Correlation among Agronomic Characteristics and Their Contribution for the Yield Improvement in F4 Generation of Cowpea (*Vigna unguiculata* (L). Walp)

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Abstract
Estimation of correlation among yield and yield related characteristics at segregating population levels is important in indirect selection process of plant breeding. Hence, segregating populations of two cowpea [*Vigna unguiculata* (L) Walp] crosses CP 19 x Waruni and CP 20 x CP 22, were assessed using three breeding methods namely, pedigree, Single Seed Descent (SSD) and modified bulk. Six F2 populations were maintained for two cowpea crosses with respect to three breeding methods during 2011 *yala* season and F3 and F4 populations for each method were established during 2012/12 *Maha* and 2012 *Yala* seasons, respectively. Data were recorded on plant height at maturity, number of peduncles per plant, number of pods per plant, number of seeds per pod, average length of pod, hundred seed weight and yield per plant in F4 generation. According to Pearson correlation analysis positive phenotypic correlations were recorded between the seed yield per plant and pods per plant, peduncle per plant and hundred seed weight. Pods per plants was correlated with yield in pedigree method for cross 01 and cross 02 by 0.745 and 0.611 and 0.612 and 0.817 ($p < 0.01$) for bulk method, respectively. Stepwise multiple regressions also revealed that pods per plant, hundred seed weight and pod length as contributing factors for seed yield per plant. Equation for SSD method in cross 01 ($Y = -23.8995 + 1.142X_2 - 0.592X_4 + 1.0513X_5 + 1.21X_6$) was included four contributing characters. Therefore pods per plant, hundred seed weight and pod length could be effectively used as selection criteria for yield improvement in cowpea breeding.

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Introduction

Cowpea [*Vigna unguicula* (L) Walp] is one of the major field crop grown by the rain fed dry zone farmers of Sri Lanka. This crop is considered as a poor man's crop since it can withstand poor soil conditions, low input and poor attention of the farmer. Unavailability of good quality seeds, lack of knowledge on new varieties, uncertainty of rainfall, occurrence of pests and diseases, poor attention of farmers and unavailability of suitable varieties for rain fed conditions are the major constraints encountered by farmers, which lead to poor yields (Jayamanne, 1989).

To fulfil the drawbacks of the recommended varieties and to attain the actual breeding requirement of cowpea growers, a continuous genetic improvement of the cowpea varieties with high yields and tolerance to biotic and abiotic stresses is essential. The knowledge on the relative efficiency of different breeding methods may help the plant breeders in selecting a better method to be adopted for a particular crop (Adnan *et al.*, 2011). Therefore, estimate of genetic parameters at segregating population levels also important to determine the efficiency of different breeding methods such as single seed descent (SSD) method, pedigree method (PM) and modified bulk method (MB) in breeding activities of cowpea. Hence, a study was conducted to estimate correlation among agronomic characters and the contribution of them for the yield at F4 generation using different breeding methods in cowpea improvement.

Materials and Methods

Two cross combinations, cross 01 and cross 02 (CP19 x Waruni and CP20 x CP22) of four distinct parents of cowpea were used to produce F3 and F4 generations with series of trials following pedigree method, modified bulk method and single seed descent method. Six F3 populations with respect to two crosses and three breeding methods were maintained separately during 2011/12 *Maha* season.

For the Pedigree method two F3 populations each with 100 progeny lines from two crosses (one from each cross) were derived from 1000 plant populations of the F2 generation of respective crosses during the 2011/12 *Maha* season. For each of the two crosses, 100 separate progeny lines derived from the F3 generation by within and between lines selections were advanced to produce the F4 generation during 2012 *Yala season*. Two F3 populations were derived from the F2 populations of the two crosses (one from each

cross) by selecting individual seed per plant from all the plants of respective F2 populations in SSD. Single seed descent F4 populations were derived from F3 populations of each of the two crosses. In modified bulk method two F3 bulk populations were derived by taking bulk samples from the F2 populations of the two crosses (one from each cross). The F4 bulk populations were established with the bulked seed samples from 5% of selected plants of the F3 generation. Based on visual observations, the superior 5% plants amounting to 100 were selected from the F4 generation.

The plant height at maturity, number of peduncles per plant, number of pods per plant, number of seeds per pod, average pod length, hundred seed weight and seed yield per plant were recorded from a randomly selected five plants from each progeny line in the F4 generation in PM, and from single plants of SSD and selected plants Modified Bulk method of the F4 generation.

The correlations of seed yield and yield attributed characteristics within the F4 generations were analyzed with Pearson correlation analysis using SPSS. Multiple regression analysis and stepwise multiple regression was carried out to find out find the most yield attributing characters with respect to both crosses and three breeding methods using SAS.

Results and Discussion

Correlation among yield and yield components

Phenotypic correlations among yield related characteristics in F4 generation are presented in Table 01. In F4 generation, significant positive correlation ($p \leq 0.01$) was recorded between seed yield per plant and peduncles per plant in both crosses in all three breeding methods. Seed yield per plant significantly positively correlated with pods per plant except in SSD in cross number 2. Siddique and Gupta, (1991) also recorded significant positive correlations between pods per plant with seed yield per plant.Patil and Shah, (1982) also recorded that grain yield per plant had significant positive correlation with number of branches, pods and clusters per plant. Except in SSD populations of two crosses and cross 02 in PM other populations of F4 generations were significantly positively correlated with seed yield per plant. Peduncles per plant showed positive correlation with plant height except cross 02 in PM and cross 01 in SSD. According to correlation analysis pods per plant, peduncles per plant and hundred seed weight were correlated characters with total seed yield per plant.

