Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2017; 6(4): 43-47
Received: 28-05-2017
Accepted: 29-06-2017

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Study of combining ability and gene action for forage yield and its component characters in forage sorghum [*Sorghum bicolor* (L.) Moench]

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Abstract
Six grain type CMS sorghum genotypes (females) were crossed with seven fodder type sorghum genotypes (males) in a line x tester mating design. A perusal of variance ratio $\sigma^2_{gca}/\sigma^2_{sca}$ suggested the preponderance of non-additive genetic variance for all the characters except plant height at 50% flowering, leaf width, dry matter content and hydrocyanic acid content. Looking to the parents for characterization of their ability to transmit desirable genes to their progenies, females SURAT 5, AKMS 14A and 3660 A and males SSG 59-3, GAFS 11 and AFS 48 were found good general combiners for green fodder yield plant^{-1} and its component traits like plant height at 50% flowering, number of leaves plant^{-1}, leaf length, leaf: stem ratio and dry matter content. Out of 42 hybrids evaluated, 7 hybrids registered significant positive sca effects for green fodder yield plant^{-1}, of these, the best three cross combinations were AKMS 14A x AFS 53, 3660 A x SSG 59-3 and SURAT 4 x GAFS 11.

Keywords: Combining ability, Gene action and Forage sorghum

1. Introduction
Fodder and feed are the major inputs in animal production especially in milch animal, which account for about 60 to 70% of total cost of milk production. Green fodder availability is 400.6 million tonnes against the requirement of 1,097 million tonnes, which shows 63.50 per cent deficit under different agro ecological zones in India (Anon., 2015) [1]. Sorghum [*Sorghum bicolor* (L.) Moench] is the fifth most important crop in the world. It is a member of Poaceae family with chromosome number 2n=2x=20. Its centre of origin is Ethiopia (Africa). It is an often cross pollinated crop, having average six percent natural cross pollination.

In order to make forage sorghum as an enterprising and remunerative crop, there is a need to develop varieties and hybrids having early maturity, faster growth and high forage yield coupled with high protein content and low HCN content at flowering stage. To develop such forage varieties/hybrids, knowledge and information on breeding strategy for genetic improvement of sorghum as forage crop is necessary. A genetic analysis of quantitative characters for forage is necessary before any breeding methodology can be effectively applied for improvement of sorghum material.

The information on the magnitude and nature of prevalent genetic variation is essentially needed to infer about genetic potential of a particular population. The development of the concept of combining ability helps in choosing the parents for hybridization. Combining ability studies are regarded useful to select good combining parents, which on crossing would produce more desirable segregants. Such studies also elucidate nature and magnitude of gene action in an inheritance of yield and its components, which will decide the breeding programme to be followed in segregating generations.

2. Materials and Methods
Six grain type CMS sorghum genotypes (SURAT 2, SURAT 3, SURAT 5, AKMS 14A, 3660 A and SURAT 4), were crossed as females with seven fodder type sorghum genotypes (SSG 59-3, GAFS 11, AFS 53, AFS 48, AFS 46, AFS 44 and COFS 29), as males in a line x tester mating design. The resulting 42 hybrids along with 13 parents and check hybrid GFSH 1 were grown in a randomized complete block design (RBD) with three replications at Genetics and Plant Breeding Farm, B. A. College of Agriculture, Anand Agricultural University, Anand during *kharif* 2016.

The observations were recorded on five randomly selected plants per entries per replication for 14 characters *viz.,* days to 50 per cent flowering, plant height (cm) at 50% flowering, number of tillers per plant, number of leaves per plant, leaf length (cm), leaf width (cm), leaf: stem ratio, stem girth (cm), green fodder yield per plant (g), dry matter content (%), crude protein content (%), HCN content (ppm), NDF content (%) and crude fibre content (%). For days to 50 percent flowering, observation was recorded on per plot basis.

The replication wise mean values for all the characters were subjected to statistical analysis. Analysis of variance and estimation of combining ability effects were made as per Kempthorne (1957) [3].

