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Genetic Variability, Correlation Studies and Path Analysis in Chilli (*Capsicum annuum L.) Genotypes*

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Abstract
The present experiment title “Genetic Variability, Correlation Studies and Path Analysis in Conducted during the kharif season of 2024-2025. Pandhurna It is located in the "Satpura Range of Mountains" southwest. The experiment was laid out in randomized block design. The experimental setup included fourteen genotypes of Chilli, which were arranged in a Randomized Block Design with three replications. Analysis of variance indicated that significant differences exist among the genotypes with respect to both quantitative and qualitative characters. Correlation studies revealed that, Days to first flowering, days to 50% flowering, days to physiological maturity, days to harvest maturity, days to fruit initiation, plant height (cm), No.of primary branches per plant, No.of secondary branches per plant, fruit length, fruit diameter, No.of fruit per plant, no.of seeds per fruit, seed yield per plant (gm), seed yield per plot (kg) had positive significant association, with yield per plant indicating the importance of these traits in selection for yield because of their direct contribution to yield. Maximum positive direct effect was observed for Days to first flowering, days to 50% flowering, days to physiological maturity, days to harvest maturity, days to fruit initiation, plant height (cm), No.of primary branches per plant, No.of secondary branches per plant, fruit length, fruit diameter, No.of fruit per plant, No.of seeds per fruit, seed yield per plant (gm), seed yield per plot (kg).

Keywords: Genetic variability, path analysis, chilli, Correlation

Introduction
The fruit and vegetable chilli (*Capsicum annuum L.)* is widely grown around the world. It is a member of the Solanaceae family and has 2n = 24 chromosomes. Chilli is a cross-pollinated crop that produces berries that resemble pods and is one of the most widely produced spices in India. It is frequently referred to as hot pepper and was brought to India from Brazil by the Portuguese in the 16th century. Chilies are an excellent source of vitamin C and contain other essential vitamins such as A, K, E, and minerals (Singh, 2007) [13]. They are nutritionally rich, with high amounts of ascorbic acid (111.07 mg), moisture (85.7 g), protein (2.9 g), fat (0.6 g), minerals (1.0 g), calcium (30.0 mg), carbohydrate (3.0 g), fiber (6.8 g), sodium (6.5 mg), magnesium (24.0 mg), chlorine (15.0 mg), sulfur (34.0 mg), copper (1.6 mg), iron (1.2 mg), phosphorus (80 mg), Riboflavin (0.39 mg), and vitamin A (292 IU). On an area of 0.377 million hectares, India produced roughly 3.783 million metric tonnes of chilies in 2019–20 (NHB Database 2019–20). Chilies are grown on 10,706 hectares in Chhattisgarh, producing 65,673 metric tonnes in 2021–22 (Agri site cg.nic.in). Breeders can find viable genotypes by thoroughly knowing the variety that is present in the breeding material for desirable qualities in a crop species. Phenotypic variation is caused by phenotypic, genotypic, and genotype-environment interactions. However, the most important factor for making wise breeding decisions is genetic variation because it is heritable. The enormous genetic diversity that chilli breeders have access to has aided in the creation of new kinds and hybrids. A secondary centre of origin for chilies is India, and the majority of features have a wide genetic range. Understanding the correlations and contributions of various character features is essential for successful breeding initiatives. Breeders can create improved cultivars with desirable qualities by utilising the genetic diversity found in chillies, which will increase production and the long-term viability of chilli agriculture. Meeting the various consumer needs and preserving the financial security of chilli producers will depend on the ongoing exploration and use of the genetic resources found in chillies.

Materials and Methods

The present investigation entitled " Genetic Variability & Association Studies in Chilli *(Capsicum annuum L.) Solanaceae*)" was conducted during kharif- 2024-25 at Experiment will be was out at the Saikheda School of Agricultural Science's Genetics and Plant Breeding Department. GHRUS During the kharif season of 2024-2025. Pandhurna. It is located in the "Satpura Range of Mountains" southwest. Its latitude ranges from 21.28 to 22.49 degrees North and its longitude from 78.40 to 79.24 degrees. The district's average elevation in Madhya Pradesh is 2215 feet (675 meters), although its altitudes range from 1,440 ft (438 meters) to 3,825 feet (1,165 meters) above sea level. This area has a subtropical climate with a tropical wet and dry climate that borders it. The summers are hot and dry, while the winters are frigid. Typically, the monsoon arrives in the latter week of June. The yearly rainfall average is 1,183 mm. The wintertime minimum temperature ranges from 4 to 6 degrees Celsius, while the summertime maximum is 38 to 42 degrees Celsius.

