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Evaluation of high-yielding F_5 progenies of chilli (*Capsicum annuum* L.) for yield and pest and diseases

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Abstract
This research paper systematically assesses diverse chilli genotypes in the Marathwada region, emphasizing growth parameters, yield characteristics, and resistance to pests and diseases. The study meticulously selected and treated seedlings, conducting comprehensive analyses of various plant features and quality parameters. Statistical analyses were employed to ascertain the significance of the results. The findings unveiled notable variations in plant height, number of primary branches, plant spread, fruit yield, capsaicin content, and resistance to pests and diseases among different chilli progenies. The research identifies superior genotypes exhibiting high productivity, resilience to pests and diseases, making them suitable for commercial cultivation in the specified region. This study provides valuable insights for breeders and cultivators seeking robust and high-yielding pepper varieties to promote sustainable agriculture in the Marathwada region.

Keywords: Chilli, yield, pest and diseases, fruit quality

Introduction
Capsicum annuum L., commonly known as Chilli, holds significant economic importance in India as a lucrative cash crop, primarily cultivated for its fruits and spice trade. Classified under the Solanaceae family, it possesses a chromosome number of 2n = 24. Originating from Tropical America, with Guatemala identified as the secondary center of origin, chilli is integral to Indian cuisine due to its attributes such as pungency, spice, appealing color, and flavor. The cultivation of chilli caters to both export and domestic markets, contributing approximately 33% to India's total spice export and holding a 16% share in global spice trade.

Chilli fruits serve as a rich source of essential vitamins A, C, and E. The pungency characteristic of chilli arises from the presence of a crystalline acrid volatile alkaloid called capsaicin, primarily located in the fruit's placenta. Capsaicin exhibits diverse prophylactic and therapeutic applications in both allopathic and ayurvedic medicine. Additionally, chilli yields oleoresin, an encompassing flavor extract obtained from dried and ground chillies. Oleoresin, concentrated into a homogeneous free-flowing product, finds varied applications in the processed food and beverage industries. Consequently, chilli emerges as a versatile resource, employed as a spice, condiment, culinary supplement, medicinal agent, vegetable, and ornamental plant. Its utilization extends to both green and dry forms in culinary preparations, appealing to individuals across different socio-economic backgrounds.

The evaluation of the nature and extent of variability within the available germplasm constitutes a prerequisite for any effective breeding program. The success of selection and the development of improved chilli varieties hinge on the variability expressed for yield and its contributing traits within the gene pool. Chilli breeding programs prioritize achieving high yield and enhancing yield-contributing characteristics while improving quality parameters. Recognizing the significance of genetically diverse genotypes with desirable combinations is acknowledged by researchers. Considering these aspects, the current investigation aims to observe the performance of chilli genotypes concerning quantitative traits and to identify superior genotypes for incorporation into subsequent breeding programs.

Within the Marathwada region, various chilli types exhibit diverse characteristics, including variations in fruit size, shape, and growth habits. Despite this variability, systematic research on the selection and evaluation of suitable chilli types has not been undertaken. Consequently, there is a pressing need to assess chilli types under Marathwada conditions, focusing on superior quality, yield, growth performance, and resistance to both biotic and abiotic stresses. The present investigation seeks to address these aspects in the context of chilli cultivation in Marathwada.

Material and Methods

The field experiment was conducted at the experimental farms of the Horticulture Research Scheme (Vegetable), College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, during the Kharif season of 2022-23. Thirteen F_5 progenies and three standard checks were used as experimental materials, all obtained from the Horticulture Research Scheme (Vegetable), Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. The experimental design employed a Randomized Block Design, consisting of 13 F_5 progenies and 2 standard checks with two replications. Each F_5 progeny was considered an individual treatment and was randomly replicated. Planting was conducted in five rows, each containing eight plants, with a spacing of 60 cm x 45 cm. To ensure uniformity, 40-day-old seedlings with an average height of 15 cm were meticulously selected and immersed in a solution composed of 10 ml of Trichoderma and 25g of Carbendazim in 10 liters of water. This treatment aimed to mitigate the risk of pests and diseases. Subsequently, chili seedlings were transplanted with a spacing of 60 x 45 cm. A random sampling technique was employed, selecting five plants from each treatment in all replications for in-depth studies on vegetative growth, yield characteristics, and the incidence of diseases and pests. Growth parameters, such as plant height (cm), number of primary branches per plant, and plant spread (cm^2), as well as fruit yield per plant (g), were recorded. Quality parameters, including the number of seeds per fruit and capsaicin content (%), were also documented. Simultaneously, instances of white fly infestation, leaf curl incidence (%), and incidence of anthracnose (%) were recorded, recognizing that pest and disease damage can significantly impact fruit yield and quality.

