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Evaluation of proso millet varieties and sowing dates for optimal growth and yield under Krishna Agro-Climatic Zone

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ABSTRACT

A field experiment was conducted in Rabi, 2023-24 to evaluate of proso millet varieties and sowing dates for optimal growth and yield. The study was conducted in a randomized block design (RBD) with a factorial concept and was replicated thrice. The experimental treatments included three proso millet varieties, TNAU 164 (V_1), TNPm 230 (V_2) and CO 4 (V_3) and three sowing dates I FN of October (D_1), II FN of October (D_2), and I FN of November (D_3). The results revealed that growth parameters, including plant height, dry matter production, days to 50% flowering, and days to maturity, were significantly influenced by both the variety and the sowing date. TNPm 230 (V_2) exhibited superior plant height and dry matter accumulation at most growth stages compared to TNAU 164 (V_1) and CO 4 (V_3). Additionally, the I FN of October (D_1) resulted in the highest growth metrics across all stages. The variety, CO 4 (V_3) took the longest time to reach days to 50% flowering and maturity, while the sowing date of I FN of October required more time for these phenological stages compared to the other sowing dates. In terms of yield attributes. This variety has achieved the highest grain yield (1551 kg ha^{-1}) and stover yield (2422 kg ha^{-1}). The sowing during the I FN of October led to the maximum grain yield (1619 kg ha^{-1}) and stover yield (2545 kg ha^{-1}). Harvest index was not significantly affected by variety but was higher for the I FN of October compared to the I FN of November month.

Keywords: *Dates of sowing, Growth parameters, Phenological stages, Proso millet and Yield.*

Millets, particularly minor varieties such as proso millet (*Panicum miliaceum* L.), are vital to agriculture due to their nutritional benefits, adaptability, and resilience. Despite their relatively modest size, millets play a crucial role in providing essential nutrients and supporting livelihoods in marginal and semi-arid regions. The term “millet” originates from the French word “mille,” meaning thousand, reflecting the multitude of grains in a handful of these small seeds. These hardy crops are often cultivated in environments with limited rainfall and marginal soils under semiarid tropics, offering reliable yields where other crops might fail (Joshi and Agnihotri, 1984; Yenagi *et al*., 2010).

Proso millet is notably called as superhero in millets for its exceptional heat and drought tolerance, high photosynthetic efficiency, and short growth cycle, typically completing its life cycle in 60–90 days of time period (Calamai *et al*., 2020). These characteristics make it particularly suitable for climate-smart resilient agriculture, providing a stable food source in the face of changing climatic conditions. Proso millet is gluten-free food and enrich in essential nutrients and minerals such as protein, iron, zinc, and calcium, offering significant health benefits and addressing issues like anaemia and diabetes (Tomar *et al*., 2020; Kam *et al*., 2016).

India is the world’s largest producer of millets, contributing to 42% of global consumption. In recognition of their importance, the United Nations declared 2023 as the “International Year of Millets,” underscoring their role in global food and nutritional security (Poshadri *et al*., 2023). Despite its historical significance and potential, proso millet has received limited modern research attention, especially concerning its optimal cultivation practices. The objective of this study was to evaluate different proso millet varieties under different sowing times to determine the most effective strategies for maximizing growth and yield in the Krishna agro-climatic zone of Andhra Pradesh.

MATERIAL AND METHODS

The experiment was piloted in field No. 7 of the Orchard block at Agricultural College Farm, Bapatla, located at 5.49 meters above mean sea level, with coordinates 15° 54' N and 80° 25' E, about 8 km from the Bay of Bengal in Andhra Pradesh, India. Weather data from 09 October 2023 to 31 January 2024 recorded weekly mean maximum temperatures between 28.7°C and 34.4°C (average 30.9°C), mean minimum temperatures from 18.0°C to 24.6°C (average 21.1°C), and total rainfall of 397.8 mm over 11 days. Relative humidity ranged from 78% to 87% at 08:30 hrs and 59% to 80% at 17:30 hrs. Sunshine hours averaged 7.4 per day, and day length averaged 11.24 hours. Soil samples from a 0-30 cm depth were collected before the experiment, mixed, air-dried, and analyzed. The soil was sandy clay loam, neutral in pH, and low in organic carbon and available nitrogen but high in available phosphorus and potassium. A Randomized Block Design (RBD) with a factorial concept was used, involving nine treatments from two factors: three varieties (TNAU 164, TNPm 230 and CO 4) and three sowing dates (I FN of October, II FN of October and I FN of November). Each treatment was replicated three times. Observations were recorded on plant height, dry matter accumulation, days to 50% flowering, days to maturity, grain yield, stover yield and harvest index.

