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Character association studies of yield and its related traits in Okra

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Abstract
The experiment was laid out in a randomized completely block design with three replications including thirty five okra genotypes. Analysis of variance revealed that highly significant differences were observed among the genotypes for yield and seed quality traits indicating existence of genetic variability in the genotypes. Correlation studies revealed that highly significant and positive association of fruit yield per plant with plant height, number of branches, fruit length, fruit weight and number of fruits per plant at both phenotypic and genotypic level, indicating the possibility of simultaneous selection for these traits. The path coefficient analysis for fruit yield per plant was carried out considering 10 dependent component characters at both phenotypic and genotypic level. Path and genotypic coefficient revealed that fruit weight, number of fruits per plant and fruit length were the most influencing factors. Thus, these characters deserve greater weightage during selection for yield. Characters having high positive direct effects along with positive significant correlation with yield per plant can be directly selected, and simultaneously the characters which show high positive indirect effects can also be selected for the improvement of yield.

Keywords: Path analysis, genotypic correlation, direct and indirect effects

Introduction

Okra [*Abelmoschus esculentus* (L.) Moench] is commonly known as 'bhendi' or lady's finger and is a priced vegetable grown for its tender fruits in India as vegetable. It is an annual herbaceous plant belongs to the family *Malvaceae* with 2n=130 chromosome number. Correlation and path coefficient analysis elucidate the intrinsic nature of observed association between yield and its component and reveals the extent of contribution made by different traits in building up the ultimate yield. Correlation measures the relationship between two or more variables and the extent of association is measured by correlation coefficient. Correlation studies provide information that selection for one character will results in progress for all positively correlated characters. This information may be used to direct selection in the construction of selection indices. The utility of estimates of correlation is considerably increased by partitioning into phenotypic, genotypic and environmental components (Burton, 1952) [3]. Moreover, the knowledge of genetic association among production characters and between production and other traits helps to improve the efficiency of favorable combinations of characters and minimizes the retarding effect of negative correlation. Path coefficient analysis helps for sorting out the total correlation into direct and indirect effects and is useful for choosing most useful traits to be used for yield improvement through selection (Singh and Ramanujam, 1981; Cox and Murthy, 1990) [14, 4].

Material and Methods

The experimental material comprised of thirty five lines of okra collected from different sources were evaluated in a randomized complete block design with two replications at the College of Agriculture, Shivamogga, Karnataka during 2017-2018. The seeds were sown at the spacing of 45 cm between rows and 30 cm between plants. Protective Irrigation, weed control and other cultural practices were followed as per the package of practices in order to raise good crop. The observations on plant height, number of branches per plant, inter nodal length, days to 50 percent flower, number of fruits per plant, fruit length, fruit diameter, number of ridges per fruits, number of vacuoles per fruit, fruit weight, fruit yield per plant, total chlorophyll content, crude fibber were recorded for statistical analysis to draw the conclusion. The correlation coefficient among all possible character combinations at phenotypic (r_p) and genotypic (r_g) level were estimated employing formula (Al-Jibouri *et al.*, 1958) [2]. Path coefficient analysis as suggested by Wright (1921) and Dewey and Lu (1959) [6] was carried out to know the direct and indirect effect of the morphological traits on vine yield using statistical software *WINDOSTAT* 9.1 developed by *INDOSAT* services Ltd. Hyderabad, India.

