

## Original Research Article

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## Genetic Variability, Character Association, Frequency and Normality Distribution Studies for F<sub>2</sub> Population of BPT-5204 x WAB-450 Cross in Rice (*Oryza sativa* L.)

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### ABSTRACT

An investigation was carried out to study the frequency distribution, variability parameters and character association of traits in F<sub>2</sub> populations of rice from the cross BPT-5204 x WAB 450 for grain yield and its component characters. In general, the PCV was higher than the GCV for all the traits and small differences between PCV and GCV were recorded for morphological traits studied which indicates less influence of environment on these characters. The high heritability was estimated for days to 50% flowering, plant height, flag leaf length, total number of tillers per plant, number of productive tillers per plant, grain yield per plant and straw yield per plant suggesting these traits are under higher genetic control. The traits viz., flag leaf length (23.12), total number of tillers per plant (49.64), number of productive tillers per plant (53.29), grain yield per plant (93.83) and straw yield per plant (88.66) had showed high heritability coupled with high genetic advance (as per cent of mean) indicating that these characters attributable to additive gene effects. Positive and significant association was manifested by traits viz., plant height (0.360), days to 50% flowering (0.308), panicle exertion (0.218) and straw yield (0.992) on grain yield. However, it has negative correlation with panicle exertion (-0.176), flag leaf length (-0.077) and number of un-productive tillers per plant (-0.017) with grain yield indicating that yield can be increased if selection is applied in favour of those yield components. Path coefficient analysis revealed that grain yield had direct effect or association from the traits viz., Days to 50% flowering (0.308), plant height (.360), panicle exertion (0.218) and straw yield per plant (0.992) and also indirect effect belonging to grain yield through flag leaf length and number of productive tillers per plant. The positively skewed and highly skewed was estimated in traits viz., panicle exertion (1.07), total number of tillers per plant (1.16), total productive tillers per plant (1.12) and straw yield per plant (1.03) and all the traits were showed with platykurtic type of kurtosis except flag leaf length.

#### Keywords

Rice, F<sub>2</sub> population, Skewness and Kurtosis, Variability and Correlation

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### Introduction

Rice (*Oryza sativa* L.) has a renowned relationship with the human since ages. It is the world's second most widely grown cereal crop after wheat and presently, more than half

of the world's population depends on it as a staple diet. 'Rice is life' for human beings especially in Asian subcontinent, Asia can be considered as "Rice Basket" of the world, as 90 per cent of world's rice is grown and consumed with 60 per cent of population and

where, about two-thirds of world's poor live (Khush and Virk, 2005). Only 4-5 per cent of world rice production enters the global market. Hence, any shortfall in rice production especially in the major rice growing countries could be disaster for food security.

The high level of genetic heterogeneity is possessed by our traditional rice varieties or landraces compared to modern cultivars. Local cultivars or landraces comprise of the unique source for gene of high adaptability but are poor yielders.

Therefore, it is an indispensable demand for varietal improvement in such situation. To formulate a sustainable breeding program precise knowledge about genetic divergence for yield components is a crucial one as varietal improvement depends mainly on the selection of parents with high genetic divergence in hybridization.

Crop improvement for specific trait has been achieved through effective use of F<sub>2</sub> segregating population and fixing desirable combinations (Mamatha *et al.*, 2018). Therefore, the present study has been undertaken to determine the estimates of variability, heritability and genetic advance as per cent of mean for grain yield and its component and frequency distribution pattern based on skewness and kurtosis in F<sub>2</sub> segregating generation for BPT 5204 and WAB-450 cross combination.

### **Materials and Methods**

The present investigation was carried out from 2012 to 2014, at UAS Raichur, Agricultural Research Station, Gangavati, representing the Northern dry zone which is located at latitude of 15°43' North and longitude of 76°53' East and altitude of 406 meters above Mean Sea Level (MSL).

### **Plant material**

In this experiment, the crossing work was carried out to develop population(s) in the background of BPT5204 variety which has been grown from many years and has occupied more than 90 per cent area under Tungabhadra river command area of India. It is a fine grain and long duration variety maturing in about 150-160 days. It has acceptable consumer quality and hence fetches high price in the market.) and WAB-450 (Interspecific line derived from *Oryza glaberrima* and *Oryza sativa* at Africa Rice Centre, WARDA) used as a donor variety for traits of interest under study.

### **Crossing programme and raising F<sub>1</sub>s**

The above mentioned BPT 5204 and WAB-450 genotypes were used as parental genotypes to derive F<sub>1</sub>s during *Kharif 2012*. Staggered sowing of the parental genotypes was done to achieve synchronization in the flowering event for effective crossing programme. The seedlings were raised by following all the recommended agronomic practices. At panicle emergence and flowering stage, the florets in panicles of female parents were hand emasculated early in the morning, before 7 a.m. and later the pollen was collected from male parent and dusted on to the stigma within 11:15 a.m. for effective pollination and fertilization. (Pictorial view of crossing programme with tools used presented in the Figure 1.)

The seed set in the female plant and male plants were collected, dried and stored after maturity. Especially in the female plant, the seeds formed due to crossing were harvested, around 25 to 30 days after crossing event. The seeds obtained from crossing (seed set in the female plant) are used further to raise F<sub>1</sub> seedlings. The F<sub>1</sub>s were raised in pots under greenhouse condition and then transplanted

into main field during *Kharif* 2013 at ARS, Gangavati, UAS, Raichur.

