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Original Research Article

Heterosis for Yield and Yield Attributing Traits in Barley (*Hordeum vulgare* L.)

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A B S T R A C T

The present investigation was carried out in 21 F_1s to study heterobeltiosis and standard heterosis for nine yield attributing traits of barley crop. The F_1s were generated by crossing seven lines with three testers in Line x Tester mating design. Results indicated considerable number of significant high heterobeltiosis for most of the traits. Positive heterobeltiosis for grain yield per plant was noticed among the cross combinations *viz*., EC-667365×NDB-3, EC-667498×Azad. Only one cross combination EC-667365×NDB-3 exhibited positive standard heterosis over standard check (RD-2552) for grain yield per plant.

Introduction

Barley (*Hordeum vulgare* L.) is a cereal crop and belongs to *Poaceae* family. Barley is the fourth largest cereal crop produced around the world. It is a staple food in North Africa and parts of Asia where people consume barley in form of unleavened bread and porridges. Barley is used both as human food (bread, soups, stews, health drinks), animal feed and as source of malt for alcoholic beverages. In other uses, soft straw of barley plant is used in making livestock bedding. The versatile nature of barley makes it an important crop and thus demands increase in production of barley.

Study of heterosis in F_1s obtained from the hybridization program can be used to develop high yielding barley varieties. Heterosis refers to superiority of F_1s over their parents for different traits. The exploitation of heterosis has been extensively utilized in improving yield in crops. For a successful hybrid breeding programme, it is essential that a significant heterosis must be available in the

F_1 populations and that a method is available for commercial seed production economically.

Understanding effectiveness of heterosis in plant breeding program; a study was undertaken to estimate heterosis in barley F_1s obtained by carrying out a crossing program in 10 barley genotypes following Line x Tester mating design.

Materials and Methods

Ten barley genotypes: NDB-3, Azad, RD-2552, EC-667526, EC-667509, EC-667498, EC-667458, EC-667377, EC-667365, and EC-667454 were used as parental material in the present study.

The selected parental materials were subjected to hybridization program following Line x Tester mating design at Genetics and Plant Breeding Research farm of Narendra Deva University of Agriculture and Technology, Narendra Nagar, Kumarganj, Faizabad (U.P.) during *Rabi* 2013 and 2014. Seven lines (EC-667526, EC-667509, EC-667498, EC-667458, EC-667377, EC-667365, EC-667454) were crossed with three testers (NDB-3, Azad, RD-2552) to generate F_1 seeds of each of the 21 crosses in *Rabi* 2013. The F_1 seeds were harvested, sundried and kept in cool and dry place. In *Rabi* 2014, the 21 F_1s along with 10 parents were sown in Randomized Block Design in two replications following a spacing of 25 x 10 cm. Package of practice was followed strictly to ensure a healthy crop stand.

Data was collected on randomly selected five plants from each of the 31 lines of two replications on traits *viz.*, days to 50% ear emergence, days to 75% maturity, numbers of effective tillers per plant, number of grains per main ear, ear length, biological yield/plant, harvest index, 1000-grain weight

and yield per plant. Analysis of variance was calculated following Panse and Sukhatme (1967). Heterobeltiosis was estimated following Fonseca and Patterson (1968). The formula used to estimate heterobeltiosis and standard heterosis is given below:

$$\text{Heterobeltiosis (HB\%)} = \frac{\overline{F_1} - \overline{BP}}{\overline{BP}} \times 100$$

$$\text{Standard heterosis (SH \%)} = \frac{\overline{F_1} - \overline{SV}}{\overline{SV}} \times 100$$

$$\text{C.D.} = \text{S.E.} \times t \text{ (at error d.f.);} \quad \text{S.E.} = (2Me/r)^{1/2}$$

Where, C.D= critical difference; S.E= standard error; Me= mean sum of square of error; r=number of replications; d.f.= degree of freedom; $\overline{SV}$ = Mean value of the standard variety; $\overline{BP}$ = Mean value of the better parent.

