

Genetic variability and association analysis in induced mutants of hard and soft hexaploid wheat (*Triticum aestivum* L.) under northern hill conditions

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Abstract

The present study was conducted during Rabi 2021-22 to study variability, correlation and path coefficients for twelve morphological characters on 90 morphologically distinct mutants in M₂ generation along with 6 checks in augmented block design at the Rice and Wheat Research Centre, Malan. It was observed that days to 75% maturity, spike length, harvest index, grains/spike and 1000-grain weight showed significant positive correlation with grain yield per plant. Biological yield per plant showed highest value for direct effect followed harvest index, spike length, peduncle length, days to 75 % maturity and 1000- grain weight. Path analysis for, biological yield had highest direct effect followed by harvest index, grains/spike, spike length, peduncle length and days to 75% maturity, peduncle length and 1000-grain weight.

Key words: Mutation in wheat, induced mutant, variability, correlation, path coefficient

1. Introduction

Wheat is one of the most important cereal crop which is produced and consumed worldwide. It is grown on more acreage land than any other commercial crop and remains the most important food grain source for human consumption (Enghiad et al. 2017, Trethowan et al., 2018). Wheat (*Triticum aestivum* L.) is an essential cereal food crop in the world. It occupies 221.85 million hectares, produces 770.08 million tonnes, and has a productivity of 3.50 tonnes per hectare (Anonymous 2021a). As a rich source of dietary nutrients, it contributes for more than 20% of the food calories consumed globally. With a productivity of 3.49 tonnes per hectare, India has the most wheat acreage in the world (30.31 million hectares) and the second-highest production (100.42 million tonnes) behind China (Anonymous 2021b). In Himachal Pradesh wheat is grown under an area of 0.33 million hectares with

a production of 0.57 million tonnes and productivity of 1.71 tonnes/ha. (Anonymous 2021c).

HPW 89 (soft) and HPW 251 (hard) are very popular in Himachal Pradesh. But there is urgent need to improve the yield potential of such varieties because of low productivity of wheat in Himachal Pradesh for more diverse germplasm. On the basis of principles of Plant breeding viz., is variation and selection; genetic variation is fundamentally important for introduction of new traits in breeding programs. It could be created through hybridisation or mutations followed by handling of different field generation by method of choice. Moreover, choice based on one character don't offer chance for the victory of advancement of other character. So, more than one character should be considered for the selection success. The selection of morphological and physiological



drought adaptable attributes is very important for next generations. Different hereditary parameters i.e. heritability, genotypic and phenotypic coefficient of variation and hereditary progresses are surveyed for morphological and physiological characteristics that can be utilized in determination of strong dry season tolerant assortment Improvement. through mutation is less time-consuming, less laborious with high genetic variation as compared to hybridisation. Mutagenesis is considered a forward genetic approach, which supplies altered phenotypes/ physiological responses that can be exploited in classical breeding programs (Abaza et al. 2021). Similarly, mutagenesis can be seen as an important strategy for the direct release of improved varieties (Dhaliwal et al. 2015). The occurrence of even a many desirable mutations in high- yielding varieties has the great advantage of getting homozygous and expressing its superiority within a couple of generations after induction in M_2 or M_3 as compared to F_6 or F_7 generations of hybridization (Balkan et al. 2019). Therefore, generation of variability through mutagenic treatments is of paramount importance for improvement of wheat.

2. Materials and Methods

Two wheat varieties viz., HPW 251 and HPW 89 were used for mutagenesis by using EMS (0.3%, 0.6% and 0.9%), Gamma rays (250 Gy, 300 Gy and 350 Gy) and their combinations. For germination (%) under lab conditions, HPW 89 (soft wheat) exhibited higher reduction in germination percentage in comparison to HPW 251 (Hard wheat) across all the mutagen doses and their combinations. The M_1 plants were harvested individually to obtain M_2 generation mutant lines (as individual plant to row progenies) for isolating superior progenies with respect to different agro- morphological traits. A total of ninety M_2 mutant lines including thirty M_2 mutant lines of wheat variety HPW 251 and 60 mutant lines of HPW 89 were evaluated in augmented block design with 6 checks in five blocks during Rabi 2021-2022 at the Rice and Wheat Research Centre, Malan. Data on five plants was recorded in each mutant line. Standard cultural practices were followed to raise a healthy crop. Data on twelve quantitative characters were recorded on five plants selected randomly from the middle rows of each replication. Individual M_2 progenies were handled in selected bulk and average of five plants plant use to

analysis the data. Data on five plants was recorded in each mutant line. This method will be helpful for selecting superior M_2 families for further evaluation and selection in next generation for yield traits. The data were subjected to analysis of phenotypic and genotypic coefficients of variability (Burton 1952), heritability and genetic advance (Johnson et al. 1955a) and genotypic and phenotypic correlation (Johnson et al., 1955b)

