, plant height and number of spikelets per spike were higher in broad sense and lower in narrow sense.

Genotypic and phenotypic correlation coefficients were estimated between all possible pairs of traits. In general, the genotypic correlations matches closely with the phenotypic correlations. The grain yield per plant was highly positive correlated with spike length, number of kernels per spike and plant weight. The correlations between earliness and the other traits showed that early genotypes are highly correlated with high grain yield, 100 kernel weight and harvesting index.

Keywords: Heritability, Yield component, Correlations yield components, Diallel, Wheat.

The primary target of most breeding programs is to improve yielding capacity

(*) This research was supported by Saudi Arabian National Center for Science and Technology (SANCST) grant No. AR - 1.0. 77.

of the crop. This objective can be achieved indirectly by breeding for resistance to one of the many adversities which influence yield, or directly by breeding for increasing yielding ability. Understanding of the genetic background is very important for plant characters directly related to production.

Expected genetical advance under selection for yield component should be most effective if the components are highly heritable, *i.e.* if they have independent genetic behaviour, and if the characters are not associated physiologically. The interrelationships among traits were estimated in terms of genotypic and phenotypic correlations. If the object of breeding program is to increase the value of two traits, then a positive correlation between them would be considered as an asset while a negative correlation would be detrimental to the program. The present study was undertaken to determine the estimates of heritabilities, genotypic and phenotypic correlations of yield and its component traits from F1 data of 5 – parent diallel cross of wheat.

Material and Methods

Diallel cross used in this investigation was made up from five wheat varieties representing broad ranges of genetic diversity. The parental varieties were (Super X, Hinta Madeni, Giza 155, Arz and Arabian). Parents and 10 F1 generations (excluding reciprocals) were planted together in Jiffy pots (one seed per pot), five weeks later, the plants were transplanted into the field in a randomized complete block design in four replicates. Each entry was represented by a row of 10 plants spaced 40 cm – apart and 30 cm between rows. The field experiment was laid out at Olisha Farm, College of Agric., University of Riyadh, in winter 1979 – 1980 season.

Data were obtained from individual plants for the following traits: grain yield/plant, number of spikes/plant, number of kernels/spike, weight of 100 kernels, plant height, plant weight, harvesting index, spike length, number of spikelets per spike, days to heading and spike density «D» $\frac{\text{Number of spikelets per spike}}{\text{Length of spike axis in mm}} \times 100$. Heritabilities in the broad sense (ratio of the total genetic variance to the phenotypic variance) and heritabilities in the narrow sense (ratio of the additive genetic to the phenotypic variance) were calculated for each given traits.

Genotypic correlations among all possible pairs of traits were calculated according to the method described by Al – Jibouri *et al.* (1958) and Miller *et al.* (1958). Similarly, the phenotypic correlations were calculated following the methods of Al-Jibouri *et al.* (1958), Miller *et al.* (1958) and Falconar (1960).

Results and Discussion

Mean values for the traits studied in 5 parents and 10 F_1's diàllel cross are given in Table 1. The analysis of variance for F1 means (Table 2) indicated highly significant differences for all measured traits except plant weight which has significant at 0.05 level.

Table 1. Mean values for different traits studied for 5 parents and 10 F1's in 1980 season.