3. Results and Discussion

Analysis of variance for combining ability (Table 1) revealed that mean squares due to females were significant for days to 50 per cent flowering, plant height at 50% flowering, leaf length, leaf width, dry matter content, hydrocyanic acid content and neutral detergent fibre content. Whereas for males, it was significant for leaf width, stem girth and green fodder yield plant^{-1}. The mean squares due to females x males interaction were significant for all the characters except plant height at 50% flowering, leaf width and dry matter content suggesting that females x males interaction variance contributed largely for total genetic variance and both females and males interacted differently in cross combinations except plant height at 50% flowering, leaf width and dry matter content.

The combining ability variance revealed that both σ^2_{gca} and σ^2_{sca} were significant for days to 50 per cent flowering, leaf length, stem girth, green fodder yield plant^{-1}, HCN content and NDF content indicating the involvement of both additive and non-additive gene action for inheritance of these characters, however, the ratio $\sigma^2_{gca}/\ \sigma^2_{sca}$ suggested the preponderance of non-additive gene action for days to 50% flowering, leaf length, stem girth, green fodder yield plant^{-1} and NDF content, whereas additive gene action was predominant for HCN content.

It was further revealed that only general combining ability variance was significant for plant height at 50% flowering, leaf width and dry matter content which indicated that these characters were mainly governed by additive gene action, whereas for characters *viz.,* number of tillers plant^{-1}, number of leaves plant^{-1}, leaf : stem ratio, crude protein content and crude fibre content only σ^2_{sca} was significant, indicating that only non-additive gene action was involved in the controlling of these characters.

The preponderance of non-additive gene action resulted in enormous heterotic response in green fodder yield, its attributes and quality traits indicating enough scope for the crop improvement through heterosis breeding in fodder sorghum. The similar results are reported by Parmar *et al.* (2004) [4] for plant height at 50% flowering and leaf width, Sumalini *et al.* (2005) [9] for dry matter content and Prakash *et al.* (2010) [7] for hydrocyanic acid content.

Looking to the parents for characterization of their ability to transmit desirable genes to their progenies, females SURAT 5, AKMS 14A and 3660 A and males SSG 59-3, GAFS 11 and AFS 48 were found good general combiners for green fodder yield plant^{-1} and its component traits like plant height at 50% flowering, number of leaves plant^{-1}, leaf length, leaf: stem ratio and dry matter content (Table 2). Therefore, these parents were noted as good source of favourable genes for increasing green fodder yield plant^{-1} through various yield component characters. With regard to fodder quality characters, the parents SURAT 5 and GAFS 11 for crude protein content; SURAT 5, AKMS 14A, 3660 A, SURAT 4 and AFS 46 for hydrocyanic acid content; SURAT 3 for neutral detergent fibre content and AFS 46 for crude fibre content were found good general combiners.

The best agreement between good general combining parents and top performing parents for days to 50 per cent flowering, plant height at 50% flowering, number of leaves plant^{-1}, leaf length, leaf width, stem girth, green fodder yield plant^{-1}, hydrocyanic acid content and crude fibre revealed parallel behavior between *per se* performance and gca effects of parents.

The estimates of sca effects (Table 3) revealed that none of the hybrid was consistently superior for all the traits. Out of 42 hybrids evaluated, 7 hybrids registered significant positive sca effects for green fodder yield plant^{-1}. The best three cross combinations on the basis of significant and positive sca effects for this trait were AKMS 14A x AFS 53 (38.79), 3660 A x SSG 59-3 (36.19) and SURAT 4 x GAFS 11 (31.19). Among these hybrids, the hybrid AKMS 14A x AFS 53 also had significant and desirable sca effects for plant height at 50% flowering, number of tillers plant^{-1} and number of leaves plant^{-1}. The another hybrid 3660 A x SSG 59-3 also possessed significant and desirable sca effects for plant height at 50% flowering, number of tillers plant^{-1}, number of leaves plant^{-1} and leaf length. The hybrid SURAT 4 x GAFS 11 had significant and desirable sca effect for number of tillers plant^{-1}, crude protein content, hydrocyanic acid content and crude fibre content. The findings are in agreement with results reported by Mukesh-Mohan *et al*. (2007) [5], Monteiro *et al*. (2008) [4], Singh and Sukhchain (2010) [8], Prakash *et al.* (2010) [7], Jain and Patel (2014) [2] who also observed significant sca effects for high green fodder yielding hybrids.

