Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.6829

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **7 (1):** 183-189 (2019)

Research Article

International Journal of Pure & Applied Bioscience

Heterosis Studies in Barley (*Hordeum vulgare* L.) Under Heat Stress Environment

Naresh Parashar*, D. K. Gothwal, Guman Singh, Mukesh Bhakal, Ravi Kumar and Vaibhav Sharma

Department of Plant Breeding and Genetics, S.K.N. Agriculture University, Jobner, Jaipur- 303329

*Corresponding Author E-mail: parashar.naresh1@gmail.com

Received: 27.08.2018 | Revised: 10.09.2018 | Accepted: 16.09.2018

ABSTRACT

The present investigation was carried out to estimate relative heterosis and heterobeltiosis in barley genotypes to identify desirable cross combinations under heat stress for days to anthesis, duration from anthesis to maturity, days to maturity, plant height, number of effective tillers per plant, flag leaf area, number of grains per spike, peduncle length, spike length, 1000-grain weight, biological yield per plant, grain yield per plant and harvest index. The F_1 crosses were made in half diallel fashion using 10 genotypes. The experiment was conducted in randomized block design with three replications during rabi 2016-17. The results revealed sufficient degree of heterosis and heterobeltiosis for all the characters studied. On the basis of per se performance, heterosis and heterobeltiosis, the crosses RD-2035XRD-2052 and RD-2592XRD-2660 emerged as good cross combinations for grain yield per plant in heat stress environment. Therefore, it could be concluded that these cross combinations may be exploited in future breeding programme for the development of good heterotic gene pool of barley for improving grain yield and other contributing traits under heat stress environment.

Key words: *Barley, Heterosis, Heterobeltiosis, Heat Stress.*

INTRODUCTION

Barley (*Hordeum vulgare* L.) is an important *rabi* cereal crop grown throughout the temperate and tropical regions of the world. It is a most paramount cereal crop and considered as the first cereal domesticated for use by man as food and feed[9]. Barley assumes fourth position in total cereal production in the world after wheat, rice and maize, each of which covers nearly 30 per cent of the world's total cereal production[3].

Currently it is being realized that we have reached a yield plateau and have to a breakthrough in grain yield. A systemic and directional breeding should be launched and attempts should be made to explore the possibility of noble genes for the inheritance of desired traits for improvement of breeding population, knowledge of gene action, heritability of the characters and genetic content of the parents is needed.

Cite this article: Parashar, N., Gothwal, D.K., Singh, G., Bhakal, M., Kumar, R. and Sharma, V., Heterosis Studies in Barley (*Hordeum vulgare* L.) Under Heat Stress Environment, *Int. J. Pure App. Biosci.* **7 (1):** 183-189 (2019). doi: http://dx.doi.org/10.18782/2320-7051.6829

The breeding method in any crop depends upon its genetic architecture and the pattern of inheritance of characters. Therefore, proper understanding of the nature of inheritance of yield and its components by estimation of genetic parameters like heterosis is required to put such a breeding programme on sound footing. The study of heterosis has a direct bearing on the breeding methodology to be employed for varietal improvement and also provides genetic information about usefulness of the parents in breeding programs[13]. Heterosis study also helps the plant breeders in eliminating the less productive crosses in early generations.

Heat stress is an important abiotic stress causing substantial crop losses worldwide. Heat tolerance is a complex polygenic trait involving epistatic interactions among loci and powerful genotype × environment interactions[1].

The success of any breeding programme depends primarily upon the proper selection of parents, mating system employed and finally the breeder's keen judgment in selecting superior genotypes from more abundant and less desirable plants within the segregating populations. The study of heterosis in most of the crops including barley is an important tool in interpreting genetic parameters. The nature and magnitude of heterosis could play a vital role for plant breeders in formulating the appropriate breeding procedures. The present investigation was carried out to delineate the magnitude of heterosis and heterobeltiosis in barley and identified superior crosses that would be gainfully utilized in further barley improvement programmes.

