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ENVIRONMENTAL EFFECT ON SORGHUM FODDER YIELD AND ITS RELATED TRAITS[1]

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SUMMARY

A study was made in *Sorghum bicolor* with line × tester (6 females × 4 males) to estimate the fodder yield and its component traits of different hybrids and parents under different environments. For this purpose, 24 specific cross combinations were developed by using 10 diverse parents during **kharif** season in 2014-15. These hybrids along with 10 parents and two standard checks (SSG 59-3 and MFSH 4) were evaluated at two locations (Hisar and Karnal) with early and late sowing during **kharif** season in 2015-16. The analysis of variance indicated the presence of variability among hybrids and their parents. Among male parents (HJ 541 and G 46), among female parents (467A and 56A) and crosses 467A × G 46 (222.1 g) and 465A × HJ 513 (220.8 g) showed higher green fodder yield on the basis of overall mean. This hybrid was also good for plant height (141.9 cm) and leaf length (81.7 cm). Other hybrids that showed better green fodder yield were 9A × IS 2389 (193.8 g), 56A × HJ 513 (190.0 g) and 31A × HJ 513 (185.9 g). Hybrid 56A × G 46 recorded higher leaf length (86.3 cm) and was also better for green fodder yield (178.3 g) and plant height (159.4 cm).

Key words : *Sorghum bicolor*, environment, quantitative traits, green fodder yield

Sorghum [*Sorghum bicolor* (L.) Moench] is popular as a dual purpose crop and is next to rice and wheat in its acreage and importance in India. Sorghum grain is used as staple food by millions of people and is grown for grain in southern and central states of India, whereas in northern states of the country (Punjab, Haryana, Uttar Pradesh, Rajasthan, etc.) it is mainly grown as fodder during summer and **kharif** seasons as a single as well as multicut crop. Among forage crops, forage sorghum could be a strategic option because of the crop's xerophilic characteristics, adaptation potential, quick growing habit, good ratoonability, palatability, digestibility and wide range of potential uses as green fodder, dry roughage, hay and silage (Kumar and Chaplot, 2015).

Sorghum has a significant role in livestock production, particularly in tropical zone where feed stuffs could not meet animal requirements due to many factors such as poor soil fertility and drought. To obtain better animal performance, forage sorghum should be nutritionally superior i. e. better in palatability, high in protein, digestibility and low in toxic constituents (Pholsen and Suksri, 2007). Forages are the backbone of livestock industry. India is having the largest livestock population of 520 million heads, which is about 15 per cent of the world's livestock population. The present feed and fodder resources of the country can meet only 48 per cent of the requirement, with a vast deficit of 52 per cent (61.1 and 21.9% of green and dry fodder) (Somashekar *et al*., 2015). Moreover, there is high pressure to grow grain crops and it is difficult to devote more acerage under fodder crops, we are left with only one alternative to increase the fodder productivity in the country (Singh and Sharma, 2015). In view, present study was done to identify the high green fodder producing hybrids and parents under different environments.

MATERIALS AND METHODS

The material for the present study was developed by crossing six diverse female lines, viz., 9A, 14A, 31A, 56A, 465A and 467A with four agronomically superior male parents to be used as testers i. e. HJ 513, HJ 541, IS 2389 and G 46. The crosses were made at

[1]Paper is based on Ph. D. thesis of first author.

research area of Forage Section, Department of Genetics & Plant Breeding, Chaudhary Charan Singh Haryana Agricultural University, Hisar during the **kharif** season of 2014-15. Hybrids and parents were evaluated at two locations i.e. Research Area of Forage Section, Department of Genetics & Plant Breeding, Chaudhary Charan Singh Haryana Agricultural University, Hisar and Regional Research Station, Uchani, Karnal with early and late sowing during the **kharif** season of 2015-16. Data on five randomly selected plants from each genotype in each replication were recorded on different quantitative characters viz., days to 50 per cent flowering, plant height (cm), number of tillers/plant, leaf length (cm), leaf breadth (cm), stem diameter (cm) and green fodder yield (g /plant) in all the four environments. All the 36 genotypes were grown in a randomized block design with three replications of in paired rows having 4.0 m length. All the recommended cultural packages of practices were followed from sowing to till the crop harvesting.

