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Genetic variability and association analysis for M_3 mutants in chilli (*Capsicum annum* L.)

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Abstract: Two hundred sixteen mutants of chilli were evaluated to study the genetic variability as well as association for 12 growth and fruit characters along with quantitative characters. Significant variation exists among all the M_3 mutants studied for yield and its components. The least differences between genotypic and phenotypic coefficient of variation observed which indicates environmental influence for the expression of most of the traits. High heritability estimates with high genetic advance as per cent mean observed for characters like plant height, number of primary branches plant^{-1}, number of secondary branches plant^{-1}, number of fruits plant^{-1}, fruit length, fruit width, fruit diameter and fruit yield plant^{-1} revealed that these characters are under the control of additive gene action. Plant height, number of primary branches plant^{-1}, number of secondary branches plant^{-1}, number of fruits plant^{-1}, fruit length and fruit weight were highly associated with dry fruit yield plant^{-1}. Estimates of path analysis reveals that days to 50 per cent flowering, number of fruits plant^{-1}, fruit length, fruit weight and number of seeds per fruit^{-1} were the five factors that extends the greater influence both directly and indirectly upon the dry fruit yield plant^{-1}, these five traits were important components that involved dry fruit yield plant^{-1}. The genotype B. dabbi recorded highest colour value of 118.35 (ASTA) and ascorbic acid of 110.23 mg/g. Genotype Indam 5 recorded highest capsaicin of 0.41 per cent.

Key words: Chilli, Correlation, Genetic variability, Mutagenic population, Path analysis

Introduction

Chilli is one of the most important vegetable cum spice crops in India. In spite of its high nutritive value, well acceptability among consumers and wide range of genetic variability, the optimum productivity in chilli still remain to be achieved. Therefore, much concerted efforts are necessary to improve its yield and yield attributes. Genetic variability for economic traits is the pre-requisite for any successful breeding programme as the degree of response to selection depends on the quantum of variability. In any crop, yield being a complex character influenced by many of its contributing characters controlled by polygenes and the environmental factors. So, an understanding of genetics of yield and its component traits, association between each component trait and yield is necessary for planning effective selection procedure in developing high yielding genotypes. However, the inheritance of quantitative traits is often influenced by variation in other characters which may be due to pleiotropy or genetic linkage. Hence, knowledge of association between yield and its attributes obtained through estimation of genotypic and phenotypic correlation helps in determining the extent of improvement that could be brought about in the characters and also in selecting suitable genotypes.

Mutation breeding is recognised as one of the driving force of evolution. It's relatively quicker method for improvement of various crop species. It is an important tool to create variability for quantitatively inherited traits in different plants and is considered as an alternative method to increase genetic variability in plant breeding. Mutation breeding often used to correct defects in cultivar which has a set of good agronomic characteristics. The present study was, therefore, undertaken to determine the extent of genetic variability for important growth and fruit characters to yield as well as to determine interrelationship among the characters and their direct and indirect effects on yield of chilli.

Material and methods

Two hundred sixteen mutants of M_3 generation along with genotype P3, as resistant and Byadagi dabbi, Byadagi kaddi, Namdhari and G-4 as susceptible checks for *Fusarium* wilt were used to carry out present investigation. Experiment was carried out at College of Agriculture, Raichur, by using Auguemented Design (Federer, 1956). Nine individual plants were transplanted 20 cm away from the centre and 13.96 cm plant to plant distance in each cement ring of size 90 cm diameter and 30 cm height with 3 replications. The four checks were replicated thrice after 72 individual plants. Observations were recorded for 12 yield and yield contributing traits from each individual plant *i.e.,* days to 50 per cent flowering, days to first fruit maturity, plant height, number of primary branches plant^1, number of secondary branches plant^1, number of fruits plant^1, fruit length, fruit diameter, fruit weight fruit^1, test weight, number of seeds fruit^1, and fruit yield fruit^1. Recommended agronomic practices for the region were adopted to raise the crop.

Ascorbic acid was estimated following the method of Sadasivam and Manickam, (1992). Capsaicin was estimated by the procedure proposed by Palacio (1977) and colour was measured as per ASTA units (American Spice Trade Association). 20 best mutant were selected based on their yield performance and marketable quality of fruits and compared with best local hybrids and varieties. The statistical analysis of the data on individual character for Genotypic Co-efficient of Variation (GCV) and Phenotypic Coefficient of Variation (PCV), heritability (h^2) and Genetic Advance (GA), correlation and path analysis was carried out on the mean values of each mutant and 5 plants of checks using WINDOSTAT package, 8.1 versions.

