Received : 07 Aug 2019 | Revised : 10 Feb 2020 | Accepted : 13 Feb 2020

Electronic Journal of Plant Breeding

Research Article

Regression analysis and inter generation trait association in F3 and F4 generation of wheat

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Abstract

The present study was carried to determine the response of selection for grain yield, yield-related components and to study the amount of genetic variation transferred from one generation to next generation viz., F_3 and F_4 segregating generations of wheat derived from a single cross WH711xPBW698. The coefficient of variation was high in the F_3 generation compared to F_4 which was low, indicating that homozygosity is attained in the F_3 generation itself. In both the generation negatively skewed platykurtic for plant height, spike length, spike weight, grain weight/ spike, the number of grains/ spike, the number of tillers/ plant, grain yield/ plant and biological yield/ plant indicated that these traits were governed by many numbers of genes and most of them with governed by dominant and dominant based duplicate epistasis. Mild selection is expected to result in a rapid genetic gain for these traits. The positively skewed platykurtic for leaf length, flag leaf area, 100 grain weight, harvest index and days to heading indicate that these traits were governed by many genes and the majority of them displaying dominant and dominant based complementary epistasis and hence the intensive selection is required for rapid genetic gain in these traits. Positive and significant values of intergenerational correlation and regression were observed for all the characters, which indicated the effectiveness and reliability of selection for these characters. The results indicate that progeny performance in the F_3 generation can be suggestive for selecting superior progenies in subsequent generations.

Keywords

Platykurtic, Duplicate Dominate Epistasis, Skewness, Kurtosis and Intergenerational correlation and regression

INTRODUCTION

Wheat (*Triticum* spp.) is the important cereal grain, belongs to the family Poaceae, the largest family within the monocotyledonous plants, which originated from the Levant region of the Near East and Ethiopian Highlands. The cytogenetic investigation of wild einkorn wheat indicates that it was first grown in the Karacadag Mountain in Southeastern Turkey but now cultivated worldwide **(**Bonjean and Angus**,** 2001**).** It is a disomic allohexaploid (2*n* = 6x = 42) with three distinct but genetically related (homoeologous) genomes A, B and D each with 7 chromosomes. Allopolyploids arise from processes of interspecific hybridization followed by spontaneous chromosome doubling and contain the entire genome of two or more species in the homozygous condition. It has a monstrously large genome of 16 million kilobases per haploid cell with 80 per cent repetitive DNA (Bennett and Smith, 1976**).** Wheat is the second most important food crop after rice both in terms of area, production and consuming countries in the world. The production of wheat has shown a tremendous increase after the green revolution. In the major states viz.. Uttar Pradesh, Punjab and Haryana. They account for nearly 70 per cent of the area due to the availability of better irrigation facilities and congenial weather conditions. The area, production and productivity of Haryana was 2.52 mha, 11.68 mt and 4.62 t/ha respectively (Anonymous, 2018).

Crop improvement for grain yield has been achieved in wheat through effective use of F_2 and F_3 segregating populations and fixing desirable character combinations. However, studies indicate that there are still possibilities to increase the yield output through appropriate breeding technologies in wheat (Jayaprakash *et al.*, 2017). The effectiveness of early generation selection was studied by many researchers in wheat through correlations between F_2 and F_3 (Pawar *et al.,* 1989) and between F_3

and F_4 (Saini and Gautam, 1990). Grain yield is a complex trait and is the result of the interaction of many variables. Parent progeny regression is a method commonly used for estimating the amount of genetic potential transferred from parent to progeny. The parent progeny correlation and regression between two generations shows lesser susceptible to the environmental effect and is very useful for selecting in segregating population for the development of new improved genotypes (Suwarto *et al.,* 2015). The present investigation was aimed at studying the descriptive statistics (third and fourth-degree statistics) response of selection for yield and its component characters through parent progeny correlation and regression method between F_3 and F_4 generations for fixing better recombinants in successive generations.

