A comparison between farmers' and breeders' Varietal Selection for Cowpea (*Vigna unguiculata* (L). Walp) Improvement

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ABSTRACT: *Farmer participatory selection of varieties in crop improvement is considered as an accelerating process in identifying adaptable varieties for farmer grown conditions. To compare the effectiveness of farmer participation in varietal selection with respect to selection at breeding stations, lines derived from two cowpea crosses CP 19 x Waruni and CP 20 x CP 22 at the Grain Legumes and Oil Crops Research and Development Center, Angunakolapellessa, using three breeding methods (pedigree, modified bulk and single seed descent) were evaluated in two Randomized Complete Block Designs during Yala 2013 and Maha 2013/14. Each trial included 30 lines which represented 10 best lines per breeding method and the parents of the cross. Same varietal composition was tested in three selected farmer fields with respect to each cross in RCBD with two replicates. At the maturity stage, evaluating of varieties of both trials of the research station was carried out by farmers and the breeders in two seasons. Farmer field trials were also evaluated following the same procedure by inviting the nearby cowpea cultivating farmers for each trial. Yields were also recorded in each farmer trial. Lines/method was found to be significant for all the characteristics studied at the research station trial for the cross CP 19 x Waruni while pod length, hundred seed weight and yield were significant for the lines in CP 20x CP 22 cross for both seasons. Mean sum of squares of seed per pod in both crosses were significantly different among three breeding methods but for other characteristics, methods were not significantly different. There was a significant difference among tested lines for farmer scores and breeder scores on the basis of Friedman test for each trial in both seasons at the research station. Except Sewanagala trial of CP19 x Waruni cross and Mahawewa trial of CP 20 x CP22 cross, lines tested in other trials at farmer fields were significantly different for farmer scores. According to adaptability testing there was a significant positive correlation with farmer ranks at farmer field level with ranking method and variance component method ranks. The correlation of breeders' ranks at the research station level with the adaptability ranks were comparatively lower than the farmer ranks at farmer field level. With respect to the four adaptability rankings, CP19 x Waruni cross has ranked five lines, S1-53, S1-35, B1-74, B1-64 and B1 - 39while CP 20 x CP22 cross ranked three lines B2-15, S2-64 and Waruni as the best. Since the top ranking lines mostly belonged to SSD and modified bulk breeding methods the two methods can be effectively used for the cowpea improvement. Further farmer participation in variety selection at their own field conditions will be much effective in testing of adaptabilities along with the proper analysis methods.*

Keywords*: Cowpea improvement, adaptability, farmer participation, targeted environments*

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INTRODUCTION

Cowpea (*Vigna unguiculata* (L). Walp) is cultivated in the rain-fed lands of dry zone of Sri Lanka. Though there are few recommended varieties by the Department of Agriculture, popularity of them among the conventional cowpea growing farmers was at considerably low level (Hewavitharana *et al.,* 2010; Millawithanachchi *et al.,* 2012). Development of farmer accepted varieties with better adaptability through proper breeding methodology is essential to fulfill the actual needs of the farmers in the rain-fed areas of Sri Lanka. In this sense, farmers' knowledge on selection of suitable varieties for their lands, climatic and other socioeconomic conditions should be considered in varietal improvement programs. Participatory Varietal Selection (PVS) has been reported as an efficient approach for introducing new improved varieties among the farmers (Witcombe *et al.*, 1996; Witcombe *et al.,* 2001). PVS could complement ongoing varietal development efforts in the region to help farmers by providing them with a wider option of germplasm to evaluate and adopt under their own conditions (Witcombe *et al.,* 1996, 2005).

According to Thapa *et al.,* 2009, PVS approach is a consultative process where scientists consult farmers about their problems and farmers provide quantitative feedback about varieties being evaluated. It is also a collaborative process where both scientists and farmers collaborate as partners in the research process. In PVS, farmers evaluate varieties under their own local practices of cultivation. (Witcombe *et al.,* 1996). However, since PVS methodology is still evolving, there could be variants to these PVS approaches depending upon local socio-economic conditions and the scope of the study.

