International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(3): 3078-3081

Received: 01-03-2019
Accepted: 03-04-2019

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Heritability and genetic advance for yield and its contributing traits in bread wheat (*Triticum aestivum* L.)

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Abstract
The present investigation entitled "Study of combining ability and heterosis in F_1 generation of bread wheat (*Triticum aestivum* L.)" was conducted at Crop Research Farm, Nawabganj, C. S. Azad University of Agriculture and Technology, Kanpur- 208 002. (U.P.) during *rabi* season, 2017-18. The experimental material comprised of parents and 28 F_1s developed by crossing of 8 genotype *viz*., HD 3171,WH 147,K-906,K 307, K 1006,K 7903, DBW 14 and PBW 502 in half diallel design to study the twelve quantitative character *viz*., day to heading (75%), plant height(cm), days to maturity, number of tillers per plant, spike length(cm), number of spikelets per spike, number of gains per spike, weight of grain per spike(g), 1000 gains weight (g), biological yield per plant(g), gain yield per plant (g) and harvest index in bread wheat. The analysis of variance revealed highly significant differences among the genotypes for all the 12 characters. In this study the high heritability (narrow sense) were recorded for plant height, days to maturity, number of spikelets per spike, spike length, biological yield and grain yield per plant while moderate heritability were found for days to heading, tillers per plant, 1000 grain weight, grains weight per spike and harvest index whereas grains per spike showed low heritability.

Keywords: Genotype, combining ability, heritability (narrow sense) and heterosis

Introduction

Wheat is one of the most important cereal crop both in regard to its antiquity and its use as a source of human food. It is a major staple food crop of the world after rice. In pre-historic times it was grown in the ancient Persia, Egypt, Greece and Europe as early as 10,000 to 15,000 B.C. Wheat for the first time reached North America with Spanish missions in the 16th century, but North America role as a major exporter of grain dates from the colonization of the prairies in the 1870s. The center of origin of wheat is Asia Minor. Wheat (*Triticum aestivum* L.) is belonging to poaceae family presently. Bread wheat is an allohexaploid (AABBDD). It has fascinating origin and provides a unique example of how closely related may be combined into polyploidy in nature. The evolution of bread wheat occurred by combining the tetraploid species *T. turgidum var. dicoccoides* (AABB) and diploid species *Aegilops squarosa* (DD) followed by doubling the chromosome number. The major wheat growing countries in the world are China, India, U.S.A., Russia, France, Canada, Germany, Turkey, Australia and Ukraine. Nearly 55 per cent of the world population depends on wheat for intake of about 20 per cent of food calories. Globally, wheat is being grown in 122 countries and occupies an area of 224.27million hectares producing nearly 732.31million tons and yield per hectare 3.27 metric tons (USDA 2017). At national level area under wheat is 30.78 million ha with the production of 98.51million tons with a productivity of 3.2 metric tons per hectare (DACFW 2017). Wheat contributed about 34% of total food grain production of country. It exceeds in acreage and production than other grain crop (including rice and maize, etc.).India stands second rank both in area and production next to China in the world. The India's share in world wheat area and production is about 13%. Wheat is only crop where in production increased more than six fold during last fifty two years (12.2 million tons in 1964-65 to 98.51 million tons in 2016-2017). During the same year, area under wheat has increased almost double 30.78 million hectare. While productivity has reached nearly three times from 0.91 to 3.2 metric tons per ha. Thus, India has enabled not only to be self-sufficient in wheat food grains but also to export on limited scale to needy and friendly countries. The consumption of wheat in the form of flour, bread, chapatti, porridge and suji etc. Nutritional value per 100 g of wheat (germ crude) provides (energy 360Kcal, Protein 23.15g, Thiamine 1.88mg, Niacin 6.81mg, Calcium 39mg, Iron 6.26mg, Magnesium 239mg). Proteins are principally concerned in providing the 'Gluten'. Wheat proteins are of special significance because Gluten provides the frame work of spongy cellular texture of bread and baked products and also very versatile in the culinary art, and is a primary protein source for much of the world's population. India has become self-sufficient in meeting wheat grain consumption of its population at present but substantial increase in wheat production will be required to provide food security to the ever increasing population of our country. The population of India is likely to reach around 1.3 billion by the year 2020. Thus, the huge target of increasing wheat production by about 35 million tons within two decades is a big challenge that can be met only by increasing the area under production and improving the production technology until and unless the genetic potential of newly developed wheat varieties for different areas and environments is enhanced considerably. Attaining higher yield level, the breeder is required to deal the complex situation through rational approaches of breeding for high grain yield in wheat. The use of component approach is very fruitful for a successful breeding programme. Diallel mating system studied the parental material by all means particularly in terms of genetic component of variance for different characters, general and specific combining ability, gene effects, heterosis, heritability, genetic advance and other useful genetic parameters.

