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ORIGINAL ARTICLE

Direct and indirect effects of various traits on Chilli (*Capsicum annuum L.)* and Suggestions

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ABSTRACT
Chilli vegetable-cum spice one of the most important commercial crops of India and is cultivated throughout the country. The cause and effect relationship is well defined in path coefficient analysis it is possible to represent the whole system of variables in the form of a diagram known as path diagram. Path coefficient analysis can be defined as the ratio of the standard deviation of the effect due to a given cause to the total standard deviation of the effect, in other words it is simply a standardized partial regression coefficient which splits the correlation coefficient into the measures of direct and indirect effects, The experiment was conducted in a Randomized block design (RBD) with three replications. Forty days old seedlings of each line/ genotype was transplanted at the experimental site. Phenotypic path coefficient analysis carried out to know the contribution characters on dependent variable dry fruit yield plant-1. It had found positive direct effect on seed yield plant-1, dry weight of red ripe fruits, fresh ripe fruit weight, number of fruits plant-1, fruit width, days to flower initiation, number of secondary branches plant-1, fruit length, pedicel length and plant height. However, number of seeds fruit-1, test weight, days to 50% flowering, number of primary branches plant-1 and days to maturity expressed negative direct effect on dry fruit yield plant-1. An examination of the path analysis reveals that seed yield plant-1, dry weight of red ripe fruits, fresh ripe fruit weight and number of fruits plant-1 exerted high positive influence both direct and indirect up on the dry fruit yield plant-1. Indicated these characters play a major role in recombination breeding.
Keywords- Phenotypic, path coefficient, spice, commercial crops

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INTRODUCTION

Chilli vegetable-cum spice one of the most important commercial corps of India and is cultivated throughout the country. It is extensively cultivated in Asia, Africa, Europe and central and southern part of America. In India, it is grown on an area of 7.6 lakh hectares with an annual production of 12.44 lakh million tonnes of dry chilli [1]. Tamil Nadu, Bihar, Rajasthan, Punjab, Haryana and Madhya Pradesh. It is grown in 47.09 thousand hectares in Madhya Pradesh with a total annual production of 42.90 thousand tonnes of dry chilli. Genetic variability in the population is a pre-requisite for starting any successful breeding programme. Selection of suitable parents in hybridization programme from available genetic variability is an important step in the development of new variety on hybrid in any crop species. Presence of high variability in this crop offers much scope for its improvement. The cause and effect relationship is well defined in path coefficient analysis it is possible to represent the whole system of variables in the form of a diagram known as path diagram. Path coefficient analysis can be defined as the ratio of the standard deviation of the effect due to a given cause to the total standard deviation of the effect.

MATERIAL AND METHODS

The present experiment was conducted at Vegetable Research Farm, Horticulture complex, Maharajpur, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.) during the year 2009-10. The experimental material for this study comprised of 30 lines/genotypes including one check (JM-218) collected from different sources. The experiment was conducted in a Randomized block design (RBD) with three replications. Forty days old seedlings of each line/ genotype was transplanted at the experimental site. The experiment was conducted in a Randomized block design (RBD) with three replications. Forty days old seedlings of each line/ genotype was transplanted at the experimental site. Designing new plant type, the knowledge of direct and indirect influence of yield contributing characters, path coefficient analysis was under taken in parents and crosses. [2] proposed the original technique this analysis was carried out by modified method devised by [4]. Following set of simultaneously equations were formed and solved for estimating direct and indirect effects.

The dependent variable was fruit yield plant^{-1}. The unexplained variation in the dependent variable was obtained as residual factor from the following equation.

$r_1Y = P_1Y + r_{12}P_2Y + r_{13}\,P_3Y + \ldots\ldots\ldots\ r_1i\,P_1Y.$

$r_2Y = r_{21}P_1Y + P_2Y + r_{23}\,P_3Y + \ldots\ldots\ldots\ r_{21}\,P_1Y.$

$r_kY = r_{k1}P_1Y + r_{k2}P_2Y + r_{k3}\,P_3Y + \ldots\ldots\ldots\ R_k\,P_kY.$

Where,

r_1Y to r_kY to i	=	Coefficient of correlation between casual factors 1 and dependent character Y
P_1Y to P_kY	=	Direct effect of characters 1 to i on character Y
r_{12} to r_{k-1}	=	Coefficient of correlation among casual factors

Direct effect:

Then the direct effects were calculated as follows –

$$P_1Y = \sum_{i=1}^{k} C_{1i}\, r_iy$$

$$P_kY = \sum_{i=1}^{k} C_{ki}\, r_ky$$

Indirect effect:

$$P_2Y = \sum_{i=1}^{k} C_{2i}\, r_iy$$

Indirect effect of any independent traits on the dependent one (= yield) via other independent traits are computed by multiplying the direct effects (P_{ky}) of that independent variables with the corresponding correlation coefficient as follows.