The objective of this study was to compare the efficiency of participatory plant breeding (PPB), especially farmer participation with respect to formal breeder selection procedure of advanced breeding lines of cowpea, and to determine the adaptability levels of the breeding lines under farmer managed conditions and possibility of adapting PVS at farmer field levels. Hence selected advanced breeding lines of two elite cowpea crosses were evaluated in RCBD for two consecutive sessions *Yala* 2013 and *Maha* 2013/14 at the Grain Legumes and Oil Crops Research and Development Center at Angunukolapellessa and six trials were conducted at rain fed cowpea growing farmer fields of Thanamalwila and Sooriyawewa with the participatory evaluations at the maturity stage of the crop.

METHODOLOGY

Participatory approach in varietal selection was assessed with the participation of farmers and breeders under research station level at GLORDC and farmer selections were also compared at different farmer field conditions. Ten best performing lines of six separate progeny lines collections belonging to different breeding methods with respect to two cross were selected with participatory selection procedure at the maturity stage of F5 during *Maha* 2012/13. Two separate RCBD trials were conducted with three replicates per cross. These trials comprised 30 different lines belonging to three breeding methods (ten per each method), their respective parents and popular varieties as standards and, were conducted during *Yala* 2013 and repeated during *Maha* 2013/14 season (Millawithanachchi *et al.,* 2014).

Participatory evaluations of trials at the maturity stage

At the maturity stage of each trial at GLORDC in both *Yala* 2013 and *Maha* 2013/14 seasons, farmers were invited from cowpea cultivation areas of Thanamalwila and Sooriyawewa for participatory evaluations of the trials. Simultaneously technical staff of the GLORDC who are involved in plant breeding activities were also invited for the evaluation procedure. During the first season (*Yala* 2013) four colour cords (polythene bands) were used. Each variety was visually assessed by the two groups of participants. It was a voting system with 'like' and 'dislike' selection and, for the farmer evaluation pink colour band was tagged for 'like' and blue colour for 'dislike'. Breeders were given white colour for 'like' and yellow colour for 'dislike'. At the end of the voting all the bands received by a variety were counted separately.

Evaluations at farmer fields

Farmer field evaluations were carried out for each cross at three locations during *Maha* 2013/14 season. Each trial was a RCDB with two replicates with similar varietal combinations as at GLORDC. Farmer fields of Mahawewa and Sooriyaara of Thanamalwila Divisional Secretariat, Sewanagala of Sewanagala Divisional Secretariat and Bolhinda of Sooriyawewa Divisional Secretariat, all belonging to the DL1a agro-ecological region, were selected for the farmer field evaluation trials.

In each replicate one variety represented 3 m long 3 rows with 40 cm within row spacing. All the management practices were according to the farmer managed conditions. Minimal land preparation was done according to the farmers wish. At the maturity stage farmers were invited to the field and farmer participatory evaluation was carried out. A voting card system was followed. A white card was used to indicate the 'likeness' to the variety while yellow card was given for 'dislike'. Final yield of each variety was recorded at the end.

Data analysis

Comparison of breeding methods

Separate ANOVA for each trial was computed. Mean separation for each trait was done using DNMRT. Significance of mean sum of squares of breeding methods was tested using the mean sum of squares of lines within methods as the error term. Analysis of variance was carried out for each season for each trial and seasonal combined analysis also were undertaken. Yield of each farmer field trial also was analyzed separately for breeding method comparisons using similar ANOVA as research field trials.

Adaptability testing

Yield data were analyzed using both ranking method (Das, 1982) and variance component method for adaptability (Abeysiriwardena, 1991). Two separate adaptability tests were carried out for different trial combinations of two crosses. Data collected from three farmer fields and from GLORDC, Angunakolapellessa, were used for the analysis. In ranking method yield of individual varieties were analyzed separately for each location and the mean yields were ranked according to DNMRT. Mean rank of the ranks of individual locations and variance of ranks over locations were calculated. Finally, the adaptability rank was

computed based on mean rank and variance of ranks. Adaptability rank 01 was given to the lines with highest mean rank and lower rank variance.