3. Results and Discussion

Parameters of variability

The estimates of various parameters of variability viz., mean, range, phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) along with heritability in broad sense (h^2_{bs}) and genetic advance (GA) expressed as percentage of mean for different traits are presented in Table 1 and described below:

Range and mean

The observations for morphological and yield traits indicated that days to 50% flowering varied from 107.98 to 156.72 days with a mean value of 123.14 days, while. days to 75% maturity ranged from 145.31 to 188.08 days with a mean value of 169.89 days The plant height ranged from 62.10 to 110.00cm with a mean value of 87.42cm, peduncle length varied from 6.19 to 16.59cm with a mean value of 10.73cm, spike length ranged from 7.60 to 16.40 cm with a mean value of 11.11 cm, flag leaf length ranged from 7.30 to 23.43cm with a mean value of 16.18cm. The tillers / plant varied from 2.44 to 9.19 with a mean value of 5.12. Grains per spike ranged from 41.22 to 66.74 with a mean value of 51.93, harvest index ranged between 17.85 to 56.01% with a mean value of 31.80%, 1000- grain weight varied from 30.94 to 53.85g with a mean value of 41.85g. The biological yield / plant ranged from 11.71 to 28.83g with a mean value of 21.27g and grain yield/ plant ranged from 4.21 to 9.48g with a mean value of 6.54g. The following results depicted the presence of wide variability among the genotypes for various traits.

Coefficient of variation

The knowledge about phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) is the most important to select better parents for initiating an effective breeding program. The estimates of PCV were greater than the estimates of GCV for all of the traits studied, indicated that the sufficient variation is not



only due to the genotypes but also due to environmental factor (Table 1). Similar results have been reported in the findings of Kumar et al. (2021), Thapa et al. (2019) and Singh et al. (2022) which observed high estimates of PCV than GCV in wheat for different traits.

High PCV (>20 %) was observed for flag leaf length, tillers / plant and harvest index, moderate PCV (10-20

%) was observed for peduncle length, biological yield / plant, grain yield / plant, spike length and plant height whereas, low PCV (<10 %) was observed for days to flowering, days to maturity, grains/spike and 1000-grain weight (Table 1), indicated the influence of environment on apparent variation.

Table 1. Genotypic and phenotypic coefficients of variability, heritability and genetic advance for ninety quantitative characters in induced mutants of hard and soft wheat

Traits	Mean	Range	PCV	GCV	Heritability h^2_{bs} (%)	Genetic advance as % of mean
Days to 50% flowering	123.14±0.79	107.98-156.72	6.17	5.65	83.8	10.66
Days to 75 % maturity	169.86±0.66	145.31-189.43	5.64	5.18	84.23	9.81
Plant height (cm)	87.42±0.96	62.1-110.00	10.43	9.65	85.69	18.44
Peduncle length (cm)	10.73±0.20	6.19-16.59	18.46	17.63	91.20	34.74
Spike length(cm)	11.11±0.08	7.6-16.40	10.81	8.80	66.26	14.78
Flag leaf length(cm)	16.18±0.36	7.3-23.43	26.5	21.44	65.45	35.78
Tillers / plant	5.12±0.16	2.44-9.19	30.16	21.02	48.58	30.23
Grains / spike	51.93±0.48	41.22-66.76	9.12	8.96	96.53	18.17
Grain yield / plant (g)	6.54±0.09	4.21-9.48	13.29	9.82	54.67	14.99
Biological yield / plant (g)	21.27±0.33	11.71-28.83	17.03	14.42	71.72	25.2
Harvest index (%)	31.8±0.74	17.85-56.01	24.79	20.91	71.14	36.39
1000- grain weight (g)	41.85±0.40	30.94-53.85	9.56	9.31	94.87	18.71

The genotypic coefficient of variation also followed a similar pattern. High GCV (>20 %) was recorded for flag leaf length, tillers / plant and harvest index, moderate GCV (10-20 %) was observed for peduncle length and biological yield / plant whereas, low GCV (<10 %) were recorded for days to 50% flowering, days to 75% maturity, plant height, spike length, grains / spike and grain yield / plant and 1000-grain weight (Table 1). As has been observed in findings of Kalimullah et al. (2012) who observed high PCV and GCV in flag leaf length, tillers / and harvest index/ plant in 41 genotypes of bread wheat. Similarly, Tanveer et al. (2022) studied genetic variability in wheat and reported that moderate PCV and GCV was observed in peduncle length and biological yield/ plant.