### **Raising F<sub>2</sub> population**

The F<sub>2</sub> seeds of all the crosses along with their parents were sown in the nursery bed and used to raise F<sub>2</sub> generation. Seeds were collected from a single F<sub>1</sub> plant and used to raise F<sub>2</sub> generation during *kharif* 2014.

All the 309 F<sub>2</sub> individuals selected were subjected for phenotypic evaluation for their yield and yield attributing traits. Observations on days to 50 per cent flowering, plant height, flag leaf length, flag leaf width, number of tillers, number of productive tillers, number of un-productive tillers per plant, panicle exertion, grain yield, straw yield, number of grains, 1000 grain weight/test weight were recorded as described earlier in the Experiment-I. All the 309 F<sub>2</sub> individuals of the crosses were selfed and seeds collected from individual F<sub>2</sub> plants were used to raise F<sub>3</sub> in generation.

### **Statistical analysis**

The statistical analysis of the data on individual characters using AGRISTAT package was carried out on the mean values of each genotypes and checks. Different statistical methods employed for the analysis are presented below:

#### **Analysis of variance (ANOVA)**

The analysis of variance as per Federer (1977) was carried out for different characters in order to assess the variability among the genotypes. The significance was tested by comparing with the table values as given by Yates (1965). Standard error of means (SEM) and Co-efficient of variation (CV) were worked out using appropriate formula for comparing individual line means.

### **Estimation of genetic variability parameters**

The co-efficient of variability (CV) both at phenotypic and genotypic levels for all the characters were analyzed by applying the formula suggested by Burton and De Vane (1953). PCV and GCV were classified as given by Robinson *et al.*, 1949.

#### **Heritability (broad sense)**

Heritability in broad sense ( $h^2$ ) estimates was computed by the formula suggested by Hanson *et al.*, (1956). The heritability percentage was categorized as suggested by Robinson *et al.*, (1949) as mentioned below:

0 – 30 per cent	Low
30 – 60 per cent	Moderate
60 per cent and above	High

#### **Genetic advance (GA)**

The extent of genetic advance expected through selection for each of the character was calculated as per the formula suggested by Johnson *et al.*, (1955). Intensity of selection as given by Lush, 1949.

#### **Genetic advance as per cent mean**

The genetic advance as per cent of mean was categorized as suggested by Johnson *et al.*, (1955) and the same is given below:

0 – 10 per cent	Low
10 – 20 per cent	Moderate
20 per cent and above	High

#### **Correlation analysis**

To estimate the degree of association between the traits studied, phenotypic correlation was computed by using the formula given by Webber and Moorthy (1952). The significance of correlation co-efficient was

tested by referring to the table value at n-2 df given by Cochran and Snedecor (1961).

## **Results and Discussion**

Success of any plant breeding programme depends on the extent of variability present in crop. The presence of genetic variability for economic trait is a key factor improving the local adopted varieties with regard to specific traits. Incidentally the parental lines used for developing mapping populations were also divergent for many of the trait related to productivity. Therefore, an effort was made to estimate variability and other related parameters for yield and yield components and also associated study have presented as follow.

### **Mean performance and variability for yield and yield related components**

The mean performance, range, standard deviation (SD), standard error (SE), variance, skewness and kurtosis for all the traits studied in F<sub>2</sub> population individuals along with mean of parents and checks were presented in Table 1. Genetic parameters of F<sub>2</sub> individual plants of BPT x WAB450 cross for yield and yield attributing characters was presented in Table 2. The frequency distribution for yield and yield attributing component traits in F<sub>2</sub> segregation population of BPT5204 x WAB450 were given in Figure 2. Results of the present investigation were presented as follow.

### **Days to 50% flowering**

The mean value for days to 50 per cent flowering among F<sub>2</sub> individuals was 102.93 days. WAB 450, a donor parent and line BW-L49 showed minimum days to flowering of 89 days. Line BW-L37 (116 days) showed maximum days to flowering. The estimate of GCV (7.058%) and PCV (18.721) were low.

Low heritability (1.00%) coupled with low genetic advance as percent of mean (0.548%) was observed for this trait.

### **Plant height (cm)**

Mean value of plant height among F<sub>2</sub> individuals was 101.94 cm. The minimum value observed was 77cm in BPT5204 and line BW-L49, and maximum value observed was 119.75 cm in parent, WAB450. Low GCV (6.858%), PCV (6.877%) and high heritability (99.4%) and genetic advance as percent mean (14.089%) was observed in the population.

### **Panicle length (cm)**

Length of the panicle observed was 22.29 with a range of 14.45 (BPT5204) to 27.0 cm (BW-L27) among F<sub>2</sub> individuals. Moderate GCV (11.63%), PCV (16.01%) and moderate heritability (49.10%) and Genetic advance as percent of mean (16.79%) was observed in the population.

### **Panicle exertion (cm)**

The mean panicle exertion observed was 2.63cm with a range of 0.0 (zero) in some lines to maximum of 8cm in line BW-L97. Moderate GCV (14.7%), PCV (18.57%) and moderate heritability (37.8%) and Genetic advance as percent of mean (17.409%) was observed in F<sub>2</sub> individuals.

### **Number of tillers per plant**

The average number of tillers per plant among the F<sub>2</sub> population was 11.22 and it ranged from 5(BW-L31) to 19(BW-L67). Moderate GCV (24.14%) and PCV (24.19%) were observed. High heritability (99.6%) and high genetic advance as percent of mean (49.64%) was noticed for this population.