MATERIALS AND METHODS

The experiment was conducted in the Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar. Genetic material consisted of 250 F_3 and F_4 progenies derived from the cross between WH 711 x PBW 698. The parent PBW 698 is resistant to yellow rust, whereas, WH 711 is susceptible to yellow rust. The parents along with their F_3 progenies were sown in the field during the Rabi season of 2016-17 and their subsequent F_4 progenies were sown during 2017-18 Rabi season along with the parents. The F_3 and F_4 progenies were sown in a single row of 1m length. The parents, F_3 and F_4 plants were evaluated for variation in morphological traits like Plant height (cm), Flag leaf length (cm), Flag leaf area (cm^2), Spike length (cm), Spike weight (g), 100 grain weight (g), Grain weight/spike, the number of grains/spike, the number of tillers/plant, grain yield/plant (g), Biological yield/plant (g), Harvest index (%) and Days to heading. The superior plants were selected from the population of F_3 progenies and subsequently, their F_4 progenies were grown in the next year. Three plants were selected randomly from each line for recording data on quantitative traits from each parent and from the progeny of F_3 and F_4 population. The average of observations recorded on these three plants was considered for statistical analysis. Mean values were used to estimate the parent-offspring correlation and regression between F3 and F4 generations. Skewness, the third-degree statistics and kurtosis, the fourth-degree statistics were estimated as per Snedecor and Cochran (1994) to understand the nature of the distribution of progenies for growth and yield-related traits. The mean values of F_3 and F_4 generation were used for estimation of coefficients of skewness and kurtosis using 'SPSS' software program. Kurtosis indicates the relative number of genes controlling the traits (Robson, 1956). Similarly, the lack of symmetry, *i.e.,* skewness was recognized based on the coefficient of skewness values which range from -3 to +3. The type of distribution based on the skewness values is as follows.

Intergenerational correlation coefficients (r) were calculated for each character between F_4 and F_5 generations. In each case, progeny means (y) of F_4 generation were regressed on the progeny means (x) of F_3 generation.

$$\text{Intergenerational correlation (r)} = byx \times \frac{óx}{óy} = \frac{\text{Covariance (xy}}{\text{Variance of x}}$$

Where,

óx = Standard deviation of x
óy = Standard deviation of y
Cov(x,y)= covariance between x and y

The degree of dependence of one variate on the other is measured by the regression coefficient (b). For regression analysis, parent progeny regression coefficients were calculated by regression of the mean value of a character in the progeny (F_4) upon the value of a character in the parent (F_3).

$$b_{\text{(parent-offspring)}} = \frac{\text{Covariance of parent-offspring}}{\text{Variance of parent}}$$

b= regression coefficient

The way to test the null hypothesis (b=0) is through the application of t' test: $t = b_{yx}/ S.E.(b)$

Then, this t-value was compared with t value from the table at the desired level of significance with the degree of freedom of the S.E. (b)

RESULTS AND DISCUSSION

The F_4 families raised from the selected F_3 populations on the basis of phenotypic performance of the crosses exhibited superior performance for yield and its contributing traits. The results revealed that there was a strong association between the yield of individual F_3 selection and the mean yield of corresponding F_4 families indicating the superiority of both individual and progeny performance. Similar improvement was observed in other yield contributing traits *viz*., number of tillers/ plant, number of grains/ spike, spike weight, spike length and harvest index.There was a relatively less magnitude in variation for plant height among the parents during both the years and the F_3 and F_4 generation progeny means gaining the plant height towards the dwarf parent. The mean value of flag leaf length in F_3 and F_4 were intermediate in plant type between both the parents. An adequate aggregate of variation was observed among the parents during both the seasons in the flag leaf area and the mean value of F_3 and F_4 generation tended towards the parent PBW698. WH711 showed higher mean values for spike length than PBW698 during 2016-17 and 2017-18, whereas the mean value of F_3 and F_4 were near to the mean value of parent PBW698. The mean value of spike weight in F_3 and F_4 exhibited the mid parental values in comparison with both the parents and the mean value of grain weight/ spike in F_3 and F_4 were near to the mean value of parent PBW698. WH711 exhibited higher mean value for the number of grains/ spike during both the year, whereas, the mean value of F_3 and F_4 generation was intermediate between both the parents. The parent PBW698 had a comparatively more number of tillers than the parent WH711 during the year 2017-2018. The intermediate number of tillers were observed in both the years. There was a high magnitude in variation for grain yield/ plant among the parents during both the years, but the mean value of F_3 and F_4 were intermediate between both the parents. There was a high magnitude of variation for grain yield/ plant among the parents during both the years but the mean value of F_3 and F_4 were intermediate between two parents. The mean valve of biological yield/ plant in F_3 and F_4 generation drift towards the parent PBW698 and the harvest index mean values in F_3 and F_4 were founded akin to each other. The mean values of all the character were intermediate to both the parents and none of the characters exhibited transgressive segregation (**Table 1**). Transgressive segregation may arise due to the dominance and dominance interaction and also by the additive x additive interaction which is fixable. Similar findings were reported by Thirugnanakumar *et al.* (2011).

Table 1. Mean performance of parents and progenies of F_3 and F_4 generations derived from the cross WH711 x PBW698 for different characters in bread wheat.