Materials and methods

The experimental material for present investigation comprised of 28 F'_1s developed by crossing 8 lines *viz*., HD3171, WH147, K906, K307, K1006, K7903, DBW14, and PBW502 following half diallel mating design. A total of 36 treatments (28 F_1's and 8 parents) were used for the study of combining ability and heterosis in F_1 generation for twelve characters in bread wheat. The genotypes under study were planted in a randomized complete block design (RCBD) with three replications per entry and one row (3m) per replication. The entries were sown in a single row plot of 3 m length with inter and intra-row spacing of 25cm and 10cm, respectively. Recommended agronomic practices were adopted to raise a good crop. The observations were recorded from the five randomly selected plants in parents and their F1s for all the following traits *viz.* days to 75% heading, number of tillers/plant, plant height (cm), days to maturity, length of spike (cm), number of spikelet/spike, number of grain/spike, grain yield/ plant (g), weight of grain per spike (g), 1000 seed weight(g), biological yield/plant(g) and harvest index%.

Estimation of selection parameters

Heritability

Heritability in narrow sense (h^2ns) and broad sense (BS) was calculated as suggested by Crum packer and Allard, (1962).

$$\text{Heritability } (\hat{h}^2) = \frac{\frac{1}{4}\hat{D}}{\frac{1}{4}\hat{D} + \frac{1}{4}\hat{H}_1 + E_1 - \frac{1}{4}F}$$

$$H(bs) = \frac{\frac{1}{4}\hat{D} + \frac{1}{4}\hat{H}_1 - \frac{1}{4}F}{\frac{1}{4}\hat{D} + \frac{1}{4}\hat{H}_1 + E_1 - \frac{1}{4}F}$$

$$E_1 = \left(\frac{E_{parent}}{n}\right) + (n-1)\frac{E_{F1}}{n}$$

Where,

$\hat{D}$ = Component of variation due to additive effects of genes

$\hat{H}_1$ = Component of variation due to dominance effects of gene

$\hat{F}$ = The mean of F_r over arrays, where F_r is the covariance of additive and dominance effects in a single array.

$\hat{E}_1$= The expected environmental component of variation

(b) Genetic advance:

The genetic advance was calculated as per formula given by Robinson *et al.* (1949).

Genetic Advance = (σ_{PH}) × (K) × (h^2 BS)

Genetic advance in per cent of mean of the character

$$\text{G.A. } (\%) = \frac{\sigma_{ph}\, x K x h^2}{\bar{X}} x100$$

Where,

G.A. = Estimate of genetic advance

K = Selection differential at 5% selection intensity (K = 2.06)

h^2 = Heritability coefficient in broad sense.

σ_{PH} = Phenotypic standard deviation.

X = Mean value of the character concerned

Result

Selection parameters

Direct selection parameters

Among the selection parameters the heritability and genetic advance are the most important direct selection parameters. Amount of total variability exists which has been transmitted from the parent to the progenies. In view of this, the heritability (in narrow sense) and genetic advance in % for the twenty eight crosses have been furnished in Table-2 generally the estimates of heritability and genetic advance were arbitrarily categorized in three by Robinson (1966) as under.

1) High (above 30%),
2) Moderate (above 10% & below 30%)
3) Low (below 10%)

Table 1: Analysis of variance of parents and F_1s for twelve traits in diallel cross of Bread Wheat

Source of variance	DF	Days to Heading	Days to maturity	No. of tiller/ plant	Plant height (cm)	Spike length (cm)	No. of spikelets /spike	No. of grains /spike	Grain weight /spike (g)	1000 grain weight (g)	Grain yield/ plant (g)	Biological yield /plant(g)	Harvest index %
Replications	2	0.67	0.39	1.34	7.52	0.06	0.78	1.00	0.02	0.73	5.88	5.71	2.15
Treatments	35	44.60**	33.72**	6.34**	89.06**	3.05**	5.01**	26.73**	0.16**	17.61**	32.76**	216.70**	32.64**
Parents	7	73.08**	63.97**	3.90**	52.72**	3.28**	12.27**	17.88**	0.20**	16.16*	42.98**	344.85**	2.21
F_1s	27	26.97**	26.69**	6.95**	100.42**	3.10**	3.02**	28.63**	0.16**	18.40**	30.65**	181.84**	41.70**
P vs F_1s	1	321.30**	11.87**	6.80**	36.72*	0.01	8.06**	37.40**	0.00	6.36	17.92**	260.83**	1.23
Error	70	2.76	0.69	0.93	5.90	0.06	0.41	1.54	0.03	6.05	2.14	3.79	1.37