For variance component method deviation from the location mean of individual variety was calculated. These deviations within locations were subjected to analysis of variance using SAS statistical package (version 9.2) and mean deviation over location was calculated. Number of positive deviations over locations, mean deviation over location and interaction variance between 'location x variety' were computed. Based on the above 3 parameters, adaptability ranks were calculated.

Participatory evaluations of crosses -Research fields

Data collected from the farmers' and breeders' selections were analyzed using non parametric analysis techniques. For each line in both RCBD trials at research station, negative votes and positive votes were counted separately for farmer response and for breeder responses. Score received was taken by subtracting positive votes from negative votes. Friedman test was used to analyze the score received for each variety for both farmer preferences and breeder preferences using statistical software SPSS 16.0. Preference data for farmer field trial also were analyzed using similar procedure (Virk and Witcombe, 2004). Wilcoxon Sign Rank Test was used to compare breeders' ranks and farmers' ranks by using mean ranks of Friedman test (Thapa *et al*., 2009; Clewer and Scarisbrick, 2001). Based on the median of mean rank of the Friedman test, lines were ranked separately for the preference of breeders and farmers and these ranks were compared with the adaptability ranks (ranks of ranking method and variance component method) using Spearman correlation test.

RESULTS AND DISCUSSION

Mean sums of squares resulted from combined analysis of variance for seasons, breeding methods, lines/methods and cv% for yield and yield related characteristics of crosses 1 and 2 are presented in Table 01. Lines/within method component was found to be significant for all mentioned characteristics except for plant height and seed per pod in cross2. Breeding methods were not significant when tested against lines/methods except for seed per pod in both crosses (significant at $p \leq 0.05$).

Table 1. Seasonal combine ANOVA results of yield and yield related characteristics of crosses 1 and 2 with respect to three breeding methods for *Yala* 2013 and *Maha* 2013/14 seasons.

Characteristic	Cross	MS for season	MS for rep/season	Ms Method	MS for lines/method	MS lines*season	CV%
plant height (cm)	cross 1	119547**	876.31**	329.6	710.15**	274.15	21.86
	cross2	21330.2**	800.39**	67.87	217.89	240.02	24.67
Pod length (cm)	cross 1	39.9**	3.74*	15.1	10.26**	0.88	8.36
	cross2	2.77	0.58	1.13	4.8**	1.45	7.16
seeds per pod	Cross1	103.12**	6.87*	29.14*	5.78**	3.76	12.28
	Cross2	11.36*	1.95	9.67*	2.49	2.43	9.5
Hundred seed weight (g)	Cross1	0.2	0.91	4.22	16.05**	1.5	9.62
	Cross2	1.05	1.181	0.25	18.13**	1.74	9.67
yield kg/ha	Cross1	525667120**	916981.8**	1769565.6	362441.5*	1821198.6	32.75
	Cross2	31294832**	337437.2**	164826.4	270632.7**	60797.2	23.29

Ms= Mean sums of square ** significant at p ≤0.01 *significant at p ≤0.05

Adaptability testing

According to analysis of variance for individual locations, there were significant differences among tested lines in all the locations for respective trials of two crosses which were located at GLORDC, Mahawewa, Sooriyaara, Sewanagala and Sooriyawewa. The parameters and ranks derived from ranking method and variance component method of respective two crosses are presented in table 02 and 03.

In ranking method based on the highest mean rank and lowest variance of ranks, adaptability ranks were given starting from 01 (Das, 1982). Adaptability ranks of variance component method was based on average yield of each variety over the locations, number of positive deviations out of four locations, mean deviations over locations and interaction variance of deviations. Better ranks were received by the varieties with non-significant interaction variance along with higher average yield, number of positive deviations and mean deviations (Abeysiriwardena *et al.,* 1991).

