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RESEARCH ARTICLE

Heterosis studies in durum wheat (*Triticum durum* L.)

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Abstract

The present investigation was undertaken at the Department of Genetics and Plant Breeding, Sam Higginbottom university of Agriculture, Technology and Sciences SHUATS, Allahabad during *Rabi* 2015-2016 in RBD with three replications. Mean performance for grain yield and its components depicted that F_1 (HI-8653 x AKDW-2997) was found superior. Higher phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were observed for character effective tillers per plant. A close perusal of heritability depicted that high heritability (>60%) was observed for plant height, days to maturity, effective tillers per plant, test weight, days to heading, days to 50% flowering, flag leaf length, grain yield per plant and grain filling period. The highest estimates of genetic gain were exhibited by effective tillers per plant. Estimates of heterosis (H_a) showed that the highest average heterosis for seed yield per plant was observed for F_1 (HI-8653 x AKDW-2997). The highest heterobeltiosis (H_b) value for seed yield per plant was depicted for F_1 (HI-8653 x AKDW-2997). A perusal of estimates of economic (H_c) heterosis revealed that the highest economic heterosis value for seed yield was observed for F_1 (HI-8653 x AKDW-2997). Estimate of heterosis (H_a) showed that the lowest average heterosis for days to maturity was observed for F_1 (RAJ-6560 x PDW-300). The lowest heterobeltiosis (H_b) value for days to maturity was depicted for F_1 (RAJ-6560 x PDW-300). A perusal of estimates of economic (H_c) heterosis revealed that the highest economic heterosis value for days to maturity was observed for F_1 (NIDW-295 x PDW-300). These crosses can be advanced to obtain desirable transgressive segregants in durum wheat.

Key words: Durum wheat, GCV, PCV, heritability, genetic gain, heterosis

Introduction

Wheat is the most important cereal crop for the majority of world's populations. It is the most important staple food of about two billion people (36% of the world population). Among the food crops, wheat is one of the most abundant sources of energy and protein for the world population (Salem *et al.*, 2007). Durum wheat plays an important role in Indian economy being the staple food of the population. In western countries durum wheat is mainly consumed as pasta product (Joshi and Mahal, 2006). Durum or macaroni wheat (*Triticum durum* L.) is grown on about 30 million hectares and accounts for almost 10 % of total world wheat production. It is the second most important cultivated species of the genus *Triticum* (Anonymous, 2011). Selection of potent parents represents the major step in the development of new high-yielding cultivars and the efficient identification of superior hybrid. The study of heterosis helps the breeders in eliminating less productive crosses in F_1 generation. Earlier heterosis in wheat have been reported by Borghi and Perenzin (1994), Budak and Yildrim (1996) and Saini *et. al.*, (2006). Heterosis is the most important aspect of any hybrid crop. The heterotic effect is in general more pronounced in cross-pollinated than in self-pollinated crops (Gallais, 1988).

Assessment of variability for yield and its component characters is essential before planning for an appropriate breeding strategy for genetic improvement. Genetic parameters such as genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) are useful in detecting the amount of variability present in the germplasm. Heritability coupled with high genetic advance would be more useful tool in the predicting the resultant effect in selection of the best genotypes for yield and its attributing traits. The more diverse parents with in all limits of fitness, the greater are the chances of heterotic responses in F_1 and broad spectrum of variability on segregation (Anand and Murthy, 1968). Keeping the above mentioned aspects in mind, the present investigation was carried out to obtain information on the genetic variability parameters among parental lines and to estimates magnitude of heterosis, heterobeltiosis, and economic heterosis among F_1 hybrids.

Materials and methods

Present study was carried out at the field experimentation centre of the Department of Genetics and Plant Breeding, Sam Higginbottom University of Agriculture, Technology and Sciences, located at 25.57^o N latitude, 81.51 ^{o} E longitude in the South-East part of Uttar Pradesh, India. The experimental material comprising of 31 diverse wheat genotypes plus 1 check variety.The experiments were conducted in a randomized block design (RBD) replicated three times. All agronomic practices were conducted as recommended. The data were recorded on five randomly selected plants of each genotype for all characters except for days to 50% flowering and days to maturity, where the observation were recorded on plot basis. The pre-harvest observations include Days to heading, days to 50% flowering, number of effective tillers/plant, flag leaf length (cm), flag leaf width (cm), plant height (cm), spike length (cm), awn length (cm), number of spikelet’s / spike, days to maturity, grain filling period and post-harvest observation includes, test weight (g), and grain yield/ plant (g). The data recorded were subjected to statistical analysis. Analysis of variance were calculated as suggested by Fisher (1936), coefficient of variation as suggested by Burton (1952) to calculate Genotypic Coefficient of Variation (GCV) and Phenotypic Coefficient of Variation (PCV), Heritability broad sense as suggested by Burton and Devane (1953) and Heterosis as suggested by Fonesea and Patterson (1968).