MATERIALS AND METHODS

The experimental material for the present study comprised of ten genetically diverse barley genotypes collected from All India Coordinated Wheat and Barley Improvement Project (AICW&BIP), Rajasthan Agricultural Research Institute, Durgapura, Jaipur and their 45 F_1's. Crosses were made among the ten barley genotypes namely; RD-2552, RD-2035, RD-2052, RD-2503, RD-2794, RD-2786, RD-2592, RD-2715, RD-2508 and RD-2660 in half diallel fashion during *rabi* 2015-16 at Agronomy Farm, S.K.N. College of Agriculture, Jobner. Ten parents and their resulting 45 F_1's were grown in a randomized block design with three replications under high temperature condition during *rabi* 2016-17 at Agronomy farm, S.K.N. College of Agriculture, Jobner. Sowing was done about 20 days later than normal date of sowing which created heat stress environment at post anthesis. The parents and F_1's were grown in a plot of two rows of 2 meter length with row to row distance of 30 cm and plant to plant distance of 10 cm. Ten competitive plants in parents and F_1's were selected randomly for recording observations on thirteen characters namely, days to anthesis, duration from anthesis to maturity, days to maturity, plant height (cm), number of effective tillers per plant, flag leaf area (cm^2), number of grains per spike, peduncle length (cm), spike length (cm), 1000-grain weight (g), biological yield per plant (g), grain yield per plant (g) and harvest index.

Analysis of variance for all the characters was done as suggested by Panse and Sukhatme[8]. The heterosis (H%) and heterobeltiosis (HB%) were estimated as deviation of F_1value from the mid-parent and the better-parent values as suggested by Fonsecca and Patterson[4], respectively.

RESULTS AND DISCUSSION

The analysis of variance in heat stress environment revealed significant differences among parents for all the characters except number of effective tillers per plant, peduncle length and harvest index. The F_1's also showed significant differences for all the characters except peduncle length and harvest index. The mean squares due to parents vs F_1's were found significant for most of the traits except harvest index. The parents vs F_1's were found significant for almost all the traits, indicating the existence of heterosis.

This study may also help to identify the cross combination which are promising in conventional breeding programme. Mackey[6] described genetic principles of expression of heterosis superior to the better parent, which may result from one or two of the following situations: (i) the accumulated action of favourable dominant or semi-dominant genes dispersed amongst two parents i.e. dominance; (ii) the complementary interaction of additive dominant on recessive genes at different loci i.e. non-allelic interaction or epistasis; (iii) favourable interaction between two alleles at the same locus i.e. intra locus or inter allelic interactions referred to as over dominance. It will be possible to recover homozygous lines as good as heterotic hybrids if either or both of the first two situations are cause heterosis, although the case with which such lines can be recovered will depend on linkage relationship of the genes involved and the ability to identify the recombinants as and when they arise. This will be particularly difficult with close linkage and when heterosis is expressed by a slight improvement in each of main yield components. If the heterosis is due to inter allelic interactions of dominant types, it is not possible to fix such heterosis in homozygous condition in subsequent generations. The commercial utilization of heterosis is regarded as magnificent implementation of genetics in the plant breeding. The magnitude of heterosis in a crop relies on its exploitation, utilization and practicability of hybrid seed production. The superiority of hybrids particularly over better parent (heterobeltiosis) is more important and useful in determining the feasibility of commercial exploitation of heterosis and also indicating the parental combinations capable of producing the highest level of transgressive seggregants.

In this study, as the parents are highly adapted varieties, heterosis over mid parent and over better parent have high practical significance. Investigation on degree of heterosis is, however, important as it may be of value in deciding the directions of future breeding programme. In the present investigations both heterosis and heterobeltiosis have been worked out. Higher grain yield is desirable, which is reflected by positive heterosis. The estimates of heterosis revealed that the crosses response to heterosis was differ in character to character as well as cross to cross in heat stress environment. The range of heterosis under heat stress environment varied from -11.86%(RD-2786XRD-2508) to 10.60% (RD-2592XRD-2660) for days to anthesis; -21.39% (RD-2052XRD-2794) to 23.08% (RD-2786XRD-2508) for duration from anthesis to maturity; -7.28% (RD-2794XRD-2715) to 7.50% (RD-2794XRD-2508) for days to maturity; -17.75%(RD-2052XRD-2786) to 20.36% (RD-2035XRD-2660for plant height; -41.51%(RD-2592XRD-2660) to 35.45% (RD-2552XRD-2503) for number of effective tillers per plant; -47.71%(RD-2503XRD-2794) to 31.54% (RD-2552XRD-2715) for flag leaf area; 5.61% (RD-2794XRD-2508) to 23.42% (RD-2035XRD-2715) for peduncle length; and -40.52% (RD-2052XRD-2503) to 34.29% (RD-2552XRD-2786) for spike length; -25.79%(RD-2503XRD-2786) to 49.34% (RD-2552XRD-2786) for number of grains per spike; -25.49% (RD-2794XRD-2592) to 38.38% (RD-2786XRD-2508) for 1000-grain weight; -41.62% (RD-2794XRD-2592) to 64.53% (RD-2592XRD-2660) for biological yield per plant; -33.75% (RD-2794XRD-2592) to 60.55% (RD-2592XRD-2660) for grain yield per plant; -9.02% (RD-2503XRD-2786) to 14.33% (RD-2052XRD-2592) for harvest index.