According to the two adaptability evaluation methods there were slight variations in the ranking of the varieties since variance component method ranks were derived based on the significance of interaction variances which lack in ranking method led to give different ranks for the same variety. The highest mean rank of ranking method is not associated with the lowest variance score and vice versa. According to Abeysiriwardena, *et al.* (1991) relative ranking method can be used to identify any genotype with significantly superior yield in all environments. This method required more replications in each environment for comparison and consequently was less informative due to lack of useful stability parameters. Therefore, in the comparison study of farmer ranking with adaptability ranks both methods were used. In the varietal evaluations of cross 01, line S1 35 was ranked 01 for ranking method while the same line received rank 04 in variance component method due to the significant interaction variance.

Table 2. Adaptability parameters and ranks derived from ranking method and variance component method of tested lines and the breeders' ranks and famers' rank based on the median of mean ranks of Friedman test of cross 01 tested at GLORDC and farmer fields

	Ranking method				Variance component method						
Variety	**RV**	**AR**	**AY t/ha**	**Rank**	**MD**	**NoPD**	**VoMD**	**Fcal**	**Rank**	**BR**	**FR**
P1-28-1-4	1.7	29.4	1.49	12	0.0855	2	0.071	0.9	13	14	15
P1-66-1-3	2.1	28.9	1.47	13	0.0904	3	0.051	0.65	14	16	19
P1-16-1	5.2	29.4	1.56	8	0.1933	3	0.058	0.74	7	23	18
P1-56-1-3	5.1	28.9	1.65	6	0.2849	2	0.415	5.27**	5	12	4
P1-26-3-3	5.6	27.1	1.07	30	-0.2889	1	0.07	0.89	30	26	32
P1-52-2-3	2.8	28.3	1.27	23	-0.0909	0	0.01	0.13	22	18	3
P1-39-1-5	3.9	28.9	1.28	22	-0.0867	1	0.083	1.06	21	27	29
P1-28-3	7	27.5	1.11	28	-0.2842	2	0.099	1.26	28	32	27
P1-32-4-3	6.6	27.6	1.24	25	-0.1253	2	0.063	0.8	23	21	16
P1-11-3-3	3.8	27.8	1.09	29	-0.279	1	0.138	1.75	29	30	31
S1 45	5.7	28	1.31	17	-0.0519	2	0.095	1.21	16	25	17
S1 53	4.9	29.3	1.74	4	0.3745	3	0.243	3.09**	3	9	2
S1 4-2	6.6	27.6	1.31	18	-0.0299	1	0.21	2.67**	18	28	30
S1 8	2.5	29	1.32	15	-0.0892	1	0.091	1.16	20	22	26
S1 55	2.2	28.1	1.13	26	-0.2342	2	0.143	1.81	26	19	12
S1 31	3.2	28.4	1.23	24	-0.1332	1	0.049	0.63	24	11	13
S1 37	2.2	28.5	1.29	19	-0.0699	1	0.021	0.26	19	29	22
S1 35	0.8	30.8	1.61	1	0.2516	3	0.298	3.79**	4	4	1
S1 5	3.8	20	1.58	7	0.0964	3	0.338	4.29**	12	13	10
B1 59	6.3	21	1.12	27	-0.2395	1	0.054	0.68	27	15	23
B1 27	6.1	22	1.3	20	-0.0632	2	0.068	0.86	17	7	20
B1 39	4.2	23	1.52	10	0.1524	3	0.063	0.8	9	10	6
B1 98	1.1	24	1.58	5	0.2174	3	0.044	0.55	6	17	8
B1 87	3.2	25	1.29	21	-0.1704	2	0.38	4.84**	25	8	25
B1 69	3.4	26	1.32	16	-0.0407	1	0.036	0.46	15	2	9
B1 03	3.2	27	1.52	9	0.1554	3	0.04	0.51	8	20	11
B1 91	1.7	28	1.06	31	-0.3782	2	0.393	5.00**	32	31	28
B1 74	2.9	29	1.71	3	0.304	3	0.127	1.62	2	5	7
B1 64	4.2	30	1.9	2	0.466	4	0.12	1.52	1	3	5
Bombay	6.3	31	1.07	32	-0.253	2	0.362	4.61**	31	6	24
Waruni	2.1	32	1.46	14	0.0993	3	0.07	0.9	11	1	21
CP 19	10.7	34	1.55	11	0.1729	3	0.295	3.75**	10	24	14