Results and Discussion

Analysis of variance for all traits except ear length was observed to be significant in the present study (Table-1). Early maturity is desirable hence negative heterosis is required for days to 50% ear emergence and days to 75% maturity. Hybrids EC-667454×Azad and EC-667526×Azad, displayed negative heterosis over check variety and EC-667498×RD-2552, EC-667509×Azad showed negative heterobeltiosis for days to 50% ear emergence. Out of 21; three cross combinations *viz.*, EC-667526×NDB-3, EC-667377×NDB-3, EC-667377×RD-2552 found to be significant and negative for better parent and only one cross combination *viz.*, EC-667377×NDB-3, showed negative significant standard heterosis for days to 75% maturity (Table-2). Lal *et al.,* (2018) observed negative heterobeltiosis for early maturity in their work. An increase in number of productive tillers/plant can positively affect grain yield per plant hence positive heterosis is required

for this trait. However, in the present finding only four of the cross combinations showed positive significant heterobeltiosis and standard heterosis *viz.*, EC-667377 × RD-2552, EC-667377 x NDB-3, EC-667377 x Azad and EC-667498 × NDB-3. These findings are in conformity with the work of Lal *et al.,* (2018).

For ear length, none of the cross combinations showed positive standard heterosis. Three cross combinations showed positive significant heterobeltiosis *viz.*, EC-667365 × Azad, EC-667498 × RD-2552 and EC-667498 × NDB-3. For standard heterosis, no cross combination showed significant heterotic effect in desirable direction.

For number of grains per spike, positive significant heterosis is required. Out of 21 crosses, three cross combinations showed desirable positive significant heterobeltiosis *viz.*, EC-667365×RD-2552, EC-667526×RD-2552 and EC-667509×RD-2552. Similarly for standard heterosis, two cross combinations showed positive significant heterosis: EC-667526×RD-2552, and EC-667509×RD-2552. Amer *et al.,* (2012), Mahmoud (2006), Eid (2006) and Mansour (2016) observed

similar findings in their work. Significant and positive heterosis is desirable for 1000-grain weight. Cross combinations EC-667365×RD-2552 and EC-667526×NDB-3 showed positive heterobeltiosis and cross combinations EC-667509 × Azad, EC-667526 × NDB-3, and EC-667365×RD-2552 showed significant positive standard heterosis. El-Bawab (2003), Eid (2006) and Mansour (2007) have also reported heterosis in positive and negative direction for 1000-grain weight.

For biological yield per plant, significant positive heterobeltiosis were found in six crosses: EC-667377 × RD-2552, EC-667365 × RD-2552, 667526 × RD-2552, EC-667498 × RD-2552, EC-667454 × RD-2552, EC-667454 × Azad. And EC-667526 × RD-2552, EC-667458 × NDB-3, EC-667509 × RD-2552, EC-667509 × NDB-3 showed positive significant heterosis over check variety. For harvest index, none of the crosses showed significant positive heterosis over better parent. While significant positive heterosis, was recorded in only one cross EC-667526×NDB-3. Parashar *et al.,* (2019) observed similar findings for biological yield and harvest index in their work.

Table.1 Analysis of variance of 21 hybrids for yield and yield attributing traits of barley

Traits	Replications	Treatments	Error
df	1	30	30
Days to 50% flowering	5.82	14.48**	2.62
Days to maturity (75%)	1.30	15.53**	2.33
Number of productive tillers/plant	0.03	0.52**	0.12
Ear length (cm)	0.02	0.91	0.39
Grains / ear	0.15	46.44**	2.97
1000- grain weight (g)	0.001	14.50**	1.40
Biological yield / plant (g)	0.80	8.90*	3.13
Harvest-index (%)	1.25	3.83**	1.07
Grain yield / plant (g)	1.25	1.63*	0.50

Significance Levels * = <.05, ** = <.01 & **

Table.2 Heterobeltiosis (HB) and Standard heterosis (SH) for yield attributing traits in barley

