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Genetic Analysis of CMS Based Rabi Sorghum (*Sorghum Bicolor* [L.] Moench) Single Cross Hybrids for Grain Yield and Yield Components

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ABSTRACT

The present investigation included twenty six CMS based rabi sorghum single cross hybrids evaluated at Foragen Seeds R&D farm located at Hyderabad, during rabi 2024. All 26 hybrids along with two commercial checks (repeated once) i.e. HT-3201 and HT-3206 for comparison. A trial of 30 hybrids was planted in randomized block design with two replications. Each hybrid was planted as 2 rows of 2m length and 30 cm spacing, all required recommended dose of fertilizers and agronomic practices were followed to see the full genetic potential of hybrids. Data was collected for five morphological traits viz., days to 50% flowering, plant height (cm), panicle length (cm), grain yield (kg ha^{-1}) and Green fodder yield (tons ha^{-1}). The ANOVA revealed that the hybrids were found significantly different for all the morphological traits under study. Based on the mean performance and cluster analysis, one hybrid i.e FGSH-7 was out yielded over check HT-3201 whereas, FGSH-25 was at par with check HT-3201 and none of the hybrids were found superior over check HT-3206. This means that hybrid FGSH-7 can be promoted for further testing in multiple locations. However, cluster I and VI were highest yielding clusters. The parents involved in the hybrids belongs to these clusters can be explored further for line development or a hybrid development program, also can be exploited for broadening of genetic base of the parents.

Keywords: *Sorghum, grain yield, variance, clustering, hybrids.*

1. INTRODUCTION

India is sixth largest producer of sorghum globally (Fig. 2) and contributing 7.21 percent share in world sorghum production (Fig. 3). Among the Indian states, Maharashtra recorded highest area and production of 16.9 lakh ha and 18.7 lakh tonnes respectively, followed by Karnataka, Rajasthan, Uttar Pradesh and Tamil Nadu during 2024-25 (Fig. 1). The productivity of the states viz., Andhra Pradesh, Madhya Pradesh and Telangana were recorded highest i.e. 3588, 2015 and 1756 kg per ha respectively, during 2024-25 (3rd advance estimate of DA&FW report 2024-25). To satisfy the growing population's need for food availability of male sterility system (CMS) in sorghum plays great role. Now nuclear male sterility system also been identified which will definitely contribute to boost the yield [1]. In many crops, including sorghum, heterosis, or hybrid vigor, the capacity of hybrids to exceed the finest inbred line is arguably the most crucial tactic to boost grain yield [2]. Cytoplasmic male sterility (CMS) currently serves as the primary method for generating male-sterile parents in the majority of crops amenable to hybrid seed mass production. Now a days, hybrids make up the majority of grain sorghum varieties utilized in agricultural production. Although there are different kinds of CMS lines available, the A_1 CMS, which was first described in the 1950s [3], is still the most common CMS line used to produce hybrids in sorghum [4]. Rabi sorghum is widely cultivated in the Deccan Plateau, specifically in the states of Maharashtra, Karnataka, and Andhra Pradesh. Rabi sorghum produces more fodder than kharif sorghum. Rabi sorghum cultivars must be resistant to significant pests (shoot fly), diseases (charcoal rot), and be ready to harvest early.

Cluster analysis is indeed a valuable technique for identifying superior grain sorghum hybrids. By grouping similar genotypes together based on traits like grain yield, green fodder yield and maturity, breeders can pinpoint promising hybrid combinations for further evaluation and selection. The goal of the current study was to identify the best sorghum hybrids for higher grain and green fodder yield and clustering of hybrids.

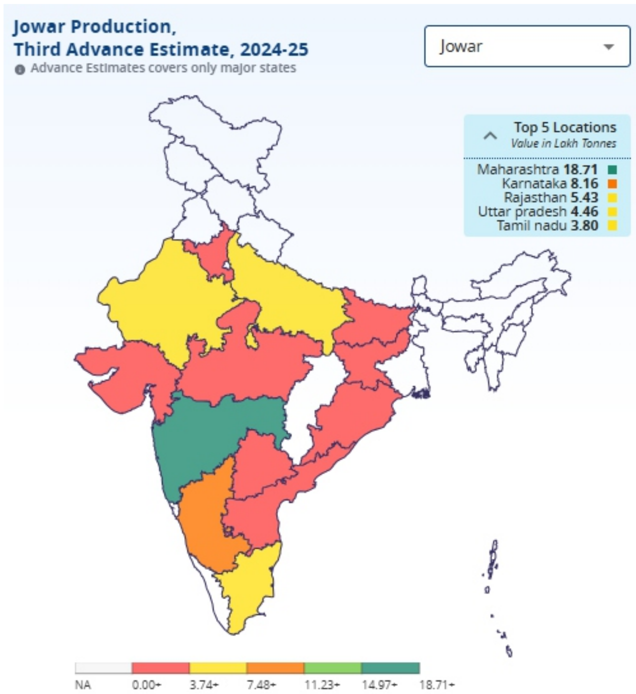

Fig 1: Top five sorghum producing states (upag.gov.in)