*Significant at 5% level; **Significant at 1% level

Table 2: Grand mean, heritability (narrow scene), genetic advance & genetic advance % over mean in twelve traits of bread wheat

Characters	Grand mean	Narrow scene heritability [(h^2) %]	Genetic advance	Genetic advance over % mean
Days to heading	78.60	29.0	9.00	11.46
Plant height (cm)	89.18	54.6	12.62	14.15
Days to maturity	123.03	43.1	8.49	6.90
No. of tillers/plant	14.41	27.0	2.87	19.97
No. of spikelets /spike	18.73	36.7	2.89	15.45
Spike length(cm)	9.39	72.7	2.55	27.23
No. of grains / spike	50.26	8.8	7.02	13.98
1000 grain weight(g)	50.55	27.7	3.22	6.38
Grain weight/spike (g)	2.05	26.3	0.42	20.51
Biological yield/plant(g)	59.68	59.1	21.66	3.30
Grain yield / plant(g)	23.29	49.3	7.66	32.90
Harvest index (%)	39.20	19.1	8.01	20.43

Heritability

Heritability (in narrow sense) in F_1 generation was calculated by the method proposed by Crumpackcr and Allard, (1962). Accordingly, high estimates of heritability were observed for plant height, days to maturity, number of spikelets per spike, spike length(cm), biological yield per plant(g) and grain yield(g) in F_1 generation. The moderate estimates were found for days to heading, number of tiller per plant, 1000 grain weight (g), grain weight per spike (g) and harvest index. The low heritability estimate was found only for number of grains per spike.

Genetic advance

In order to ascertain relative merit of different attributes, genetic advance in per cent of mean was worked out for all the twelve characters in F_1 generation. The estimate of genetic advance in percentage over mean ranged from3.30 (biological yield per plant) to 32.90 (grain yield per plant) in F_1 generation. The high value of genetic advance was recorded for grain yield per plant. Moderate genetic advance was recorded for days to heading, plant height (cm), number of tiller per plant, number of spikelets per spike, spike length (cm), number of grain per spike, grain weight per spike (g) and harvest index. Low values of genetic advance were recorded for days to maturity, 1000 grain weight and biological yield in F_1generation.

Discussion

Heritability and genetic advance

Heritability and genetic advance are the important parameters under the direct selection. Heritability denotes transmissibility of a character from parent to offspring. In this study the high heritability (narrow sense) were recorded for plant height, days to maturity, no of spikelets per spike, spike length, biological yield and grain yield per plant while moderate heritability were found for days to heading, tillers per plant, 1000-grain weight, grains weight per spike and harvest index whereas grains per spike showed low heritability. Genetic advance, though not an independent identity, has an added advantage over heritability as a guiding factor to the breeders in selection Programme. Johnson et al., (1955) stated that without genetic advance, estimates of the heritability would not be of practical importance based on phenotypic expression and emphasized the concurrent use of genetic advance along with heritability.

The estimates of genetic advance in percent over mean of characters ranged from 3.30 (biological yield) to 32.90 (grains yield per plant). The high genetic advance in percent over mean was observed in grains yield per plant (32.90), while days to heading, plant height, number of tiller per plant, spikelets per spike, spike length, grains per spike, grains weight per spike and harvest index showed moderate whereas days to maturity, 1000-grains weigh and biological yield were observed low genetic advance in percent over mean. Same thing was observed by Dhananjay *et al.* (2012) Kumar *et al.* (2013) [6], Navin Kumar *et al*. (2014) [7], Pradeep *et al.* (2016).

Conclusion

High heritability and high or moderate genetic advance for a character spike length and grain yield per plant, respectively indicated that the characters will be responsible for selection and selection will be profitable. Studies revealed that the grain yield per plant with high heritability and high genetic advance followed by days to 75% heading, plant height, number of tillers per plant, number of spikelets per spike, spike length and harvest index were the major yield attributing traits coupled with moderate genetic advance, so due consideration should be given for these traits at the time of simple selection,

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