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Growth parameters, yield attributing characters and economics of different HYVs of Foxtail millet (*Setaria italica* L.) in the upland of Tripura

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Abstract— *A field experiment was conducted in January 2023 at the upland farm of the College of Agriculture, Lembucherra, West Tripura, to evaluate the performance of ten different high-yielding varieties of foxtail millet (Setaria italic L.) under upland conditions. The experiment was laid out in a randomized block design with three replications. The treatments consisted of 10 varieties viz., IIM-FXM-4 (V_1), Prasad (V_2), Garuda (V_3), GPUF-4 (V_4), GPUF-3 (V_5), Fingu (Local) (V_6), Black (Local) (V_7), SiA-4200 (V_8), SiA-3159 (V_9), SiA-3156 (V_{10})with plot size of 4.5m x 3.0m and 100-50-50 NPK kg ha^{-1} recommendation of fertilizer dose.Results of the experiment showed that among the varieties GPUF-3 recorded significantly highest values of plant height (135.33 cm), number of tillers plant^{-1} (8.50), dry matter accumulation (14.76 g) in all the growth stages of foxtail millet during the year of experimentation. GPUF-3 recorded superior yield attributes namely number of ears plant^{-1} (4.47), number of grains ear head^{-1} (1418.62), grain weight ear head-1 (4.97), length of ear head (21.33 cm) and 1000 seed weight (3.63 g) which ultimately produce higher seed yield (2245.81 kg ha^{-1}) stover yield (4215.02 kg ha^{-1}) during the year of experiment.From the economic point of view GPUF-3 fetched higher in terms of gross return, net return and B:C ratio due to higher seed yield.*

Keywords— ***Foxtail millet, varieties, growth and yield parameters, high yielding varieties, BCR***

I. INTRODUCTION

Small millets are increasingly important for food security amid climate change, addressing global warming, water scarcity, and health issues. These nutrient-dense crops are resilient to pests, temperature fluctuations, and drought, supporting over 60% of small and marginal farmers in arid regions. Displaced by larger grains over the past forty years, millets like foxtail, proso, barnyard, and tiny millet offer potential as the yield of major cereals stagnates. Millets, from the Poaceae family, produce numerous grains from a single seed and thrive on short, slender, grassy plants.

Small millets like finger, foxtail, little, kodo, barnyard, and proso millet are vital to India's dry farming, known as "nutritious cereals" for their rich nutrients. Essential for the world's poorest in semi-arid tropics, these crops thrive in dry areas with minimal water, quick maturation, and adaptability to various ecological conditions. They excel in challenging environments with little rainfall, poor soil, and uneven terrain(Chandel *et al*., 2014). Rising diabetes rates highlight millets as the healthiest diet for diabetics, spurring interest in health foods and commercialization(Sateesh, 2010). Foxtail millet, the second most cultivated, is notable for its drought resistance and moisture stress tolerance.

Foxtail millet, also known as Italian millet (*Setaria italica* L.), is one of the earliest and second most widely grown small millets. Renowned for its drought tolerance and adaptability to various soils(Cheng and Liu, 2003), it grows quickly and offers affordable nutrition, including protein,

vitamins, and minerals. It is a staple for the less fortunate in society(Muniratnam *et al*., 2006).Foxtailmillet is rich in fiber (8g), protein (12g), carbs (60.9g), fat (4.3g), calcium (31mg), iron (2.8mg), phosphorus (290mg), vitamins, amino acids, minerals, and provides 323-350 K Cal per 100g(Vanithasri *et al.,* 2012). Abundant in protein, iron, and β-carotene, it has a low glycemic index, making it ideal for diabetics. Its nutritional benefits have increased its demand in recent years(Hariprasanna, 2006).

India leads in millet production, contributing around 41% of the global output in 2021(Kumar *et al*., 2023), with an annual production of 10.08 million metric tonnes. Foxtail millet is cultivated on 0.87 lakh hectares, producing approximately 0.66 lakh tonnes with an average yield of 762 kg/ha(Hariprasanna, 2023). Andhra Pradesh, Karnataka, and Tamil Nadu account for 90% of foxtail millet cultivation, with Andhra Pradesh alone contributing 79% of the area. Despite low production potential due to traditional farming practices and inadequate management, new high-yielding varieties like SiA 3085 and SiA 3088, yielding 20-25 q/ha, offer potential for expansion.