Grain yield per plant is an important character for improvement of crop productivity. An overall study of grain yield per plant for heterosis revealed that out of 45 crosses, nineteen crosses showed positive significant heterosis and nine crosses revealed positive significant heterobeltiosis. Thus, these crosses were observed highly desirable for this trait under heat stress environment. Cross RD-2592XRD-2660 followed by RD-2035XRD-2052 and RD-2503XRD-2715 had highest positive significant value of heterosis and cross RD-2592XRD-2660 followed by RD-2035XRD-2052 and RD-2592XRD-2715 had highest positive significant value of heterobeltiosis, thus these crosses were observed most desirable cross combinations under heat stress environment (Table 1). Maximum heterosis for grain yield per plant over mid-parent was observed as 60.55%

under heat stress environment. Similarly, maximum heterosis over better parent for grain yield per plant was observed as 51.64% in heat stress condition (Table 1). Three best heterotic and heterobeltiotic crosses for different yield attributing traits has been presented in Table 2. An interesting relation between heterosis and heterobeltiosis for grain yield per plant and other yield attributing traits revealed that the crosses RD-2592XRD-2660 and RD-2035XRD-2052 in heat stress environment, exhibited most desirable heterosis and heterobeltiosis for four or more than four yield attributing traits.

In present experiment, heterosis over mid parent was observed maximum for biological yield per plant followed by grain yield per plant, number of grains per spike and number of effective tillers per plant under heat stress condition.

Table 1: Estimates of heterosis and heterobeltiosis for grain yield per plant in heat stress environment

Character	Grain yield per plant (g)	
Crosses	**H**	**HB**
RD-2552xRD-2035	-9.22	-17.56
RD-2552xRD-2052	32.43**	29.16**
RD-2552xRD-2503	14.60*	3.51
RD-2552xRD-2794	4.32	3.38
RD-2552xRD-2786	30.14**	13.92
RD-2552xRD-2592	15.56	12.69
RD-2552xRD-2715	5.99	-5.45
RD-2552xRD-2508	18.77*	1.17
RD-2552xRD-2660	-2.04	-9.64
RD-2035xRD-2052	54.76**	37.43**
RD-2035xRD-2503	13.16	-6.18
RD-2035xRD-2794	-6.21	-14.12
RD-2035xRD-2786	-6.42	-10.18
RD-2035xRD-2592	-6.49	-13.08
RD-2035xRD-2715	11.21	9.03
RD-2035xRD-2508	11.64	3.94
RD-2035xRD-2660	23.37*	21.28*
RD-2052xRD-2503	4.81	-3.14
RD-2052xRD-2794	26.33**	22.12**
RD-2052xRD-2786	30.64**	11.94
RD-2052xRD-2592	-15.51*	-19.59*
RD-2052xRD-2715	30.63**	14.01
RD-2052xRD-2508	9.71	-8.45
RD-2052xRD-2660	26.18**	13.76
RD-2503xRD-2794	2.37	-8.30
RD-2503xRD-2786	-8.77	-26.77**
RD-2503xRD-2592	4.31	-7.88
RD-2503xRD-2715	49.46**	21.98**
RD-2503xRD-2508	16.18*	-8.95
RD-2503xRD-2660	34.09**	12.72
RD-2794xRD-2786	-20.49*	-29.85**
RD-2794xRD-2592	-33.75**	-34.81**
RD-2794xRD-2715	-7.99	-17.26
RD-2794xRD-2508	2.83	-11.74
RD-2794xRD-2660	34.97**	25.55**
RD-2786xRD-2592	32.26**	18.37
RD-2786xRD-2715	-3.02	-5.09
RD-2786xRD-2508	4.44	1.17
RD-2786xRD-2660	3.13	-2.61
RD-2592xRD-2715	48.58**	35.59**
RD-2592xRD-2508	31.40**	14.34
RD-2592xRD-2660	60.55**	51.64**
RD-2715xRD-2508	20.33	14.16
RD-2715xRD-2660	-13.89	-1698
RD-2508xRD-2660	35.19**	23.90*
SE	0.78	0.90

Table 2: Top three crosses for their heterosis and heterobeltiosis estimates in heat stress environment for different characters