Estimates of sca effects did not reveal any specific trend among the crosses. The crosses exhibited high sca effects did not always involve both parents as good general combiners with high gca effects, thereby suggesting importance of intra as well as inter-allelic interactions. The high sca effects of crosses in general correspond to their high heterotic effects, but these might also be accompanied by poor and /or average gca effects of their parents. The crosses which having high sca effects for green fodder yield plant^{-1} had also registered significant sca effects in desired direction for some of the yield component characters.

Table 1: Analysis of variance (mean squares) and variance components for combining ability for various traits studied

Source of Variation	D.F.	Days to 50% flowering	Plant height at 50% flowering	No. of tillers plant^{-1}	No. of leaves plant^{-1}	Leaf length	Leaf width	Leaf : stem ratio
Replication	2	0.17	324.83	0.02	0.05	31.99	0.08	0.0012
Females	5	46.08*	2854.81**	0.32	3.63	286.75*	2.75**	0.0049
Males	6	11.31	419.91	0.25	0.54	207.76	1.84**	0.0082
Females x Males	30	17.26**	509.98	0.57**	1.81**	89.25**	0.51	0.0098*
σ^2 gca	-	0.59*	57.81**	#	0.01	8.10*	0.09**	#
σ^2 sca	-	3.34**	61.50	0.15**	0.38**	16.61**	0.04	0.0132*
σ^2 gca/σ^2 sca	-	0.18	0.94	#	0.04	0.49	2.45	#
Error	82	7.23	325.48	0.12	0.67	39.42	0.39	0.0058
Source of Variation	**D.F.**	**Stem girth**	**Green fodder yield plant^{-1}**	**Dry matter content**	**Crude protein content**	**HCN content**	**NDF content**	**Crude fibre content**
Replication	2	0.036	130.03	10	0.14	33.27	16.52	0.13
Females	5	0.0456	2059.17	26.88*	0.90	2652.66**	34.32*	4.19
Males	6	0.1643**	5343.07**	5.48	1.27	112.4	4.72	17.28
Females x Males	30	0.0347**	980.59**	7.82	1.000**	129.58**	10.15*	10.86**
σ^2 gca	-	0.0036**	139.51**	0.43*	0.004	64.25**	0.48*	#
σ^2 sca	-	0.0070**	277.26**	0.31	0.260**	35.20**	1.36*	2.64**
σ^2 gca/σ^2 sca	-	0.5123	0.50	1.37	0.02	1.83	0.35	#
Error	82	0.0142	148.82	6.88	0.21	23.97	6.07	2.95

*, ** Significant at P = 0.05 and P = 0.01 levels, respectively, HCN=Hydrocyanic acid content, NDF=neutral detergent fibre content and # indicated negative variance.

Table 2: Estimates of general combining ability (gca) effects of parents for various characters