In Tripura, Foxtail Millet, locally known as Kaon, is the predominant millet grown across all eight districts, primarily consumed by the tribal community. Historically cultivated during the Kharif season, a shift to the Rabi season began in 2020-21 with sustainable water practices. From 2016-17 to 2020-21, the cultivation area grew from 352 to 1,119 hectares, and production increased from 282 to 873 metric tons. Despite annual productivity fluctuations, an overall positive trend is evident, with the highest productivity of 849 kg/ha recorded in the Rabi season of 2020-21.Traditionally cultivated using jhum methods in Tripura, foxtail millet's productivity declined due to low yields. Recently, its nutritional benefits and climate resilience have sparked a resurgence. Studies aim to improve its yield and quality, as foxtail millet remains well-suited to Tripura's climate.

Objectives

To study the growth and yield attributing parameters of foxtail millet cultivars under Tripura condition.To study the performance foxtail millet cultivars under Tripura condition and to work out the economics of foxtail millet cultivation.

II. MATERIALS AND METHODS

During Rabi season of2023, the experiment was carried out at the College of Agriculture Tripura, Lembucherra. The experimental field is located at a South-westerly direction (23°54' N latitude and 91°19' E longitude, 45 M m.s.l.) about 260 metres from the college campus. The field soil is sandy clay loam in texture with pH 5.2 i.e., soil is moderately acidic in nature, bulk density of 1.481 g cc^{-1}. The available soil nitrogen (N) was found 289.23 kg ha^{-1}, phosphorus (P) 6.38 kg ha^{-1} and potassium (K) 110.28 kg ha^{-1} initially.The experimental field was laid out in Randomised Block Design (RBD) by having ten treatments (varieties) which were replicated three time, rows and plants were spaced at 25 x 8 cm. Germplasms were collected from IIMR (Indian Institute of MilletsResearch)Hyderabad, Telangana. Fertiliser dose was recommended 100:50:50 NPK, P and K were applied in full dose and N was applied in two equal splits, one at sowing another at30 DAS.

III. RESULT AND DISCUSSION

Performance of varieties on growth and yield attributes

Plant height (cm)

During harvest, significantly superior plant height was recorded with GPUF-3 over Fingu (Local), Black (Local) and SiA-4200. The variety Fingu recorded the shortest plant height.As the crop growth phase progresses with time the plant height variation was observed among the treated varieties. Garuda excelled in plant height to others at 20 DAS, at 40 ,60 DAS and at harvest GPUF-3 was noted tallest. The advancement in plant height might be due to genetic potential. These results were corroborated with Ravindranadh *et al.* (2019) and Nagaraja *et al.* (2022).

Number of tillers $plant^{-1}$

The total number of tillers $plant^{-1}$ recorded at harvest was significantly influenced by different varieties. At harvest, higher number of tillers $plant^{-1}$ was found with GPUF-3 which was significantly superior than all other varieties. The lowest number of tillers $plant^{-1}$ was obtained with the variety Prasad.These variations of producing different no of tillers among the varieties might be attributed to the genetic factors and the environment grown. These results were in conformity with Radhakumari *et al.* (2017).

Leaf Area Index (LAI)

At 60 DAS, variety SiA-3159 shown the higher leaf area index and was significantly superior over IIM-FXM-4, Garuda, Fingu (Local), Black (Local) and SiA-3156 and was statistically at par with Prasad, GPUF-3, GPUF-4, SiA-3159 and SiA-4200. Fingu was found to have the lowest index among the varieties.At all the intervals of growth phase variety SiA-3159 exhibited the superior index over the others and Fingu was found to have the least leaf area index throughout the course of crop growth. This might be due to variation on genetic potential for heavy vegetative structure. These results were found similar with Ravindranadh *et al.* (2019).

Dry matter accumulation

At harvest dry matter accumulation was found to be highest in the variety GPUF-3 which was significantly superior over IIM-FXM-4, Prasad, Garuda, Black (Local) and SiA-4200 and statistically at par with rest varieties. The lowest record was found in variety Prasad.Variations in dry matter accumulations might be due to production of more number of tillers and genetic character for higher photosynthetic capacity. Genotypic variations in dry matter accumulation in foxtail millet genotypes were also reported by Vaghdevi *et al.* (2020).

