Forage Res., **51**(1) : pp. 104-110 (2025) **http://forageresearch.in**

ASSESSMENT OF GROWTH AND YIELD CHARACTERISTICS OF FODDER BAJRA (*PENNISETUM GLAUCUM* L.) VARIETIES UNDER VARYING SHADE LEVELS IN THE SOUTHERN LATERITES OF KERALA (AEU 8)

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(Received: 30 May 2025; Accepted: 9 June 2025)

SUMMARY

The present investigation entitled 'Assessment of growth and yield characteristics of fodder bajra (*Pennisetum glaucum* L.) varieties under varying shade levels in the Southern Laterites of Kerala (AEU 8)' was conducted during *Rabi* 2023 and Summer 2024 at Instructional Farm, College of Agriculture, Vellayani, Thiruvananthapuram, Kerala, to identify suitable fodder bajra variety under open, 25 per cent and 50 per cent shade conditions. The three experiments were laid out in randomized block design with six varieties, *viz*., BAIF 1 (V_1), TSFB 15-4 (V_2), TSFB 15-8 (V_3), TSFB 17-7 (V_4), CO-9 (V_5) and CO-10 (V_6) with four replications each. The variety V_1 recorded the highest plant height, number of leaves, leaf length, leaf breadth, green fodder yield and dry fodder yield in both the seasons in all experiments. The variety V_1 exhibited excellent performance under shaded conditions, yielding well and demonstrating that fodder bajra can be successfully cultivated in partially shaded environments such as coconut gardens and other shade-dominant cropping systems. Hence, BAIF 1 can be considered an optimal fodder bajra variety for both *Rabi* and Summer seasons, as its ability to tolerate shade makes it well-suited for inclusion in existing cropping systems, thereby contributing to the current fodder requirements.

Key words: Fodder bajra, shade levels, varieties, green fodder and dry fodder yield

The livestock sector plays an important role in agriculture by ensuring nutritional security and employment generation in livelihoods. It also contributes nearly 4.11 per cent to India's GDP making it an indispensable commodity in national economics. According to the 20th Livestock Census, the total livestock population in India is 535.78 million, showing an increase of 4.6 per cent over the last livestock census in 2012 (GOI, 2019). India is the leading milk producing country in the world, even when animal productivity is low (1538 kg year^{-1}) when compared to the global average (2238 kg year^{-1}). The low productivity is due to malnutrition of livestock caused by unavailability of quality animal feed (Vijay *et al.*, 2018). The livestock sector in India experiences continuous malnutrition throughout the year as a result of a net supply deficit of both green fodder and dry fodder, which keeps their production capacity below the optimum level (Bijarnia *et al.,* 2020). In order to satisfy the future fodder needs of the expanding livestock population, it is necessary to increase the production of good quality fodder. Utilising non-arable land for fodder cultivation and growing dual purpose crops like fodder millets are two effective ways to balance the demand and supply of quality fodder (Dahiya and Kharab, 2003; Vijay *et al.,* 2018). Fodder millets have short growing period (Yadav and Rai, 2013; Kumar *et al.,* 2018), which enable them to incorporate in the existing cropping systems (Kumar *et al*., 2020), can be grown under stressed conditions (Rathinapriya *et al.,* 2020; Babele *et al.,* 2022), require low land investment (Saxena *et al*., 2018; Ceasar and Maharajan, 2022) and are more resilient to climate change (Nagaraja and Das, 2016; Varshney, 2021). Thus, cultivating fodder millet is an excellent way to satisfy the present requirements of fodder deficit in India.

Fodder bajra is one of the major fodder millet crops that can be used as livestock feed. It serves as a valuable fodder crop for livestock and is a crucial part of livestock ration feed as it is nutrient-rich and provides sufficient amount of dry matter. It also has less anti-nutritional factors like hydrocyanic acid (HCN) and oxalic acid (Pankaj and Dhankar, 2023) while being enriched with protein, calcium, phosphorus and other minerals (Adegbola *et al.*, 2023). It could be grown on marginal lands (Miller *et al.*, 2016) and is more resilient to climate change (Varshney, 2021). In view of the above benefits of fodder bajra, a study was conducted to identify a promising fodder bajra variety under open and partial shade condition for Kerala (AEU 8).