Traits	WH711		PBW698		F_3	F_4
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Plant height (cm)	102.1±2.8	105.0±2.8	96.3 ±2.2	98.3±1.8	99.1±2.2	97.2±2.1
Fag Leaf length (cm)	32.3±0.5	33.5±0.8	25.3 ±0.8	26.5±0.8	27.3±1.8	30.1±1.2
Flag leaf area (cm^2)	65.2±1.5	68.2±1.4	58.3 ±1.7	60.1±1.7	59.7±3.9	61.3±4.5
Spike length (cm)	12.0±0.5	11.8±0.4	8.5±0.8	9.1±0.6	9.8±0.6	10.2±0.5
Spike weight (g)	3.4±0.2	3.2±0.3	4.0 ±0.7	4.1±0.5	3.7±0.9	3.8±0.4
Grain weight/ spike (g)	2.8±0.5	2.5±0.5	3.2±0.3	3.5±0.8	3.4±0.8	3.0±0.1
Number of grains/ spike	59.6±1.5	58.0±2.8	50.0±0.8	51.0±0.7	53.9±1.7	54.3±1.3
100 grain weight (g)	4.2±0.5	4.0±0.2	4.4±0.5	4.5±0.2	4.5±0.7	4.3±0.2
Number of tillers/ plant	7.0±0.5	8.0±0.5	11.3±0.7	12.0±0.5	9.1±0.8	9.6±0.5
Grain yield/ plant (g)	15.0±1.4	13.6±1.5	21.0±1.2	20.0±1.1	18±1.5	19.3±1.2
Biological yield/ plant (g)	34.6±1.4	33.6±2.5	45.0+1.4	44.0±1.4	43.4±1.3	41.1±1.6
Harvest index (%)	43.6±2.7	40.4±2.2	46.6±2.9	44.0±2.1	41.5±1.9	42.3±2.5
Days to heading	86.0±1.3	88.0±1.8	93.0±0.5	94.0±0.8	89.0±1.4	87.0±1.6

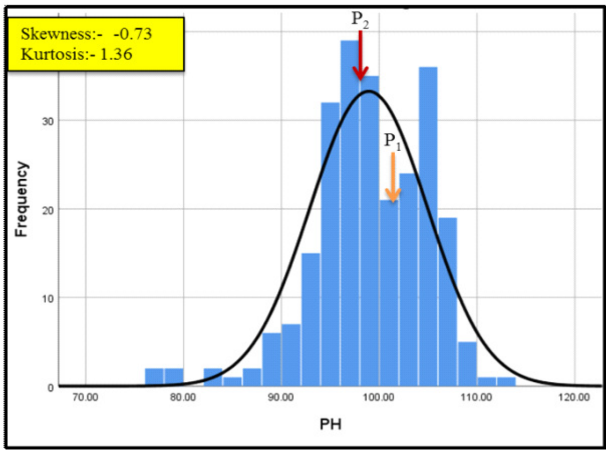
Table 2. Estimation of range, coefficient of variation, third (Skewness) and fourth (Kurtosis) degree statistics in the F_3 generation.

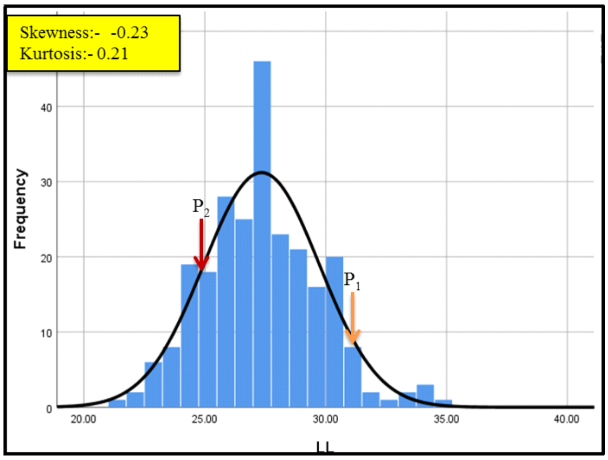
Traits	Range	C.V. (%)	Skewness	Kurtosis
Plant height (cm)	76.00-113.00	3.8	-0.73	1.36
Flag Leaf length (cm)	21.50-35.00	8.6	0.23	0.21
Flag leaf area (cm^2)	43.00-80.00	11.4	0.38	0.80
Spike length (cm)	7.00-13.33	9.9	-0.43	0.03
Spike's weight (g)	2.40-4.60	9.1	-0.44	0.18
Grain weight/ spike (g)	1.90-4.30	9.4	-0.60	0.51
Number of grains/ spike	41.00-63.00	5.4	-0.26	1.17
100 grain weight (g)	3.20-5.30	7.1	0.28	-0.07
No of tillers/ plant	4.00-13.00	13	-0.26	-0.62
Grain yield/ plant (g)	10.00-24.00	14	-0.40	0.48
Biological yield/ plant (g)	32.00-52.00	7.1	-0.01	0.14
Harvest index (%)	27.00-52.00	8.6	0.09	0.20
Days to heading	82.00-98.00	2.4	0.01	0.10

