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ISSN: 0975-928X

Volume: 10

Number:2

EJPB (2019) 10(2):592-600

DOI:10.5958/0975-928X.2019.00075.9



Research Article

Frequency distribution of yield related traits in BC₁F₁, BC₂F₁ and BC₂F₂ backcross population of maize

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(Received: 10 Jun 2019; Revised: 12 Jun 2019; Accepted: 12 Jun 2019)

Abstract

The number of genes controlling the traits and the nature of gene action are the important criteria for the selection of individual traits in a segregating population. The current study is focused to analyze the skewness and kurtosis in the backcross population of UMI1200β⁺ × HKI163 and UMI1230β⁺ × HKI163. The BC₂F₂ population showed positive skewness and platykurtic distribution for plant height. In the present study the dominant × dominant based complementary gene action played a role and more number of genes controlled the plant height. Hence, rigorous selection is needed to achieve the genetic gain in the later generation. The negative skewness and platykurtic distribution was recorded for single plant yield in UMI1200β⁺ × HKI163 which indicated the duplicate gene action and required mild selection to fix the individual traits for rapid genetic gain.

Key words

Maize, gene action, skewness, kurtosis, marker assisted backcross breeding.

Introduction

Maize (*Zea mays* L.) is one of the primary cereal grown all over the world in wide areas and regions due to its broader availability (Kogbe and Adediran, 2003) and is the staple food for most of the diverse populations of the world. The primary purpose of the maize grains is food but now is expanded to feed stocks as well (Pimentel and Patzek, 2005). In the year 2018 the production all over the world for maize was found to be 1078.56 million tones with a cultivated area of 186.86 million hectares and a productivity of 5.77 tonnes ha⁻¹. The frequency distribution is the visual graphical representation of the category wise number of individuals on a scale of measurement (Gravetter *et al.*, 2000). The skewness is used to measure the symmetry of the population, more accurately the absence of symmetry and is used to represent the nature of gene action (Fisher, 1932). Kurtosis measures whether the data is left or right tailed in relation to its normal distribution and also the number of genes that controls the trait (Robson, 1956). The non-additive gene action will be dominant and the genotype influences the skewness of the distribution. The positive skewness is related to the complementary gene action whereas the negative skewness is related to the duplicate gene

action. Kurtosis was divided into three categories by Kapur (1980) as (i) leptokurtic (positive kurtosis) (ii) platykurtic (Negative kurtosis) and (iii) Mesokurtic (Zero kurtosis). With these views in mind, the present study was aimed at studying backcross populations (BC₁F₁, BC₂F₁ and BC₂F₂) for descriptive statistics, frequency distribution patterns based on their skewness and kurtosis in order to obtain useful individuals with high yield combined with appropriate agronomical traits.

Materials and Methods

The backcross population of UMI1200β⁺ × HKI163 and UMI1230β⁺ × HKI163 were developed in order to introgress QPM trait in to high beta carotene maize inbred lines *viz.*, UMI1200β⁺ and UMI1230β⁺. The crosses were made during Kharif 2016 and the F₁'s of UMI1200β⁺ × HKI163 and UMI1230β⁺ × HKI163 were evaluated during Rabi 2016. The F₁ progenies were backcrossed with the recurrent parents and were evaluated during Kharif 2017. To generate the BC₂F₁ generation the progenies from BC₁F₁ were backcrossed with their recurrent parents and were evaluated in the Rabi 2017. These were selfed to

generate the BC₂F₂ generation that was evaluated in the kharif 2018.

Fourteen biometrical traits were recorded in the backcrossed (BC₁F₁ and BC₂F₁) and selfed (BC₂F₂) progenies that included days to tasseling (days), days to silking (days), plant height (cm), ear height (cm), tassel length (cm), number of tassel branches (Nos.), leaf length (cm), leaf breadth (cm), cob length (cm), cob girth (cm), number of kernel rows per cob (Nos), number of kernels per row (Nos), 100 grain weight (g) and single plant yield (g). The mean values of the agronomical traits in backcross population were used for the calculation of descriptive statistics with the help of the SPSS 16.0 software. Descriptive statistics *viz.*, mean, median, mode, range, standard deviation, variance, skewness and kurtosis were used to find the nature of gene action.

