Genetic variability and interrelationships of grain yield and its components of selected bread wheat genotypes

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ABSTRACT

High temperature is one of major constraints of bread wheat production in the Sudan. Evaluation of different genotypes under heat stress conditions is one of the main tasks of breeders for exploiting genetic variations to improve cultivars under heat stress. Also, association of yield and yield contributing traits is important for selection. The objective of this study was to evaluate bread wheat genotypes under the irrigated hot environment of the Gezira, Sudan. Experiments were conducted at Gezira Research Farm, Wad Medani, Sudan for two consecutive seasons 2006/07 and 2007/08. The experiments were arranged in an augmented design with six checks, 4 and 12 blocks in the first and second seasons, respectively. Results showed wide ranges of variations in grain yield among these genotypes in both seasons. Grain yield ranged from 965 to 4019 kg/ha and from 133 to 6258 kg/ha in the first and second seasons, respectively. Similar wide ranges of variations were found in biomass, harvest index, number of spikes m^{-2}, days to heading, days to maturity and plant height. Grain yield showed positive and significant correlation coefficients with biomass and harvest index, in both seasons. Path coefficient analysis indicated that biomass and harvest index were the most directly related parameters to grain yield, in both seasons.

INTRODUCTION

High temperature is the major constraint of bread wheat production in the Sudan (Elahmadi *et. al.*, 1996). Breeding for heat tolerance is one of the main objectives of the wheat breeding program in the Sudan. Breeding materials and introductions at Gezira Research Station, Sudan, showed very large variability for grain yield among wheat genotypes. Yield, as a function of various components, is a complex character. Many characters have been suggested as selection criteria for heat tolerance or avoidance (Elahmadi *et. al*, 1996; Tahir *et. al.*, 2006).Variations in the degree of response to heat stress with respect to different characters are observed. Correlation among these characters and selection for heat tolerance are important to increase yield. Also study of direct and indirect effects of components provides the basis for successful selection (Choudhry *et al*., 1986).

The aims of this study were to investigate genetic variability, interrelationships and path analysis of yield and yield components among some genotypes selected from different trials of the wheat breeding program of the Sudan.

MATERIALS AND METHODS

The experiments were conducted in two consecutive growing seasons (2006/2007 and 2007/2008) at the Gezira Research Farm (GRF), of the Agricultural Research Corporation (ARC), Wad Medani, Sudan (latitude of 14°-24´ N and longitude of 29°-33´ E and 407 masl). The soil of GRF is classified as heavy clay soil, pH of about 8.0-8.4, low organic matter (0.05), deficient in nitrogen (380 ppm), and phosphorus (ESP, 4 ppm).

The experiments were conducted using 94 and 174 genotypes in the first and second seasons, respectively. Genotypes were selected from different trials in the wheat breeding program of the Sudan. The experiments were arranged in an augmented design with six checks, 4 and 12 blocks in the first and second seasons, respectively. Checks were assigned at random to plots within each block while the remaining plots were assigned randomly to the new genotypes under test. Each plot consisted of two rows, 2 and 5 m long in the first and second seasons, respectively and 0.2 m apart.

Seeds were sown at the rate of 120kg/ha in mid November (optimum sowing date). The recommended dose of fertilizer (43 kg P_2O_5/ha) was applied prior to sowing and 86 kg N/ha as urea was applied with the second and fourth irrigations. The experiments were irrigated at 10-12 days interval.

Data were recorded on days to heading and maturity, chlorophyll content (SPAD), plant height (cm), number of spikes/m², biomass (kg/ha), harvest index and grain yield (kg/ha). The data were statistically analyzed using IRRISTAT for Windows (Version: 5.0.20050211), simple correlation coefficients were calculated using Stat View for Windows (SAS Institute Inc. Version 5.0.1) and path coefficient was calculated using Excel Computer Program.

