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GENE ACTION AND COMBINING ABILITY FOR FODDER YIELD AND ITS CONTRIBUTING TRAITS IN FODDER COWPEA [*VIGNA UNGUICULATA* (L.) WALP.]

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SUMMARY

Thirty-two hybrids developed following line x tester mating design involving eight lines (high yielding) and four testers (low yielding) along with parents were analysed for combining ability. The analysis of variance revealed significant differences among the genotypes for all the 10 traits, thereby justifying the selection of parents for the study. The mean sum of squares due to hybrids was highly significant, indicating the diverse performance of different cross combinations. Among the lines CPD-31, MFC-09-09 and EC-458505, and NBC-2, IC-1071 and EC-170578-1-1 among the testers were identified as good general combiners. Out of 32 hybrids, CPD-31 x NBC-2 was identified as good specific combination followed by CPD-31 x EC-170578-1-1. The sca variance was predominant for all characters indicating presence of non-additive gene action.

Key words : Combining ability, fodder yield, line x tester, *Vigna unguiculata*, germplasm

Cowpea [*Vigna unguiculata* (L.) Walp.] is a versatile short duration leguminous plant, commonly grown as grain pulse, vegetable and fodder in semi-arid and humid tropics (Okigbo and Greenland,1976). As a forage crop, it is quick growing, high yielding, with substantially rich biomass production, grows well with associated crops and is highly proteinaceous. Fodder cowpea occupies 0.3 million hectare out of 0.65 million hectare area under different pulse and vegetable cowpea types. It is the only important **kharif** fodder-cum-pulse crop for rainfed as well as irrigated areas (IGFRI, Vision, 2050).

The success of breeding programme depends upon the genetic variability present in the particular crop. Thus, knowledge on genetic variability, heritability and genetic advance in cowpea is essential for a breeder to choose good genotypes for crop improvement. Several researchers have reported the presence and variability in cowpea germplasm for fodder yield (Thaware *et al.*, 1992; Girish *et al.*, 2006; Singh *et al.*, 2010). Several traits contributing to fodder yield, providing better source population for developing high yielding fodder cowpea varieties are under additive genetic effects (Malarvizhi *et al.*, 2005; Singh *et al.* (2010).

Combining ability analysis is one of the powerful tools in selecting the desirable parents and crosses based on their general and specific combining effects for the exploitation of heterosis. Presence of heterosis and combining ability (both general combining ability and specific combining ability) effects for fodder yield and its contributing traits in cowpea are reported by Radhika (2005), Rashwan (2010) and Shyama Kumari *et al.* (2012). Accordingly, the present study was carried out to assess the nature of combining ability and gene action in respect of fodder yield and its contributing traits in 32 hybrids and their 12 parents of cowpea.

MATERIALS AND METHODS

The present investigation was initiated during **kharif** 2013 at Zonal Agriculture Research Station, V. C. Farm, Mandya, Karnataka. Based on the fodder yield and yield attributes, eight high yielding lines viz., IC-402174, EC-458505, CPD-31, MFC-09-6, MFC-

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TABLE 1

Analysis of variance for combining ability with respect to 10 characters in fodder cowpea

Analysis of variance	d. f.	Days to 50% flowering	Plant height (cm)	No. of branches/ plants	No. of leaves/ plant	Total leaf area (m^2)	Green fodder yield (g)	Dry matter yield (g)	Dry weight of leaves (g)	Dry weight of stem (g)	Leaf/stem ratio
Replication	1	0.25	14.11	3.94**	15.23	0.64	10.22	0.31	53.69	50.85	0.02
Cross	31	21.67**	51.09**	2.01**	21.38*	2.62**	13.10**	0.23**	306.03**	107.54**	0.09**
Lines effect	7	12.64	95.87*	4.47*	25.75	4.58	18.32	0.30	493.03	167.75	0.09
Tester effect	3	13.96	44.23	0.34	14.64	2.39	16.50	0.42	282.40	146.23	0.09
L × T effect	21	25.78**	37.14**	1.43**	20.88*	2.00**	10.88**	0.18*	247.07**	81.94*	0.09**
Error	31	5.67	9.14	0.16	10.21	0.42	1.81	0.09	18.27	13.39	0.02
Variance components											
σ^2 gca	-	- 0.12	0.041	0.08	0.01	0.016	14.90	3.53	0.64	0.76	0.00
σ^2 sca	-	10.06	13.99	0.63	5.33	0.79	121.01	70.68	35.21	34.27	0.03
σ^2 gca/σ^2 sca	-	- 0.012	0.003	0.127	0.002	0.023	0.015	0.020	0.015	0.021	0.000
Contribution % of											
Lines		13.17	42.37	50.26	27.20	39.44	31.57	42.36	30.38	35.92	24.12
Testers		6.23	8.38	1.64	6.63	8.83	12.19	17.80	15.93	13.27	10.11
Lines x testers		80.59	49.25	48.11	66.18	51.73	56.24	45.84	54.69	51.82	65.77