Result and Discussion

Skewness and kurtosis are the higher order statistics which is used to study the nature of gene action and the number of genes controlling the traits. Skewness provides an idea about the cluster of deviations that is above or below the measure of central tendency and describes the positive or negative extend of the individuals in the population where the positive skewness is associated with complementary gene action and the negative skewness is associated with duplicate gene action. Kurtosis provides an idea of peakedness over the population, positive kurtosis indicates the presence of gene action and is governed by lesser number of genes whereas, negative kurtosis indicates the absence of gene action and is controlled by a large number of genes (poorni *et al.*, 1977).

Frequency distribution for fourteen yield contributing traits was studied for UMI1200β⁺ × HKI163 in BC₁F₁, BC₂F₁ and BC₂F₂ generations (Table 1 and Figure1). Among the traits the cob length, single plant yield, days to silking and plant height showed wide variation. In BC₁F₁, The plant height ranged from 191.00 cm to 202.00 cm with an average of 196.99 cm and days to silking showed narrow range from 57.00 to 60.00 days with a mean of 58.67. The trait plant height and days to silking recorded negative skewness and platykurtic distribution showed duplicate epistasis gene action and the trait is controlled by a large number of genes. The single plant yield showed wide range from 155.00 g to 169.50 g with an average of 161.57 and the cob length showed the lowest range from 10.70 cm to 17.00 cm with a mean of 15.73. The positive skewness and platykurtic distribution was observed for single plant yield indicating that the genes were governed by dominant × dominant based complementary

gene action and controlled by a large number of genes. The cob length recorded negative skewness and leptokurtic distribution which showed complementary gene action and the trait is controlled by lesser number of genes. In BC₂F₁ population, wide range of variation (160.00 cm to 166.50 cm) was observed for plant height with an average of 161.32cm. The days to silking showed the range from 56.00 to 60.00 days with a mean value of 58.69. The trait plant height showed positive skewness and leptokurtic distribution which indicated complementary gene action and is controlled by lesser number of genes. The days to silking reported positive skewness and platykurtic distribution which showed complementary gene action. The single plant yield varied from 90.00 g to 105.00 g with an average of 95.60 g. The cob length recorded the narrow range of variation from 10.00 cm to 14.00 cm with a mean value of 16.45cm. The single plant yield and the cob length showed positive skewness and leptokurtic distribution which resulted in complementary gene action. In the BC₂F₂ population wide range of variation (157.00 cm to 166.00 cm) was observed in plant height with a mean value of 155.04 cm. The variation in plant characters of BC₂F₂ were shown in Figure 3. The days to silking recorded the range from 58.00 to 63.00 days with an average of 61.50 days. Positive skewness and platykurtic distribution was noticed in plant height and days to silking which resulted in complementary gene action. The single plant yield ranged from 66.00 g to 95.00 g with a mean value of 82.00 g. The cob length showed variation between 8.40 cm to 15.10 cm with an average of 14.08 cm. The single plant yield and cob length recorded negative and platykurtic distribution which indicated duplicate gene action. The results are in accordance with Tamil kumar (2012) and Suresh (2014).

Similarly, the frequency distribution for fourteen yield contributing traits was studied for UMI1230β⁺ × HKI163 in BC₁F₁, BC₂F₁ and BC₂F₂ generations (Table 2 and Figure2). In the BC₁F₁ population wider range (170.00 cm to 207 cm) was observed for plant height with a mean of 184.29cm. The days to silking recorded the range from 52.00 to 54.00 days with an average of 52.40 cm. Plant height showed positive skewness and platykurtic distribution resulted in complementary gene action. The days to silking showed positive skewness and leptokurtic distribution indicating the complimentary gene action. The single plant yield scored mean value of 142.62 g ranging from 133.70 g to 149.70 g. The cob length recorded the range from 14.00 cm to 14.80 cm with an average of 14.31cm. The single plant yield noticed positive and leptokurtic distribution resulting in complementary gene action. The cob length