Results and discussion

All the 12 characters under study showed highly significant variation among the genotypes indicating their importance in the study of genetic variability (Arouldoss *et al.,* 2015) Estimates for the PCV and GCV, heritability in broad sense (h^2) and GA as % of mean for these characters are presented in the Table 1.

Genotypic and phenotypic coefficients of variation of plant height, number of primary branches plant^{-1}, number of secondary branches plant^{-1}, number of fruits plant^{-1} fruit weight, number of seeds fruit^{-1} and fruit yield plant^{-1} were high and these traits exhibited high heritability coupled with very high genetic advance as per cent of mean which indicating the presence of considerable genetic variation and additive gene effects. Hence, the improvement of these characters could be effective through phenotypic selection. These findings are in confirmation with (Sarkar *et al.,* 2009, Sharma *et al.,* 2010 and Daudu and Falusi 2011). Fruit length, fruit diameter and test weight showed moderate genotypic and phenotypic coefficients of variation. This indicates the existence of comparatively moderate variability, which could be exploited for improvement through selection in advanced generations. Similar findings were observed by Smitha and Basavaraj (2006) and Sarkar *et al.* (2009).

Days to 50 per cent flowering, days to first fruit maturity showed low genotypic and phenotypic coefficients of variation and high heritability with low genetic advance as per cent of mean revealed presence of non additive gene and low scope for improvement of these traits through selection. These findings are in confirmation with Sharma *et al.* (2010).

Dry fruit yield had significant and positive correlation with plant height, number of primary branches plant^{-1}, number of secondary branches plant^{-1}, number of fruits plant^{-1}, fruit length, fruit weight fruit^{-1}, number of seeds and test weight (Table 2). Similar findings were obtained by Kumar *et al.* (2003) and

Table 1. Estimates of range, mean and genetic parameters for yield and its attributing traits of M_3 mutants of chilli

Characters	Range		Mean.	GCV (%)	PCV (%)	Heritability (%)	Genetic	Genetic
	Minimum	Maximum				broad sense	advance	Advance as % of mean
X1	31.00	54.00	44.78	7.75	8.64	80.50	6.41	14.14
X2	71.00	94.00	84.77	4.23	4.55	86.15	6.84	8.07
X3	12.00	97.00	48.75	31.00	31.25	98.45	30.56	63.35
X4	2.00	5.00	2.72	20.68	32.38	40.79	0.74	27.20
X5	4.00	15.00	6.50	34.99	37.12	88.94	4.33	67.98
X6	5.00	64.00	22.93	45.75	46.16	98.22	20.58	93.38
X7	1.82	9.12	4.85	16.40	17.41	88.69	1.44	31.81
X8	8.22	18.11	12.64	14.42	14.64	97.10	3.87	29.27
X9	0.23	1.89	0.84	32.30	32.43	99.21	0.55	66.26
X10	14.00	138.00	81.20	25.42	25.61	95.30	0.55	12.00
X11	0.25	6.75	4.58	13.52	29.03	21.70	10.19	12.97
X12	2.99	64.16	19.37	53.43	54.62	96.74	19.60	108.24

Where,

X1 = Days to 50% flowering
X2 = Days to first fruit maturity
X3 = Plant height (cm)
X4 = Number of primary branches plant^{-1}
X5 = Number of secondary branches plant^{-1}
X6 = Number of fruits plant^{-1}
X7 = Fruit length (cm)
X8 = Fruit diameter (mm)
X9 = Fruit weight fruit^{-1} (g)
X10 = Test weight (g)
X11 = Number of seeds fruit^{-1}
X 12= Fruit yield plant^{-1} (g)

Table 2. Estimates of phenotypic correlation coefficient between fruit yield and its components in M_3 mutants of chilli

Traits	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	$r_{(FYPP)}$
X1	1.0000	0.9995**	-0.0339	0.0427	0.0462	-0.0743	0.0769	0.0431	0.0315	0.1053	0.0970	-0.0562
X2		1.000	-0.0346	0.0421	0.0459	-0.0768	0.0708	0.0461	0.0301	0.1030	0.0929	-0.0595
X3			1.0000	0.5333**	0.4373**	0.5709**	0.1373*	-0.1698**	-0.0112	0.0344	0.0101	0.3907**
X4				1.0000	0.5671**	0.3327**	-0.0092	-0.0303	0.1354*	0.0285	0.0393	0.2615**
X5					1.0000	0.3253**	0.1365*	0.0182	0.1849**	0.1756**	0.1522**	0.2958**
X6						1.0000	0.2436**	-0.2705**	-0.0042	0.0894	0.0880	0.7799**
X7							1.0000	-0.3086**	0.1677**	0.3773**	0.4087**	0.3540**
X8								1.0000	0.0188	-0.1004	-0.1637**	-0.2348**
X9									1.0000	0.1169*	0.1351*	0.5111**
X10										1.0000	0.9269**	0.1499**
X11											1.0000	0.1434*
X12												1.0000