### **Number of productive tillers per plant**

Number of productive tillers per plant varied from 3 to 18 in lines BW-L45 and BW-L31 among F<sub>2</sub> individuals respectively. Mean value for this character found to be 9.77. The estimates of GCV and PCV were 29.72 % and 34.15% respectively. High heritability (75.80%) coupled with high genetic advance as percent of mean (53.29%) was observed for this character.

### **Flag leaf length (cm)**

Considerable variation among F<sub>2</sub> individuals observed for flag leaf length character with minimum of 19.0cm in line BW-L20 and maximum of 35.0 cm in lines BW-L44 and WB-L75. Mean value 27.03 cm was recorded. Estimates of PCV and GCV were 12.30% and 13.49%. High heritability (83.2%) coupled with moderate GAM (23.13%) was observed for this character.

### **Flag leaf width (cm)**

Flag leaf width was ranged from 1.2 cm in line BW-L42 to 2.5 cm in line BW-56 among F<sub>2</sub> individuals and had mean value of 1.56 cm. Moderate GCV and high PCV were found to be 14.43% and 15.84% respectively. Very low heritability (1.06%) coupled with very low genetic advance as percent of mean (3.81%) were observed for this character.

### **Grain yield per plant (g)**

Regarding grain yield/plant, the F<sub>2</sub> population recorded the mean value of 28.05 g per plant with a range varied between from 9.50 g (BW-L29) to 73.50 g (BW-L40). High GCV (45.60%) and PCV (45.66%) were observed. Whereas, high heritability (99.8%) and high GA as per cent mean (93.83%) was recorded in the population.

### **Straw yield per plant (g)**

The straw yield per plot was ranged in between 15.68 (BW-L29) and 110.25g (BW-L40) with a mean yield of 42.25 g. The high GCV (43.83%) and PCV (44.64%) with high heritability (96.4%) and GA as per cent mean (88.66%) were observed.

The traits studied in the present investigation exhibited low, moderate and high PCV and GCV values. In the present study, the estimates of PCV were slightly higher than the corresponding GCV estimates and small differences between PCV and GCV recorded for morphological traits studied indicating that the portion of PCV was more contributed by the genotypic component and less influenced by the environment. Therefore, selection on the basis of phenotype alone can be effective for the improvement of these traits.

In the present study high estimates of PCV and GCV were observed for the traits viz., total number of tillers per plant, number of productive tillers per plant, grain yield per plant and straw yield per plant (Table 2).

These kinds of results also noticed for the studied traits by Savitha and Ushakumari (2015), El-Badri *et al.*, (2016), Hefena *et al.*, (2016), Rani *et al.*, (2016) and Manjunatha *et al.*, (2018). Similar findings were also supported by Arpita *et al.*, (2014); Priyanka *et al.*, (2011) for flag leaf area; Ashok *et al.*, (2013) for 1000 grain weight and Kiran *et al.*, (2012) for number of tillers per plant, number of productive tillers per plant and grain yield per plant.

The traits exhibiting high GCV and PCV indicating prominent variation or substantial amount of genetic variability presents in the population for the concerned trait and hence, there is scope for selection.

In the present study, an estimated of moderate PCV values was exhibited by days to 50% flowering, panicle length, panicle exertion, flag leaf length, flag leaf width and number of unproductive tillers per plant while, low PCV value was shown by only by plant height trait. Similarly trend was also followed for GCV values except for days to 50% flowering which was shown low GCV value. This suggests that the genetic improvement through selection for these traits may not be always effective. Similar results obtained by Khare *et al.*, (2014), Arpita *et al.*, (2014) for days to maturity and days to 50 per cent flowering; Laxuman *et al.*, (2010) for days to fifty percent flowering and Bekele *et al.*, (2013) for days to maturity. These findings were in consonance with the reports made by Bhadru *et al.*, (2012); Prajapathi *et al.*, (2011); Singh *et al.*, (2011) and Ananadarao *et al.*, (2011) earlier in rice for days to 50% flowering, plant height and panicle length.

The high heritability estimates for exhibited traits suggesting these traits are under higher genetic control. High heritability (in broad sense) was noted for plant height similar to results shown by Padmaja *et al.*, (2008); Umesh *et al.*, (2015); Bhuvanewari *et al.*, (2015) and Shashidhara *et al.*, (2017), panicle length similar to reports of Ogunbayo *et al.*, (2014); Shrivastava *et al.*, (2015) and Shashidhara *et al.*, (2017), yield per plant similar to reports of Padmaja *et al.*, (2008); Augustina *et al.*, (2013 and Bhuvanewari *et al.*, (2015) and 100-grain weight similar to results shown by Padmaja *et al.*, (2008). Ansari *et al.*, (2004) stated that high heritability percentage reflects the large heritable variance which may offer the possibility of improvement through selection and similar results were also reported by Priyanka *et al.*, (2011) for plant height, days to 50% flowering and flag leaf length and Padmaja *et al.*, (2008), karthikeyan *et al.*, (2010) and Khare *et al.*, (2014) for test

weight, plant height and days to 50 per cent flowering. Ashok *et al.*, (2013) and Kole and Hasib (2008) for days to 50% flowering and plant height, Kundu *et al.*, (2008) for 1000 grain weight.

While, moderate heritability was estimated for panicle length and panicle exertion but low heritability was recorded for the traits flag leaf width and number of unproductive tillers per plant. The moderate heritability was noted for days to flowering (60 percent), days to maturity (40percent) as given by Abebe *et al.*, (2017); number of tiller per plant (65 percent); panicle no. per plant as reported by Ogunbayo *et al.*, (2014) and spikelet fertility percentage by Umesh *et al.*, (2015). The low heritability showed by flag leaf width and number of unproductive tillers per plant which indicates greater role of environment on the expression of the traits, thus, direct selection for these traits will be ineffective.