recorded negative skewness and leptokurtic distribution resulted in duplicate gene action. In BC₂F₁, higher range (150.00 cm to 157.00 cm) was recorded in plant height with a mean of 152.28 cm. The days to silking showed a mean value of 61.52 with the range from 60.00 to 63.00 days. For plant height the frequency distribution pattern showed positive skewness and leptokurtic distribution indicates complementary gene action. The days to silking recorded negative skewness and platykurtic distribution where duplicate gene action is predominant. The single plant yield recorded a mean value of 87.80 g with a range of 83.00g to 100.00 g. The cob length showed the range of 13.00 cm to 14.30 cm with an average of 13.33 cm. The frequency distribution showed that single plant yield with positive skewness and platykurtic distribution resulted in complementary gene action. The cob length frequency distribution recorded positive skewness and leptokurtic distribution which indicates complementary gene action. In BC₂F₂, the plant height showed a mean value of 146.53cm with the range from 135.50 cm to 157.50 cm and days to silking recorded the range of 60.00 to 64.00 days with an average of 62.67 days. The plant height recorded positive skewness and platykurtic distribution indicates complementary gene action. The variation in plant characters of BC₂F₂ were shown in Figure 3. The days to silking was recorded with negative skewness and leptokurtic distribution which indicates duplicate gene action. The single plant yield had a higher range (83.30 g to 111.50 g) with a mean value of 95.81g and cob length the range recorded from 11.40 cm to 17.00 cm with an average of 14.80 cm. The frequency distribution showed that the single plant yield recorded positive kurtosis and leptokurtic distribution with the complementary gene action. The cob length showed negative kurtosis and platykurtic distribution resulted in duplicate mode of gene action. The results are in accordance with Pukalenty *et al.*, 2018.

The backcross and selfed population (BC₁F₁, BC₂F₁ and BC₂F₂) showed a wide range of variations for plant height, days to silking, cob length and single plant yield. Among the traits plant height showed positive skewness and platykurtic distribution resulted in complementary gene action. The cob length showed negative skewness and platykurtic in its distribution which indicates the duplicate gene action. Hence the present study indicated that the traits controlled by complementary gene action have to be selected in the later generation and for the traits controlled by duplicate gene action, selection can be practiced in the early generation.

Acknowledgement

This work was financially supported through the Department of Biotechnology, Government of India by the project entitled “Enrichment of nutritional quality in maize through molecular breeding “(BT / PR 10922AGII/106/9442014). We extend our gratitude to the Centre of Innovation (NADP-RKVY), Agricultural College and Research Institute, Madurai for providing lab facilities. The funders had no role in the work designed, data collection and analysis or decision and preparation of manuscript.

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Table 1. Estimation of range, mean, standard deviation and variance of UMI1200 β + \times HKH163