MATERIALS AND METHODS

The field experiments were carried out at Instructional Farm, College of Agriculture, Vellayani, Thiruvananthapuram, Kerala, during *Rabi* 2023 and Summer 2024. The experiment fields were geographically located at 8°25′40′′N latitude, 76°59′17′′E longitude at an altitude of 54.6m above MSL (open experiment); 8°25′38′′N latitude, 76°59′17′′E longitude at an altitude of 52.97m above MSL (25% shade experiment) and 8°25′38′′N latitude, 76°59′17′′E longitude at an altitude of 53.26 m above MSL (50% shade experiment). The mean maximum and minimum temperature ranged from 31.6° to 36.4° and 19° to 24.8°, respectively and mean RHI and RHII ranged from 87 per cent to 98 per cent and 60 per cent to 91 per cent, respectively, with a mean evaporation of 3.5mm per day. Mean bright sunshine hours varied from 1.2 h to 10 h. A total rainfall of 15.6mm was received during the first experimental period. During the confirmatory experimental period, the mean maximum and minimum temperature ranged from 27.8° to 35° and 22.4° to 29.2°, respectively and mean RHI and RHII ranged from 82 per cent to 98 per cent and 60 per cent to 98 per cent, respectively, with a mean evaporation of 2.8mm per day. Mean

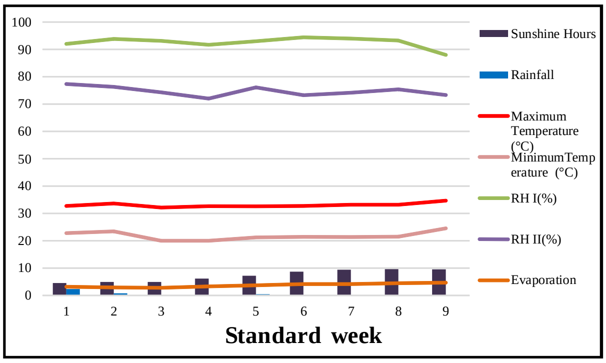

Fig. 1a. weather data during the crop season *Rabi* 2023.

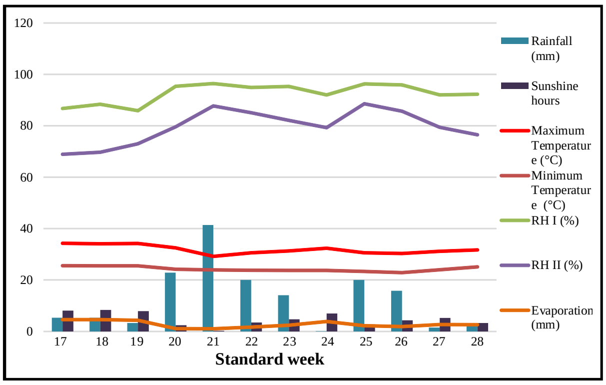

Fig. 1b. weather data during the crop season *Summer* 2024.

bright sunshine hours varied from 0.5 h to 10 h. A total rainfall of 1058.1mm was received throughout the crop sowing period of the confirmatory trial.

Three experiments were carried out simultaneously in both Rabi and Summer season for open, 25 per cent shade and 50 per cent shade condition which were laid out in randomized block design with four replications. The first trial was conducted in rabi season and its confirmatory trial was conducted in the summer season. The treatments consisted of six fodder bajra varieties, namely BAIF 1 (V_1), TSFB 15-4 (V_2), TSFB 15-8 (V_3), TSFB 17-7 (V_4), CO-9 (V_5) and CO-10 (V_6). All the treatments followed a spacing of 30 cm × 15cm and FYM @ 12.5 t/ha were uniformly applied to all the plots at the time of final land preparation. The treatments were given a basal fertilizer dose of 25:20:12 kg NPK ha^{-1} followed by 25 kg/ha nitrogen at 30 days after sowing (DAS).