The statistical analysis adhered to standard methods outlined by Panse and Sukhatme (1985) [24]. Standard errors (S.E.) of means were calculated, and critical differences (CD) at a 5% significance level were determined when the results exhibited significance. The data for individual plant characteristics underwent the method of analysis of variance, commonly applicable to the randomized block design.

Result and Discussion

The height of the chili plants represents a crucial growth parameter impacting crop yield. The vigor of the plant significantly influences crop yield, with plant height playing a pivotal role. Table 1 presents data indicating notable variations in plant height at 30 days after transplanting (DAT), ranging from 19.14 to 32.55 cm. Progeny PBNC-19 exhibited the highest plant height (32.55 cm), on par with PBNC-341 and BSS-355, while progeny PBNC-7 recorded the lowest (19.34 cm). The mean height at 30 DAT was 26.35 cm. At 60 DAT, plant height varied between 25.37 and 48.52 cm, with a mean of 39.22 cm. PBNC-19 displayed the highest height (48.52 cm), similar to PBNC-16, PBNC-15, whereas PBNC-7 exhibited the lowest height (25.37 cm).

By 90 DAT, plant height ranged from 39.91 to 77.38 cm, with a mean of 60.84 cm. PBNC-18 had the highest height (77.38 cm), on par with PBNC-15, PBNC-16, and PBNC-17, while PBNC-7 displayed the lowest height (39.91 cm). At 120 DAT, plant height ranged from 52.22 to 92.94 cm, with a mean of 74.28 cm. PBNC-16 exhibited the highest height (92.94 cm), similar to PBNC-17 and PBNC-15, whereas PBNC-7 showed the lowest height (52.22 cm). The variation in plant height was primarily attributed to genetic potential (Aloni *et al*., 1999) [2], influenced by environmental factors, particularly temperature (Erard *et al*., 2002; Abdullah *et al*., 2003; Sreelathakumary and Rajamony, 2004) [2, 1, 19].

The number of primary branches per plant directly correlated with plant spread and influenced decisions regarding plant spacing for optimal fruit yield. Table 2 presents data on the number of primary branches in different chili F_5 progenies. At 30 DAT, the number of primary branches varied significantly, ranging from 1.16 to 4.74, with a mean of 2.78. PBNC-16 recorded the highest number of branches, on par with PBNC-15, PBNC-17, BYDGI-341, and BSS-355, while PBNC-7 had the lowest (1.16).

At 60 DAT, the number of primary branches ranged from 2.61 to 5.79, with a mean of 4.27. PBNC-16 exhibited the highest, on par with PBNC-15, PBNC-17, and PBNC-19, while PBNC-7 showed the minimum (2.61). By 90 DAT, the number of primary branches ranged from 4.07 to 7.52, with a mean of 6.22. PBNC-15 recorded the maximum, on par with PBNC-16, PBNC-17, and PBNC-19, while PBNC-7 had the minimum (4.07). At 120 DAT, the number of primary branches varied from 6.01 to 9.16, with a mean of 7.49. PBNC-16 exhibited the highest, on par with PBNC-15 and PBNC-17, while PBNC-7 showed the minimum (6.01).

Variation in the number of primary branches per plant may arise from progeny characteristics, environmental interactions, and soil factors. This observation aligns with findings by Smitha and Basavaraja (2006) [17], Ukkund *et al*. (2007) [21], and Sandeep *et al*. (2008) [14]. The data in Table 3 present plant spread (N-S) at different growth stages. Significant differences in plant spread (N-S) were observed among F_5 progenies. Progeny PBNC-16 consistently exhibited the highest plant spread (N-S) at all growth stages (28.85 cm, 37.07 cm, 46.89 cm, and 68.08 cm at 30, 60, 90, and 120 DAT, respectively), on par with PBNC-17 (28.03 cm, 36.25 cm, 45.23 cm, and 66.79 cm at the corresponding stages). Progeny PBNC-7 recorded the significantly least plant spread (N-S) at early growth stages (15.06 cm, 22.93 cm, and 26.76 cm at 30, 60, and 90 DAT, respectively), while PBNC-4 exhibited the least spread (N-S) at 120 DAT (40.93 cm).