Traits	BC ₁ F ₁					BC ₂ F ₁					BC ₂ F ₂				
	Range		Mean	Standard deviation	Variance	Range		Mean	Standard deviation	Variance	Range		Mean	Standard deviation	Variance
	Min	Max				Min	Max				Min	Max			
DT	55.00	57.00	55.97	0.81	0.66	56.00	60.00	58.69	0.95	0.91	56.00	60.00	58.90	1.14	1.30
DS	57.00	60.00	58.67	0.96	0.92	60.00	63.00	61.39	0.94	0.89	58.00	63.00	61.50	1.35	1.83
PH	191.00	202.00	196.99	5.72	32.66	160.00	166.50	161.32	1.33	1.77	157.00	166.00	155.04	2.24	5.01
EH	78.00	88.00	82.99	3.44	11.81	75.00	79.00	76.84	1.51	2.29	57.00	76.00	62.87	4.49	20.16
TL	42.00	45.00	43.81	0.77	0.59	30.00	33.00	30.81	0.77	0.59	20.00	35.40	31.86	2.41	5.83
NTB	14.50	16.60	15.74	0.79	0.62	9.00	14.00	12.34	1.24	1.53	7.00	17.00	11.00	2.18	4.77
LL	65.00	68.00	65.70	1.41	1.98	54.00	59.00	55.14	0.95	0.90	32.90	74.20	53.53	7.33	53.75
LB	8.10	8.50	8.30	0.26	0.07	6.70	7.80	6.99	0.25	0.06	5.50	7.20	6.45	0.34	0.12
CL	10.70	17.00	15.73	0.91	0.83	10.00	14.00	16.45	0.62	0.39	8.40	15.10	14.08	1.31	1.71
CG	15.00	16.90	15.68	0.71	0.51	14.00	15.90	16.47	0.63	0.40	10.00	15.90	11.90	1.22	1.48
NKRC	14.00	16.00	14.93	1.12	1.26	12.00	16.00	14.39	1.64	2.69	8.00	16.00	12.75	1.80	3.26
NKR	30.00	33.00	31.97	1.17	1.36	25.00	29.00	25.76	0.86	0.74	22.30	29.50	21.00	2.06	4.25
100KW	28.60	33.90	32.08	1.66	2.74	25.00	26.60	25.48	0.50	0.25	15.00	33.00	27.00	3.49	12.15
SPY	155.00	169.50	161.57	11.95	142.70	90.00	105.00	95.60	15.92	253.35	66.00	95.00	82.00	7.20	51.91

Note: DT- Days to tasseling; DS- Days to silking; PH- Plant height; EH- Ear height; TL- Tassel length; NTB- Number of tassel branches; LL- Leaf length; LB-Leaf breadth; CL- Cob length; CG- Cob girth; NKRC- Number of kernel rows per cob; NKR- Number of kernel rows; KW- Kernel weight; SPY- Single plant yield.



Table 2. Estimation of range, mean, standard deviation and variance of UMI1230 β \times HKI163

Traits	BC ₁ F ₁					BC ₂ F ₁					BC ₂ F ₂				
	Range		Mean	Standard deviation	Variance	Range		Mean	Standard deviation	Variance	Range		Mean	Standard deviation	Variance
	Min	Max				Min	Max				Min	Max			
DT	55.00	57.00	55.38	0.93	0.87	58.00	60.00	58.97	0.82	0.67	56.00	62.00	59.75	1.39	1.94
DS	52.00	54.00	52.40	1.52	2.30	60.00	63.00	61.51	0.79	0.62	60.00	64.00	62.67	0.95	0.90
PH	170.00	207.00	184.29	10.71	114.77	150.00	157.00	152.28	1.37	1.86	135.50	157.50	146.53	4.71	22.14
EH	70.00	75.00	73.02	3.31	10.94	51.00	55.00	51.83	1.01	1.02	35.40	69.60	51.06	7.16	51.22
TL	40.00	44.00	43.01	2.57	6.58	28.00	29.50	28.44	0.48	0.23	23.25	46.00	31.79	4.90	24.01
NTB	14.00	18.00	14.89	0.97	0.94	11.00	15.00	12.05	1.15	1.31	8.00	16.00	12.45	2.09	4.37
LL	80.00	105.00	87.31	7.79	60.68	55.00	56.00	55.43	0.45	0.20	41.20	73.40	54.78	7.51	56.43
LB	9.10	11.50	10.29	0.89	0.79	7.40	7.80	7.61	0.13	0.02	5.10	10.80	7.83	1.11	1.23
CL	14.00	14.80	14.31	0.34	0.12	13.00	14.30	13.33	0.26	0.07	11.40	17.00	14.80	1.41	1.99
CG	14.00	15.99	15.18	0.81	0.65	11.00	11.50	11.18	0.14	0.02	11.30	16.73	13.41	0.98	0.97
NKRC	14.00	16.00	14.81	0.82	0.67	12.00	13.00	12.38	0.49	0.24	12.00	14.00	12.32	0.74	0.55
NKR	31.00	37.00	33.47	1.04	1.09	25.00	26.50	25.52	0.53	0.28	18.00	30.00	24.30	2.90	8.42
100KW	28.10	34.90	31.38	1.44	2.08	25.00	27.90	25.85	0.78	0.60	18.60	38.50	28.68	4.92	24.16
SPY	133.70	149.70	142.62	0.93	0.87	83.00	100.00	87.80	5.44	29.60	83.30	111.50	95.81	5.96	35.54

