Research Article

Studies on variability, correlation and path analysis of traits contributing to fruit yield and its components in okra (*Abelmoschus esculentus* L. Moench)

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Abstract
The present investigation was conducted to estimate genetic parameters such as genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability and genetic advance (GA) along with correlations and path coefficients from data collected on 52 okra genotypes collected from the IIHR, Bengaluru, India. Analysis of variance indicated significant differences among the genotypes for different morphological characters. High GCV and PCV were observed for yield per plant, no. of fruits per plant, no. of seeds per fruit, where as moderate GCV and PCV was observed for average fruit weight. High heritability coupled with high GAM were observed for almost all the characters studied, except days to 50% flowering and days to 80 % maturity shows low heritability with low GAM. The yield per plant, plant height and number of seeds per fruit showed high genetic advance that helped in effective and reliable selection through these characters for crop improvement. Fruit yield per plant showed positive association with stem girth, number of branches per plant, plant height, first fruit producing node, fruit length, fruit diameter, average fruit weight, number of fruits per plant, number of seeds per fruit and 100 seed weight while, negative association with days to 50% flowering, number of locules per fruit and days to 80 % maturity. The number of fruits per plant had maximum direct effect on fruit yield per plant followed by average fruit weight. Number of branches per plant, plant height and first fruit producing node contributed to fruit yield per plant indirectly via stem girth, average fruit weight, and number of fruits per plant. Hence, number of fruits and average fruit weight are identified as key traits for developing high fruit yielding genotypes of okra for future breeding programme.

Key words
Fruit yield, GCV, PCV, okra, correlation, path analysis

Introduction

Okra (*Abelmoschus esculentus* (L.) Moench) an annual, often cross-pollinated crop belonging to the family Malvaceae, is an important crop of the tropics and subtropics of the world. The logical way to start any breeding programme is to assess the existing genetic variability which is the basis for any crop improvement programme. Hence, before taking up any breeding programme, a thorough knowledge regarding the nature and magnitude of genetic variability, heritability and association among the various characters including yield is very essential. The value of a germplasm collection depends not only on the number of accessions it contains, but also upon the diversity present in those accessions.

An improvement way to increase productivity in any crop plant is to first select desirable genotypes from among the existing variations and to use the superior types in the breeding programme. Correlation is an association of two variables. Since, all genes affecting phenotype of two variables may not be completely linked, correlation is seldom complete and must be tested for its significance to confirm whether observed correlation is real or by chance. The path analysis advised by Dewey and Lu, (1959) provides an effective means of finding out direct and indirect causes of associations and permits a critical examination of given correlation and measure relative importance of each factor. Such information reveals the possibility of simultaneous improvement of various attributes and also helps in increasing the efficiency of selection of complex inherited traits. Therefore, the present investigation conducted to estimate genetic parameters along with correlations and path analysis for yield and its component traits in okra.

Materials and methods

The experimental materials for the present study consisted of 52 genotypes were collected from Indian Institute of Horticultural Research (IIHR), Hessaghatta, Bengaluru. The genotypes were evaluated through a field experiment conducted in randomized block design with three replications at Babbur farm, ICAR-Krishi Vigyan Kendra, Chitradurga District of Karnataka during late *kharif* 2015-2016. Each entry was sown at 30 cm between rows and 15 cm between plant, accommodating 30 plants in each row per replication. All the recommended package of practices was followed for raising a healthy crop. The observations were recorded as per NBPGR minimal descriptors from five competitive plants

from each replication on thirteen parameters *viz.*, plant height (cm), number of branches per plant, first fruit producing node, days to 50 % flowering, days to 80 % maturity, stem girth (mm), fruit length (cm), fruit width (mm), number of fruits per plant, average fruit weight (g), number of seeds per fruit, hundred seed weight (g) and total fruit yield per plant (g) computed in each genotype by adding the fruit weight of all the pickings and divided by number of plants. The mean values were subjected to statistical analysis (ANOVA) as suggested by Panse and Sukatme, 1967. Phenotypic and genotypic co-efficient of variation (Burton and De-Vane, 1953), heritability, genetic advance as per cent mean were calculated. Correlation coefficient was computed by using the formula of Johnson *et al*. (1955) and path coefficient by Dewey and Lu, (1959).

