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Character association studies and path coefficient analysis for yield and yield attributing traits in Ridge gourd [*Luffa acutangula (*L.*)* Roxb.]

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Abstract
To know the association of various growths and yield attributing traits with the complex yield, eighteen genotype of ridge gourd were subjected to study the genotypic and phenotypic correlation and path analysis. High genotypic co-efficient of variation (GCV) was observed for yield per vine, chlorophyll content of leaf and proline content of leaf indicating little influence of environment and the presence of inherent association between characters. Vine length (0.460), number of leaves (0.578), number of fruits per vine (0.993), fruit length (0.830) and days to first female flowering (-0.269) to the fruit yield per vine at both genotypic and phenotypic level, the associations of these characters is in the desirable direction. Thus, selection for these characters will improve the yield. Path coefficient analysis revealed that number of leaves per vine, tendril length, number of fruits per vine and fruit diameter showed positive direct effects on total yield per vine.

Key words: Ridge gourd, phenotypic correlation, genotypic correlation, Fruit yield per vine

Introduction

Ridge gourd [*Luffa acutangula* (Roxb.) L.] is an important warm season cucurbitaceous vegetable crop grown in different parts of India and in the tropical countries of Asia and Africa (Reddy *et al.*, 2013). Being a warm season crop, it has the ability to tolerate hotter conditions, which makes it suitable for widespread cultivation throughout the tropics. Determining the components of variability (genotypic and phenotypic) in yield will enable us to know the extent of environmental influence on yield, taking into consideration of the fact that yield and its components are quantitative characters and are affected by environment (Ahmed *et al*., 2007).

Due to monoecious sex form, ridge gourd is highly cross pollinated and had wide variation in growth and fruit characters. Thus, there is a need to identify stable and superior genotypes through screening of germplasm at large scale for commercial use. The success of any breeding programme depends upon selection of a proper plant. The efficiency of selection depends on the magnitude and nature of genetic variation in a specific population for effective breeding program (Debnath 1988). Yield is polygenic in nature and influenced by environmental factors, which complicate the selection process thus, the knowledge of correlation of the traits is necessary for effective selection process (Choudhary *et al.* 2008). Therefore, before aiming an improvement in yield, it is necessary to have the knowledge of correlation with yield. The existence of wide genetic variation in ridge gourd in hot arid areas provides ample scope for screening the best genotypes for specific traits. Thus, the present investigation was carried out to work out phenotypic and genotypic association of important genetic and biochemical traits and path analysis between components of yield in ridge gourd, so as to make effective selection for improvement of this crop. Much work has not been done in genetic improvement of ridge gourd with reference to biochemical. Hence, an investigation was undertaken to study the character association and path analysis in ridge gourd.

Materials and Methods

The study was conducted with the eighteen genotypes of ridge gourd in Randomized Complete Block Design (RCBD) with three replications at Department of Crop Improvement and Biotechnology, Kittur Rani Channamma College of Horticulture, Arabhavi during 2012-14. The intercultural practices were followed as per the package of practices of horticultural crops of

University of Agricultural Sciences, Dharawad (Anon., 2010). The vines were staked individually using wooden sticks and were trained uniformly. This helped the plants for better spreading and easy harvesting. Observations were recorded on vine length, tendril length, number of leaves, number of branches, days to first female flowering, days to 50 per cent flowering, total chlorophyll content, proline content of leaf, number of fruits per vine, average fruit weight, flesh thickness and rind thickness to know the association of these traits with the fruit yield per vine. The biometrical analysis of the data was carried out using Indostat programmes. Analysis of variance was carried out as per the procedure given by Panse and Sukhatme (1967) using the mean values of random plants in each replication from all treatments to find out the significance of treatment effects.

The test of significance for association between characters was done by comparing table ‘r’ values at n-2 error degrees of freedom for phenotypic and genotypic correlations with estimated values, respectively.

Results and Discussion

The analysis of variance revealed that all the growth, biochemical and yield attributing characters under study were highly significant among the genotypes. This indicates presence of sufficient amount of variation for all the traits and selection will be very effective in improving them. The genotypic and phenotypic correlation co-efficient were determined to obtain information on the relationship among the characters in ridge gourd and are presented in Table 2.

Phenotypic coefficients of variation were greater than genotypic coefficients of variation indicating influence of environment. Phenotypic and genotypic coefficient of variation (Table 01) was highest for total chlorophyll (46.42, 45.80) and proline content (45.82, 44.83) followed by yield per vine (30.09, 27.37) and number of branches per plant (21.42, 20.34), a wide range of variation indicates more opportunity for selection of better genotypes. Similar results were reported by Ram *et al.*, (2005) and Singh *et al*., (2012).