Crop Growth Rate (g m^{-2} day^{-1})

The highest crop growth rate was observed in GPUF-4 at 40-60 DAS which was statistically at par with GPUF-3, Fingu (Local) and SiA-3159 and significantly superior than others. The lowest was found in SiA-4200. Towards the harvest maximum crop growth rate was noted in Prasad which was significantly higher than GPUF-4, Fingu, SiA-3159 and SiA-3156 and rest varieties are at par. The minimum growth rate was discovered in Fingu. Crop growth rate was found to be highest at 40-60 DAS of interval and declined towards the harvest which might be due to the growth has entered the senescence stage since reproductive phase. Greater CGR is resulted from the greater dry matter production which might be due to different genetic makeup of different Varieties. These findings were found to be similar with Ravindranadh *et al.* (2019).

Table 1: Growth parameters of foxtail millet as influenced by different varieties

Varieties	Plant height (cm)	Number of tillers $plant^{-1}$	Leaf Area Index	Total dry matter accumulation $plant^{-2}$ (g)	Crop Growth Rate ($gm^{-2}day^{-1}$)
IIM-FXM-4	126.57	5.43	3.47	11.77	10.38
Prasad	125.70	4.47	3.84	11.17	11.31
Garuda	120.57	6.00	3.44	12.02	11.80
GPUF-4	124.14	7.53	4.00	13.70	17.95
GPUF-3	135.33	8.50	3.94	14.76	16.76
Fingu (Local)	96.97	4.89	3.34	13.01	15.85
Black (Local)	112.44	4.60	3.53	11.87	11.30
SiA-4200	114.03	5.60	4.04	11.26	8.30
SiA-3159	130.07	7.26	4.10	14.32	17.02
SiA-3156	128.17	6.56	3.53	13.13	14.07
$SE_{m(\pm)}$	5.43	0.29	0.14	0.59	0.85
CD at 5%	16.40	0.87	0.42	1.78	2.58
CV (%)	7.75	8.19	6.55	7.96	10.97

Yield and yield attributing characters

Among the investigated varieties, GPUF-3 recorded better number of ears which was significantly superior over IIM-FXM-4, Prasad, Garuda, Fingu (Local) and Black (Local) and rest varieties are at par. These findings were similar with Raviraja *et al.* (2020), Radha kumari and Sahadeva Reddy (2023).

Among the tested varieties, GPUF-3 yielded the highest number of grains per ear head which was significantly superior over Garuda, Fingu (Local), Black (Local), SiA-4200 and rest are statistically at par. Fingu exhibited the lowest grain count possibly due to differences in photosynthate translocation efficiency and genetic potential, consistent with previous studies of Yadav *et al.* (2023).

Among the tested varieties, GPUF-3 exhibited the highest grain weight per ear head which was statistically at par with GPUF-3 and SiA-3159 and significantly superior than rest varieties (Table 2). Conversely, Prasad had the lowest grain weight per ear head.Similar results were reported by Srikanya *et al.* (2019).

GPUF-3 exhibited superior ear head length than other varieties which was statistically at par with varieties Garuda, GPUF-4, GPUF-3, SiA-3159 and significantly superior than rest varieties. However, Prasad had the lowest ear head length. This difference may be attributed to the

genetic potential of the variety in determining ear head length and its effectiveness in assimilate partitioning from source to sink. Similar findings were reported by Deva *et al.* (2019) and Srikanya *et al.* (2020).

Among the ten conducted varieties GPUF-3 outperformed the others by having highest weight which was statistically at par with Garuda, GPUF-4, GPUF-3, SiA-3159 and significantly superior than rest varieties. The least weight was found in Prasad. These results are in agreement with the findings of Sahaja *et al.* (2019).

Table 2: Effect of varieties on yield attributes of foxtail millet

Varieties	No. of ears plant^{-1}	Grain no. ear head^{-1}	Grain wt. ear head^{-1} (g)	Length of ear head (cm)	Test weights (g)
IIM-FXM-4	3.20	1310.42	4.10	16.83	3.13
Prasad	2.77	1293.90	3.79	14.83	2.97
Garuda	3.53	1180.10	4.15	19.63	3.55
GPUF-4	4.10	1389.69	4.51	19.80	3.26
GPUF-3	4.47	1418.62	4.97	21.33	3.63
Fingu (Local)	3.13	1139.70	3.90	18.30	3.45
Black (Local)	3.00	1167.17	4.02	14.93	3.48
SiA-4200	3.10	1142.46	3.92	16.97	3.46
SiA-3159	4.37	1373.96	4.81	20.80	3.41
SiA-3156	3.93	1358.63	4.49	19.23	3.33
SEm (±)	0.22	48.47	0.13	0.69	0.10
CD at 5%	0.65	146.34	0.40	2.07	0.31
CV (%)	10.53	6.57	5.38	6.51	5.20

Seed and stover yield (kg ha^{-1})

Analysis of the data on grain yield reveals that GPUF-3 achieved the highest grain yield, significantly outperforming the other nine varieties of foxtail millet. Secondly followed by SiA-3159 which was statistically at par. Prasad attained the least grain yield and two local varieties viz., Black and Fingu exhibited the similar yield which were slightly higher than Prasad. The genetic makeup of the variety in yield attributing morpho-physiological factors and maximal dry matter content may be the cause of its notable advantage for grain yield. Nagaraja *et al.* (2022), Ravindranadh *et al.* (2019) reported the similar records.