Both the generation revealed the high mean and wide range of expression of different characters (**Table 1** and **Table 2**) which indicates the presence of sufficient variability existed in the genetic material selected for the study and indicates the scope for selection of suitable breeding material for crop improvement Yadawad *et al.* (2015), Shankarrao *et al.* (2010), Kaushik *et al.* (2013), Maurya *et al.* (2014), Kalimullah *et al.* (2012) and Basavaraj *et al.* (2015) also reported similar results. The coefficient of variation was higher in F3 generation than in F_4 generation for all the characters except flag leaf length, flag leaf area and harvest index (**Table 1** and **Table 2**). This indicates the low heterozygosity in the F_4 generation.

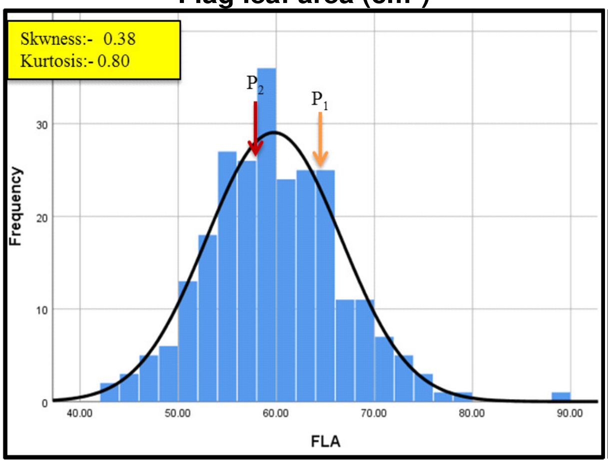
In both the seasons negatively skewed platykurtic (**Table 1 and Table 2**) for plant height, spike length, spike weight, grain weight/ spike, the number of grains/ spike, the number of tillers/ plant, grain yield/ plant and biological yield/ plant, indicated that these traits were governed by a number of genes and the majority of them expressing dominant and dominant based duplicate epistasis, and hence mild selection is expected to result in a rapid genetic gain for these traits. The positively skewed platykurtic (**Table 1 and Table 2**) for leaf length, flag leaf area, 100-grain weight, harvest index and days to heading suggest that these traits were governed by a large number of genes and the majority of them with dominant and dominant based complementary epistasis and hence intense selection is required for rapid genetic gain in these traits. Similar results reported by Pooni *et al.* (1977) (**Fig 1 and Fig 2**).

Plant height (cm) Flag leaf length (cm)

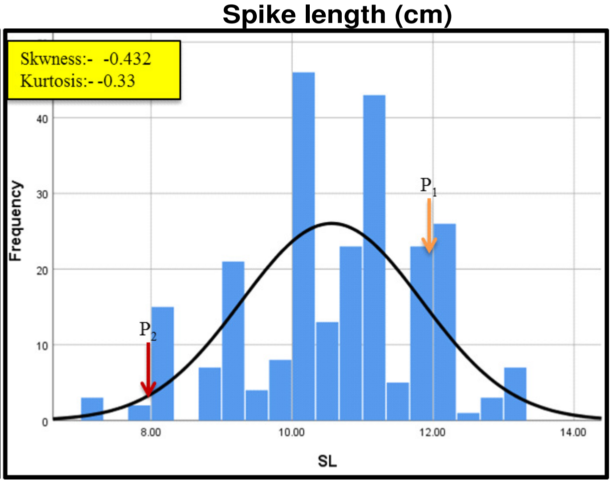




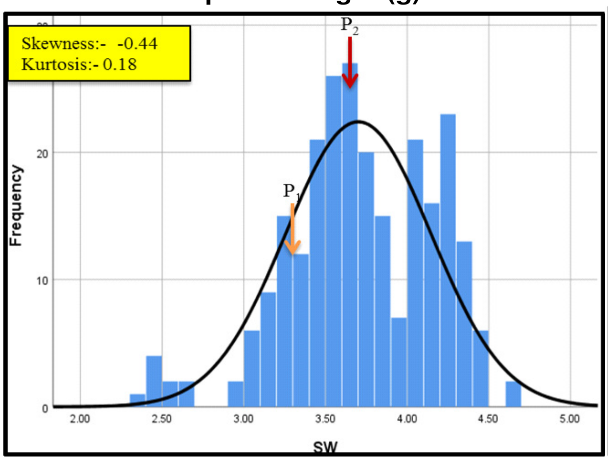
Flag leaf area (cm²)



