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Evaluation of F_2 population for yield and yield attributing characters in Chilli (*Capsicum annuum* L.)

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Abstract
In the present study, in F_2 population 350 test entries along with 4 checks were estimated in an augmented block design for yield and yield contributing traits. The analysis of variance revealed significant mean sum of squares for all traits for different sources of variation. The number of genotypes that exceeded the best check was 62 (plant height), 59 (number of primary branches), 55 (days to 50% flowering), 49 (number of fruits per plant), 52 (fruit length), 47 (fruit width), 49 (fruit weight), 48 (fruit shape index), 46 (pedicel length), 48 (yield per plant), 45 (dry yield per plant) and 47 (dry recovery %). Plant number 91 was the best genotype among all the test treatments for all traits except days to 50% flowering and fruit width. Among the checks, B-HP-143 was observed to be best for plant height, days to 50% flowering, number of fruits per plant, yield per plant, dry yield per plant and dry recovery %, whereas, B-HP-144was found to be superior over all the checks for rest of the traits.

Keywords: Chilli, evaluation, yield, yield attributing traits, Augmented design

Introduction
Chilli (*Capsicum annuum* L.) is one of the most important popular vegetable crop of India. The most cultivated varieties in chilli belong to *Capsicum annuum*. It is an important spice because of its pungency, flavour, attractive colour and taste. It ranks second after black pepper (*Piper nigrum* L.) among different spices in the international spice trade. *Capsicum* spp. comprise of different crucial nutrients and secondary metabolites which are known to reveal antioxidant, antimicrobial, antiviral, anti-inflammatory and anticancer properties (Khan *et al*., 2014) [7]. In India, it is a vital part in daily routine and is also used in the preparation of different processed products like pickles, chutneys, sauces *etc*. The pungent principle 'capsaicin' existing in placenta and pericarp of the fruit which is crystalline, acrid and volatile in nature and has great prophylactic and therapeutic uses. Oleoresin which is extracted from chilli fruits, has wide uses in processed items, beverage industries and high export potential too. In developed countries, natural colour extracts of chilli are also gaining popularity instead of artificial colours in the food items. India has better potential to upsurge the chilli cultivation in order to encourage foreign exchange earnings which may help in price equilibrium of the product within the country, particularly during the topmost times of production. In India, chilli is being cultivated in an area of 363000 ha. with a production of 4027000 MT and productivity of 11.09 MT/ha. (Agricultural Statistics, 2019-20). The low efficiency may be due to the limiting factors such as unavailability of superior genotypes / improved cultivars for use in breeding programme, heavy occurrence of insect pests (thrips, mites and borers) and diseases (anthracnose, leaf spots and viral diseases) resulting in remarkable fall in yield and quality. Further, the high variability existing in the chilli has not been fully utilized in the crop improvement programme. Chilli genotypes are found with varying characters of various kinds. Hence, there is need to assess chilli genotypes and segregating population to learn yield and growth performance and resistance to biotic and abiotic stresses. Considering the problems, present study was commenced in chilli to gather data on yield and yield constituents and to identify appropriate chilli types for Odisha conditions.

Materials and Methods
The material used in current study included of 354 genotypes which indicates 350 test treatments and four checks namely B-HP-143, B-HP-144, G4 and G5. The material was estimated in augmented block design (Federrer, 1956) [5].

The method comprised of 14 blocks containing 29 genotypes in each which includes 25 test treatments and four check treatments. In each block the checks were allotted randomly.
Standard package of practices along with plant protection measures were taken as per the requirement. Data was collected from ten randomly selected plants on various yield and yield quantitative traits *viz*., plant height (cm), number of primary branches, days to 50% flowering, number of fruits per plant, fruit length (cm), fruit width (cm), fruit shape index, fruit weight (g),pedicel length (cm), yield per plant (g), dry yield per plant (g) and dry recovery %. The recorded data was statistically analyzed through statistical software.

