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EXPOSURE OF THE HETEROSIS IN BARLEY THROUGH LINE × TESTER METHOD

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ABSTRACT

Barley is important cereal crop, which is considered to be the first cereal that domesticated by man. It is been grown in India since the ancient time. But due to the green revolution and emphasis on wheat it is mostly under-utilized crop. There is little or negligible work is done in barley to exploit its full potential in term of heterosis. Many workers have tried to exploit heterosis in barley so it can serve as alternative to other crop in problematic soil and condition. More and more work is needed to be done, some worker contribution in terms of the exposing barley heterosis is listed here.

Introduction

Barley (*Hordeum vulgare* L.) is rabi cereal crop grown in various parts of the world and as it is a temperate region crop. It is considered to be the most paramount cereal crop because of it use in various purpose and it is also considered as the first cereal that domesticated by man for it use. (Potla *et al*., 2013). As barley is grown widely in the world it is assumed that barley comes in fourth position in terms of production in the world which comes after the major cereal like wheat, rice and maize. (FAOSTAT, 2004). Barley belongs to the family *Poaceae* (formerly called *Gramineae* or grass family). It is self-pollinated crop having chromosome number 14 (2n=2x=14). Barley has been cultivated since the Stone Age, making it one of the oldest domesticated plants in history (Salamini *et al*., 2002).

As it is widely grown and first domesticated extensive research work has been carried out on barley to study the various aspects of the genetics and breeding. Extensive and detail study on barley based on various science led barley to the model crop in terms of the, genetics, cytogenetics, pathology, virology and biotechnology studies (Hockett and Nilan 1985; Hagberg, 1987).

Selection of suitable parents is always been the primary objective in breeding methodology due to that only good cultivar can be raised through various breeding methodology. To make cross through efficient breeding schemes is also essential for plant breeder to develop highly useful hybrids. Efficient selection is necessary or it can be regarded as the first step to the development. To decide that through which method of mating to make cross is crucial, which is found to be depended upon many factors like stage of breeding programme, presence of variance, availability of resources, generation to be evaluated and others. Through crossing we could achieve heterosis. There is mainly two mating design used in crops like barley, which consist of diallel mating design and line × tester mating design. Among the two; line × design is discussed here with.

Heterosis is firstly defined by Shull as the positive or negative value of the F_1 cross over the parent, heterosis value for the different character are seen in cross but most generally high heterosis values for the character grain yield are considered as desirable. Breeding programmes are generally taken with final goal of the improvement of the crop genetic architecture through crossing that ultimately helps to increase in the yield. Breeding programme also take consideration in the improvement in the quantitatively inherited trait because grain yield is dependent character, which in say depend upon various quantitative character. It is necessary to frame a genetic model in relation to the experimental material. In line × tester design of mating when cross was made, which will help in the evaluation of the general combing ability of the parents and specific combing ability of the cross. That will help in the selection of those lines or cross in the future for carry out further breeding. GCA (general combining ability) is basically the average performance of a line or parents, and represents additive gene action (fixable genes). The cross may, however, deviate from this expected value to a greater or lesser extent. This deviation is called the specific combining ability (SCA) of the two lines in combination. SCA represents epistatic (non additive) gene action which are not fixable. The general combining ability effects of the parents helps in selection of superior parents from the population taken in consideration and specific combining ability effects helps in selection of superior hybrids from the total cross (Patial M. *et al.,* 2018)

Since *per se* performance of parents may not reveal their combining ability, so the information on nature of gene actions and their expression in terms of combining ability is necessary. The nature of gene action such as additive or non-additive would help in predicting the efficiency of selection in pertaining population. A distinct type of gene action, weather additive or non-additive, its magnitude and constitution of genetic architecture of crop are of fundamental importance to plant breeder for improvement of the cultivar. (Deepak P. *et al.,* 2019)

