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Research Article

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Drought Tolerance in Upland Rice: Pattern of F_2 Segregation for Yield and Yield Contributing Traits under Upland and Drought Condition

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ABSTRACT

A study on drought tolerance in upland rice was carried out using seven genotypes, including four parents and three F_2 populations. The genotypes were grown under upland field condition exposed to natural stress and under protected condition imposing artificial stress. The pattern of F_2 segregation for yield and yield contributing traits under both conditions were evaluated and frequency distribution graphs were prepared. In majority of the characters considered the frequency distribution graph under protected condition showed moderate to high positive skewness which points out that the performance of all the three F2 populations under artificial stress were lower than the respective performance noted under upland field condition. Based on the performance of the genotypes superior segregants were selected combining drought tolerance and high yield for carrying forward to the next generation.

Key words: *Upland, Stress, Genotpes, F_2 segregants, Skewness*

INTRODUCTION

Rice (*Oryza sativa* L.) is the world's second most important cereal crop following maize. It is grown in almost all the continents with more than 90 percent produced and consumed in south and south-east Asia where China and India lead the way[1]. Rice production in India holds a major share of national economy. Our country occupies first position in area and second position in production of rice. Rice is semi-aquatic and may be cultivated either as irrigated (lowland) or rainfed (upland). Being an extravagant consumer of water, more than 50 percent of all water used for irrigation in Asia is expended on rice. Most of the researches till date are concentrating on improving lowland rice productivity. Since the availability of good quality water is diminishing, upland rice which depends entirely on rainfall needs special attention. Genetic improvement addresses the major research topics for overcoming these constraints and improving yield. Genetic diversity among the parents plays a key role in selection of parents with wider adaptability[2]. Superior hybrids and durable transgressive segregants are a result of hybridisation programme using such diverse parents[3].

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Thus, to increase the productivity, the breeder needs to maintain a pool of highly diverse donor parents[4]. Keeping this in view, the present investigation was carried out to evaluate the pattern of segregation in F_2 for yield and yield contributing traits under upland and drought situations and to select superior segregants combining drought tolerance and high yield.

MATERIAL AND METHODS

The study was conducted in the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani, Thiruvananthapuram in two separate experiments during the period from June, 2017 to May, 2018. The study material included three F_2 populations planted in Randomised Block Design in three replications. In experiment I, F_2 segregants were raised in the field under rainfed upland condition exposed to natural stress. Experiment II was drought screening of F_2 populations in controlled condition where the genotypes raised in rainshelter was subjected to reproductive stage moisture stress. Irrigation was given at 20mm depth once in seven days from panicle initiation stage onwards. Observations on various charactes such as Number of productive tillers plant^{-}, Number of spikelets panicle^{-1}, Number of filled grains panicle^{-1}, 1000 grain weight (g), Grain yield plant^{-1} (g) and Straw yield plant^{-1}(g) were recorded and frequency distribution graphs drawn.

The pattern of variability in F_2 segregants for various characters can be represented using frequency distribution graphs. Such graphs clearly show the pattern of distribution of the population for a character. Few terms associated with the frequency distribution graphs are range, standard error of mean (SE(m)), skewness and kurtosis. Range is calculated as the difference between the highest and lowest value recorded for a character. Standard error (mean) is the deviation of the values from the mean value. Skewness reflects the asymmetry of a distribution. A graph is said to be positively skewed when most of the values are falling on the left side and the tail is longer towards the right side. Similarly, a graph is said to be negatively skewed when most of the values are falling on the right side and the tail is longer towards the left. Blumer[5], reported a thumb rule to interpret the skewness of a frequency distribution graph[5]. According to the rule if the value for skewness is less than -1 or more than +1, the graph is highly skewed. If the value is between -0.5 and -1 or, +0.5 and +1, the graph is moderately skewed. If the value falls between -0.5 and +0.5, the graph is approximately symmetrical. The kurtosis reflects the characteristics of the tails of a distribution. Balanda and Mc Gillivray[6] suggested that if the value for kurtosis is zero, the graph is a normal distribution (Mesokurtic)[6]. If kurtosis is negative, the central peak is lower or broader and the population is more distributed (Platykurtic). A positive kurtosis denotes a higher or sharper central peak and in such cases majority of the individuals will be concentrated at or near the mean value (Leptokurtic). The range, SE(m), skewness and kurtosis for various F_2 distributions are presented in Table 1 (a), 1(b) and 1(c).

RESULTS AND DISCUSSION

In F_2 distribution for number of productive tillers plant^{-1} under upland condition, the population of Vaishak x Vyttila 6 recorded the highest mean (12.47) and the range was from 9 to 15 tillers (Fig. 1(a)). The same F_2 population was found to have high mean value (4.23) for productive tillers compared to other F_2 means when grown under stress (Fig. 1(b)) . The graphs under both conditions were approximately symmetrical with negative kurtosis. This indicates a normal distribution for the population. The ability to maintain a higher number of productive tillers under stress resulted in a notably high grain yield in Vaishak x Vyttila 6 segregants even under adverse condition. This is in line with the reports of Valarmathi and Leenakumary[7]. and Haunsajirao[8]. that grain yield increased with increase in number of productive tillers[7,8].

For number of spikelets panicle⁻¹, in Vaishak x Vyttila 6 segregants the number ranged from 149 to 178 under normal condition with a mean of 169.73 (Fig.4(a)). The frequency distribution graph under normal condition was highly negatively skewed suggesting the presence of more individuals with number of spikelets higher than the mean value. Under stress condition, the same F_2 recorded the highest mean number of spikelets panicle⁻¹ which was 147.23. The graph was approximately symmetrical signifying a normal distribution and the number of spikelets ranged from 128 to 174 (Fig.4(b)).

In the F_2 distribution for number of filled grains panicle⁻¹under normal condition**,** Vaishak x Harsha segregants recorded the highest mean value (150.37) and it ranged from 133 to 157 (Fig. 8(a)). The graph was highly negatively skewed with a positive kurtosis stating that a higher frequency of individuals had values at or near to the mean value. Under stress condition, the number of filled grains reduced considerably ranging from 80 to 118 with a mean of 95.67 (Fig. 8 (b)). The graph under stress was moderately positively skewed with a negative kurtosis. The decrease in mean number of filled grains under stress for this population was the lowest compared to others which shows that stress has not affected Vaishak x Harsha segregants much.