Heritability provides an idea to the extent of genetic control for expression of a particular trait and the reliability of phenotype in predicting its breeding value (Chopra, 2000; Tazeen *et al*. 2009). The present study revealed that total chlorophyll content (97.00), proline content (96.00), number of branches (90.00), vine length (88.00) and number of leaves (79.00) showed high heritability values. High heritability indicates less environmental influence in the observed variation (Mohanty, 2003; Ansari *et al.*, 2004; Songsri *et al*., 2008; Eid, 2009). The estimate of genetic advance is more useful as a selection tool when considered jointly with heritability estimates (Johnson *et al*., 1955; Panse, 1967).

The genetic gain was maximum in the traits proline content (27.24), vine length (53.85) and yield (515.39). High heritability and high genetic advance for a given trait indicates that it is governed by additive gene action and therefore, provides the most effective condition for selection (Tazeen *et al*., 2009; Ullah *et al*., (2012); Choudhary *et al*., (2014). Flesh thickness, fruit length and days to first female flowering reported low genotypic coefficient of variation (7.31, 15.56 and 4.41 respectively), moderate heritability (48.00, 67.00 and 58.00 respectively) and low genetic gain (0.23, 6.67 and 3.45 respectively) indicating preponderance of non additive gene action and influence of environment.

Genotypic correlation (Table 02) revealed that yield per vine showed significant positive correlation with proline content (0.725), number of leaves (0.578), number of fruits (0.993), average fruit weight (0.984), flesh thickness (0.884) and rind thickness (0.716). Selection to increase leaves and number of fruits would invariably result in increased fruit yield in cucurbits (Afangideh *et al*., 2005). Islam *et al*. (1993) reported significant positive correlation between number of fruits per plant and yield and Ramirez *et al*. (1988) also observed significant positive correlations between number of fruits per plant and fruit yield in cucumber. Therefore these traits should be taken into consideration while making selection for improvement in fruit yield. Days to first female flowering (-0.697) exhibited negative significant correlation with fruit yield which is in desirable direction and implying selection for this trait leads to early yield.

Number of leaves showed positive significant correlation with total chlorophyll content (0.284), proline content (0.424), number of fruits (0.581), average fruit weight (0.547) and flesh thickness (0.545)**.** However, days to first female flowering and proline content of leaf were negatively correlated indicating selection for early genotypes results in less amount of proline content of leaf since proline accumulates as the crop duration extends and drought occurs (Chavan *et al*. 2010). Phenotypic correlation coefficients (Table 02) for all the characters under study were lower in magnitude compared to genotypic coefficients indicating influence of environment on their expression and they were following the same trend as that of genotypic correlations.

Path analysis reveals the direct and indirect association which is the most reliable method in addition to the correlation coefficient and genetic variation (Singh *et al*., 2014). Genotypic and phenotypic path coefficient analysis (Table 03) was carried out taking yield per plant as dependent variable. The analysis revealed that number of leaves (0.8031) and fruit diameter (0.5471) had highest positive direct effect on yield per plant at both genotypic and phenotypic levels. Number of fruits was ranking third with respect to positive direct effect on yield followed by flesh thickness. The similar findings of Ullah *et al*., (2012) and Singh *et al.,* (2012) boost the present investigation.

In case of negative direct effects, proline content of leaf (-0.8536) has highest direct effect followed by days to first female flowering (-0.6333) at both genotypic and phenotypic level. The highest negative indirect effect was recorded by proline content of leaf (-0.4880) *via* fruit diameter. Chlorophyll content of leaf exhibited the negative direct effects on yield indicating contributions of this character through assimilation of all credited photosynthates to the sink *i.e* number of fruits per vine and total yield per vine. The low residual effect (0.0241) at genotypic level indicates that all the important characters correlated with fruit yield in ridge gourd. Dey *et al*, (2006), Husna *et al*., (2011) and Yadav *et al.*, (2013) also supported the results.

From the above discussion, number of branches, proline content of leaf, days to first female flowering and rind thickness were shown to have high to moderate genotypic variance, high heritability, greater genetic gain and significant positive correlation with yield. Selection can therefore be based on these characters and their phenotypic expression would be a good indicator of their genotypic potentiality. Genotypic and phenotypic correlation and path analysis also indicated total chlorophyll content, fruits per plant, flesh thickness and fruit weight as the most effective variables contributing to the grain yield. So, it is concluded that these traits may be considered as the selection criteria for the improvement of ridge gourd fruit yield.

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Table 01: Genetic and phenotypic coefficient of variation of various growth, yield and yield attributing traits in ridge gourd.