Genetic advance was recorded high for the traits *viz.*, grain yield and straw yield while remaining all the traits showed with low genetic advance at 5%. These traits indicate the predominance of additive gene effects in their expression and would respond to selection effectively as they are least influenced by environment. Johnson *et al.*, (1955) reported that heritability estimates together with genetic advance are more important than heritability alone to predict the resulting effect of selecting the best individuals.

These findings were in accordance with the reports made earlier in rice by Bhadru *et al.*, (2012), Arpita *et al.*, (2014) and Parameshwar *et al.*, (2015) for in1000 grain weight and average flag leaf length, Rema Bai *et al.*, (1992) and Priyanka *et al.*, (2011) for flag leaf length. Heritability alone provides no indication of the amount of genetic improvement that would result from

selection of individual genotypes. Hence, knowledge about heritability coupled with genetic advance is most useful. In the present study, the traits viz., flag leaf length, total number of tillers per plant, number of productive tillers per plant, grain yield per plant and straw yield per plant had showed high heritability coupled with high genetic advance (as per cent of mean) indicating that these characters attributable to additive gene effects. These results were in accordance with the earlier findings of Anilkumar (2008) and Sangeetha (2013).

The aforesaid points revealed additive gene action and showed the possibility of selection per se in these crosses for the improvement of number of productive tillers per plant and the traits were under the control of additive gene action and this was in accordance with Sala, (2012) and Sangeetha, (2013). Hence selection for this trait was effective for improvement through selection.

Similar results were also reported by Pratap *et al.*, (2012), Gangashetty *et al.*, ((2013) and Khare *et al.*, (2014). While, moderate GA as % mean was recorded for plant height, panicle length and panicle exertion followed by low GA as per cent of mean was recorded by traits days to 50% flowering and flag leaf length.

High heritability accompanied with low genetic advance indicates of non-additive gene action. The high heritability is being exhibited due to the favorable influence of environment rather than genotypes and selection of such traits offers little scope for improvement by selection.

High heritability with low genetic advance was reported by Singh *et al.*, (2006). Although Low estimates of genetic advance as percent mean was indicates the characters governed by non-additive gene action and

heterosis breeding will be useful. Hence, making based on simple selection could be effective for improving those characters, as reported by (Abebe *et al.*, 2017) and Hoque (2013) for panicle number per panicle.

### **Correlation studies for yield components**

The degree of correlation among characteristics is an important factor, especially regarding economic and complex characteristics such as yield direct selection, which shows low effectiveness (Kiani, and Nematzadeh, 2012). Correlation coefficient is a measure of the degree association and relationship between two variables. It is important in plant breeding as it can be used for indirect selection.

The study of association between different characters may help the plant breeder to know how the improvement of one character will bring simultaneous changes in other characters (Adhikari, *et al.*, .2018). In the present study, correlation coefficients among F<sub>2</sub> individuals of the population, BPT5204 x WAB450 for yield and yield attributing characters are presented in Table 3.

Grain yield has a positive and significant correlation with plant height (0.360), days to 50% flowering (0.308), panicle exertion (0.218) and straw yield (0.992). However, it has negative correlation with panicle exertion (-0.176), flag leaf length (-0.077) and number of un-productive tillers per plant (-0.017).

The plant height was positively correlated with panicle length (0.120), panicle exertion (0.230), flag leaf length (0.161), flag leaf width (0.146) and number of tillers per plant (0.068), straw yield (0.374), grain yield (0.360) and root dry weight (0.078) but negatively associated with root volume (-0.015) and negatively correlated with number

of un-productive tillers per plant.

There was a significant positive correlation days to 50 per cent flowering with that of plant height (0.333), grain yield (0.308) and straw yield (0.326), but has significant negative correlation with number of tillers per plant (-0.193). A significant positive correlation of straw yield with days to 50 per cent flowering (0.326), plant height (0.374) and panicle exertion (0.194), whereas, number of tillers showed significant negative correlation with days to 50 per cent flowering (-0.193) followed by number of un-productive tillers per plant with number of productive tillers per plant (-0.370) respectively.

Panicle exertion showed positive significant correlation with plant height (0.230), similarly followed by traits *viz.*, flag leaf width with panicle exertion (0.233), total number of tillers with flag leaf length (0.215) and number of productive tillers with total number of tillers per plant (0.956) respectively. A strong correlation of grain yield with these traits indicated that, simultaneous improvement of these traits is possible.

Previous studies have mentioned similar findings (Abarshahr *et al.*, 2011; Lanceras *et al.*, 2004; Muhammed *et al.*, 2007; Samonte *et al.*, 1998). Mirza *et al.*, (1992) reported positive correlation of number of panicles/m<sup>2</sup> and grain yield with number of tillers/plant. Kumar *et al.*, (1998) observed high positive correlation of grain yield with spikelet fertility.

### **Path coefficient analysis**

The estimates of path coefficient analysis are furnished for yield and yield component characters are given in Table 4. Path coefficient analysis revealed that grain yield had direct effect or association from the traits *viz.*, Days to 50% flowering (0.308), plant height (0.360), panicle exertion (0.218) and

straw yield per plant (0.992) and direct negative effect was recorded for traits namely, panicle length, flag leaf width, total number of tillers per plant and number of unproductive tillers per plant. An indirect positive effect belonging to grain yield per plant through flag leaf length (0.006) and number of productive tillers per plant (0.011) was recorded (Table 4). These findings are in agreement with the results of Krishna (2007), Yogameenakshi and Vivekanandan (2010). These findings assist in imposing differential selection pressure during selection of genotypes for efficient root characters under moisture stress condition.