1000 grain weight of all the three F_2 populations was comparable when grown under upland condition (Fig. 10 (a), 11(a) and 12(a)) and it did not show a notable decrease in weight when grown under stress (Fig. 10(b), 11 (b) and 12(b)). The decrease in 1000 grain weight was the least for Vaishak x Vyttila 6 segregants where it ranged from 23.78g to 26.15g with a mean of 25.01g which was comparable to the mean under normal condition (27.80g). The graph under normal condition was moderately negatively skewed with a negative kurtosis. Under stress condition the population was more distributed.

In the F_2 distribution for grain yield plant⁻¹,Vaishak x Harsha segregants recorded the highest mean (43.65g) under normal condition with individual values ranging from 38.45g to 48.15g (Fig. 14(a)). The frequency distribution graph under normal condition was moderately negatively skewed and mesokurtic. A considerable decrease in grain yield was observed under stress condition wherein the least decrease was noted in segregants of Vaishak x Vyttila 6 (Fig 13(b)). Grain yield ranged from 11.80g to 18.88g with a mean of 14.64g and the graph was approximately symmetrical with a negative kurtosis (Fig. 5(b)). Fukai and Cooper[9] reported a relative yield advantage in stress tolerant genotypes compared to susceptible ones when grown under moisture stress, suggesting that Vaishak x Vyttila 6 segregants are the most stress tolerant F_2 population[9].

The highest mean straw yield plant⁻¹ under upland condition was recorded by Vaishak x Harsha segregants where it ranged from 49.38g to 59.20g with a mean of 54.36g (Fig. 17(a)). The frequency distribution graph was approximately symmetrical with a negative kurtosis. A notable decease in biomass production was observed in all the F_2 populations when grown under stress and the decrease was comparatively less in Vaishak x Vyttila 6 segregants (8.73g - 22.45g) with a mean of 14.23 which was the highest mean value recorded under stress condition (Fig. 16 (b)). The graph was moderately positively skewed and platykurtic.

The above results are in agreement with the findings of Jambhulkar and Bose[10] and Haunsajirao[8] that a selection based on 1000 grain weight and number of productive tillers is more advantageous for yield improvement and drought tolerance in upland rice[8,10]. Similar results were reported by Kahani and Hittalmani[11] that grain yield plant⁻¹ has a positive association with number of tillers, number of panicles and straw yield and these characters should be given more importance while selecting for yield advantage under moisture stress condition[11].

Table 1(a). Mean, Standard Error (mean), Range, Skewness and Kurtosis values of frequency distribution graphs for six characters in Vaishak x Vyttila 6

Sl. No.	Character		Mean	Standard Error (mean)	Range	Skewness	Kurtosis
1	Number of productive tillers plant^{-1}	Normal	12.47	0.34	9-15	-0.36	-0.63
		Stress	4.23	0.20	3-6	0.22	-1.25
2	Number of spikelets panicle^{-1}	Normal	169.73	1.51	149 – 178	-1.69	2.20
		Stress	147.23	3.34	128 - 174	0.37	-1.80
3	Number of filled grains panicle^{-1}	Normal	136.80	2.29	120 – 157	0.48	-1.20
		Stress	133.70	2.82	102 – 155	-0.53	-0.74
4	1000 grain weight(g)	Normal	27.80	0.22	24.88 – 28.67	-0.58	-0.65
		Stress	25.01	0.15	23.78 – 26.15	-0.36	-1.10
5	Grain yield plant^{-1} (g)	Normal	37.89	0.76	28.36 – 43.13	-0.86	0.08
		Stress	14.64	0.40	11.80 – 18.88	0.47	-0.88
6	Straw yield plant^{-1}(g)	Normal	43.27	0.96	31.88 – 48.74	-1.34	0.46
		Stress	14.23	0.74	8.73 – 22.45	0.55	-0.53

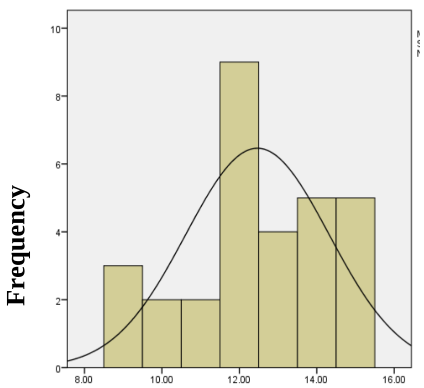
Table 1(b). Mean, Standard Error (mean), Range, Skewness and Kurtosis values of frequency distribution graphs for six characters in Vaishak x Harsha

Sl. No.	Character		Mean	Standard Error (mean)	Range	Skewness	Kurtosis
1	Number of productive tillers plant^{-1}	Normal	12.23	0.42	9 – 16	0.31	-1.10
		Stress	3.50	0.23	2 – 6	0.53	-0.59
2	Panicle length (cm)	Normal	23.75	1.62	148 – 171	0.15	-1.70
		stress	22.99	0.46	19.6 0– 27.50	0.49	-1.18
3	Number of spikelets panicle^{-1}	Normal	159.83	1.62	148 – 171	0.15	-1.70
		stress	102.77	1.94	90 – 127	0.86	0.06
4	Number of filled grains panicle^{-1}	Normal	150.37	1.43	133 – 157	-1.27	0.18
		stress	95.67	2.36	80 - 118	0.59	-1.15
5	1000 grain weight(g)	Normal	27.48	0.21	25.45 – 28.78	-0.55	-0.99
		stress	20.86	0.35	17.50 – 23.75	-0.15	-0.10
6	Grain yield plant^{-1}(g)	Normal	43.65	0.56	38.45 – 48.15	0.07	-1.23
		stress	8.05	0.63	4.25 – 17.15	1.38	2.05
7	Straw yield plant^{-1}(g)	Normal	54.36	0.73	49.38 – 59.20	-0.26	-1.92
		stress	10.97	0.34	8.10 – 14.15	-0.05	-1.01

Table 1(c). Mean, Standard Error (mean), Range, Skewness and Kurtosis values of frequency distribution graphs for six characters in Thottacheera x Harsha

