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Estimation of heritability and genetic advance for grain yield and its metric characters in F_1 generation of bread wheat (*Triticum aestivum* L.)

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Abstract
wheat is one of the most significant cereal crops. It is possible to trace the beginnings of wheat to Asia Minor. It occupies more than 17% of all arable land, is consumed by nearly 40% of the world's population, and makes up roughly 32% of all cereal growing land. Over 4.5 billion people in developing countries rely on it to meet 21% of their protein needs. The experimental material for the present investigation comprised of 45 F_1s developed by crossing 10 lines *viz*., DBW-187, HD-3249, K-1006, PBW-723, PBW-757, HD-3271, HD-3298, K-8434, K - 9107, KRL-350 by following half diallel mating design. The experimental materials consisted of 55 genotype (45 F_1s + 10 Parents). The high heritability in broad sense was estimated for all the characters except for day to 50% heading, flag leaf area (cm^2), number of leaves/main tiller, number of spikelets/ear and protein content (%) in F_1 generation.. A high value of heritability suggests that it could be due to a higher contribution of genotypic components. The estimate of genetic advance in percentage over mean ranged from 0.16 (flag leaf area) to 39.18 (Grain yield / Plant (g)) in F_1 generation. The high genetic advance in percent over mean was observed in, biological yield per plant, Grain yield / Plant (g)), productive tiller per plant and seed hardness.

Keywords: Heritability, genetic advance, grain yield and bread wheat

Introduction
It is widely believed that wheat was the initial crop to be domesticated by humans on Earth (Sootaher *et al*., 2020) [10]. Wheat (*Triticum aestivum* L. em. Thell), is a self-pollinated crop belonging to the Poaceae family. It is considered one of the leading cereals in numerous countries, including India. In fact, wheat holds great significance as the most important food crop in India, serving as a major source of protein and energy. In terms of both land area and production, wheat ranks second after rice as the most crucial food crop in India. It has earned the title of the "King of cereals" due to its extensive cultivation, high productivity, and significant role in international food grain trade. Wheat can be cultivated in various climates, ranging from temperate, irrigated, and dry areas to warm, humid, and cold environments. It is consumed in diverse forms, such as bread, chapatti, porridge, flour, and suji. Wheat contains relatively high levels of niacin and thiamin, which are primarily responsible for the presence of a special protein known as "Gluten." This protein is of immense importance as it provides the structural framework and spongy texture to bread and baked goods. Globally, wheat is grown across 224.49 million hectares, with an estimated annual production of 792.4 million tonnes. (United States Department of Agriculture 2020-21). In India, the total land area dedicated to wheat cultivation in 2021-22 was 30.47 million hectares, resulting in a production of 106.84 million tonnes. In Uttar Pradesh (U.P.), specifically, the cultivated area for wheat in the same year was 9.54 million hectares, yielding a production of 32.74 million tonnes (Agricultural Statistics at a Glance 2022). However, with the expected increase in demand for wheat, there is a need to enhance productivity. Understanding genetic variability, heritability, correlation coefficients, and other related parameters can aid in improving grain yield through targeted selection of specific traits and their relationship with overall productivity. Therefore, the present study aims to assess the variability and heritability in wheat, with the goal of utilizing this information in selection programs to enhance productivity in future wheat genotypes.

Materials and Methods

The experimental material comprised of 45 F_1s developed by crossing 10 lines *viz*., DBW-187, HD-3249, K-1006, PBW-723, PBW-757, HD-3271, HD-3298, K-8434, KRL-350, K -9107 following half diallel mating design. The experimental materials consisted of 55 genotype (45 F1s +10 Parents) were sown in Randomized Block Design with three replications at the Student Instruction Farm, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, during the rabi season of 2022-23. Each cultivar was grown in a single row plot measuring 4 meters in length, with a distance of 23 centimeters between rows. The plants within each plot were spaced 10 centimeters apart. Various quantitative characteristics of the wheat plants were recorded as observations. These characteristics included the number of days to reach 50% heading, the number of days to maturity, plant height in centimeters, flag leaf area in square centimeters, number of leaves on the main tiller, number of productive tillers per plant, ear length in centimeters, number of spikelets per ear, number of grains per ear, biological yield per plant in grams, grain yield per plant in grams, harvest index as a percentage, 1000-grain weight in grams, seed hardness, and protein content as a percentage. For each replication and for all characteristics except for the number of days to 50% heading and days to maturity, five randomly selected competitive plants were recorded. The heritability in broad sense (h^2) was determined using the method described by Burton and Vane (1953). The genetic advance was calculated based on the formula provided by Johnson *et al.* (1955) [12].

Results and Discussion

Heritability (in broad sense) in F_1 generation was calculated by the method proposed by Crumpacker and Allard, (1962) [7]. Accordingly, high estimates of heritability were observed for days to maturity (days), plant height (cm), biological yield /plant, 1000 grain- weight, seed hardness and grain yield / plant (g) in F1 generation. The moderate heritability estimate was found for days to 50% heading, no of grains/ear and protein content. A high heritability means that the most of individual variation is caused by genetic variation rather than environmental variation. Knowing the heritability is important because, when a breeder selects a phenotype, only the genes of the plant, not the effects of the environment, are passed on. High heritability qualities are preferred by breeders because they enable them to select individuals who will pass the desired trait to their progeny

Genetic Advance

Genetic advance in percent of mean was calculated for all the characters in the F1 generation in order to determine the relative merit of certain attributes. The estimate of genetic advance in percentage over mean ranged from 0.16 (flag leaf area) to 39.18 (Grain yield / Plant (g)) in F1generation. The high genetic advance in percent over mean was observed in productive tillers per plant, biological yield/plant and seed hardness. High value of genetic advance is indicative of additive gene action. The results for various characters are described as under here:

Days to 50% heading (days)

Days to 75% heading showed grand mean (84.95), heritability (30.5), genetic advance (1.06) and genetic advance over % mean (1.25).

