



Evaluating the Performance of Indigenous Foxtail Millet *Setaria italica* (L.) P. Beauc. Cultivars under Rainfed Conditions in Nagaland

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ABSTRACT

Background: Foxtail millet (*Setaria italica*), known for its drought tolerance and nutritional value, is suited to Nagaland conditions. It has however fallen in cultivation due to low profitability, labour issues and limited market access. With renewed interest in millets for health motive, this study assesses the growth, yield and economic performance of indigenous foxtail millet cultivars under rainfed conditions in Nagaland.

Methods: A field experiment at the School of Agricultural Sciences (SAS), Nagaland University, Medziphema campus, the *kharif* season of the year 2022. The experiment aimed to evaluate the agronomic performance of indigenous foxtail millet cultivars in a randomized block design (RBD) with three replications and eight treatments of different indigenous cultivars: Titse, Atsube, Tsu, Titsi, Sherha, Asuna, Chinchang and check variety SiA 3156.

Result: The results revealed significant variation in growth and yield attributes among the different cultivars where cultivar Sherha reached early maturity at 75 days, while Chinchang took 95 days. Chinchang also recorded significantly higher growth and yield attributes including highest seed yield (2312 kg ha⁻¹), straw yield (3133 kg ha⁻¹), followed by Titse and Asuna. However the check variety SiA 3156 exhibited a higher number of tillers, number of leaves, number of panicles m⁻². Based on this investigation, it can be seen that among the different indigenous foxtail millet cultivars, Chinchang demonstrated superior growth and yield performance, making it the best cultivar evaluated in this study.

Key words: Cultivars, Farming, Foxtail, Millet.

INTRODUCTION

Small millets hold great promise for strengthening the nation's food and nutritional security. They are widely recognized as nutrient-dense crops and are highly valued for their exceptional ability to withstand climate-related stresses (Sivakumar *et al.*, 2022). Millets, being of small-seeded cereals from the *Poaceae* family, are vital for food and fodder security in rainfed agriculture, being rich in dietary fibres, protein, antioxidants, vitamins, essential amino acids, bioactive compounds, gluten-free and non-allergenic (Bhat *et al.*, 2018). Foxtail millet (*Setaria italica*), also known as Italian or German millet, is a self-pollinating diploid crop and is highly water and nitrogen efficient, tolerating drought, heat and salinity and requiring minimal water to produce biomass. Millet is the most produced in India, accounting for 26% of the global millet area and 83% of Asia's (Meena *et al.*, 2021). India ranks third globally in millet production, with 1057 million hectares under cultivation, with a yield of 2290 million tonnes at 2166 kg ha⁻¹, contributing 2.42% to global production (Anonymous, 2021). In Nagaland, millet cultivation supports subsistence farmers and includes varieties like foxtail millet, pearl millet, finger millet and sorghum and job's tear. Small millets cover 1442 hectares, with an average productivity of 987 kg ha⁻¹ from 1997-2016. Millet productivity in Nagaland faces challenges such as low farm profitability, labour

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shortages, lack of market information and government support, technological gaps and wildlife damage, reducing millet cultivation. Research on indigenous foxtail millet landraces in Nagaland is very limited, despite their importance to local farming communities and their potential

resilience under rainfed conditions. With growing interest in climate-resilient and nutritious crops, it is necessary to evaluate these landraces for their growth, yield and economic performance. This study helps fill the knowledge gap and supports the selection and promotion of suitable cultivars for sustainable and profitable millet cultivation in the region.

MATERIALS AND METHODS

Site

A field experiment was carried out at the experimental research field of Department of Agronomy, School of Agricultural Sciences, Nagaland University, Medziphema campus, Nagaland located at an elevation of 310 m above mean sea level with geographical location of 25°45'43"N latitude and 95°53'04"E longitude. The season experienced mean summer temperatures between 21°C and 30°C and in winter the temperature seldom drops below 8°C because of the high relative humidity with annual rainfall averages between 2000 and 2500 mm, with most precipitation occurring from April to September, while the months from October to March are relatively dry.

Design

The experiment used an RBD design with three replications and eight treatments, using one check variety (SiA 3156, obtained from the Indian Institute of Millet Research, Hyderabad) along with seven indigenous varieties of the state.