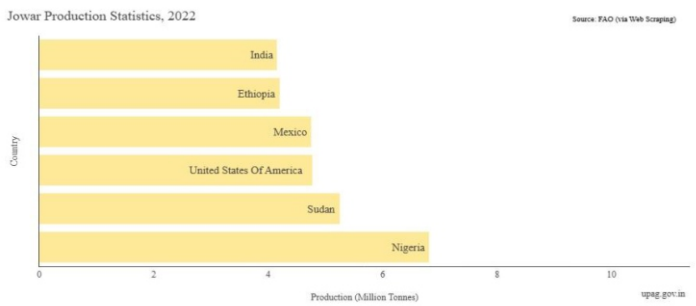

Fig 2: Sorghum statistics 2022 (upag.gov.in)

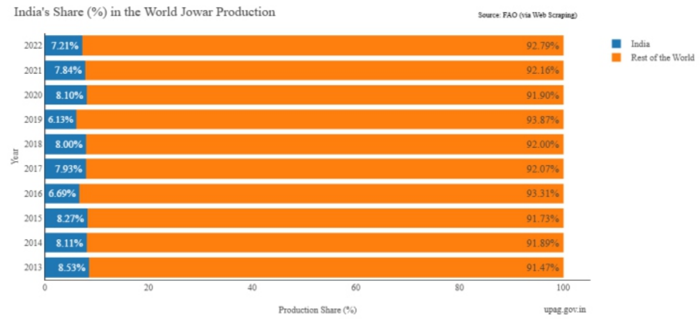

Fig 3: Percent share of India in the world sorghum production 2022 (upag.gov.in)

2. MATERIAL AND METHODS

A trial of twenty six CMS based grain sorghum hybrids along with two commercial checks viz., HT 3201 and HT 3206 was planted at the research farm of Foragen Seeds Private limited, Hyderabad. Each hybrid was planted as 2 rows of 2m row length and 30 cm row to row spacing with two replications in randomized block design during rabi season of 2024. Checks were repeated once. All agronomic practices were followed to grow the crop. Hybrids were designated as foragen grain Sorghum hybrids (FGSH) (Table 1). Data was recorded for five morphological traits viz., days to 50% flowering, plant height (cm), panicle length (cm), grain yield (kg ha^{-1}) and green fodder yield (tons ha^{-1}). Mean performance (table 1), analysis of variance (Table 2) and clustering of hybrids (table 3 and Fig. 5) were done by GRAPES software. Weather data during season shown in Fig 3.

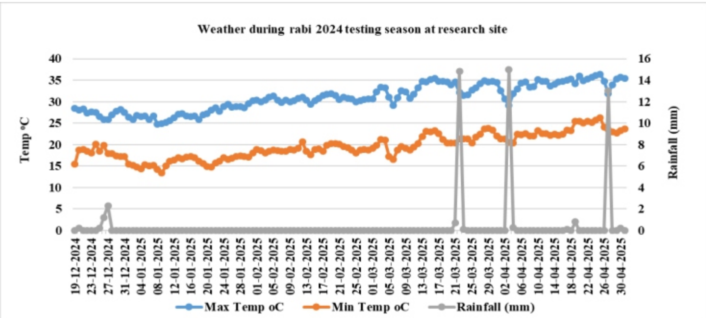

Fig. 4: Weather during growing season of rabi 2024.

3. RESULT AND DISCUSSION

Significant differences were observed between the hybrids for all the characters (Table 2). A 23.9% and 20.6% CV for sorghum grain yield and green fodder yield points to a notable range of yield performance among different sorghum grain hybrids, potentially offering a good starting point for breeding programs aimed at improving the crop's productivity. Whereas, the lowest CV recorded for days to 50% flowering revealed less amount of variability observed for this trait.