Entries	Grain yield/ plant	No. of spikes/ plant	No. of kernels/ spike	Plant weight	Harvesting index	100-kernel weight	Days to heading	Plant height	Spike length	No. of spike-lets/spike	Spike density
Super X (Sup)	21.0	19.6	81.3	81.6	0.339	2.22	84.9	58.5	12.1	42.2	38.1
Hinta (H)	12.8	26.2	52.5	88.4	0.180	2.02	91.8	66.8	10.6	41.4	43.1
Giza 155 (G)	18.6	22.4	54.6	82.6	0.274	2.57	84.2	61.3	9.7	40.1	45.7
Arz (Z)	19.9	22.4	67.3	85.9	0.288	2.47	83.4	58.9	10.8	42.9	43.3
Arabian (A)	22.7	19.8	76.1	96.3	0.311	2.30	83.3	63.1	10.5	50.1	53.1
Sup X H	27.0	26.5	77.2	104.6	0.368	2.37	81.4	64.3	11.8	41.1	37.6
Sup X G	31.1	26.7	83.1	119.6	0.378	2.49	80.1	60.0	12.2	42.9	38.1
Sup X Z	29.0	25.5	75.6	106.4	0.356	2.62	80.3	61.4	11.5	43.7	42.6
Sup X A	23.5	20.3	76.4	90.5	0.350	2.40	82.9	57.9	11.7	40.6	37.6
H X G	18.9	31.1	56.0	117.5	0.257	2.23	87.2	67.3	11.1	42.4	43.1
H X Z	21.5	22.8	68.6	86.6	0.319	2.57	85.1	63.7	11.3	42.8	41.4
H X A	14.6	19.0	63.6	88.7	0.209	2.02	87.7	59.3	10.6	50.6	51.1
G X Z	25.7	31.0	64.3	107.5	0.343	2.53	79.0	69.4	11.0	44.0	44.2
G X A	20.4	26.4	61.2	87.6	0.286	2.46	79.9	69.5	10.1	41.7	45.3
Z X A	24.1	23.3	76.2	106.5	0.339	2.57	81.6	64.8	11.1	48.7	49.5

Table 2. Mean squares for different traits in F1 hybrids in 1980 season.

Source of variation	df	Grain yield/ plant	No. of spikes/ plant	No. of kernels/ spike	Plant weight	Harvesting index	100-kernel weight	Days to heading	Plant height	Spike length	No. of spikelets/ spike	Spike density
Replications	3	63.7509*	38.8780*	66.1220	390.5449	0.0067*	0.1304*	3.1667	225.6356**	0.0136	11.3429	2.3869
Genotypes	9	97.8414**	64.3418**	305.0543**	611.5758*	0.0116**	0.2127**	38.7444**	67.4711**	1.5225**	42.6829**	88.4711**
Error	27	18.2502	11.1476	72.6411	236.7186	0.0016	0.0427	3.3622	11.9615	0.2673	4.2585	5.9747

*, **: Significant at 5% and 1% levels respectively.

Heritability

Heritability estimates in both broad and narrow sense for all traits studied are given in Table 3. Broad sense heritability estimates were quite large in magnitudes for all traits, ranging from 73.64 to 94.58%. Heritabilities in the narrow sense were smaller than the corresponding broad sense ones for all traits with the exception of plant weight and grain yield per plant. This irregularity in the estimates of heritability can be blamed for the presence of large but negative estimates of dominance genetic variance. Abo – Elenein and Gomma (1977), found that the narrow sense heritability was higher than the broad sense for plant height, and Ali and El – Haddad (1978) for number of fertile tillers.

The narrow sense heritability estimates ranged from 10.53% for 100 – kernel weight to 95.68% for plant weight. The most relative consistent between broad and narrow sense estimates was obtained for grain yield per plant, number of spikes and plant weight which showed high levels of heritability. It can be concluded that most of the total genetic variance was associated with additive effect on these traits. These results are in agreement with previous findings reported by Fonseca and Patterson (1968), and Ali and El – Haddad (1978) on number of spikes. Whereas, values obtained for days to heading, plant height, number of spikelets and 100 – kernel weight were the most variable between the broad sense and narrow sense estimates. These differences suggested that these traits were more influenced by dominance effects rather than additive.

Table 3. Broad sense and narrow sense heritabilities for yield and yield component traits from F1 data of 5 – parent diallel cross in wheat.