Note: DT- Days to tasseling; DS- Days to silking; PH- Plant height; EH- Ear height; TL- Tassel length; NTB- Number of tassel branches; LL- Leaf length; LB-Leaf breadth; CL- Cob length; CG- Cob girth; NKRC- Number of kernel rows per cob; NKR- Number of kernel rows; KW- Kernel weight; SPY- Single plant yield.



Table 3. Estimation of skewness and kurtosis in the BC₁F₁, BC₂F₁ and BC₂F₂ of UMI1200β⁺×HKI163 and UMI1230β⁺×HKI163

Traits	UMI1200β ⁺ ×HKI163						UMI1230β ⁺ ×HKI163					
	BC ₁ F ₁		BC ₂ F ₁		BC ₂ F ₂		BC ₁ F ₁		BC ₂ F ₁		BC ₂ F ₂	
	Skewness	Kurtosis	Skewness	Kurtosis	Skewness	Kurtosis	Skewness	Kurtosis	Skewness	Kurtosis	Skewness	Kurtosis
DT	0.03	-0.55	-0.15	-0.17	0.17	-0.72	1.11	0.26	0.06	-1.51	-0.35	-0.22
DS	-0.03	-0.74	0.25	-0.79	0.25	-0.70	1.11	0.27	-0.32	-0.36	-0.67	0.41
PH	-0.35	-0.48	0.89	0.67	0.28	-0.46	0.43	-0.97	0.70	2.37	0.38	0.17
EH	0.79	-0.27	0.06	-1.48	-0.83	0.13	-0.50	-0.54	1.08	0.56	0.34	-0.14
TL	-0.60	0.34	0.83	-0.92	0.21	1.79	-1.17	0.19	0.64	-0.85	0.52	-0.24
NTB	-0.36	-0.89	0.03	-1.22	-0.12	-0.29	1.49	2.93	0.96	0.08	-0.11	-1.03
LL	0.71	-0.83	0.98	1.47	-0.40	1.01	1.08	0.44	0.26	-1.69	0.47	-0.06
LB	-0.10	-0.38	1.01	0.44	-0.52	0.19	0.15	-1.44	-0.05	-1.39	0.28	-0.26
CL	-3.13	2.16	0.93	-0.27	0.27	0.19	-0.13	-1.31	1.09	2.09	-0.32	-0.73
CG	0.37	0.16	-0.05	-1.42	-0.04	-0.29	-0.37	-0.67	0.03	-1.28	0.31	0.44
NKRC	0.14	-2.02	1.07	-0.21	0.09	-0.12	0.18	-0.59	0.49	-1.81	1.86	1.50
NKR	-0.39	-0.99	0.80	-0.01	-0.13	-0.89	0.03	-1.35	0.34	-1.40	-0.22	-0.62
100KW	-0.24	-0.86	0.73	-0.59	0.08	0.11	0.02	-1.13	0.78	-0.34	0.21	-0.52
SPY	0.10	-0.88	0.09	-1.18	-0.20	-0.63	1.11	0.26	1.13	-0.32	0.46	0.31

Note: DT- Days to tasseling; DS- Days to silking; PH- Plant height; EH- Ear height; TL- Tassel length; NTB- Number of tassel branches; LL- Leaf length; LB-Leaf breadth; CL- Cob length; CG- Cob girth; NKRC- Number of kernel rows per cob; NKR- Number of kernel rows; KW- Kernel weight; SPY- Single plant yield.