RV – Rank variance; AR- Average rank; AY- Average yield; MD – mean deviation; NoPD –No of positive deviations; VoMD Variance of mean deviations BR – breeders rank; FR- Farmers rank
P= Pedigree method, S= Single Seed Decent method, B=modified bulk method
** Significant at p ≤0.01

Table 3. Adaptability parameters and ranks derived from ranking method and variance component method of tested lines and the breeders' ranks and famers' rank based on the median of mean ranks of Friedman test of cross 02 tested at GLORDC and farmer fields

	Ranking method				Variance component method						
Variety	**RV**	**AR**	**AY t/ha**	**Rank**	**MD**	**NoPD**	**VoMD**	**Fcal**	**Rank**	**BR**	**FR**
B2 85	0.4	30.4	1.1	19	-0.05	1	0.02	0.59	20	11	14
B2 58	2.92	29.8	1	25	-0.11	2	0.11	2.81**	27	26	17
B2 42	1.56	30.1	1.1	15	0.05	3	0	0.09	11	1	7
B2 82	1.56	30.9	1.3	5	0.22	4	0.03	0.85	3	9	18
B2 44	6.08	30.3	1	26	-0.19	2	0.25	6.52**	25	20	15
B2 60	0.08	30.8	1.2	7	0.14	4	0.01	0.27	8	15	12
B2 40	4.56	28.9	0.8	33	-0.3	0	0.03	0.9	32	24	33
B2 15	0.56	32.1	1.6	1	0.56	4	0.14	3.73**	5	5	2
B2 29-2	8.06	30.1	1.2	18	0.04	2	0.15	3.85**	12	19	10
B2 81	1.06	30.4	1.2	11	0.08	3	0.03	0.84	10	13	9
S2 50	1	31	1.2	10	0.01	2	0.1	2.609**	14	22	22
S2 37	1.42	30.8	1.3	9	0.15	4	0.03	0.71	7	30	23
S2 66	2.73	29.6	1	22	-0.09	2	0.03	0.86	22	2	13
S2 64	0.83	31.5	1.4	2	0.34	4	0.02	0.5	1	4	3
S2 62	0.33	31	1.2	8	0.12	4	0	0.08	9	12	6
S2 21	3.73	29.4	0.9	27	-0.15	1	0.02	0.57	26	28	31
S2 24	4.25	28.8	0.9	32	-0.19	0	0.01	0.18	30	3	4
S2 40	0.75	30.3	1.1	14	0.01	1	0.01	0.35	15	7	21
S2 11	0.73	30.9	1.1	13	0	2	0.12	3.01**	17	18	11
S2 28	1.23	29.9	1.1	16	-0.01	1	0.02	0.47	18	33	25
P2 -4-1	4.9	28.9	0.9	29	-0.18	0	0.01	0.34	28	14	26
P2 – 26-2	4.08	31.3	1.4	6	0.25	3	0.06	1.64	4	6	16
P2 - 35- 1	1.67	29	0.8	30	-0.26	0	0.02	0.43	31	31	32
P2 – 4 – 2	2	29	0.7	31	-0.35	1	0.13	3.315**	33	16	27
P2- 26-1	0.25	30.8	1.1	12	0	2	0.03	0.84	16	25	19
P2-24-3	1.17	31	1.3	4	0.23	4	0.02	0.62	2	23	8
P2-19-2-2	3.17	29.5	1.1	23	-0.02	1	0.02	0.63	19	10	5
P2-9-1	2.92	29.8	1.1	17	0.03	4	0.03	0.82	13	29	28
P2-42-1	0.25	30.3	1	20	-0.1	2	0.06	1.61	21	17	29
Bombay	3.42	29.3	1	24	-0.11	1	0.03	0.84	24	21	24
CP 22	1.23	29.9	1	21	-0.06	2	0.09	2.32**	23	32	20
Waruni	2.06	31.1	1.4	3	0.38	4	0.13	3.34**	6	8	1
CP 20	5.67	29	0.9	28	-0.18	1	0.05	1.34	29	27	30

