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An Estimate of Variability, Heritability and Genetic Advance for Grain Yield and Yield Components in Bread Wheat (*Triticum aestivum* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. Author SCG planned the experiment and performed the statistical analysis. Further, author RJ carried out experiment in field, wrote the first draft of manuscript and helped in statistical analysis. Author SKJ managed the literature search and guided the author RJ in writing the manuscript. Author SKJ and AK edited the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Problem: Wheat (*Triticum aestivum* L.) is one of the principal cereal crops grown worldwide and one of the important staples of nearly 2.5 billion of world population. India ranks second position in terms of both in area and production after china. The substantial improvement in production is utmost necessary to feed the growing population.
Objective: In India, wheat requirement by 2030 has been estimated at 100 million metric tons and to achieve this target, wheat production can be increased either through horizontal approach i.e. by the increasing area under cultivation or through vertical approach i.e. varietal/ hybrid improvement. For effective selection and utilization of superior genotype in the germplasm lines, knowledge of genetic parameters such as genetic variability, heritability and genetic advance is essential.
Materials and Methods: The experimental material comprised of ten parents, their 45 F1s and 45 F2s developed by the crossing of 10 parents *viz*. HUW 510, HUW 234, HUW 468, UP 2338, HD 2402, RAJ 1972, HD 2329, LOK-1, SONALIKA and K 65 in half-diallel programme to study the

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fourteen characters. The final trial of F1, F2 including parents was conducted during Rabi 2014-15 with three replications employing Randomized Complete Block Design at Research Farm, BRDPG College, Deoria, Uttar Pradesh, India.
Result: Wider range of phenotypic coefficient of variation (PCV) was observed for all the traits in F1 generation ranged from 2.19 (days to 50% flowering) to 13.47 (leaf area index) while, genotypic coefficient of variation (GCV) ranged from 1.50 (days to 50% flowering) to 11.28 (leaf area index). High heritability was observed in both F1 and F2 generation for leaf area index and day to maturity while, moderate to low level of heritability was recorded for other characters. The high value of genetic advance was not recorded in both F1 and F2 generation. Only moderate to the low value of genetic advance was observed for all the fourteen characters under study.
Conclusion: Estimate of phenotypic and genotypic coefficient of variation of fourteen characters in both generations reveals sufficient variability indicating ample scope for genetic improvement of these traits through selection. Moderate level of heritability accompanied with a moderate level of genetic advance was observed for plant height, leaf area index, days to maturity and grain yield per plant in both F1 and F2 generation indicates additive gene effect and selection may be effective.

Keywords: Triticum aestivum L.; heritability; genetic advance; hybridization.

1. INTRODUCTION

Wheat is the principal food crop in most areas of the world and also occupies a prominent position in Indian agriculture after rice. Owing to the high nutrient content and suitability to all agro-climatic regions, wheat is considered as the king of all cereal crops [1]. It is nutritionally important cereal essential for food security, poverty alleviation and for livelihoods. Globally, wheat is being grown in 122 countries and occupies an area of 224.27 million hectares producing nearly 732.31million tons with a productivity of 3.27 tons per hectare [2]. The major wheat-producing countries are China, India, USA, France, Russia, Canada, Australia, Pakistan, Turkey, UK, Argentina, Iran and Italy. These countries contribute about 76% of the total world wheat production. Wheat is also an important crop of India not only in terms of acreage, but also in terms of its versatility for adoption under a wide range of agro-climatic conditions and crop growing situations. India ranks second position in terms of both in area and production after China. Wheat is a major contributor to the food security system in India as well, occupying nearly area 30.78 million hectare producing 98.5 million tons with average productivity of 3.2 ton/hectare [3]. The major wheat producing states in India are Uttar Pradesh, Punjab and Haryana. Wheat has 34% contribution to food basket of India. 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). The substantial improvement in production is utmost necessary not only to meet ever increasing food requirement for domestic consumption, but also for export to earn foreign exchange. To feed the growing population, the country's wheat requirement by 2030 has been estimated at 100 million metric tons and this can be achieved through horizontal approach i.e. by increasing area under cultivation or through vertical approach i.e. varietal / hybrid improvement, which is one of the strongest tool to take a quantum jump in production and productivity under various agro-climatic conditions [4]. Genetic improvement for quantitative traits depends upon the nature and amount of variability present in the genetic stock and the extent to which the desirable traits are heritable. For effective selection of superior genotype in the germplasm lines, knowledge of genetic parameters such as variability, heritability and genetic advance is very much essential. Heritability and genetic advance are the important parameters under the direct selection. Heritability denotes transmissibility of a character from parent to offspring. 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. [5] 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.