Particulars	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Mean	243.80	4.68	62.15	27.32	1.44	30.16	49.78	56.17	6.71	147.31	25.34	27.29	2.26	1.73	1004.48
Range	199.50 - 290.50	2.33 - 6.17	48.6 - 73.67	24.17 - 30.83	0.46 - 2.39	12.08 - 56.71	46.33 - 54.00	54.00 - 59.66	5.50 - 9.66	125.03 - 182.25	19.70 - 33.03	22.29 – 31.92	1.87 - 2.68	1.38 - 2.28	695.98 - 1760.53
GV	775.59	0.88	35.52	2.60	0.44	182.86	4.81	2.22	0.94	284.84	15.56	4.38	0.03	0.08	75630.00
PV	880.35	0.98	45.24	3.55	0.45	191.22	8.26	2.23	1.28	489.60	23.09	26.46	0.06	0.12	91377.28
PCV	12.17	21.42	10.82	6.90	46.42	45.84	5.77	2.66	16.86	15.02	18.95	18.85	10.53	20.17	30.09
GCV	11.42	20.34	9.59	5.90	45.80	44.83	4.41	2.65	14.49	11.45	15.56	7.66	7.31	16.47	27.37
h2	88.00	90.00	79.00	73.00	97.00	96.00	58.00	100	73.00	58.00	67.00	16.00	48.00	66.00	62.00
GA	53.85	18.40	10.88	2.84	1.34	27.24	3.45	3.07	1.72	0.26	6.67	1.75	0.23	0.48	515.39
GAM	22.09	39.80	17.51	10.40	93.03	90.30	6.93	5.47	25.66	18.00	26.33	6.42	10.46	27.72	51.30

GCV = Genotypic coefficient of variation, GA = Expected genetic advance, h^2 = Heritability (broad sense),
PCV = Phenotypic coefficient of variation, PV= Phenotypic variance, GV= Genotypic variance,
GAM = Genetic advance as per cent mean, AGR= Absolute growth rate, CGR= Crop growth rate,
RGR= Relative growth rate, NAR= Nett assimilation Rate.

1: Vine length @ 90 DAS
2: Branches @ 90 DAS
3: Number of leaves @ 90 DAS
4: Tendril length @ 90 DAS
5: Total chlorophyll @ 90 DAS
6: Proline content @90 DAS
7: Days to 1st female flowering
8: Days to 50% flowering
9: Number of fruits
10: Average fruit weight
11: Fruit length
12: Fruit diameter
13: Flesh thickness
14: Rind thickness
15: Fruit yield per vine

Table 02: Genotypic correlation co-efficient among growth and yield components in ridge gourd (*Luffa acutangula* (L.) Roxb.)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	G	1.000	0.600**	0.731**	0.401*	0.312	0.215	-0.171	0.088	0.400*	0.487**	0.358	0.689**	0.554**	0.626**	0.460**
	P	1.000	0.581**	0.693**	0.385	0.808**	0.211	-0.171	0.072	0.385	0.439*	0.334	0.534**	0.477**	0.566**	0.447**
2	G		1.000	0.847**	0.368	0.094	0.236	-0.116	-0.007	0.376	0.411*	0.504**	0.351	0.399*	0.613**	0.407*
	P		1.000	0.806**	0.356	0.096	0.230	-0.117	-0.010	0.343	0.367	0.466**	0.264	0.325	0.557**	0.385*
3	G			1.000	0.479*	0.284	0.424*	-0.049	-0.110	0.581**	0.547**	0.650**	0.497**	0.545**	0.587**	0.578**
	P			1.000	0.427*	0.275	0.401*	-0.031	-0.089	0.521**	0.507	0.593**	0.405**	0.473**	0.530**	0.546**
4	G				1.000	0.543**	0.287	-0.097	0.368	0.358	0.358	0.167	0.268	0.343	0.412*	0.385
	P				1.000	0.516**	0.262	-0.880**	0.333	0.320	0.289	0.152	0.158	0.298	0.345	0.343
5	G					1.000	0.055	-0.234	0.243	0.232	0.379	-0.054	0.068	0.267	0.279	0.323
	P					1.000	0.056	-0.210	0.234	0.214	0.337	-0.056	0.048	0.234	0.251	0.309
6	G						1.000	-0.659**	0.046	0.730**	0.683**	0.469**	0.728**	0.757**	0.580**	0.725**
	P						1.000	-0.594**	0.046	0.683**	0.601**	0.422*	0.571**	0.638**	0.534**	0.692**
7	G							1.000	-0.147	-0.289	-0.145	0.246	-0.358	-0.492**	-0.425**	-0.269
	P							1.000	-0.143	-0.243	-0.195	0.201	-0.233	-0.392	-0.369	-0.257
8	G								1.000	0.170	0.270	-0.091	-0.256	-0.189	-0.244	-0.221
	P								1.000	0.163	0.275	-0.105	-0.171	-0.139	-0.236	-0.217
9	G									1.000	0.960**	0.877**	0.911**	0.930**	0.790**	0.993**
	P									1.000	0.808**	0.753**	0.655**	0.771**	0.697**	0.964**
10	G										1.000	0.774**	0.756**	0.766**	0.549**	0.984**
	P										1.000	0.666**	0.511**	0.651**	0.518**	0.931**
11	G											1.000	0.566**	0.573**	0.567**	0.830**
	P											1.000	0.447**	0.456**	0.509**	0.742**
12	G												1.000	0.969**	0.084	0.865**
	P												1.000	0.659**	0.777**	0.628**
13	G													1.000	0.947**	0.884**
	P													1.000	0.735**	0.736**
14	G														1.000	0.716**
	P														1.000	0.669**