Parents		Days to 50% flowering	Plant height at 50% flowering	No. of tillers plant^{-1}	No. of leaves plant^{-1}	Leaf length	Leaf width	Leaf : stem ratio
Females	SURAT 2	-1.24**	7.48*	-0.18**	-0.69**	0.02	0.15	0.01
	SURAT 3	0.01	5.56	0.01	-0.28*	-0.26	-0.53**	-0.01
	SURAT 5	-1.62**	3.22	0.13*	0.22	2.43*	-0.09	0.01
	AKMS 14A	0.43	4.55	0.14*	0.07	5.27**	0.56**	0.01
	3660 A	-0.14	2.47	-0.08	0.45**	-1.88	0.06	0.01
	SURAT 4	2.57**	-23.54**	-0.01	0.23	-5.57**	-0.16	-0.02*
S. Em. ±		0.47	3.14	0.06	0.14	1.09	0.11	0.01
Males	SSG 59-3	0.81	9.77**	0.06	0.15	3.94**	0.14	0.02*
	GAFS 11	-0.02	-0.77	0.14*	-0.12	0.59	0.23	0.02*
	AFS 53	0.09	0.29	-0.02	0.21	5.08**	0.26*	0.01
	AFS 48	0.53	0.70	-0.15*	-0.28	-4.17**	-0.20	-0.04**
	AFS 46	-1.63**	-0.88	-0.06	-0.09	-2.25	0.24*	0.01
	AFS 44	-0.13	-3.81	-0.12	0.12	-1.62	-0.06	0.01
	COFS 29	0.37	-5.30	0.14*	0.00	-1.57	-0.61**	-0.02*
S. Em. ±		0.51	3.44	0.07	0.16	1.20	0.12	0.01
Parents		**Stem girth**	**Green fodder yield plant^{-1}**	**Dry matter content**	**Crude protein content**	**HCN content**	**NDF content**	**Crude fibre content**
Females	SURAT 2	-0.01	-12.21**	-0.07	0.01	10.95**	-0.04	-0.21
	SURAT 3	-0.02	-9.62**	-0.28	-0.06	17.20**	-2.27**	-0.08
	SURAT 5	-0.02	7.10**	-0.22	0.31**	-9.22**	0.88*	-0.51
	AKMS 14A	0.05**	8.25**	0.84	-0.04	-6.27**	0.23	-0.25
	3660 A	0.06**	10.63**	1.53**	0.11	-8.70**	-0.27	0.73*
	SURAT 4	-0.06**	-4.15	-1.80**	-0.32**	-3.96**	1.46**	0.31
S. Em. ±		0.02	2.12	0.46	0.08	0.85	0.43	0.30
Males	SSG 59-3	-0.02	26.53**	0.43	-0.23**	4.43**	0.56	-0.58
	GAFS 11	0.08**	10.32**	-0.62	0.32**	-1.10	-0.29	-0.59
	AFS 53	0.14**	-11.92**	0.21	-0.46**	-0.6	0.49	0.01
	AFS 48	0.01	9.49**	-0.75	0.17	-0.44	0.4	2.00**
	AFS 46	0.04*	-12.66**	-0.27	0.08	-3.85**	0.54	0.26
	AFS 44	-0.10**	-23.94**	0.70	0.13	0.58	-0.24	-1.01**
	COFS 29	-0.13**	2.18	0.31	-0.02	0.98	-0.66	-0.09
S. Em. ±		0.02	2.33	0.50	0.09	0.93	0.47	0.33

*, ** Significant at P = 0.05 and P = 0.01 levels, respectively. HCN=Hydrocyanic acid content and NDF=neutral detergent fibre content

Table 3: Estimates of specific combining ability (sca) effect of hybrids for different characters