K^{th} trait via (n-1) = rk (n-1) p (n-1) y

Residual effect:

Residual effect was obtained as per for formula given below –

$R = \sqrt{1 - \Sigma d_i r_{ij}}$

Where,

d_i = Direct effect of the i^{th} character

r_{ij} = Correlation coefficient of the i^{th} character with j^{th} character.

Path coefficient were to be rated based on the scales given below. (Lenka and Mishra 1973)

> 1.0	Very high
0.30 – 0.99	High
0.2 – 0.29	Moderate
0.1 – 0.19	Low
0.00 – 0.09	Negligible

RESULTS

Path coefficient analysis

A path coefficient is a standardized partial regression coefficient and as such measures the direct influence of one variable upon another and permits partitioning of the correlation coefficients into components of direct and indirect effects. In general, it was observed that genotypic direct and indirect effects were higher than their corresponding phenotypic values. The results obtained in genotypic and phenotypic direct and indirect effects are presented in Table 1 and 2. Discussed characters wise at phenotypic level here under.

Plant height (cm): Plant height (0.011) revealed negligible positive direct effect on dry fruit yield plant^{-1}. While, it expressed negligible positive indirect effect via seed yield plant^{-1} (0.003), test weight (0.003), pedicel length (0.003), days to flower initiation (0.002), days to 50% flowering (0.002), dry weight of red ripe fruits (0.002), number of fruits plant^{-1} (0.002), fresh ripe fruit weight (0.001), fruit length (0.001), days to maturity (0.001) and number of secondary branches plant^{-1} (0.0004). However, the negative indirect effect of this trait was negligible via number of primary branches plant^{-1} (-0.001), number of seeds fruit^{-1} (-0.001) and fruit width (-0.0003)[3].

Number of primary branches plant^{-1}: Number of primary branches plant^{-1} (-0.033) exhibited negligible direct influence on dry fruit yield plant^{-1} with quite low indirect effect via number of secondary branches plant^{-1} (-0.023), pedicel length (-0.007), fruit widt (-0.005), test weight (-0.004) and fruit length (-0.003). It contributes positive indirect effect through other traits viz., fresh ripe fruit weight (0.006), days to maturity (0.006), number of fruits plant^{-1} (0.004), seed yield plant^{-1} (0.003), dry weight of red ripe fruits (0.003)[6], number of seeds fruit^{-1} (0.002) and plant height (0.002).

Number of secondary branches plant^{-1}: Positive direct effect of number of secondary branches plant^{-1} (0.022) was negligible on dry fruit yield. While, its revealed negligible positive indirect effect via number of primary branches plant^{-1} (0.015), days to flower initiation (0.005), days to 50% flowering (0.005), pedicel length (0.003), fruit width (0.002), plant height (0.001), test weight (0.0003) and fruit length (0.0002). However, negative indirect effect via fresh ripe fruit weight (-0.005), days to maturity (-0.004), dry weight of red ripe fruits (-0.002), number of seeds fruit^{-1} (-0.002) and seed yield plant^{-1} (-0.001)[7].

Days to flower initiation: Positive direct effect of days to flower initiation (0.039) was negligible on dry fruit yield. While, it expressed positive indirect effect via days to 50% flowering (0.039), fruit length (0.018), fruit width (0.014), fresh ripe fruit weight (0.013), dry weight of red ripe fruits (0.013), pedicel length (0.011), test weight (0.008), number of secondary branches plant^{-1} (0.008), number of primary branches plant^{-1} (0.007), plant height (0.006), number of seeds fruit^{-1} (0.003) and seed yield plant^{-1} (0.001). However, days to maturity (-0.013) and number of fruits plant^{-1} (-0.007) revealed negligible indirect effect.

