Similar results have also been reported by Katiyar *et al.*(1977) and Govil (1980). The pods per plant showed positive and significant genotypic correlation with days to maturity and grain yield per plant indicated that late varieties will bear more number of pods per plant with more yield. However, the days to maturity showed significant negative correlation with thousand grain weight.

The grain yield per plant showed significant positive correlation with the plant height. The plant height did not show significant phenotypic correlation with any of the characters under study except the grain yield per plant. The pods per plant had negative correlation with 1000 grain weight , Chand *et al.* (1975) also reported that pod number per plant was negatively correlated with hundred grain weight.

The most of the environmental correlation coefficients were having negative values. However, the grain yield per plant had significant and positive environmental correlation with days to flower and days to maturity. The plant height also had significant positive correlation with days to flower. It may finally be concluded that for selecting high yielding genotypes, the selection based on pods per plant, plant height and 1000 grain weight would be more useful.

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HETEROSIS AND COMBINING ABILITY IN FODDER COWPEA FOR GREEN FODDER AND SEED YIELD

S.ARAVINDHAN AND L.D. VIJENDRA DAS

Department of Agricultural Botany
Agricultural College and Research Institute,
Tamil Nadu Agricultural University
Killikulam, Vallanad 627 252

ABSTRACT

Forty-two crosses of cowpea derived from 14 lines and 3 testers were utilised for heterosis and combing ability studies for green fodder as well as grain yield and yield components. Scope for exploitation of heterosis in cowpea was indicated with the materials studied. The highest heterotic expression for green fodder yield was recorded by the hybrid UPC 9201 x CO 5 (121.01 per cent) over the standard parent CO 5. The hybrid CS 55 x CO 4 recorded the maximum heterotic effect (215.34 per cent) over the standard parent for seed yield. The GCA:SCA variance ratio for all the traits showed predominance of SCA variance over GCA variance indicating predominance of non-additive gene action. Among the parents, the lines UPC 9103 and UPC 9201 and the tester CO 5 were found to be the best combiners. Selection of hybrids based on *per se* performance, *sca* effects and heterotic effects will be effective

KEY WORDS : Fodder Cowpea, Yield, Heterosis, Combining Ability

Table 1. Heterotic response for different characters in 42 crosses of cowpea

Characters	Heterotic response (%)								
	Relative heterosis (di)			Heterobeltiosis (dii)			Standard heterosis (diii)		
	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
Leaf area index	-51.38	178.05	63.34	-67.54	120.72	26.59	-59.38	120.72	30.67
Specific leaf weight (mg.cm^{-2})	-23.42	77.21	26.90	-24.22	60.98	18.38	-7.67	97.08	44.71
Green fodder yield (g)	-50.17	178.34	64.09	-58.02	129.32	35.65	-50.90	121.01	35.06
Drymatter yield (g)	-50.18	178.34	64.08	-58.02	137.08	39.53	-50.91	137.08	43.09
Leafstem ratio	-30.41	82.52	26.06	-45.33	22.52	-11.41	-55.57	22.52	-16.53
Crude protein content (%)	-11.35	44.66	16.66	-22.74	33.68	5.47	-28.17	57.63	14.73
Seed yield (g)	-24.76	93.04	34.14	-38.36	69.54	15.59	-38.36	215.34	88.49
Total drymatter production (g)	-21.26	76.44	27.59	-34.77	66.96	16.10	-32.67	125.80	46.57

di = Mid parent heterosis; dii = Better parent heterosis; diii = Standard parent heterosis

Information on the magnitude of hybrid vigour should be known by the breeder for the development of hybrids in any crop. Although cowpea *(Vigna unguiculata*(L.) Walp. is highly an autogamous plant with a strict restriction for the heterosis breeding, the knowledge on the extent of heterosis could help in the choice of best crosses for selection of elite segregants in the later generations. Combining ability analysis provides the necessary information on the nature of gene action governing a character and also helps in identification of superior parents and crosses. In the present investigation, an attempt has been made to assess heterosis and combining ability estimates for green fodder and seed yield components in cowpea.