Kiani, and Nematzadeh, (2012) revealed that panicles per plant had the highest direct positive effect on grain yield and high direct positive effect of this character was nullified by the negative indirect effect of panicle length and non-filled grains per panicle, however its indirect effect via filled grains per panicle was high bringing the total correlation to  $r = 0.750$  with grain yield.

Results on importance of direct effect of panicles per plant were reported by several researchers (Bagheri *et al.*, 2011; Kumar, 1992; Madhavalatha *et al.*, 2005; Yadav and Bhushan, 2001; Yogameenakshi and Vivekanandan, 2010). Many researches the filled grains per panicle have been reported as effective trait with the highest direct effect on grain yield improvement (Bagheri *et al.*, 2011; Ram, 1992; Sundaram and Palanisamy, 1994; Samonte *et al.*, 1998).

But the magnitude of direct effect of the panicles per plant was high followed by filled grains per panicle, confirming the results of Basavaraja *et al.*, (1997) and Kole *et al.*, (2008). Then, appropriate selection indices should be formulated using these traits for yield improvement.



**Table.1** Trait means, range, standard deviation (SD), Standard error (SEm), Variance, Skewnes and Kurtosis for morphological and productivity traits in F<sub>2</sub> population individuals of BPT5204 x WAB450

Trait	Range	Minimum	Maximum	Mean	Std. Deviation	Std. Error	Variance	Skewness	Kurtosis
<b>DFF</b>	27.00	89.00	116.00	102.94	7.27	0.70	52.78	-0.18	-1.17
<b>PH</b>	42.75	77.00	119.75	101.94	6.99	0.67	48.88	-0.30	0.77
<b>PaL</b>	12.55	14.45	27.00	22.30	2.60	0.25	6.73	-0.37	-0.21
<b>PaE</b>	8.00	0.00	8.00	2.64	2.53	0.24	6.39	0.49	-1.26
<b>FLL</b>	16.00	19.00	35.00	27.03	3.33	0.32	11.07	-0.03	-0.30
<b>FLW</b>	1.30	1.20	2.50	1.56	0.23	0.02	0.05	1.07	2.06
<b>TNT</b>	14.00	5.00	19.00	11.22	2.71	0.26	7.34	0.57	0.46
<b>NPT</b>	15.00	3.00	18.00	9.78	2.91	0.28	8.45	0.46	0.21
<b>NUPT</b>	4.00	0.00	4.00	1.44	0.86	0.08	0.73	0.37	-0.06
<b>GY</b>	64.00	9.50	73.50	28.06	12.80	1.23	163.70	1.12	1.28
<b>St.Y</b>	94.57	15.68	110.25	42.26	18.52	1.77	343.06	1.08	1.23

DFF - Days to 50% flowering  
 PaE - Panicle exsertion (cm)  
 TNT - Total number of tillers/ plant  
 GY - Grain yield per plant (g)

PH - Plant height at maturity (cm)  
 FLL - Flag leaf length (cm)  
 NPT - Number of productive tillers/ plant  
 St.Y - Straw yield per plant (g)

PaL - Panicle length (cm)  
 FLW - Flag leaf width (cm)  
 NUPT - Number of un-productive tillers/plant

**Table.2** Genetic parameters of 109 F<sub>2</sub> plants of BPT x WAB450 for yield and yield attributing characters

Traits	GCV	PCV	h <sup>2</sup> (bs)	Genetic Advance 5%	Genetic Advance 1%	Gen.Adv. as% of Mean 5%	Gen. Adv. as % of Mean 1%
<b>DFF</b>	7.058	18.712	99.00	0.564	0.723	0.548	0.703
<b>PH</b>	6.858	6.877	99.40	14.362	18.406	14.089	18.055
<b>PaL</b>	11.635	16.601	49.10	3.746	4.801	16.799	21.529
<b>PaE</b>	14.790	18.571	37.80	4.594	5.887	17.409	22.311
<b>FLL</b>	12.309	13.491	83.20	6.253	8.014	23.132	29.645
<b>FLW</b>	14.431	15.840	01.60	0.060	0.076	3.817	4.891
<b>TNT</b>	24.146	24.194	99.60	5.570	7.138	49.643	63.620
<b>NPT</b>	29.725	34.151	75.80	5.212	6.680	53.298	68.305
<b>NUPT</b>	5.93	12.536	22.40	0.833	1.068	57.836	74.119
<b>GY</b>	45.605	45.662	99.80	26.324	33.736	93.831	120.025
<b>St.Y</b>	43.833	44.642	96.40	37.464	48.012	88.661	113.623

DFF - Days to 50% flowering  
 PaE - Panicle exertion (cm)  
 TNT - Total number of tillers/ plant  
 GY - Grain yield per plant (g)

PH - Plant height at maturity (cm)  
 FLL - Flag leaf length (cm)  
 NPT - Number of productive tillers/ plant  
 St.Y - Straw yield per plant (g)

PaL - Panicle length (cm)  
 FLW - Flag leaf width (cm)  
 NUPT - Number of un-productive tillers/plant

**Table.3** Phenotypic correlations among grain yield and yield components in F<sub>2</sub> progenies of BPT5204 x WAB450