Table 3 also provides data on plant spread (E-W) at different growth stages. The plant spread (E-W) varied significantly among progenies. PBNC-16 consistently displayed the highest plant spread (E-W) at all stages (27.61 cm, 37.70 cm, 54.65 cm, and 67.40 cm at 30, 60, 90, and 120 DAT, respectively), on par with PBNC-15 (26.74 cm, 36.30 cm, 53.55 cm, and 64.96 cm at the corresponding stages). Progeny PBNC-4 exhibited the significantly least plant spread (E-W) at all stages (14.21 cm, 26.07 cm, 30.21 cm, and 40.81 cm at 30, 60, 90, and 120 DAT, respectively).

The wide variation in plant spread may be attributed to the direct effects of soil and agro-climatic conditions and the indirect effects of the number of branches per plant. This observation aligns with the findings of Mahantesh *et al*. (2002) [12], Vijaya *et al*. (2014) [22], and Sharma *et al*. (2015) [16].

Table 4 highlights significant differences in fruit yield per plant. Progeny PBNC-16 recorded the highest fruit yield per plant (1824.16 g), on par with PBNC-15, PBNC-17, PBNC-16, PBNC-17, PBNC-19, and PBNC-20. Progeny PBNC-4 exhibited the lowest fruit yield per plant (1033.97 g). Fruit yield per plant is a crucial trait for chili progeny selection, with potential attributed to progeny adaptability and performance in different environmental conditions. This potential is influenced by inherent genetic characteristics, including the number of fruits per plant, higher fruit weight, and the presence of primary and secondary branches. This aligns with the findings of Herison *et al*. (2014) [8], Jamal *et al*. (2015) [10], and Zhani *et al*. (2015) [23], suggesting that the highest yield is associated with the highest number of fruits per plant.

Data in Table 4 show that fruit yield per plot ranged from 43.42 kg to 76.61 kg, with a general mean of 59.87 kg. Progeny PBNC-16 exhibited the maximum fruit yield per plot (76.61 kg), followed by PBNC-15 (75.08 kg) and PBNC-17 (73.96 kg). Progeny PBNC-4 recorded the minimum fruit yield per plot (43.42 kg), followed by PBNC-7 (45.67 kg). The overall mean fruit yield per plot was 59.87 kg.

Data presented in Table 4 reveal that the mean value for the number of seeds per fruit ranged from 71.92 to 100.70, with a mean of 84.99. Progeny PBNC-18 exhibited the highest number of seeds per fruit (100.70), on par with PBNC-16, PBNC-15, and PBNC-17, while PBNC-7 recorded the lowest number of seeds per fruit (74.78), followed by PBNC-4 (76.75). Variations in the number of seeds per chili fruit were also noted by Manju and Sreelathakumary (2019) [4], Smitha and Basavaraja (2006) [17], and Dhaliwal *et al*. (2014) [6].

Regarding capsaicin content, data in Table 4 show a range from 0.22 to 0.49 percent, with a mean of 0.37 percent. PBNC-17 recorded the significantly highest capsaicin content of 0.49 percent, on par with PBNC-22 at 0.48 percent. In contrast, PBNC-7 exhibited the significantly lowest capsaicin content of 0.22 percent. Capsaicin percentage, influencing the hot flavor, holds importance for market value and industrial purposes. This variability may stem from gene-modifying factors for pungency, the ratio of placental tissue to seed, and pericarp characteristics. Lekshmi and Sreelathakumary (2019) [4] also observed a capsaicin range of 0.10-0.88 percent in chili.

Table 5 presents data on the mean performance for pest and disease reactions of chili progenies. Whitefly infestation ranged from 6.70 to 17.28 percent, with a mean infestation of 8.52 percent. PBNC-16 exhibited the minimum whitefly infestation (6.70 percent), while PBNC-23 recorded the maximum infestation (17.28 percent). Thirteen F_5 hybrids and three checks were assessed against the churda murda complex, with promising hybrids PBNC-15, PBNC-16, PBNC-17, and PBNC-19 displaying resistant reactions, with disease infection percentages of 15.77, 16.09, 16.28, and 17.61, respectively. Most F_5 hybrids exhibited moderate resistance, while some showed moderate susceptibility.

Concerning anthracnose infection, five F_5 progenies (PBNC-16, PBNC-15, PBNC-17, PBNC-18, and PBNC-20) were found resistant, with disease infection percentages of 7.18, 7.28, 8.29, 9.51, and 9.51, respectively. Six progenies displayed moderate resistance, three were moderately susceptible, and one (PBNC-19) was susceptible. Among the fifteen F_5 progenies evaluated, PBNC-15 showed the lowest anthracnose infection (7.18 percent), while PBNC-19 exhibited the highest (10.00 percent). Similar reports of chili resistance to anthracnose infection have been documented by Souza and Cafe-Filho (2003) [18] and Rajesh *et al*. (2015) [13].

