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ASSESSMENT OF QUALITY COMPONENTS IN MULTICUT FORAGE SORGHUM IN DIFFERENT ENVIRONMENTS

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SUMMARY

Hybrids were developed in a Line x Tester mating fashion on six females (lines) using four males (testers) to estimate the variability in quality traits in different environments. For this purpose, 24 specific cross combinations were developed by using these 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. High and positive environmental index showed that E_1 was the best environment for the expression of protein content, protein yield, *in vitro* dry matter digestibility, dry matter digestibility and HCN content. Hybrids 31A × IS 2389 recorded minimum HCN content (33.41 mg per kg green weight) followed by 9A × HJ G 46 (35.50 mg per kg green weight), 9A × HJ 541(38.18 mg per kg green weight). Other hybrids that showed low HCN content were 56A × IS 2389 (41.75 mg per kg green weight), 31A × HJ 513 (42.91 mg per kg green weight), 467A × G 46 (46.95 mg per kg green weight) and 9A × HJ 513 (47.92 mg per kg green weight)

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

The main quality attributes in forage sorghum are protein, IVDMD and HCN content. Out of these protein and IVDMD are the most important. Like other straw, the nutritive value of sorghum fodder is also low due to presence of high content of above mentioned cell wall constituents as well as lignin and low content of protein and minerals. Crude protein (CP) content is often considered as a good determinant of quality. Crude protein is commonly used measure of feed quality. Good quality forage generally will have higher protein content. The major goal in breeding programme is to improve crude protein more than 9 per cent (Kumar *et al*. 2011).

At present, livestock population survives to a large extent on crop residues, which are nutritionally poor. For stepping up livestock production, the evaluation of sorghum fodder for its nutritive value in an inescapable obligation. Improvement in digestibility, protein per cent and intake may lower the animal production costs. The most rapid method of improving forage sorghum quality is to improve IVDMD *i.e.* i*n vitro* dry matter digestibility. When IVDMD is increased, winter hardiness is decreased, prussic acid glycosides may be increased and maturity is extended. Availability of genetic variability for the component characters is a major asset for initiating a fruitful crop improvement programme. 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.

MATERIALS AND METHOD

The experimental material for the present study comprised of 24 forage sorghum hybrids, 10 parents (six female and four male) and two standard checks (SSG 59-3 and MFSH 4). Hybrids were developed in a Line x Tester mating fashion on six females (lines) using four males (testers). The crosses were made in research area of Forage section, Department of Genetics and Plant Breeding, CCS HAU, 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 and Plant Breeding, Chaudhary Charan Singh Haryana Agricultural University, Hisar and Regional Research Station Uchani, Karnal with two date of sowing (Early and late sowing) during the *kharif* season of 2015-16. All the thirty six genotypes were grown in a randomized block design in three replications of a two-row plot of 4.0 m length. All the recommended cultural package of practices was followed from sowing to harvesting of the crop. Data on five randomly taken plants from each genotype in each replication were recorded on different quality characters *viz.* TSS content [total soluble sugars (%)], protein content (%), protein yield (g/plant), IVDMD [(*in vitro* dry matter digestibility (%)], DDM [dry matter digestibility (g/plant)] and HCN content (mg/kg green weight) in all the four environments (Table 3) at first cut (55 days after sowing) and second cut (45 days after first cut).

RESULTS AND DISCUSSION

Total soluble sugars [TSS (%)]