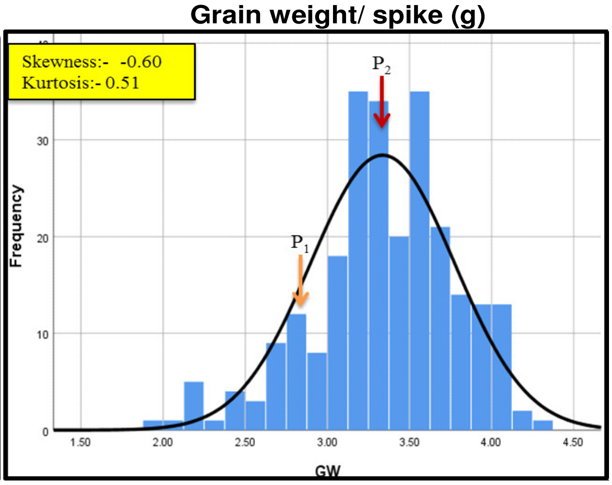
Spike length (cm)

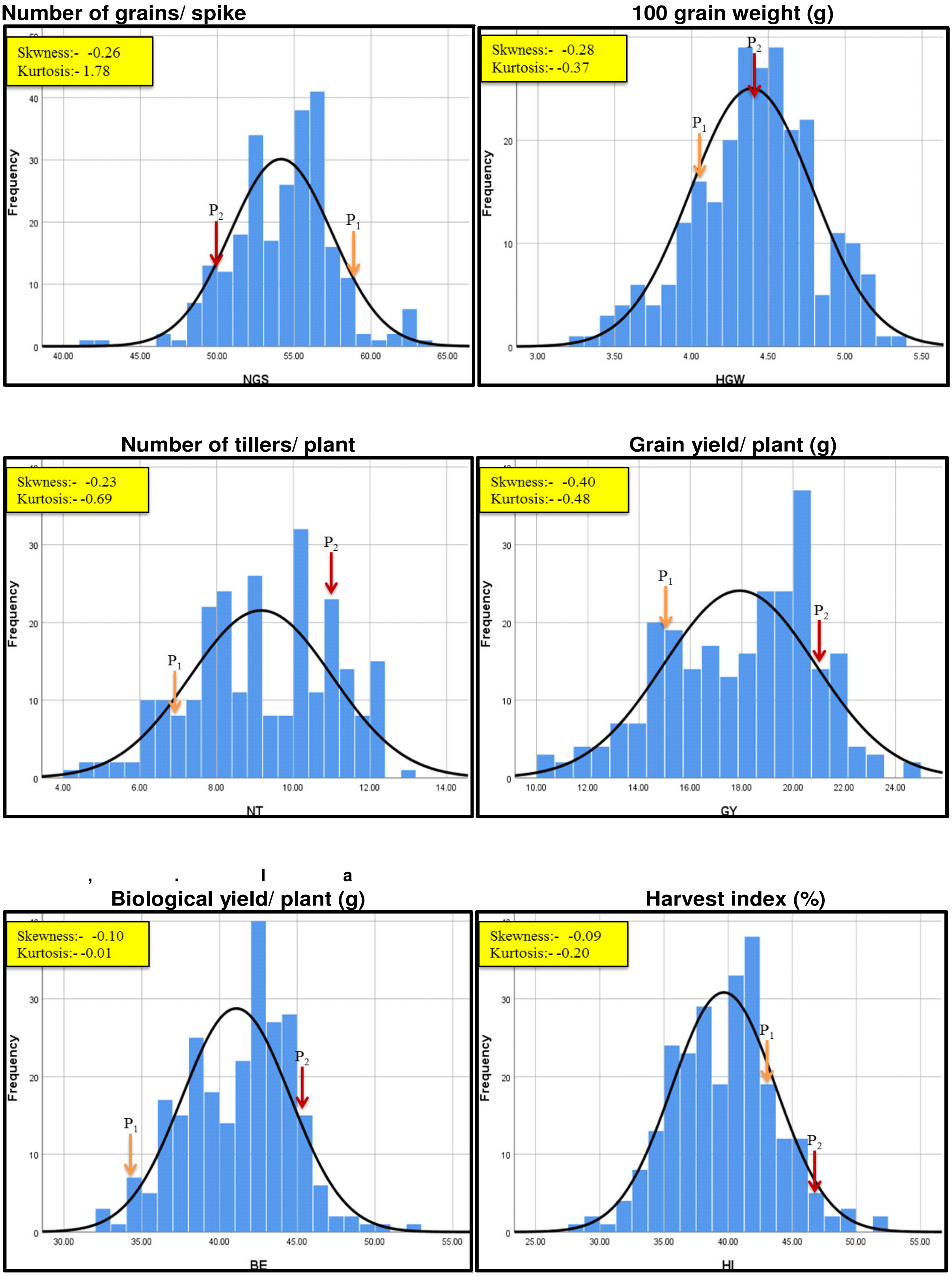


Spike's weight (g)