Results and discussion

The analysis of variance showed that, the variance due to treatments (genotypes) was significant (at P=0.05) for all the traits studied (Table 1), indicating thereby the presence of genetic variability in the experimental material. There was highly significance differences were recorded for all the characters studied.

The estimates of mean, genotypic co-efficient of variance (GCV), phenotypic co-efficient of variance (PCV), heritability (h^2), genetic advance (GA) and genetic advance over mean (GAM) for different characters are presented in table 2 and Fig.1. The phenotypic coefficient of variation ranged from 1.02 % for days to 80 % maturity to 34.13 % for total yield per plant (g). High GCV and PCV were also observed number of seeds per fruit and number of fruits per plant, where as moderate GCV and PCV was observed for average fruit weight and first fruit producing node. Balakrishnan and Balakrishnan, (1988) also reported the same.

In general the phenotypic values were higher than genotypic values, but differences were less for plant height, number of branches per plant, first fruit producing node, fruit length, number of fruits per plant, average fruit weight, number of seeds per fruit and yield per plant, suggesting that these characters were less influenced by the environmental factors and thus selection on phenotypic basis would holds good. These results are in agreement with earlier findings Mittal *et al*. (1996). The genotypic coefficient of variation alone is not sufficient to estimate the heritable variation present in a present population. But, heritability along with genetic advance provides a more reliable estimate for predicting the selection advance. The estimate of heritability was highest for total yield per plant (99.48%), while it was least for stem girth (34.80%). High magnitude of broad sense heritability was noticed for plant

height, first fruit producing node, fruit length, no. of fruits per plant, average fruit weight, no. of seeds per fruit, 100 seed weight. Jeyapendi and Balakrishnan, (1992), Mahajan and Sharma, (1979), Prakash and Pitchaimuthu, (2010) recorded maximum heritability for yield per plant. Whereas Gandhi *et al*. (2001) observed for higher heritability estimates for plant height.

Though, the heritability estimates provide the information on the magnitude of inheritance of quantitative characters, it does not indicate the magnitude of genetic gain obtained by selection of best individual from the best population. So, heritability along with genetic advance is more useful for selection than heritability alone. The study reveled that the characters yield per plant, plant height, no. of seeds per fruit and no. of fruits per plant had higher genetic advance as per cent of mean. Lower genetic advance was exhibited by the characters days to 80 % maturity, days to 50 % flowering, stem girth and fruit diameter. High heritability coupled with high GAM were observed for most all the characters studied, except days to 80% maturity and days to 50 % flowering which showed high heritability with low GAM confirming the preponderance of additive genes in controlling the expression of these characters and thus were found to be providing better opportunity for effective and reliable selection for these characters. These results agreed with the earlier workers Sarkar *et al*. (2004), Panda and Singh, (1997) and Prakash and Pitchaimuthu, (2010). Moderate heritability with moderate to low genetic advance as percent of mean was recorded for stem girth and fruit diameter. This might be attributed to the fact that the parental genotypes might have possessed both additive and/or non additive genes for these traits in different magnitudes and as a result of more pronounced expressions of non additive genes moderate heritability with low genetic advance was noticed. The findings were also collaborated with findings of Panda and Singh, (1997) and Gandhi *et al*. (2001).