The growth and yield attributes *viz.*, plant height, number of leaves per plant, leaf length, leaf breadth, length of internodes, green fodder yield and dry fodder yield were recorded at time of harvest. Plant height of the observational plants was measured from the base to the tip of the plant and the mean plant height was worked out. The total number of fully developed leaves were counted from the observational plants and their mean was recorded as the number of leaves per plant. The length and breadth of the leaves from observational plants were measured, and their average was calculated.

$$\text{Dry fodder yield} = \frac{\text{Dry weight of sample plants}}{\text{Fresh weight of sample plants}} \times \text{Green fodder yield}$$

The treatments were harvested when they reached 50 per cent flowering. Green fodder yield was recorded for each treatment by cutting the plants in the net plot area, then they were weighed and expressed in t/ha. The fresh weight of the observational plants from the respective varieties were recorded soon after their harvest. These were then oven dried at 65 ± 5! until a constant weight was achieved. The dry fodder yield was then calculated and expressed in t/ha using the following equation.

RESULTS AND DISCUSSION

Growth parameters

Plant height was significantly affected by the different varieties across various shade levels. In open condition, variety V_1 produced the tallest plants in both the initial trial (144.92 cm) and the confirmatory trial (173.17 cm). During the summer season, variety V_6 (150.33 cm) was statistically on par with V_1. The shortest plants were recorded in variety v_2 during the rabi season (114.75 cm) and in V_4 during summer (124.17) as shown in Table 1. In the 25 per cent shade trials, V_1 consistently exhibited the highest plant height (155.8 cm and 191.1 cm), with V_5 (146.1 cm) showing similar performance during the rabi season. The shortest plants under 25 per cent shade were observed in V_4 for both seasons (Table 2). In the 50 per cent shade condition, v_1 again produced significantly taller plants (172.67 cm and 232.75 cm) in both trials, whereas V_3 had the shortest plants (Table 3). Similar results were reported by Brahmaiah (2016), Sannagoudar *et al.*, (2017) and Gupta (2022) in fodder bajra. The observed variation in plant height among the varieties can be attributed to differences in their genetic makeup and their adaptability to the local climatic conditions. Each variety possesses distinct yield potential and exhibits unique growth and developmental patterns. These differences are likely influenced by a combination of morphological, physiological, and biochemical factors, as well as their interactions with environmental variables such as climate and soil conditions. Similar finding was reported by Mohammad *et al.* (2002), who noted that plant height is influenced by the genetic composition of the plant as well as prevailing environmental conditions.

The variety V_1 had higher number of leaves (8.33, 10.5) in rabi as well as summer season in open condition. The least number of leaves per plant were recorded in V_2 in rabi and V_3 in summer (Table 1). Similarly, in 25 per cent and 50 per cent shade experiments, variety V_1 exhibited the highest number of leaves *viz.*, 8.1, 8.5 and 8.17, 9.17 respectively. In 25 per cent shade the minimum number of leaves were observed in V_4. The variety V_6 in rabi and V_4 in summer resulted in the lowest number of leaves in 50 per cent shade trial. Under open condition, the variety V_1 had significantly greater leaf length (54.67 cm, 61.17 cm) as represented in Table 1. The lowest leaf length was recorded by V_3 in rabi and v_4 in summer. In 25 per cent shade trial, the variety V_1 showed better result (50.92 cm, 77.67 cm) when compared to other varieties while V_3 and V_4 resulted in minimum leaf length among the varieties during rabi and summer respectively (Table 2). Similarly, v_1 achieved the best results (66.33 cm, 59.0 cm) in 50 per cent shade trial with V_5 being on par (54.67 cm) in rabi season as shown in Table 3. The varieties V_4 and v_6 recorded the lowest leaf length in rabi and summer respectively, in 50 per cent shade trial. In the open condition experiment, variety V_1 recorded the highest leaf breadth in both the rabi (2.76 cm) and summer (3.07 cm) seasons. During the rabi season, varieties V_5 (2.73 cm) and V_6 (2.37 cm) were statistically on par with V_1. The lowest leaf breadth was observed in variety V_2 during rabi and in V_4 during summer. In the 25% shade trial, V_1 again showed the maximum leaf breadth (2.85 cm in rabi and 3.32 cm in summer), with V_6 (2.82 cm) performing comparably during the rabi season. The minimum leaf breadth in this trial was recorded in variety V_3 during rabi and V_4 during summer. Under 50% shade conditions, v_1 consistently outperformed other varieties, achieving a leaf breadth of 3.03 cm in both seasons, while the lowest values were noted in variety V_6 across both rabi and summer seasons (Table 1). The genetic composition of the variety and the local climate may have an impact on the leaf characteristics. Ren *et al.* (2020) observed that leaf morphological traits vary widely and significantly among different varieties, primarily due to strong genetic control. They also emphasized that highly variable environmental factors, such as climate and soil conditions across different locations, play a major role in influencing the phenotypic variation and plasticity of leaves. These results are in conformity with the findings of Kale and Takawale (2023). The length of internodes showed no significant differences among the varieties in most instances. Under open conditions during the summer, varieties V_1 and V_6 recorded longer internodes compared to the others. However, during the rabi season, no significant differences were observed among the varieties. Similarly, in the 25 per cent and 50 per cent shade conditions, the variations in internode length across the varieties were not statistically significant.