Characters	Heterosis	Heterobeltiosis
Days to anthesis	RD-2786XRD-2508	RD-2786XRD-2660
	RD-2786XRD-2660	RD-2786XRD-2508
	RD-2715XRD-2660	RD-2715XRD-2660
Duration from anthesis to maturity	RD-2052XRD-2794	RD-2592XRD-2660
	RD-2592XRD-2660	RD-2052XRD-2794
	RD-2052XRD-2503	RD-2052XRD-2503
Days to maturity	RD-2794XRD-2715	RD-2794XRD-2715
	RD-2508XRD-2660	RD-2508XRD-2660
	RD-2592XRD-2715	RD-2052XRD-2786
Plant height	RD-2052XRD-2786	RD-2035XRD-2660
	RD-2052XRD-2794	RD-2052XRD-2786
	RD-2035XRD-2508	RD-2035XRD-2508
1000-grain weight	RD-2786XRD-2508	RD-2786XRD-2508
	RD-2715XRD-2508	RD-2715XRD-2508
	RD-2592XRD-2715	RD-2552XRD-2592
Biological yield per plant	RD-2592XRD-2660	RD-2592XRD-2660
	RD-2035XRD-2052	RD-2035XRD-2052
	RD-2503XRD-2715	RD-2552XRD-2052
Grain yield per plant	RD-2592XRD-2660	RD-2592XRD-2660
	RD-2035XRD-2052	RD-2035XRD-2052
	RD-2503XRD-2715	RD-2592XRD-2715
Harvest index	RD-2052XRD-2592	RD-2052XRD-2592
	RD-2035XRD-2715	RD-2035XRD-2715
	RD-2052XRD-2715	RD-2052XRD-2715
No. of effective tillers per plant	RD-2552XRD-2503	RD-2552XRD-2503
	RD-2503XRD-2715	RD-2794XRD-2508
	RD-2794XRD-2508	RD-2552XRD-2508
Flag leaf area	RD-2552XRD-2715	RD-2552XRD-2715
	RD-2592XRD-2660	RD-2503XRD-2786
	RD-2503XRD-2786	RD-2035XRD-2503
Peduncle length	RD-2035XRD-2715	RD-2786XRD-2592
	RD-2786XRD-2592	RD-2035XRD-2715
	RD-2052XRD-2715	RD-2052XRD-2715
Spike length	RD-2552XRD-2786	RD-2552XRD-2786
	RD-2508XRD-2660	RD-2552XRD-2503
	RD-2552XRD-2503	RD-2552XRD-2592
No. of grains per spike	RD-2552XRD-2786	RD-2508XRD-2660
	RD-2786XRD-2715	RD-2035XRD-2660
	RD-2508XRD-2660	RD-2794XRD-2592

Table 3: Crosses possessing with high heterosis (H) and heterobeltiosis (HB) for grain yield per plant (g) along with desirable (+) heterotic expression for other characters under heat stress environment

Particulars	Crosses possessing high heterosis and heterobeltiosis for grain yield per plant	Days to anthesis	Duration from anthesis to maturity	Days to maturity	Plant height	No. of effective tillers per plant	Flag leaf area	Peduncle length	Spike length	Number of grains per spike	1000-grain weight	Biological yield per plant	Harvest index
Heterosis	RD-2592XRD-2660	-	-	-	-	+	+	+	-	+	-	+	-
	RD-2035XRD-2052	-	-	-	+	-	-	+	-	-	-	+	-
	RD-2503XRD-2715	-	-	-	+	+	-	+	-	+	-	+	-
Heterobeltiosis	RD-2592XRD-2660	-	-	+	-	+	-	+	-	-	-	+	-
	RD-2035XRD-2052	-	-	+	+	-	-	+	-	-	-	+	-
	RD-2592XRD-2715	+	-	+	+	-	-	+	-	+	+	+	-

Heterosis and heterobeltiosis for grain yield per plant was mainly contributed by days to maturity, plant height, peduncle length, number of effective tillers per plant, number of grains per spike and biological yield per plant in heat stress environment (Table 3). Findings of this investigation supported the contentions of Grafius[5], who suggested that there could be no separate gene system for yield *per se* as yield is an end product of the multiplicative interactions among its various attributes. Thus, heterobeltiosis for various yield contributing characters might be the result in the expression of heterobeltiosis for grain yield. However,the crosses showing heterotic expression for grain yield per plant were not heterotic for all the characters. It was also noted that the expression of heterosis and heterobeltiosis was influenced by the environments for almost all the characters. This was because of significant G x E interaction.The results in stress environment for different characters are in harmony with the findings of Mansour[7], Ram and Shekhawat[10], Amer *et al.*[2], Potla *et al*.[9], Sharma[11], Yilmaz and Konak[14], and Singh *et al.*[12], who also reported maximum heterosis for grain yield per plant.