RESULTS AND DISCUSSION

Genetic variability

The mean, lowest and highest grain yield and other important traits of the checks and adjusted data of the 94 and 174 new entries are shown in Tables 1 and 2. The adjusted grain yield of the new entries ranged from 965 to 4019 (kg/ha), biomass from 3448 to 9948 (kg/ha) and harvest index from 20.5 to 50.4%. In addition, wide ranges were observed in number of spikes m^{-2}, days to heading and maturity, chlorophyll content and plant height in the first season (Table 1). In the second season, grain yield of the new entries ranged from 133 to 6258 (kg/ha), biomass from 4153 to 18838 (kg/ha) and harvest index from 18.4 to 49.6%. Similarly, wide ranges were found in number of spikes m^{-2}, days to heading and maturity and plant height (Table 2). These results were in agreement with those of Reynolds *et al.*, 1994, Elahmadi *et al* 1996, Khopra and Viswanthan, 1999, Slafer *et al.*, 2005 and Mehment and Telat 2006. They showed significant phenotypic variability for different traits such as days to heading, days to maturity, plant height, number of spikes m^{-2}, biomass and grain yield. Genotypes differed significantly for all traits among these experiments indicating the presence of sufficient genetic variability for selection to identify the superior genotypes.

Table 1. Mean, lowest and highest values for grain yield and other important traits of the 94 new entries and six checks used in the first season (2006/07).

	Grain yield (kg/ha)	Biomass (kg/ha)	Harvest index (%)	Spikes m^{-2}	Heading (days)	Maturity (days)	Chlorophyll content (SPAD)	Plant height (cm)
				New entries				
Highest	4019	9948	50.4	725	67	104	56.5	104
Lowest	965	3448	20.5	203	53	82	34.7	63
Mean	2329	6807	43.9	425	61	96	42.3	84
				Checks				
El Neilain	2824	7812	36.6	398	61	101	34.7	92
Sasaraib	2222	8906	25.2	373	64	93	56.5	75
Imam	2799	7656	38.8	405	66	101	39.8	89
Khalifa	2525	5469	37.0	398	63	93	38.8	82
Tagana	2309	8125	28.9	450	65	104	43.9	87
Bohaine	2698	7500	36.0	495	54	87	43.5	65
Mean	2562	7578	33.8	419	62	95	42.9	81
S.E.±	77.1	1350	4.1	17.8	1.2	1.6	1.7	2.9
C.V %	7.8	16.7	18.6	9.3	1.8	1.6	3.7	3.4

Table 2. Mean, lowest and highest values for grain yield and other important traits of the 174 new entries and six checks used in the second season (2007/08).

	Grain yield (kg/ha)	Biomass (kg/ha)	Harvest index (%)	Spike m^{-2}	Heading (days)	Maturity (days)	Plant height (cm)
				New entries			
Highest	6258	18838	49.6	737	72	109	108
Lowest	1331	4153	18.4	280	41	74	51
Mean	4087	10740	38.7	542	57	92	75
				Checks			
Debeira	5177	14430	35.8	676	59	96	81
Wadi Elneil	4609	11930	40.0	535	64	103	87
Imam	4409	17030	36.7	550	66	99	83
Tagana	4109	17470	33.0	605	69	103	85
Bohaine	4099	10310	39.2	668	51	90	67
Nebta	3833	9375	41.5	477	55	91	65
Mean	4373	13424	38.0	585	61	97	78
S.E.+	730.7	1641	7.2	90.7	1.6	2.4	2.6
C.V %	16.8	14.1	19.1	16.3	2.7	2.4	5.9

Traits associations

Simple correlation coefficients of grain yield and some important traits of the 94 and 174 entries in the first and second seasons, respectively, are shown in Table 3. Grain yield was positively and significantly correlated with biomass and harvest index in both seasons and was positively and significantly correlated with number of spikes m^{-2}, days to heading, days to maturity and plant height in the second season. Many research workers reported similar findings (Shpiler and Blum; 1986, Hezhong and Rajaram, 1994; Tamman *et al*., 2000; Osman *et al*., 2006). In addition, biomass and harvest index are very important selection criteria for yield under high temperature conditions (Hezhong and Rajram 1994, Tahir 1999).

Table 3. Simple correlation coefficients of grain yield and some traits of 94 and 174wheat genotypes grown at the Gezira Research Farm (GRF), seasons 2006/07 and 2007/08.