Heritability in broad sense (h^2_{bs})

In the present study, high heritability (>60 %) was observed for traits like days to 50 % flowering, days to 75% maturity, plant height, peduncle length, spike length, flag leaf length, grains / spike, biological yield / plant, harvest index and 1000-grain weight thereby, indicating the ability of the genotypes to transmit genes to their progeny for

these traits (Table 1), while moderate heritability was observed for tillers / plant and grain yield / plant. High heritability for these traits revealed lesser influence of environment and greater role of genetic component of variation. Thus, the phenotypic selection for all these traits would be more effective and can be relied upon. Comparable results were reported in findings of Singh et al. (2022), who observed high heritability for biological yield/ plant, flag leaf length, peduncle length, grain yield / plant, number of productive tillers, plant height, grains / spike, harvest index. Similarly, Kumar et al. (2017) and Ahmad et al. (2016) reported high heritability for harvest index and plant height and Bayisa et al. (2020) observed high heritability for days to heading, days to maturity, grain filling period, spike length, biomass weight, plant height and harvest index.

Genetic Advance (GA) as per cent of mean

Knowledge of heritability estimates alone is not sufficient but simultaneous study of genetic advance along with heritability is more useful for an effective selection program. Genetic advance has an advantage over heritability as both



are important parameters for obtaining higher genetic gain. Genetic advance may or may not be proportional to the genetic variability and heritability estimates.

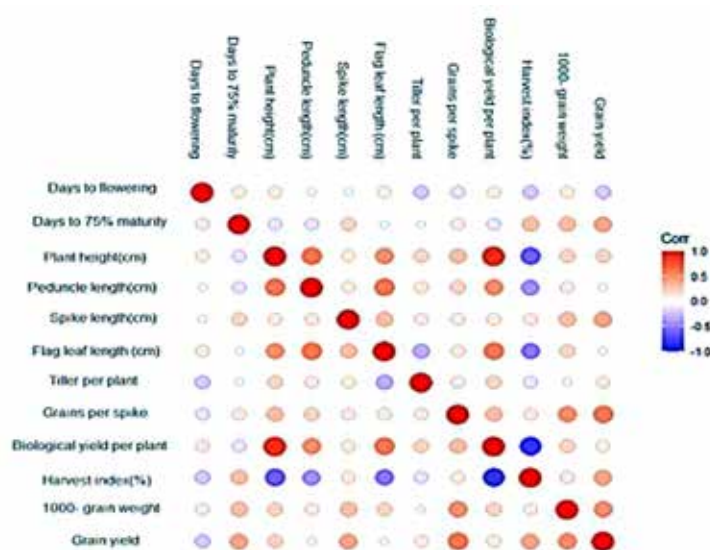
In the present study genetic advance expressed as percentage of mean was observed to be high (>20) for peduncle length, flag leaf length, tillers /plant, biological yield and harvest index. Moderate Genetic advance (10-20%) for days to 50% flowering, plant height, spike length, grains / spike, grain yield / plant and 1,000-grain weight whereas, it was low ($<10\%$) only for days to 75% maturity. Similar results of high genetic advance for flag leaf length, biological yield / plant, productive tillers / plant, harvest index and grain yield / plant were reported by Singh et al. (2022). Similarly, Yadawad et al. (2015) and Rajput (2018) also observed high genetic advance as percent for grain yield / plant.

High heritability ($>60\%$) coupled with high genetic advance ($>20\%$) was observed for peduncle length, flag leaf length, biological yield / plant and harvest index indicating the predominance of additive gene action in the inheritance of these characters. Therefore, selection for these traits would be effective in the early generation. High heritability ($>60\%$) with moderate genetic advance (10-20 %) was observed for days to 50% flowering, plant height, spike length, grains per spike and 1000-grain weight grain yield / plant. High heritability ($>60\%$) coupled with low genetic advance ($<10\%$) were observed for days to 75% maturity revealing the predominance of non-additive gene action.

Correlation analysis

The knowledge of the degree and direction of association amongst the characters under study is essential while aiming at a rational genetic improvement in economic yield through approaches of selection in a population. In the present study grain yield / plant exhibited significant positive correlation with days to 75% maturity, spike length, grains per spike, 1000-grain weight and harvest index (Table 2). These results corroborate the findings of earlier workers. Days to 75% maturity expressed positive significant correlation with harvest index and 1,000-grain weight. Spike length showed positive significant correlation with flag leaf length and 1000-grain weight. Verma et al. (2021) also reported a significant positive correlation between spike length and flag leaf length. Grains/ spike had positive significant correlation with biological yield and 1000-grain weight, whereas 1000-grain weight had significant positive association with days to 75% maturity, spike length, flag leaf length and grains / spike. Harvest index showed significant positive correlation with days to 75% maturity and plant height whereas it showed significant negative correlation with peduncle length, flag leaf length and biological yield / plant. These results indicated that selection for positively correlated traits days to 75 % maturity and plant height may increase harvest index and lead to yield improvement. Similar findings of negative correlation between harvest index and biological yield per plant was observed by Ayer et al. (2017); Kumar et al. (2019).