Days to 50% flowering: Negative direct effect of days to 50% flowering (-0.046) on dry fruit yield was revealed negligible. While, it expressed positive indirect effect via days to maturity (0.016) and number of fruits plant^{-1} (0.007). The characters viz., days to flower initiation (-0.046), fruit length (-0.022), fruit width (-0.017), dry weight of red ripe fruits (-0.015), fresh ripe fruit weight (-0.014), pedicel length (-0.013), number of secondary branches plant^{-1} (-0.010), number of primary branches plant^{-1} (-0.009), test weight (-0.009), plant height (-0.007), number of seeds fruit^{-1} (-0.004) and seed yield plant^{-1} (-0.002) excerted negligible negative indirect effects.

Days to maturity: Negligible negative direct effect was revealed days to maturity (-0.018) on dry fruit yield plant^{-1}. While, it also negligible negative indirect effect through number of fruits plant^{-1} ((-0.002), fruit length (-0.001), pedicel length (-0.001) and plant height (-0.001). However, the positive indirect effect of this trait was negligible via days to flower initiation (0.006), days to 50% flowering (0.006), number of seeds fruit^{-1} (0.006), number of primary branches plant^{-1} (0.003), number of secondary branches plant^{-1} (0.003), fruit width (0.003), dry weight of red ripe fruits (0.003), test weight (0.002), seed yield plant^{-1} (0.002) and fresh ripe fruit weight (0.001).

Pedicel length (cm): Pedicel length (0.011) was revealed negligible positive direct effect on dry fruit yield plant^{-1}. While, its indirect effect via fruit length (0.006), days to flower initiation (0.003), days to 50% flowering (0.003), fresh ripe fruit weight (0.003), dry weight of red ripe fruits (0.003), plant height (0.002), number of primary branches plant^{-1} (0.002), number of secondary branches plant^{-1} (0.002), fruit width (0.001), test weight (0.001) and number of seeds fruit^{-1} (0.001) was positive and negligible. However, negative effect via number of fruits plant^{-1} (-0.005) and seed yield plant^{-1} (-0.001) revealed negligible.

Fruit length (cm): Positive direct effect of fruit length (0.012) was negligible on dry fruit yield. While, it revealed negligible positive indirect effect via fresh ripe fruit weight (0.007), dry weight of red ripe fruits (0.006), days to 50% flowering (0.006), days to flower initiation (0.006), pedicel length (0.006), fruit width (0.004), test weight (0.003), plant height (0.001), number of primary branches plant^{-1} (0.001) and number of seeds fruit^{-1} (0.001). However, negative indirect effect via number of fruits plant^{-1} (-0.005) and seed yield plant^{-1} (-0.001) were expressed negligible[8].

Fruit width (cm): Fruit width (0.061) exhibited negligible positive direct effect on dry fruit yield plant^{-1}. While, it expressed positive indirect effect via dry weight of red ripe fruits (0.043), fresh ripe fruit weight (0.042), test weight (0.037), number of seeds fruit^{-1} (0.025), days to flower initiation (0.022), days to 50% flowering (0.022), fruit length (0.019), seed yield plant^{-1} (0.017), number of primary branches plant^{-1} (0.008), pedicel length (0.007) and number of secondary branches plant^{-1} (0.004) were negligible. However, the negative indirect effect of this trait was negligible via number of fruits plant^{-1} (-0.018), [9] days to maturity (-0.009) and plant height (-0.002).

Fresh ripe fruit weight (g): Low positive direct effect was revealed by fresh ripe fruit weight (0.138) on dry fruit yield plant^{-1}. While, the low indirect effect of this trait was dry weight of red ripe fruits (0.129). However, it expressed negligible indirect effect via fruit width (0.094), fruit length (0.077), number of seeds fruit^{-1} (0.077), test weight (0.069), days to flower initiation (0.044), days to 50% flowering (0.042), seed yield plant^{-1} (0.042), pedicel length (0.041) and plant height (0.017). Whereas, negative indirect effect via number of fruits plant^{-1} (-0.050), number of secondary branches plant^{-1} (-0.029), number of primary branches plant^{-1} (-0.023) and days to maturity (-0.009) were[10] negligible.