RESULTS AND DISCUSSION

The analysis of variance (Table 1) indicated that the mean squares of genotypes for all the characters investigated were significantly different, indicating the presence of variability among hybrids and their parents except number of tillers in E_4. Mean performance and range of hybrids and parents are presented in Tables 2 and 3, respectively. Progress in plant breeding depends on the extent of genetic variability present in a population. Therefore, the first step in any plant breeding programme is the study of genetic variability, which cannot easily be measured. In order to get enhanced performance of animals, quality of fodder being fed to them is of utmost importance.

Green Fodder Yield/Plant

The green fodder yield was recorded by taking the fresh weight of selected plants. The range for green fodder yield varied from 118.3 g (467A × HJ 541) to 265.0 g (465A × HJ 513) with mean of 180.7 g in E_1; from 141.7 g (465A × HJ 541) to 271.7 g (9A × IS 2389) with mean 183.7 g in E_2; from 115.0 g (56A × HJ 541) to 240.0 g (467A × G 46) with mean of 164.2 g in E_3 and from 118.3 g (14A × HJ 513) to 240.0 g (9A × HJ 541) with mean of 159.4 g in E_4. On the basis of overall mean in all the environments among male parents, HJ 541 (181.7 g) and G 46 (155.4 g) and among female parents, 196.7 g (56A) and 214.2 g (467A) showed maximum green fodder yield per plant and the crosses 222.1 g (467A × G 46) recorded maximum green fodder yield per plant, followed by 220.8 g (465A × HJ 513) and 198.3 g (14A × G 46). Above findings were supported by Pandey *et al.* (2013) and Prabhakar *et al.* (2013).

Plant Height

The maximum height was shown by the cross 56A × G 46 (199.3 cm) followed by 14A × IS 2389 (195.0 cm) and MFSH-4 check (191.0 cm) in E_1; while in E_2, the cross 31A × G 46 (185.3 cm) followed by MFSH-4 check (170.0 cm) and 14A × G 46 (167.7 cm). The maximum height was shown by the MFSH-4 check (172.7 cm) followed by cross 56A × HJ 513 (171.7 cm) and 14A × HJ 541 (168.3 cm) in E_3; while in E_4, the cross 467A × HJ 513 (173.0 cm) gained highest plant height, followed by 467A × IS 2389 (168.7 cm) and 31A × IS 2389 (168.7 cm). On the basis of overall mean over all the four environments among male parents, IS 2389 (167.1 cm) and G 46 (160.6 cm) and among female parents 467A (155.5 cm) and 465A (145.5 cm) showed highest plant height. The check MFSH-4 (172.3 cm) attained maximum plant height, followed by cross 14A × IS 2389 (164.1 cm) and 56A × G 46 (159.4 cm). Similar results reported by Abubakar were and Bubuche (2014).

Number of Tillers/Plant

All the tillers which had come out from the base were counted in all the parents as well as hybrids at first cut. The highest number of tillers/plant was shown by the checks MFSH-4 (3.0) and SSG 59-3 (3.0) followed by cross 467A × IS 2389 (2.7), 9A × G 46 (2.3) and 9A × HJ 541 (2.3) in E_1; while in E_2, the check MFSH-4 (2.3) and cross 14A × IS 2389 (2.3) and 31A × G 46 (2.3) gained maximum number of tillers/plant. The maximum number of tillers/plant was shown by the checks SSG 59-3 (3.0) and check MFSH-4 (2.3) in E_3; while in E_4, checks MFSH-4 and SSG 59-3 (3.0) gained maximum number of tillers/plant, followed by the cross 31A × IS 2389 (2.3) and 31A × HJ 541(2.3). On the basis of overall mean in all the four environments among male parents, IS 2389 (1.6) and G 46 (1.6) and among