Kumar, (2007) described that correlation studies were helpful in formulating efficient breeding program for multiple trait selection. It measures the mutual relationship between various plant characters and provides reasonable indication for plant breeders for their selection on characters to improve economic yield and also for planning more efficient breeding program. Therefore findings of this study revealedthat pods per plant peduncles per plant and hundred seed weight can be used as selection criteria for yield in cowpea improvement.

Stepwise multiple linear regression

For two crosses of each breeding method fitted stepwise multiple regression models was significant at $p<0.001$ level (Table 02). According to the fitted linear models between seed yield per plant and other agronomic characters pods per plant was highly related with seed yield per plant by including all the fitted models for both crosses and for each breeding method. Hundred seed weight also related with the seed yield per plant by including 5 models out of six. Pod length has contributed for yield in three equations. Therefore pods per plant can be considered as the most contributing character for yield followed by hundred seed weight and pod length.

Conclusion

According to correlation analysis significant positive phenotypic correlations were recorded between the seed yield per plant and pods per plant, peduncle per plant and hundred seed weight. Stepwise multiple regressions also revealed that pods per plant, hundred seed weight and pod length as contributing factors for seed yield per plant.Four contributing characters were included in the equation derived for SSD method, cross 01 ($Y = -23.8995 + 1.142X_2 - 0.592 X_4 + 1.0513X_5 + 1.21X_6$).Therefore pods per plant, hundred seed weight and pod length could be effectively used as selection criteria for yield improvement in cowpea breeding.

Table 1: Correlation of characters in F4 of CP 19 x Waruni cross and CP 20 x CP22 cross

Character	Selection method	Cross	pod/ plant	Peduncles /plant	pod length (cm)	seeds/ pod	Hundred seed weight (g)	Seed yield per plant (g)
Plant height (x1)	PM	Cross 01	0.278*	0.319**	-0.142	-0.094	0.066	0.17
		Cross 02	0.076	-0.056	0.164	0.074	0.039	0.137
	SSD	Cross 01	.489*	0.273	-0.377	0.157	-0.054	.507*
		Cross 02	0.144	0.353*	0.22	0.458**	0.294	-0.007
	MB	Cross 01	0.152	.269**	0.131	.260*	-0.06	-0.034
		cross 02	0.33**	0.475**	0.189	0.179	0.291**	0.384**
Pod/Plant (x2)	PM	Cross 01		0.368	0.021*	0.23*	-0.046	0.745**
		Cross 02		0.724**	-0.142	0.111	-0.402**	0.611**
	SSD	Cross 01		.868**	-0.027	0.089	-0.145	.828**
		Cross 02		0.795**	0.186	0.455**	-0.137	0.519
	MB	Cross 01		.500**	-0.05	-0.119	-0.166	.612**
		cross 02		0.663**	0.061	0.098	0.182	0.817**
Peduncles/plant (x3)	PM	Cross 01			0.09	-0.026	0.039	0.344**
		Cross 02			0.069	0.417	-0.227*	0.379**
	SSD	Cross 01			0.306	-0.074	-0.212	.595**
		Cross 02			0.363*	0.442**	-0.006	0.488**
	MB	Cross 01			.219*	.433**	0.036	.376**
		cross 02			0.17	0.342**	0.192	0.555**
Pod length (x4)	PM	Cross 01				0.412**	0.001	0.232*
		Cross 02				0.529**	0.174	0.005
	SSD	Cross 01				-0.119	0.22	-0.234
		Cross 02				0.415*	0.196	0.262
	MB	Cross 01				.517**	-0.054	0.041
		cross 02				0.311**	0.009	0.296**
Seeds/pod (x5)	PM	Cross 01					0.213*	0.456**
		Cross 02					0.087	-0.065
	SSD	Cross 01					0.044	0.328
		Cross 02					0.165	0.228
	MB	Cross 01					0.006	-0.07
		cross 02					0.063	0.156
Hundred seed weight (x6)	PM	Cross 01						0.264*
		Cross 02						-0.062
	SSD	Cross 01						0.158
		Cross 02						0.064
	MB	Cross 01						.440**
		cross 02						0.406**

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

Table 2: Stepwise multiple regression equations with respect to seed yield per plant and other agronomic characters in f4 generation of two crosses

Breeding method	Cross	Stepwise multiple regression equation	R^2 (Adjusted)
PM	Cross 01	$Y = -14.62 + 0.8437X_2 + 0.4282X_4 + 0.559X_6$	0.7131
	Cross 02	$Y = -3.618 + 0.8189X_2 + 0.682X_6$	0.4127
SSD	Cross 01	$Y = -23.8995 + 1.142X_2 - 0.592X_4 + 1.0513X_5 + 1.21X_6$	0.8874
	Cross 02	$Y = 5.139 + 0.6801X_2$	0.2700
MB	Cross 01	$Y = -2.594 + 1.1517X_2 + 0.2692X_6$	0.6754
	cross 02	$Y = -18.95 + 1.118X_2 + 0.866X_4 + 0.7315X_6$	0.7969

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