MATERIALS AND METHODS

Experimental material for the study comprised of 42 crosses derived from 14 lines of fodder cowpea *viz.,* IFC 9201, UPC 9203, UPC 9202, UPC 9201, CS 55,UPC 9103, CS 82, UPC 287, RFC 84-2, IFC 901, CS 91, RFC 8903, CL 324 and CS 98 three testers viz., CO 4, CO 5 and C 152. Crosses were grown along with their parents in randomised block design with three replications at the Agricultural College and Research Institute,

Table 2. Best hybrids based on *per se* performance, *sca* effects and heterotic effects

Character	*Per se* performance	*Sca* effects	Relative heterosis (di) (%)	Heterobeltiosis (dii) (%)	Standard heterosis (diii) (%)
Leaf area index	UPC 9201 x CO 5 (7.13)	UPC 9103 x CO 5 (2.15)	UPC 9201 x CO 5 (178.05)	UPC 9201 x CO 5 (120.72)	UPC 9201 x CO 5 (120.72)
Specific leaf weight (mg.cm^{-2})	UPC 9201 x CO 5 (6.76)	UPC 9201 x CO 5 (1.60)	UPC 9201 x CO 5 (77.21)	UPC 9201 x CO 5 (60.98)	UPC 9201 x CO 5 (97.08)
Green fodder yield (g)	UPC 9103 x CO 5 (296.13)	UPC 9103 x CO 5 (111.42)	UPC 9201 x CO 5 (178.34)	UPC 9103 x CO 5 (129.32)	UPC 9201 x CO 5 (121.01)
Drymatter yield (g)	UPC 9103 x CO 5 (36.74)	UPC 9103 x CO 5 (14.15)	UPC 9201 x CO 5 (178.34)	UPC 9103 x CO 5 (137.08)	UPC 9103 x CO 5 (137.08)
Leafstem ratio	UPC 9201 x CO 5 (3.88)	UPC 9201 x CO 5 (0.68)	UPC 9203 x C 152 (82.52)	UPC 9201 x CO 5 (22.52)	UPC 9201 x CO 5 (22.52)
Crude protein content (%)	CS 55 x CO 5 (31.53)	CS 55 x CO 5 (3.34)	CS 55 x CO 5 (44.66)	CS 55 x CO 5 (33.66)	CS 55 x CO 5 (57.63)
Seed yield (g)	CS 55 x CO 4 (44.05)	CS 55 x CO 4 (11.73)	CS 55 x CO 4 (93.04)	CS 55 x CO 4 (69.54)	CS 55 x CO 4 (215.34)
Total drymatter production (g)	CS 55 x CO 4 (77.82)	CS 55 x CO 4 (18.82)	UPC 9201 x CO 5 (76.44)	UPC 9201 x CO 5 (66.96)	CS 55 x CO 4 (125.80)

di = Mid parent heterosis; dii = Better parent heterosis; diii = Standard parent heterosis

Table 3. Analysis of variance for combining ability and magnitude of GCA and SCA variances

Character	Mean sum of squares			Magnitude of GCA and SCA variances		
	Lines (df = 13)	Testers (df = 2)	Lines x Testers (df = 26)	GCA variance (σ^2 GCA)	SCA variance (σ^2 SCA)	$\frac{\sigma^2 GCA}{\sigma^2 SCA}$
Leaf area index	8.00**	7.76**	4.29**	0.01	2.11	0.0087
Specific leaf weight (mg.cm^{-2})	1.84*	1.83	1.89*	-0.0003	0.61	-0.0005
Green fodder yield (g)	12446.20**	14032.37**	7623.83**	25.04	3632.67	0.0069
Drymatter yield (g)	179.31**	206.10**	114.40**	0.34	53.38	0.0064
Leafstem ratio	1.50*	4.05*	0.31	0.01	0.60	0.0126
Crude protein content (%)	106.47**	85.59**	3.70**	0.49	18.94	0.0263
Seed yield (g)	285.94**	334.33**	37.02**	1.27	65.65	0.0194
Total drymatter production (g)	782.49**	438.00**	168.88**	2.47	131.01	0.0189

* Significant at 5 per cent level; ** Significant at 1 per cent level

Killikulam during summer 1993 under irrigation. Each genotype was sown in three rows of 4m length and a spacing of 45 x 20 cm was adopted. Leaving two border rows, five plants from the middle one was taken for eight quantitative observations *viz.*, leaf area index, specific leaf weight, green fodder yield, drymatter yield, leaf stem ratio, crude protein content, seed yield and total drymatter production. For seed yield, another five plants were selected separately at random in the same row. Crude protein content was determined following micro kjeldahl N method (Humphries, 1956). Mean data were used for combining ability analysis following Kempthorne (1957) model. Expression of heterosis was assessed in terms of deviations of mean F_1 from mid parent, better parent and standard parental (CO 5) values.

RESULTS AND DISCUSSION

Data on heterotic response for yield and yield components in 42 crosses are presented in Table 1. Average mid and better parent heterosis were maximum for green fodder yield, drymatter yield and leaf area index (64.09%, 64.08% and 63.34%). Similar results were also reported by Kohli (1990), Sanghi and Kandalkar (1991) and Sahoo *et al* (1990), for the above traits. Average heterosis for leaf stem ratio over better and standard parents were negative (-11.41%, -16.53%). Heterotic studies revealed that the hybrids UPC 9201 x CO 5 and UPC 9103 x CO 5 were superior for green fodder and dry matter yield, the hybrid CS 55 x CO 5 for crude protein content and the hybrid CS 55 x CO 4 for seed yield (Table 2).