Results and discussion

The present investigation was carried out with 31 durum wheat genotypes which includes parents (9), their crosses (21) and check (1) to study the magnitude of genetic variability and estimates of heterosis, heterobeltiosis and economic heterosis for various quantitative characters. Analysis of variance revealed that the mean sum of squares due to genotypes showed significant differences for all characters studied (Table1) thus suggesting that substantial genetic variability was present in the experimental materials. Similar findings in durum wheat have also reported by Dwivedi *et. al.*, (2002).

Table1: Analysis of variance for different quantitative characters in durum wheat

Sr. No.	Characters	Mean Sum of Squares		
		Replications	**Genotypes**	**Error**
		(df = 2)	**(df = 9)**	**(df = 18)**
1	Days to heading	1.02	26.93**	0.50
2	Days to 50% flowering	0.04	37.41**	0.77
3	Number of effective tillers/plant	1.29	95.35**	0.71
4	Flag leaf length	0.72	35.51**	0.67
5	Flag leaf width	0.01	0.05*	0.01
6	Plant height	0.67	171.76**	0.66
7	Spike length	0.02	1.58	0.29
8	Awn length	0.12	1.81	0.45
9	Number of spikelet's / spike	0.26	8.32**	0.39
10	Days to maturity	0.09	170.48**	0.63
11	Grain filling period	0.08	5.66*	0.52
12	Grain yield / plant	0.07	7.66*	0.91
13	Test weight	0.26	67.97**	0.51

**and*Significant at 1% and 5% level of significance respectively

Table 2: Mean performance of durum wheat genotypes for different quantitative characters

Genotypes	DH	DF	NET	FLL	FLW	PH	SL	AL	NSS	DM	GFP	GY	TW
PDW-300	88.4	97.4	6.4	28.8	1.6	91.4	9.0	15.1	22.6	116.5	27.2	10.7	34.7
NIDW-295	87.1	92.9	7.3	21.4	1.5	82.8	7.2	15.1	20.9	114.0	28.3	9.4	32.4
AKDW-2997	85.2	91.3	6.2	30.1	1.5	96.2	7.3	14.6	19.3	115.4	31.2	9.3	26.7
RAJ-6560	83.6	88.3	7.4	24.5	1.7	76.1	6.6	15.3	19.2	112.6	29.8	11.7	27.9
RAJ1535	87.8	93.1	7.3	25.9	1.7	75.8	8.0	13.4	20.1	117.0	29.6	11.7	26.2
DBP-01-11	83.9	91.2	7.3	25.3	1.8	82.3	7.8	13.9	19.5	114.4	30.5	9.3	29.7
DBP-01-12	85.9	93.1	5.7	26.5	1.7	82.5	7.0	14.8	19.2	113.2	28.0	9.4	30.9
HI-8653	85.97	92.5	7.0	22.4	1.8	74.5	7.4	14.9	19.1	115.3	29.0	9.7	31.1
RD-1008	78.30	84.3	5.8	18.4	1.4	85.3	6.9	16.1	16.9	110.3	31.0	10.9	39.0
HD 2009 ©	82.5	88.9	5.6	24.4	1.6	93.3	6.6	15.6	17.0	119.1	30.6	14.2	39.9
Mean	84.8	91.3	6.5	24.8	1.6	84.0	7.4	14.9	19.4	114.8	29.5	10.6	31.8
C.V.	0.8	0.9	9.8	3.3	6.5	0.9	7.2	4.4	3.2	0.6	2.4	8.9	2.2
S.E.	0.4	0.5	0.4	0.4	0.1	0.4	0.3	0.3	0.3	0.4	0.4	0.5	0.4
C.D. 5%	1.2	1.5	1.4	1.4	0.1	1.3	0.9	1.1	1.0	1.3	1.2	1.6	1.2
Minimum	78.3	84.3	5.7	18.4	1.4	74.5	6.6	13.4	16.9	110.3	27.2	9.3	26.2
Maximum	88.4	97.4	7.4	30.1	1.8	96.2	9.0	16.1	22.6	119.1	31.2	14.2	39.9