All the treatments were randomly distributed among the plots and replicate three times. Transplanting of seedlings was done at spacing of 45x60 cm. The observations were recorded on five plants per plots Days to first flowering, days to 50% flowering, days to physiological maturity, days to harvest maturity, days to fruit initiation, plant height (cm), No. of primary branches per plant, No. of secondary branches per plant, fruit length, fruit diameter, No. of fruit per plant, No. of seeds per fruit, seed yield per plant (gm), seed yield per plot (kg). The data recorded during observation was used for analysis to test the level of significance as per method given by (Chandel, 1984). The data were analysed to work out various components coefficient of variation and heritability in broad sense and expected genetic advance as percent of Mean were estimated as suggested by (Johnson *et al*, 1955) respectively.

Results and Discussion

Pooled data over one years (2024-2025) have been utilized to study genetic variability among the fourteen chilli genotypes for the studied fourteen characters. The analysis of variance, presented in Table 1, clearly suggests significant differences among the genotypes for all the characters (at P=0.01), indicating presence of significant genetic variability in the experimental material. This finding was in accordance with those of Khurana *et al.*, (2003) [17]. (71.83%), fruit yield per plot (54.590%), fruit yield per hectare (48.144%), fruit length (41.661) The high genetic advance % for these characters showed that these characters are governed by additive gene action and selection will be rewarding for the further improvement of such traits. Similar finding reported by Shrishat *et al.* (2007) [8] for fruit length, number of fruits per plant, Sharma *et al*. (2010) [2] for fruit girth and fresh weight, number of primary branches, Patel *et al.* (2015) for fruit weight and fruit yield per plant and Kumar *et al*. (2020) [9] for fruit yield per hectare Moderate heritability coupled with moderate genetic advance was observed for characters namely; fresh fruit weight, plant height. Similar finding reported by Sharma *et al*. (2010) [2] for fresh weight.

Table 1: Analysis of variance for fruit yield and its attributing traits in hot pepper

Character	Mean Squares		
	Replication df(2)	Treatments df(6)	Error df(12)
Days to first flowering	49.63	2.71	6.99
Days to 50% flowering	116.32	3.12	12.75
Days to physiological maturity	101.41	5.29	11.84
Days to harvest maturity	119.94	11.76	6.32
Days to fruit initiation	65.10	5.33	12.00
Plant height (cm)	52.76	0.33	6.17
No. Of primary branches per plant	5.10	0.33	0.67
No. Of secondary branches per plant	3.05	0.43	0.43
Fruit length	14.98	2.33	1.72
Fruit diameter	0.10	0.21	0.03
No. Of fruit per plant	295.97	11.48	24.59
No. Of seeds per fruit	519.83	19.19	22.80
Seed yield per plant (gm)	776.60	107.48	333.37
Seeds yield per plot (kg)	0.38	0.20	0.45

The study conducted simple correlation coefficients (both phenotypic and genotypic) (Table-3 & 4) to examine the relationship between yield and its various components, as well as quality parameters. Fruit yield per ha. (yield)had highly positively and significantly correlated both at genotypic and phenotypic levels with fruit yield per plot, numbers of fruit per plant, fruit weight per plant, fresh fruit weight, fruit length, fruit girth, plant height, total numbers of picking. whereas days to first flowering and days to 50% flowering this character showed negative significant correlation. Similar finding is reported by Nehru *et al*. (2003) [10], Gogoi and Gautam (2002) [11], Sandeep (2007) [12], Datta and Jana (2013) [3], and Patel *et al*. (2009).

Table 2: Estimation of genetic parameter of variation for fruit yield and its attributing traits in chilli

Sr. No	Characters	Range			Variance		GCV	PCV	H^2	GA
		Max	Min	Mean	GV	PV	(%)	(%)	(%)	
1	Days to first flowering	52.67	40.0	45.29	14.21	21.21	8.30	10.14	71.29	6.66
2	Days to 50% flowering	59.33	40.00	50.19	34.52	47.27	11.71	13.70	70.58	9.96
3	Days to physiological maturity	97.67	78.00	86.43	29.86	41.70	6.32	7.47	71.60	9..52
4	Days to harvest maturity	97.67	76.33	86.05	37.87	44.19	7.15	7.73	85.70	11.74
5	Days to fruit initiation	92.67	77.00	84.48	17.70	29.70	4.98	6.45	59.59	6.69
6	Plant height (cm)	53.33	40.33	44.80	15.53	21.70	8.80	10.40	71.58	6.87
7	No.of primary branches per plant	6.67	2.67	5.19	1.48	2.14	23.41	28.20	68.89	2.08
8	No. of secondary branches per plant	6.33	3.33	5.29	0.87	1.30	17.68	21.58	67.07	1.58
9	Fruit length,	15.00	7.67	11.19	4.42	6.14	18.79	22.15	71.96	3.67
10	Fruit diameter	0.93	0.47	0.73	0.03	0.05	21.77	31.41	48.03	0.23
11	No. of fruit per plant	86.67	67	67.10	90.46	115.05	14.18	15.99	78.63	17.37
12	No. of seeds per fruit	86.67	62	64.38	165.67	188.48	19.99	21.32	87.90	24.86
13	Seed yield per plant (gm)	200.67	159.00	177.62	147.75	481.11	6.84	12.35	30.71	13.88
14	Seed yield per plot (kg)	4.14	3.13	3.72	0.02	0.43	0.0	17.61	5.45	0.07