Traits	DFF	PH	PaL	PaE	FLL	FLW	TNT	NPT	NUPT	St.Y	GY
<b>DFF</b>	1										
<b>PH</b>	0.3322**	1									
<b>PaL</b>	0.0991	0.1202	1								
<b>PaE</b>	0.1800	0.2305*	0.1224	1							
<b>FLL</b>	-0.1492	0.1615	0.1475	0.1113	1						
<b>FLW</b>	0.0719	0.1469	0.2330**	0.0439	0.169	1					
<b>TNT</b>	-0.1936*	0.0681	-0.1344	-0.1267	0.2156*	-0.0968	1				
<b>NPT</b>	-0.1703	0.0765	-0.1292	-0.1496	0.1675	-0.1168	0.9561**	1			
<b>NUPT</b>	-0.0342	-0.0444	0.0135	0.1070	0.1140	0.0903	-0.0823	-0.3706**	1		
<b>St.Y</b>	0.3267**	0.3747**	-0.1696	0.1946*	-0.1146	0.0087	-0.0239	0.0057	-0.0951	1	
<b>GY</b>	0.3082**	0.3602**	-0.1764	0.2185*	-0.0776	0.0063	-0.0176	0.0114	-0.0945	0.9921**	1

Significance levels      0.05      0.01      0.005      0.001  
 If correlation =>      0.1882      0.2457      0.267      0.3109

DFF - Days to 50% flowering                      PH - Plant height at maturity (cm)                      PaL - Panicle length (cm)  
 PaE - Panicle exsertion (cm)                      FLL - Flag leaf length (cm)                      FLW - Flag leaf width (cm)  
 TNT - Total number of tillers/ plant                      NPT - Number of productive tillers/ plant                      NUPT - Number of un-productive tillers/plant  
 GY - Grain yield per plant (g)                      St.Y - Straw yield per plant (g)

**Table.4** Path analysis of yield component on grain yield in BPT5204 x WAB450

Traits	DFE	PH	PaL	PaE	FLL	FLW	TNT	NPT	NUPT	St.Y
<b>DFE</b>	<b>-0.0094</b>	-0.0031	-0.0009	-0.0017	0.0014	-0.0007	0.0018	0.0016	0.0003	-0.0031
<b>PH</b>	-0.0075	<b>-0.0227</b>	-0.0027	-0.0052	-0.0037	-0.0033	-0.0015	-0.0017	0.0010	-0.0085
<b>PaL</b>	-0.0012	-0.0014	<b>-0.0119</b>	-0.0015	-0.0018	-0.0028	0.0016	0.0015	-0.0002	0.0020
<b>PaE</b>	0.0052	0.0066	0.0035	<b>0.0286</b>	0.0032	0.0013	-0.0036	-0.0043	0.0031	0.0056
<b>FLL</b>	-0.0059	0.0064	0.0058	0.0044	<b>0.0396</b>	0.0067	0.0085	0.0066	0.0045	-0.0045
<b>FLW</b>	-0.0002	-0.0004	-0.0007	-0.0001	-0.0005	<b>-0.0030</b>	0.0003	0.0003	-0.0003	0.0000
<b>TNT</b>	0.5411	-0.1903	0.3757	0.3543	-0.6028	0.2707	<b>-2.7957</b>	-2.6731	0.2300	0.0668
<b>NPT</b>	-0.5107	0.2294	-0.3875	-0.4484	0.5021	-0.3501	2.8668	<b>2.9983</b>	-1.1112	0.0170
<b>NUPT</b>	-0.0298	-0.0388	0.0118	0.0934	0.0995	0.0788	-0.0718	-0.3236	<b>0.8732</b>	-0.0830
<b>St.Y</b>	0.3267	0.3747	-0.1696	0.1946	-0.1146	0.0087	-0.0239	0.0057	-0.0950	<b>0.9999</b>
<b>GY</b>	0.3082**	0.3602**	-0.1764	0.2185*	-0.0776	0.0063	-0.0176	0.0114	-0.0945	0.9921**

R SQUARE = 0.9870

RESIDUAL EFFECT = 0.1139

DFE - Days to 50% flowering

PaE - Panicle exertion (cm)

TNT - Total number of tillers/ plant

GY - Grain yield per plant (g)

PH - Plant height at maturity (cm)

FLL - Flag leaf length (cm)

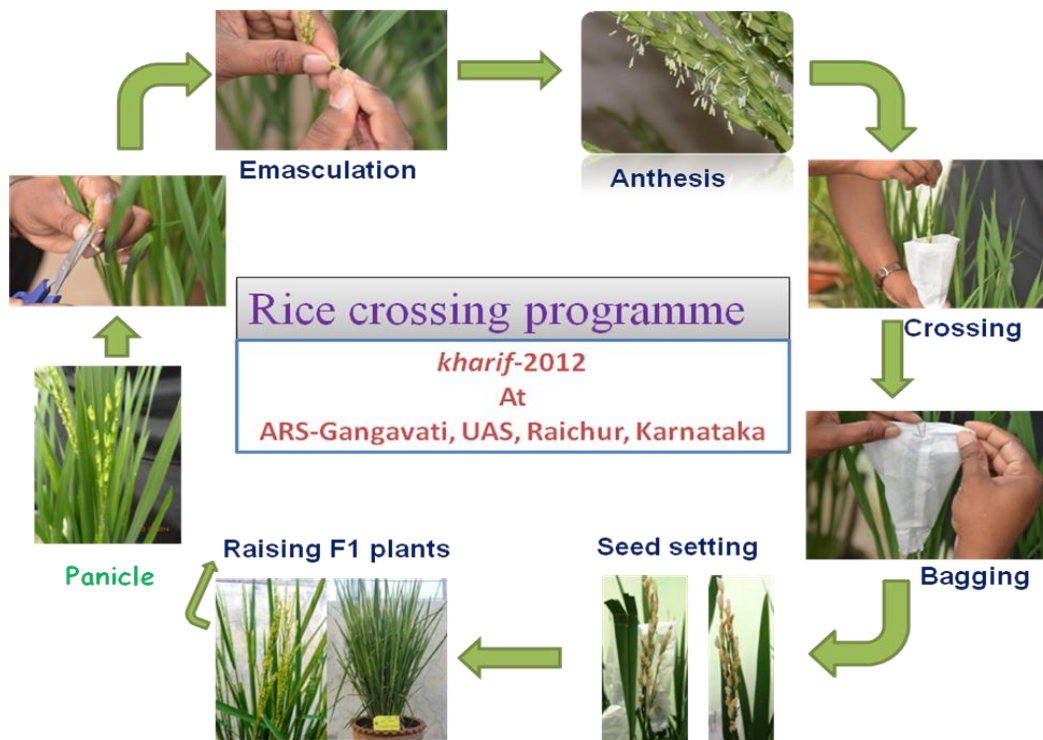
NPT - Number of productive tillers/ plant