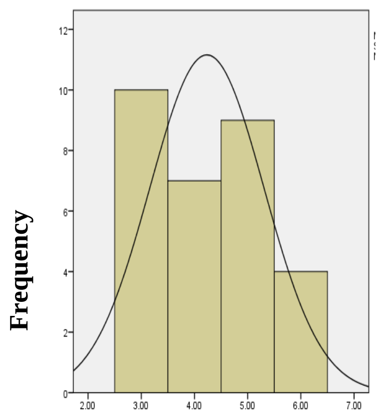
Sl. No.	Character		Mean	Standard Error (mean)	Range	Skewness	Kurtosis
1	Number of productive tillers plant^{-1}	Normal	12.27	0.47	7 – 9	0.08	-1.58
		stress	4.13	0.23	3 – 7	1.21	0.56
2	Number of spikelets panicle^{-1}	Normal	161.43	1.97	143 – 174	-0.46	-1.37
		stress	83.27	1.60	70 – 100	0.41	-0.79
3	Number of filled grains panicle^{-1}	Normal	133.07	1.85	120 – 151	0.64	-0.94
		stress	68.77	1.91	52 – 88	-0.02	-1.13
4	1000 grain weight(g)	Normal	25.54	0.27	23.28 – 28.12	0.16	-0.99
		stress	20.32	0.22	17.00 – 22.16	-1.36	2.23
5	Grain yield plant^{-1} (g)	Normal	33.41	0.72	25.88 – 38.30	-0.50	-0.92
		stress	10.15	0.32	8.10 – 14.19	0.86	0.22
6	Straw yield plant^{-1}(g)	Normal	43.15	1.72	29.95 – 58.19	0.16	-1.21
		stress	11.03	0.42	8.20 – 16.15	0.81	-0.12

1(a)



Number of productive tillers plant^{-1}

1(b)



Number of productive tillers plant^{-1}

Fig. 1: F_2 distribution for number of productive tillers plant in Vaishak x Vyttila 6

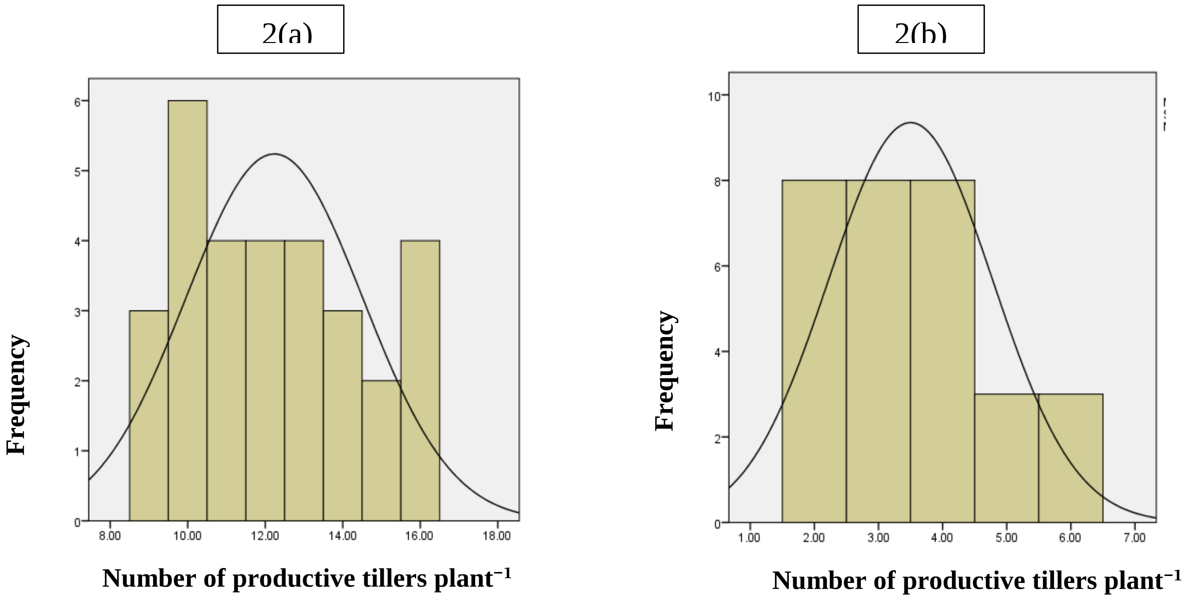


Fig. 2: F_2 distribution for number of productive tillers plant in Vaishak x Harsha

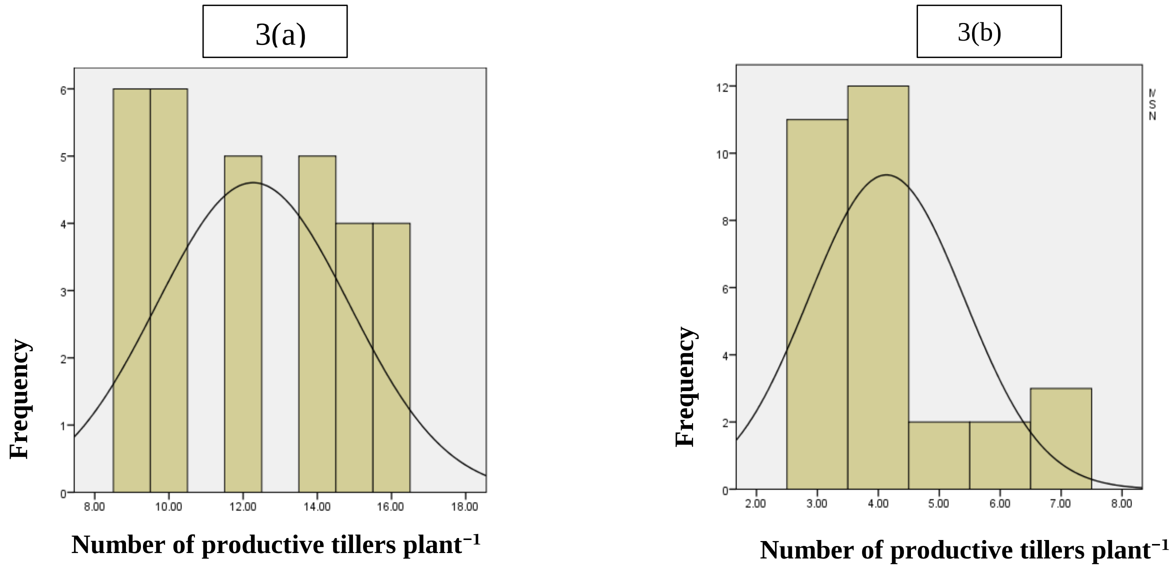


Fig. 3: F_2 distribution for number of productive tillers plant in Thottacheera x Harsha