Dry weight of red ripe fruits (g): Dry weight of red ripe fruits (0.305) expressed high positive direct effect on dry fruit yield plant^{-1}. While, the indirect effect of this trait through fresh ripe fruit weight (0.286), fruit width (0.213), number of seeds fruit^{-1} (0.182), test weight (0.175), fruit length (0.163) and seed yield plant^{-1} (0.126) were exhibited moderate to low. However, it expressed negligible positive indirect effect via days to flower initiation (0.099), days to 50% flowering (0.096), pedicel length (0.076) and plant height (0.060). Whereas, it revealed negative indirect effect via number of fruits plant^{-1} (-0.084), days to maturity (-0.044), number of primary branches plant^{-1} (-0.027) and number of secondary branches plant^{-1} (-0.025).

Test weight (g): Test weight (-0.215) indicated moderate negative direct effect on dry fruit yield. While, it expressed low indirect effect via fruit width (-0.130) and dry weight of red ripe fruits (-0.124). However, seed yield plant^{-1} (-0.086), number of seeds fruit^{-1} (-0.081), fruit length (-0.052), plant height (-0.046), days to flower initiation (-0.044), days to 50% flowering (-0.043), pedicel length (-0.025), number of primary branches plant^{-1} (-0.022) and number of secondary branches plant^{-1} (-0.003) expressed negligible negative indirect effect. Whereas, this trait was positive indirect effect via number of fruits plant^{-1} and days to maturity (0.026) revealed negligible.

Number of fruits plant^{-1}: Number of fruits plant^{-1} (0.134) expressed low positive direct effect on dry fruit yield plant^{-1}. While, its indirect effect via seed yield plant^{-1} (0.087), plant height (0.027), days to maturity (0.013) and number of secondary branches plant^{-1} (0.001) were positive and negligible. However, negligible negative effect via pedicel length (-0.058), fruit length (-0.057), fresh ripe fruit weight (-0.049), dry weight of red ripe fruits (-0.037), test weight (-0.027), days to flower initiation (-0.023), days to 50% flowering (-0.021), number of seeds fruit^{-1} (-0.019) and number of primary branches plant^{-1} (-0.017).

Number of seeds fruit^{-1}: Moderate negative direct effect on dry fruit yield plant^{-1} was revealed by number of seeds fruit^{-1} (-0.260). While, indirect effect of this trait through dry weight of red ripe fruits (-0.155), fresh ripe fruit weight (-0.145), seed yield plant^{-1} (-0.136) and fruit width were low effect. However, test weight (-0.098), fruit length (-0.028), pedicel length (-0.023), days to flower initiation (-0.021) and days to 50% flowering (-0.021) expressed negligible indirect effect. The negligible positive indirect effect observed by days to maturity (0.087), number of fruits plant^{-1} (0.037), number of secondary branches plant^{-1} (0.030), plant height (0.023) and number of primary branches plant^{-1} (0.015).

Seed yield plant^{-1}: Highest positive direct effect was revealed by seed yield plant^{-1} (0.873) on dry fruit yield plant^{-1}. While, the high indirect effect of number of fruits plant^{-1} (0.565), number of seeds fruit^{-1} (0.457), dry weight of red ripe fruits (0.361) and test weight (0.351) was positive. However, it expressed moderate indirect effect via fresh ripe fruit weight (0.267), fruit width (0.243) and plant height (0.219). Days to 50% flowering (0.031) and days to flower initiation (0.018) expressed negligible effect. While, its revealed low negative indirect effect of pedicel length (-0.119). However, days to maturity (-0.019), number of primary branches plant^{-1} (-0.088), fruit length, (-0.075) and number of secondary branches plant^{-1} (-0.034), observed negligible, negative-indirect-effect.