TABLE 1

Analysis of variance for different characters in different environments in single cut in forage sorghum

Source of variation	d. f.	Environments	Plant height (cm)	No. of tillers/plant	Leaf length (cm)	Leaf breadth (cm)	Stem diameter (g)	Green fodder yield/plant (g)
Replication	2	E_1	60.663	0.480	6.657	0.937	0.843	289.951
		E_2	26.304	0.010	32.069	0.012	0.593	73.775
		E_3	119.147	1.088	95.951	0.170	0.820	217.892
		E_4	151.010	0.029	49.618	0.030	0.187	265.441
Treatment	33	E_1	1002.092**	1.928*	181.442**	3.262**	21.464**	4857.583**
		E_2	668.187**	1.889*	215.412**	1.849**	10.479**	4838.859**
		E_3	450.244**	2.207**	134.616**	1.713**	22.049**	2711.081**
		E_4	430.353**	1.667	142.883**	1.772**	24.175**	2738.243**
Error	66	E_1	65.153	0.309	15.950	0.392	1.295	106.113
		E_2	63.435	0.293	20.523	0.460	1.688	104.078
		E_3	62.612	0.088	16.001	0.429	1.447	105.266
		E_4	67.626	0.252	11.739	0.470	1.380	85.391

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

E_1–Early sowing at Hisar, E_2–Early sowing at Karnal, E_3–Late sowing at Hisar and E_4–Late sowing at Karnal.

female parents 31A (1.6) and 56A (1.6) showed maximum number of tillers/plant. The checks MFSH-4 (2.7) and SSG 59-3 (2.7) attained maximum number of tillers/plant, followed by cross 467A × IS 2389 (1.8), 31A × HJ 541 (1.8) and 31A × IS 2389 (1.8). Similar results were reported by Agarwal and Shrotria (2005), Satpute *et al.* (2005) and Rana *et al.* (2013).

Leaf Length

In case of leaf length, highest leaf length was shown by the cross 14A × IS 2389 (90.0 cm) followed by 56A × IS 2389 (86.7 cm), 56A × HJ 541 (86.3 cm) and 467A × HJ 513 (86.3 cm) in E_1; while in E_2, the cross 56A × G 46 (92.3 cm) gained longer leaf length, followed by 56A × IS 2389 (87.0) and 465A × HJ 513 (86.0). The maximum length was shown by the cross 14A × G 46 (93.0 cm) followed by cross 31A × G 46 (89.3 cm) and 56A × G 46 (86.3 cm) in E_3; while in E_4, the cross 31A × HJ 513 (92.3 cm) gained maximum leaf length, followed by 465A × IS 2389 (86.7 cm) and 56A × G 46 (86.7 cm). On the basis of overall mean in all the four environments among male parents, HJ 513 (83.4 cm) and HJ 541 (81.4 cm) and among female parents 9A (84.8 cm) and 14A (82.5 cm) showed maximum leaf length. The cross 56A × G 46 (86.3) recorded maximum leaf length, followed by cross 465A × IS 2389 (84.3 cm) and 9A × G 46 (83.8 cm). Similar results were reported by Bibi *et al.* (2012) and Anarese *et al.* (2015).

Leaf Breadth

Leaf breadth was measured across the centre of fifth leaf. The highest leaf breadth was shown by the cross 465A × HJ- 541 (8.5 cm) followed by 467A × HJ 513 (8.2 cm) and 14A × IS 2389 (8.0 cm) in E_1; while in E_2, the cross 14A × HJ 513 (7.6 cm) gained broader leaf breadth, followed by 31A × G 46 (7.5 cm) and 9A × IS 2389 (7.3 cm). The maximum leaf breadth was shown by the 56A × HJ 541 (7.3 cm) followed by cross 31A × HJ 513 (7.1 cm), 14A × G 46 (7.0 cm) and 56A × G 46 (7.0 cm) in E_3; while in E_4, the cross 467A × HJ 513 (7.3 cm) and 14A × HJ 541 (7.3 cm) gained maximum leaf breadth, followed by 31A × HJ 541 (7.3 cm), 465A × G 46 (7.3 cm) and 467A × IS 2389 (7.0 cm). On the basis of overall mean in all the four environments among male parents, HJ 513 (6.7 cm) and G 46 (6.1 cm) and among female parents 467A (7.3 cm) and 14A (6.8 cm) showed maximum leaf breadth. The cross 56A × HJ 541 (7.1 cm) noted maximum leaf breadth, followed by cross 467A × HJ 513 (7.0 cm) and 14A × HJ 513 (7.0 cm). Above findings were supported by Wang *et al.* (2013). Somashekar *et al.* (2015).