The check SSG 59-3 (5.8 per cent) showed maximum TSS followed by the check MFSH 4 (4.5 per cent) and crosses 31A × IS 2389 and 465A × HJ 541 (4.3 per cent) in E_1; while in E_2, the check SSG 59-3 (6.3 per cent) exhibited maximum TSS, followed by check MFSH 4 (4.5 per cent) and cross 467A × G 46 (4.0 per cent). The maximum TSS was shown by the check SSG 59-3 (5.5 per cent) followed by Check MFSH 4 (5.4 per cent) and cross 14A × HJ 513, 14A × IS 2389, 465A × HJ 513 and 467A × IS 2389 (4.3 per cent) in E_3; while in E_4, the check MFSH 4 and cross 31A × IS 2389 (4.8 per cent)] recorded maximum total soluble sugar, followed by 31A × G 46 (4.5 per cent), 9A × HJ 541, 31A × HJ 541 and 56A × G 46 (4.3 per cent) (Table 1). As far as parents are concerned, among male parents HJ 513 (3.8 per cent) and G 46 (3.6 per cent) and among female parents 465A (3.9 per cent) and 9A (3.7 per cent) showed maximum TSS (Table 4.3c). The check SSG 59-3 (5.4 per cent) had maximum TSS followed by the check MFSH 4 (4.8 per cent) and cross 9A × IS 2389 (3.7 per cent) on the basis of overall mean in all the four environments (Table 2). Similar results have been reported by Joshi *et. al* (2009).

Protein content (%)

The highest protein content was shown by the cross 56A × HJ 541 (11.19 per cent) followed by 9A × G 46 (10.75 per cent) and 9A × HJ 513 (10.46 per cent) in E_1; while in E_2, the cross 14A × HJ 541 (10.39 per cent) exhibited maximum protein content followed by 9A × G 46 (9.85 per cent) and 465A × HJ 513 (9.69 per cent). The highest protein content was shown by the crosses 467A × IS 2389 and 465A × HJ 541 (10.75 per cent) and followed by 31A × HJ 541, 31A × G 46, 56A × G 46 and 467A × HJ 513 (10.20 per cent) in E_3; while in E_4, the crosses 14A × G 46, 31A × G 46, 56A × IS 2389, 467A × IS 2389 and 465A × IS 2389 (10.20 per cent) attained maximum protein content followed by 9A × IS 2389 and 14A × HJ 541 (10.08 per cent) (Table 1). In case of male parents, HJ 513 (9.76 per cent) and IS 2389 (9.56 per cent) and among female parents 9A (9.91 per cent) and 465A (3.9 per cent) showed maximum protein content (Table 2). The crosses 31A × G 46 (10.03 per cent) had maximum protein content followed by 14A × G 46 (9.97 per cent) and 9A × G 46 (9.89 per cent) on the basis of overall mean in all the four environments (Table 1 and 2). Similar results have been reported by Tariq *et. al* (2012).

Protein yield per plant (g)

The highest protein yield was shown by the cross 465A × HJ 513 (13.87 g) followed by 9A × G 46 (13.59 g) and 14A × G 46 (12.53 g) in E_1; while in E_2, the cross 14A × HJ 541 (13.02 g) exhibited maximum protein yield followed by crosses 9A × IS 2389 (12.13 g) and 465A × HJ 513 (11.99 g). The highest protein yield was shown by the cross 467A × IS 2389 (10.68 g) followed by 56A × IS 2389 (10.40 g) and 465A × HJ 541 (10.38 g) in E_3, the cross 9A × HJ 541 (11.02 g) had maximum protein yield followed by 467A × HJ 541 (10.53 g) and 467A × HJ 513 (10.35 g) in E_4. On the basis of overall mean in all the four environments, male parents HJ 513 (8.24 g) and G 46 (7.85 g) and female parents 56A (9.85 g) and 467A (9.43 g) showed maximum protein yield. The cross 14A × G 46 (10.46 g) exhibited maximum protein yield, followed by 9A × G 46 (10.20 g) and 14A × HJ 541 (10.14 g) (Table 1 and 2). Similar results have been reported by Cunha and Lima (2010) and Tariq *et. al* (2012).

