Research Paper

Estimation of Genetic Parameters and Path Analysis on Yield and Yield-Related Characteristics of Ridged Gourd (*Luffa acutangula* L. Roxb.)

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Abstract

The present study was conducted with the objectives of evaluating genetic parameters, and identify yield-related characteristics that may be improved through selection in ridge gourd breeding. The experimental material consisted of 30 F_1 hybrids produced at the Horticultural Crops Research and Development Institute, Gannoruwa, Sri Lanka. Experiment was conducted in Randomized Complete Block Design with two replicates. Days to first male flowering and female flowering, days to 50% flowering, number of pods per plant, pod weight, pod length, pod circumference and yield per plant were recorded. All the characteristics showed a higher phenotypic coefficient of variation than the genotypic coefficient of variation. Though days to first male and female flowering and 50% flowering showed high heritability values, none of them showed significant correlations with per-plant-yield indicating that selection for those characteristics has no influence on per-plant-yield of ridge gourd. Per-plant-yield showed positive significant genotypic and phenotypic correlations only with the number of pods per plant which also showed a significant negative correlation with pod weight. This indicates the possibility of improving yield through selection based on the number of pods per plant within the limits that it is not affecting pod weight to maximize yield in ridge gourd.

Keywords: Genetic similarity, Heritability, Hybridization, Ridge gourd breeding, Path analysis

Introduction

Ridged gourd or luffa is one of the major vegetable crops grown in Sri Lanka and is listed in medium priority crop group. The extent of cultivation is 4,498 ha which is 17.22% from the total extent of vegetable cultivation and production is 46,124 t, 3.95% of total vegetable production (DoA, 2019). It can be grown in almost all vegetable growing areas but major cultivated areas are located in central, north central and southern parts of the country. Market demand of this vegetable is mainly decided based on the fruit colour; dark green and fruit length; medium. There are few varieties developed by the Department of Agriculture namely, *Gannoruwa Ari*, *Asiri*, *LA 33* but not very popular among farmers due to delay flowering, low yield and inferior pod quality. There are many imported high yielding varieties with attractive pod characteristics however, they are prone to diseases due to low adaptability to local environmental conditions. Therefore, it is important to develop new high yielding luffa varieties locally, that can compete with imported varieties to save foreign exchange for seed imports while catering the farmer and consumer demands.

Understanding on genetic behavior of parents and hybrids in relation to the yield and other characteristics are important in selecting promising hybrids. Hence, the studies to gather information on heritability, genetic relationships on yield and important morphological characteristics are very important. Those information can be used in predicting behavior of the parents that involve in hybridization for developing high yielding genotypes with better quality (Zubair *et al*., 1989). Heritability is a significant parameter for the selection of characteristics that are mainly influenced by the genetic effect but least influenced by the environmental effect. Correlation and path coefficient analysis are reliable statistical analysis methods that can be used to get a clear understanding on the relationships among plant traits and to quantify the interrelationships among yield and yield components. Path analysis describes the direct influence of plant characteristics on yield and yield components that are considered mainly in crop improvement process i.e. yield, as well as indirect path ways for ultimate effects (Mohsin *et al*., 2009). Present study was conducted to estimate genetic parameters including heritability of yield and yield related characteristics and direct and indirect contribution of yield related characteristics on yield in order to select the most desirable characteristics that can be utilized in the selection process for an effective breeding program of luffa to develop high yielding hybrid varieties accordance with farmer and consumer demand.

Materials and Methods

The experiment was undertaken during the year 2017 and 2018 at the Horticultural Crops Research and Development Institute (HORDI), Gannoruwa, Sri Lanka. Thirty F_1 hybrids were produced by crossing eleven developed inbred lines at HORDI as parents in 2017/2018 *Maha* season. F_1 seeds were planted during 2018 *Yala* in a Randomized Complete Block Design with two replications in 4.5 m x 3 m size

plots. Fertilizer application and other management practices were done according to the recommendations of Department of Agriculture.

Yield was recorded as per plant yield (PPY). Days to first male flowering (DFMF), days to first female flowering (DFFF), days to 50% flowering (DFF), number of pods per plant (NPPP), pod weight (PW), pod length (PL) and pod circumference (PC) were recorded as yield related characteristics. Data were recorded on five randomly selected plants from each F_1 progenies from each replicate.

Statistical Analysis

Broad sense heritability (h^2), correlation (genotypic and phenotypic) and path coefficient values were calculated by the method suggested by Singh and Chaudhry (1985). The analyses of variance (ANOVA) for the quantitative parameters were performed using SAS 9.1 software package.

$$h^2(bs) = \frac{\sigma_g^2}{\sigma_p^2} X\ 100 \quad \text{.....eq. 1}$$

$$\%PCV = \frac{\sqrt{\sigma_p^2}}{n} X\ 100 \quad \text{.....eq. 2}$$

$$\%GCV = \frac{\sqrt{\sigma_g^2}}{n} X\ 100 \quad \text{.....eq. 3}$$

Where,

$h^2(bs) = Broad\ sence\ heritability$

$\sigma_g^2 = Genotypic\ variance,$

$\sigma_p^2 = Phenotypic\ variance$

$\%PCV = Phenotypic\ coefficient\ of\ variation$

$\%\ GCV = Genotypic\ coefficient\ of\ variation$

Results & Discussion

Results of the analyses of variance (Table 1) revealed that all the characteristics studied including yield were significantly different among genotypes. Thus, all characters were subjected to calculate genetic parameters.