Hybrids	DF	PH	NT	NL	LL	LW	LS
SURAT 2 x SSG 59-3	-3.76**	-2.29	0.62**	-0.56	0.63	-0.05	0.02
SURAT 2 x GAFS 11	-0.93	-7.81	-0.13	-0.26	0.24	-0.02	-0.01
SURAT 2 x AFS 53	0.29	2.28	0.41**	-1.47**	-3.18	-0.24	0.08**
SURAT 2 x AFS 48	3.85**	-10.21	-0.24	0.66	3.17	-0.38	-0.03
SURAT 2 x AFS 46	1.35	9.54	-0.40**	1.05**	-0.56	0.11	0.00
SURAT 2 x AFS 44	-2.82*	3.84	0.00	0.20	1.48	0.29	0.02
SURAT 2 x COFS 29	2.02	5.64	-0.26	0.38	-1.79	0.29	-0.07*
SURAT 3 x SSG 59-3	0.33	-2.67	-0.63**	0.09	-0.69	-0.13	0.04
SURAT 3 x GAFS 11	-1.50	-3.17	-0.57**	-0.11	-5.31*	0.10	-0.01
SURAT 3 x AFS 53	0.39	7.45	-0.54**	-0.09	-2.45	-0.45	0.04
SURAT 3 x AFS 48	-1.06	1.05	0.78**	-1.09**	1.23	0.06	-0.03
SURAT 3 x AFS 46	0.44	-0.68	0.26	0.26	3.26	0.11	0.02
SURAT 3 x AFS 44	2.28*	14.89	0.36**	-0.09	4.30	0.34	-0.03
SURAT 3 x COFS 29	-0.89	-16.86*	0.36**	1.03**	-0.34	-0.04	-0.03
SURAT 5 x SSG 59-3	0.29	-1.55	-0.03	-0.51	2.23	0.58*	-0.06*
SURAT 5 x GAFS 11	3.79**	-4.94	0.30*	0.51	1.85	0.46	0.12**
SURAT 5 x AFS 53	0.34	-2.96	0.13	0.79*	8.55**	0.22	0.00
SURAT 5 x AFS 48	1.23	12.91	0.12	0.55	-0.35	-0.64*	-0.02
SURAT 5 x AFS 46	-0.94	13.75	-0.17	-0.45	2.87	0.60*	-0.01
SURAT 5 x AFS 44	-0.77	-16.73*	-0.31*	0.29	-6.59*	-0.52	0.01
SURAT 5 x COFS 29	-3.94**	-0.50	-0.04	-1.19**	-8.56**	-0.71**	-0.05
AKMS 14A x SSG 59-3	4.90**	-16.31*	-0.04	-0.13	-6.24*	-0.19	-0.01
AKMS 14A x GAFS 11	0.74	7.02	-0.26	0.07	1.80	-0.20	-0.05
AKMS 14A x AFS 53	-1.37	15.40*	0.44**	1.14**	2.02	0.51	-0.02
AKMS 14A x AFS 48	-1.15	-12.47	-0.03	-0.56	-5.02	0.27	0.00
AKMS 14A x AFS 46	-2.98**	-9.37	0.14	-1.22**	-1.85	-0.52	0.09**
AKMS 14A x AFS 44	-1.15	3.36	-0.06	0.77*	-1.04	0.10	-0.01
AKMS 14A x COFS 29	1.02	12.36	-0.19	-0.08	10.33**	0.04	0.00
3660 A x SSG 59-3	-0.86	35.09**	0.71**	1.54**	11.68**	0.11	0.02
3660 A x GAFS 11	-0.69	11.14	0.03	-0.12	0.90	-0.37	-0.04
3660 A x AFS 53	-3.13**	-18.62*	0.11	-0.51	0.66	-0.36	-0.07*
3660 A x AFS 48	-1.25	-10.52	-0.27	-0.30	-1.47	0.29	0.04
3660 A x AFS 46	2.25*	-14.66	-0.10	-0.08	-10.79**	0.31	-0.06*
3660 A x AFS 44	3.09**	-1.96	-0.44**	-0.28	0.83	-0.37	-0.05
3660 A x COFS 29	0.59	-0.47	-0.04	-0.23	-1.81	0.39	0.15**
SURAT 4 x SSG 59-3	-0.90	-12.28	-0.63**	-0.43	-7.62**	-0.32	-0.01
SURAT 4 x GAFS 11	-1.40	-2.25	0.63**	-0.09	0.53	0.02	-0.01
SURAT 4 x AFS 53	3.48**	-2.54	-0.55**	0.13	-5.60*	0.32	-0.03
SURAT 4 x AFS 48	-1.63	19.24*	-0.35	0.74*	2.44	0.39	0.05
SURAT 4 x AFS 46	-0.13	1.42	0.28	0.44	7.05**	-0.61*	-0.04
SURAT 4 x AFS 44	-0.63	-3.40	0.44**	-0.88*	1.03	0.15	0.06*
SURAT 4 x COFS 29	1.21	-0.18	0.17	-0.08	2.18	0.04	-0.01
S. Em. ±	1.15	7.69	0.15	0.35	2.68	0.27	0.03

DF= Days to 50% flowering, PH= Plant height at 50% flowering, NT= No. of tillers plant^{-1}, NL= No. of leaves plant^{-1}, LL= Leaf length, LW= Leaf width and LS= Leaf : stem ratio