Where, Days to heading (DH),Days to 50% flowering (DF), Number of effective tillers/ plant (NET)Flag leaf length (FLL) (cm), Flag leaf width (FLW) (cm),Plant height (PH) (cm), Spike length (SL) (cm) Awn length (AL) (cm), Number of spikelet's/ spike (NSS), Days to maturity (DM),Grain filling period (DFP), Grain yield/ plant (GY), Test weight (TW) (g)

Mean performance for seed yield per plant were more for genotype HD-2009 (14.28g) followed by AKDW-2997 (11.79g), RAJ1535 (11.73g), RD-1008 (10.90g) and PDW-300 (10.75g) (Table 2). This indicates that the genotypes selected were genetically variable and considerable amount of variability existed among them. Thus, indicating ample scope for selection for different quantitative characters for durum wheat improvement.

PCV was higher than GCV for all characters studied and the difference between these two was less, indicating little role of environment on the expression of these characters (Table 3). Higher PCV and GCV were observed for characters like number of effective tillers per plant followed by days to maturity, grain yield per plant, test weight and flag leaf length. These findings were in agreement with those of Dwivedi *et. al*., (2002), and Baranwal *et. al*., (2012), who have also observed that the PCV values were higher than GCV values for different quantitative characters in durum wheat.

A close perusal of heritability depicted that high heritability (>60%) was observed for days to maturity(99%), plant height (99%) followed by number of effective tillers per plant(98%), test weight (98%), days to heading (95%), days to 50% flowering, flag leaf length (94%), number of spikelet's per spike (87%), grain yield per plant (71%) and grain filling period (67%) as depicted in table 3.0. High values for heritability were also recorded by Amin *et. al.*, (1990) for 1000 grain weight.. Joshi and Mahal (2004) and Baranwal *et. al*., (2012) observed high value of heritability for grain yield and its components in durum wheat. A perusal of genetic advance for different characters as presented in table 3.0 revealed that is ranged from 0.21 (flag leaf width) to 70.97 (days to maturity). The character days to maturity (70.97) showed highest genetic advance followed by plant height (19.82), number of effective tillers per plant (14.66) and test weight (12.38).

Table 3:Estimate of genetic parameters for quantitative characters

S. No	Characters	Vg	Vp	GCV (%)	PCV (%)	h^2(bs) (%)	GA	GA as % of Mean
1.	Days to heading	8.71	9.21	3.48	3.57	95	7.57	8.92
2.	Days to 50% flowering	12.21	12.98	3.83	3.94	94	8.95	9.79
3.	Effective tillers/plant	31.55	32.25	65.80	66.53	98	14.66	71.81
4.	Flag leaf length	11.61	12.29	13.73	14.13	94	8.74	35.23
5.	Flag leaf width	0.02	0.03	6.69	9.39	51	0.21	12.60
6.	Plant height	57.03	57.69	8.98	9.03	99	19.82	23.58
7.	Spike length	0.43	0.72	8.85	11.41	60	1.35	18.13
8.	Awns length	0.46	0.90	4.52	6.36	50	1.27	8.47
9.	Spikelet's / spike	2.64	3.04	8.37	8.97	87	4.00	20.59
10.	Days to maturity	73.28	73.92	21.89	21.90	99	70.97	57.78
11.	Grain filling period	1.71	2.23	4.42	5.05	67	3.03	10.25
12.	Grain yield / plant	2.25	3.16	14.05	16.65	71	3.34	31.32
13.	Test weight	22.49	22.99	14.87	15.04	98	12.38	38.82

Vg = Genotypic variance, Vp = Phenotypic variance, GA = Genetic advance,GCV = Genotypic coefficient of variation, PCV = Phenotypic coefficient of variance,h^2 (bs) = Heritability , GA as % = Genetic advance as percent of mean

Heterosis, heterobeltiosis and economic heterosis

Estimates of heterosis (H_a) showed that the highest average heterosis for grain yield per plant varied from 20.33 (RAJ1535 x NIDW-295) to 266.67 (HI-8653 x AKDW-2997) (Table 4). Significant heterosis effect was observed in 20 hybrids, which exhibited positive desirable heterotic effect. The cross combination HI-8653 x AKDW-2997 (266.67) exhibited the highest heterosis followed by AKDW-2997 x NIDW-295(203.73), RAJ1535 x DBP-01-12 (203.08), HI-8653 x DBP-01-12 (166.57), HI-8653 x RAJ 6560 (165.93) and DBP-01-12 x

