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SELECTION OF TRAITS FOR YIELD IMPROVEMENT IN CHILLI (*Capsicum annuum* L.)

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ABSTRACT

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The experiment was conducted at R & D Farm, Lal Teer Seeds Limited, Gazipur, Bangladesh. At Phenotypic level, yield per plant was significantly and positively correlated with fruit length, fruit weight and number of fruits per plant and days to fruit maturity (green). At Genotypic level, yield per plant significantly and positively correlated with all the characters mentioned above including fruit width. Significant and positive correlation was existed between plant height and plant canopy width at genotypic level. Fruit length had significant and positive genotypic and phenotypic correlation with fruit width and fruit weight. Multicolinearity between the traits was minumum. Number of fruits per plant was positively and significantly correlated with yield per plant (0.519) at phenotypic level. The direct effect of number of fruits per plant (0.653) was very close to correlation value and five different characters were involved to indirect positive effect. At genotypic level, the direct effect (0.501) was closer to correlation value (0.542) and indirect positive effect was acting through seven different characters. Selection should be done through number of fruits per plant. The residual effect of path analysis was 0.21 at genotypic level indicated all the important traits had been considered.

Key words: *correlation, path analysis, chilli*

INTRODUCTION

Yield is a complex trait and highly influenced by many genetic factors and environmental fluctuations. In plant breeding program, direct selection for yield as such could be misleading. Yield and yield contributing traits in chilli are correlated as reported by many researchers. A successful selection depends upon the information on the genetic variability and association of morpho-agronomic traits with yield. Correlation studies along with path analysis provide a better understanding of the association of different characters with yield. Path coefficient analysis separates the direct effects from the indirect effects through other related characters by partitioning the correlation coefficient (Dixet and Dubey, 1984).

In any crop improvement program, it is a prerequisite to critically assess the interrelationship for yield and its contributing characters. Yield is the result of the expression and association of several plant growth components. The study of relationships among quantitative traits is important for assessing the feasibility of joint selection of two or more traits. Correlation studies provide information about the nature and magnitude of various associations among the traits. It measures the mutual association between two variables but not permit to depict the cause and effect relationship of traits contributing directly or indirectly towards the economic yield. Path coefficient is partially standardized regression coefficient and as such measures the direct influence of one variable upon another and specifies the causes and measure their relative importance each casual variable.

Chilli is grown in all over the Bangladesh and in most areas, land races are cultivated. The yield of these land races is very low. During 1998-1999 to 2005-2006, average yield was 0.89 ton/ha (BBS 2007) which is much lower than our neighboring country India. In India, during 2003-2004 to 2007-2008, the average chilli production was 1.6 tons/ha (MoA, 2010). Improving the crop through developing high-yielding varieties with desirable qualities could reverse the existing trend of low productivity of the crop. Efforts to improve the crop have been constrained mainly by a lack of adequate information on the genetic control of characteristics of the yield and yield related traits of Bangladeshi landraces. Considering the importance of chilli and in view of the above-mentioned constraints, the present study was undertaken aiming at to study the relationship of different quantitative characters and to identify suitable indirect selection criteria for yield improvement.

MATERIALS AND METHOD

Materials

Twenty chilli genotypes were taken for this study. These genotypes, selfed for several generations, were supplied by Lal Teer Seed Limited (Formerly East West Seed (Bangladesh) Limited).

Method

During 2006-2007, the twenty different genotypes were grown in Research and Development Farm of Lal Teer Seed Limited, Basan (North 23.9763^o and East 090.3539^o), Gazipur starting from October, 2006. The experiment was laid out in randomized complete block design with three replications.

The seeds of the 20 different chilli germplasm were sown in Seedling Tray. The media in the seedling tray have been prepared by using coconut coir, ash and decomposed cow dung at a ratio of 50%, 25% and 25% respectively. The media were boiled by steam for two hours. After cooling the media, the seeds were sown on

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17 October, 2006. The seedlings at the age of 4 to 5 leaves were suitable for transplanting and this took 35-45 days after sowing.