*,**Significant at P=0.05 and P=0.01 levels, respectively.

09-13, MFC-09-17, MFC-09-10 and MFC-09-09 were selected as lines and four low yielding lines viz., EC-170578-1-1, IC-1071, NBC-2 and EC-458402 were used as testers to produce 32 hybrids. These 32 hybrids along with 12 parents and three checks viz., BL-1, UPC-5286 and KBC-2 were evaluated following randomized block design with two replications. Each entry was raised in single row of 3 m length with spacing of 30 x 15 cm. Observations on 10 quantitative traits viz., days to 50 per cent flowering, plant height (cm^2), number of branches per plant, number of leaves per plant, total leaf area (m^2), green fodder yield (g), dry matter yield (g), dry weight of leaf (g), dry weight of stem (g) and leaf/stem ratio were recorded. Combining ability was estimated as per method suggested by Kempthorne (1957) and Arunachalam (1974) using “TNAUSTAT-Statistical package”.

TABLE 2

Estimates of general combining ability effects of lines and testers

S. No.		Days to 50% flowering	Plant height (cm)	No. of branches/ plant	No. of leaves/ plant	Total leaf area (m^2)	Green fodder yield (g)	Dry matter yield (g)	Dry weight of leaves (g)	Dry weight of stem (g)	Leaf/stem ratio
Lines											
1.	IC-402174	0.94	-4.6**	-0.47**	0.09	-0.22	-28.61**	-5.30	-1.91	-2.05	0.07
2.	EC-458505	1.44	-4.38**	0.41**	2.58*	-0.90**	-8.28	-3.69	-3.68**	-3.70**	0.03
3.	CPD-31	1.19	-1.93	0.98**	1.32	0.64**	46.71**	17.91**	7.23**	7.99**	-0.09
4.	MFC-09-6	0.44	1.41	0.60**	-2.08	-0.44	-1.01	0.84	0.11	-1.41	-0.17**
5.	MFC-09-13	-0.81	2.41*	0	-1.83	-0.70**	3.83	6.02*	3.31*	3.54**	-0.05
6.	MFC-09-17	-2.31 **	-0.76	0.30*	-2.00	-0.36	-21.88**	-12.49**	-6.53**	-6.67**	0
7.	MFC-09-10	-0.19	3.37**	-0.45**	1.50	0.99**	4.35	-2.27	-0.39	-0.16	0
8.	MFC-09-09	-0.69	4.49**	-1.38**	0.42	0.98**	4.88	-1.01	1.85	2.45	0.21**
	S. Em±	0.84	1.06	0.14	1.12	0.22	3.01	2.56	1.28	1.29	0.05
Testers											
1.	EC-170578-1-1	0.69	1.30	0.04	0.34	-0.25	-2.66	3.53	2.31*	2.17*	0.09*
2.	IC-1071	0.25	1.57*	-0.13	1.20	-0.26	-0.43	-1.05	-0.83	-0.71	-0.10*
3.	NBC-2	0.44	-1.41	0.19	-0.83	0.56*	20.04**	4.13*	2.79**	2.53**	0
4.	EC-458402	-1.38*	-1.47	-0.10	-0.71	-0.05	-16.94**	-6.61**	-4.27**	-3.98**	0.01
	S. Em±	0.60	0.76	0.09	0.80	0.15	2.96	1.81	0.91	0.92	0.08

*,**Significant at P=0.05 and P=0.01 levels, respectively.