Grain weight/ spike (g)

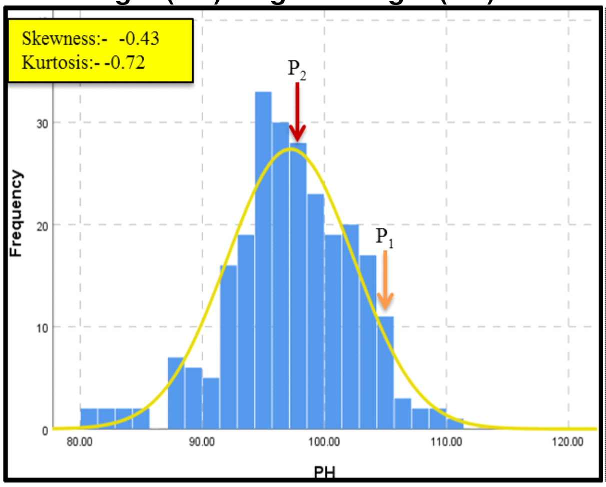


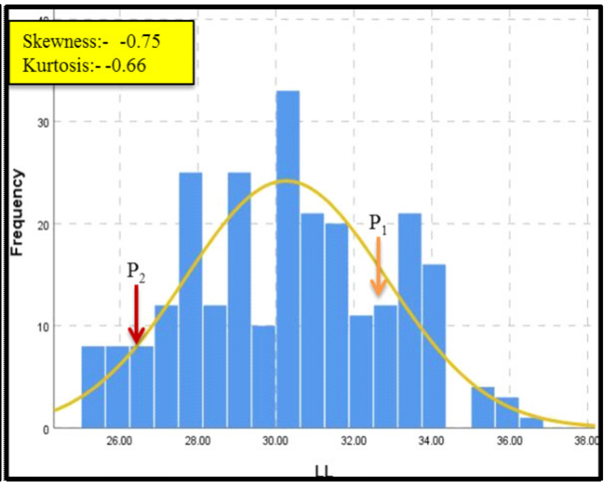


P_1:- Parent WH711 P_2:- Parent PBW698

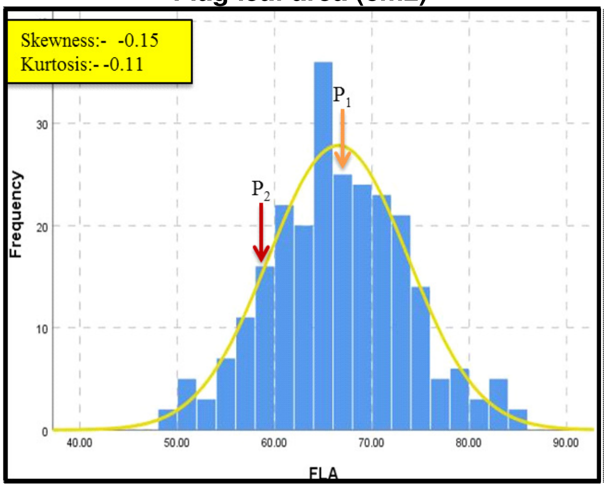
Fig 1. Frequency distribution patterns of different traits in F_3 generation

Plant height (cm) Flag leaf length (cm)