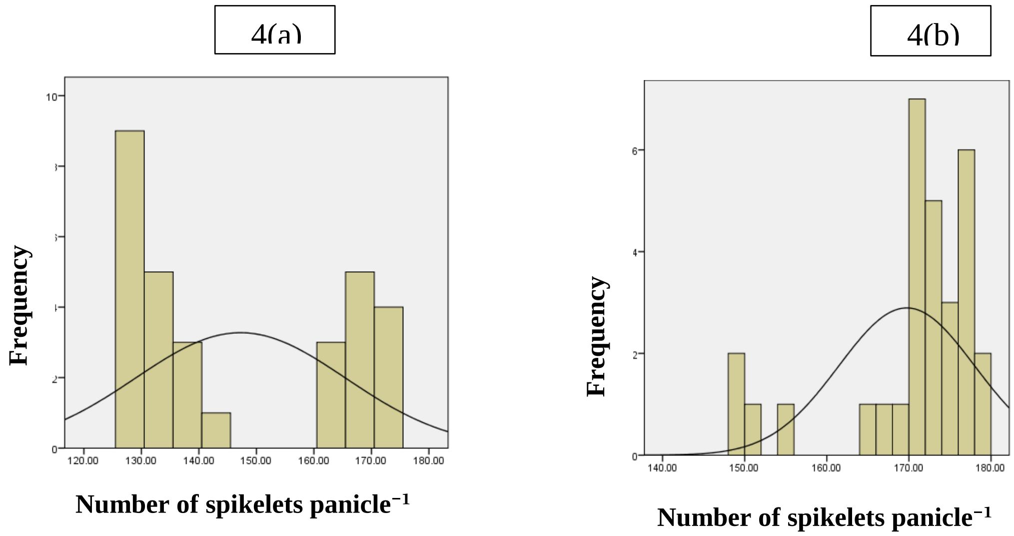


Fig. 4: F_2 distribution for number of spikelets panicle^{-1} in Vaishak x Vyttila 6

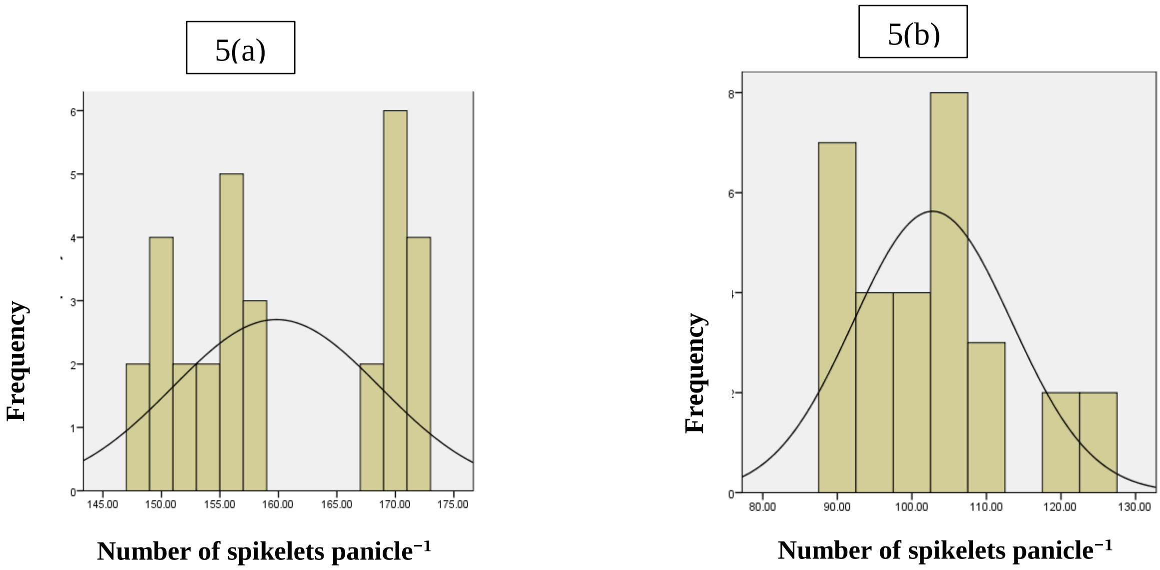


Fig. 5: F_2 distribution for number of spikelets panicle^{-1} in Vaishak x Harsha

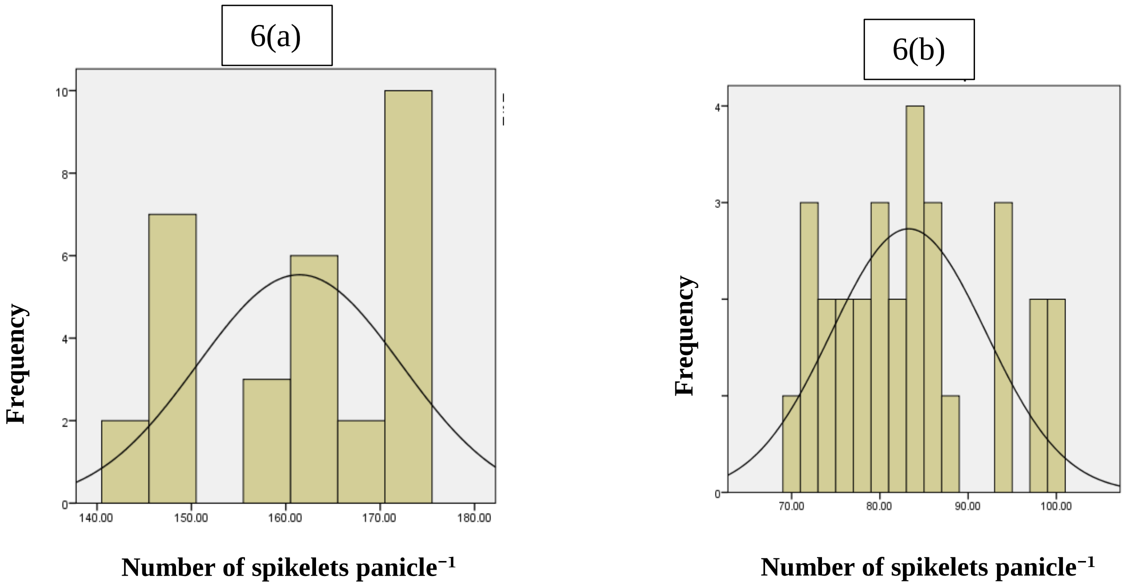


Fig. 6: F_2 distribution for number of spikelets panicle^{-1} in Thottacheera x Harsha