	GY	BIO	HI	SP/m^{-2}	DH	DM
First season (2006/07), N = 94						
Grain yield						
Biomass	0.67***					
Harvest index	0.41***	-0.37***				
No of spikes m^{-2}	0.03	-0.03	0.04			
Days to heading	0.11	0.08	0.09	-0.04		
Days to maturity	-0.26*	0.11	0.19	-0.05	0.62***	
Plant height	-0.02	-0.05	0.03	0.28**	0.03	0.177
Second season (2007/08), N = 174						
Grain yield						
Biomass	0.77***					
Harvest index	0.21**	-0.45***				
No of spikes m^{-2}	0.34***	0.37***	-0.10			
Days to heading	0.29***	0.58***	-0.49***	0.20**		
Days to maturity	0.33***	0.59***	-0.45***	0.27***	0.93***	
Plant height	0.67***	0.67***	-0.48***	0.26***	0.77***	0.77***

N = number of genotypes, GY = grain yield (kg/ha), Bio = biomass (kg/ha), HI = harvest index, SP/m^{-2} = number of spikes/m^{2}, DH = days to heading, DM = days to maturity
and *, ** and *** Significant at 0.05, 0.01 and 0.001 probability levels, respectively.

Path coefficient analysis

The results of the path coefficient analysis based on data for both seasons are presented in Table 4. Biomass and harvest index had the highest direct positive contribution to grain yield for both seasons. their contribution were 1.07 and 0.93 in the first season and 0.82 and 0.74 in the second season. These results indicated that biomass and harvest index are the most important traits related to grain yield. These finding were supported by the correlation analysis (Table 3). Many research workers reported similar findings (Choudhry *et al*., 1986, Sharma *et al*.1985; Attarbashi *et al*.,2002).

Table 4. Path coefficient analysis of the direct and indirect effects of some important yield components and their simple correlation coefficient with grain yield (kg/ha).

	Biomass (kg/ha)	Harvest index (%)	Spike m^{-2}	Heading (days)	Maturity (days)	Plant height (cm)	Grain yield (kg/ha)
First season (2006/2007)							
Biomass (kg/ha)	1.07	-0.34	0.00	0.03	-0.09	-0.00	0.67***
Harvest index (%)	-0.39	0.93	-0.00	0.04	-0.17	0.00	0.41***
Spike m^{-2}	0.03	0.03	-0.09	-0.01	0.04	0.01	0.03
Heading (days)	0.08	0.08	0.00	0.48	-0.54	0.00	0.11
Maturity (days)	0.12	0.18	0.01	0.30	-0.88	0.01	-0.26
Plant height (cm)	0.05	0.02	-0.02	0.013	-0.15	0.07	-0.02
Second season (2007/2008)							
Biomass (kg/ha)	0.82	-0.33	-0.00	-0.17	-0.11	0.57	0.77***
Harvest index (%)	-0.37	0.74	0.00	0.14	0.09	-0.40	0.21**
Spike m-^{2}	0.31	-0.07	-0.00	-0.06	-0.05	0.22	0.34***
Heading (days)	0.47	-0.36	-0.00	-0.30	-0.1	0.66	0.29***
Maturity (days)	0.48	-0.33	-0.00	-0.28	-0.20	0.66	0.33***
Plant height (cm)	0.54	-0.35	-0.00	-0.23	-0.15	0.85	0.67***

, * Significant at 0.01 and 0.001 probability levels, respectively.

REFERENCES

Attarbashi, M., R. S. Galeshi and A. Zinali. 2002. Relationship of phenology and physiological traits with grain yield in wheat under rain-fed conditions. Iranian Journal of Agricultural Sciences 33: 8 -21.

Choudhry, A., R. Shah, A. H. Ali and L. M. Bashir.1986. Path coefficient analysis of yield and yield components in wheat. Pakistan Journal of Agricultural Research 7(2): 71-75.

Elahmadi, A. B., O. A. Ageeb, M. B. Solh and M. C. Saxena. 1996. Review of wheat production and improvement in the Sudan. Proceedings of the National Research Review Workshop. 27-30 August 1995, Wad Medani, Sudan.