** Significance at p = 0.01 * Significance at p = 0.05

Where,

X1 = Days to 50% flowering
X2 = Days to first fruit maturity
X3 = Plant height (cm)
X4 = Number of primary branches plant^{-1}
X5 = Number of secondary branches plant^{-1}
X6 = Number of fruits plant^{-1}
X7 = Fruit length (cm)
X8 = Fruit diameter (mm)
X9 = Fruit weight fruit^{-1} (g)
X10 = Test weight (g)
X11 = Number of seeds fruit^{-1}
X 12= Fruit yield plant^{-1} (g)

Table 3. Phenotypic path of different characters affecting fruit yield per plant in M_3 mutants of chilli

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
X1	0.3452	0.3450	-0.0117	0.0147	0.0160	-0.0257	0.0265	0.0149	0.0109	0.0363	0.335	-0.0562
X2	-0.3622	-0.3624	0.0126	-0.0153	-0.0167	0.0278	-0.0257	-0.0167	-0.0109	-0.0373	-0.0337	-0.0595
X3	0.0018	0.0019	-0.0544	-0.0290	-0.0238	-0.0311	-0.0075	0.0092	0.0006	-0.0019	-0.0005	0.3907**
X4	-0.0010	-0.0010	-0.0128	-0.0240	-0.0136	-0.0080	0.0002	0.0007	-0.0033	-0.0007	-0.0009	0.2615**
X5	-0.0016	-0.0016	-0.0154	-0.0200	-0.0352	-0.0114	-0.0048	-0.0006	-0.0065	-0.0062	-0.0054	0.2958**
X6	-0.0599	-0.0619	0.4597	0.2679	0.2619	0.8052	0.1962	-0.2178	-0.0034	0.0720	0.0709	0.7799**
X7	0.0069	0.0063	0.0123	-0.0008	0.0122	0.0218	0.0894	-0.0276	0.0150	0.0337	0.0365	0.3540**
X8	-0.0008	-0.0008	0.0031	0.0006	-0.0003	0.0050	0.0057	-0.0183	-0.0003	0.0018	0.0030	-0.2348**
X9	0.0162	0.0155	-0.0058	0.0696	0.0951	-0.0022	0.0862	0.0097	0.5141	0.0601	0.0694	0.5111**
X10	0.0143	0.0140	0.0047	0.0039	0.0239	0.0122	0.0514	-0.0137	0.0159	0.1362	0.1262	0.1499**
X11	-0.0151	-0.0145	-0.0016	-0.0061	-0.0237	-0.0137	-0.0636	0.0255	-0.0210	-0.1443	-0.1556	0.1434*

Residual effect = 0.3331

Where,

X1 = Days to 50% flowering
X2 = Days to first fruit maturity
X3 = Plant height (cm)
X4 = Number of primary branches plant^{-1}
X5 = Number of secondary branches plant^{-1}
X6 = Number of fruits plant^{-1}
X7 = Fruit length (cm)
X8=Fruit diameter (mm)
X9 = Fruit weight fruit^{-1} (g)
X10 = Test weight (g)
X11 = Number of seeds fruit^{-1}
X12= Fruit yield plant^{-1} (g)

Tembhurne *et al.* (2008). Days to 50 per cent flowering and days to first fruit maturity showed negative correlation with fruit yield plant^{-1}. These were in accordance with findings of Wilson and Philip (2009). Fruit diameter had significant and negative correlation with fruit yield.

In the present study out of 12 characters, five characters had positive and direct effect on fruit yield plant^{-1}. The character *viz.,* number of fruit plant^{-1} had maximum positive direct effect on fruit yield plant^{-1} followed by fruit weight, days to 50 per cent flowering, number of seeds fruit^{-1} and fruit length (Table 3) which indicates that if other factors are held constant, an increase in these characters individually will reflect in an increased yield. These results revealed that importance of number of fruits plant^{-1} in determining selection criteria for improvement of chilli yield. Similar results were obtained by researchers, Hasanuzzaman and Faruq (2011). Whereas six traits *viz.,* days to first fruit maturity, plant height, number of primary branches, number of secondary branches, fruit diameter and test weight had negative direct effect on fruit yield plant^{-1}. Still they contribute positively towards yield this is because of positive indirect effects of these traits towards yield through other characters. These results are in conformity with the observations made by Ahmed *et al.* (2013). High direct positive effects were also shown by fruit diameter with fruit yield and these results were contradictory with Sharma *et al.* (2007).