S.N	Crosses	Days to 50% ear emergence		Days to 75 %maturity		Productive Tillers/ Plant		Ear Length (cm)		Grains/ Spike	
		HB	SH	HB	SH	HB	SH	HB	SH	HB	SH
1	EC-667377×RD-2552	-1.03	-1.03	-3.20*	-0.82	14.29*	14.29*	4.56	4.56	-12.32*	-10.87*
2	EC-667377×NDB-3	7.69*	1.03	-4.37*	-1.23*	24.19*	21.01*	-7.61	1.40	-7.29*	-5.77
3	EC-667377×Azad	7.14*	0.52	-1.94	3.69*	12.71*	13.45*	-10.86	-13.21	-24.96*	-23.72*
4	EC-667365×RD-2552	-2.58	-2.58	0.40	2.05	-5.88	-5.88	-5.53	3.74	16.23*	-16.23*
5	EC-667365×NDB-3	0.00	0.00	-0.40	2.87*	-4.84	-0.84	13.09	-4.56	-4.02	-5.11
6	EC-667365×Azad	0.00	0.00	-1.55	4.10*	-12.07	-14.29*	24.16**	-16.72	-14.32*	-15.98*
7	EC-667526×RD-2552	-1.03	-1.03	-2.33	3.28*	-7.56	-7.56	-0.86	-0.82	21.05*	11.86*
8	EC-667526×NDB-3	4.37*	-1.55	-5.04*	0.41	-3.23	0.84	-8.15	-0.82	-19.28*	-9.88*
9	EC-667526×Azad	2.19	-3.61*	0.00	5.74*	3.45	0.84	9.16	3.10	-18.87*	-9.43*
10	EC-667458×RD-2552	-0.52	-0.52	-0.39	5.33*	7.56	7.56	-10.51	-5.55	-3.08	-3.08
11	EC-667458×NDB-3	-0.52	-1.03	-1.55	4.10*	-14.528	-10.92	-17.89*	-9.88	-4.93	-6.01*
12	EC-667458×Azad	3.11	2.58	0.00	5.74*	-12.07	-14.29*	-2.27	3.16	-18.02*	-19.60*
13	EC-667498×RD-2552	-4.57*	-3.09	2.35	6.97*	-7.14	-7.14	16.54*	-16.54	-21.21*	-21.21*
14	EC-667498×NDB-3	-1.52	0.00	1.57	6.15*	22.58*	19.33*	14.32*	-5.96	1.48	0.33
15	EC-667498×Azad	-1.02	0.52	-0.39	5.33*	6.90	4.20	5.66	-11.62	-0.38	-2.31
16	EC-667509×RD-2552	-1.53	-0.52	-0.39	4.10*	-3.95	-3.95	-9.06	-9.06	8.54*	7.18*
17	EC-667509×NDB-3	0.00	1.03	-0.39	4.10*	-3.23	0.84	-21.30**	-13.62	-6.98*	-5.60
18	EC-667509×Azad	-3.57*	-2.58	-1.94	3.69*	5.17	2.52	11.92	-3.39	-6.79*	-5.41
19	EC-667454×RD-2552	1.55	1.55	6.15*	6.15*	10.92	10.92	-4.96	-2.63	-9.39*	-9.39*
20	EC-667454×NDB-3	7.69*	1.03	-0.40	2.87*	-4.84	-0.84	-14.86*	-6.55	-1.27	-2.39
21	EC-667454×Azad	0.00	-6.19*	0.39	6.15*	-17.80*	-18.49*	-9.30	-7.07	-6.09*	-7.91*

Significance Levels * = <.05, ** = <.01 & **

Table.3 Heterobeltiosis (HB) and Standard heterosis (SH) for yield attributing traits in barley