Hezhong, H. and S. Rajram.1994. Differential responses of bread wheat characters to high temperature. Euphytica 72:197 - 203.

Khopra, R., and C. Viswanthan. 1999. Evaluation of heat stress in irrigated environment of *Triticum asetivum L*. and related species for stability in yield and yield components. Euphytica 106: 169-180.

Mehment, A., and Y. Telat. 2006. Heritability of yield and some yield components in bread wheat genotypes. Bangladesh Journal of Botany 35: 17-22.

Osman, S. I., M. Tang and M. R. Muhammad. 2006. Phenotypic and genotypic correlation coefficients between yield and yield components in wheat. Journal of Agricultural Research 44 (1):100-108.

Reynolds, M. P., M. Balota, M. I. Delgoado, I. A. Amani and R. A. Fischer. 1994. Physiological and morphological traits associated with spring wheat yield under hot irrigated conditions. Australian Journal of Plant Physiology 21: 717 - 730.

Sharma, D.J., P. K. Yadav and R. K Sharma. 1995. Genetic variability and association for some yield components in winter spring nursery of wheat. Advances in Plant Sciences. 8 (1): 95-99.

Shpiler, L.and A. Blum. 1986. Heat tolerance for yield and its components in different wheat cultivars. Euphytica 51: 257 - 263.

Slafer, G., A. J. L. Araus and C. Royo. 2005. Physiological traits for genetic improvement of cereal yields in Mediterranean environments. Applied Biology 146 (1): 61 - 67.

Tahir, I. S. A., N. Nakata, A. M. Ali, H. M Mostafa, A . S. I.Saad, K. Takata, N. Ishikawa and O. S. Abdalla. 2006. Temperature effects on wheat grain yield and quality in hot irrigated environment. Plant Breeding 125: 323 - 330.

Tahir, I. S.A.,1999. Genetic improvement in grain yield and accompanied changes in associated traits of bread wheat cultivars in the Sudan. M. Sc. Thesis, University of Gezira, Wad Medani, Sudan.

Tamman, A. M., A. S. Ali and E. A. M. El-Sayed. 2000. Phenotypic, genotypic correlation and path coefficient analysis in some bread wheat crosses. Agricultural Science 31(3): 73 - 85.

التباين الوراثي والعلاقات المتداخلة للإنتاجية ومكوناتها في بعض السلالات المختارة من القمح

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الخلاصة

تعتبر درجة الحرارة العالية إحدى التأثيرات الرئيسية في إنتاج القمح الطري في السودان. تقييم السلالات المتباينة وراثيا في ظرف إجهاد الحرارة احد المهام الرئيسية للمربين لاستغلال هذا التباين الوراثي في تحسين الأصناف بالإضافة لأهمية تحديد صفات الانتخاب المهمة. الهدف من الدراسة تقييم 94 و174 من سلالات القمح الطري في ظرف البيئة الحارة بمزرعة بحوث الجزيرة بود مدني، السودان في موسمي 2007/2006 و2008/2007. استخدم التصميم المدمج بوجود ست شواهد في كل موسم ووزعت السلالات على 4 و12 قطاع للموسم الاول والثاني علي التوالي. اظهرت النتائج اختلافاً كبيراً في انتاجية الحبوب بين هذه السلالات اذ تراوح من 965 إلى 4019 ومن 133 الى 6258 كيلوجرام/هكتار في الموسم الاول والثاني علي التوالي. وجدت هذه الاختلافات الكبيرة في صفات الكتلة العضوية، دليل الحصاد، عدد السنابل في المتر المربع، عدد أيام الاسبال والنضج وارتفاع النبات. اظهرت الدراسة أن انتاجية الحبوب للهكتار لها ارتباطاً موجباً ومعنوياً مع الكتلة العضوية ودليل الحصاد. كما اوضح تحليل المسار أن الكتلة العضوية ودليل الحصاد هي اهم الصفات التي لها علاقة مباشرة مع الإنتاجية للهكتار.