Table 1: Genotypic path for yield and its components in chilli genotypes

DFYP (g)	**16**	0.325	-0.381	-0.125	0.107	0.119	-0.060	-0.097	0.056	0.334	0.442
SYPP (g)	**15**	0.005	0.478	-0.386	-0.283	0.401	0.026	0.009	-0.050	-0.057	2.833
NSPF	**14**	-0.002	-0.006	-0.542	-1.169	1.113	0.081	-0.007	0.066	-0.092	5.536
NFRP	**13**	0.004	0.714	-0.296	2.216	-1.742	-0.020	0.029	-0.241	0.062	-3.529
TWT (g)	**12**	0.004	-0.407	0.191	-2.586	2.164	0.037	-0.008	0.136	-0.126	4.832
DWRF (g)	**11**	0.004	0.414	-0.726	-4.149	3.521	0.040	-0.016	0.295	-0.144	8.827
FRFW (g)	**10**	0.002	0.818	-1.796	-4.111	3.453	0.023	-0.019	0.308	-0.139	**9.317**
FRWT (cm)	**9**	0.000	-0.452	0.349	-4.542	4.031	0.045	-0.007	0.168	**-0.205**	6.348
FRLT (cm)	**8**	0.002	-0.228	0.078	-6.029	5.262	-0.006	-0.035	**0.548**	-0.063	5.243
PDLT (cm)	**7**	0.004	-0.636	1.048	-3.675	3.270	-0.016	**-0.065**	0.294	-0.022	2.737
DMT	**6**	0.001	1.163	-2.249	5.755	-4.756	**-0.204**	-0.005	0.015	0.045	-1.048
DFFL	**5**	0.003	-0.799	1.879	-10.169	**6.482**	0.093	-0.020	0.275	-0.079	3.069
DFRI	**4**	0.003	-0.790	1.809	**-10.158**	6.492	0.097	-0.020	0.272	-0.076	3.150
NSBR	**3**	0.000	-2.196	**5.004**	-4.396	3.935	0.092	-0.014	0.009	-0.014	-3.345
NPBR	**2**	-0.002	**-2.228**	4.931	-4.307	3.757	0.106	-0.019	0.056	-0.042	-3.420
PLHT (cm)	**1**	**0.018**	0.260	0.389	-1.838	1.462	-0.014	-0.016	0.064	0.005	1.222
Characters		**PLHT (cm)**	**NPBR**	**NSBR**	**DFRI**	**DFFL**	**DMT**	**PDLT (cm)**	**FRLT (cm)**	**FRWT (cm)**	**FRFW (g)**
S.No.		1	2	3	4	5	6	7	8	9	10

DWRF (g)	TWT (g)	NFRP	NSPF	SYPP (g)
11	12	13	14	15
-1.253	0.530	1.310	-0.232	-1.583
1.137	0.429	-2.065	0.007	1.279
0.888	0.090	-0.381	-0.258	0.460
-2.087	0.500	-1.175	0.229	-0.139
-2.054	0.486	-1.071	0.253	-0.228
1.207	-0.424	0.624	-0.946	0.762
-1.530	0.274	-2.887	0.243	0.865
-3.294	0.583	-2.840	0.286	0.548
-4.301	1.453	-1.967	1.070	-1.654
-5.794	1.220	-2.442	1.415	-1.813
6.115	1.371	-1.807	1.512	-2.500
-3.563	**2.352**	-1.316	1.025	-2.438
1.714	-0.480	**6.447**	-0.332	-3.922
-3.883	1.012	-0.898	**2.382**	-3.182
-2.554	0.962	4.241	1.271	**-5.962**
0.537	0.297	0.625	0.410	0.933

Residual effect G = 1 - 1.362

PLHT (cm): Plant height (cm), NPBR: No. of primary braches plant^{-1}, NSBR : No. of secondary branches plant^{-1}, DFRI : Days to flower initiation, DFFL : Days to 50% flowering, DMT : Days to maturity, PDLT (cm) : Pedicel length (cm), FRLT (cm) : Fruit length (cm), FRWT (cm) : Fruit width (cm), FRFW (g) : Fresh ripe fruit weight (g), DWRF (g) : Dry weight of red ripe fruits (g), TWT (g) : Test weight (g), NFRP : No. of fruits plant^{-1}, NSPF : No. of seeds fruit^{-1}, DFYP (g) : Dry fruit yield plant^{-1}, SYFP (g) : Seed yield plant^{-1}