The phenotypic and genotypic correlation coefficients between different characters are presented in table 3 and fig. 2**.** Genotypic coefficient of correlation, in general, were greater in magnitude than the corresponding phenotypic ones, indicating that there was an inherent association among various characters and phenotypic expression of correlation was lessened under the influence of environment. Fruit yield per plant showed positive association with stem girth, number of branches per plant, plant height, first fruit producing node, fruit length, fruit diameter, average fruit weight, number of fruit s per plant, number of seeds per fruit and 100 seed weight were observed at genotypic and phenotypic levels, indicating mutual association of these traits. It could be suggested from correlations estimates that

yield could be improved through selection based on either of these characters. These findings are in agreement with those of Mandal and Dana (1993), Gondane *et al.*, (1995), Yadav, (1996) and Pooja *et al.* (2011). The negative correlation of fruit yield per plant was observed between days to 50 per cent flowering, number of locules per fruit and days to 80% maturity. Fruit weight had positive and strong significant association with fruit length, fruit diameter, first fruit producing node, stem girth and no. of branches per plant could be improved through selection based on either of these characters.

In path coefficient analysis, where the total genotypic association between fruit yield per plant and other characters revealed that maximum direct contribution was made by number of fruits per plant (0.6309) followed by average fruit weight (0.6165), days to 50% Flowering (0.0671) and fruit length (0.0573) (Fig. 3). The trend of results collaborated by Dhall *et al.* (2000) and Sood *et al.* (1993). The high positive indirect effect was found in case of stem girth, no. of branches per plant, plant height, first fruit producing node, fruit length, fruit diameter, average fruit weight, no. of fruits per plant. These have also been corroborated by Reddy *et al.* (1985) and there were most important characters for selection for these traits can also be relied upon for improving fruit yield of the crop.

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Table 1. Pooled analysis of variance fruit yield and yield its component characters in okra

Source of variance	d.f.	Plant height (cm)	Stem girth (mm)	No. of branches per plant	Days to 50% Flowering	First Fruit producing node	Fruit length (cm)	Fruit Diameter (mm)	Average fruit weight (g)	Days to 80% maturity	No. of Fruit s per plant	No. of Seeds per fruit	100 Seed Weight (g)	Yield per Plant (g)
Replication	2	4.44	6.02	0.36	8.54	1.36	2.67	1.58	2.86	8.48	11.56	1.44	0.08	565.43
Treatment	51	1592.89*	30.54*	1.74*	2.99*	5.35*	22.47*	11.10*	65.45*	0.81*	226.02*	459.44*	3.02*	331768.57*
Error	102	4.17	11.74	0.07	0.62	0.14	0.38	1.05	0.39	0.42	1.09	2.48	0.06	574.63

* Significance at 5 per cent

Table 2. Estimates of mean, genotypic coefficient of variance (GCV), phenotypic coefficient of variance (PCV), heritability (h^2), genetic advance (GA) and genetic advance over mean (GAM) for fruit yield and its component characters in okra

S. No.	Characters	Mean+S.Em	GCV (%)	PCV (%)	Heritability (%)	GA	GAM (%)
1	Plant height (cm)	137.38 ± 1.18	16.75	16.82	99.22	47.22	34.37
2	Stem girth (mm)	21.41 ± 1.99	11.69	19.82	34.80	3.04	14.21
3	Number of branches per plant	4.23 ± 0.15	17.37	18.40	89.07	1.45	33.78
4	Days to 50 % Flowering	55.01 ± 0.45	1.61	2.16	55.81	1.37	24.82
5	First Fruit producing node	7.53 ± 0.22	17.53	18.23	92.46	2.62	34.73
6	Fruit length (cm)	15.91 ± 0.35	17.06	17.49	95.10	5.45	34.27
7	Fruit Diameter (mm)	19.02 ± 0.59	9.62	11.03	76.15	3.29	17.30
8	Days to 80 % maturity	72.75 ± 0.37	0.49	1.02	23.41	0.36	0.49
9	Number of Fruit s per plant	39.75 ± 0.60	21.78	21.94	98.57	17.71	44.55
10	Average fruit weight (g)	24.53 ± 0.36	18.98	19.15	98.22	9.50	38.76
11	Number of Seeds per fruit	60.40 ± 0.91	20.43	20.59	98.40	25.22	41.75
12	100 Seed Weight (g)	6.00 ± 0.14	16.55	17.05	94.20	1.99	33.09
13	Yield per Plant (g)	975.56 ± 13.84	34.06	34.13	99.48	682.68	69.97