Results and Discussion

Augmented block design (Federrer, 1956) [5] is a technique of optimal to commence initial survey of huge planting material to observe the genotypes good for different features of crop breeding. This method plays important role, where initial seed quantity is limited. The design makes use of a practice wherein a huge test treatments to be assessed along with control treatments, with the control treatments existing duplicated unsystematically in all blocks. The data from checks is used to see the adjust mean values of test entries and to make them comparable and also to provide an estimation of experimental error. In the current experiment, 350 test treatments along with four checks were tested in an augmented block design for different quantitative traits. The mean values (Table 1) of plant height (cm), number of primary branches, days to 50% flowering, number of fruits per plant, fruit length (cm), fruit width (cm), fruit shape index, fruit weight (g),pedicel length (cm), yield per plant (g), dry yield per plant (g) and dry recovery % were 74.9, 3.4, 90.8, 314.7, 5.0, 1.2, 3.5, 4.4, 2.6, 769.1, 128.9 and 18.5 respectively. The range for these traits were 49.4-102.4, 1.6-5.1, 76.3-107.4, 144.3-526.3, 1.9-9.1, 0.5-1.9, 1.3-6.4, 1.1-7.8, 1.3-4.3, 261.9-1891.2, 35.6-341.5 and 10.1-30.2 respectively. The highest value of co-efficient of variation (C.V) was found in case of days to 50% flowering (19.1%) followed by dry recovery % (18.7%) while dry yield per plant (11.9%) had lower co-efficient of variation values. Mopidevi *et al*., (2018) [10] evaluated 53 germplasm genotype of chilli and observed substantial variability for the 12 quantitative traits studied.
The analysis of variance revealed significant differences among the genotypes for all the twelve characters studied indicating the presence of genetic variability in the genotypes and considerable scope for their improvement. These results are in conformity with earlier reports of Farhad *et al*., (2008) [4], Gupta *et al*., (2009) [6], Suryakumari *et al*., (2010) [14] and Kumar *et al*., (2012) [8] in chilli. Twenty outstanding genotypes for different characters in F_2 population are mentioned in table number 2.
Plant height of genotypes varied from 49.4 cm to 102.4 cm with a mean of 74.9 cm (Table 1). Among the genotypes, plant number 91 (102.4 cm) recorded maximum plant height followed by plant number 149 (97.7 cm), whereas, minimum plant height was recorded in plant number 105 (49.4 cm). For plant height 62 genotypes were found significantly superior than best check B-HP-143 (73.9 cm). The highest number of primary branches was recorded in the plant number 276 (5.1), while plant number 185 had minimum number of primary branches (1.6) among the population from F_2 generation. The general mean was observed to be 3.4. 59 genotypes were found significantly superior than the best check B-HP-144(4.0) for number of primary branches. These results are in confirmity with results of Munshi *et al*., (2010) and Nehru *et al*., (2012), who also revealed highest variability for above traits. The plant number 107 was found to have late flowering (107.4days), while plant number 16 earliest to flower (76.3days) among the population from F_2 generation. The general mean was observed to be 90.8 days. For days to 50% flowering 55 genotypes were found significantly superior over best check B-HP-143 (82.8 days). Bharadwaj *et al*., (2007) [7], Tembhurne *et al*., (2008) [15] and Arup *et al*., (2011) [1] stated same line of work with flowering in chilli. The plant number 91 had maximum number of fruits per plant (526.3), while plant number 131 had minimum number of fruits per plant (144.3). The general mean was 314.7. For number of fruits per plant, 49 genotypes were found significantly higher than the best check B-HP-143 (314.1). The plant number 91 was found to have maximum fruit length (9.1cm), while plant number 131 had minimum fruit length (1.9 cm). The general mean was observed to be 5.0 cm. 52 genotypes were found to be significantly superior to the best check B-HP-144(6.9cm) for fruit length. Padhar and Zaveri (2010), Arup *et al*., (2011) [1], Lakshmi and Padma (2012) and Vijaya *et al*., (2014) also described similar findings of range for number of fruits and fruit length.