Table 1: Performance of different chilli progenies in respect to plant height.

Genotype	Plant height (cm)			
	30 DAT	60 DAT	90 DAT	120 DAT
	Mean	Mean	Mean	Mean
PBNC-4	22.33	34.78	53.48	60.93
PBNC-7	19.14	25.37	39.91	52.22
PBNC-10	26.71	38.28	43.69	57.19
PBNC-13	26.05	39.48	56.70	67.83
PBNC-14	23.60	40.75	44.80	63.34
PBNC-15	28.90	45.32	73.98	89.66
PBNC-16	29.07	46.30	77.38	92.94
PBNC-17	28.56	44.18	72.53	88.82
PBNC-18	20.44	37.03	65.62	71.77
PBNC-19	32.55	48.52	70.76	83.78
PBNC-20	26.21	30.21	65.78	77.65
PBNC-22	22.36	38.20	52.33	68.59
PBNC-23	27.14	40.30	66.17	76.24
BYDGI-341	29.54	38.40	64.10	79.73
BSS-355	29.63	43.23	65.43	83.48
Mean	26.35	39.22	60.84	74.28
Range	19.14-32.55	25.37-48.52	39.91-77.38	52.22-92.94
Result	SIG	SIG	SIG	SIG
SE(m)	1.15	1.03	2.08	2.33
CD	3.50	3.13	6.31	7.07

Table 2: Performance of different chilli progenies in respect of number of primary branches per plant.

Genotype	Number of primary branches per plant			
	30 DAT	60 DAT	90 DAT	120 DAT
	Mean	Mean	Mean	Mean
PBNC-4	1.67	3.66	5.68	7.48
PBNC-7	1.16	2.61	4.07	6.01
PBNC-10	1.19	3.29	5.26	6.47
PBNC-13	2.59	3.83	5.94	7.54
PBNC-14	2.99	4.02	6.37	7.14
PBNC-15	3.35	5.07	7.52	8.67
PBNC-16	4.74	5.79	7.29	9.16
PBNC-17	3.62	5.42	7.01	8.43
PBNC-18	2.89	4.18	6.17	7.29
PBNC-19	2.84	4.74	6.92	6.98
PBNC-20	2.65	3.97	5.74	7.27
PBNC-22	2.90	4.11	5.41	6.92
PBNC-23	2.67	3.60	6.09	7.02
BYDGI- 341	3.36	4.3	6.61	7.89
BSS-355	3.77	5.00	6.23	8.05
Mean	2.78	4.27	6.22	7.49
Range	1.16-4.74	2.61-5.79	4.07-7.52	6.01-9.16
Result	SIG	SIG	SIG	SIG
SE(m)	0.48	0.37	0.28	0.34
CD	1.45	1.12	0.86	1.05

Table 3: Performance of different chilli progenies in respect plant spread (N-S) and (E-W).

Genotype	Plant spread (North-South)				Plant spread (East-West)			
	30DAT	60 DAT	90 DAT	120 DAT	30DAT	60 DAT	90 DAT	120 DAT
	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
PBNC-4	19.60	24.78	35.50	40.33	18.85	29.89	35.46	43.08
PBNC-7	15.06	22.93	26.76	41.93	14.21	26.07	30.21	40.81
PBNC-10	17.86	25.55	28.15	39.83	18.10	27.16	39.15	46.55
PBNC-13	19.86	24.79	31.85	44.02	18.21	29.19	41.22	42.90
PBNC-14	16.79	28.75	30.45	41.67	17.01	28.02	34.23	44.08
PBNC-15	27.88	36.10	45.58	66.61	26.74	36.30	53.55	64.96
PBNC-16	28.85	37.07	46.89	68.08	27.61	37.70	54.65	67.40
PBNC-17	28.03	36.25	45.23	66.79	26.29	36.88	52.43	65.37
PBNC-18	21.10	25.09	35.55	43.47	20.82	29.34	36.40	43.65
PBNC-19	18.97	25.18	33.55	45.35	18.29	27.01	38.29	48.74
PBNC-20	24.73	26.58	32.95	46.40	21.72	27.32	33.78	46.48
PBNC-22	21.28	27.82	31.05	32.99	17.56	29.04	30.21	44.65
PBNC-23	16.90	25.35	38.10	40.80	17.00	30.05	35.72	43.57
BYDGI-341	26.66	28.37	36.85	41.23	23.18	28.98	37.99	47.59
BSS-355	24.59	29.50	41.58	46.87	24.47	30.15	41.05	48.13
Mean	21.88	28.27	36.00	46.56	20.67	30.20	39.42	49.10
Range	15.06-28.85	22.93-37.07	26.76-46.89	40.33-68.08	14.21-27.61	26.07-37.70	30.21-54.65	40.81-67.40
Result	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG
SE(m)	0.91	0.79	1.14	1.14	1.14	0.95	1.83	1.66
CD	2.76	2.41	3.47	3.46	3.46	2.90	5.57	5.05

Table 4: Fruit Yield and Fruit quality parameters of different Chilli progenies.