Soil status

The initial soil was acidic (pH 4.2) and determined with Digital pH meter while 0.79% OC was detected by Walkley and Black Method, (Jackson 1973), 288.51 kg ha⁻¹ N determined by Alkaline Potassium Permanganate Method (Subbiah and Asija 1956), 21.10 kg ha⁻¹ P₂O₅ determined by Bray's No.1 Method (Brays and Kurtz 1945) and 185 kg ha⁻¹ K₂O by Flame Photometer (Hanway and Heidal, 1952) and the experiment was conducted on a field with a net plot size of 4.2 × 5 m² and a gross area of 504 m².

Crop management

Field preparation began with ploughing by a tractor-drawn cultivator on 24 June 2022, followed by harrowing with a rotovator on 28 June, then levelling and removal of stubbles and weeds. The seeds were sown at 10 kg ha⁻¹ with 30 cm row spacing and 10 cm between plants and hand weeding occurred at 25 and 50 days after sowing. The field was then harrowed with rotavator followed by levelling, removal of stubbles and weeds and harrowing was done so as to break up clods and provide fine tilth suitable for seed germination. Well decomposed FYM @ 10 t ha⁻¹ was uniformly broadcasted and RDF of N:P₂O₅:K₂O @ 40:20:20 kg ha⁻¹ in the form of urea, single super phosphate and muriate of potash were applied in the field while half dose of nitrogen and full dose of P and K were applied as basal

dose. The remaining half dose of nitrogen was applied as top dressing at tillering and panicle initiation stage. Thinning and gap filling operations were carried out 15 days after sowing while the excess germinated seedlings were uprooted and gaps were resown to ensure optimal plant population and spacing and weeding was performed manually using a khurpi or local hoe during 25 days after sowing, followed by a second weeding at 50 days after sowing. During the vegetative stage, soil drenching with Chlorpyrifos at 2 ml litre⁻¹ of water was applied every 15 days to control termite infestation. In the grain-filling stage, bird pests were managed through the use of bird scaring tape, bird traps and bagging of panicles to prevent further damage and the grain-filling stage, bird infestation became a major issue, so bird-scaring tapes, traps and panicle bagging were employed to prevent further damage to the crop. The local cultivars (Titse, Atsube, Tsu, Titsi, Sherha, Asuna and Chinchang) were obtained in various foxtail millet growing regions in Nagaland and check variety SiA 3156 from Indian institute of Millet Research (IIMR), Hyderabad and to check the viability of seeds, germination test was performed both in laboratory and field condition.

Selection

The cultivars were collected from different districts and each showed slight variations in their physical characteristics. So after the collection it was followed by a germination test conducted in a small plot and the cultivars were selected based on their germination percentage. Overall, the cultivars used in the study were chosen according to their availability and their performance in the germination test. Plant height was recorded from five randomly selected and tagged plants in each plot at 30 DAS, 60 DAS and at harvest with measurements were taken in centimetres using a ruler, from the base of the plant to its tip while number of tillers per plant⁻¹ was determined by counting tillers from five tagged plants in each plot and calculating the average. Similarly, the number of leaves plant⁻¹ was counted from five randomly tagged plants at 30 and 60 DAS and the mean leaf number for each treatment was computed and the recorded data of various parameters were subjected to the statistical test of Analysis of Variance as mentioned by Gomez and Gomez (1976).

RESULTS AND DISCUSSION

Growth parameter

A good range of variation was found in the plant height at 60 DAS where Asuna cultivar (129.40cm) was found to exhibit highest plant height, followed by Titse (128.60cm), Chinchang (126.68cm), Tsu (125.27cm) and Atsube (124.60 cm) respectively while Titsi had the lowest plant height of 102.83 cm while even the check variety SiA 3156 and the local cultivar Sherha also exhibited notably greater plant heights (120.70 cm and 120.20 cm, respectively) than Titsi. During the harvest phase, Chinchang (134.33 cm) displayed maximum height followed by Titse (132.84 cm)