Traits	Heritability %	
	Broad sense	Narrow sense
Grain yield/plant	86.79	87.46
No. of spikes/plant	86.94	73.97
No. of kernels/spike	81.28	64.13
Plant weight	73.64	95.68
Harvesting index	89.47	68.42
100 – kernel weight	80.58	10.53
Days to heading	93.93	30.31
Plant height	84.76	42.00
Spike length	85.71	65.31
No. of spikelets/spike	89.92	– 1.69
Spike density	94.58	58.64

Bhatt (1972), and Ali and El – Haddad (1978) confirmed the same results in days to heading, plant height and 100 – kernel weight. High broad sense heritability and relatively high or intermediate narrow sense were obtained for harvesting index, spike length, number of kernels per spike and spike density. It means that both additive and non – additive genetic variance may affect these traits but additive represent a greater portion. Similar results were obtained by Johnson *et al.* (1966) for spike length and Fonseca and Patterson (1968) for number of kernels per spike. The narrow sense heritability showed biased estimate for number of spikelets per spike. The negative estimate may be because of high confounding effects of additive and dominance genetic variance with the environment.

Genotypic and Phenotypic Correlations

The genotypic and phenotypic correlation coefficients among all possible pairs of traits are presented in Table 4.

The data showed highly significant positive genotypic and phenotypic correlations between grain yield per plant and the other yield component traits such as number of kernels per spike and other traits, namely, spike length and harvesting index. It means that these traits are primary targets of yield; and each had high direct effect on grain yield. Syme (1972) and Nass (1973) reported high correlations between harvest index and grain yield. Highly significant positive genotypic correlations were observed between number of kernels per spike with each of spike length, weight of 100 – kernels and harvesting index. The respective phenotypic correlations were in agreement with the genotypic correlations in sign and tend to be relatively smaller in magnitudes with a highly significant value in the first set (number of kernels with spike length) and a significant level for the other two. This indicates that selection for increasing number of kernels per spike will increase directly spike length, weight of 100 – kernels and harvesting index. Lebsock and Amaya (1969) and Joppa (1973) obtained highly significant negative correlation between kernel weight and kernels per spike. While Soomro and Aksel (1975) reported that number of seeds per spike and 1000 – kernel weight were not correlated.

Number of spikes per plant showed positive genotypic correlations on a highly significant level with plant height and a significant value with plant weight. Significant positive phenotypic correlations were obtained between number of spikes per plant and the other two traits. It means that factors affecting number of spikes per plant are also influencing, at the same time, plant height and weight.

Table 4. Genotypic (upper) and phenotypic (lower) correlation coefficients among all possible pairs of traits studied in Fl of 5-parent diallel cross in wheat.

	Plant height (PH)	Plant weight (PW)	No. of spikes (No.S)	Grain yield (GY)	Spike length (SL)	No. of spikelets (No.Sp)	No. of kernels (No.K)	Spike density (SD)	Harvesting index (HI)	100-Kernel weight (KW)
Days to heading (DH)	-0.324 -0.266	-0.248 -0.230	-0.371 -0.351	-0.813** -0.774*	-0.224 -0.168	0.351 0.347	-0.575 -0.472	0.312 0.299	-0.718* -0.700*	-0.631* -0.582
Plant height (PH)		0.059 0.135	0.798** 0.738*	-0.215 -0.110	-0.715* -0.570	-0.223 -0.167	-0.686* -0.597	0.244 0.225	-0.093 -0.105	0.101 0.167
Plant weight (PW)			0.753* o.678	0.511 0.557	0.565 0.484	-0.074 -0.087	0.360 0.222	-0.197 -0.228	0.459 0.334	0.057 0.115
No. of spikes (No.S)				0.281 0.328	-0.007 -0.007	-0.459 -0.410	-0.296 -0.303	-0.238 -0.214	0.190 0.184	0.127 0.189
Grain yield (GY)					0.867** 0.720*	-0.478 -0.415	0.970** 0.974**	-0.675* -0.562	0.951** 0.872**	0.574 0.561
Spike length (SL)						-o.455 -0.338	0.845** 0.789**	-0.798** -0.742*	0.807** 0.667*	0.233 0.210
No. of spikelets (No.Sp.)							-0.226 -0.113	0.898** 0.868**	-0.506 -0.463	-0.294 -0.271

(*,: Significant at 5% and 1% levels respectively)**

Table 4.Cont.