Line x tester design

Line x tester is basically an extension of top cross design in the sense that instead of one tester as used in topcross, more than one's testers are used under L × T mating design. Line × tester mating design was first proposed by Kempthorne in 1957. This design involves hybridization between lines (f) and wide based testers in one – to - one fashion generating f x m = fm hybrids. It is the simplest mating design that provides both full-sibs and half-sibs simultaneously as opposed to topcross which provides only half-sibs. It provides SCA of each cross, and it is not providing GCA of lines only but of the testers also, as liner and tester both are different sets of genotypes. Nduwumuremyi, A. (2013)

In a self-pollinated crop, the utilization of heterosis depends mainly upon the direction and magnitude of heterosis. The study of heterosis helps the plant breeder in selection of the superior cross as well as in eliminating the less productive crosses in early generations.

Knowledge of the tester and lines that were to be used in the breeding programme is must and regarded as to be the very important (in open pollinated species but also self-pollinated crops). As generally the tester are taken as poor as compare to the lines in line

× tester mating design. The line × testers analysis method gives idea about superior parents and crosses and their GCA and SCA.

Efficient breeding programme is when the cross or hybrids gain its commercial exploration and their significant level of economic heterosis. Suneson (1940) try out the possibility of commercial exploitation of the barley through use of the genetic male sterile line.

In Arizona of the U.S. the first commercial hybrid barley was grown. It was a spring type, named Hembar, that was produced by crossing a genetic recessive male sterile diploid with the commercial inbred cultivar Arivat. (Ramage 1983). Two major problems limited the commercial production of the first hybrids, lodging and ergot *(Clavicepts prupurea).*

Performance of Hybrid Barley

A number of publications have reported grain yields from hybrid barleys. Much of this data was generated from hand-crossed seed sown in space-planted plots at very low seeding rates.

Data obtained from wide spacings may not be applicable to commercial seeding rates (Severson and Rasmusson 1968; Matchett and Cantu 1977). However, data from small plots seeded at spacing comparable to commercial seeding rates indicates that hybrid performance in small plots is equivalent to performance in conventional drilled trials (Foster and Fothergill 1982).

The first assessment of yield heterosis in barley was by Immer (1941) who reported a 27% yield increase. Hagberg (1953) worked with 17 barley hybrids and observed no heterosis for grain yield. He did report evidence of heterosis for total plant weight.

Amer *et al.* (2012) in his experiment with four lines and three testers reported, heterosis over better parent were studied for plant height, spike length, no. of spikes per plant, no. of grains per spike, 100-grain weight and grain yield per plant. Study data revealed that most of the variance that presence which is due to the lines, testers and line × testers were highly significant for most studied traits. There has been seen of the positive and negative heterosis over better parent and mid-parent which were detected for most traits indicating that parental genotypes were genetically diverse. Positive significant or highly significant heterosis over better parent values were obtained for; plant height, spike length and number of grains per spikes, number of spikes per plants, 100-grain weight and for grain yield per plant in all crosses.

Abaas *et al.* (2016) carried out experiment with ten lines and three testers, which were used to improve barley productivity under normal conditions. Through this study, heterosis over better parent were estimated for days to heading, days to maturity, grain filling period, grain filling rate, plant height, spike length, no. of spikes per plant, no. of grains per spike, 100-grain weight and grain yield per plant. Data revealed that the variance due to the lines, testers and line x testers were highly significant for most studied traits.

Bornare *et al.* (2014) in their experiment used four females (Testers 6 rowed), six males (lines 2 rowed) and their resultant F_1's with standard check k-603. Twenty-two crosses, excluding BCU-4925 x K-603 and BCU-4922 x Karan-16, showed significant positive economic heterosis for grain yield per plant. All the 24 crosses showed significant and positive economic heterosis for thousand seed weight whereas, negative heterosis for number of grains per spike. The number of grains per spike showed negative heterosis.

Elakhdar *et al.* (2017) studied six-generations (P_1, P_2, F_1, F_2, BC_1, and BC_2). Positive heterosis over the mid- and better-parent was quite similar for the most traits, except for heading and maturity dates, that showed negative heterotic effects.