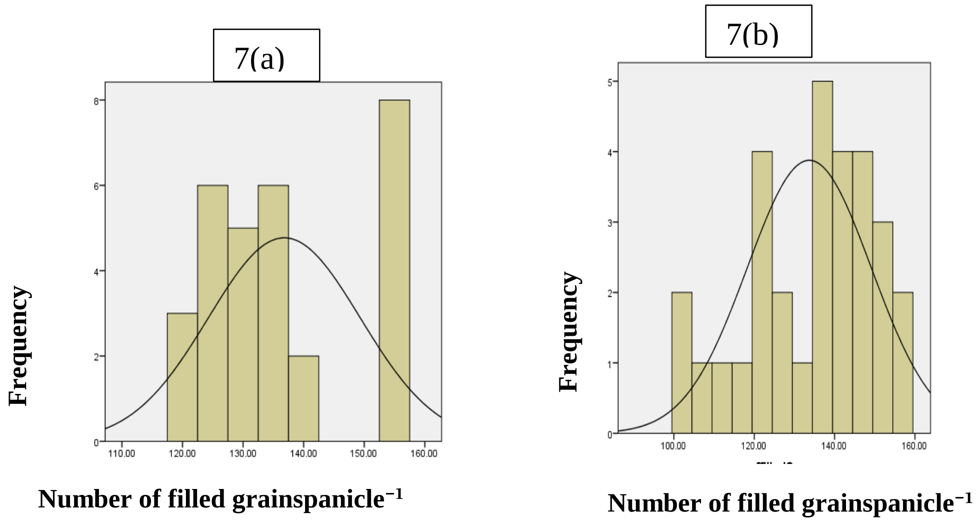


Fig. 7: F_2 distribution for number of filled grains panicle^{-1} in Vaishak x Vyttila 6

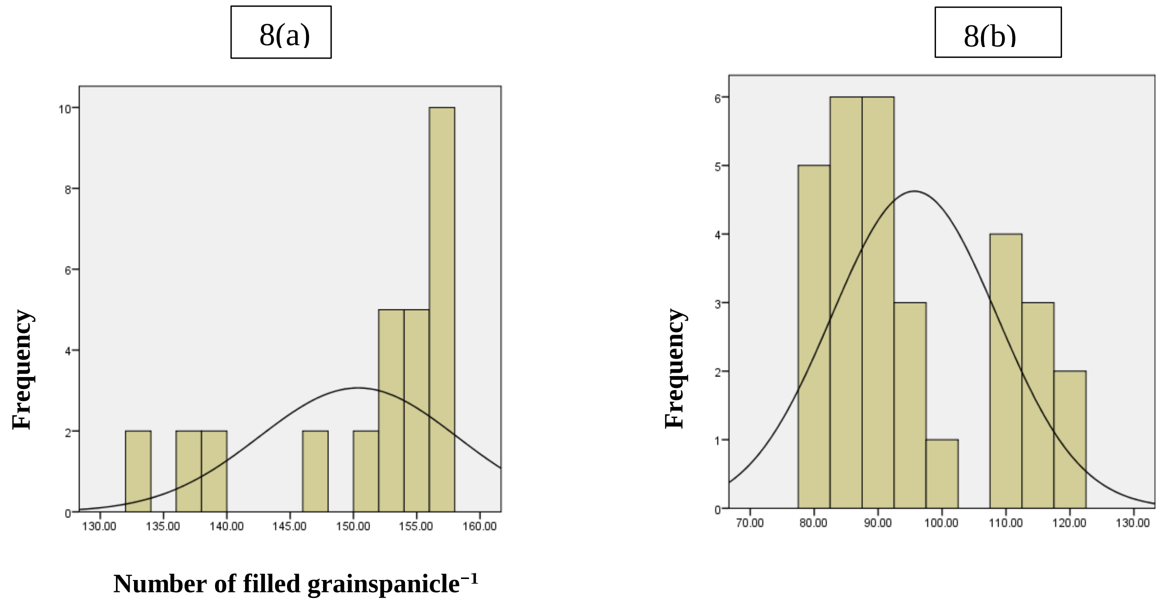


Fig. 8: **F_2 distribution for number of filled grai**

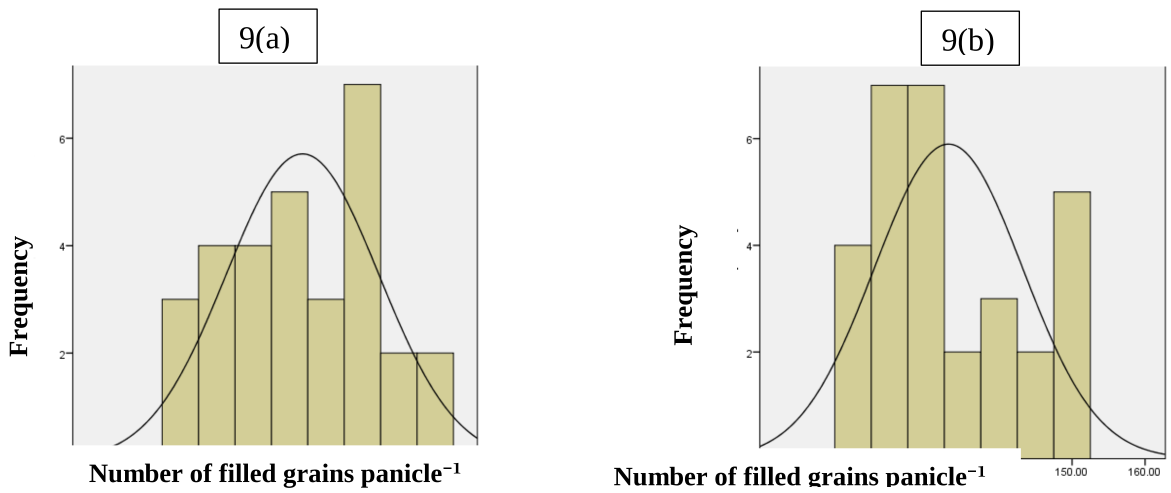


Fig. 9: F_2 distribution for number of filled grains panicle^{-1} in Thottacheera x Harsha