On December 5, 2006, the transplantation of seedlings was done. Raised beds were prepared for transplanting. The width of raised bed was 1.5 meter. Plant to Plant distance was 50 cm and row to row distance was 70 cm. Bed to bed distance is 1.0 meter that was used as drain. Cow dung, Urea, TSP, MP, Gypsum and Zinc Oxide were applied @ 15 tons, 200 kg, 300 kg, 200 kg, 110 kg and 5 Kg per hectare respectively. The entire amount of cow dung, TSP, Zinc Oxide, Gypsum and one-third of the urea and MP is applied at the time of final land preparation while the rest of the urea and MP is applied at two equal installments, 25 and 50 days after transplanting (Rashid and Singh, 2000).

For soil treatment at the time of transplanting, Dursbarn 20 EC and Ridomil MZ 68 WP were used at the rate of 5 ml/L and 3g/L respectively. Irrigation was given as and when necessary. After every 20 days of transplanting, weeding was done.

Genotypic and phenotypic correlation coefficients between characters contributing to yield were estimated following the formula suggested by Miller *et al.* (1958). The cause and effect relationship between yield and its component characters, were studied through path coefficient analysis. Path coefficient of the traits related to yield was analyzed from the phenotypic and genotypic correlations following method of Singh and Chaudhary (1985); Dabholkar (1992) which was originally developed by Wright (1921).

RESULTS AND DISCUSSION

Analysis of Correlation

Table 1 and 2 show the estimates of phenotypic and genotypic correlations between yield and yield contributing characters. In most of the cases, it was observed that the magnitude of genotypic correlations were higher than the corresponding phenotypic correlations. Higher genotypic correlation than their phenotypic ones were reported in many crops including chilli (Singh *et al.* 2007; Kumar *et al.* 2003; Rathod *et al.* 2002). Such high genotypic correlation coefficient between yield and yield related traits indicated presence of genetic relation between them but environmental effects reduced the values at phenotypic level.

At phenotypic level, yield per plant was significantly and positively correlated with fruit length, fruit weight and number of fruits per plant and days to fruit maturity (green). At genotypic level, yield per plant was significantly and positively correlated with all the characters mentioned above including fruit width. Similar results were obtained by Acharyya *et al*. (2007), Rathod *et al*. (2002) and Munshi *et al*. (2000) who reported that fruit yield had a significant positive association with number of fruits per plant, both at the genotypic and phenotypic levels. Bharadwaj *et al*. (2007), Kumar *et al*. (2003) and Khurana *et al*. (2003) also reported that fruit yield was positively associated with number of fruits/plant. Singh *et al*. (2007) reported that total yield had positive and significant phenotypic and genetic correlations with fruit length, fruit breadth and fruits per plant. However, days to 50% flowering and number of seeds per fruit had no significant genotypic and phenotypic correlation with any other characters. Significant and positive correlation was existed between plant height and plant canopy width at genotypic level. Plant height and yield per plant had very close to significant negative correlation. Fruit length had significant and positive genotypic and phenotypic correlation with fruit width and fruit weight. Munshi *et al*. (2000) reported that fruit weight showed significant positive correlation with fruit length. Fruit width had significant and positive genotypic and phenotypic correlation with fruit weight. Kumar *et al*. (2003) also reported that fruit length and width showed positive correlation with fruit weight. Significant and positive genotypic and phenotypic correlations existed between fruit weight and days to fruit maturity (green). However, fruit weight had only significant and positive genotypic correlation existed with days to fruit maturity (ripe). Barai and Roy (1989) reported that fruit weight was positively correlated with days to maturity. Positive and significant genotypic and phenotypic correlation were present between days to fruit maturity (green) and (ripe). Plant height had significant and positive genotypic correlation with plant canopy width.

From overall genetic studies, it is emphasized that in any selection and breeding program, characters least affected by the environment and characters closely related together must be considered (Singh and Singh, 1979). Higher magnitude of genotypic correlation than phenotypic correlation was noticed for almost combinations indicating inherent association between characters that might be due to masking or modifying effect of environment (Shukla and Khanna, 1987; Singh and Khanna, 1993; Singh *et al.* 2003).