PDW-300 (151.79). Positive significant heterosis for grain yield and other attributes in durum wheat were also reported by Batool *et. al*., (2013), Shahnaz *et. al*., (2005), Prasad and Shinha (2004), and Shehzad *et. al*., (2004). The heterobeltiosis for grain yield per plant varied from 15.29 (RAJ-1535 x AKDW-2997) to 259.67 (HI8653 x AKDW-2997) (Table 4). Twenty crosses depicted significant positive heterosis. The highest significant heterosis was exhibited by the cross HI8653 x AKDW-2997 (259.67) followed by AKDW-2997 x NIDW-295 (202.73), RAJ1535 x DBP-01-12 (174.23), HI8653 x DBP-01-12 (163.51) and HI-8653 x RAJ-6560 (142.53). The above findings are in agreement with finding of Çifci (2012) and Chaudhary *et. al*., (2005) also reported high estimates of heterobeltiosis for grain yield and its component in durum wheat.

The highest economic heterosis value for grain yield per plant varied from 11.36 (RAJ-6560 x PDW-300) to 144.77 (HI8653 x AKDW-2997). Out of 21 heterotic crosses, the economic heterosis was significant and positive in 13 crosses. The cross combination HI8653 x AKDW-2997 had highest (144.77) heterosis followed by RAJ1535 x DBP-01-12 (125.15), HI-8653 x RAJ 6560 (100.26), AKDW-2997 x NIDW-295 (99.73) and HI8653 x DBP-01-12 (79.28). Significant desired economic heterosis for grain yield per plant and other contributes in durum wheat were also reported by Srivasta and Singh (2008).

Table 4:Heterosis (H_a), Heterobeltiosis (H_b) and Economic Heterosis (H_c) for grain yield

S. No	Genotypes	Grain yield/plant		
	F₁	H_a	H_b	Hc
1.	AKDW-2997xNIDW-295	203.73**	202.73**	99.25**
2.	AKDW2997xPDW-300	43.33**	33.91**	….
3.	DBP-01-11xAKDW-2997	107.03**	106.92**	35.28**
4.	DBP-01-11xNIDW-295	98.61**	97.84**	30.21**
5.	DBP-01-12xAKDW2997	96.25**	94.63**	29.37**
6.	DBP-01-12xDBP-01-11	….	….	….
7.	DBP-01-12xPDW-300	151.79**	137.07**	78.44**
8.	DBP-01-12xRAJ-6560	29.27**	16.67**	….
9.	RAJ1535xAKDW2997	78.18**	60.81**	32.78**
10.	HI-8653xAKDW2997	266.84**	259.67**	144.70**
11.	HI8653xDBP-01-12	166.57**	163.51**	79.28**
12.	HI-8653xPDW-300	53.24**	45.88**	….
13.	HI-8653xRAJ-6560	165.93**	142.53**	100.26**
14.	NIDW-295xPDW-300	91.93**	79.88**	35.39**
15.	RAJ1535xAKDW-2997	28.37**	15.29*	….
16.	RAJ1535xDBP-01-12	203.08**	174.23**	125.15**
17.	RAJ1535xNIDW-295	46.25**	31.74**	….
18.	RAJ1535xPDW-300	20.33**	15.32*	….
19.	RAJ1535xRAJ-6560	69.20**	68.72**	39.31**
20.	RAJ-6560 xNIDW-295	39.72**	25.54**	….
21.	RAJ-6560xPDW-300	41.11**	34.87**	11.36*

**and*Significant at 1% and 5% level of significance respectively

In conclusion results of the present investigation revealed that cross HI-8653 x AKDW-2997 showed highest positive significant economic heterosis for grain yield per plant (144.70%), test weight (8.69%), spike length (9.60%) and number of spikelet per spike (16.57%). Therefore the cross can be advanced to obtain desirable transgressive segregants in durum wheat. Estimates of heritability and genetic advance depicted that characters like test weight, number of grains per spikelet and number of tillers per plant can be used as selection parameters for improvement in durum wheat germplasm. Further, testing of these genotypes is required to confirm the consistency of results.

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