Table 2: Phenotypic path for yield and its components in chilli genotypes

S.No.		1	2	3	4
Characters		PLHT (cm)	NPBR	NSBR	DFRI
PLHT (cm)	**1**	**0.011**	0.002	0.001	0.006
NPBR	**2**	-0.001	**-0.033**	0.015	0.007
NSBR	**3**	0.0004	-0.023	**0.022**	0.008
DFRI	**4**	0.002	-0.006	0.005	**0.039**
DFFL	**5**	0.002	-0.006	0.005	0.039
DMT	**6**	0.001	0.006	-0.004	-0.013
PDLT (cm)	**7**	0.003	-0.007	0.003	0.011
FRLT (cm)	**8**	0.001	-0.003	0.0002	0.018
FRWT (cm)	**9**	-0.0003	-0.005	0.002	0.014
FRFW (g)	**10**	0.001	0.006	-0.005	0.013
DWRF (g)	**11**	0.002	0.003	-0.002	0.013
TWT (g)	**12**	0.003	-0.004	0.0003	0.008
NFRP	**13**	0.002	0.004	0.0001	-0.007
NSPF	**14**	-0.001	0.002	-0.002	0.003
SYPP (g)	**15**	0.003	0.003	-0.001	0.001
DFYP (g)	**16**	0.313	-0.169	-0.054	0.104

0.115	-0.040	-0.089	0.058	0.338	0.442	0.535	0.296	0.623	0.387	0.926
-0.002	0.002	-0.001	-0.001	0.017	0.042	0.126	-0.086	0.087	-0.136	**0.873**
-0.004	0.006	0.001	0.001	0.025	0.077	0.182	-0.081	-0.019	**-0.260**	0.457
0.007	-0.002	-0.005	-0.005	-0.018	-0.050	-0.084	0.043	**0.134**	0.037	0.565
-0.009	0.002	0.001	0.003	0.037	0.069	0.175	**-0.215**	-0.027	-0.098	0.351
-0.015	0.003	0.003	0.006	0.043	0.129	**0.305**	-0.124	-0.037	-0.155	0.361
-0.014	0.001	0.003	0.007	0.042	**0.138**	0.286	-0.109	-0.049	-0.145	0.267
-0.017	0.003	0.001	0.004	**0.061**	0.094	0.213	-0.130	-0.039	-0.106	0.243
-0.022	-0.001	0.006	**0.012**	0.019	0.077	0.163	-0.052	-0.057	-0.028	-0.075
-0.013	-0.001	**0.011**	0.006	0.007	0.041	0.076	-0.025	-0.058	-0.023	-0.119
0.016	**-0.018**	0.0004	0.0004	-0.009	-0.009	-0.044	0.026	0.013	0.087	-0.091
-0.046	0.006	0.003	0.006	0.022	0.042	0.096	-0.043	-0.021	-0.021	0.031
-0.046	0.006	0.003	0.006	0.022	0.044	0.099	-0.044	-0.023	-0.021	0.018
-0.010	0.003	0.002	0.0001	0.004	-0.029	-0.025	-0.003	0.001	0.030	-0.034
-0.009	0.003	0.002	0.001	0.008	-0.023	-0.027	-0.022	-0.017	0.015	-0.088
-0.007	-0.001	0.002	0.001	-0.002	0.017	0.060	-0.046	0.027	0.023	0.219
DFFL	**DMT**	**PDLT (cm)**	**FRLT (cm)**	**FRWT (cm)**	**FRFW (g)**	**DWRF (g)**	**TWT (g)**	**NFRP**	**NSPF**	**SYPP (g)**
5	6	7	8	9	10	11	12	13	14	15

Residual effect P = 0.144

PLHT (cm): Plant height (cm), NPBR: No. of primary braches plant^{-1}, NSBR : No. of secondary branches plant^{-1}, DFRI : Days to flower initiation, DFFL : Days to 50% flowering, DMT : Days to maturity, PDLT (cm) : Pedicel length (cm), FRLT (cm) : Fruit length (cm), FRWT (cm) : Fruit width (cm), FRFW (g) : Fresh ripe fruit weight (g), DWRF (g) : Dry weight of red ripe fruits (g), TWT (g) : Test weight (g), NFRP : No. of fruits plant^{-1}, NSPF : No. of seeds fruit^{-1}, DFYP (g) : Dry fruit yield plant^{-1}, SYFP (g) : Seed yield plant^{-1}