RV – Rank variance; AR- Average rank; AY- Average yield; MD – mean deviation; NoPD –No of positive deviations;VoMD Variance of mean deviations BR – breeders rank; FR- Farmers rank
P= Pedigree method, S= Single Seed Decent method, B=modified bulk method
** Significant at $p \leq 0.01$

Evaluation of farmer and breeder scores

Results of individual analysis of lines against the farmer scores for each farmer field trial and GLORDC trials of the two crosses are presented in table 04 and 05. According to Friedman test, except farmer field trial at Sevenagala for cross 01 and Mahawewa trial of Cross 02, the other location trials were significantly different among tested lines for farmer scoring. The tested lines also were significantly different for breeder scores for both seasons at GLORDC trials table 04 and 05. Virk and Witcombe (2004) described that the use of Friedman test as an alternative non parametric technique for evaluating farmer scores in replicated trials. Willcoxon Sign Rank Test was used to compare each pair of farmer trials with research station trials and, the Friedman test for the research station trials of two seasons (Thapa *et al*., 2009; Clewer and Scarisbrick, 2001). It was revealed that there were no significant differences in any pair of comparison at $p<0.05$ level. Spearman correlation (r) between the farmer score and breeder for season 01 for cross 01 and cross 02 were 0.781 and 0.679 and for the second season 0.828 and 0.81443 respectively at $p< 0.01$ probability level. These results were provided evidence for the effectiveness of farmer participation also comparable with the breeders' selection.

Further, average of mean ranks of Friedman test of farmers scores was used to give an overall rank for farmer selection and same procedure was followed for breeder scores also (table 04 and 05). Five lines (S1-53, S1-35, B1-74, B1-64 and B1 -39) received ranks less than ten from four methods used in cross one. Three lines ranked less than ten by all the four methods (B2-15, S2-64 and Waruni) in cross 02. Further Spearman correlation between different ranks revealed that the farmer rank correlation with ranking method ranks ($r=0.714$), with variance component method ranks ($r=0.732$) and breeder ranks ($r=0.586$) significant at $p< 0.01$ probability. Further breeder rank was correlated with ranking method ranks ($r=0.462$), with variance component method ranks ($r=0.479$) significant at $p< 0.01$ probability in cross 01. In cross 02 farmer ranks were correlated with ranking method ranks ($r=0.561$) with variance component method ranks ($r=0.583$) and breeder ranks ($r=0.672$) significant at $p< 0.01$ probability. The breeder rank correlation was not significant with ranking method ranks ($r=0.307$), and its correlation with variance component method ranks was $r=0.347$ and was significant at $p< 0.05$. This was evident that the farmers' ranks from farmer fields were more related to adaptability ranks derived from ranking and variance component method than the breeders ranks at the research fields levels. Therefore, farmer participation in variety selection at their own field conditions will be much effective in testing of adaptabilities along with the proper analysis methods.

Table 4. Mean ranks of Friedman test received by individual line in individual farmer locations and GLORDC trials for cross 01