In vitro dry matter digestibility [IVDMD (%)]

The cross 9A × G 46 (60.11 per cent) showed maximum IVDMD followed by 9A × IS 2389 (58.36 per cent) and 467A × HJ 513 (56.90 per cent) in E_1; while in E_2, the cross 9A × HJ 513 (59.80 per cent) exhibited maximum IVDMD, followed by 14A × HJ 541 (58.00 per cent) and 9A × HJ 541 (56.32 per cent). The highest IVDMD was shown by the cross 465A ×

TABLE 1

Mean performance of different hybrids under different environments for different characters in forage sorghum

Hybrids	Total soluble sugars (%)					Protein content (%)					Protein 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	2.7	2.8	3.0	3.2	2.9	10.46	8.80	10.08	9.65	9.75	8.85	7.55	9.39	9.30	8.77
9A × HJ 541	3.2	4.0	3.0	4.3	3.6	10.20	9.64	8.87	9.32	9.51	8.14	7.23	7.68	11.02	8.52
9A × IS 2389	3.7	2.7	4.2	4.2	3.7	9.08	8.89	8.87	10.08	9.23	11.21	12.13	7.99	8.87	10.05
9A × G 46	2.7	2.0	3.2	2.7	2.6	10.75	9.85	10.08	8.87	9.89	13.59	11.02	9.38	6.80	10.20
14A × HJ 513	3.0	2.8	4.3	2.3	3.1	8.81	9.05	7.89	8.87	8.65	8.94	9.04	6.71	6.48	7.79
14A × HJ 541	3.0	2.8	2.7	4.2	3.2	9.65	10.39	9.08	10.08	9.80	9.81	13.02	8.33	9.40	10.14
14A × IS 2389	4.2	3.0	4.3	3.0	3.6	9.32	9.53	8.87	7.89	8.90	9.91	9.71	7.53	5.78	8.23
14A × G 46	4.2	3.0	2.5	4.2	3.5	10.39	9.20	10.08	10.20	9.97	12.53	10.74	8.73	9.83	10.46
31A × HJ 513	4.2	2.7	2.8	3.2	3.2	9.11	7.68	7.89	9.08	8.44	10.02	9.58	7.73	8.00	8.83
31A × HJ 541	3.2	2.8	4.0	4.3	3.6	10.08	8.91	10.20	9.65	9.71	10.23	8.74	10.00	7.38	9.09
31A × IS 2389	4.3	2.7	2.3	4.8	3.5	8.99	8.58	7.80	9.32	8.67	9.57	8.74	5.82	10.23	8.59
31A × G 46	1.5	3.0	4.2	4.5	3.3	10.08	9.65	10.20	10.20	10.03	8.72	8.87	10.18	7.78	8.89
56A × HJ 513	2.2	3.5	3.0	3.0	2.9	8.87	8.55	9.08	7.80	8.58	10.70	8.69	8.03	7.24	8.67
56A × HJ 541	3.0	3.3	3.0	4.2	3.4	11.19	8.81	9.65	9.85	9.88	10.64	9.81	7.05	9.86	9.34
56A × IS 2389	2.7	3.0	4.2	2.7	3.1	7.99	9.52	9.32	10.20	9.26	6.52	8.27	10.40	8.65	8.46
56A × G 46	2.7	3.8	3.2	4.3	3.5	9.02	9.47	10.20	9.08	9.44	10.23	9.57	9.50	6.82	9.03
465A × HJ 513	3.5	3.2	4.3	2.5	3.4	10.29	9.69	7.80	8.22	9.00	13.87	11.99	8.57	6.01	10.11
465A × HJ 541	4.3	2.8	2.7	4.2	3.5	8.87	8.86	10.75	9.11	9.40	7.81	7.42	10.38	8.54	8.54
465A × IS 2389	2.8	3.0	4.3	2.7	3.2	10.08	9.42	8.81	10.20	9.63	8.38	7.84	7.45	9.85	8.38
465A × G 46	2.5	3.7	2.5	2.8	2.9	7.89	9.56	9.65	8.76	8.97	7.34	9.37	9.50	8.02	8.56
467A × HJ 513	2.8	3.2	2.8	4.0	3.2	8.88	8.60	10.20	9.84	9.38	9.45	8.37	9.17	10.35	9.33
467A × HJ 541	3.2	3.5	4.0	2.7	3.3	9.32	8.22	9.08	9.85	9.12	6.98	7.29	8.19	10.53	8.25
467A × IS 2389	3.7	3.0	4.3	3.0	3.5	8.76	9.11	10.75	10.20	9.71	9.34	9.60	10.68	9.50	9.78
467A × G 46	2.5	4.0	3.0	2.7	3.0	9.11	8.02	8.81	9.08	8.76	11.56	8.95	9.74	9.99	10.06
SSG 59-3 (Check)	5.8	6.3	5.5	3.8	5.4	8.75	8.57	8.21	10.07	8.90	7.16	7.87	8.10	8.38	7.88
MFSH 4 (Check)	4.5	4.5	5.4	4.8	4.8	9.85	8.43	9.09	8.86	9.06	9.53	8.02	8.65	8.14	8.59
General mean	3.3	3.3	3.6	3.5	3.4	9.45	9.04	9.28	9.40	9.29	9.66	9.21	8.65	8.57	9.02
Range	1.5- 5.8	2.0- 6.3	2.3- 5.5	2.3- 4.8	2.6- 5.4	7.89- 11.19	7.68- 10.39	7.80- 10.75	7.80- 10.20	8.44- 10.03	6.52- 13.87	7.23- 13.02	5.82- 10.68	5.78- 11.02	7.79- 10.46
C.D. at 5 %	1.21	1.20	1.32	1.25		0.22	0.40	0.17	0.17		1.00	0.88	0.90	0.75	
S.E.(m)	0.43	0.42	0.46	0.44		0.08	0.14	0.06	0.06		0.35	0.31	0.32	0.26	
C.V. (%)	22.32	22.35	22.57	21.36		4.44	5.72	4.13	4.09		6.30	5.79	6.35	5.31	