Phenotypic Path coefficient analysis revels that Maximum positive direct effect was observed for
Days to first flowering (0.0153), days to 50% flowering (0.0753), days to physiological maturity (0.072),
days to harvest maturity (-0.085), days to fruit initiation (0.0575), plant height (cm) (-0.225), No. of primary branches per plant (0.353), No. of secondary branches per plant (-0.1163) fruit length (-0.0478), fruit diameter (0.428)), No of fruit per plant (0.4464), No. of seeds per fruit (0.233), seed yield per plant (gm) (0.515

Table 3: Geno Table-4: phenotypic coefficient of correlation for fruit yield and yield attributing character in chilli

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1		0.086	-0.232	-0.289	-0.104	0.520**	-0.079	0.581**	0.501**	0.464**	0.406*	0.607**	0.626**	0.611**
2			0.294	0.252	0.096	0.002	-0.160	0.163	-0.273	0.392*	-0.401*	0.010	-0.159	-0.087
3				0.550**	0.255	-0.375*	0.063	-0.488**	-0.334*	-0.272	-0.492**	-0.511**	-0.556**	-0.489**
4					0.222	-0.337*	-0.022	-0.366*	-0.280	0.019	-0.358*	-0.333*	-0.498**	-0.369*
5						-0.285	0.115	-0.293	0.023	0.025	-0.379*	-0.166	-0.367*	-0.179
6							0.128	0.501**	0.413*	0.446**	0.626**	0.712**	0.724**	0.733**
7								-0.219	-0.169	-0.314	-0.137	-0.238	-0.180	0.022
8									0.510**	0.667**	0.262	0.724**	0.569**	0.492**
9										0.545**	0.311	0.706**	0.512**	0.510**
10											0.062	0.793**	0.478**	0.559**
11												0.569**	0.730**	0.702**
12													0.831**	0.861**
13														0.888**
14														

1. Days to first flowering	5. Days to fruit initiation	9. Fruit length,	13.Seed yield per plant (gm)
2. Days to 50% flowering	6. Plant height (cm)	10.Fruit diameter	14.Seeds yield per plot (kg)
3. Days to physiological maturity	7. No.of primary branches per plant	11.No.of fruit per plant	
4. Days to harvest maturity	8. No.of secondary branches per plant	12.No.of seeds per fruit	

The value of residual factor (0.05019) was found to be low thereby, suggesting that the effect of all the yield attributing characters on fruit yield per hectare has been studied and that not more contribution of other major yield component traits has been left to be

Table 4: Phenotypic coefficient of correlation for fruit yield and yield attributing character in chilli

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1		0.086	-0.232	-0.289	-0.104	0.520**	-0.079	0.581**	0.501**	0.464**	0.406*	0.607**	0.626**	0.611**
2			0.294	0.252	0.096	0.002	-0.160	0.163	-0.273	0.392*	-0.401*	0.010	-0.159	-0.087
3				0.550**	0.255	-0.375*	0.063	-0.488**	-0.334*	-0.272	-0.492**	-0.511**	-0.556**	-0.489**
4					0.222	-0.337*	-0.022	-0.366*	-0.280	0.019	-0.358*	-0.333*	-0.498**	-0.369*
5						-0.285	0.115	-0.293	0.023	0.025	-0.379*	-0.166	-0.367*	-0.179
6							0.128	0.501**	0.413*	0.446**	0.626**	0.712**	0.724**	0.733**
7								-0.219	-0.169	-0.314	-0.137	-0.238	-0.180	0.022
8									0.510**	0.667**	0.262	0.724**	0.569**	0.492**
9										0.545**	0.311	0.706**	0.512**	0.510**
10											0.062	0.793**	0.478**	0.559**
11												0.569**	0.730**	0.702**
12													0.831**	0.861**
13														0.888**