Results and Discussion

At genotypic level (Table.1), plant height had significant and positive association with number of branches per plant (r_g =0.886), fruit length (r_g = 0.588), number of fruits per plant (r_g = 1.0724) and yield per plant (r_g = 0.7992). But it was negatively and significantly associated with Fruit diameter (r_g = -0.358), fruit weight (r_g = -0.3317), days to 50% flower (r_g = -0.5989), number of vacuoles (r_g = -0.4305), and number of ridges (r_g = -0.4717). Inter nodal length was positively and significantly associated with fruit diameter (r_g =0.928), fruit weight (r_g = 0.7655) and days to 50% flower (r_g = 0.3983). But it was negatively and significantly associated with number of branches per plant (r_g = -0.4008), yield per plant (r_g = -0.100), number of vacuoles (r_g = -0.0874) and number of fruits per plant (r_g = -0.7137). Number of branches per plant was positively and significantly associated with fruit length (r_g =0.4949), number of fruits per plant (r_g = 0.7840) and yield per plant (r_g = 0.5908). But it was negatively and significantly associated with fruit diameter (r_g = -0.9030), fruit weight (r_g = -0.2863), days to 50% flower (r_g = -0.2994), number of ridges (r_g = -0.6691) and number of vacuoles (r_g = -0.6376). Fruit length was positively and significantly associated with fruit weight (r_g 0.7576), number of fruits per plant (r_g =0.5684) and yield per plant (r_g =1.1448). But it was negatively and significantly associated with fruit diameter (r_g = -0.3662), days to 50% flower (r_g = -0.4911) number of ridges (r_g = -0.100) and number of vacuoles (r_g = -0.100). Fruit diameter was positively and significantly (at p = 0.01) associated with fruit weight (r_g =0.5856), days to 50% flower (r_g =0.9400) Number of vacuoles (r_g =0.5055) and number of ridges (r_g =0.4343). But it was negatively and significantly (at p = 0.01) associated with Number of fruits per plant (r_g = -1.0514) and yield per plant (r_g = -0.6013). Fruit weight was positively and significantly (at p = 0.01) associated with 50% flower (r_g =0.0796) and yield per plant (r_g =0.4531). But it was negatively and significantly (at p = 0.01) associated with Number of fruits per plant (r_g = -0.3328), Number of vacuoles (r_g = -0.1450) and number of ridges (r_g = -0.1731). Number of fruits per plant was positively and significantly associated with yield per plant (r_g =0.6931). But it was negatively and significantly associated with 50% flower (r_g = -0.6734), number of vacuoles (r_g = -0.2106) and number of ridges (r_g = -0.2504). Days to 50% flower was negatively and significantly associated with number of vacuoles (r_g =-0.5368), number of ridges (r_g= -0.5539) and yield per plant (r_g = -0.6029).

Phenotypic correlation coefficients among growth and yield attributes are presented in tables 2. At phenotypic level, plant height was positively and significantly associated with Number of branches per plant (r_g = 0.6684), fruit length (r_g = 0.3294) number of fruits per plant (r_g = 0.7590) and yield per plant (r_g = 0.4456). But it was negatively and significantly associated with internodal length (r_g = -0.3040), fruit diameter (r_g = -0.6001), number of ridges (r_g = -0.1711) days to 50% flower (r_g = -0.2545), number of vacuoles (r_g = -0.1969) and fruit weight (r_g = -0.2776). (Table7). Internodal length was positively and significantly associated with fruit diameter (r_g =0.2952) and fruit weight (r_g =0.2409). But it was negatively and significantly associated with number of fruits per plant (r_g = -0.4272). Number of branches per plant was positively and significantly associated with fruit length (r_g = 0.2952), number of fruits per plant (r_g = 0.2952) and yield per plant (r_g = 0.2952). But it was negatively and significantly associated with fruit diameter (r_g = -0.4957) and number of vacuoles (r_g = -0.2870). Fruit length was positively and significantly associated with fruit weight (r_g = 0.4653), number of fruits per plant (r_g = 0.2761) and yield per plant (r_g = 0.5682). Fruit diameter was positively and significantly associated with fruit weight (r_g = 0.4301). But it was negatively and significantly associated with Number of fruits per plant (r_g = -0.5675). Fruit weight and number of fruit per plant was positively and significantly associated with yield per plant (r_g = 0.5387 and r_g = 0.7326 respectively).

Plant height showed positive significant correlation with yield per plant with positive significant correlation with Number of branches per plant, Fruit length and Number of fruits per plant at both phenotypic and genotypic level. These results are similar with findings of Sreenivas *et al*. (2015) [16] and Nwangburuka *et al*. (2012) [10]. Number of branches per plant, fruit weight, fruit length and number fruit per plant showed positive significant correlation with yield per plant at both phenotypic and genotypic level. The results are line with the findings of Nwangburuka *et al.* (2012) [10], Singh and Sharma (2012) [15] and Deepak *et al.* (2015) [5].