Qualities of chillies are judged commercially by its pungency and colour value *etc.* The maximum ascorbic acid was recorded in Byadagi dabbi and the least was observed in M-456. Similarly, the capsaicin content was more in Indam-5 and least was in M-379. Among the different genotypes tested, the colour value of Bydagi Dabbi was recorded highest and least was observed in M-456. This is in accordance with the findings Abdul Salam and Thoppil (2010), Sharma *et al.* (2010) and Naima *et al.* (2013). However, among the 20 selected mutants none of the mutants was superior for ascorbic acid over genotype P3 which was used for mutation treatment. However, 9 selected mutants i.e., M-250, M-270, M-298, M-315, M-319, M-321, M-421, M-440 and M-456 were superior for capsaicin and 17 mutants like M-250, M-270, M-294, M-296, M-298, M-309, M-315, M-319, M-321, M-351, M-357, M-362, M-671, M-379, M-397, M-421 and M-440 for colour over genotype P3. As per the mean per se performance is concerned for quality parameters

Table 4. Mean performance of selected M_3 chilli mutants and checks for quality parameters

Sl. No	Mutants	Ascorbic acid (mg)	Capsaicin (%)	Colour value (ASTA)	Yield/ Plant (g)
1	M-250	23.48	0.24	86.78	24.36
2	M-270	25.45	0.23	82.64	11.88
3	M-294	28.29	0.16	83.16	6.16
4	M-296	22.59	0.12	71.49	15.05
5	M-298	21.04	0.17	89.70	18.9
6	M-309	18.47	0.15	79.64	21.06
7	M-315	31.28	0.21	84.63	27.3
8	M-319	22.94	0.17	91.40	27.3
9	M-321	24.66	0.17	78.42	6.48
10	M-351	20.58	0.12	71.10	11.88
11	M-357	22.55	0.16	62.92	54.36
12	M-362	35.48	0.15	56.77	25.20
13	M-371	23.46	0.16	68.09	7.68
14	M-379	31.70	0.08	57.82	19.71
15	M-384	18.45	0.16	53.38	8.73
16	M-395	22.08	0.14	64.78	23.75
17	M-421	26.60	0.22	71.30	27.59
18	M-440	31.40	0.17	71.74	22.50
19	M-441	26.52	0.14	53.45	26.46
20	M-456	14.55	0.18	53.39	13.86
Checks					
21	P3	56.18	0.16	54.61	15.08
22	Byadagi .D	110.23	0.11	118.35	11.64
23	Sitara	98.85	0.21	101.73	68.35
24	Indam 5	82.40	0.41	90.27	07.25
25	JCH-42	101.69	0.22	92.26	75.86
26	JNA1× KA2long	101.18	0.34	87.57	73.84
Mean		40.08	0.18	75.67	25.09
CV		3.48	4.71	1.47	
C.D. @1%		3.05	0.028	2.43	

top five best genotypes were selected for further breeding programme (Table 4).

Ascorbic acid content: Byadagi dubbi, JCH-42, Sitara, Indam 5 and JNA1/KA2long

Capsaicin content: JCH-42, Indam 5, JNA1/KA2long, M-250 and M-270

Color value: Byadagi dubbi, Sitara, JCH-42, Indam 5 and M-319

Conclusion

From the present investigation it has been concluded that the higher genotypic and phenotypic coefficients of variation were observed for number of fruits plant^{-1}, number of secondary branches plant^{-1}, fruit weight, plant height and fruit yield plant^{-1}along with highest genetic advance indicated the possibility to improve these characters through selection. High significant positive correlation along with high magnitude of path coefficient was observed for number of fruits plant^{-1}, fruit weight, fruit length and test weight with fruit yield hence, these traits are important for the improvement of chilli. None of the selected mutants was superior for ascorbic acid over genotype P3 which was used for mutation treatment. However, 9 selected mutants were superior for capsaicin and 17 mutants for colour over genotype P3 therefore, mutation breeding will be rewarded for the improvement of capsaicin content and colour value.

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