2. MATERIALS AND METHODS

The materials for the present investigation comprised of ten widely diverse varieties *viz.* HUW 510, HUW 234, HUW 468, UP 2338, HD 2402, RAJ 1972, HD 2329, LOK-1, SONALIKA and K 65 employed under half-diallel crossing programme to develop first filial generation during Rabi 2012-13. The 50 per cent seed materials of F_1 were selfed to produce F_2 seeds during Rabi 2013-14 while, remaining 50 per cent seeds was kept safe for final trial. The final trial of F_1, F_2 including parents was conducted during Rabi 2014-15 with three replication adopting Randomized Complete Block Design at Research Farm, BRDPG College, Deoria, Uttar Pradesh, India. The plot size was maintained at 1.5 m length and 0.70 m width containing 3 rows in each plot at 25 cm apart. To avoid the border effect, border rows were raised all around the experimental area. Other cultural practices as and when required were applied to maintain the health of the crop with application of recommended dose of fertilizers (120 kg N, 60 kg P_2O_5, 40 kg K_2O). To avoid the deficiency of Zinc, Zinc sulphate @ 25 kg/hectare were applied before sowing during the preparation of land. The data was recorded for fourteen characters *viz.,* days to 50 percent flowering, number of tillers per plants, plant height, spike length per plant, number of spikelet's per spike, peduncle length of main shoot, leaf area index, days to maturity, grain yield per plant, 1000-grain weight, biological yield per plant, number of grains per spike, protein content and gluten content. Standard statistical procedures were followed for estimating genetic constants i.e. phenotypic and genotypic coefficients of variation [6], heritability in broad sense [7] and genetic advance [5].

3. RESULTS AND DISCUSSION

The quantitative measurement of individual character provides the basis for an interpretation of different variability parameters. Estimation of phenotypic and genotypic coefficient of variation for fourteen characters studied in F_1 and F_2 generation is presented in Table 1 and Table 2. Gupta and Verma [8] reported that phenotypic coefficient of variation (PCV) is much higher than the genotypic coefficient of variation for number of tillers per plant, grain yield per plant and harvest index indicating that apparent variation. In the present investigation, in general, estimates of phenotypic coefficient of variation was found higher than their corresponding genotypic coefficient of variation, indicating that the little influence of environment on the expression of these characters. A wide range of phenotypic coefficient of variation (PCV) was observed for all the traits in F_1 generation ranged from 2.19 (days to 50% flowering) to 13.47 (leaf area index). Higher magnitude of PCV was recorded for leaf area index (13.47), grain yield per plant (10.89), peduncle length of main shoot (9.85), spikelet's/ Plant (8.77), biological yield per plant (7.36), and 1000-grain weight (7.32). Genotypic coefficient of variation (GCV) ranged from 1.50 (days to 50% flowering) to 11.28 (leaf area index). Leaf area index had maximum estimate of both the coefficient of variation in present study. Low value of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) observed for characters like days to 50% flowering and days to maturity. Shoran [9] also indicated little variability and scope for selection for days to 50% flowering and days to maturity in his study. Higher magnitude of phenotypic and genotypic coefficient of variation suggests sufficient variability and thus scope for genetic improvement through selection for these traits. These findings were in agreement with those of Amin et al. [10], Panwar and Singh [11], Bergale et al. [12] and Dwivedi et al. [13]. They also observed the PCV values higher than GCV values for different quantitative characters in wheat in F_1 generation. In F_2 generation, phenotypic coefficients of variation were also found higher than their corresponding genotypic coefficient of variation (Table 2). Higher magnitude of PCV and GCV were recorded in peduncle length of main shoot (13.36) and (12.46), respectively.