Table 3. Genotypic (G) and phenotypic (P) coefficient of correlation among fruit yield and its component characters in okra

Characters		Days to 50% Flowering	Stem girth (mm)	No. of branches per plant	Plant height (cm)	First Fruit producing node	Fruit length (cm)	Fruit Diameter (mm)	No. of ridges per fruit	No of locules per fruit	Average fruit weight (g)	Days to 80% maturity	No. of Fruits per plant	No. of Seeds per fruit	100 Seed Weight (g)
Stem girth (mm)	(P)	1.68**													
	(G)	-2.18													
No. of branches per plant	(P)	-0.18*	0.62**												
	(G)	-0.27	0.58												
Plant height (cm)	(P)	0.11	0.65**	0.19*											
	(G)	0.15	0.53	0.19											
First Fruit producing node	(P)	-0.16*	0.62**	0.46**	0.41**										
	(G)	-0.20	0.56	0.52	0.43										
Fruit length (cm)	(P)	-0.12	0.21**	0.13	0.10	0.02									
	(G)	-0.17	-0.18	0.13	0.09	0.02									
Fruit Diameter (mm)	(P)	-0.06	0.29**	-0.14	0.14	-0.17*	0.54**								
	(G)	0.13	-0.42	-0.21	0.16	-0.18	0.64								
No. of ridges per fruit	(P)	-0.03	0.40**	0.05	-0.08	-0.07	-0.13	0.16*							
	(G)	-0.03	-0.22	0.06	-0.09	-0.07	-0.15	0.18							
No of locules per fruit	(P)	-0.05	0.27**	-0.01	-0.29**	-0.17*	-0.11	0.22**	0.79**						
	(G)	-0.05	-0.39	-0.01	-0.31	-0.19	-0.11	0.23	0.85						
Average fruit weight (g)	(P)	-0.12	0.44**	0.24**	0.13	0.26**	0.36**	0.23**	0.04	-0.08					
	(G)	-0.14	0.26	0.26	0.13	0.27	0.37	0.27	0.04	-0.08					
Days to 80% maturity	(P)	0.30**	3.61**	-0.04	-0.09	-0.05	0.00	-0.01	-0.09	-0.01	-0.01				
	(G)	0.97	-6.69	-0.06	-0.20	-0.09	-0.10	-0.11	-0.25	-0.14	-0.05				
No. of Fruits per plant	(P)	0.06	0.69**	0.52**	0.50**	0.42**	-0.03	-0.00	0.14	0.05	0.26**	-0.04			
	(G)	0.09	0.74	0.55	0.51	0.44	-0.03	-0.01	0.15	0.05	0.26	-0.10			
No. of Seeds per fruit	(P)	-0.02	0.36**	0.05	0.17*	0.09	0.10	0.07	-0.16*	-0.19*	0.25**	-0.20*	0.24**		
	(G)	-0.05	0.16	0.06	0.18	0.09	0.11	0.09	-0.17	-0.20	0.25	-0.40	0.25		
100 Seed Weight (g)	(P)	0.02	0.38**	0.29**	0.22**	0.27**	0.04	-0.05	-0.34**	-0.33**	0.18*	0.04	0.19*	-0.03	
	(G)	0.07	0.09	0.30	0.23	0.29	0.05	-0.08	-0.38	-0.38	0.18	0.06	0.20	-0.03	
Yield per Plant (g)	(P)	-0.02	0.60	0.48	0.40	0.43	0.21	0.13	0.11	-0.02	0.77	-0.04	0.79	0.34	0.22
	(G)	-0.03	0.75**	0.51**	0.41**	0.45**	0.22**	0.16**	0.12	-0.02	0.78**	-0.10	0.80**	0.35**	0.23**