TABLE 1
Growth parameters of fodder bajra varieties under open condition

Open

Varieties	Plant height (cm)		Number of leaves		Leaf length (cm)		Leaf breadth (cm)	
	Rabi (2023)	*Summer* (2024)	*Rabi* (2023)	*Summer* (2024)	*Rabi* (2023)	*Summer* (2024)	*Rabi* (2023)	*Summer* (2024)
V_1- BAIF 1	144.92	173.17	8.33	10.5	54.67	61.17	2.76	3.07
V_2- TSFB 15-4	114.75	138.25	4.67	8.72	43.03	51.5	2.03	2.25
V_3- TSFB 15-8	117.83	131.67	5.17	5.67	41.17	48.67	2.23	1.88
V_4- TSFB 17-7	118.33	124.17	5.67	6.33	47.08	48.28	2.29	1.84
V_5- CO 9	126	134	5.67	7.17	47.56	47.67	2.73	2.02
V_6 - CO 10	115.17	150.33	5.17	8	45.58	48	2.37	2.3
SE m (±)	5.89	7.39	0.55	0.42	2.32	1.51	0.14	0.2
CD (0.05)	18.57	23.29	1.72	1.33	6.99	5.49	0.41	0.72

TABLE 2
Growth parameters of fodder bajra varieties under 25 per cent shade

25% shade

Varieties	Plant height (cm)		Number of leaves		Leaf length (cm)		Leaf breadth (cm)	
	Rabi (2023)	*Summer* (2024)	*Rabi* (2023)	*Summer* (2024)	*Rabi* (2023)	*Summer* (2024)	*Rabi* (2023)	*Summer* (2024)
V1- BAIF 1	155.83	191.17	8.10	8.50	50.92	77.67	2.85	3.32
V2- TSFB 15-4	143.17	158.17	6.80	6.86	46.82	60.67	2.47	2.73
V3- TSFB 15-8	140.33	130.17	6.31	5.67	42.25	60.33	2.37	2.75
V4- TSFB 17-7	118.00	120.83	5.67	5.50	45.58	44.83	2.26	2.35
V5- CO 9	146.08	149.33	6.46	6.50	45.63	54.83	2.50	2.60
V6- CO 10	133.17	154	6.79	6.72	45.58	46.17	2.82	2.42
SE m (±)	3.15	9.06	0.4	0.37	1.07	1.7	0.11	0.11
CD (0.05)	9.93	28.55	1.26	1.18	3.22	6.2	0.34	0.41