Table 1: Mean, range and least significant differences in Augmented Block Design for various characters of F_2 population among chilli genotypes

Sl. No.	Characters	Genotypes		Checks				CV	CM	AVSB	AVDB	AVAC
		Mean	Range	B-HP-143	B-HP-144	G4	G5					
1	Plant height (cm)	74.9	49.4-102.4	73.9	70.4	68.3	72.9	12.7	1.6	6.1	7.4	5.4
2	Number of primary branches	3.4	1.6-5.1	3.7	4.0	3.0	3.4	12.6	0.6	2.4	2.9	2.1
3	Days to 50% flowering	90.8	76.3-107.4	82.8	87.2	83.4	84.5	19.1	1.3	5.1	6.2	4.6
4	Number of fruits per plant	314.7	144.3-526.3	314.1	256.7	202.9	154.7	17.2	4.6	17.5	21.4	15.6
5	Fruit length (cm)	5.0	1.9-9.1	6.4	6.9	6.5	5.0	17.4	0.4	1.5	1.8	1.3
6	Fruit Width (cm)	1.2	0.5-1.9	1.2	1.4	1.3	1.2	18.5	0.2	0.7	0.9	0.6
7	Fruit weight (g)	3.5	1.3-6.4	4.5	5.0	2.7	4.3	13.2	0.5	1.9	2.3	1.7
8	Fruit shape index	4.4	1.1-7.8	4.6	5.3	4.3	3.9	15.7	0.2	0.8	1.0	0.7
9	Pedicel length (cm)	2.6	1.3-4.3	3.2	3.7	3.5	3.4	12.2	0.3	1.3	1.6	1.1
10	Yield per plant (g/plant)	769.1	261.9-1891.2	1209.7	1180.8	417.6	564.3	14.4	3.8	14.3	17.5	12.8
11	Dry yield per plant (g)	128.9	35.6-341.5	255.1	186.8	78.9	89.7	11.9	3.5	13.3	16.3	11.9
12	Dry recovery %	18.5	10.1-30.2	22.4	21.4	19.4	17.3	18.7	1.5	5.8	7.2	5.2

CM= least significant difference between the means of two check varieties, AVSB = least significant difference between adjusted values of two selections in the same block, AVDB = least significant difference between adjusted value of two selection in different blocks, AVAC = least significant difference between an adjusted selection value and a check mean.

Table 2: List of outstanding genotypes for different characters in F_2 population