The correlation coefficient measures the relationship existing between pairs of characters. But, a dependent character is an interaction product of many mutually associated component characters and change in any one component will disturb whole network of cause and effect system. The path coefficient analysis, a statistical device developed by Wright (1921), which takes into account the cause and effect relation between the variables, is unique in partitioning the association into direct and indirect effects through other independent variables. Path analysis also measures the relative importance of causal factors involved. This is simply a standardized partial regression analysis, wherein total correlation value is subdivided into causal scheme.

Both phenotypic (Table-3) and genotypic (Table.4) path coefficient analysis for yield per plant revealed that the characters namely number of fruits per plant, fruit weight and fruit length had maximum positive direct effect on fruit yield per plant. Whereas, plant height at, days to 50% flower, number of vacuole and inter nodal length negative direct effect on yield per plant. Therefore, direct selection for these traits would reward for improvement of yield. These results are in accordance with findings of Saifulla and Rabbani (2010) [12] and Ramanjinappa (2011) [11]. Number of branches per plant effect on yield per plant and positive association of this trait with yield per plant are mainly because of its indirect positive effects through fruit length, number fruit per plant and plant height (Gangashetty *et al.*, 2010) [7]. Fruit length exhibited positive direct effect on yield per plant and positive association of this trait with yield per plant is mainly because of its indirect positive effects through number fruit per plant fruit weight, number of branches, fruit weight and plant height (Adiger *et al.*, 2011) [1].

Fruit weight exhibited positive direct effect on yield per plant and positive association of this trait with yield per plant is mainly because of its indirect positive effect through fruit length; inter nodal length and plant height (Nirosha, 2014) [9]. Magar and Madrap (2009) [8] reported that number of fruits per plant had maximum direct contribution towards total yield followed by fruit weight, plant height and days to first flowering. Number of fruits per plant exhibited positive direct effect on yield per plant and positive association of this trait with yield per plant is mainly because of its indirect positive effect through plant height, number of branches and fruit length (Sarkar *et al.*, 2004) [13].

Table 1: Genotypic correlation coefficients among yield and yield components in okra

Traits	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	11
1	1.0000	-0.6463	0.8860	0.5888	-0.8717	-0.3317	1.0724	-0.5989	-0.4305	-0.4717	0.7992
2		1.0000	-0.4008	0.0181	0.9289	0.7655	-0.7137	0.3983	-0.0874	0.0778	-0.1003
3			1.0000	0.4949	-0.9030	-0.2863	0.7840	-0.2994	-0.6376	-0.6691	0.5908
4				1.0000	-0.3662	0.7576	0.5684	-0.4911	-0.6337	-0.6218	1.1448
5					1.0000	0.5856	-1.0514	0.9400	0.5055	0.4343	-0.6013
6						1.0000	-0.3328	0.0796	-0.1450	-0.1731	0.4531
7							1.0000	-0.6734	-0.2106	-0.2504	0.6931
8								1.0000	-0.5368	-0.5539	-0.6029
9									1.0000	1.0001	-0.3752
10										1.000	-0.4421

1. Plant height 2. Internodal length 3. Number of branches per plant 4. Fruit length 5. Fruit diameter 6. Average fruit weight 7. Number of fruits per plant 8. days taken to 50% flowering 9. Number of vacuoles 10. Number of ridges 11. yield per plant

Table 2: Phenotypic correlation coefficients among yield and yield components in okra

Traits	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	1.0000	-0.3040*	0.6684**	0.3294**	-0.6001**	-0.2776*	0.7590**	-0.2545 *	-0.1969	-0.1711	0.4456**
2		1.0000	-0.1610	-0.0511	0.2952*	0.2409*	-0.4272**	0.0303	0.0557	-0.1310	-0.2003
3			1.0000	0.2542*	-0.4957**	-0.1427	0.5631**	-0.1057	-0.2870 *	0.0888	0.3757**
4				1.0000	-0.2041	0.4653**	0.2761*	0.0050	-0.1335	-0.0124	0.5682**
5					1.0000	0.4301**	-0.5675**	0.1602	0.1557	-0.0055	-0.1903
6						1.0000	-0.1573	-0.0033	-0.0079	-0.0161	0.5387**
7							1.0000	-0.2319	-0.1975	-0.0121	0.7326**
8								1.0000	-0.2298	-0.2141	-0.1930
9									1.0000	0.9892 **	-0.1983
10										1.0000	0.0048

Significance levels, If correlation r = 0.235 (at 5%) and 0.305 (at 1%)