TABLE 3
Growth parameters of fodder bajra varieties under 50 per cent shade

50% shade

Varieties	Plant height (cm)		Number of leaves		Leaf length (cm)		Leaf breadth (cm)	
	Rabi (2023)	*Summer* (2024)	*Rabi* (2023)	*Summer* (2024)	*Rabi* (2023)	*Summer* (2024)	*Rabi* (2023)	*Summer* (2024)
V1- BAIF 1	172.67	232.75	8.17	9.17	66.33	59.00	3.03	3.03
V2- TSFB 15-4	147.92	209.00	6.50	8.14	49.5	50.17	2.33	2.32
V3- TSFB 15-8	137.17	116.33	5.83	6.33	42.21	47.00	2.21	2.21
V4- TSFB 17-7	148.33	155.83	5.67	5.50	41.58	47.12	2.22	2.42
V5- CO 9	152.92	176.33	6.00	5.83	54.67	43.06	2.45	2.07
V6- CO 10	141.67	190.17	5.5	6.33	46.83	41	2.19	2.12
SE m (±)	4.15	7.08	0.27	0.31	4.47	1.9	0.17	0.12
CD (0.05)	13.07	22.32	0.84	0.96	13.47	6.91	0.5	0.43

Yield parameters

The best performing variety with significantly greater green fodder yield was found to be V_1 in open (17.78 t/ha, 48.86 t/ha), 25 per cent shade (12.41 t/ha, 32.75 t/ha) and 50 per cent shade (11.58 t/ha, 18.06 t/ha) experiments in both the seasons. The superior green fodder yield observed in variety V_1 can be ascribed to its robust vegetative growth and advantageous yield-related traits, including increased plant height, longer and wider leaves, and a higher leaf count. Kale and Takawale

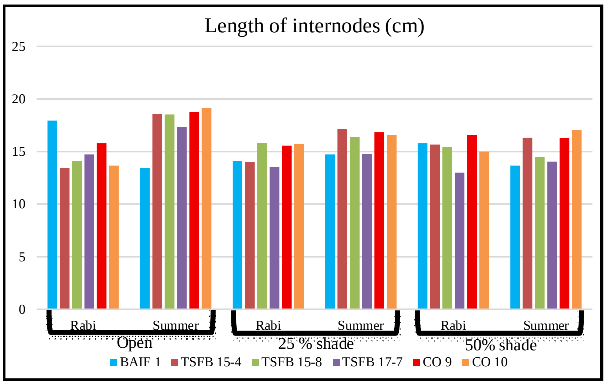

Fig. 2. Variation in internode length among varieties under different shade levels.

(2023) and Sannagoudar (2015) reported similar findings in fodder bajra varieties. Variety V_3 recorded the lowest green fodder yield under open conditions in both the rabi and summer seasons. Under 25 per cent shade, the minimum yield was observed in variety V_4 during the rabi season and in V_3 during summer. In the 50 per cent shade trial, variety V_4 consistently produced the lowest green fodder yield. The green fodder yield of BAIF 1in 25 per cent and 50 per cent shade was 69.84 per cent and 65.15 per cent of that in open condition in rabi season and 67.02 per cent and 37 per cent in the summer season. This shows that fodder bajra can be profitably planted in shaded areas like coconut gardens and other cropping systems where shade is prevalent. This also facilitates seamless integration of the crop into existing cropping systems owing to its shade tolerance and high productivity.

The variety V_1 was observed to be the best variety in terms of dry fodder yield in both the seasons across all the experiments *viz*., open (3.20 t/ha, 8.80 t/ha), 25 per cent (2.23 t/ha, 5.90 t/ha) and 50 per cent shade (2.08 t/ha, 3.25 t/ha). In open and 25 per cent shade experiments, V_6 and V_5 recorded the least dry fodder yield in rabi and summer respectively, while V_6 recorded the lowest dry fodder yield in 50 per cent shade trail. According to the findings of Jain and Patel (2013), dry fodder yield is positively influenced by factors such as green fodder yield, number of leaves, plant height, and leaf characteristics. Accordingly, variety V_1, which exhibited superior growth and yield attributes, recorded the highest dry fodder yield among all the varieties evaluated.