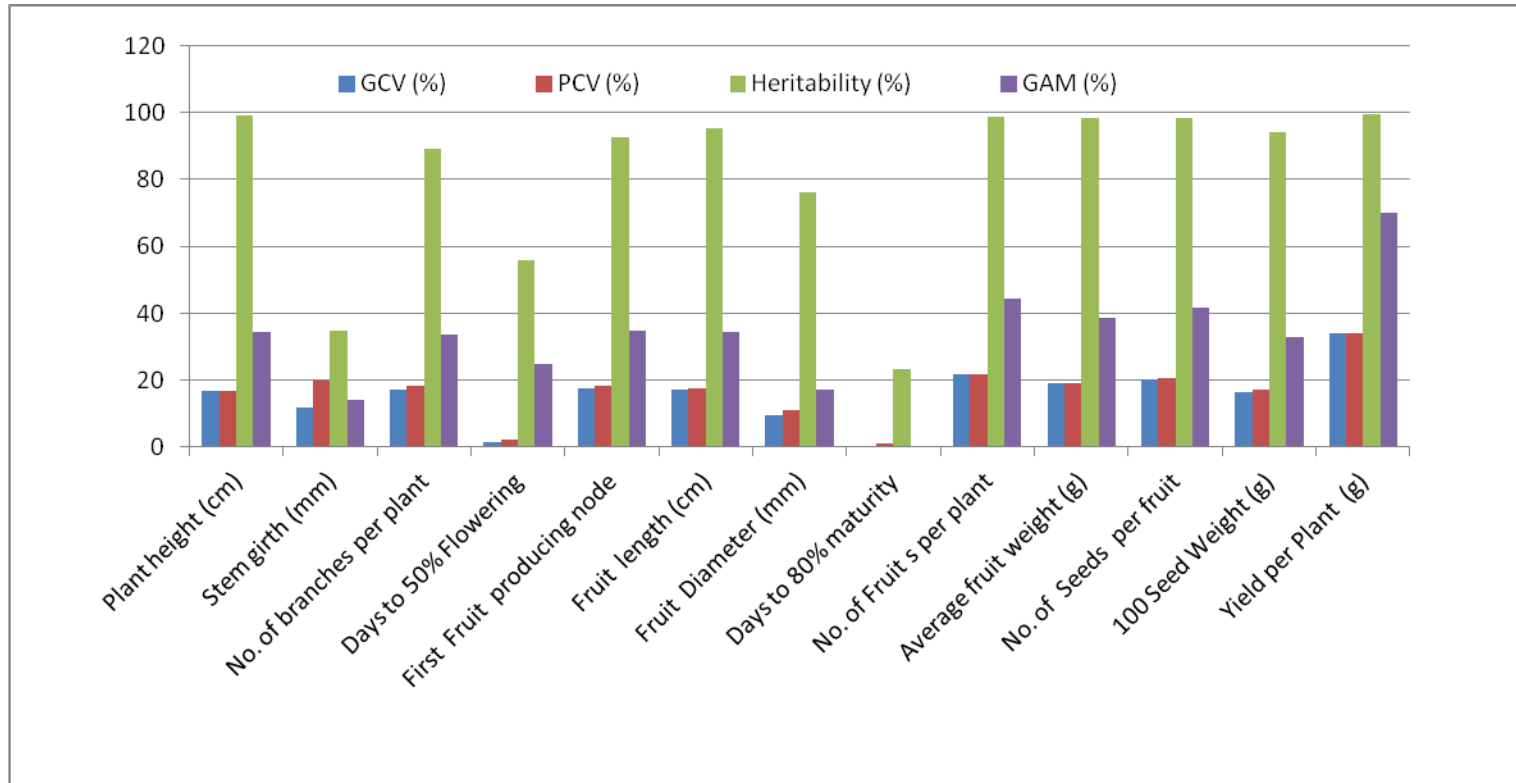*, ** significant at 5 and 1 per cent level, respectively