Path analysis

Path coefficient analysis was based on correlation using yield per plant as the dependent factor (effect) and ten other quantitative characters viz., days to 50% flowering, fruit length, fruit width, fruit weight, number of seeds per fruit, number of fruits per plant, days to fruit maturity (green), days to fruit maturity (ripe), plant height, plant canopy width as independent factor (cause). Correlation coefficient of each independent quantitative character was partitioned into direct and indirect effects towards yield per plant. All the direct effects were less than one indicating that inflation due to multicolinearity was minimal (Gravois and Helms, 1992).

Path analysis at phenotypic and genotypic level is presented in Table 3 and Table 4 respectively. Among the ten independent factors, fruit length, fruit width, fruit weight, number of fruits per plant, days to fruit maturity (green), days to fruit maturity (ripe) and plant breadth are positively correlated at phenotypic and genotypic level with yield per plant. Except, at phenotypic level, days to fruit maturity (green) and at genotypic level, fruit width and days to fruit maturity (ripe), all of them had positive direct effect with yield per plant. Positive direct effect at phenotypic level of fruit length, fruit width, days to fruit maturity and plant canopy width was very low. Fruit length had positive significant correlation with yield per plant at phenotypic level. However, its direct effect was low (0.037) and indirect positive effect was high (0.57) and this positive indirect effect acting through seven different characters (Table 5). Highest indirect effect of fruit length was acting through fruit weight (0.453). Nevertheless, at genotypic level, five characters were used for indirect effect and fruit weight contributed maximum (0.573) for indirect positive effect (Table 6).

Fruit weight had significant positive correlation with yield per plant (0.642) at phenotypic level. Indirect positive effects of fruit weight were acting through six different characters and indirect negative effects were acting through three different characters. However, the contribution of negatively acting characters was slightly higher than positively acting characters. The number of fruits per plant had highest negative contribution (-0.143). Nevertheless, at genotypic level, contribution of negatively acting characters was higher than the characters at phenotypic level and two more characters were included.

On the contrary, number of fruits per plant was positively and significantly correlated with yield per plant (0.519) at phenotypic level. The direct effect of number of fruits per plant (0.653) was very close to correlation value and five characters were involved to indirect positive effect (Table 5 and Figure 1). At genotypic level, the direct effect (0.501) was closer to correlation value (0.542) and indirect positive effect was acting through seven different characters (Table 6 and Figure 2).

A number of researchers were worked on path analysis in different growing environments, places and years. They reported that number of fruits per plant, fruit weight, fruit length, fruit width had high positive direct effects on yield (Singh *et al*. 2007; Kumar *et al*. 2003; Munshi *et al*. 2000; Solanki *et al*. 1986; Bharadwaj *et al*. 2007; Das and Choudhary, 1999a; Raikar *et al*. 2005; Nandadevi and Hosamani, 2003; Ajjapplavara *et al*. 2005; Pawade *et al*. 1995). However, most of the cases, number of fruit per plant and fruit weight were common characters that had positive direct effect on yield. Fruit number per plant showed a positive indirect effect through fruit weight (Kumar *et al*. 2003). Negative indirect effect of fruits per plant through fruit weight was also reported (Munshi *et al*. 2000). Path analysis revealed the importance of number of fruits per plant and fruit weight in determining selection criteria for improvement of chilli yields (Nandadevi and Hosamani, 2003; Das and Choudhary, 1999a; Ajjapplavara *et al*. 2005; Raikar *et al*. 2005). In the present study, path analysis also indicated the importance of fruit weight and number of fruits per plant. However, it is better to select number of fruits per plant for yield improvement in chilli, because, increase of fruit weight could not be done beyond certain level. Not only this, increase of fruit weight exceeding the certain level would decrease the customers' preference may cause low market demand in this country.

The low residual effect (0.21) at genotypic level indicated that all the important characters were correlated with yield per plant. Yield contributing characters considered in this experiment explained about 79% of the variability in the yield per plant. Rao and Chonkar (1981) and Munshi *et al*. (2000) also observed low residual value on their study.