Among the hybrids, FGSH-9 (68 days) and FGSH-16 (65 days) were flowered early than the checks (74 to 76 days). This early flowering this is often a desirable trait, as early flowering can help the crop escape certain environmental stresses like drought or pests that may become more severe later in the season [5]. Under drought conditions, selection may promote early flowering [6, 7, 8]. Earliness have very high importance in cereal production, the genetics of earliness has been studied very well from long period of evidence-based research [9, 10, 11]. Ten hybrids were recorded higher plant height ranged from 161 cm to 198 cm, than the checks (141 to 160 cm). Two hybrids exhibited higher plant height i.e. FGSH-3 (198 cm) and FGSH-7 (186 cm). Generally, taller plants can lead to higher green fodder yield [12, 13, 14]. Among the hybrids, panicle length of two hybrid i.e. FGSH-23 (39 cm) and FGSH-25 (38 cm) showed longer panicle length which contributes for higher grain yield [15] than the commercial checks. [16] reported positive but non-significant association with grain yield. Hybrid FGSH-25 showed longest panicle length (38 cm) with higher grain yield (8822.9 kg ha^{-1}) which was at par with check HT-3201 (8822.9 kg ha^{-1}). For grain yield, two hybrids i.e. FGSH-7 (10208.3 kg ha^{-1}) and FGSH-25 (8822.9 kg ha^{-1}) were found superior over check HT-3201 (8822.9 kg ha^{-1}). Whereas, none of the hybrid was found superior over both the commercial checks. Similarly, hybrids, FGSH-12 (61.1 t ha^{-1}) and FGSH-23 (49.7 t ha^{-1}) were out yielded for green fodder yield over both the checks viz., HT 3206 (45.1 t ha^{-1}) and HT 3201 (34.1 t ha^{-1}) (Table 1).

Agglomerative hierarchical clustering of the data interpreted on the basis of Euclidean distance matrix by utilizing the Ward's linkage protocol and presented in Fig 4 revealed that all thirty hybrids including checks were divided into seven clusters. Cluster VII grouped highest number of hybrids viz., FGSH-4, FGSH-5, FGSH-6, FGSH-7, FGSH-12, FGSH-24 and check HT-3201. Whereas, cluster IV grouped lowest number of hybrid i.e. check HT-3206. Cluster IV recorded highest grain yield i.e. 13380.2 kg ha^{-1} whereas, cluster I was second ranker for grain yield i.e. 7853.1 kg ha^{-1}) (Table 3).

Table 1: Performance of grain sorghum hybrids along with checks at Hyderabad during rabi 2024 for grain yield and component traits

Hybrid code	DF	PH	PL	GY	GFY	% Increase Over HT 3201 (GY)	% Increase Over HT 3206 (GY)	Ranks GY	Ranks GFY
FGSH-1	75	132	29	1837.5	39.5	-79.17	-86.27	18	7
FGSH-2	73	130	31	5614.6	23.5	-36.36	-58.04	6	16
FGSH-3	78	198	34	1312.5	12.8	-85.12	-90.19	22	24
FGSH-4	79	177	32	5250.0	27.6	-40.50	-60.76	8	12
FGSH-5	78	175	32	7466.7	40.0	-15.37	-44.20	4	6
FGSH-6	75	171	34	5454.2	24.3	-38.18	-59.24	7	15
FGSH-7	76	186	35	10208.3	44.7	15.70	-23.71	1	4
FGSH-8	78	170	34	1947.9	8.6	-77.92	-85.44	17	26
FGSH-9	68	159	32	3383.3	15.0	-61.65	-74.71	11	22
FGSH-10	72	160	33	3222.9	19.4	-63.47	-75.91	12	18
FGSH-11	77	161	37	3460.7	27.0	-60.78	-74.14	10	13

FGSH-12	73	160	33	5133.3	61.1	-41.82	-61.63	9	1
FGSH-13	79	159	25	1210.4	17.3	-86.28	-90.95	23	20
FGSH-14	80	141	30	1406.3	23.3	-84.06	-89.49	20	17
FGSH-15	82	147	30	555.8	2.8	-93.70	-95.85	26	28
FGSH-16	65	139	30	1108.3	14.9	-87.44	-91.72	24	23
FGSH-17	80	146	28	2172.9	17.1	-75.37	-83.76	15	21
FGSH-18	77	150	29	3077.1	39.3	-65.12	-77.00	13	8
FGSH-19	70	169	25	772.9	5.6	-91.24	-94.22	25	27
FGSH-20	79	135	28	1385.4	19.2	-84.30	-89.65	21	19
FGSH-21	83	147	30	2000.0	26.5	-77.33	-85.05	16	14
FGSH-22	82	143	37	479.2	11.0	-94.57	-96.42	27	25
FGSH-23	85	148	39	6883.3	49.7	-21.98	-48.56	5	2
FGSH-24	80	168	31	2260.4	40.5	-74.38	-83.11	14	5
FGSH-25	88	165	38	8822.9	37.3	0.00	-34.06	2	10
FGSH-26	72	141	27	1720.8	38.9	-80.50	-87.14	19	9
HT 3201	**76**	**160**	**31**	**8822.9**	**34.1**	0.00	-	2	11
HT 3206	**74**	**141**	**34**	**13380.2**	**45.1**	-	0.00	-	3
Over all mean	**77**	**156**	**32**	**4418.5**	**28.2**	-	-	-	-
C.D.	**10.6**	**33.9**	**7.3**	**2172.9**	**12.0**	-	-	-	-
SE(m)	**3.7**	**11.7**	**2.5**	**747.5**	**4.1**	-	-	-	-
SE(d)	**5.2**	**16.5**	**3.6**	**1057.1**	**5.8**	-	-	-	-
C.V.	**6.8**	**10.6**	**11.3**	**23.9**	**20.6**	-	-	-	-

DF: Days to 50% flowering; PH: Plant height (cm) PL: Panicle length (cm); GY: Grain yield (kg ha^{-1}) and Green fodder yield (tons ha^{-1}); FGSH: Foragen Grain Sorghum Hybrid Numbers.