The broad sense heritability percentage of measured characteristics ranged from 14.70% (average pod circumference) to 87.40% (days to first female flowering). It is assumed that the heritability >85% show highest heritability followed by <84% >50% medium and < 50% is lowest. Highest heritability (>85%) observed in days to first female flowering and days to 50% flowering suggested that the environmental effect on those traits was marginal. Medium heritability (<84% - >50%) was recorded in days to first male flowering, number of fruits per plant and pod length while low heritability (<50%) was recorded in pod weight, per plant yield and pod circumference (Table 2). The mid and low heritability were observed mainly in yield and yield related characteristics which are the major characteristics considered in breeding programs. However, these characteristics indicated relatively large effect of environment on expressing them. Heritability is one of the useful parameters on which the selection efficiency is based. Heritability estimates have been used in estimating expected progress in determining the degree of transmitting the character from parents to offspring (Singh *et al*., 2012). Therefore, it is essential to assess the relative effect of genotype and environment in expressing the characteristics. Present data provide an estimate of the extent to which

genetic improvement is possible in the characteristics under consideration.

Co-efficient of variation measures the magnitude of variability present in a population while heritability indicates the reliability with which the genotype is recognized by its phenotypic expression (Kumar *et al*., 2019). In present study all studies characters showed higher phenotypic coefficient of variation than genotypic coefficient of variation (Table 2). Number of pods per plant showed highest GCV and PCV followed by per plant yield suggesting that there is a wide variation within those characteristics, hence having high potential for improvement. This is in agreement with Kumar *et al*. (2019) who also reported the highest GCV and PCV for per plant yield and number of fruits per plant in sponge gourd. Comparatively low GCV and PCV were recorded in pod circumference, days to first male flowering, days to first female flowering and fifty percent flowering indicating that scope for selection for these traits is limiting. This is in agreement with the findings of Karthik *et al*., 2017; Kannan *et al*., 2019 and Vijayakumar *et al*., 2020, where flowering characters (days to first male flowering, days to first female flowering and fifty percent flowering) showed low GCV and PCV values and stated that the selection resulted in attaining homozygosity and further selection will not affect to alter these traits.

Table 1. Analyses of variance of Luffa genotypes for yield and yield related characteristics.

Characteristic	Grand mean	Genotype	Error
PPY (g)	1560.53	395611.27*	216895.98
DFMF (no.)	33.47	6.65*	1.26
DFFF (no.)	34.49	10.86*	0.73
DFF (no.)	38.45	29.37*	2.09
NPPP (no.)	3.43	1.92*	0.51
PW (g)	508.35	9540.79*	4104.69
PL (cm)	43.92	58.51*	19.09
PC (cm)	19.96	2.57*	1.91

**Values are significant at p<0.05*

Yield per plant (PPY), Days to First Male Flowering (DFMF), Days to First Female Flowering (DFFF), Days to Fifty Percent Flowering (DFF), Number of Pods Per Plant (NPPP), Pod Weight (PW), Pod Length (PL) and Pod Circumference (PC)

Table 2. Heritability, Genotypic coefficient of variance (%GCV) and phenotypic coefficient of variance (%PCV) of yield and related characteristics in tested Luffa hybrids.

Characteristic[$]	Grand mean	Parameter[#]				
		h^2 (bs) %	σ^2_g	σ^2_p	% GCV	%PCV
PPY	1560.53	29.18	89357.64	306253.63	19.16	35.46
DFMF	33.47	68.14	2.69	3.95	4.90	5.94
DFFF	34.49	87.40	5.07	5.80	6.53	6.98
DFF	38.45	86.74	13.64	15.73	9.61	10.31
NPPP	3.43	57.73	0.70	1.21	24.39	32.20
PW	508.35	39.84	2718.05	6822.74	10.26	16.25
PL	43.92	50.80	19.71	38.80	10.11	14.18
PC	19.96	14.70	0.33	2.24	2.88	7.50

h^2 (bs) = Broad Sence Heritability, σ^2_g= Genotypic Variance, σ^2_p= Phenotypic Variance, *%PCV= Phenotypic Coefficient of Variation,% GCV = Genotypic Coefficient of Variation, Yield Per Plant (PPY), Days to First Male Flowering (DFMF), Days to First Female Flowering (DFFF), Days to Fifty Percent Flowering (DFF), Number of Pods Per Plant (NPPP), Pod Weight (PW), Pod Length (PL) and Pod Circumference (PC)*