DISCUSSION

Genotypic path analysis of the different characters revealed that fresh ripe fruit weight was positive direct effect on dry fruit yield plant^{-1} followed by days to 50% flowering, number of fruits plant^{-1}, dry weight of red ripe fruits, number of secondary branches plant^{-1}, number of seeds fruit^{-1}, test weight, fruit length and plant height. Similar results were also reported by [11] [12], [13], [14]) and [15] for fruit plant^{-1}, fruit weight and fruit girth. Direct influence of fruit length and weight on yield was observed by [16], [17],Phenotypic path analysis of the different characters revealed that seed yield plant^{-1} was positive direct effect on dry fruit yield plant^{-1} followed by dry weight of red ripe fruits, fresh ripe fruit weight, number of fruits plant^{-1}, fruit width, days to flower initiation, number of secondary branches plant^{-1}, fruit length, pedicel length and plant height. Similar finding were observed by [18] for fruit length and weight on yield, [21] for number of fruits on fruit yield, [11], [19] and [20] for fruits plant^{-1}, fruit weight and fruit width on yield. However negative direct effect on dry fruit yield plant^{-1} was found in cases of number of seeds fruit^{-1}, test weight, days to 50% flowering, number of primary branches plant^{-1} and days to maturity. Thus increasing dry fruit yield plant^{-1} direct selection for these traits should be avoided instead indirect selection should be more appropriate to apply. Although, the characters viz., plant height, number of secondary branches plant^{-1}, days to flower initiation, pedicel length, fruit length and fruit width did not exhibit, high direct effect on yield. Seed yield plant^{-1} revealed a high positive indirect effect on dry fruit yield through number of fruits plant^{-1}, number of seeds fruit^{-1}, dry weight of red ripe fruits, test weight, fresh ripe fruit weight, fruit width and plant height. Similarly, dry weight of red ripe fruits had also high positive indirect effect on dry fruit yield through fresh ripe fruit weight fruit width, number of seeds fruit^{-1} and test weight. Fresh ripe fruit weight also expressed exerted low positive indirect effect on dry fruit yield through dry weight of red ripe fruits. Results revealed that, simultaneous selection for these characters can be made for the improvement of yield. Similar results were also reported by [22] [23] for plant height, number of branches plant^{-1} and fruit length on yield expressed indirect effect. Phenotypic path coefficient analysis carried out to know the contribution characters on dependent variable dry fruit yield plant-1. It had found positive direct effect on seed yield plant-1, dry weight of red ripe fruits, fresh ripe fruit weight, number of fruits plant-1, fruit width, days to flower initiation, number of secondary branches plant-1, fruit length, pedicel length and plant height. However, number of seeds fruit-1, test weight, days to 50% flowering, number of primary branches plant-1 and days to maturity expressed negative direct effect on dry fruit yield plant-1. However negative direct effect on dry fruit yield plant-1 was found in cases of number of seeds fruit-1, test weight, days to 50% flowering, number of primary branches plant-1 and days to maturity. Thus increasing dry fruit yield plant-1 direct selection for these traits should be avoided instead indirect selection should be more appropriate to apply. Although, the characters viz., plant height, number of secondary branches plant-1, days to flower initiation, pedicel length, fruit length and fruit width did not exhibit, high direct effect on yield. Seed yield plant-1 revealed a high positive indirect effect on dry fruit yield through number of fruits plant-1, number of seeds fruit-1, dry weight of red ripe fruits, test weight, fresh ripe fruit weight, fruit width and plant height. Similarly, dry weight of red ripe fruits had also high positive indirect effect on dry fruit yield through fresh ripe fruit weight fruit width, number of seeds fruit-1 and test weight. Fresh ripe fruit weight also expressed excerted low positive indirect effect on dry fruit yield through dry weight of red ripe fruits. Results revealed that, simultaneous selection for these characters can be made for the improvement of yield. Similar results were also reported by [21] & [22] for plant height, number of branches plant-1 and fruit length on yield expressed indirect effect.

SUGGESTIONS

The identified genotypes/varieties as high yielding viz., BVC-37, GUK 2-1-1, Pant C-1, Pusa Sadabahar and LCA-960 should be tested in different agro-climatic conditions and these found suitable could be recommended for commercial cultivation. Study on estimation of components of genetic variance may be carried out for improvement of yield through component traits. Traits identified for high heritability coupled with high or moderate genetic gain may be considered well in selection for the improvement of chilli crop. Characters having desirable association and direct effect with dry fruit yield should be given due to consideration for genetic improvement in chilli.

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