Table 2: Analysis of variance for grain yield and component traits of grain sorghum

Source	Df	mean sum of square				
		DF	PH	PL	GY	GFY
Treatments	29	53.13*	552.09*	24.46*	28358047.4**	422.06**
Replications	1	86.40	141.07	14.02	3349001.3	80.50
Error	29	26.74	271.83	12.60	1117528.4	33.76
Total	59	40.72	407.37	18.46	14544757.6	225.41

**, ** - significance level at 5% and 1%*

Table 3: Distribution of thirty grain sorghum hybrids into seven clusters for grain and green fodder yield

Clusters	# hybrids	Hybrids codes	GY (kg ha^{-1})	GFY (t ha^{-1})	Cluster ranks for GY
1	2	FGSH-23, FGSH-25	7853.1	43.5	2
2	6	FGSH-13, FGSH-14, FGSH-15, FGSH-17, FGSH-20 and FGSH-21	1455.1	17.7	7
3	4	FGSH-1, FGSH-2, FGSH-18 and FGSH-26	3062.5	35.3	4
4	1	**Check-HT 3206**	13380.2	45.1	1
5	4	FGSH-9, FGSH-10, FGSH-16 and FGSH-19	2121.9	13.7	5
6	7	**Check-HT 3201**, FGSH-4, FGSH-5, FGSH-6, FGSH-7, FGSH-12 and FGSH-24	6677.3	38.3	3
7	4	FGSH-3, FGSH-8, FGSH-11 and FGSH-22	1800.1	14.8	6

FGSH – Foragen Grain Sorghum Hybrid Numbers

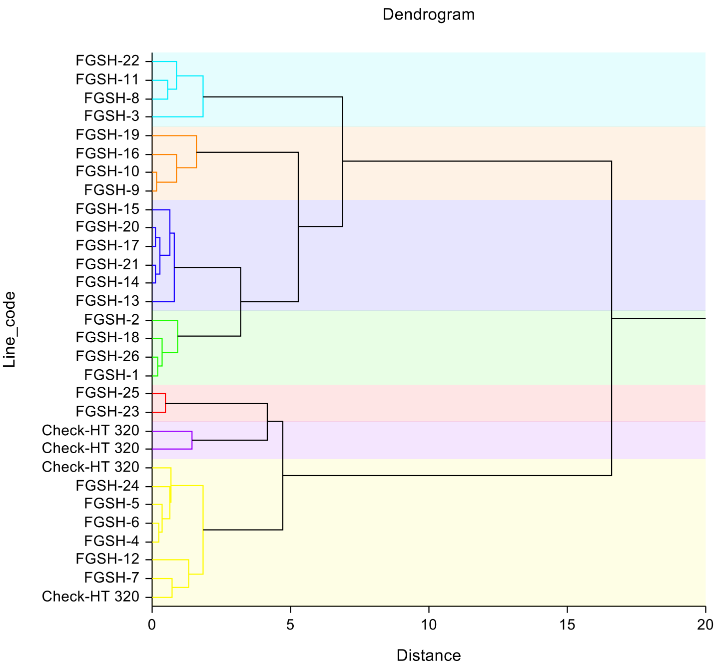

Fig. 4. Phenotypic dendrogram generated by Hierarchical Clustering method

4. CONCLUSION

All hybrids are highly diverse for grain yield and green fodder yield. Hybrid FGSH-7 was showed the highest mean grain yield, 10208.3 kg ha^{-1}. However, FGSH-12 recorded highest green fodder yield (61.1 t ha^{-1}). Both of these hybrids were grouped into the largest cluster i.e., cluster VI. So, these hybrids can be directly promoted for further testing and their parents can be utilized for improvement of hybrid parent breeding programs. Clusters I and VI were highest yielding clusters. Hybrid parents involved in these clusters can be recombined for the development of hybrids and hybrid parent composites.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

AUTHORS' CONTRIBUTIONS

Manish V Boratkar – The conception, design, execution, or interpretation of the reported study.

Hasanali Nadaf – Generation of experimental hybrids.

Manish Kumar Pandey – Data collection and trial conductance.

Prabhakar Babu Gunturu – Administrative and financial support.

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