and Asuna (130.74 cm) respectively, which were significantly superior to Titsi, which had the lowest plant height at 105.77 cm. The genetic makeup of these cultivars, along with differences in internodal length, may have led to the observed variation in plant height among the foxtail millet cultivars. These findings are consistent with the reports of Srikanth *et al.* (2020); Ravindranadh *et al.* (2019) and comparable to the findings of Reddy (2020) who meticulously noted that the change in plant height was accounted by the differences in genetic properties as well as internodal length and CGR peaked at 60 days after sowing and then slowly dwindled and the rising straw production was accredited to more vegetative growth. At 60 DAS, the number of tillers per plant showed significant variation among the foxtail millet cultivars as check variety SiA 3156 produced the highest number of tillers plant⁻¹ (2.93), which was markedly superior to all other indigenous cultivars, while no tillers were observed in the cultivar Sherha. The indigenous cultivar Titse also recorded a significantly higher tiller count (1.23) and the cultivars Tsu, Chinchang, Atsube, Titsi and Asuna (1.03, 1.02, 1.02, 1.02 and 1.01 tillers plant⁻¹, respectively) were statistically at par with each other. It has also been noted from the findings of Radhakumari *et al.* (2017) in the two-year experiment during the kharif season to identify suitable foxtail millet varieties for rainfed alfisols in a low-rainfall zone where six varieties: Narasimharaya, Krishnadevaraya, Srilakshmi, SiA 3088, Prasad and Suryanandi were tested, the results showed that Narasimharaya and Krishnadevaraya are recommended for dual purposes due to their higher grain and stover yields, while SiA 3088 is suitable for grain production due to its lower straw yield and the paper has also established the fact that different varieties contributed to number of tiller plant⁻¹, panicle length and panicle weight in Table 1. This may be primarily due to the cultivar's genetic potential for greater plant height at harvest and larger leaf area and the expansion of the assimilatory surface likely enhanced biomass production, resulting in the accumulation of a higher amount of photoassimilates. The highest number of leaves plant⁻¹ was observed at 60 DAS across all

cultivars, coinciding with their early reproductive stage. Significant differences were noted among the cultivars as check variety SiA 3156 produced the greatest number of leaves (10.67), which was statistically at par with the indigenous cultivar Chinchang (10.10). Both cultivars recorded significantly more leaves than Asuna, Tsu, Atsube, Sherha and Titsi (8.23, 7.92, 7.73, 7.17 and 6.94 leaves plant⁻¹, respectively). Titsi showed the lowest leaf count (6.94). The indigenous cultivar Titse (8.87 leaves plant⁻¹) was statistically comparable to Chinchang, Asuna, Tsu, Atsube and Sherha and also produced significantly more leaves than Titsi. Variations in leaf number among cultivars may be influenced by differences in plant height, tiller number and genetic potential for leaf production and these findings align with the reports of Nandini and Sridhara (2019). The significantly higher leaf numbers recorded in SiA 3156, Chinchang and Titse may be attributed to their greater plant height and higher tiller numbers. Although Sherha produced no tillers, it still had a leaf count comparable to Titsi, likely due to its taller plant stature and inherent genetic attributes.

Yield parameter

Among all the cultivars evaluated, the indigenous cultivar Chinchang produced the highest panicle weight (10.30 g panicle⁻¹), while Sherha recorded the lowest (5.05 g panicle⁻¹) while panicle weight of Titse (7.37 g panicle⁻¹) was statistically on par with Asuna (6.24 g panicle⁻¹) and both outperformed Titsi, Atsube and Sherha (5.13, 5.07 and 5.05 g panicle⁻¹, respectively). Titse was also significantly superior to Tsu and SiA 3156 (5.22 and 5.19 g panicle⁻¹), whereas Tsu showed no significant difference from SiA 3156, Titsi, Atsube, or Sherha. The higher panicle weight observed in Chinchang may be due to its better growth characteristics, including a greater number of leaves as the variations among cultivars align with the findings of Radhakumari *et al.* (2017) and Thimmaiah *et al.* (2016). The increase in panicle weight among foxtail millet cultivars may be influenced by factors such as test weight, number of grains panicle⁻¹ and panicle length. The longest panicle

Table 1: Effect of different foxtail millet cultivars on growth parameters.