Table 1. Phenotypic correlation coefficients of yield components in chilli

	Fruit length (cm)	Fruit width (mm)	Fruit weight (g)	Number of seeds per fruit	Number of fruits per plant	Days to fruit maturity (green)	Days to fruit maturity (ripe)	Plant height (cm)	Plant canopy width (cm)	Yield per plant (g)
Days to 50% flowering	-0.27	0.01	-0.14	0.15	-0.01	0.01	-0.07	0.18	0.10	-0.15
Fruit length		0.51*	0.70**	-0.27	0.01	0.27	0.17	-0.41	-0.04	0.60**
Fruit width			0.57**	0.21	-0.08	0.22	0.05	-0.09	-0.17	0.42
Fruit weight				-0.02	-0.22	0.51*	0.41	-0.32	-0.15	0.64**
Number of seeds per fruit					0.08	-0.11	0.05	0.12	-0.20	-0.03
Number of fruits per plant						0.003	-0.04	-0.17	0.25	0.52*
Days to fruit maturity (green)							0.69**	-0.19	0.11	0.46*
Days to fruit maturity (ripe)								-0.23	0.03	0.37
Plant height									0.36	-0.40
Plant canopy width										0.12

* P<0.05, ** P<0.01 respectively

Table 2. Genotypic correlation coefficients of yield components in chilli

	Fruit length (cm)	Fruit width (mm)	Fruit weight (g)	Number of seeds per fruit	Number of fruits per plant	Days to fruit maturity (green)	Days to fruit maturity (ripe)	Plant height (cm)	Plant canopy width (cm)	Yield per plant (g)
Days to 50% flowering	-0.39	0.07	-0.22	0.21	0.001	-0.03	-0.02	0.32	0.21	-0.20
Fruit length		0.61**	0.72**	-0.31	0.01	0.33	0.22	-0.44	-0.04	0.61**
Fruit width			0.70**	0.28	-0.09	0.17	-0.01	-0.26	-0.28	0.49*
Fruit weight				-0.02	-0.22	0.55*	0.50*	-0.39	-0.20	0.66**
Number of seeds per fruit					0.07	-0.15	0.06	0.13	-0.37	-0.04
Number of fruits per plant						0.004	-0.05	-0.19	0.31	0.54*
Days to fruit maturity (green)							0.89**	-0.39	0.07	0.54*
Days to fruit maturity (ripe)								-0.34	0.02	0.43
Plant height									0.54*	-0.43
Plant canopy width										0.19

* P<0.05, ** P<0.01 respectively

Table 3. Phenotypic path analysis showing direct (Bold) and indirect effect of traits on yield per plant

	Days to 50% flowering	Fruit length	Fruit width	Fruit weight	Number of seeds per fruit	Number of fruits per plant	Days to fruit maturity (green)	Days to fruit maturity (ripe)	Plant height	Plant canopy width
Days to 50% flowering	**-0.019**	0.005	0.0001	0.003	-0.003	0.0001	-0.0003	0.001	-0.004	-0.002
Fruit length	-0.010	**0.037**	0.019	0.026	-0.010	0.0004	0.010	0.006	-0.015	-0.001
Fruit width	0.001	0.051	**0.101**	0.058	0.021	-0.008	0.022	0.006	-0.009	-0.017
Fruit weight	-0.094	0.453	0.372	**0.652**	-0.014	-0.143	0.330	0.266	-0.212	-0.096
Number of seeds per fruit	-0.009	0.017	-0.013	0.001	**-0.062**	-0.005	0.007	-0.003	-0.008	0.013
Number of fruits per plant	-0.004	0.007	-0.055	-0.143	0.052	**0.653**	-0.002	-0.026	-0.114	0.163
Days to fruit maturity (green)	-0.0001	-0.002	-0.002	-0.004	0.001	2.89 E-05	**-0.009**	-0.006	0.002	-0.001
Days to fruit maturity (ripe)	-0.008	0.019	0.006	0.047	0.005	-0.005	0.080	**0.116**	-0.026	0.004
Plant height	-0.008	0.018	0.004	0.014	-0.005	0.008	0.008	0.010	**-0.043**	-0.016
Plant canopy width	0.007	-0.003	-0.013	-0.011	-0.015	0.019	0.008	0.003	0.027	**0.076**
Phenotypic Correlation with yield per plant	-0.146	0.602**	0.420	0.642**	-0.029	0.519*	0.455*	0.373	-0.402	0.122