RESULTS AND DISCUSSION

Analysis of Variance

The analysis of variance for combining ability revealed significant differences among the genotypes tested for all the 10 traits, thereby justifying the selection of parents for the study. Sca variance was predominant for all the characters studied as indicated by gca and sca ratio (Table 1). The predominance of sca variance indicated prevalence of non-additive gene action. Similar results were also reported by Radhika *et al.* (2004), Valarmathi *et al.* (2007) and Mittal *et al*. (2009).

General Combining ability

Among the eight lines evaluated, CPD-31 was found be a good general combiner for number of branches/plant, total leaf area (m^2/plant), green fodder yield (g), dry matter yield (g), dry weight of leaf (g) and dry weight of stem (g). The line MFC-09-09 was a good source of favourable genes for plant height (cm) and

TABLE 3

Estimates of specific combining ability (sca) effects in hybrids for 10 characters in fodder cowpea [*Vigna unguiculata* (L). Walp.]

S. No.	Crosses	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
1.	IC-402174 × EC-170578-1-1	-2.81	1.73	-0.33	-0.88	-0.09	6.17	-0.29	0.67	0.82	-0.16
2.	IC-402174 × IC-1071	3.63*	-2.19	0.52	4.92*	0.37	-20.53	-3.37	-7.31**	-6.93*	-0.21*
3.	IC-402174 × NBC-2	-4.06*	-0.71	-0.56	-1.88	-0.31	-2.35	-9.16	-2.00**	-1.73	0.31**
4.	IC-402174 × EC-458402	3.25	1.18	0.37	-2.17	0.03	16.72	12.81*	8.63**	7.84**	0.07
5.	EC-458505 × EC-170578-1-1	-2.31	-0.97	-0.14	-1.04	0.29	-15.97	-11.8*	-10.11**	-10.09**	0.19
6.	EC-458505 × IC-1071	2.63	-0.24	-0.8**	1.59	0.48	-14.24	1.78	3.58	3.34	0.35**
7.	EC-458505 × NBC-2	-3.56*	-0.60	1.00**	-1.54	-0.77	29.77*	11.38*	9.36**	10.00**	-0.15
8.	EC-458505 × EC-458402	3.25	1.80	-0.05	1.00	0	0.44	-1.36	-2.83	-3.25	-0.39**
9.	CPD-31 × EC-170578-1-1	0.94	1.41	1.57**	5.56*	-0.14	-43.60**	3.62	1.61	0.85	0
10.	CPD-31 × IC-1071	0.38	0.97	0.32	-3.38	-0.22	11.80	5.96	4.65	3.74	0.16
11.	CPD-31 × NBC-2	0.69	-3.72	-1.30**	-2.11	0.79	91.92**	17.59**	9.9**	10.26**	-0.15
12.	CPD-31 × EC-458402	-2.00	1.34	-0.59*	-0.07	-0.42	-60.12**	-27.17**	-16.16**	-14.86	-0.01
13.	MFC-09-6 × EC-170578-1-1	-0.31	-5.92**	0.15	-1.04	0.16	16.82	4.69	0.73	0.25	-0.05
14.	MFC-09-6 × IC-1071	3.13	8.30**	-0.71*	0.76	0.65	-24.97	-7.85	-2.61	-1.35	-0.05
15.	MFC-09-6 × NBC-2	1.44	-3.22	-0.92**	0.62	0.51	-7.95	-4.04	-2.33	-4.19	0.06
16.	MFC-09-6 × EC-458402	-4.25*	0.84	1.47**	-0.34	-1.32**	16.09	7.20	4.21	5.29*	0.04
17.	MFC-09-13 × EC-170578-1-1	6.94**	-4.92*	0	2.54	1.06*	-3.94	-2.90	-1.20	-0.43	0.03
18.	MFC-09-13 × IC-1071	-3.63*	3.80	0.50	0.84	-0.02	44.25**	8.60	2.99	3.00	0.11
19.	MFC-09-13 × NBC-2	-3.31	4.95*	0.74*	1.37	-0.78	-26.87	-2.71	-2.01	-2.11	-0.05
20.	MFC-09-13 × EC-458402	0	-3.82	-1.24**	-4.75*	-0.26	-13.43	-2.99	0.21	-0.46	-0.09
21.	MFC-09-17 × EC-170578-1-1	0.94	-1.26	-0.57*	-2.63	-0.56	6.97	0.53	4.14	4.28	0.01
22.	MFC-09-17 × IC-1071	-2.13	-4.53*	0.53	-1.49	1.14*	5.27	-0.99	-1.97	-2.09	0.10
23.	MFC-09-17 × NBC-2	-0.31	2.62	-0.15	-1.13	-1.29**	-14.06	-0.57	-2.32	-2.05	-0.01
24.	MFC-09-17 × EC-458402	1.50	3.18	0.19	5.25*	0.71	1.82	1.03	0.15	-0.15	-0.09
25.	MFC-09-10 × EC-170578-1-1	0.31	1.12	-0.55	-3.13	-0.93	-4.63	0.74	2.78	2.55	-0.22*
26.	MFC-09-10 × IC-1071	-3.75*	-0.66	0	-3.66	-1.67**	11.79	2.74	2.27	2.27	-0.17
27.	MFC-09-10 × NBC-2	4.06*	0.16	0.8**	2.71	0.54	-33.99*	-8.29	-7.01*	-7.11**	0.07
28.	MFC-09-10 × EC-458402	-0.63	-0.62	-0.25	4.08	2.05**	26.83	4.81	1.96	2.29	0.32**
29.	MFC-09-09 × EC-170578-1-1	-3.69*	8.82**	-0.13	0.62	0.2	38.17*	5.4	1.39	1.78	0.21
30.	MFC-09-09 × IC-1071	-0.25	-5.45*	-0.36	0.42	-0.72	-13.37	-6.88	-1.62	-1.99	-0.29**
31.	MFC-09-09 × NBC-2	5.06**	0.53	0.39	1.96	1.3**	-36.46*	-4.2	-3.59	-3.08	-0.08
32.	MFC-09-09 × EC-458402	-1.13	-3.91	0.1	-3	-0.77	11.66	5.68	3.82	3.28	0.16
	S. Em±	1.69	2.18	0.28	2.26	0.44	0.95	0.20	3.02	2.86	0.1