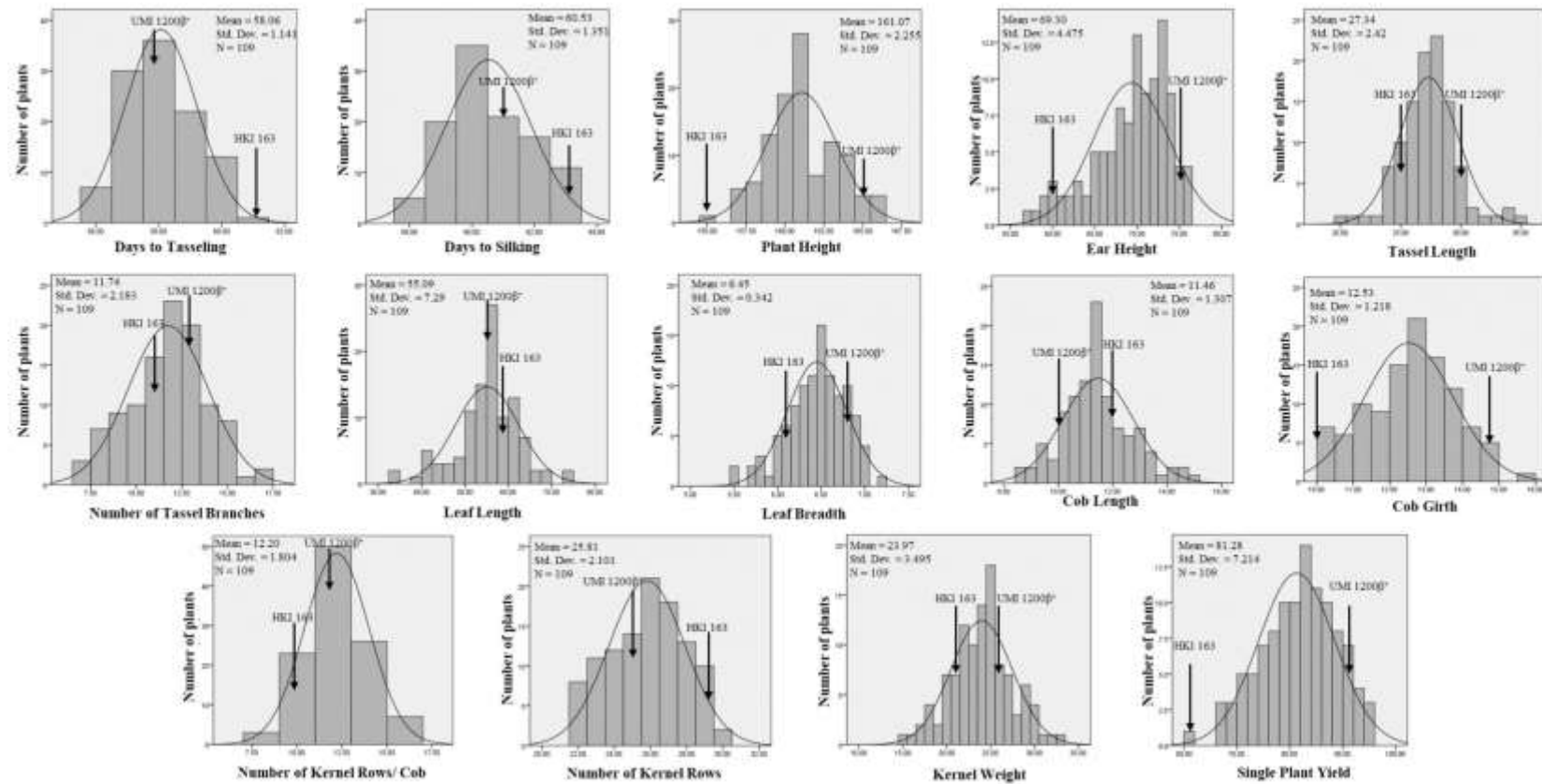


Figure 1. Frequency distribution for biometric traits in BC_2F_2 population of UMI1200P x HKI163