Residual effect= 0.33 * P<0.05, ** P<0.01 respectively

Table 4. Genotypic path analysis showing direct (Bold) and indirect effect of traits on yield per plant

	Days to 50% flowering	Fruit length	Fruit width	Fruit weight	Number of seeds per fruit	Number of fruits per plant	Days to fruit maturity (green)	Days to fruit maturity (ripe)	Plant height	Plant canopy width
Days to 50% flowering	**-0.028**	0.011	-0.002	0.006	-0.006	0.0001	0.001	0.001	-0.009	-0.006
Fruit length	-0.028	**0.070**	0.043	0.050	-0.022	0.001	0.023	0.015	-0.031	-0.003
Fruit width	-0.013	-0.106	**-0.175**	-0.121	-0.048	0.016	-0.030	0.002	0.046	0.050
Fruit weight	-0.180	0.573	0.558	**0.802**	-0.014	-0.176	0.444	0.399	-0.311	-0.160
Number of seeds per fruit	0.057	-0.082	0.074	-0.005	**0.267**	0.020	-0.040	0.017	0.035	-0.099
Number of fruits per plant	-0.001	0.004	-0.046	-0.110	0.037	**0.501**	-0.002	-0.024	-0.096	0.158
Days to fruit maturity (green)	-0.014	0.138	0.072	0.232	-0.063	-0.002	**0.418**	0.374	-0.162	0.028
Days to fruit maturity (ripe)	0.010	-0.097	0.005	-0.222	-0.028	0.022	-0.397	**-0.445**	0.153	-0.008
Plant height	-0.079	0.110	0.065	0.097	-0.033	0.048	0.097	0.086	**-0.249**	-0.133
Plant canopy width	0.074	-0.013	-0.102	-0.071	-0.132	0.113	0.024	0.006	0.192	**0.358**
Genotypic Correlation with yield per plant	-0.201	0.609**	0.492*	0.657**	-0.042	0.542*	0.537*	0.430	-0.433	0.185

Residual effect= 0.21 * P<0.05, ** P<0.01 respectively

Table 5. Direct and indirect effect with contributing characters of phenotypic path analysis

Character	Correlation with yield per plant	Direct effect	Indirect effect			
			Positively acting characters		Negatively acting characters	
			Total value	No. of Characters	Total value	No. of characters
Days to 50% flowering	-0.146	-0.019	0.008	2	-0.135	7
Fruit length	0.602**	0.037	0.570	7	-0.005	2
Fruit width	0.420	0.101	0.401	4	-0.083	5
Fruit weight	0.642**	0.652	0.149	6	-0.158	3
Number of seeds per fruit	-0.029	-0.062	0.080	4	-0.047	5
Number of fruits per plant	0.519*	0.653	0.027	5	-0.161	4
Days to fruit maturity (green)	0.455*	-0.009	0.466	7	-0.002	2
Days to fruit maturity (ripe)	0.373	0.116	0.292	6	-0.035	3
Plant height	-0.402	-0.043	0.029	2	-0.388	7
Plant canopy width	0.122	0.076	0.179	3	-0.133	6

* P<0.05, ** P<0.01 respectively

Table 6. Direct and indirect effect with contributing characters of genotypic path analysis

Character	Correlation with yield per plant	Direct effect	Indirect effect			
			Positively Acting Characters		Negatively acting Characters	
			Total value	No. of Characters	Total value	No. of characters
Days to 50% flowering	-0.201	-0.028	0.142	3	-0.315	6
Fruit length	0.609**	0.070	0.837	5	-0.298	4
Fruit width	0.492*	-0.175	0.817	6	-0.150	3
Fruit weight	0.657**	0.802	0.385	4	-0.529	5
Number of seeds per fruit	-0.042	0.267	0.037	1	-0.346	8
Number of fruits per plant	0.542*	0.501	0.219	7	-0.178	2
Days to fruit maturity (green)	0.537*	0.418	0.589	5	-0.470	4
Days to fruit maturity (ripe)	0.430	-0.445	0.899	8	-0.024	1
Plant height	-0.433	-0.249	0.426	4	-0.610	5
Plant canopy width	0.185	0.358	0.236	3	-0.408	6