X_1–Days to 50 per cent flowering, X_2–Plant height (cm), X_3–No. of branches/plant, X_4–No. of leaves/plant, X_5–Total leaf area (m^2), X_6–Green fodder yield (g), X_7–Dry matter yield (g), X_8–Dry weight of leaves (g), X_9–Dry weight of stem (g) and X_{10}–Leaf/stem ratio.

*,**Significant at P=0.05 and P=0.01 levels, respectively.

leaf/stem ratio. Among the four testers, NBC-2 was a good general combiner for the traits total leaf area (m^2/plant), green fodder yield (g), dry weight of leaf (g) and dry weight of stem (g) (Table 2).

Specific Combining ability

Among 32 hybrids, CPD-31 x NBC-2 was found to be good specific combiner for green fodder yield (g), dry matter yield (g), dry weight of leaf (g) and dry weight of stem (g). The hybrid CPD-31 x EC-170578-1-1 was good specific combiner for number of branches per plant and number of leaves per plant in desirable direction (Table 3). Similarly findings were published by Radhika (2005), Rashwan (2010) and Shyang Kumari *et al.* (2012) in cowpea.

Interaction Effect

The proportional contribution of the interaction effect of line × tester to the variation observed in hybrids was higher for days to 50 per cent flowering (80.59%), plant height (49.25%), number of leaves/plant (66.18%), total leaf area (51.73%), green fodder yield (56.24%), dry matter yield (45.84%), dry weight of leaf (54.69%), dry weight of stem (51.82%) and leaf/stem ratio (65.77%) indicating higher estimates of specific combining ability variance effects (Table 1). Lines × tester interaction as it is not under the breeder's control, but it depends on the particular way in which the lines and testers interact. It also depends on the environment in which the hybrids are grown.

The potential hybrid combinations identified in the present study viz., CPD-31 x NBC-2, CPD-31 x IC-1071 and MFC-09-13 x IC-1071 with higher green fodder yield need to be further evaluated in large scale over locations and seasons to confirm their potentiality and stability for exploitation and their use in commercial cultivation.

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