Days to maturity (days)

Days to maturity (days) showed grand mean (124.96), heritability (67.7), genetic advance (3.64) and genetic advance over % mean (2.91).

Plant height (cm)

Plant height (cm) showed grand mean (94.83), heritability (84.3), genetic advance (8.74) and genetic advance over % mean (9.22).

Flag leaf area(cm^2)

Flag leaf area showd grand mean (24.24), heritability (1.2), genetic advance (0.04) and genetic advance over % mean (0.16).

No. of leaves per main tiller

No. of leaves per main tiller showd grand mean (5.33), heritability (9.9), genetic advance (0.043) and genetic advance over % mean (0.81).

Productive tillers / plant

Productive tillers/plant showed grand mean (7.97), heritability (7.8), genetic advance (1.83) and genetic advance over % mean (23.04).

Ear length (cm)

Ear length (cm) showed grand mean (10.20), heritability (3.7), genetic advance (0.12) and genetic advance over % mean (1.18).

No. of spikelets /ear

No. of spikelets /ear showed grand mean (20.08), heritability (8.5), genetic advance (0.27) and genetic advance over % mean (1.36).

No. of grains /ear

No. of grains /ear showed grand mean (50.23), heritability (36.9), genetic advance (2.26) and genetic advance over % mean (4.50).

Biological yield/plant(g)

Biological yield/plant(g) showed grand mean (38.90), heritability (92.8), genetic advance (13.47) and genetic advance over % mean (34.62).

Grain yield / Plant (g)

Grain yield / Plant (g) showed grand mean (15.62), heritability (95.2), genetic advance (6.12) and genetic advance over % mean (39.18).

Harvest index(%)

Harvest index(%) showed grand mean (42.33), heritability (13.9), genetic advance (0.43) and genetic advance over % mean (1.03).

1000 grain weight (g): 1000 grain weight (g) showed grand mean (44.45), heritability (74.6), genetic advance (4.11) and genetic advance over % mean (9.26).

Seed hardness

Seed hardness showed grand mean (8.65), heritability (81.2), genetic advance (2.01) and genetic advance over % mean (23.16).

Protein content(%)

Protein content (%) showed grand mean (12.37), heritability (42.5), genetic advance (0.97) and genetic advance over % mean (7.84).

High heritability coupled with high genetic advance as percent of mean was recorded for no. of productive tillers / plant, biological yield/plant, 1000 grain weight (g), seed hardness and grainyield/ plant(g) reflecting the presence of additive gene action for the expression of these traits and improvement of these traits could be done through selection. High heritability with low genetic advance was observed for days to maturity and seed hardness. It suggested non-additive gene action for the expressions of these characters. Selection for such features may not be profitable because the high heritability was caused by the environment's beneficial influence rather than the genotype. It became clear that additive gene influences control the character. Due to significant environmental influences, a low heritability was seen. Selection for this character may not be successful as a result. Breeders consider the heritability of a metric character to be a crucial parameter because it measures the degree of similarity between parents and offspring. Its magnitude also indicates how effectively a genotype can be identified by its phenotypic expression, and genetic progress helps apply the necessary selection pressure.

Table 1: Direct selection parameters for 15 characters of 10 parent diallel cross set in F_1 of wheat (*Triticum aestivum* L.)

Characters	Grand mean	Heritability (%) (h^2) (Broad Sense)	GA	GA in% over mean
Days to 50% heading	85.22	30.5	1.06	1.25
Days to maturity	125.19	67.7	3.64	2.91
Plant height (cm)	95.23	84.3	8.74	9.22
Flag leaf area (cm^2)	24.13	1.2	0.04	0.16
Number of leaves/main tiller	5.32	9.9	0.043	0.81
Productive tillers/plant	8.20	7.8	1.83	23.04
Ear length (cm)	10.06	3.7	0.12	1.18
Number of spikelets/ear	20.03	8.5	0.27	1.36
Number of grains/ear	50.08	36.9	2.26	4.50
Biological yield/plant (g)	41.07	92.8	13.47	34.62
Grain yield/plant (g)	16.53	95.2	6.12	39.18
Harvest index (%)	40.32	13.9	0.43	1.03
1000-grain weight (g)	45.37	74.6	4.11	9.26
Seed hardness	8.39	81.2	2.01	23.16
Protein content (%)	12.50	42.5	0.97	7.84

Conclusion

Wheat stands as a cornerstone cereal crop globally, originating from Asia Minor and playing a pivotal role in feeding nearly 40% of the world's population. Its cultivation spans diverse climates and contributes significantly to both agricultural land use and food security, particularly in developing countries. The study on genetic variability, heritability, and genetic advance in wheat highlighted traits like grain yield, biological yield, and seed hardness as having substantial heritability and genetic advance, suggesting their potential for improvement through breeding programs. These findings underscore the importance of genetic research in enhancing wheat productivity and meeting future global demands for this essential crop.

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