* P<0.05, ** P<0.01 respectively

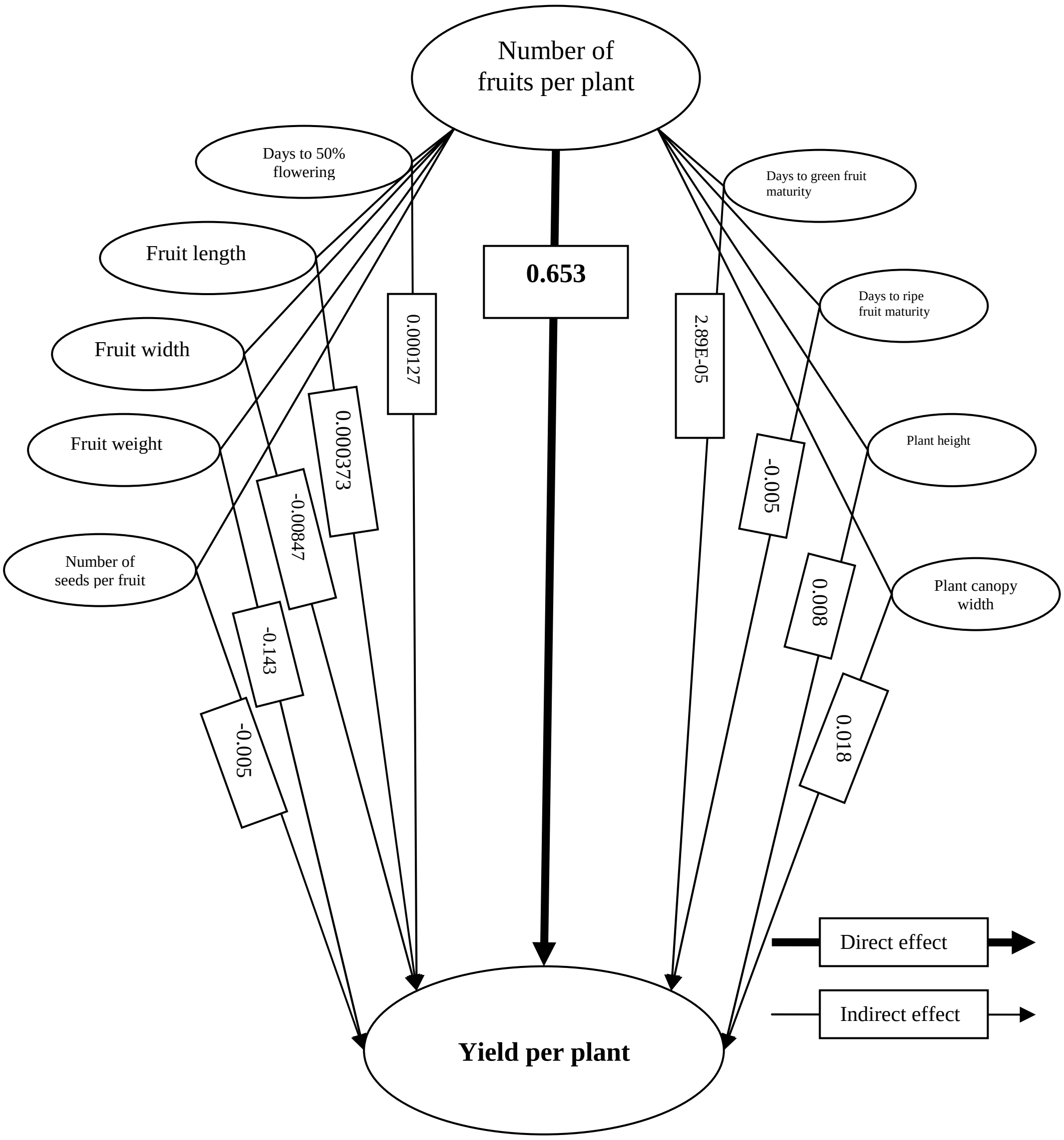

Figure 1. Showing phenotypic direct and indirect effect of number of fruits per plant on yield per plant