Stem Diameter

In forage sorghums thin stem is preferred by livestock. The minimum stem diameter was shown by the cross 467A × IS 2389 (11.3 cm) followed by 31A ×

TABLE 2
Mean performance of different hybrids under different environments in forage sorghum

Hybrids	Plant height (cm)					Total number of tillers per plant					Leaf length (cm)				
	E_1	E_2	E_3	E_4	Mean	E_1	E_2	E_3	E_4	Mean	E_1	E_2	E_3	E_4	Mean
9A × HJ 513	142.7	155.7	147.3	135.0	145.2	1.3	1.3	1.3	1.0	1.2	70.7	70.3	85.0	77.7	75.9
9A × HJ 541	152.0	149.7	132.7	129.0	140.9	2.3	1.3	1.0	1.0	1.4	71.3	74.3	75.0	66.7	71.8
9A × IS 2389	179.3	141.3	151.7	129.3	150.4	1.7	1.7	1.0	1.0	1.4	78.0	64.3	84.7	72.3	74.8
9A × G 46	160.0	143.0	151.7	148.0	150.7	2.3	1.7	1.0	1.7	1.7	85.3	82.7	81.0	86.3	83.8
14A × HJ 513	148.3	134.0	141.7	147.0	142.8	1.0	1.7	1.0	1.0	1.2	84.7	74.7	77.0	76.7	78.3
14A × HJ 541	157.7	140.7	168.3	139.0	151.4	2.0	2.0	1.3	1.3	1.7	77.3	67.7	85.7	78.0	77.2
14A × IS 2389	195.0	150.7	157.0	153.7	164.1	2.0	2.3	1.3	1.3	1.7	90.0	71.3	70.7	74.0	76.5
14A × G 46	140.3	167.7	140.0	146.0	148.5	1.3	2.0	1.0	1.7	1.5	78.7	78.7	93.0	75.7	81.5
31A × HJ 513	155.7	151.0	154.3	167.0	157.0	2.0	2.0	1.3	1.0	1.6	74.3	71.3	85.0	92.3	80.7
31A × HJ 541	145.0	144.7	134.0	153.0	144.2	1.7	1.7	1.3	2.3	1.8	58.3	75.3	75.0	80.7	72.3
31A × IS 2389	171.3	142.7	124.3	168.7	151.8	2.0	2.0	1.0	2.3	1.8	72.0	56.3	83.0	85.0	74.1
31A × G 46	151.7	185.3	138.0	147.3	155.6	2.0	2.3	1.0	1.0	1.6	74.0	68.0	89.3	75.0	76.6
56A × HJ 513	169.0	129.0	171.7	143.0	153.2	1.0	1.0	1.0	1.3	1.1	74.0	79.0	77.7	84.7	78.9
56A × HJ 541	151.3	140.7	160.3	139.7	148.0	1.3	1.0	1.0	1.3	1.2	86.3	81.7	66.7	74.0	77.2
56A × IS 2389	148.3	149.7	155.7	156.0	152.4	1.7	1.3	1.3	1.3	1.4	86.7	87.0	72.3	86.3	83.1
56A × G 46	199.3	144.7	156.7	137.0	159.4	2.0	1.0	1.3	1.7	1.5	79.7	92.3	86.3	86.7	86.3
465A × HJ 513	134.0	140.7	152.3	146.0	143.3	1.3	1.0	1.3	1.3	1.2	86.0	86.0	76.7	74.0	80.7
465A × HJ 541	154.3	117.3	151.3	134.0	139.2	1.3	1.0	1.3	2.0	1.4	71.7	74.3	83.0	86.3	78.8
465A × IS 2389	134.0	136.3	147.3	150.3	142.0	2.0	1.3	1.0	1.7	1.5	85.0	81.0	84.3	86.7	84.3
465A × G 46	169.0	165.0	131.0	137.7	150.7	1.3	1.0	1.0	1.3	1.2	85.7	73.3	75.3	85.0	79.8
467A × HJ 513	127.3	156.3	143.7	173.0	150.1	1.0	2.0	1.0	1.0	1.3	86.3	80.0	80.7	75.0	80.5
467A × HJ 541	158.3	116.3	127.0	157.7	139.8	1.3	1.7	1.3	1.3	1.4	80.7	84.0	69.0	84.7	79.6
467A × IS 2389	132.3	144.7	158.3	168.7	151.0	2.7	1.7	1.3	1.3	1.8	67.3	85.7	71.3	71.3	73.9
467A × G 46	156.0	130.0	152.7	128.7	141.9	1.7	2.0	1.0	1.3	1.5	85.7	70.7	85.3	85.0	81.7
SSG 59-3 (Ch.)	162.3	145.0	144.0	142.7	148.5	3.0	1.7	3.0	3.0	2.7	78.0	75.0	73.0	71.3	74.3
MFSH 4 (Ch.)	191.0	170.0	172.7	155.3	172.3	3.0	2.3	2.3	3.0	2.7	77.7	80.7	79.0	78.0	78.9
Mean	157.1	145.9	148.7	147.4	149.8	1.8	1.6	1.3	1.5	1.6	78.7	76.4	79.4	79.6	78.5
Range	127.3-199.3	116.3-185.3	124.3-172.7	128.7-173.0		1.0-3.0	1.0-2.3	1.0-3.0	1.0-3.0		58.3-90.0	56.3-92.3	66.7-93.0	66.7-93.0	
C. D. (P=0.05)	13.38	13.29	13.06	12.81		1.01	0.84	0.58	0.93		6.35	6.89	6.92	5.26	
S. E(m)	4.69	4.66	4.58	4.49		0.35	0.29	0.20	0.32		2.23	2.41	2.43	1.84	
C. V. (%)	5.18	5.54	5.34	5.29		4.73	3.69	7.81	7.11		4.91	5.49	5.30	4.02	