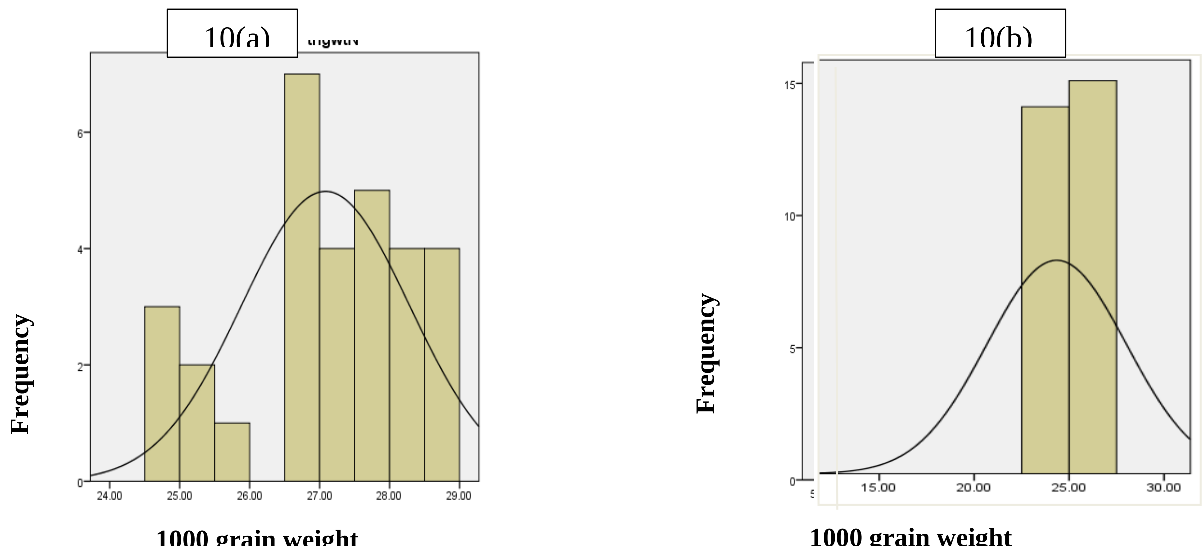


Fig. 10: F_2 distribution for 1000 grain weight in Vaishak x Vyttila 6

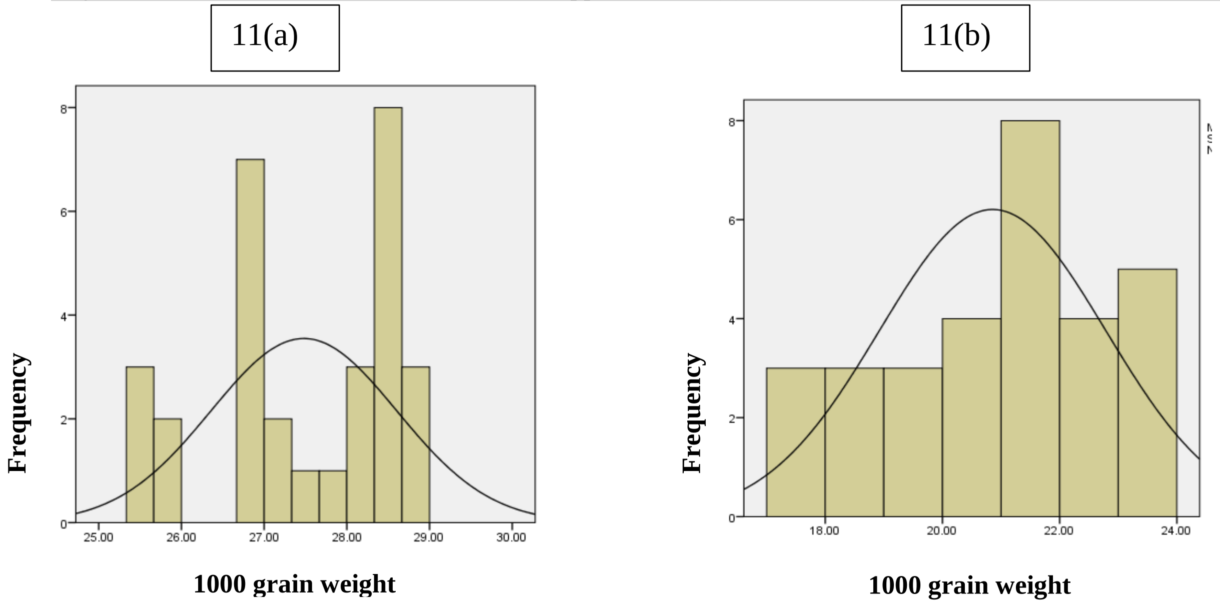


Fig. 11: F_2 distribution for 1000 grain weight in Vaishak x Harsha

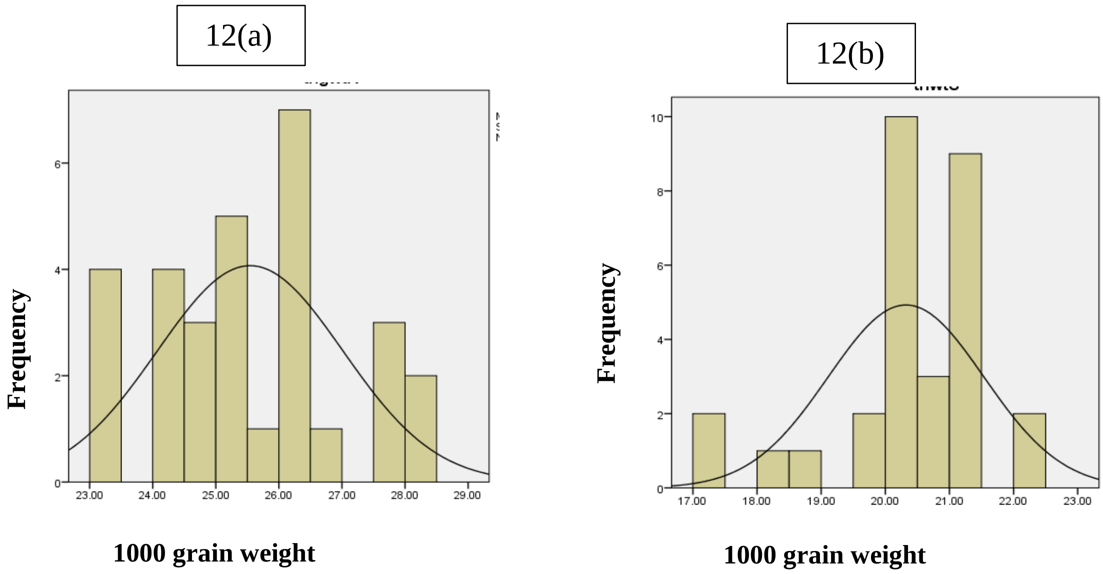


Fig. 12: F_2 distribution for 1000 grain weight in Thottacheera x Harsha

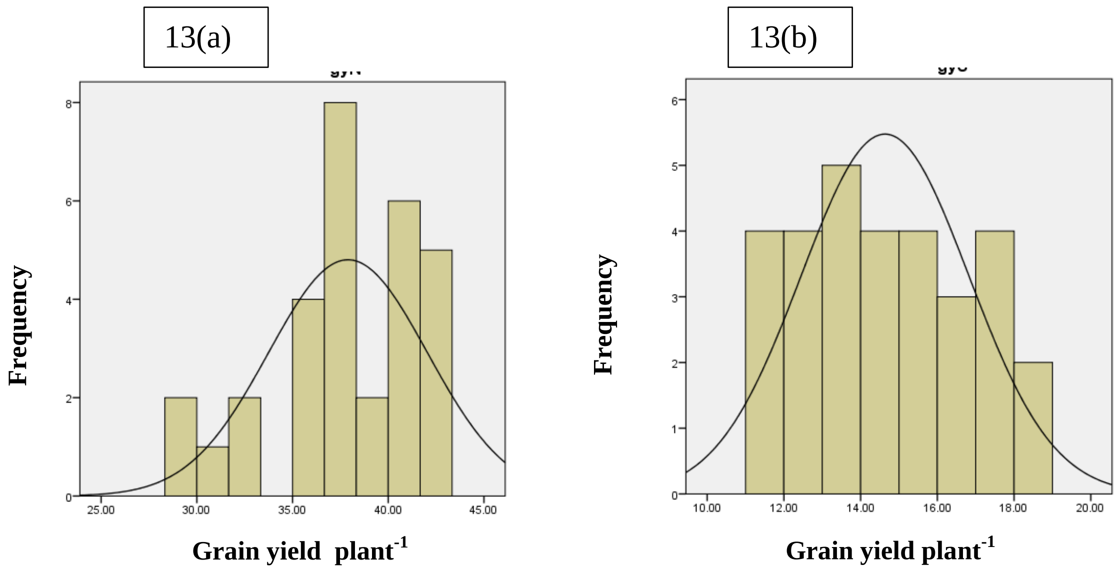


Fig. 13: F_2 distribution for grain yield plant^{-1} in Vaishak x Vyttila 6

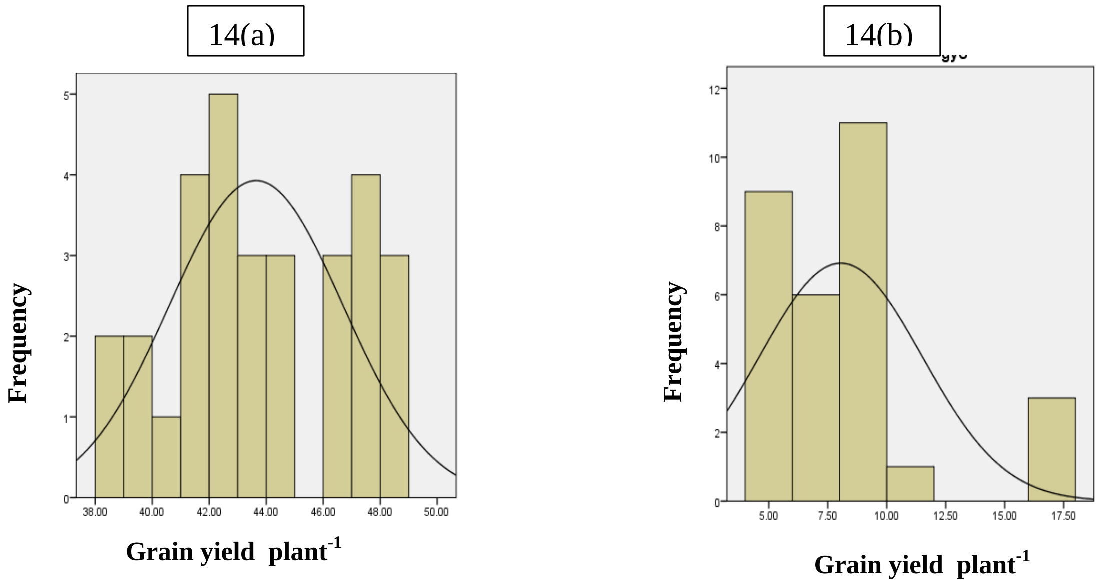


Fig. 14: F_2 distribution for grain yield plant^{-1} in Vaishak x Harsha

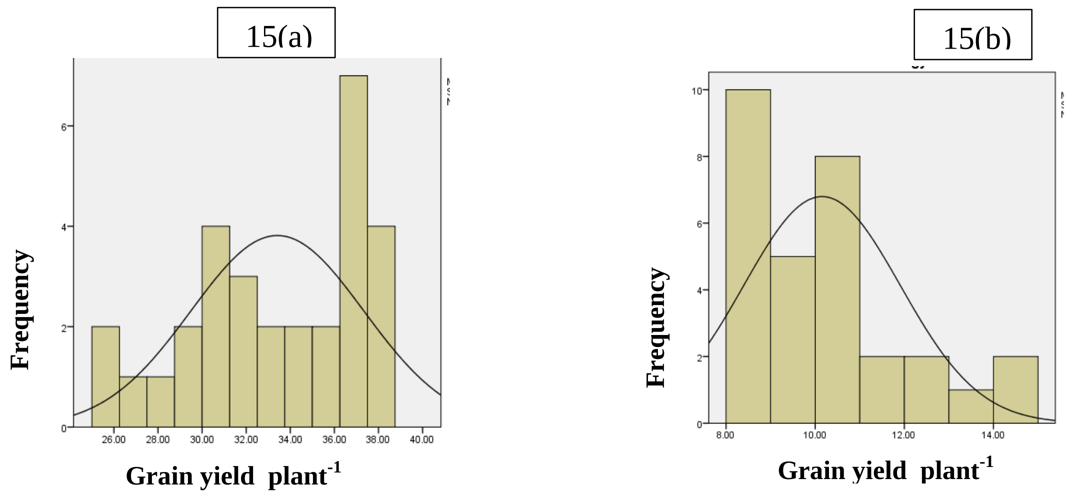


Fig. 15. F_2 distribution for grain yield plant^{-1} in Thottacheera x Harsha