The estimates of genotypic correlations were significantly higher than their corresponding phenotypic correlations for some pairs of characteristics (pod weight, pod length and pod circumference) in the present study (Table 3). According to Singh *et al.* (2017) this may be due to an inherent association among those characteristics and the phenotypic expression of characteristics may have less effect by the influence of environment. The present study shows positive significant genotypic and phenotypic correlation of per plant yield only with number of pods per plant. All the other characteristics showed no correlation with per plant yield so that there is a possibility to improve yield through selection based on the number of pods per plant. However, number of pods per plant showed significant negative correlations with pod weight and length indicating that there is a limit of increasing the number of pods per plant without affecting the pod weight and length. Pod weight is mainly dependent on pod length as the data show significantly higher correlation. Therefore, selection for comparatively higher number of pods per plant should be performed carefully without affecting pod weight and length to maximize yield in luffa since farmer and consumer demand is also depend on pod quality.

Days to first female and male flowering showed high significant genotypic and phenotypic correlations with days to fifty percent flowering as expected. However, none of these characteristics showed significant correlations with per plant yield indicating that selection for days to male, female or fifty percent flowering has no influence on per plant yield of luffa.

Table 3. Phenotypic (Rp) and Genotypic (Rg) correlation coefficients between tested yield and related characteristics of tested luffa hybrids.

Characteristic		DFMF	DFFF	DFF	NPPP	PW	PL	PC
PPY	Rp	0.033	0.075	-0.009	0.792*	0.228	0.108	0.267
	Rg	0.221	0.184	0.175	0.840*	-0.292	-0.251	-0.061
DFMF	Rp	1.000	0.566*	0.542*	0.073	0.060	-0.019	-0.010
	Rg	1.000	0.708*	0.694*	0.143	0.237	0.178	-0.140
DFFF	Rp		1.000	0.747*	-0.045	0.103	0.104	-0.078
	Rg		1.000	0.818*	0.001	0.229	0.244	-0.110
DFF	Rp			1.000	0.004	-0.087	-0.146	0.069
	Rg			1.000	0.008	-0.065	-0.147	0.283
NPPP	Rp				1.000	-0.101	-0.246	0.363
	Rg				1.000	-0.633*	-0.774*	0.681*
PW	Rp					1.000	0.802*	0.030
	Rg					1.000	0.998*	-0.252
PL	Rp						1.000	-0.293
	Rg						1.000	-0.208
PC	Rp							1.000
	Rg							1.000

**Values are significant at p<0.05*

Yield Per Plant (PPY), Days to First Male Flowering (DFMF), Days to First Female Flowering (DFFF), Days to Fifty Percent Flowering (DFF), Number of Pods Per Plant (NPPP), Pod Weight (PW), Pod Length (PL) and Pod Circumference (PC)

According to the path analysis, days to first flowering, number of fruits per plant, average pod weight and pod length were positively correlated and the highest direct contribution was recorded in average fruits per plant followed by average pod weight (Table 4). Krishnamoorthy and Ananthan, (2017) also found highest positive direct effect for number of fruits per plant and fruit weight. However, according to that study fruit length had highest negative direct effect.

Days to first male flowering and days to fifty percent flowering exhibited negative direct effect while days to first male flowering gave the highest negative direct effect. This result is in accordance with the findings of Ramesh *et al*., 2018. Conversely Khan *et al*., 2009 found that, those two characters show positive indirect effect to per plant fruits. Selection of such attributes will be beneficial to increase the yield. Correlation coefficients explain only the relationship of yield to its related characters but not give any idea about direct and indirect effects of different characters on yield.

Table 4.Direct (Diagonal) and indirect effect of genetic correlated characters on per plant yield of Luffa

Character	DFMF	DFF	FF	NPPP	PW	PL	PC
DFMF	-0.1003	-0.0528	-0.0544	-0.0074	-0.0060	0.0019	0.0010
DFF	0.0872	0.1656	0.1237	-0.0075	0.0170	0.0173	-0.0129
FF	-0.0238	-0.0328	-0.0439	-0.0002	0.0038	0.0064	-0.0030
NPPP	0.0632	-0.0388	0.0031	0.8595	-0.0872	-0.2117	0.3122
PW	0.0103	0.0176	-0.0150	-0.0174	0.1717	0.1377	0.0051
PL	-0.0030	0.0167	-0.0233	-0.0393	0.1279	0.1596	-0.0468
PC	-0.0001	-0.0009	0.0008	0.0041	0.0003	-0.0033	0.0114

Days to First Male Flowering (DFMF), Days to First Female Flowering (DFFF), Days to Fifty Percent Flowering (DFF), Number of Pods Per Plant (NPPP), Pod Weight (PW), Pod Length (PL) and Pod Circumference (PC)

Conclusions

The present study gives an idea on the selection of characteristics for the improvement of yield in variety development programs of luffa. Selection would be beneficial for yield based on number of pods per plant without affecting pod weight. Selection for days to male, female or fifty percent flowering has no influence on per plant yield of luffa though these characteristics showed high heritability.

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