Table 1 contd.

Hybrids	In vitro dry matter digestibility (%)					Dry matter digestibility per plant (g)					HCN (mg/kg green weight)				
	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	53.86	59.80	55.40	60.26	57.33	45.75	50.86	51.68	58.21	51.62	50.32	48.24	44.87	48.24	47.92
9A × HJ 541	50.32	56.32	47.92	49.92	51.12	40.25	42.24	41.51	59.08	45.77	40.54	35.98	40.38	35.82	38.18
9A × IS 2389	58.36	43.96	45.56	52.36	50.06	72.02	60.05	41.01	46.21	54.82	50.88	52.96	47.60	47.60	49.76
9A × G 46	60.11	49.69	44.89	59.71	53.60	76.12	55.48	41.84	45.75	54.80	31.57	35.74	35.58	39.10	35.50
14A × HJ 513	54.11	55.69	47.29	54.51	52.90	55.02	55.70	40.20	39.93	47.71	51.44	50.16	48.72	46.15	49.12
14A × HJ 541	46.46	58.00	42.00	48.46	48.73	47.22	72.51	38.50	45.23	50.87	51.12	52.08	49.04	58.01	52.56
14A × IS 2389	47.78	47.70	43.30	40.18	44.74	50.92	48.51	36.78	29.45	41.41	46.23	49.44	48.56	49.36	48.40
14A × G 46	49.78	48.14	45.74	48.98	48.16	59.82	56.21	39.65	47.36	50.76	64.34	66.59	58.81	67.31	64.26
31A × HJ 513	48.12	44.92	49.32	49.32	47.92	52.96	56.12	48.47	43.51	50.27	41.59	41.99	42.47	45.59	42.91
31A × HJ 541	45.07	53.47	42.27	42.27	45.77	45.81	52.57	41.57	32.37	43.08	52.56	50.32	54.49	55.13	53.12
31A × IS 2389	53.47	55.00	45.80	42.27	49.14	57.01	55.93	34.31	46.47	48.43	39.10	34.78	29.81	29.97	33.41

Contd.

Table 1 contd..