*and ** indicates significance at 5 and 1 per cent probability levels, respectively. Critical r (p=0.05) =0.389 Critical r (p=0.01) = 0.447

1: Vine length @ 90 DAS; 5: Total chlorophyll @ 90 DAS; 9: Number of fruits; 13: Flesh thickness
2: Branches @ 90 DAS; 6: Proline content @90 DAS; 10: Average fruit weight; 14: Rind thickness
3: Number of leaves @ 90 DAS; 7: Days to 1st female flowering; 11: Fruit length; 15: Fruit yield per vine
4: Tendril length @ 90 DAS; 8: Days to 50% flowering; 12: Fruit diameter; G: Genotypic correlation P: Phenotypic correlation.

Table 03: Direct (diagonal) and indirect path effects of different characters towards fruit yield per plant in ridge gourd (*Luffa acutangula* (L.) Roxb.)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	**-0.6795**	-0.3953	-0.4711	-0.2621	-0.2094	-0.1437	0.1165	-0.0491	-0.2618	-0.2984	-0.2272	-0.3632	-0.3245	-0.3847	0.4478
2	-0.0237	**-0.0408**	-0.0329	-0.0146	-0.0039	-0.0094	0.0048	0.0004	-0.0140	-0.0150	-0.0191	-0.0108	-0.0133	-0.0227	0.3854
3	0.5568	0.6479	**0.8031**	0.3432	0.2216	0.3222	-0.0254	-0.0721	0.4192	0.4078	0.4770	0.3254	0.0180	0.4258	0.5469
4	0.0234	0.0216	0.0259	**0.0606**	0.0313	0.0159	-0.0054	0.0202	0.0194	0.0176	0.0092	0.0096	0.3804	0.0209	0.3430
5	-0.0076	-0.0024	-0.0068	-0.0127	**-0.2045**	-0.0014	0.0052	-0.0057	-0.0053	-0.0083	0.0014	-0.0012	0.0181	-0.0062	0.3091
6	-0.1806	-0.1969	-0.3425	-0.2244	-0.0480	**-0.8536**	0.5078	-0.3097	-0.5836	-0.5136	-0.3608	-0.4880	-0.0058	-0.4561	0.6926
7	0.1086	0.0744	0.0201	0.0569	0.1330	0.3768	**-0.6333**	0.0910	0.1542	0.1239	-0.1278	0.1478	-0.5451	0.2339	-0.2673
8	-0.0009	0.0001	0.0011	-0.0042	-0.2209	-0.0006	0.0018	**-0.0125**	-0.0020	-0.0034	0.0013	0.0021	0.2485	0.0026	0.2277
9	0.1643	0.1465	0.2225	0.1365	-0.0916	0.2915	-0.1038	0.0695	**0.4263**	0.3448	0.3214	0.2795	0.0017	0.2972	0.9644
10	0.1065	0.0891	0.1231	0.0730	0.0818	0.1459	-0.0474	0.0667	0.1961	**0.2424**	0.1616	0.1240	0.3290	0.1258	0.9396
11	-0.0277	-0.0388	-0.0492	-0.0126	0.0047	-0.0350	-0.0167	0.0087	-0.0624	-0.0552	**-0.0828**	-0.0371	0.1579	-0.0422	0.7425
12	0.2924	0.1446	0.2216	0.0865	0.0264	0.3128	-0.1277	-0.0939	0.3586	0.2797	0.2889	**0.5471**	-0.0978	0.4251	0.6287
13	-0.0664	-0.0453	-0.0659	-0.0415	-0.0327	-0.0889	0.0546	0.0195	-0.1074	-0.0906	-0.2669	-0.0917	**0.3606**	-0.1023	0.7630
14	0.0261	0.0257	0.0244	0.0159	0.0116	0.0246	-0.0170	-0.0095	0.0321	0.0239	0.0235	0.0358	-0.1939	**0.0461**	0.6696

Residual effect: **0.0241**

1: Vine length @ 90 DAS
2: Branches @ 90 DAS
3: Number of leaves @ 90 DAS
4: Tendril length @ 90 DAS
5: Total chlorophyll @ 90 DAS
6: Proline content @90 DAS
7: Days to 1st female flowering
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