Among the varieties examined, SiA-3159 achieved the highest stover yield which was statistically at par with GPUF-4, GPUF-3 and significantly superior than rest varieties. Lowest stover yield was observed in Prasad. The genetic characteristics of the variety and environmental factors contributed to increased dry matter production, consequently enhancing the stover yield. These findings were in agreement with Sahoo *et al.* (2020) and Ravindranadh *et al.* (2019).

Harvest Index

Highest index was found in GPUF-3 which outperformed the others and was statistically at par with IIM-FXM-4, GPUF-4, SiA-3159 and significantly higher than rest varieties. The minimum index was recorded with Prasad. Variations in harvest indices were the results from dry matter production in terms of no. of tillers, no. of leaves produced in a plant of different varieties. These results were in consonance with the findings of Nandini and Sridhara (2020).

Table 3: Seed, stover yield and harvest indexas influenced by varieties of foxtail millet

Varieties	Seed yield (kg ha^{-1})	Stover Yield (kg ha^{-1})	Harvest Index
IIM-FXM-4	1303.78	2781.37	32.85
Prasad	1099.85	2766.55	28.36
Garuda	1328.31	3275.96	28.92

GPUF-4	1994.17	4255.84	31.90
GPUF-3	2245.81	4215.02	34.76
Fingu (Local)	1257.60	3671.84	25.51
Black (Local)	1164.22	3028.09	27.73
SiA-4200	1179.36	2865.71	29.17
SiA-3159	2101.40	4560.22	31.55
SiA-3156	1542.16	3617.01	29.63
$SE_{m(\pm)}$	79.94	181.68	1.29
CD at 5%	241.37	548.53	3.91
CV (%)	9.10	8.98	7.46

Economic studies

The maximum gross return was achieved with the cultivation GPUF-3 which was statistically at par with SiA-3159 and significantly superior than rest varieties. The minimum return was recorded with Prasad due to its poor performance in terms of producing lower yields. These results are supported with the findings of Shashma *et al.* (2023) and Reddy *et al.* (2023).

GPUF-3 outstood in terms of net returns over the others and was at par with SiA-3159 and significantly superior than rest varieties. Prasad was found to have given the lowest net return. The mentioned findings were in agreement with Shashma *et al.* (2023) and Upadhaya *et al.* (2022).

GPUF-3 attained the highest B:C ratio which was at par with SiA-3159 and significantly higher than rest varieties and conversely found lowest in Prasad. Similar results were reported by Upadhaya *et al.* (2022) and Sathisha *et al.* (2022).

Table 4.14 Gross returns, net returns and B:C ratio as influenced by different varieties

Varieties	**Gross returns (Rs. ha^{-1})**	**Net returns (Rs. ha^{-1})**	**B:C Ratio**
IIM-FXM-4	45632.18	23854.18	2.10
Prasad	38494.87	16716.87	1.77
Garuda	46490.73	24712.73	2.13
GPUF-4	69795.83	48017.83	3.20
GPUF-3	78603.47	56825.47	3.61
Fingu (Local)	44016.00	22238.00	2.02
Black (Local)	40747.70	18969.70	1.87
SiA-4200	41277.48	19499.48	1.90
SiA-3159	73549.00	51771.00	3.38
SiA-3156	53975.60	32197.60	2.48
$SE_{m(\pm)}$	2798.02	2798.02	0.13
CD at 5%	8447.79	8447.79	0.39
CV (%)	9.10	15.39	9.10

IV. CONCLUSION

Based on the observations, it appears that among the ten varieties of foxtail millet studied, GPUF-3 showed superior performance in terms of growth and yield characteristics, followed closely by SiA-3159. In, under upland conditions, GPUF-3 exhibited higher profitability and production compared to other varieties. Both GPUF-3 and SiA-3159 showed a competitive edge in various aspects of growth and yield.

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