14													

1. Days to first flowering	5. Days to fruit initiation	9. Fruit length,	13.Seed yield per plant (gm)
2. Days to 50% flowering	6. Plant height (cm)	10.Fruit diameter	14.Seeds yield per plot (kg)
3. Days to physiological maturity	7. No.of primary branches per plant	11.No.of fruit per plant	
4. Days to harvest maturity	8. No.of secondary branches per plant	12.No.of seeds per fruit	

Table 5: Characters for fruit yield and yield attributing character in chilli

	Characters													
S. No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1	0.0153	0.00646	-0.01685	0.02459	-0.00598	-0.11722	-0.02795	-0.09482	-0.02396	0.19872	0.18888	0.14143	0.3228	0.611**
2	0.00131	0.07534	0.02138	-0.02151	0.00552	-0.00039	-0.05655	-0.02656	0.01304	0.16776	-0.18639	0.00233	-0.08184	-0.087
3	-0.00355	0.02215	0.0727	-0.04689	0.01469	0.08452	0.02238	0.07974	0.01596	-0.11645	-0.22856	-0.11907	-0.28653	-0.489**
4	-0.00442	0.01902	0.04001	-0.0852	0.01275	0.07601	-0.00775	0.05975	0.01337	0.00813	-0.16636	-0.07762	-0.25666	-0.369*
5	-0.00159	0.00724	0.01857	-0.0189	0.0575	0.06423	0.0407	0.04783	-0.00109	0.01051	-0.17597	-0.03879	-0.1893	-0.179
6	0.00795	0.00013	-0.02725	0.02872	-0.01638	-0.22551	0.04522	-0.08178	-0.01974	0.19108	0.29094	0.16594	0.3732	0.733
7	-0.00121	-0.01205	0.0046	0.00187	0.00662	-0.02883	0.35367	0.03567	0.00809	-0.13449	-0.06378	-0.0554	-0.0928	0.022
8	0.00889	0.01226	-0.0355	0.03118	-0.01684	-0.11295	-0.07728	-0.16327	-0.02438	0.28566	0.12161	0.16884	0.2933	0.492
9	0.00767	-0.02055	-0.02426	0.02383	0.00132	-0.09311	-0.05988	-0.08327	-0.04781	0.23327	0.14455	0.16466	0.2638	0.510
10	0.0071	0.02952	-0.01977	-0.00162	0.00141	-0.10063	-0.11108	-0.10892	-0.02604	0.42819	0.02891	0.18486	0.2465	0.559
11	0.00622	-0.03022	-0.03576	0.0305	-0.02177	-0.1412	-0.04855	-0.04273	-0.01487	0.02664	0.46465	0.13252	0.3762	0.702
12	0.00928	0.00075	-0.03714	0.02837	-0.00957	-0.16054	-0.08405	-0.11826	-0.03377	0.33958	0.26417	0.23309	0.4287	0.861
13	0.00958	-0.01196	-0.04039	0.04241	-0.02111	-0.16324	-0.06368	-0.09287	-0.02446	0.20475	0.33901	0.1938	0.5156	0.888

Conclusion

The analysis of variance, presented in Table 1, clearly suggests significant differences among the genotypes for all the characters (at P=0.01), indicating presence of significant genetic variability in the experimental material. High magnitude to genotypic coefficient of variation (GCV) coupled with phenotypic coefficient of variation (PCV) i.e., (>20%) were observed in characters namely; Days to first flowering (8.30 and 10.14), days to 50% flowering (11.71 and 13.70),days to physiological maturity (6.32 and 7.47), days to harvest maturity (7.15 and 7.73), days to fruit initiation (4.98 and 6.45), plant height (cm) (8.80 and 10.40), No. of primary branches per plant (23.41 and 28.20), No. of secondary branches per plant (17.68 and 21.58), fruit length (18.79 and 22.15), fruit diameter (21.77 and 31.41), No.of fruit per plant (14.18 and 15.99), No.of seeds per fruit (19.99 and 21.32), seed yield per plant (gm) (6.84 and 12.35), seed yield per plot (kg) (0.0 and 17.61).

Fruit yield per ha. (yield) highly positively and significantly correlated both at genotypic and phenotypic levels with whereas days to first flowering and days to 50% flowering this character showed negative significant correlation. Phenotypic Path coefficient analysis revels that Maximum positive direct effect was observed for Days to first flowering (0.0153), days to 50% flowering(0.0753), days to physiological maturity(0.072),days to harvest maturity (-0.085), days to fruit initiation (0.0575), plant height (cm) (-0.225), No. of primary branches per plant (0.353), No. of secondary branches per plant (-0.163), fruit length (-0.0478), fruit diameter (0.428), No. of fruit per plant (0.464), No. of seeds per fruit (0.233), seed yield per plant (gm) (0.515),

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