Fig. 1. Estimates of genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (h^2) and genetic advance over mean (GAM) for fruit yield and its component characters in okra
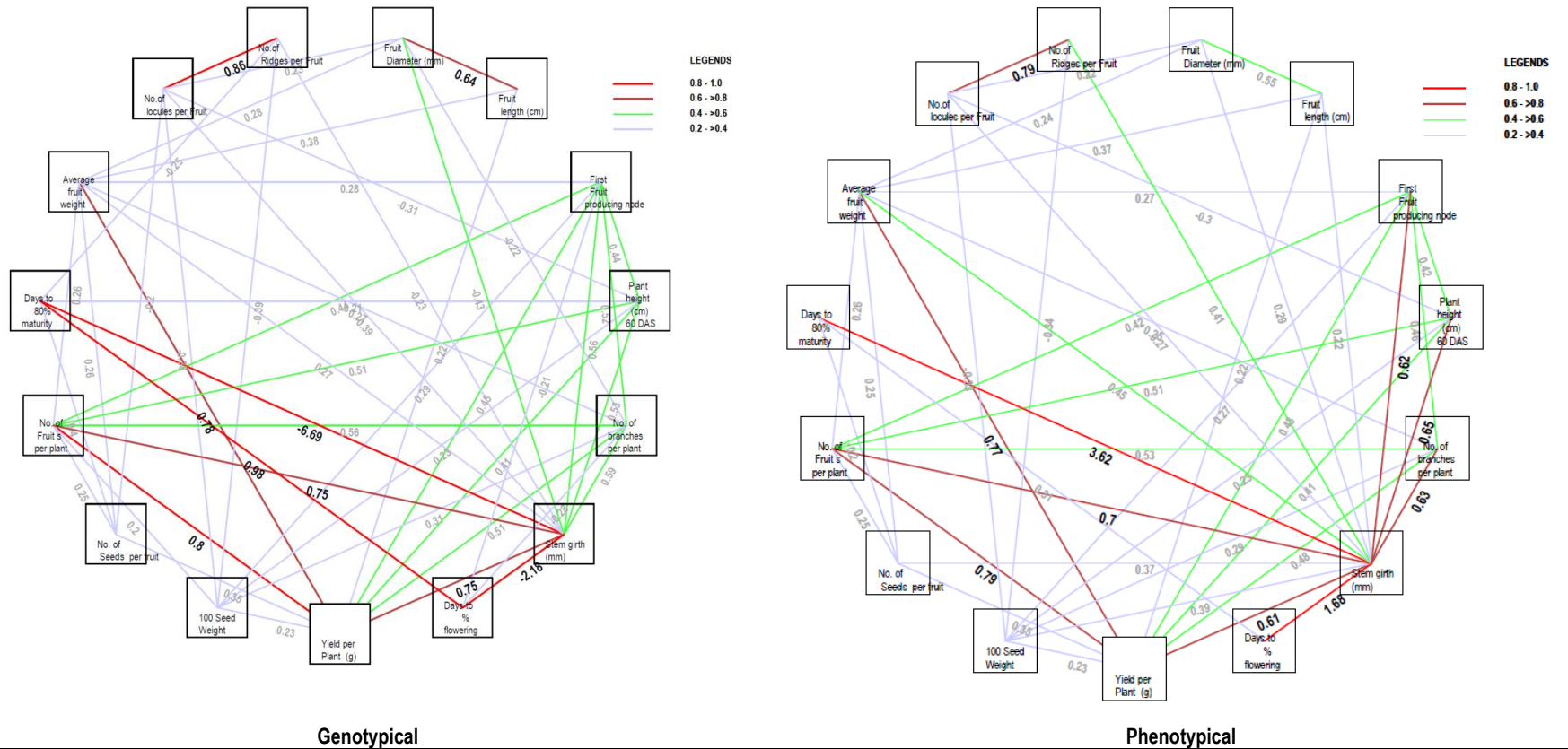