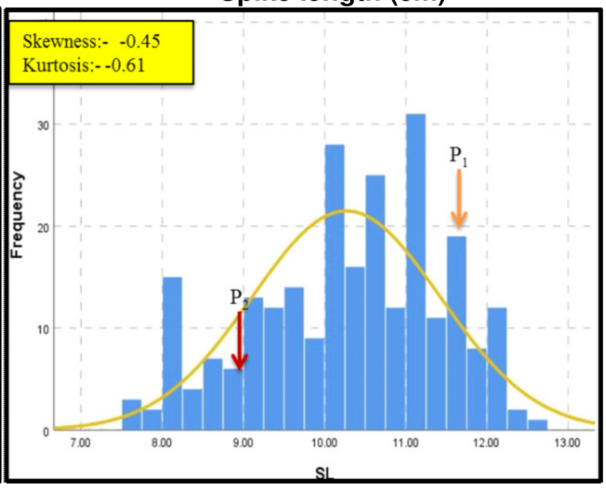




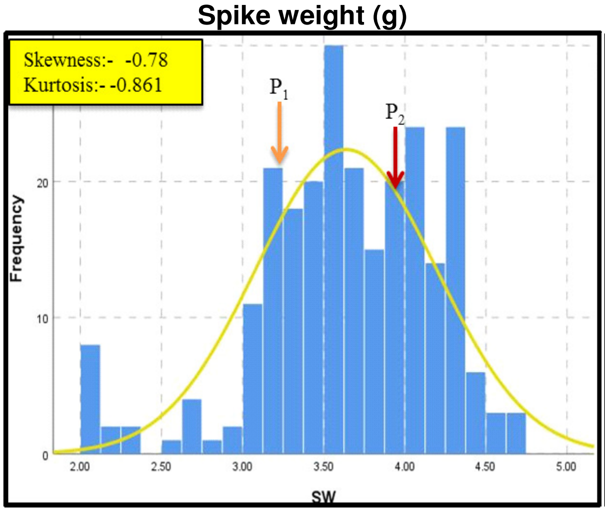
Flag leaf area (cm2)



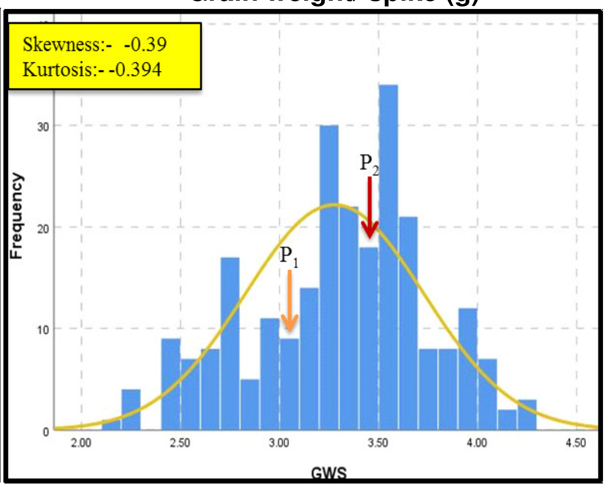
Spike length (cm)