1. plant height 2. Internodal length 3. Number of branches per plant 4. Fruit length 5. Fruit diameter 6. Average fruit weight 7. Number of fruits per plant 8. 50% flower 9. Number of vacuoles 10. number of ridges 11. yield per plant

Table 3: Direct (diognal) and indirect effects of yield contributing character on yield in okra at genotypic level

Traits	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	-0.2178	0.1407	-0.1929	-0.1282	0.2619	0.0722	-0.2335	0.1304	0.0937	0.1525	0.7992
2	0.0405	-0.0627	0.0251	-0.0011	-0.0582	-0.0480	0.0447	-0.0250	0.0055	-0.0115	-0.1003
3	0.1468	-0.0664	0.1657	0.0820	-0.1496	-0.0474	0.1299	-0.0496	-0.1056	-0.1723	0.5908
4	0.0534	0.0016	0.0449	0.0906	-0.0332	0.0687	0.0515	-0.0445	-0.0574	-0.1104	1.1448
5	0.1144	-0.0884	0.0859	0.0348	-0.0951	-0.0557	0.1000	-0.0894	-0.0481	-0.0054	-0.6013
6	-0.2320	0.5354	-0.2003	0.5299	0.4096	0.6994	-0.2327	0.0557	-0.1014	-0.1186	0.4531
7	0.7654	-0.5093	0.5595	0.4057	-0.7504	-0.2375	0.7137	-0.4806	-0.1503	-0.1991	0.6931
8	0.0892	-0.0593	0.0446	0.0732	-0.1400	-0.0119	0.1003	-0.1490	0.0800	0.0495	-0.6029
9	0.0394	0.0080	0.0583	0.0579	-0.0462	0.0133	0.0193	0.0491	-0.0914	-0.1959	-0.3752
10	-0.0798	0.0132	-0.1132	-0.1052	0.0735	-0.0293	-0.0424	-0.0937	0.1692	0.1692	-0.4421

R square = 1.0268 Residual effect=SQRT(1- 1.0268)

1. Plant height 2. Internodal length 3. Number of branches per plant 4. Fruit length 5. Fruit diameter 6. Average fruit weight 7. Number of fruits per plant 8. 50% flower 9.Number of vacuoles 10. number of ridges 11. yield per plant

Table 4: Direct and indirect effects of yield contributing character on yield in okra at phenotypic level

Traits	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	-0.0413	0.0125	-0.0276	-0.0136	0.0248	0.0115	-0.0313	0.0105	0.0081	-0.0100	0.4456
2	0.0008	-0.0025	0.0004	0.0001	-0.0007	-0.0006	0.0011	-0.0001	-0.0001	0.0043	-0.2003
3	-0.0012	0.0003	-0.0018	-0.0005	0.0009	0.0003	-0.0010	0.0002	0.0005	-0.0030	0.3757
4	0.0178	-0.0028	0.0137	0.0540	-0.0110	0.0251	0.0149	0.0003	-0.0072	-0.0010	0.5682
5	-0.0071	0.0035	-0.0059	-0.0024	0.0118	0.0051	-0.0067	0.0019	0.0018	0.0003	-0.1903
6	-0.1749	0.1517	-0.0899	0.2931	0.2709	0.6299	-0.0991	-0.0021	-0.0050	-0.0025	0.5387
7	0.6409	-0.3608	0.4755	0.2331	-0.4793	-0.1328	0.8445	-0.1958	-0.1668	-0.0102	0.7326
8	0.0040	-0.0005	0.0016	-0.0001	-0.0025	0.0001	0.0036	-0.0156	0.0036	0.0031	-0.1930
9	0.0066	-0.0019	0.0096	0.0044	-0.0052	0.0003	0.0066	0.0077	-0.0333	-0.0297	-0.1983
10	-0.0041	-0.0031	0.0021	-0.0003	-0.0001	-0.0004	-0.0003	-0.0051	-0.0023	0.0238	0.0048

Residual effect = 0.1503 Bold diagonal value indicates direct effect R square = 0.9774

1 plant height 2 Inter-nodal length 3 Number of branches per plant 4 Fruit length 5 Fruit diameter 6 Average fruit weight 7 Number of fruits per plant 8 50% flower 9 Number of vacuoles 10 number of ridges 1 yield per plant

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