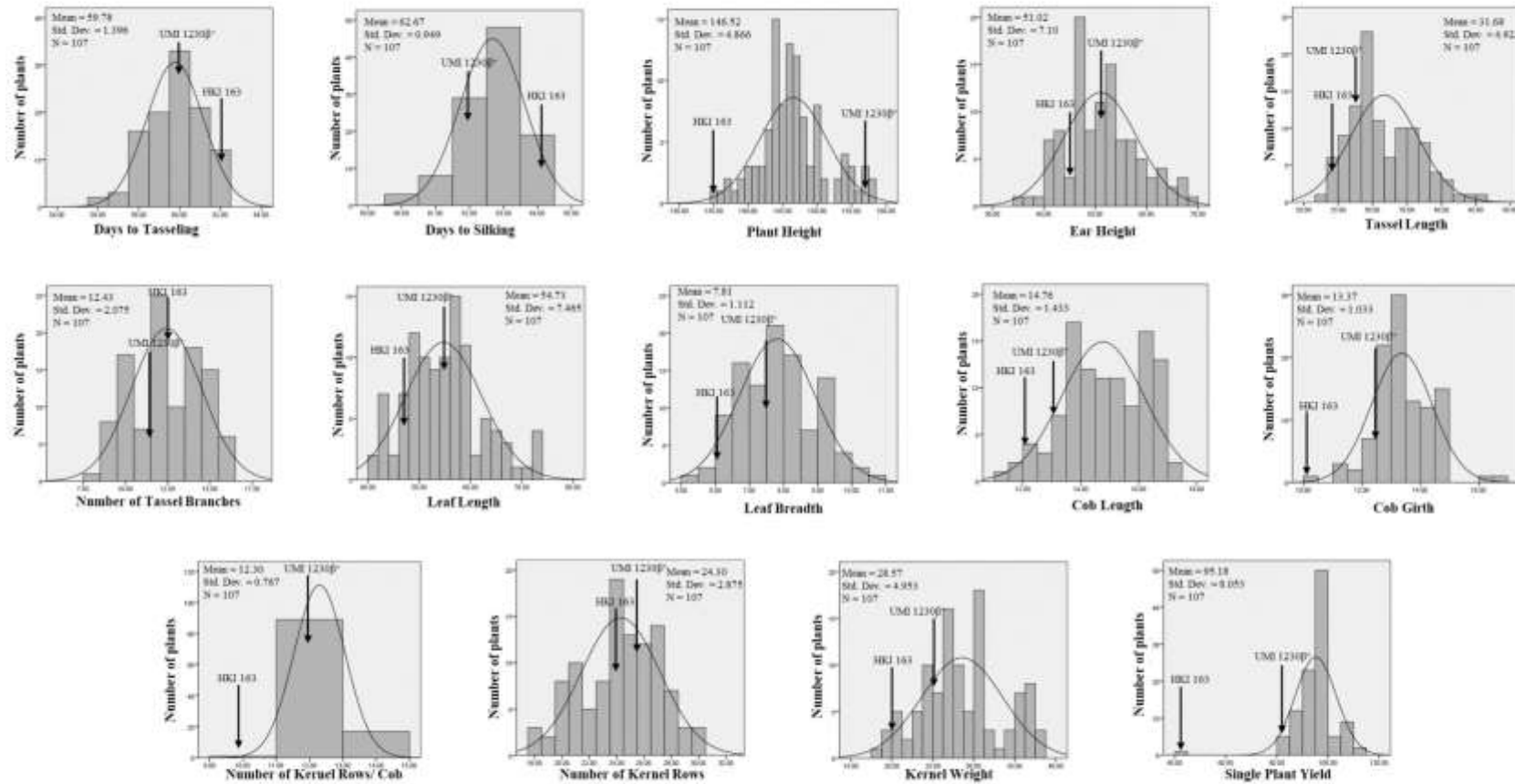


Figure 2. Frequency distribution for biometric traits in BC_2F_2 population of UMI1230P x HKI163



Figure 3. Plant variation in the segregating population (BC_2F_2)

Note: A- $UMI1200\beta^+ \times HKI163$, B- $UMI1230\beta^+ \times HKI163$, 1- $UMI1200\beta^+$, 2-4(BC_2F_2 progenies), 5- $UMI1230\beta^+$, 6-8 (BC_2F_2 progenies)