St.Y - Straw yield per plant (g)

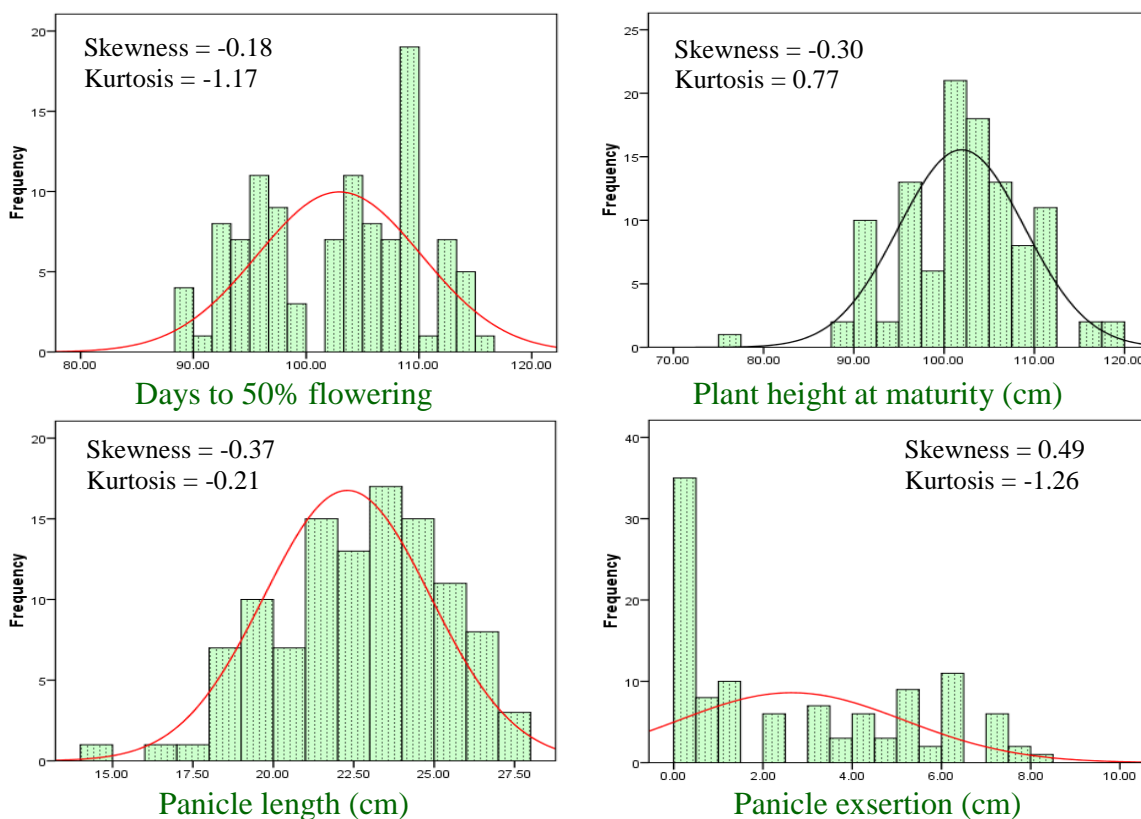
PaL - Panicle length (cm)