Fig. 2. Pictorial representation of Genotypical *vs* Phenotypical correlation among fruit yield and its component characters in okra
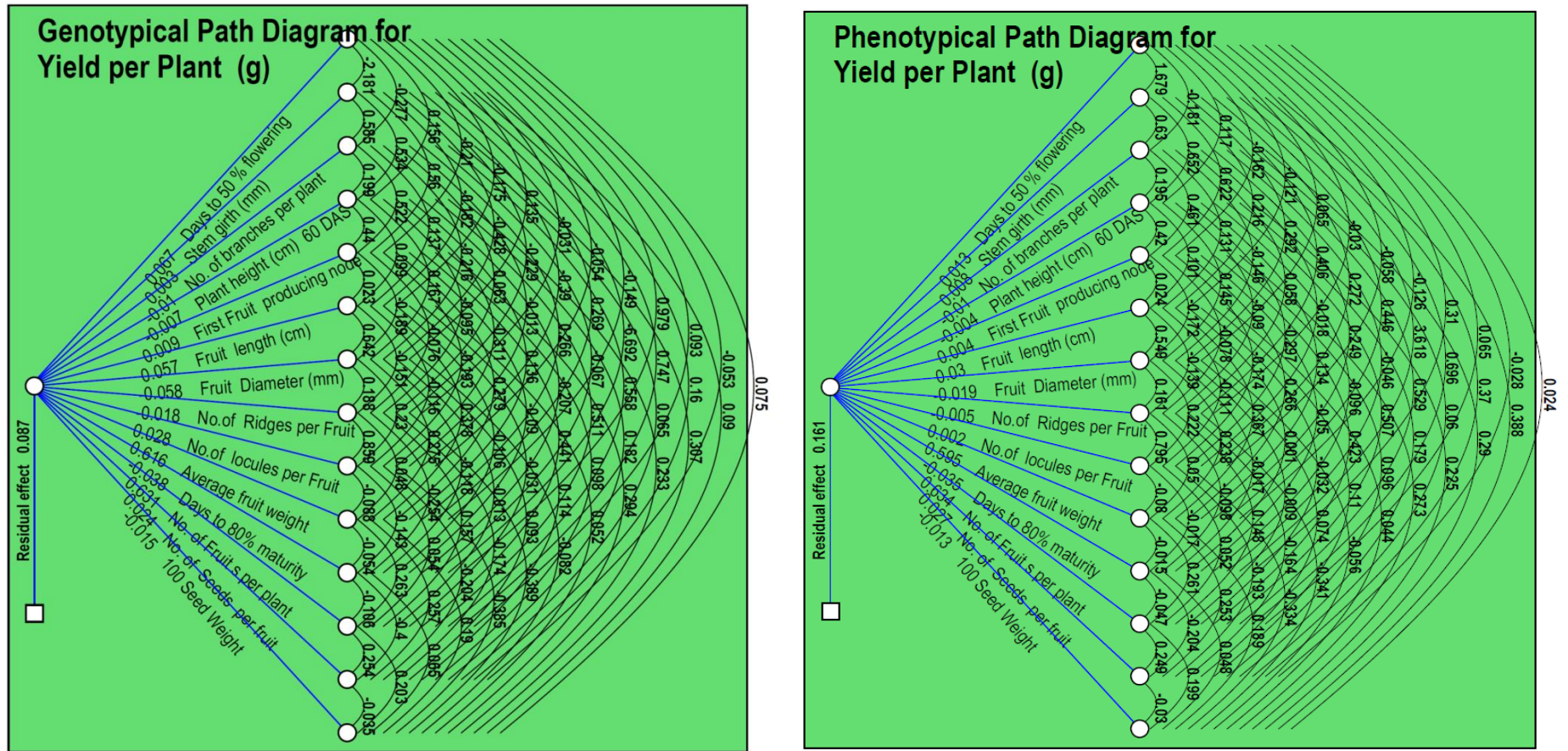
Fig. 3. Pictorial representation of genotypical *vs* phenotypical path diagram for yield per plant (g)