Genotype	Green fruit yield per plant (g)	Green fruit yield per plot (kg)	Capsaicin (%)	No. of seed per fruit
	Mean	Mean	mean	Mean
PBNC-4	1033.97	43.42	0.35	76.75
PBNC-7	1086.09	45.64	0.22	74.78
PBNC-10	1306.33	54.86	0.36	78.63
PBNC-13	1448.61	60.84	0.34	88.98
PBNC-14	1542.12	64.76	0.47	81.74
PBNC-15	1796.39	75.08	0.43	89.27
PBNC-16	1824.16	76.61	0.37	94.09
PBNC-17	1782.89	73.96	0.49	93.59
PBNC-18	1335.12	56.07	0.33	100.70
PBNC-19	1229.75	51.64	0.27	81.75
PBNC-20	1465.24	61.54	0.38	92.22
PBNC-22	1285.95	54.00	0.48	79.28
PBNC-23	1257.75	52.82	0.40	71.92
BYDGI- 341	1463.96	61.48	0.42	81.67
BSS-355	1639.03	68.83	0.26	85.50
Mean	1425.69	59.87	0.37	84.99
Range	1033.97-1824.16	43.42-76.61	0.22-0.49	71.92-100.70
Result	SIG	SIG	SIG	NS
SE(m)	15.69	0.51	0.13	1.55
CD	43.02	1.56	0.40	4.72

Table 5: Reaction of chilli progenies against incidence of leaf curl (%), incidence of powdery mildew and thrips under field condition.

Genotype	Incidence of leaf curl (%)			Incidence of anthracnose			Incidence of white fly
	Percent of disease infection	Grade	Reaction	Percent of disease infection	Grade	Reaction	Mean
PBNC-4	19.27	2	MR	8.16	1	R	7.00
PBNC-7	21.31	2	MR	8.91	2	MR	9.60
PBNC-10	20.00	1	R	9.51	1	R	13.39
PBNC-13	18.73	2	MR	9.58	3	MS	14.95
PBNC-14	17.42	2	MR	9.00	4	S	10.10
PBNC-15	16.28	2	MR	7.18	2	MR	12.35
PBNC-16	15.77	2	MR	9.87	2	MR	6.70
PBNC-17	17.61	2	MS	7.28	2	MR	8.62
PBNC-18	18.00	1	R	9.51	4	S	8.60
PBNC-19	16.09	3	MS	10.00	2	MR	7.00
PBNC-20	17.07	3	MS	8.29	3	MS	9.46
PBNC-22	16.22	2	MR	9.22	2	MR	11.20
PBNC-23	16.41	2	MR	8.64	2	MR	17.28
BYDGI-341	14.13	2	MR	6.18	3	MS	07.77
BSS-355	18.33	3	MS	7.59	2	MR	16.45
Mean	17.51	-	-	8.59	-	-	8.52
Range	-	-	-	-	-	-	6.70-17.28
Result	-	-	-	-	-	-	SIG
SE(m)	-	-	-	-	-	-	0.67
CD	-	-	-	-	-	-	1.93

Conclusion

In conclusion, the study encompassed a comprehensive evaluation of various traits in thirteen F_5 progenies and two checks. Notably, PBNC-18 exhibited the highest seed yield per fruit, showcasing its potential for enhanced productivity. Additionally, PBNC-17 demonstrated the highest capsaicin content, highlighting its significance in the context of spice production. White fly infestation varied across progenies, with PBNC-16 emerging as the least affected, emphasizing its resistance to this common pest. In the realm of viral resistance, PBNC-18, PBNC-15, PBNC-16, and PBNC-17 stood out as promising progenies against leaf curl virus, with seven hybrids displaying moderate resistance. The assessment of anthracnose resistance identified five hybrids as resistant and six as moderately resistant. While no F_5 hybrid displayed immunity to these diseases, PBNC-16, PBNC-15, and PBNC-17 recorded green fruit yields surpassing 550 q/ha, establishing them as superior choices for commercial cultivation in the Maharashtra region. Overall, these findings offer valuable insights for cultivators seeking resilient and high-yielding pepper varieties for sustainable agriculture in the specified region.

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