Green and dry fodder yields exhibited substantial seasonal variation. For instance, the green fodder yield of BAIF 1 under open conditions increased markedly from 17.78 t/ha in the rabi season to 48.86 t/ha in the summer. This significant rise in yield can likely be attributed to the variation in weather condition prevailing during the summer season. The data on normal rainfall and sunshine hours of the experimental area were taken to compare the weather data. The rainfall received during the month of May (649.9 mm) was 185.8 per cent more than the normal rainfall recorded (227.4 mm). The average sunshine hours recorded was 4.5 hours which was 41.67 per cent less than the normal (7.2 hours). These factors could have prolonged the vegetative growth and subsequently the duration of the crop, thus remarkably increasing the yield in the summer season. Lai *et al.* (2022) reported that increased precipitation positively influenced the yield of summer forage crops. Similarly, Ozkaynak (2013) noted that extended vegetative growth resulting from changes in weather patterns contributed to higher yields in field crops. These findings are further supported by the results of Zheng

TABLE 4

Yield parameters of fodder bajra varieties under open condition

Open

Varieties	Green fodder yield (t/ha)		Dry fodder yield (t/ha)	
	Rabi (2023)	*Summer* (2024)	*Rabi* (2023)	*Summer* (2024)
V_1- BAIF 1	17.78	48.86	3.2	8.8
V_2- TSFB 15-4	11.67	28.78	2.44	6.05
V_3- TSFB 15-8	10.47	19.44	2.25	4.19
V_4- TSFB 17-7	10.94	19.36	2.19	3.87
V_5- CO 9	12.03	21.39	1.96	3.48
V_6- CO 10	12.64	26.94	1.9	4.04
SE m (±)	0.7	1.32	0.15	0.32
CD (0.05)	2.11	3.96	0.46	0.95

TABLE 5

Yield parameters of fodder bajra varieties under 25 per cent shade condition

25% shade

Varieties	Green fodder yield (t/ha)		Dry fodder yield (t/ha)	
	Rabi (2023)	*Summer* (2024)	*Rabi* (2023)	*Summer* (2024)
V_1- BAIF 1	12.42	32.75	2.24	5.9
V_2- TSFB 15-4	9.18	25.58	1.92	5.42
V_3- TSFB 15-8	8.33	14.58	1.8	3.14
V_4- TSFB 17-7	7.22	15.86	1.44	3.17
V_5- CO 9	9.91	17.22	1.62	2.8
V_6- CO 10	8.33	19.44	1.25	2.92
SE m (±)	0.59	1.48	0.15	0.37
CD (0.05)	1.79	4.46	0.44	1.12

TABLE 6
Yield parameters of fodder bajra varieties under 50 per cent shade condition

50% shade

Varieties	Green fodder yield (t/ha)		Dry fodder yield (t/ha)	
	Rabi (2023)	*Summer* (2024)	*Rabi* (2023)	*Summer* (2024)
V_1- BAIF 1	11.58	18.06	2.09	3.25
V_2- TSFB 15-4	8.75	13.92	1.84	2.89
V_3- TSFB 15-8	7.75	11.29	1.66	2.43
V_4- TSFB 17-7	6.53	9.97	1.31	1.99
V_5- CO 9	8.11	12.36	1.33	2.01
V_6 - CO 10	7.94	12.86	1.19	1.93
SE m (±)	0.88	0.87	0.19	0.15
CD (0.05)	2.66	2.63	0.58	0.46

(2024), reinforcing the role of environmental factors in influencing crop productivity.

CONCLUSION

The investigation found that the fodder bajra variety BAIF 1 outperformed other varieties *viz*., TSFB 15-4, TSFB 15-8, TSFB 17-7, CO 9 and CO 10, in Kerala (AEU 8), demonstrating the highest green and dry fodder yields, plant height and favourable leaf characteristics. These results held true under open field conditions as well as under 25 per cent and 50 per cent shade. Therefore, BAIF 1 can be recommended as an ideal fodder bajra variety for both the *rabi* and summer seasons, as its shade tolerance allows it to integrate into existing cropping systems, helping to meet the prevailing fodder needs.

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