The relative estimates of variances due to general and specific combining ability are presented in Table 3. The analysis of variance showed significant differences among the genotypes for all the characters. The relative estimates of GCA and SCA variances indicated that variances due to *sca* effects were predominant for all the characters studies and in turn it indicated the predominance of non-additive gene action control on all the traits. Similar results were reported by Hebbal (1985).

In the present study (Table 4), there are lines and testers with high *per se* performance showed the highest significant *sca* effects. The line UPC 287 for leaf area index (1.44), specific leaf weight (0.49), green fodder yield (59.23) and drymatter yield (7.08); IFC 9201 for leaf stem ratio(0.61), CS 55 for crude protein content (6.51), seed yield (11.69) and total drymatter production (14.54). The tester CO 5 for leaf area index (0.36), drymatter yield (1.83), leaf stem ratio (0.35) and crude protein content (1.65) and the tester CO 4 for seed yield (3.09) and total drymatter production (3.45) showed the highest *per se* performance and the highest *gca* effects. These findings are in close agreement with Dasgupta and Das (1991) who reported that *per se* performance of parents helps to provide a good indication of their combingability. Therefore, parents identified for high *per se* performance and *gca* effects could be included in

Table 4. Best parents selected based on high *per se* performance and *gca* effects

Character	*Per se* performance		*gca* effects	
	Lines	Testers	Lines	Testers
Leaf area index	CS 55, UPC 287 (6.30) (5.66)	CO 5, C 152 (3.23) (4.04)	UPC 287, RFC 84-2 (1.44) (1.01)	CO 5, CO 4 (0.36) (0.10)
Specific leaf weight ($mg.cm^{-2}$)	UPC 9203, UPC 287 (5.21) (4.36)	CO 4, C 152 (3.61) (4.29)	CS 91, UPC 287 (0.70) (0.49)	CO 5 (0.22)
Green fodder yield (g)	CS 55, UPC 287 (252.06) (226.53)	CO 4, C 152 (123.93) (161.86)	UPC 287, RFC 84-2 (59.23) (39.35)	CO 4, CO 5 (4.09) (15.88)
Drymatter yield (g)	CS 55, UPC 287 (30.24) (27.18)	C 152, CO 5 (19.42) (15.49)	UPC 287, RFC 84-2 (7.08) (4.70)	CO 5, CO 4 (1.93) (0.48)
Leafstem ratio	IFC 9201, CS 55 (3.26) (3.19)	CO 5, CO 4 (3.16) (3.07)	IFC 9201, CS 82 (0.61) (0.33)	CO 5 (0.35)
Crude protein content (%)	CS 55, UPC 9103 (23.59) (20.36)	CO 5, CO 4 (20.00) (18.60)	CS 55, IFC 901 (6.51) (4.45)	CO 5 (1.65)
Seed yield (g)	CS 55, CS 82 (25.98) (23.67)	CO 4 (19.65)	CS 55, CS 82 (11.69) (5.73)	CO 4 (3.09)
Total drymatter production (g)	CS 55, CS 82 (61.23) (54.07)	CO 4, C 152 (39.40) (38.29)	CS 55, UPC 287 (14.54) (11.09)	CO 4 (3.45)

the hybridization programme for the improvement of respective traits.

In the present study, the crosses UPC 9103 x CO 5 (leaf area index, green fodder yield and drymatter yield), UPC 9201 x CO 5 (specific leaf weight and leaf stem ratio) CS 55 x CO 4 (seed yield and total drymatter production) having high *sca* effects involving at least one parent with high *gca* effect (Tables 2 and 4). These results are in accordance with Dasgupta and Das (1991) who reported the crosses that involved at least one parent with high *gca* effect would be the best and ideal for selection and these crosses were expected to produce segregants of fixable nature is segregating generations following simple pedigree method.

In the present study there was a fair agreement between *sca* effects, *per se* performance and heterosis (Table 2.) The cross combinations, UPC 9201 x CO 5 (specific leaf weight and leaf stem ratio,) UPC 9103 x CO 5 (drymatter yield), CS 55 x CO 5 (crude protein content) and CS 55 x CO 4 (seed yield and total dry matter production) were found to be superior in *per se* performance, *sca* effects and standard heterotic response. These results indicated that selection based on *sca* effects alone may not always lead to correct choice of hybrid combinations and hence selection based on high *per se* performance, *sca* effects and heterotic effects will be a valuable one.

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