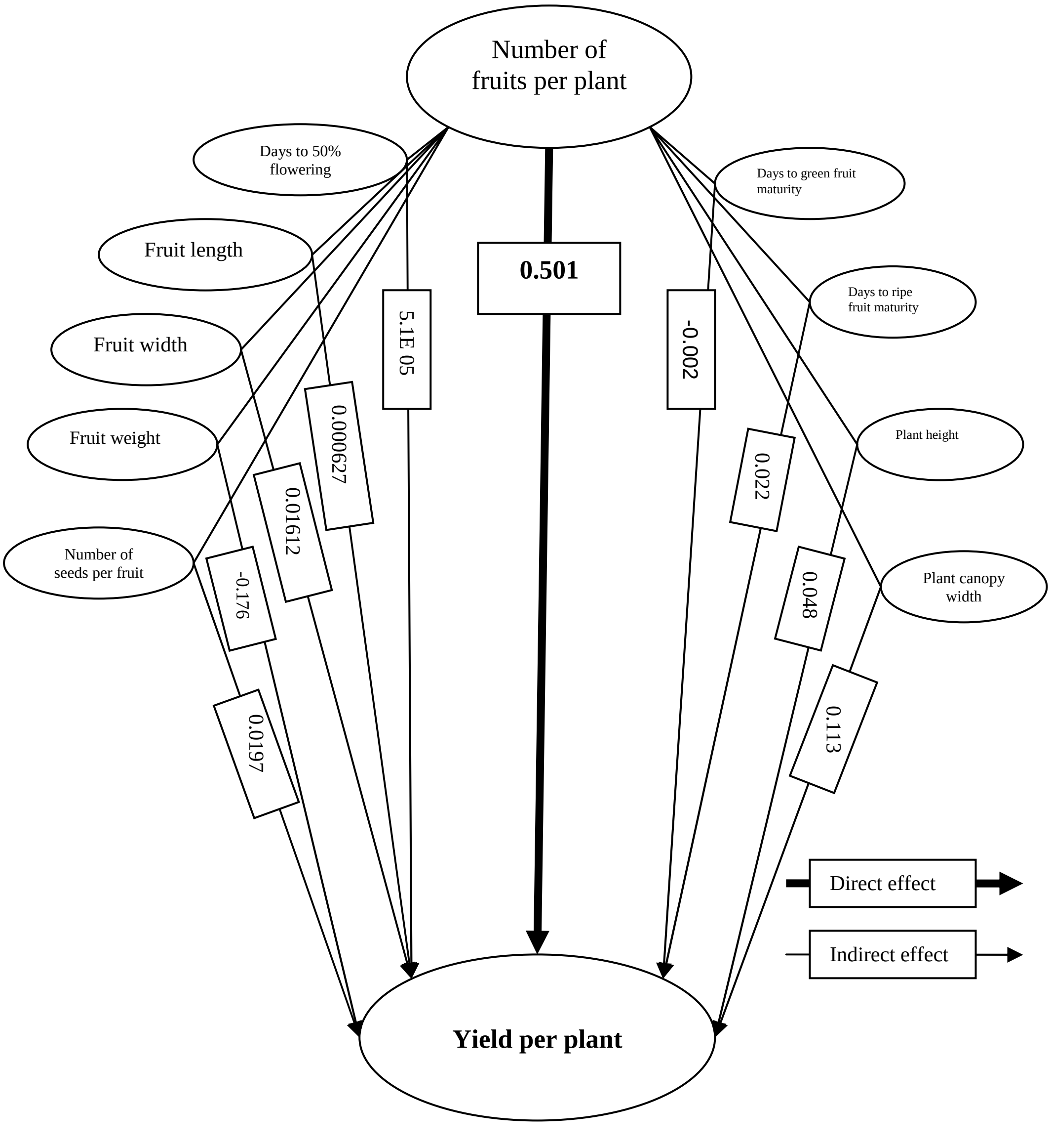

Figure 2. Showing genotypic direct and indirect effect of number of fruits per plant on yield per plant

CONCLUSION

In conclusion, yield is a complex character, contributed by many traits. In the present study, among the ten traits, number of fruits per plant had high direct effect at phenotypic and genotypic level on yield per plant indicating that selection could be effective through this trait for yield increase. The ten traits studied were adequate to explain the variability of yield per plant.

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