Variety	SA	MW	SEW	FS2 GLORDC	MoMR(F)	FR	RCBD1 S1B	RCBD1 S2B	MoMR (B)	BR
P1-28-1-4	13.5	21.5	14	23.17	17.8	15	18.7	19	18.8	14
P1-66-1-3	6	17.75	14	18.33	15.9	19	17.3	18.33	17.8	16
P1-16-1	14.5	23	19	13.17	16.8	18	20.3	7	13.7	23
P1-56-1-3	24	23	13.75	23	23.0	4	22.2	17.67	19.9	12
P1-26-3-3	1.75	3.25	26.5	7	5.1	32	13	11.5	12.3	26
P1-52-2-3	29	8.75	24.25	22.5	23.4	3	12.7	22.17	17.4	18
P1-39-1-5	12	5	14	7.5	9.8	29	7.83	13.17	10.5	27
P1-28-3	4.25	15.25	19.25	6.5	10.9	27	7.5	5.33	6.4	32
P1-32-4-3	1.75	25.5	26.5	8.83	17.2	16	26.7	6.5	16.6	21
P1-11-3-3	11.25	18	3.75	4.67	8.0	31	6.67	7.83	7.3	30
S1 45	24.75	9.25	21.25	12.33	16.8	17	12.2	13	12.6	25
S1 53	14.5	28.5	24.5	22.5	23.5	2	29.7	16	22.8	9
S1 4-2	9	4.25	13.75	10	9.5	30	10.7	7.67	9.2	28
S1 8	7.25	15.25	28	9.17	12.2	26	16	13.83	14.9	22
S1 55	24	7.75	21.25	16	18.6	12	12.3	21.83	17.1	19
S1 31	20.75	5.5	29.5	15.83	18.3	13	20.3	21.33	20.8	11
S1 37	14	15.5	27.5	9.83	14.8	22	9.83	7.83	8.8	29
S1 35	30.25	21.5	9.75	27.17	24.3	1	24.5	28.33	26.4	4
S1 5	17.5	24	9.5	25.83	20.8	10	16.2	23.33	19.8	13
B1 59	13	16	9.5	18.83	14.5	23	18.8	18.5	18.7	15
B1 27	16.5	20.25	14.25	14	15.4	20	32	16	24.0	7
B1 39	25.25	23	2.5	22.33	22.7	6	20.3	24	22.2	10
B1 98	26	24.75	18	16.17	21.4	8	16.8	18.5	17.7	17
B1 87	15.75	9.5	11.5	17.17	13.6	25	24.5	21.5	23.0	8
B1 69	23	21.75	14	21	21.4	9	31.3	23.5	27.4	2
B1 03	17.5	27.5	7.25	24	20.8	11	10.7	23.33	17.0	20
B1 91	9	4	24.25	11.5	10.3	28	5.33	8.67	7.0	31
B1 74	23.25	20	13.75	31.17	21.6	7	26	26.67	26.3	5
B1 64	20.5	27.25	13.75	25.33	22.9	5	26.5	28	27.3	3
Bombay	13.75	6.75	13.75	.	13.8	24	26.2	.	26.2	6
Waruni	29.75	18.75	5.25	12	15.4	21	34	26	30.0	1
CP 19	14.75	16	20.25	28.83	18.1	14	19.3	7.67	13.5	24
$\chi 2$	45.48	43.32	40.18	62.43			64.02	57.87		
probability	0.045	0.07	0.125	0.01			0.01	0.02		

SA- sooriyaara; MW-Mahawewa; SEW – Sewanagala, F(S2)GLORDC farmer mean rank at GLORDC trial, MoMR(F) Median of mean ranks of farmers;FR- farmer rank; RCBD1S1B – breeder mean rank at season 01; RCBD1S2B – breeder mean rank at season 02; MoMR (B)– Median of mean ranks of breeders; BR- breeder rank

Table 5. Mean ranks of Friedman test received by individual line in individual farmer locations and GLORDC trials for cross 02 and final farmer and breeder ranks