Treatments	Plant height at 60 DAS	Plant height at Harvest	No of tiller at 60 DAS	No of leaves at 60 DAS
T ₁ (Titse)	128.60	132.84	1.23	8.87
T ₂ (Atsube)	124.60	126.57	1.02	7.73
T ₃ (Tsu)	125.27	127.27	1.03	7.92
T ₄ (Titsi)	102.83	105.77	1.02	6.94
T ₅ (Sherha)	120.20	120.80	1.01	7.17
T ₆ (Asuna)	129.40	130.74	1.01	8.23
T ₇ (Chinchang)	126.68	134.33	1.02	10.10
T ₈ (SiA 3156)	120.70	123.43	2.93	10.67
SEm ±	1.84	2.29	0.06	0.60
CD (P=0.05)	5.58	6.95	0.19	1.83
CV (5%)	2.6	3.17	8.4	12.3

SEm ±= Standard error of mean; CD= Critical difference at P= 0.05; DAS = Days after sowing.

was recorded in the indigenous cultivar Chinchang (26.37 cm), which was significantly superior to all other cultivars evaluated while shortest panicle was recorded in the indigenous cultivar Titsi (13.43 cm). The variation in panicle length may be largely attributed to the genetic constitution of the cultivars and these findings corroborate the reports of Srikanya *et al.* (2020) and Radhakumari *et al.* (2017). SiA 3156 produced the highest number of panicles (46.67 panicles m⁻²), significantly exceeding all other cultivars tested, while Sherha recorded the lowest (29.67 panicles m⁻²) as shown in Table 2. Significant differences were also observed between Titse (40.67 panicles m⁻²) and the cultivars Titsi (37.03 panicles m⁻²), Chinchang (34.18 panicles m⁻²) and Azha (29.67 panicles m⁻²), although Titse was statistically similar to Tsu, Atsube and Asuna (38.80, 38.44 and 37.74 panicles m⁻², respectively). The greater number of panicles m⁻² recorded in SiA 3156, Titse and Tsu may be linked to their higher tiller production. Differences in panicle number among cultivars likely stem from their genetic capacity to produce more productive tillers m⁻², consistent with the findings of Srikanya *et al.* (2020). The indigenous cultivar Chinchang, which produced 5819 grains panicle⁻¹, was significantly superior to all other cultivars, this may be attributed to greater panicle compactness and increased panicle length, while such similar results regarding the significant influence of cultivar on grains per panicle were also reported by Srikanya *et al.* (2020). The check variety SiA 3156 recorded the lowest number of grains panicle⁻¹ (953 grains panicle⁻¹), while cultivar Titse, with 2494.67 grains panicle⁻¹, was statistically comparable to Tsu, Sherha, Asuna and Atsube (2312.00, 2250.00, 2197.33 and 2051.67 grains panicle⁻¹, respectively), as presented in Table 2. The indigenous cultivar Chinchang recorded the highest grain yield at 2312 kg ha⁻¹ and all indigenous cultivars except Sherha outperformed the check variety SiA 3156 (Table 2) and this align with the records of Munirathnam *et al.*, (2006). Chinchang's superiority performance can be attributed to its highly favourable yield

traits, particularly it is more compact and longer panicles, which enabled it to produce a markedly higher number of grains panicle⁻¹ and these strong morphological advantages, combined with vigorous vegetative growth, likely enhanced photosynthetic efficiency and assimilate accumulation. As a result, Chinchang achieved the highest seed (2312 kg ha⁻¹) and straw yields among all cultivars, demonstrating its strong genetic potential for productivity. Chinchang and Titse can be linked to improved yield attributes and their enhanced vegetative growth likely promoted better photosynthetic efficiency, aligning with the findings of Nandini and Sridhara (2019) and Samundeswari *et al.* (2018). Chinchang also produced the highest straw yield at 3133 kg ha⁻¹, significantly exceeding all other cultivars followed by Titse recorded the next highest straw yield at 2540 kg ha⁻¹, performing better than Atsube (2208 kg ha⁻¹), SiA 3156 (2077 kg ha⁻¹), Tsu (2068 kg ha⁻¹), Sherha (2052 kg ha⁻¹) and Titsi (2007 kg ha⁻¹). The elevated straw yields of these cultivars can be attributed to their robust vegetative growth, consistent with observations by Reddy (2020) and Ravindranadh *et al.* (2019), which is likely influenced by their genetic makeup.

Economics

The cost of cultivation associated with the indigenous foxtail millet cultivars was calculated and is presented in Table 3. The cultivation cost remained constant across all cultivars, as each treatment incurred identical expenses. The total cost of cultivation was ₹ 24,917.17 ha⁻¹, comprising an operational cost of ₹ 14,270 ha⁻¹ and an input cost of ₹ 10,647.71 ha⁻¹. Among the cultivars evaluated, Chinchang recorded the highest gross returns (₹ 84,064.74 ha⁻¹), followed by Titse (₹ 28,623.25 ha⁻¹) and Asuna (₹ 22,893.80 ha⁻¹), while Sherha registered the lowest gross returns (₹ 35,500.22 ha⁻¹) as the variation in gross returns was primarily attributed to differences in seed and straw yields. Chinchang also exhibited the maximum net returns (₹ 59,147.74 ha⁻¹), which were significantly higher than

Table 2: Effect of different foxtail millet cultivars on yield parameters.