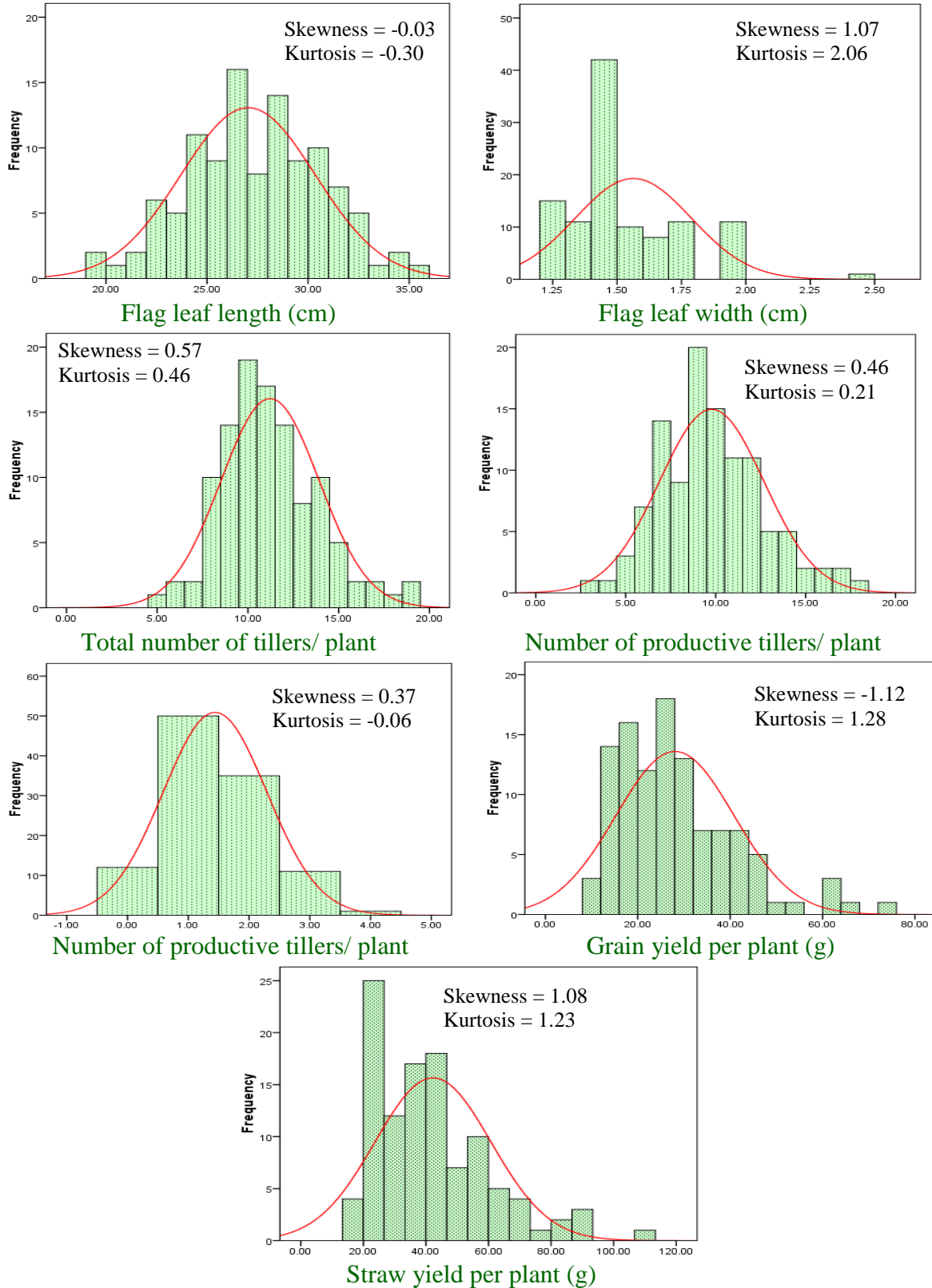
FLW - Flag leaf width (cm)

NUPT - Number of un-productive tillers/plant



**Figure.1** Pictorial view of Crossing programme with tools used in development of F2 population of the cross BPT 5204 x WAB 450





**Figure.2** Frequency distribution for yield and yield attributing component traits in  $F_2$  population of BPT5204 x WAB450

## Skewness and Kurtosis

The results from the present investigation was revealed that positively skewed and highly skewed was estimated in traits *viz.*, panicle exertion (1.07), total number of tillers per plant (1.16), total productive tillers per plant (1.12) and straw yield per plant (1.03). Similarly, number of unproductive tillers per plant (0.56) and grain yield per plant (0.85) was recorded positive skewed and moderately skewed followed by negatively skewness for plant height (-0.50), panicle length (-0.33), flag leaf width (-1.09). The data of fairly symmetrical was recorded in days to 50% flowering (0.13) and flag leaf length (0.06) traits under study. The data on skewness and kurtosis was presented in the Table 1.

In the present study, majority traits were recorded platykurtic type of kurtosis (Kurtosis < 3) where distribution is shorter, tails are thinner than the normal distribution and the peak is lower and broader than Mesokurtic, which means that data are light-tailed or lack of outliers except flag leaf length which had Leptokurtic (Kurtosis > 3) where distribution is longer, tails are fatter, peak is higher and sharper than Mesokurtic, which means that data are heavy-tailed or profusion of outliers. The graphical representation of frequency distribution, skewness and kurtosis for yield and yield attributing component traits in F<sub>2</sub> population of BPT5204 x WAB450 were presented in Figure 2.

Mamatha *et al.*, (2019) revealed from their studies in 'Rajamudi × BR-2655' and 'Rathnhoodi × BR-2655' crosses of rice that platykurtic and positively skewed distribution indicated dominance based complementary gene interaction involving presence of large number of genes having decreasing effect on the trait days to 50% flowering in both the populations. The trait plant height appeared to be controlled by few

segregating genes with majority of them exhibiting decreasing effect and dominance based complementary gene interaction as indicated by the leptokurtic and negatively skewed. The platykurtic and negatively skewed distribution indicated dominance based complementary gene interaction involving presence of large number of genes having decreasing effect in the inheritance of grains per panicle.

Results of the investigation indicates that selection will be effective in the test materials used in this study as revealed by the significant substantial variations among the F<sub>2</sub> individuals for all the characters observed. These lines have been actively utilized in further breeding program. Traits showing high heritability coupled with high genetic advance (as per cent of mean) indicating that these characters attributable to additive gene effects. Yield can be improved directly by effecting selection for the traits manifested positive and significant association *viz.*, plant height, days to 50% flowering panicle exertion and straw yield.

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