CONCLUSION

1. Sufficient degree of heterosis and heterobeltiosis were observed for all the characters studied. The crosses RD-2592XRD-2660 and RD-2035XRD-2052 exhibited desirable heterosis and heterobeltiosis for most of the characters. Therefore, above crosses may be observed as promising types for tangible advancement in yield potential in barley under heat stress condition.
2. An overall evaluation of Heterosis for grain yield per plant revealed that the maximum value of relative heterosis was observed as 60.55% (RD-2592XRD-2660). Similarly, maximum value of heterobeltiosis was observed as 51.64% (RD-2592XRD-2660). Therefore, these crosses were observed more heterotic for grain yield per plant under heat stress environment.
3. The magnitude of Heterosis was observed maximum for biological yield per plant followed by grain yield per plant, number of grains per spike and number of effective tillers per plant under heat stress condition.
4. On the basis of *per se* performance, heterosis and heterobeltiosis, the crosses

RD-2035XRD-2052 and RD-2592XRD-2660 observed as good crosses for grain yield per plant in heat stress environment.

5. The present investigation reveals an ample scope for exploitation of hybrid vigour for commercial production as well as isolation of pure lines among the progenies of heterotic F_1 for tangible advancement of grain yield in barley under heat stress environment.

Acknowledgement

The author is extremely acknowledged to the Department of Plant Breeding and Genetics, S.K.N. College of Agriculture Jobner and RARI, Durgapura, Jaipur for the material and other supports. They also acknowledge the unfailing cooperation and assistance of Agronomy Farm, S.K.N. College of Agricuture, Jobner for providing the necessary facilities and field assistance for conducting experiment.

REFERENCES

1. Abou-Elwafa, S.F. and Amein, K.A., Genetic diversity and potential high temperature tolerance in barley (*Hordeum vulgare*). *World J. Agric. Res.* **4(1):** 1-8 (2016).
2. Amer, K.A., Eid, A.A. and El-Sayed, M.M.A., Genetic analysis of yield and its components under normal and drought conditions in some barley crosses. *Egypt. J. Plant Breed.* **15(2):** 65-79 (2011).
3. F.A.O.S.T.A.T., http:/apps.fao.org/faostat/default.jsp, accessed Feb. (2004).
4. Fonseca, S. and Patterson, F.L., Hybrid vigour in a seven parental diallel cross in common winter wheat (*Triticum aestivum* L.). *Crop Sci.* **51(9):** 623-626 (1968).
5. Grafius, J.E., Heterosis in barley. *Agron. J.*, **51(9):** 551-554 (1959).
6. Mackey, I., Genetic and Evolutionary Principles of Heterosis. *In:* Janossy, A. and Lupton, F.G.H. (Eds), Heterosis in Plant Breeding. Proc.VIII Congr. EUCARPIA Elsevier Scientific Pub. Co., Amsterdam. pp.17-33 (1976).
7. Mansour, M., Genetical analysis of some quantitative traits in barley under saline soil conditions.Proceedings, The sixth field crops conference, FCRI, ARC, Giza, Egypt, 22-23 Nov. 2016. pp 99-107 (2016).
8. Panse, V.C. and Sukhatme, P.V., Statistical methods for agricultural workers Published by ICAR, New Delhi (1985).
9. Potla, K.R., Bornare, S.S., Prasad, I.C., Prasad, R. and Madakemohekar, A.H., Study of heterosis and combining ability for yield and yield contributing traits in barley (*Hordeum vulgare* L.). *The Bioscan*. **8(4):** 1231-1235 (2013).
10. Ram, M. and Shekhawat, A.S., Heterosis, inbreeding depression and combining ability analysis for yield and its component traits in barley (*Hordeum vulgare* L.). *Plant Archives.* **17(2):** 851-860 (2017).
11. Sharma, Y., Genetic architecture of grain yield and its associated traits in six-rowed barley (*Hordeum vulgare* L.). Ph.D. Thesis submitted to RAU, Bikaner (2002).
12. Singh, I., Dashora, S.L., Sharma, S.N., Sastry, E.V.D., Inheritance of some quantitative characters in six-rowed barley. *Indian J. Genet.* **59(1):** 99-101 (1999).
13. Singh, K., Sharma, S.N., Sharma, Y. and Tyagi, B.S., Combining ability for high temperature tolerance and yield contributing traits in bread wheat.*J. Wheat Res.* **4(1):** 29-37 (2012).
14. Yilmaz, R. and Konak, C., Heterotic effects regarding salt tolerance in some characters of barley (*Hordeum vulgare* L.). *Turkish Journal of Agriculture and Forestry*. **24(6):** 643-648 (2000).