Potla K R *et al.* (2013) thirteen diverse barley genotypes were selected and crossed in a line × tester fashion to evaluate heterosis to identify promising hybrids for ten quantitative traits including yield and its components, where using tester as female and lines as male parents of barley. Cross IBNON-65 × RD-2508 was recorded highest magnitude of economic heterosis over the best standard check viz., K- 603 for grain yield per plant in barley.

Xinzhong Zhang *et al.* (2015) used eight CMS line (A) and nine restorer line (R) crossed to make 72 hybrids of barley. Five crosses, Hu1154 A×8032 R, Humai10 A×8040 R, Mian684 A×8037 R, Mian684 A×8041 R and 86F098 A×8037 R, showed superior heterosis for most characters. The mid-parent heterosis of barley grain yield ranged from 0.7 to 19.9% among different hybrids with an average value of 11.3%, while better-parent heterosis ranged from -1.7 to 18.3% with a slightly lower value of 9.2%.

Pesaraklu *et al.* (2016) reported that three crosses 216.352×283.352, 104.110×216.352 and Sahra×216.352 showed the highest values of heterosis for grain number per spike (4.95), grain weight per spike (44.13) and 1000-grain weight (31.6), respectively.

Madhukar *et al.* (2018) studied heterosis of barley with line into tester method. For grain yield, the maximum per cent heterosis over standard check was observed in Lakhan × K-551, Lakhan × Geetanjali and Lakhan × Harmal while the crosses RD-2552 × K-551 followed by Lakhan × K-551 and Lakhan × Geetanjali showed significant heterosis over better parent.

Naresh P *et al.* (2019) evaluated that crosses response to heterosis was differ in character to character. range of heterosis under heat stress environment varied from -11.86% to 10.60% for days to anthesis, 17.75 to 20.36% for plant height, 25.79% to 49.34% for number of grains per spike; -25.49% to 38.38% for 1000 grain weight; -41.62% to 64.53% for biological yield per plant.

Zerihun Jalata *et al.* (2019) experimented on 28 barley genotypes. Large range of heterosis values (-23.8 to 86 and -40.6 to 43.2 %) for grain yield per plant over mid parent and better parent, respectively. For thousand kernel weight, all F_1 hybrids gave greater than the parental mean (41.8 g) for spike length, 18 hybrids had better than the parental mean. However, few genotypes gave lower mean performance for days to heading and days to maturity than parental means.

Ashutosh kumar singh *et al.* (2020) studied thirteen diverse Indian genotypes, The 13 parents were involved in a crossing programme to develop a line × tester set (10 lines + 3 testers) which were crossed to obtain a series of crosses to estimate the level of heterosis and heterobeltiosis among F_1 hybrids along with their parents. The presence of significant heterosis for grain yield was also accompanied by heterosis for yield components, such as days to 50% flowering, plant height, number of effective tillers per plant, number of spikelets per spike, number of grains per spike, days to maturity,1000- grain weight, biological yield per plant, grain yield per plant and harvest index.

The use of F_1 hybrids will probably be restricted to high-yield areas because of the cost of producing hybrid seed. If F_2 populations could be developed that outyielded commercial inbred cultivars, barley producers could recover some of the initial cost of hybrid seed. The cost of F_2 seed should be less than that of F_1 seed, so areas of production might theoretically be extended into more marginal areas.

Conclusion

Work designed to result in commercial production of hybrid barley has stimulated much thinking and experimentation in other areas such as genetics, cytogenetics, plant breeding and agronomy. The existence of adequate levels of heterosis for commercial exploitation have been demonstrated. Heterosis in barley is still under the exploration. As area under the barley crop in India is decreased due to more preference to the wheat, now a days barley gaining importance due to health benefit this will also increase in exploration of heterosis and making of new best of cultivar of barley in prosperity of the farmer. Line × tester design has some advantage over the diallel mating design and *vice a versa,* there is need of the identifying best lines and their combination that can be used in future for further improvement of the barley as whole.

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