Hybrids	Leaf breadth (cm)					Stem diameter (cm)					Green fodder yield per plant (g)				
	E_1	E_2	E_3	E_4	Mean	E_1	E_2	E_3	E_4	Mean	E_1	E_2	E_3	E_4	Mean
9A × HJ 513	4.2	7.3	6.6	6.2	6.1	13.0	18.0	19.2	16.4	16.7	153.3	155.0	168.3	171.7	162.1
9A × HJ 541	6.3	6.8	6.3	5.2	6.2	17.0	20.1	12.7	14.6	16.1	163.3	151.7	146.7	240.0	175.4
9A × IS 2389	6.2	7.3	6.3	4.6	6.1	19.2	16.3	14.7	18.0	17.1	213.3	271.7	148.3	141.7	193.8
9A × G 46	5.5	6.0	6.4	6.6	6.1	13.5	17.6	13.4	21.8	16.6	228.3	195.0	156.7	133.3	178.3
14A × HJ 513	7.8	7.6	6.2	6.3	7.0	21.8	13.8	16.4	20.0	18.0	181.7	178.3	163.3	118.3	160.4
14A × HJ 541	8.0	6.6	5.2	6.3	6.5	20.0	17.1	14.6	17.2	17.2	161.7	218.3	168.3	173.3	180.4
14A × IS 2389	8.0	6.0	6.6	6.2	6.7	17.3	16.3	19.2	12.6	16.4	171.7	170.0	146.7	125.0	153.4
14A × G 46	7.0	6.3	7.0	5.2	6.4	14.6	14.6	13.8	14.7	14.4	240.0	233.3	148.3	171.7	198.3
31A × HJ 513	5.2	6.6	7.1	4.6	5.9	12.7	16.4	17.1	18.0	16.1	211.7	233.3	156.7	141.7	185.9
31A × HJ 541	7.2	6.7	6.3	7.3	6.9	14.7	14.1	13.4	13.1	13.8	181.7	173.3	181.7	133.3	167.5
31A × IS 2389	6.3	6.8	6.2	5.3	6.2	15.6	13.6	12.7	19.2	15.3	171.7	165.0	118.3	181.7	159.2
31A × G 46	6.4	7.5	5.2	5.5	6.2	12.7	15.8	14.7	13.4	14.2	136.7	155.0	173.3	125.0	147.5
56A × HJ 513	7.6	7.0	6.6	6.3	6.9	17.8	14.0	18.0	13.8	15.9	243.3	181.7	163.3	171.7	190.0
56A × HJ 541	7.6	7.1	7.3	6.3	7.1	13.2	14.0	18.0	17.1	15.6	168.3	200.0	115.0	181.7	166.3
56A × IS 2389	7.3	6.3	6.6	6.4	6.7	13.0	12.9	20.1	12.7	14.7	146.7	171.7	195.0	141.7	163.8
56A × G 46	6.3	5.7	7.0	6.2	6.3	14.2	13.4	19.2	14.7	15.4	211.7	198.3	170.0	133.3	178.3
465A × HJ 513	7.2	6.5	6.3	5.2	6.3	13.0	14.9	17.2	18.0	15.8	265.0	266.7	233.3	118.3	220.8