Heritability plays an important role in deciding the suitability and strategy for selection of a character. In the present study heritability estimated ranged from 15.0 to 68.0 per cent indicating high heritability was observed for day to maturity (61.0) and leaf area index (60.0) while, moderate heritability value were recorded for plant height (59.0), grain yield per plant (56.0), 1000-grain weight (50.0), days to 50% flowering (47.0), peduncle length of main shoot (46.0), number of grains per spike (45.0), spike length per plant (42.0), biological yield per plant (41.0), number of tillers per plant (40.0) and number of spikelet's per spike (31.0). Low value of heritability was observed for protein content (27.0) and gluten content (15.0) in F_1 generation (Table 1). Similarly in F_2 generation, high heritability value were recorded for day to maturity (68.0) and leaf area index (61.0) while, moderate level were recorded for plant height (58.0), peduncle length of main shoot (57.0), spike length per plant (45.0), number of grains per spike (44.0), days to 50 per cent flowering (43.0), grain yield per plant (42.0), biological yield per plant (40.0), number of tillers per plant (35.0) and gluten content (32.0). Low value of heritability was observed for 1000 grain weight (29.0) and protein content (27.0) (Table 2). The high heritability values indicate that heritability may be due to higher contribution of genotypic component. High heritability estimates were also reported by Saini et al. [14] for days to maturity, Amin et al. [10] for 1000 grain weight, Panwar and Singh [11] and Asif et al. [15] for plant height while Rasal et al. [16] observed high value of heritability for most of the characters studied. Heritability alone provides no indication of amount of genetic improvement that could result from selection of individual genotype; hence knowledge about genetic advance coupled with heritability is most useful [17].

Genetic advance is the improvement in the mean of selection family over the base population [5,18]. Characters exhibiting high heritability may not be necessarily give high genetic advance. Johnson et al. [5] showed that high heritability should be accompanied by high genetic advance to arrive at more reliable conclusion. The breeder should cautious in making selection based on heritability as it includes both additive and non-additive gene effect. The high value of genetic advance in per cent over mean in F_1 generation was not recorded. Only moderate to low value were confined for biological yield per plot (8.05), plant height (7.12), grain yield per plant (6.74), peduncle length of main shoot (5.71), leaf area index (5.07), day to maturity (4.22), 1000-grain weight (4.19), days to 50 per cent flowering (2.06), number of grains per spike (1.52), spikelet's per spike (0.75), spike length per plant (0.60), protein content (0.39), number of tillers per plant (0.35) and gluten content (0.21) (Table 1). Similarly in F_2 generation, moderate to low value was observed for biological yield per plant (7.12), plant height (6.74), peduncle length of main shoot (6.35), day to maturity (5.70), grain yield per plant (4.50), leaf area index (4.04), days to 50 per cent flowering (1.99), 1000-grain weight (1.99), number of grains per spike (1.42), number of tillers per plant (0.63), Spikelet's per spike(0.63), spike length per plant (0.57), gluten content (0.51) and protein content (0.41) (Table 2). Moderate genetic advance was reported by Saini et al. [14] for plant height, number of tiller per plant, number of spikelets per spike, spike length per plant and number of grain per spike, while low values of genetic advance were recorded for days to maturity, 1000 grain weight and biological yield in F_1 generation. Similar observation were also observed by Singh et al. [19], Kumar et al. [20], Kumar et al. [21] and Kumar et al. [22]. Moderate level heritability accompanied with moderate level genetic advance was found for plant height, leaf area index, days to maturity and grain yield per plant in F_1 and F_2 generation indicates that most likely the heritability is due to additive gene effect and selection may be effective.