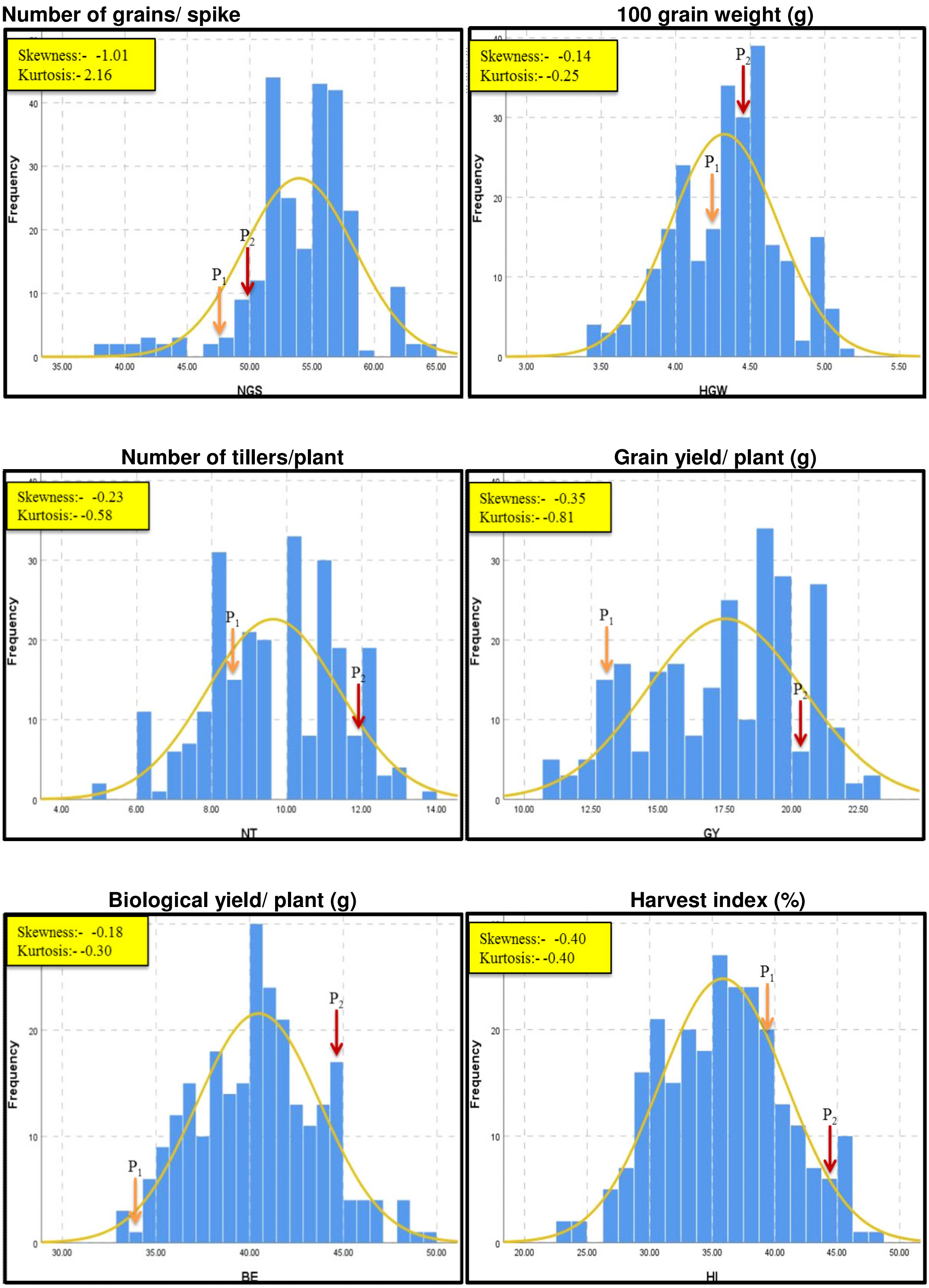


Spike weight (g)



Grain weight/ spike (g)





P_1:- Parent WH711 P_2:- Parent PBW698

Fig 2. Frequency distribution patterns of different traits in the F_4 generation

Intergenerational correlation studies by parent-offspring regression method give an idea about the extent of transmission of the genetic variation in a character from one generation to another generation. Due to minimal environmental effects, the parent progeny correlation and regression between the two generations is very useful for the selection of superior recombinants in the segregating population for utilization in breeding programs to develop new and improved genotypes. The F_3 generation progenies depicted highly significant and positive values of intergenerational correlation and regression with F_4 generation progenies for all the characters in the crosses consider for the present study (**Table 3**). The significant and positive values of intergenerational correlation of grain yield/ plant in this study is in concordance with findings of Wagoire *et al.* (1999) for grain yield and Suwarto *et al.* (2015) for plant height in F_2 and F_3 generations. Shanatava *et al.* (2014) reported that intergenerational correlation coefficients between F_2 and F_3 were positive and significant for almost all the characters except for plant height. A positive and significant intergeneration correlation was also observed for grain number/ spikelet and grain number/ ear by Islam *et al.* (1984) in wheat.

Table 3. Estimation of range, coefficient of variation, third (Skewness) and fourth (Kurtosis) degree statistics in in F_4 generation

Traits	Range	C.V. (%)	Skewness	Kurtosis
Plant height (cm)	80.00-111.00	3.7	-0.43	0.78
Leaf length (cm)	25.00-36.00	8.5	0.07	0.66
Flag leaf area (cm^2)	49.00-85.00	13.6	0.10	0.11
Spike length (cm)	7.60-12.50	10.2	-0.40	-0.61
Spike's weight (g)	2.00-4.00	6.6	-0.78	0.86
Grain weight/ spike (g)	2.17-4.20	6.3	-0.39	-0.39
Number of grains / spike	38.00-64.00	4.3	-0.11	2.16
100 grain weight (g)	3.40-5.10	4.8	0.14	-0.12
No of tillers/ plant	5.00-13.00	10.9	-0.23	-0.58
Grain yield/ plant (g)	10.00-23.00	11.8	-0.35	-0.81
Biological yield/ plant (g)	33.00-49.00	6.8	0.18	0.33
Harvest index (%)	23.00-48.00	11.7	0.72	0.40
Days to heading	83.00-90.00	3.2	-0.27	0.33

Table 4. Regression coefficient and intergenerational correlation between F_3 and F_4 generation progenies derived from the cross WH711 x PBW698 for different characters in bread wheat

Traits	Correlation F3 – F4	Regression F3 – F4
Plant height (cm)	0.514**	0.721**
Leaf length (cm)	0.351**	0.591**
Flag leaf area (cm^2)	0.621**	0.691**
Spike length (cm)	0.721**	0.831**
Spike's weight (g)	0.717**	0.334**
Grain weight/ spike (g)	0.551**	0.731**
Number of grains / spike	0.442**	0.661**
100 grain weight (g)	0.635**	0.794**
No of tillers/ plant	0.678**	0.824**
Grain yield/ plant (g)	0.698**	0.758**
Biological yield/ plant (g)	0.505**	0.709**
Harvest index (%)	0.474**	0.689**
Days to heading	0.432**	0.561**

The present study confirmed the usefulness of early generation selection, and it may have a greater impact on the breeding program of wheat with respect to yield component characters and single plant yield. Parent-offspring correlation showed a strong association among all the characters in F_3 and F_4 generation which is indicative of effective selection at this stage. The results indicated that progeny performance in $F_{3\text{ is a good}}$ indicative of F_4 performance for all the traits.

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