Contd.

Table 2 contd.

465A × HJ 541	8.5	5.8	6.2	6.6	6.8	16.7	15.5	12.6	21.8	16.7	145.0	141.7	173.3	173.3	158.3
465A × IS 2389	6.3	7.1	5.2	6.3	6.2	13.7	13.6	16.4	20.0	15.9	148.3	153.3	141.7	168.3	152.9
465A × G 46	7.9	6.9	4.6	7.0	6.6	17.2	17.6	14.6	13.0	15.6	156.7	173.3	163.3	146.7	160.0
467A × HJ 513	8.2	6.3	6.3	7.3	7.0	13.1	13.9	18.0	19.2	16.1	180.0	170.0	155.0	173.3	169.6
467A × HJ 541	7.9	5.4	6.4	6.3	6.5	19.5	15.5	20.1	16.4	17.9	118.3	150.0	151.7	181.7	150.4
467A × IS 2389	7.2	4.7	6.2	7.0	6.3	11.3	13.7	12.7	14.6	13.1	173.3	171.7	171.7	170.0	171.7
467A × G 46	6.1	5.7	5.2	6.2	5.8	19.2	13.7	14.7	17.2	16.2	223.3	191.7	240.0	233.3	222.1
SSG 59-3 (Ch.)	4.8	4.6	5.7	5.4	5.1	14.2	11.7	12.7	13.0	12.9	146.7	150.0	165.0	141.7	150.9
MFSH 4 (Ch.)	5.2	5.2	5.5	5.6	5.4	13.8	14.1	14.7	14.2	14.2	156.7	155.0	155.0	153.3	155.0
Mean	6.8	6.4	6.2	6.1	6.4	15.5	15.1	15.8	16.3	15.7	180.7	183.7	164.2	159.4	172.0
Range	4.2- 8.5	4.6- 7.6	4.6- 7.3	4.6- 7.3		11.3- 21.8	11.7- 20.1	12.6- 20.1	12.6- 21.8		118.3- 265.0	141.7- 271.7	115.0- 240.0	118.3- 240.0	
C. D. (P=0.05)	0.92	0.97	1.15	1.15		1.86	2.22	2.11	1.80		15.97	16.81	16.33	14.90	
S. E(m)	0.32	0.34	0.40	0.40		0.65	0.78	0.74	0.63		5.60	5.90	5.73	5.23	
C. V. (%)	8.25	9.31	11.37	11.62		7.32	8.97	8.14	6.73		5.37	5.57	6.05	5.69	