	Plant height (PH)	Plant weight (PW)	No. of spikes (No.S)	Grain yield (GY)	Spike length (SL)	No. of spikelets (No.SP)	No. of kernels (No.K)	Spike density (SD)	Harvesting Index (HI)	100 - kernel weight (KW)
No. of kernels (No.K)								- 0.567 -0.482	0.864** 0.741*	0.826** 0.607*
Spike density (SD)									- 0.695* - 0.631*	- 0.253 - 0.240
Harvesting Index (HI)										0.636* 0.615*

The same results were obtained in the association between harvesting index and spike length and weight of 100 - kernel. This indicated that selection for increasing harvesting index may increase directly the spike length and weight of 100 - kernel. High significant positive genotypic and phenotypic correlation was obtained between number of spikelets per spike and density. It means that breeding for increasing one variable would increase the other at the same time.

On the other hand, significant negative genotypic and phenotypic correlations were obtained between earliness (days to heading) and the grain yield per plant, weight of 100 - kernel and harvesting index. This indicated that the early genotypes tended to have greater grain weight per plant, weight of 100 - kernel and harvesting index. Fonseca and Patterson (1968) found negative association between earliness and both of grain yield and kernel weight. Also plant height was negatively correlated with spike length and number of kernels per spike. On the basis of these, high negative correlation will make it nearly impossible to improve either of these traits without harming the other. Reddi *et al.* (1969) reported similar results regarding the correlations between plant height and spike length. The results obtained between plant height and kernels per spike were partially in agreement with the findings of Joppa (1973). The negative genotypic correlation coefficients were obtained between spike density with grain yield, harvesting index (at 0.01 level) and spike length. It means that the increase of spike density would result in a decrease in the other three traits. these results of genotypic and phenotypic correlations were in general agreement with those obtained by Johnson *et al.* (1966), Baker *et al.* (1968). Fonseca and Patterson (1968), and Soomro and Aksel (1975).

Acknowledgement

This research was supported by Saudi Arabian National Center for Science and Technology (SANCST) grant No. AR1 0.77. Technical assistance of Mr. A.M. Meligy is gratefully appreciated and acknowledged.

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كفاءة التوريث والتلازم بين المحصول ومكونات المحصول في هجن الداي أليل في القمح

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استخدمت في هذا البحث خمسة أصناف من القمح زرعت مع هجن الجيل الأول الناتجة عنها (10 F_1's) في تجربة ذات تصميم قطاعات كاملة عشوائية في موسم ١٩٨٠ م وقد درست الصفات الآتية: محصول الحبوب بالنبات، عدد السنابل بالنبات، عدد الحبوب بالسنبلة، وزن النبات، معامل الحصاد، وزن ١٠٠ حبة، عدد الأيام حتى طرد السنابل، طول النبات، طول السنبلة، عدد السنيبلات في السنبلة وكثافة السنبلة.

أوضحت النتائج أن كفاءة التوريث Heritability، بكل من معناها العام Broad sense ومعناها الخاص Narrow sense، ذات قيم عالية لصفات محصول الحبوب بالنبات، عدد السنابل بالنبات، ووزن النبات، كما أظهرت صفات طول السنبلة، عدد الحبوب بالسنبلة، معامل الحصاد، وكثافة السنبلة قيماً مرتفعة لكفاءة التوريث بالمعنى العام وقيماً عالية نسبياً أو متوسطة بالمعنى الخاص. كما اتضح أن

التفارق واضح وكبير بين قيم كفاءة التوريث بمعنياها لكل من صفات وزن ١٠٠ حبة، عدد الأيام حتى طرد السنابل، طول النبات وعدد السنيبلات في السنبلة.

قدر معامل التلازم الوراثي والمظهري بين الصفات المدروسة وظهر بصفة عامة أن كليهما يسير جنباً إلى جنب مع الآخر. وقد كان التلازم موجباً ومعنوياً بين محصول الحبوب بالنبات مع طول السنبلة، وعدد الحبوب بالسنبلة، ووزن النبات. كما اتضح من النتائج أن الطرز المبكرة كانت شديدة التلازم مع زيادة محصول النبات، وزن ١٠٠ حبة، ومعامل الحصاد.