Table 1. Means, genotypic coefficient of variance, phenotypic coefficient of variance, heritability and genetic advance of fourteen characters in 45 F_1 generation of 10 parent diallel cross of wheat

Characters	Mean	GCV	PCV	h^2	GA at 5%	GA at 1%
Days to 50 % Flowering	76.46	1.50	2.19	47.0	1.61	2.06
Tillers/ Plant	8.84	2.34	3.69	40.0	0.27	0.35
Plant Height (cm)	100.14	3.51	4.57	59.0	5.55	7.12
Spike length /Plant (cm)	10.58	3.30	5.08	42.0	0.47	0.60
Spikelet's/ Plant	10.60	4.86	8.77	31.0	0.59	0.75
PLMS (cm)	47.69	6.68	9.85	46.0	4.45	5.71
Leaf Area Index	20.34	11.28	13.47	60.0	3.96	5.07
Day to Maturity	112.70	1.81	2.32	61.0	3.29	4.22
Grain Yield/ Plant (g)	41.81	8.15	10.89	56.0	5.26	6.74
1000 Grain Weight (g)	43.59	5.17	7.32	50.0	3.27	4.19
Biological Yield/ Plant (g)	101.10	4.71	7.36	41.0	6.28	8.05
Grains/ Spike	21.03	4.09	6.08	45.0	1.19	1.52
Protein Content (%)	11.95	2.37	4.58	27.0	0.30	0.39
Gluten Content (%)	8.72	2.40	6.30	15.0	0.16	0.21

Table 2. Means, genotypic coefficient of variance, phenotypic coefficient of variance, heritability and genetic advance of fourteen characters in 45 F_2 generation of 10 parent diallel cross of wheat

Characters	Mean	GCV	PCV	h^2	GA at 5%	GA at 1%
Days to 50 % Flowering	76.31	1.50	2.28	43.0	1.56	1.99
Tillers/ Plant	8.27	4.92	8.38	35.0	0.49	0.63
Plant Height (cm)	96.37	3.47	4.54	58.0	5.26	6.74
Spike length /Plant (cm)	10.08	3.17	4.71	45.0	0.44	0.57
Spikelet's/ Plant	10.22	4.89	10.26	23.0	0.49	0.63
PLMS (cm)	40.27	12.46	13.36	57.0	6.35	6.35
Leaf Area Index	19.63	9.97	12.77	61.0	3.15	4.04
Day to Maturity	113.59	2.31	2.80	68.0	4.45	5.70
Grain Yield/ Plant (g)	39.91	6.62	10.26	42.0	3.51	4.50
1000 Grain Weight (g)	42.52	3.27	6.05	29.0	1.55	1.99
Biological Yield/ Plant (g)	98.51	4.35	6.91	40.0	5.56	7.12
Grains/ Spike	20.71	3.93	5.95	44.0	1.11	1.42
Protein Content (%)	11.87	2.43	4.53	29.0	0.32	0.41
Gluten Content (%)	8.70	3.89	6.83	32.0	0.40	0.51

4. CONCLUSION

In the present investigation, estimate of phenotypic and genotypic coefficient of variation for fourteen characters in F_1 and F_2 generations reveals sufficient variability for each of traits and thus, ample scope for genetic improvement of these traits through selection. The estimate of phenotypic coefficient of variation was found higher than their corresponding genotypic coefficient of variation, indicating that the little influence of environment on the expression of these characters. The high heritability values observed for day to maturity and leaf area index in both the generation indicate that heritability may be due to higher contribution of genotypic component. Moderate to low value of genetic advance was observed for most of the character studied. Moderate level of heritability accompanied with moderate level of genetic advance observed for plant height, leaf area index, days to maturity and grain yield per plant in F_1 and F_2 generation indicates additive gene action for these traits and selection may be effective.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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