TABLE 3

Mean performance of parents under different environments for various characters in forage sorghum

Parents	Plant height (cm)					Total number of tillers per plant					Leaf length (cm)				
	E_1	E_2	E_3	E_4	Mean	E_1	E_2	E_3	E_4	Mean	E_1	E_2	E_3	E_4	Mean
9A	142.7	147.3	141.0	149.7	145.2	1.3	1.3	1.3	1.3	1.3	93.0	86.0	85.3	75.0	84.8
14A	155.3	126.0	142.0	152.7	144.0	1.7	1.3	1.0	1.3	1.3	84.7	86.0	74.7	84.7	82.5
31A	137.0	121.3	131.7	160.0	137.5	1.3	2.0	2.0	1.0	1.6	71.7	80.0	70.0	66.7	72.1
56A	146.7	138.3	134.3	148.3	141.9	2.0	1.3	2.0	1.0	1.6	76.3	61.0	91.7	72.3	75.3
465A	133.7	128.7	162.0	157.7	145.5	2.0	1.3	1.0	1.3	1.4	74.0	79.0	76.7	86.3	79.0
467A	146.7	157.7	166.0	151.7	155.5	2.0	1.3	1.0	1.0	1.3	75.7	88.7	83.0	76.7	81.0
HJ 513	177.0	153.7	165.0	141.7	159.4	1.7	1.3	1.0	1.3	1.3	92.3	87.3	78.3	75.7	83.4
HJ 541	141.7	151.3	151.7	168.3	153.3	2.0	1.0	1.0	1.0	1.3	80.7	79.3	73.3	92.3	81.4
IS 2389	191.7	166.3	153.3	157.0	167.1	1.7	1.3	1.0	2.3	1.6	88.7	81.3	73.0	80.7	80.9
G 46	173.3	157.0	156.0	156.0	160.6	2.3	1.3	1.0	1.7	1.6	81.0	66.7	80.3	70.7	74.7
Mean	154.6	144.8	150.3	154.3	151.0	1.8	1.3	1.2	1.3	1.4	81.8	79.5	78.6	78.1	79.5
Range	133.7- 191.7	121.3- 166.3	131.7- 166.0	141.7- 168.3		1.3- 2.3	1.0- 2.0	1.0- 2.0	1.0- 2.3		71.7- 93.0	61.0- 88.7	70.0- 91.7	66.7- 92.3	
C. D. (P=0.05)	14.43	12.55	13.31	18.50		0.87	1.02	0.32	2.74		5.63	8.03	7.43	13.48	
S. E.(m)	4.82	4.19	4.45	6.19		0.29	0.34	0.11	0.91		1.88	2.68	2.48	4.51	
C. V. (%)	5.40	5.01	5.12	8.09		18.09	20.17	14.80	22.81		3.98	5.84	5.47	9.44	

Table 3 contd.