31A × G 46	55.07	48.33	47.53	54.27	51.30	47.69	44.33	47.55	41.56	45.28	75.72	78.20	65.22	70.43	72.39
56A × HJ 513	48.34	51.54	45.94	51.14	49.24	58.13	52.39	40.60	47.70	49.70	62.58	59.21	58.17	53.04	58.25
56A × HJ 541	51.58	52.38	49.58	55.58	52.28	49.00	58.50	36.33	55.57	49.85	50.96	48.48	47.11	53.28	49.96
56A × IS 2389	52.27	54.63	48.63	53.07	52.15	42.68	47.43	54.35	45.10	47.39	47.60	51.28	33.65	34.45	41.75
56A × G 46	49.91	50.71	57.11	37.91	48.91	56.57	51.56	53.31	28.42	47.47	62.18	60.82	58.01	54.09	58.77
465A × HJ 513	50.60	56.20	58.20	45.40	52.60	68.28	70.27	64.05	33.26	58.96	69.39	64.42	72.76	70.99	69.39
465A × HJ 541	47.06	42.30	55.90	63.06	52.08	41.53	35.28	54.03	58.88	47.43	57.13	54.81	53.69	51.52	54.29
465A × IS 2389	51.83	45.81	48.21	50.63	49.12	43.16	38.19	40.94	48.92	42.80	82.85	80.21	73.72	81.97	79.69
465A × G 46	47.75	47.37	44.97	54.55	48.66	44.50	46.57	44.23	49.96	46.31	51.84	46.47	46.31	48.48	48.28
467A × HJ 513	56.90	46.50	53.30	44.90	50.40	60.68	44.99	47.99	47.12	50.20	52.48	46.79	55.93	43.35	49.64
467A × HJ 541	50.95	43.39	54.99	44.95	48.57	38.17	38.34	49.50	47.93	43.48	63.14	69.63	68.59	64.82	66.55
467A × IS 2389	53.40	45.80	48.20	40.20	46.90	56.95	48.12	48.10	37.51	47.67	53.77	51.36	48.88	55.29	52.32
467A × G 46	56.61	49.39	51.39	49.01	51.60	71.74	55.17	56.61	53.93	59.36	50.72	41.59	48.88	46.63	46.95
SSG 59-3 (Check)	45.45	47.50	45.90	48.65	46.88	37.18	43.56	45.18	40.59	41.63	51.13	52.33	48.72	58.58	52.69
MFSH 4 (Check)	50.60	42.33	47.53	45.00	46.37	48.97	40.23	45.17	41.32	43.92	45.52	49.92	47.76	49.92	48.28
General mean	51.38	49.88	48.73	49.48	49.87	52.62	50.81	45.52	45.05	48.50	53.72	52.84	51.07	52.27	52.47
Range	45.07-60.11	42.30-59.80	42.00-58.20	37.91-63.06	44.74-57.33	37.18-76.12	35.28-72.51	34.31-64.05	28.42-59.08	41.41-59.36	31.57-82.85	34.78-80.21	29.81-73.72	29.97-81.97	33.41-79.69
C.D. at 5 %	0.17	0.18	0.19	0.16		5.03	4.85	4.66	3.97		0.34	0.34	0.55	0.39	
S.E.(m)	0.06	0.06	0.07	0.06		1.77	1.70	1.64	1.40		0.12	0.12	0.19	0.14	
C.V. (%)	3.20	3.22	3.24	3.20		5.81	5.80	6.22	5.36		4.38	4.39	4.66	4.45	