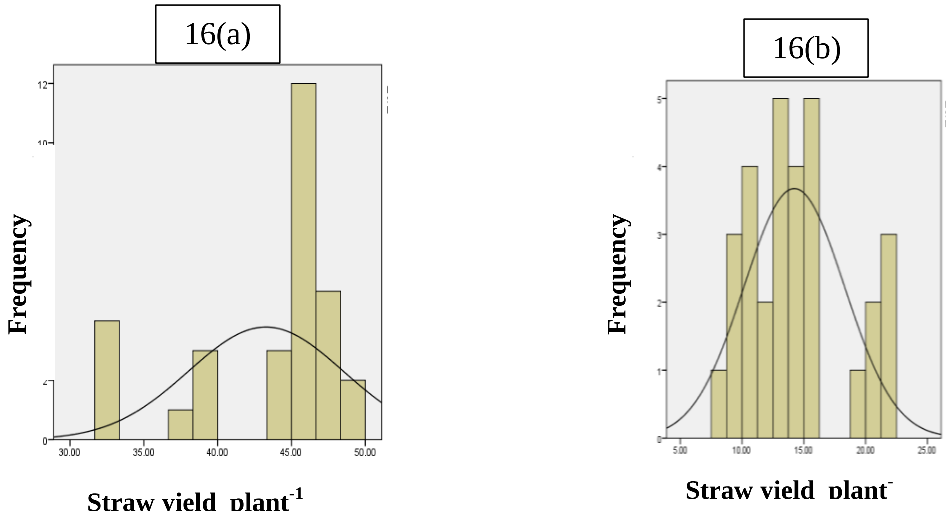


Fig. 16: F_2 distribution for straw yield plant^{-1} in Vaishak x Vyttila 6

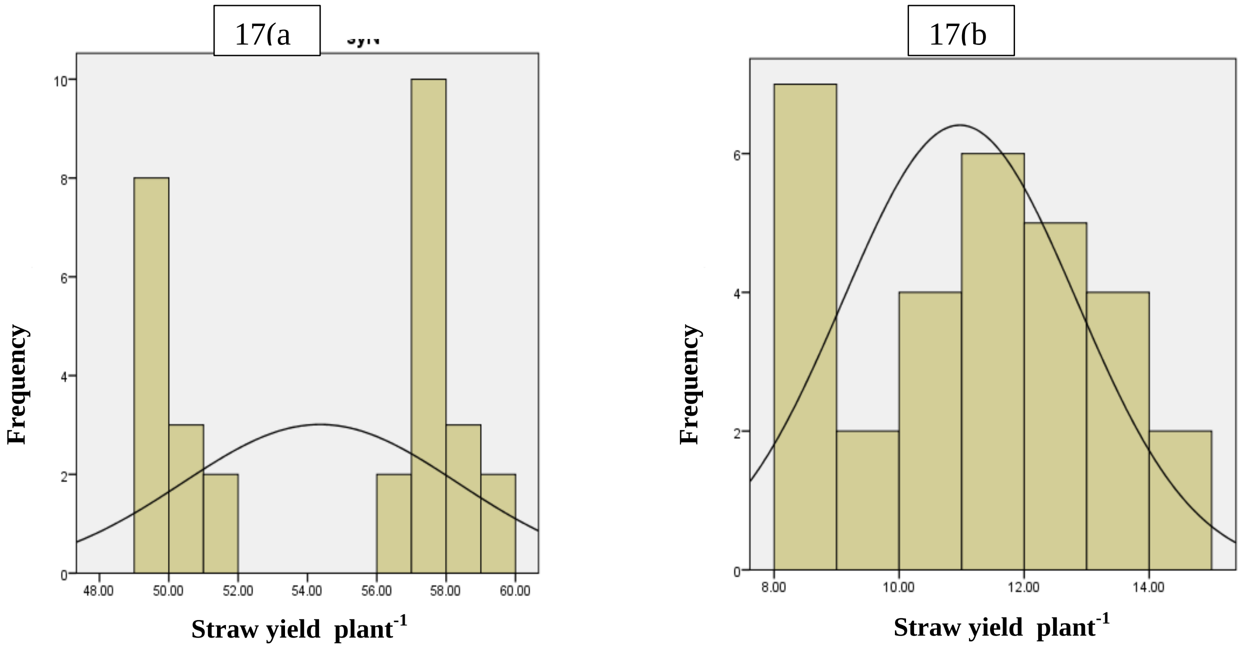


Fig. 17: F_2 distribution for straw yield plant^{-1} in Vaishak x Harsha

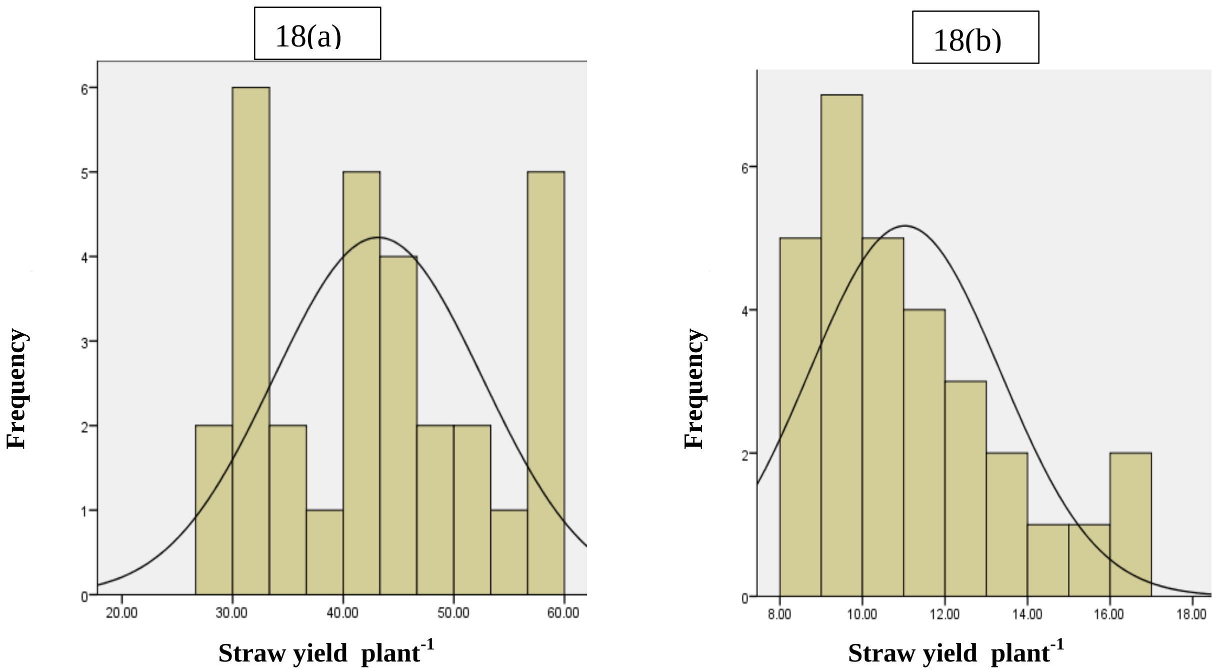


Fig. 18: F_2 distribution for straw yield plant^{-1} in Thottacheera x Harsha

CONCLUSION

Comparison of frequency distribution graphs for the F_2 populations under upland and controlled condition for yield related characters such as number of productive tillers plant^{-1}, number of spikelets panicle^{-1}, number of filled grains panicle^{-1}, 1000 grain weight, grain yield plant^{-1} and straw yield plant^{-1} was done. The results reveal that in majority of the characters considered the frequency distribution graph for F_2 segregants of Vaishak x Vyttila 6 and Vaishak x Harsha were not much affected by the stress condition and showed moderate to high positive skewness. There can be a probability that their female parent Vaishak might have transferred its superior yield and drought tolerance traits to the progeny. It also points out that the performance of all the three F_2 populations under artificial stress were lower than the respective performance noted under upland field condition.

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