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

Hybrids	SG	GFY	DM	CP	HCN	NDF	CF
SURAT 2 x SSG 59-3	-0.14**	-12.80*	-0.25	0.29	-1.33	2.49*	-1.09
SURAT 2 x GAFS 11	-0.07	-2.98	2.49*	0.77**	5.77**	-0.06	-1.98**
SURAT 2 x AFS 53	-0.01	10.82*	0.04	-0.28	0.13	0.09	3.49**
SURAT 2 x AFS 48	0.06	-0.46	-1.60	0.33	1.07	-2.82**	0.24
SURAT 2 x AFS 46	-0.02	-13.97**	1.18	-0.26	2.82	1.02	-0.64
SURAT 2 x AFS 44	0.11*	20.83**	-2.75*	-0.14	-7.10**	-2.20*	-2.09**
SURAT 2 x COFS 29	0.07	-1.45	0.89	-0.70**	-1.36	1.47	2.07**
SURAT 3 x SSG 59-3	0.00	-0.36	2.76*	0.28	-2.27	-1.93	-1.23
SURAT 3 x GAFS 11	-0.07	-1.47	-0.86	-0.96**	-1.94	2.76**	3.82**
SURAT 3 x AFS 53	-0.11*	8.69	-1.68	-0.52**	6.94**	0.82	-0.59
SURAT 3 x AFS 48	0.01	0.01	-2.02	0.20	-2.02	1.90	-1.73*
SURAT 3 x AFS 46	-0.03	-13.82**	0.96	0.24	-10.20**	-1.05	2.13**
SURAT 3 x AFS 44	0.10*	4.38	-0.61	0.63**	8.72**	-0.57	-1.28
SURAT 3 x COFS 29	0.11*	2.56	1.44	0.12	0.76	-1.92	-1.12
SURAT 5 x SSG 59-3	-0.18**	1.29	0.20	-0.34	-1.64	-0.40	-0.99
SURAT 5 x GAFS 11	0.10*	-1.16	-1.10	-1.06**	-1.11	0.89	1.72*
SURAT 5 x AFS 53	0.18**	-9.16	-0.32	0.11	-7.27**	-1.50	-0.91
SURAT 5 x AFS 48	0.04	7.26	1.48	-0.25	8.18**	1.64	2.32**
SURAT 5 x AFS 46	0.03	6.38	1.19	-0.19	6.46**	0.01	-3.16**
SURAT 5 x AFS 44	-0.09	-0.51	-0.71	0.79**	0.13	0.06	1.69*

SURAT 5 x COFS 29	-0.07	-4.10	-0.74	0.95**	-4.75**	-0.71	-0.67
AKMS 14A x SSG 59-3	0.08	-11.99*	-0.44	-0.68**	-8.01**	-0.67	-0.48
AKMS 14A x GAFS 11	-0.08	-11.94*	0.41	0.19	8.85**	0.19	-1.12
AKMS 14A x AFS 53	0.09	38.79**	-0.34	0.20	-1.30	-0.76	-0.74
AKMS 14A x AFS 48	0.04	0.15	0.45	0.53**	0.43	-0.07	-0.93
AKMS 14A x AFS 46	0.03	-25.76**	0.44	0.39*	10.98**	-0.34	2.32**
AKMS 14A x AFS 44	-0.06	0.81	0.60	-0.42*	-11.84**	1.19	1.54*
AKMS 14A x COFS 29	-0.10*	9.96	-1.12	-0.21	0.90	0.47	-0.60
3660 A x SSG 59-3	0.26**	36.19**	0.22	0.37	8.90**	0.61	0.48
3660 A x GAFS 11	0.04	-13.62**	-0.30	0.36	-4.44*	-3.66**	-0.56
3660 A x AFS 53	-0.14**	-36.75**	0.44	0.71**	-0.16	0.98	0.23
3660 A x AFS 48	-0.04	7.07	1.70	-0.58**	-5.71**	-2.19*	1.03
3660 A x AFS 46	0.04	22.80**	-3.45**	-0.34	-1.86	1.36	-1.13
3660 A x AFS 44	-0.13**	-13.26*	1.19	-0.79**	1.63	3.89**	0.01
3660 A x COFS 29	-0.02	-2.42	0.20	0.25	1.63	-0.97	-0.06
SURAT 4 x SSG 59-3	-0.03	-12.33*	-2.49*	0.07	4.34*	-0.10	3.32**
SURAT 4 x GAFS 11	0.08	31.19**	-0.65	0.70**	-7.13**	-0.12	-1.88**
SURAT 4 x AFS 53	-0.02	-12.39*	1.87	-0.21	1.67	0.37	-1.49*
SURAT 4 x AFS 48	-0.10*	-14.03**	-0.01	-0.23	-1.95	1.56	-0.93
SURAT 4 x AFS 46	-0.04	24.37**	-0.32	0.16	-8.20**	-1.00	0.47
SURAT 4 x AFS 44	0.08	-12.26*	2.28*	-0.07	8.46**	-2.37*	0.13
SURAT 4 x COFS 29	0.02	-4.55	-0.68	-0.42*	2.82	1.65	0.37
S. Em. ±	0.05	5.20	1.12	0.20	2.09	1.05	0.73

SG= Stem girth, GFY= Green fodder yield plant^{-1}, DM= Dry matter content, CP= Crude protein content, HCN=Hydrocyanic acid content, NDF=neutral detergent fibre content and CF= crude fibre content

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

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