Lines	SA	MW	SOW	F(S2) GLORDC	MoMR (F)	FR	RCBD2 S1B	RCBD2 S2B	MoMR (B)	BR
B2 85	25.5	15	8	24.83	19.9	14	10.33	30.67	20.5	11
B2 58	16.75	4.25	28.25	22	19.4	17	3.33	22	12.7	26
B2 42	16	27.5	24.25	21.33	22.8	7	30	26.33	28.2	1
B2 82	12.25	13	24.25	28	18.6	18	19.33	25.83	22.6	9
B2 44	23.75	12.5	21	18.5	19.8	15	11.5	20.67	16.1	20
B2 60	7.5	27.5	18.25	23.17	20.7	12	17.83	20	18.9	15
B2 40	6	7	3.25	5	5.5	33	20.5	6.17	13.3	24
B2 15	22	30.25	25.25	32.33	27.8	2	17.5	34	25.8	5
B2 29-2	1.75	32	23.25	20.33	21.8	10	15.5	19.5	17.5	19
B2 81	27.25	13.5	28.25	17.83	22.5	9	24.5	15.33	19.9	13
S2 50	13	15.75	23	14.33	15.0	22	23.17	6.33	14.8	22
S2 37	13.5	16.5	21.25	10.5	15.0	23	6.83	13.17	10.0	30
S2 66	28.25	7.75	12.75	31.5	20.5	13	24.67	30.33	27.5	2
S2 64	28.25	26	24.25	23.67	25.1	3	29.17	23.5	26.3	4
S2 62	26	22.25	15.5	23.5	22.9	6	19.17	21.33	20.3	12
S2 21	3.25	8.5	2.25	9.67	5.9	31	9.33	14.17	11.8	28
S2 24	13.75	26.25	26.5	20.83	23.5	4	32.67	20.83	26.8	3
S2 40	11.75	19.5	10.75	27.17	15.6	21	19.83	26.67	23.3	7
S2 11	31.5	7.75	24.25	17.33	20.8	11	21	15	18.0	18
S2 28	14.25	14	2.25	12.5	13.3	25	5.33	8.33	6.8	33
P2 -4-1	16.75	11.5	9.75	7.5	10.6	26	28.33	10.83	19.6	14
P2 – 26-2	28.25	12	13	25.83	19.4	16	21	29.83	25.4	6
P2 - 35- 1	6.5	5.25	8.5	2.5	5.9	32	12.67	5	8.8	31
P2 – 4 - 2	5	14.75	9.5	11.17	10.3	27	20.33	17.33	18.8	16
P2- 26-1	18	19	24.5	5.33	18.5	19	18.67	6.67	12.7	25
P2-24-3	20.75	24.5	13	25.67	22.6	8	10.33	19	14.7	23
P2-19-2-2	22	24.75	14.5	25.5	23.4	5	11.33	31.83	21.6	10
P2-9-1	19.25	14	5.5	6	10.0	28	12.17	10.33	11.3	29
P2-42-1	12.75	5.75	24.5	7	9.9	29	25.67	10.83	18.3	17
Bombay	18.5	30.5	10.75	9.17	14.6	24	18	12.17	15.1	21
CP 22	15.75	17.25	24.5	18.33	17.8	20	9	5.33	7.2	32
Waruni	27.25	17.5	31.75	28.33	27.8	1	20.5	25.83	23.2	8
CP 20	8	7.5	4.5	9	7.8	30	17.83	7.17	12.5	27
$\chi 2$	46.586	42.352	52.371	74.84			52.84	74.92		

SA- sooriyaara; MW Mahawewa; SOW – Sooriyawewa, F(S2)GLORDC farmer mean rank at GLORDC trial season 02, MoMR(F) Median of mean ranks of farmers;FR- farmer rank; RCBD2S1B – breeder mean rank at season 01; RCBD2S2B – breeder mean rank at season 02; MoMR (B)– Median of mean ranks of breeders; BR- breeder rank

CONCLUSIONS

Pedigree, single seed descent and modified bulk breeding methods were found to be similar in performance, yet SSD and modified bulk breeding methods have produced top rankers in adaptability testing. Therefore, SSD and modified bulk methods can be effectively used for developing adaptable cowpea varieties. Farmer ranks for the farmer field evaluations were significantly and positively correlated with ranks of ranking method and variance component method. Therefore, farmer participation in variety selection at their own field conditions will be much effective in testing of adaptabilities along with the proper analysis methods.

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