Parents	Leaf breadth (cm)					Stem diameter (cm)					Green fodder yield per plant (g)				
	E_1	E_2	E_3	E_4	Mean	E_1	E_2	E_3	E_4	Mean	E_1	E_2	E_3	E_4	Mean
9A	5.5	7.0	4.6	5.2	5.6	17.1	16.2	13.4	12.6	14.8	156.7	140.0	141.7	141.7	145.0
14A	7.1	7.0	6.6	6.6	6.8	15.6	17.5	16.4	13.4	15.7	206.7	213.3	133.3	153.3	176.7
31A	6.3	6.6	6.3	7.3	6.6	17.2	16.4	14.6	18.0	16.6	146.7	115.0	181.7	170.0	153.4
56A	5.6	5.3	6.3	7.0	6.1	12.6	14.6	21.8	13.0	15.5	195.0	195.0	163.3	233.3	196.7
465A	7.7	5.5	6.4	7.1	6.7	15.7	17.0	20.0	18.0	17.7	173.3	181.7	168.3	181.7	176.3
467A	7.5	7.5	7.3	7.0	7.3	17.4	12.2	19.2	20.1	17.2	273.3	281.7	146.7	155.0	214.2
HJ 513	5.2	7.9	6.3	7.3	6.7	13.4	13.8	13.8	16.4	14.4	125.0	135.0	171.7	151.7	145.9
HJ 541	6.2	5.4	5.7	6.3	5.9	14.2	11.6	17.1	14.6	14.4	171.7	166.7	240.0	148.3	181.7
IS 2389	5.2	6.2	5.5	6.3	5.8	11.8	14.3	13.0	13.0	13.0	135.0	141.7	115.0	156.7	137.1
G 46	6.6	5.2	6.3	6.4	6.1	12.9	15.8	13.4	19.2	15.3	120.0	133.3	195.0	173.3	155.4
Mean	6.3	6.4	6.1	6.7	6.4	14.8	14.9	16.3	15.8	15.5	170.3	170.3	165.7	166.5	168.2
Range	5.2- 7.7	5.2- 7.9	4.6- 7.3	5.2- 7.3		11.8- 17.4	11.6- 17.5	13.0- 21.8	12.6- 20.1		120.0- 273.3	115.0- 281.7	115.0- 240.0	141.7- 233.3	
C. D. (P=0.05)	1.32	1.48	2.25	2.54		1.88	1.79	4.62	6.58		19.91	16.06	18.92	23.86	
S. E.(m)	0.44	0.50	0.75	0.85		0.63	0.60	1.54	2.20		6.65	5.36	6.33	7.98	
C. V. (%)	12.14	13.50	10.49	12.26		7.36	6.95	6.74	7.59		6.76	5.45	8.07	9.09	

HJ 513 (12.7 cm) and 31A × G 46 (12.7 cm) in E_1; while in E_2, the check SSG 59-3 (11.7 cm) gained minimum stem diameter, followed by 56A × IS 2389 (12.9 cm) and 56A × G 46 (13.4 cm). The minimum stem diameter was shown by the 465A × HJ 541 (12.6 cm) followed by cross 9A × HJ 541 (12.7), 31A × IS 2389 (12.7 cm), check SSG 59-3 (12.7 cm) and 467A × IS 2389 (12.7 cm) in E_3; while in E_4, the cross 14A × IS 2389 (12.6 cm) attained minimum stem diameter, followed by 56A × IS 2389 (12.7 cm), check SSG 59-3 (13.0 cm) and cross 465A × G 46 (13.0 cm). On the basis of overall mean across all the four environments among male parents, IS 2389 (13.0 cm) and HJ 513 (14.4 cm) and HJ 541 (14.4 cm) and among female parents 9A (14.8 cm) and 56A (15.5 cm) showed maximum stem diameter. The check SSG 59-3 (12.9 cm) recorded minimum stem diameter, followed by cross 467A × IS 2389 (13.1 cm) and 31A × HJ 541 (13.8 cm). Similar results were reported by Agarwal and Shrotria (2005), Satpute *et al.* (2005), Wang *et al.* (2013) and Rana *et al.* (2013).

CONCLUSION

On the basis of overall mean performance, hybrids 467A × G 46 showed maximum green fodder yield (222.1 g) followed by 465A × HJ 513 (220.8 g) and 14A × G 46 (198.3 g). This hybrid was also good for plant height (141.9 cm) and leaf length (81.7 cm). Hybrid 56A × G 46 (86.3 cm) recorded higher leaf length and is also better for green fodder yield (178.3 g) and plant height (159.4 cm). Hybrid 9A × G 46 (83.8 cm) recorded higher leaf length and was also better for green fodder yield (178.3 g) and plant height (150.9 cm). This information thus obtained can be used for breeding of multicut varieties of sorghum to meet ever increasing demand of green fodder for the livestock.

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