Sl. No.	RIL number	Plant height (cm)	Number of primary branches	Days to 50% flowering	Number of fruits per plant	Fruit length (cm)	Fruit width (cm)	Fruit weight (g)	Fruit shape index	Pedicel length (cm)	Yield per plant (g)	Dry yield per plant (g)	Dry recovery percent
1	91	102.4	4.9	79.0	526.3	9.1	1.7	6.4	7.8	4.3	1891.2	341.5	30.2
2	149	97.7	4.8	77.3	490.1	8.0	1.8	6.1	7.7	**4.3**	1862.3	341.1	30.0
3	173	97.4	5.0	78.1	489.7	7.8	1.8	6.0	7.3	4.2	1859.2	305.8	29.1
4	174	96.2	5.0	78.3	479.3	7.7	**1.9**	5.9	7.2	4.1	1787.5	297.0	29.1
5	276	95.9	**5.1**	77.6	474.9	7.7	1.6	5.7	7.2	4.1	1783.5	284.0	29.1
6	66	95.6	4.8	78.8	470.1	7.5	1.6	5.6	7.0	4.0	1678.9	283.6	29.0
7	16	95.6	5.0	**76.3**	469.0	7.4	1.6	5.5	6.9	4.0	1675.0	282.6	27.8
8	29	95.5	4.7	79.5	468.6	7.3	1.6	5.5	6.9	4.0	1625.8	281.2	27.6
9	40	94.8	4.7	79.8	468.1	7.3	1.6	5.5	6.9	4.0	1622.7	277.4	27.4
10	41	94.7	4.7	79.8	464.6	7.3	1.6	5.5	6.7	3.9	1421.2	273.4	27.2
11	45	94.6	4.6	80.4	461.7	7.3	1.6	5.3	6.5	3.9	1418.7	268.2	27.1
12	98	94.4	4.6	80.4	459.7	7.3	1.6	5.3	6.4	3.9	1407.0	266.2	26.9
13	110	94.0	4.6	80.4	451.4	7.2	1.6	5.3	6.3	3.9	1388.4	262.6	26.7
14	121	93.6	4.6	80.5	447.5	7.1	1.6	5.3	6.2	3.8	1385.3	261.1	26.6
15	125	93.2	4.5	80.6	446.4	7.1	1.6	5.3	6.1	3.8	1372.3	255.1	26.4
16	241	92.5	4.5	81.0	445.9	7.1	1.6	5.2	6.0	3.8	1368.3	249.9	25.5
17	134	92.2	4.5	81.1	445.5	7.0	1.6	5.2	5.8	3.7	1353.5	239.1	25.4
18	154	92.2	4.4	81.2	444.1	7.0	1.5	5.2	5.7	3.7	1348.0	235.7	25.3
19	163	91.7	4.4	81.4	443.5	7.0	1.5	5.1	5.5	3.7	1344.4	234.1	25.3
20	196	91.5	4.4	81.5	443.4	7.0	1.5	5.1	5.5	3.7	1340.7	233.9	25.1

Among 350 test entries, the plant number 174 was found to have maximum fruit width (1.9cm), while plant number 185 had minimum fruit width (0.5 cm). The general mean was observed to be 1.2 cm. 47 genotypes were found to be significantly superior to the best check B-HP-144 (1.4cm) for fruit width. Fruit weight was recorded highest in plant number 91 (6.4 g) and lowest in plant number 131 (1.3 g) among the plants. The general mean was observed to be 3.5 g. 49 genotypes were found significantly superior over the best check B-HP-144(5.0g) for fruit weight. These findings were in accordance with earlier reports of Gupta *et al*., (2009) [6]. The plant number 91 observed to be highest (7.8) and the plant number 131 (1.1) observed to be lowest for fruit shape index. The general mean was observed to be 4.4. 48 genotypes were found significantly superior over the best check B-HP-144(5.3) for fruit shape index. For the character pedicel length plant number 91 and 149 (4.3 cm) and 161 (1.3 cm) were found to be highest and lowest respectively. The general mean was recorded to be 2.6 cm. 46 genotypes were found significantly superior over the best check B-HP-144(3.7 cm) for pedicel length. The plant number 91 was found to have maximum yield per plant (1891.2 g), while plant number 185 had minimum yield per plant (261.9 g) and the general mean was observed to be 769.1g. 48 genotypes were found significantly superior over the best check B-HP-143 (1209.7 g) for yield per plant. Suryakumari *et al*., (2010) [14] Kumar *et al*., (2012) [8] and Mopidevi *et al*. (2018) [10] were also observed wider range of variation among the genotypes studied. The range for dry yield per plant of F_2 population varied from 341.5 g (plant number 91) to 35.6 g (plant number 194) and the general mean was 128.9 g. 45 genotypes were found significantly superior over the best check B-HP-143 (255.1 g) for dry yield per plant. The plant number 91 was found to have maximum dry recovery percentage (30.2%), while plant number 185 had minimum dry recovery percentage (10.1%). The general mean was observed to be 18.5%.47 genotypes were found significantly superior over the best check B-HP-143 (22.4%) for dry recovery.

The characters showing wide range of variation provide an ample scope for selecting superior types and the selected genotypes can be used in further crop improvement programme.

It is concluded in the present study as, a high range of variability was observed for all the characters. The genotypes which perform better for various yield traits may be further evaluate to find the best one at other location to use in breeding programme.

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