Table 2. Correlation coefficients for ninety quantitative characters in induced mutants of hard and soft wheat



Path analysis

In the present investigation grain yield / plant was considered as the dependent variable and the phenotypic correlation of this character with other quantitative characters were partitioned into their corresponding direct and indirect effects through path coefficient analysis (Table 3).

At phenotypic level, biological yield had the highest direct effect followed by harvest index, grains / spike, spike length, peduncle length and days to 75% maturity, peduncle length and 1000-grain weight, while plant height, flag leaf area and days to 50% flowering had the highest negative direct effect on grain yield per plant. A perusal Table 3 indicated that significant positive correlation of days to 75% maturity with grain yield was mainly because of low magnitude of its direct effect and high magnitude of its indirect effect via harvest index. Grains / spike have positive direct effect of low magnitude on grain yield but exhibited high positive indirect effect via biological yield leading to the positive correlation with the grain yield. The positive correlation of spike length with the grain yield/ plant was due to the high positive direct effect as well as high positive indirect effect via biological yield / plant on grain yield / plant. The positive correlation of harvest index with grain yield/ plant was due to the high positive direct effect and indirect effect via grains / spike on grain yield / plant. Though 1000-grain weight had the low magnitude of direct effects but it exhibited high positive indirect effects via biological yield / plant and harvest index. A similar result of significant positive correlation of 1000-grain weight with grain yield due to positive indirect effects via biological yield and harvest index, was also reported by Anubhav et al. (2020). Present findings corroborate the findings of earlier workers Ayer et al. (2017), Baye et al. (2020), Anubhav et al. (2020) and thus should be considered as important selection criteria for improving yield.

Considering both, the correlation coefficients and path coefficients together, biological yield, harvest index and grains / spike emerged as important components of grain yield which should be given due importance during direct and indirect selection aimed at improvement of grain yield in wheat. Importance of harvest index as selection criterion has also been highlighted in studies by researchers namely Kumar et al. (2019) and Anubhav et al. (2020).

Table 3. Path coefficient analysis of 12 characters on grain yield in induced mutants of hard and soft wheat

Characters	Days to 50 % flowering	Days to 75% maturity	Plant height (cm)	Peduncle length (cm)	Spike length (cm)	Flag leaf length (cm)	Tillers / plant	Grains / spike (no.)	Biological yield / plant (g)	Harvest index (%)	1000-grain weight (g)	Correlation with yield
Days to 50% flowering	-0.027	0.013	-0.026	0.003	0.007	-0.011	0.015	-0.018	0.118	-0.241	0.006	-0.160
Days to 75% maturity	-0.003	0.107	0.016	-0.006	0.032	0.001	0.003	0.018	-0.144	0.337	0.019	0.380*
Plant height (cm)	-0.003	-0.006	-0.264	0.048	0.084	-0.064	-0.015	0.157	0.989	-0.770	0.014	0.170
Peduncle length (cm)	-0.001	-0.009	-0.158	0.170	0.017	-0.163	-0.009	0.035	0.628	-0.518	0.008	-0.010
Spike length (cm)	-0.001	0.018	-0.034	0.007	0.186	-0.037	-0.008	0.020	0.170	0.060	0.019	0.400*
Flag leaf length (cm)	-0.002	-0.001	-0.124	0.045	0.050	-0.135	0.018	0.022	0.746	-0.614	0.016	0.020
0Tillers / plant	0.006	-0.005	-0.061	0.011	0.022	0.037	-0.066	0.027	0.209	-0.108	-0.002	0.070
Grains / spike (no.)	0.002	0.010	-0.076	0.014	0.019	-0.015	-0.009	0.196	0.379	0.079	0.037	0.630*
Biological yield/plant (g)	-0.002	-0.012	-0.232	0.131	0.175	-0.077	-0.011	0.057	0.908	-0.820	0.013	0.130
Harvest index (%)	0.005	0.020	-0.033	0.029	0.069	0.057	0.058	0.189	-0.885	0.904	0.007	0.420*
1000- grain weight (g)	-0.002	0.028	-0.050	0.008	0.048	-0.030	0.002	0.098	0.235	0.108	0.074	0.520*



Author contributions

All authors contributed equally for preparing the final version of the manuscript.

Conflict of Interest

Authors declare no conflict of interest.

Ethical Approval

The article doesn't contain any study involving ethical approval.

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