Table 2

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

Hybrids	Total soluble sugars (%)					Protein content (%)					Protein 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	4.2	3.2	3.0	4.3	3.7	10.61	9.72	9.65	9.65	9.91	8.35	7.24	7.37	7.40	7.59
14A	2.7	2.3	4.2	2.5	2.9	8.34	9.75	10.20	9.32	9.40	8.77	10.58	7.63	7.60	8.65
31A	3.3	3.0	2.8	2.7	3.0	8.79	9.08	9.08	10.08	9.26	7.02	6.66	8.93	9.24	7.96
56A	2.8	2.7	4.0	3.0	3.1	9.53	9.65	9.85	8.87	9.48	10.05	10.29	8.73	10.33	9.85
465A	4.0	5.2	3.2	3.3	3.9	10.33	9.89	9.65	8.22	9.52	8.77	8.70	9.32	8.38	8.79
467A	2.7	4.8	2.8	3.0	3.3	9.53	7.99	9.32	9.11	8.99	12.11	10.54	7.59	7.47	9.43
HJ 513	4.3	4.5	3.2	3.0	3.8	9.55	10.20	10.20	9.08	9.76	7.15	7.80	9.82	8.19	8.24
HJ 541	2.5	3.3	4.3	3.0	3.3	8.64	7.80	9.08	8.87	8.60	7.91	6.77	9.70	6.66	7.76
IS 2389	3.8	2.3	4.2	3.0	3.3	9.26	8.82	10.08	10.08	9.56	7.29	7.18	7.37	9.05	7.72
G 46	3.3	4.2	2.7	4.2	3.6	10.20	9.20	8.87	7.89	9.04	7.63	7.50	9.03	7.23	7.85
General mean	3.4	3.6	3.4	3.2	3.4	9.48	9.21	9.60	9.12	9.35	8.50	8.33	8.55	8.16	8.38
C.D. at 5 %	1.40	1.16	1.24	1.45		0.44	0.32	0.13	0.18		0.86	0.89	0.95	0.84	
S.E.(m)	3.14	0.39	0.43	0.47		0.15	0.11	0.04	0.06		0.29	0.30	0.32	0.28	
C.V. (%)	24.04	18.88	21.84	25.21		6.67	6.01	5.78	5.13		5.87	6.17	6.44	5.93	

Parents	In vitro dry matter digestibility (%)					Dry matter digestibility/plant (g)					HCN content (mg/kg green weight)				
	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	63.46	63.04	52.24	49.46	57.05	49.72	47.26	40.00	37.92	43.73	50.88	53.77	51.76	52.88	52.32
14A	54.15	50.61	47.81	42.15	48.68	56.89	54.85	35.85	34.43	45.50	69.39	64.10	73.72	70.03	69.31
31A	50.57	54.59	45.39	42.17	48.18	40.44	39.98	44.62	38.68	40.93	40.30	41.91	39.90	43.27	41.35
56A	51.82	56.24	45.04	45.82	49.73	54.45	59.98	39.80	53.41	51.91	58.25	57.61	52.08	55.77	55.93
465A	43.27	43.69	47.29	49.27	45.88	36.77	38.60	45.68	50.09	42.79	55.69	49.52	53.69	47.03	51.48
467A	54.12	49.76	42.16	48.52	48.64	68.58	65.53	34.40	39.63	52.04	56.49	54.81	52.72	57.61	55.41
HJ 513	51.00	55.80	43.40	45.00	48.80	38.24	42.74	41.88	40.50	40.84	34.62	43.75	37.82	38.62	38.70
HJ 541	55.45	58.27	45.87	47.45	51.76	50.81	50.55	48.97	35.58	46.48	37.90	30.37	30.93	35.74	33.73
IS 2389	53.09	47.87	49.47	42.29	48.18	41.62	39.10	36.23	38.05	38.75	52.48	51.28	54.33	56.17	53.57
G 46	37.84	45.02	42.22	49.44	43.63	28.35	36.77	42.93	45.34	38.35	58.49	56.97	51.92	55.53	55.73
General mean	51.48	52.49	46.09	46.16	49.05	46.59	47.54	41.04	41.36	44.13	51.45	50.41	49.89	51.27	50.75
C.D. at 5 %	0.16	0.12	0.12	0.16		4.89	4.28	4.37	3.93		0.27	0.39	0.45	0.25	
S.E.(m)	0.05	0.04	0.04	0.05		1.63	1.43	1.46	1.31		0.09	0.13	0.15	0.08	
C.V. (%)	3.18	3.13	3.15	3.20		6.08	5.21	6.16	5.50		4.31	4.45	4.52	4.28	