S. N	Crosses	Biological Yield/ Plant (g)		Grain Yield/ Plant (g)		Harvest Index (%)		1000 Grain Weight (g)	
		HB	SH	HB	SH	HB	SH	HB	SH
1	EC-667377×RD-2552	18.40*	-18.40*	-25.60*	-25.60*	-10.00*	-8.52*	-21.79*	-12.86*
2	EC-667377×NDB-3	-5.75	-13.21*	18.28*	-23.35*	-6.80*	-3.41	-16.67*	-7.14*
3	EC-667377×Azad	-12.61*	-19.53*	-18.88*	-22.64*	-12.47*	-4.29	-17.95*	-8.57*
4	EC-667365×RD-2552	20.68*	-20.68*	-18.58*	-18.58*	2.33	2.33	10.00*	10.00*
5	EC-667365×NDB-3	7.37	-5.29	9.33	0.14	1.94	5.65	1.52	-4.29
6	EC-667365×Azad	-1.01	-13.70*	-9.41	-13.61	-9.16*	-0.68	-4.29	-4.29
7	EC-667526×RD-2552	16.33*	-16.33*	-17.19*	-17.19*	-5.70	-1.60	-7.14*	-7.14*
8	EC-667526×NDB-3	-9.91	-17.54*	-7.58	-11.56	3.20	7.68*	13.64*	7.14*
9	EC-667526×Azad	-9.58	-17.24*	-18.06*	-21.59*	-11.08*	-2.77	-12.86*	-12.86*
10	EC-667458×RD-2552	-9.98	-9.98	-14.42*	-14.42*	-5.47	-5.47	-4.29	-4.29
11	EC-667458×NDB-3	12.31*	-22.26*	-14.70	-21.87*	-3.51	0.00	-3.08	-10.00*
12	EC-667458×Azad	2.11	-9.46	-6.86	-11.17	-9.11*	-0.61	-12.86*	-12.86*
13	EC-667498×RD-2552	-21.86*	-21.86*	24.64*	-24.64*	-4.53	-4.53	-9.59*	-5.71
14	EC-667498×NDB-3	-9.68	-20.34*	-15.02	22.16*	-7.71*	-4.36	-5.48	-1.43
15	EC-667498×Azad	4.44	-8.95	4.26	-0.57*	-7.13*	1.54	-12.33*	-8.57*
16	EC-667509×RD-2552	20.44*	-20.44*	-23.88*	23.88*	-5.98	-5.98	-14.33*	-4.54
17	EC-667509×NDB-3	-20.66*	-24.16*	-22.83*	-28.32*	0.41	4.06	-7.69*	2.86
18	EC-667509×Azad	-14.49*	-18.26*	-19.08*	-22.83*	-9.25*	-0.77	0.00	11.43*
19	EC-667454×RD-2552	-12.65*	-12.65*	-15.00*	-15.00*	-0.57	-0.57	-10.00*	-10.00*
20	EC-667454×NDB-3	5.33	-7.09	-5.21	-13.18	-10.71*	-7.47*	-13.04*	-14.29*
21	EC-667454×Azad	15.12*	-26.01*	-24.44*	-27.94*	-12.74*	-4.59	-11.43*	-11.43*

Significance Levels * = <.05, ** = <.01 & **

Increase in yield is the prime objective of any breeding program. The yield per plant trait showed desirable significant positive heterobeltiosis in two cross combinations *viz*., EC-667377 × NDB-3 and EC-667498 × RD-2552. While significant standard heterosis was found in cross combinations: EC-667377×NDB-3, EC-667498 × NDB-3, and EC-667509×RD-2552 (Table-3). Higher magnitude of heterotic response for seed yield in barley has been reported earlier in barley by Singh *et al.,* (2002), Rugen *et al.,* (2004), Huang *et al.,* (2007), Vishwakarma *et al.,* (2011), Saad *et al.,* (2013), Shendy (2015), Mansour (2016), and Ram and Shekhawat (2017).

In conclusion the present findings, the number of cross combinations with significant heterosis in desirable direction was few which can be attributed to parental materials used in the experiment. Nevertheless, the cross combinations which showed heterosis for yield and yield attributing traits in higher magnitude and in desirable direction can be utilized in future barley breeding program.

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