Treatments	Weight of the panicle (g panicle ⁻¹)	Length of the panicle (cm)	No. of panicles m ⁻²	No. of grains panicle ⁻¹	Seed yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)
T ₁ (Titse)	7.37	18.40	40.67	2494.67	1457	2540
T ₂ (Atsube)	5.07	15.27	38.44	2051.67	1171	2208
T ₃ (Tsu)	5.22	17.25	38.80	2312.00	1189	2068
T ₄ (Titsi)	5.13	13.43	37.03	1809.00	1099	2007
T ₅ (Sherha)	5.05	13.63	29.67	2250.00	956	2052
T ₆ (Asuna)	6.24	17.92	37.74	2197.33	1300	2320
T ₇ (Chinchang)	10.30	26.37	34.18	5819.00	2312	3133
T ₈ (SiA 3156)	5.19	15.45	46.67	953.00	1169	2077
SEm ±	0.36	1.03	0.99	186.67	67.18	80.37
CD (P=0.05)	1.11	3.12	3.02	566.19	203.78	243.78
CV (5%)	10.1	10.3	4.5	13.0	8.7	6.05

SEm ± = Standard error of mean; CD= Critical difference at P= 0.05.

Table 3: Economics as influenced by different indigenous cultivars.

Treatments	Cost of cultivation (₹ ha ⁻¹)	Gross returns (₹ ha ⁻¹)	Net returns (₹ ha ⁻¹)	Benefit cost ratio (BCR)
T ₁ (Titse)	24917.17	53540.25	28623.25	2.15
T ₂ (Atsube)	24917.17	43184.25	18267.25	1.73
T ₃ (Tsu)	24917.17	43695.23	18778.23	1.75
T ₄ (Titsi)	24917.17	40473.38	15556.38	1.62
T ₅ (Sherha)	24917.17	35500.22	10583.22	1.42
T ₆ (Asuna)	24917.17	47810.8	22893.8	1.92
T ₇ (Chinchang)	24917.17	84064.74	59147.74	3.37
T ₈ (SiA 3156)	24917.17	43003.67	18086.67	1.73

Selling price- ₹ 35 kg⁻¹.

those of Titse (₹ 53,540.25 ha⁻¹) and Asuna (₹ 47,810.80 ha⁻¹). The lowest net returns were observed in Sherha (₹ 10,583.22 ha⁻¹). The magnitude of net returns reflected the relative differences between gross income and the uniform cost of cultivation. Similarly, the benefit-cost ratio (BCR) was highest in Chinchang (3.37), followed by Titse (2.15), Asuna (1.92), Tsu (1.75), Atsube (1.73), SiA 3156 (1.73) and Titsi (1.62) while Sherha recorded the lowest BCR (1.43). Higher BCR values were associated with superior seed and straw yields in relation to cultivation costs and these findings are consistent with those reported by Srikanthya *et al.* (2020) and Jyothi *et al.* (2016).

CONCLUSION

The superior performance of the Chinchang cultivar can be attributed to its favourable yield-enhancing traits, particularly its compact and elongated panicles, which contributed to a substantially higher number of grains panicle⁻¹.

The economic analysis clearly indicates that Chinchang is the most profitable cultivar, exhibiting the highest gross returns, net returns and benefit-cost ratio (BCR). Despite a uniform cost of cultivation across all cultivars, the substantial differences in yield performance led to notable variations in economic outcomes. Overall, the results emphasize that cultivar choice plays a critical role in maximizing profitability, with Chinchang offering the greatest economic advantage under the given production conditions. These morphological advantages, coupled with vigorous vegetative growth, likely improved photosynthetic efficiency and assimilate accumulation, ultimately resulting in the highest grain and straw yields among all tested cultivars. Titse also exhibited enhanced yield attributes and strong vegetative growth, ranking second after Chinchang. Overall, Chinchang emerged as the most productive foxtail millet cultivar evaluated, followed by Titse, highlighting their strong genetic potential for improved yield performance.

Conflict of interest

All authors declared that there is no conflict of interest.

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