HJ 513 (58.20 per cent) followed by 56A × G 46 (57.11 per cent) and 465A × HJ 541 (55.90 per cent) in E_3; while in E_4, the cross 465A × HJ 541 (63.06 per cent) attained maximum IVDMD, followed by 9A × HJ 513 (60.26 per cent) and 9A × G 46 (59.71 per cent). Male parents HJ 513 (3.8 per cent) and G 46 (3.6 per cent) and female 465A (3.9 per cent) and 9A (3.7 per cent) showed highest IVDMD. The cross 9A × HJ 513 (57.33 per cent) had highest IVDMD followed by 9A × G 46 (53.60 per cent) and 14A × HJ 513 (52.90 per cent) on the basis of overall mean in all the four environments (Table 1 and 2). Similar results have been reported by Bhatt and Singh (2005) and Joshi *et. al* (2009).

Dry matter digestibility per plant [DDM (g)]

The highest DDM was recorded by the cross 9A × G 46 (76.12 g) followed by 9A × IS 2389 (72.02 g) and 467A × G 46 (71.74 g) in E_1; while in E_2, the cross 14A × HJ 541 (72.51 g) exhibited highest DDM followed by 465A × HJ 513 (70.27 g) and 9A × IS 2389 (60.05 g). The highest DDM) in E_3 was shown by the cross 465A × HJ 513 (64.05 g) followed by 467A × G 46 (56.61 g) and 56A × IS 2389 (54.35 g). The cross 9A × HJ 541 (59.08 g) had maximum DDM, followed by 465A × HJ 541 (58.88 g) and 9A × HJ 513 (58.21 g) in E_4. HJ 541 (46.48 g) and HJ 513 (40.84 g) among male and 467A (52.04 g) and 56A (51.91 g) among the female showed maximum DDM. The cross 467A × G 46 (59.36 g) exhibited maximum DDM followed by 465A × HJ 513 (58.96 g) and 9A × IS 2389 (54.82 g) on the basis of overall mean in all the four environments (Table 1 and 2). Similar results have been reported by Singh *et. al* (2010), and Tariq *et. al* (2012).

HCN content (mg/kg green weight)

Low HCN is desirable and hence the cross combinations having negative heterosis for HCN content were desirable. The minimum HCN was shown by the cross 9A × G 46 (31.57 mg) followed by 31A × IS 2389 (39.10 mg) and 9A × HJ 541 (40.54 mg) in E_1; while in E_2, the cross 31A × IS 2389 (34.78 mg) exhibited minimum HCN, followed by 9A × G 46 (35.74 mg) and 9A × HJ 541 (35.98 mg). The minimum HCN was shown by the cross 31A × IS 2389 (29.81 mg) followed by 56A × IS 2389 (33.65 mg) and 9A × G 46 (35.58 mg) in E_3; while the cross 31A × IS 2389 (29.97 mg) recorded minimum HCN, followed by 56A × IS 2389 (34.45 mg) and 9A × HJ 541 (35.82 mg) in E_4. On the basis of overall mean in all the four environments, among male parents HJ 541 (33.73 mg) and among female parent 31A (41.35 mg) showed minimum HCN. The cross 31A × IS 2389 (33.41 mg) had minimum HCN, followed by 9A × G 46 (35.50 mg) and 9A × HJ 541 (38.18 mg) on the basis of overall mean (Table 1 and 2).

On the basis of overall mean performance, top ten promising hybrids in all the four test environments were identified for HCN content. Hybrids 31A × IS 2389 recorded minimum HCN content (33.41 mg per kg green weight) followed by 9A × HJ G 46 (35.50 mg per kg green weight), 9A × HJ 541(38.18 mg per kg green weight). Other hybrids that showed low HCN content were 56A × IS 2389 (41.75 mg per kg green weight), 31A × HJ 513 (42.91 mg per kg green weight), 467A × G 46 (46.95 mg per kg green weight) and 9A × HJ 513 (47.92 mg per kg green weight). Similar results have been reported by Singh *et. al* (2010), Cunha and Lima (2010) and Tariq *et. al* (2012).

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