RESULTS AND DISCUSSION

Effect of Varieties

At 15 and 45 DAS, the proso millet variety TNPm 230 (V_2) exhibited the tallest plant height, reaching 31.6 cm, 75.2 cm, respectively, which was significantly higher than that of TNAU 164 (V_1) and CO 4 (V_3). (Table) The plant heights of TNAU 164 (V_1) and CO 4 (V_3) were similar to each other. At 30, 60 DAS and at harvest, TNPm 230 (V_2) continued to show significantly higher plant height compared to CO 4 (V_3) and was statistically similar to TNAU 164 (V_1). These findings are consistent with those of Swathi *et al*. (2021), who observed that TNPm 230 exhibited maximum height during the *rabi* season. The variation in plant height among the varieties is attributable to their genetic characteristics, with increased height associated with enhanced cell division and elongation, as supported by Kandel *et al*. (2020).

At 15 DAS, TNPm 230 (V_2) recorded the highest dry matter accumulation at 54 kg ha^{-1}, significantly surpassing TNAU 164 (V_1) at 49 kg ha^{-1} and CO 4 (V_3) at 48 kg ha^{-1}, with TNAU 164 (V_1) being similar to CO 4 (V_3). By 30 DAS, TNPm 230 (V_2) accumulated 563 kg ha^{-1} of dry matter, significantly more than CO 4 (V_3) at 476 kg ha^{-1} and comparable demonstrated superior dry matter accumulation of 2346 kg ha^{-1} compared to TNAU 164 (V_1) at 2089 kg ha^{-1} and CO 4 (V_3) at 1667 kg ha^{-1}. At 60 DAS and at harvest, TNPm 230 (V_2) accumulated 3526 kg ha^{-1} and 4013 kg ha^{-1} of dry matter, respectively, which was statistically similar to TNAU 164 (V_1) at 3437 kg ha^{-1} and 3837 kg ha^{-1}, but significantly higher than CO 4 (V_3) at 2570 kg ha^{-1} and 2939 kg ha^{-1}. The increased dry matter in TNPm 230 (V_2) is likely due to its greater plant height and leaf area, supported by genetic factors, consistent with findings by Saini and Thakur (1997) and Srikanya *et al*. (2020).

Among the varieties, CO 4 (V_3) took the longest to reach days to 50% flowering (41 days), significantly longer than TNAU 164 (V_1) (37 days) and TNPm 230 (V_2) (38 days)(Table 3). This extended flowering period in CO 4 is due to its longer duration compared to the other varieties. CO 4 (V_3) required the maximum number of days to reach maturity (76 days), significantly longer than TNAU 164 (V_1) (70 days) and TNPm 230 (V_2) (72 days)(Table 3).

The grain yield of proso millet was significantly influenced by both variety and sowing date, though their interaction was not significant. TNPm 230 had the highest yield (1551 kg ha^{-1}), outperforming TNAU 164 (1356 kg ha^{-1}) and CO 4 (1128 kg ha^{-1}) by 12.57% and 27.27%, respectively (Table 4). This is attributed to TNPm 230's superior dry matter accumulation, productive tillers, and panicle weight, aligning with findings from Nirmalakumari *et al*. (2020) and Swathi *et al*. (2021). Stover yield was significantly affected by variety and sowing date, with no significant interaction. TNPm 230 produced the highest stover yield (2422 kg ha^{-1}), significantly higher than CO 4 (1989 kg ha^{-1}).

Effect of dates of sowing

Plant height varied significantly with sowing dates. The maximum height was observed when sown in the I FN of October (D_1) at all growth stages (15, 30, 45, 60 DAS and at harvest), compared to sowing in the I FN of November (D_3). Early sowing allowed plants to benefit from favourable environmental conditions, leading to greater height. Similar observation was recorded by Swathi *et al*. (2021).

Among the different dates of sowing tried, drymatter accumulation recorded with I FN of October sowing was maximum and significantly superior at 15 and 45 DAS with 55 and 2444 kg ha

$^{-1}$, respectively compared to II FN of October sowing with 50 and 2131 kg ha^{-1}, respectively and I FN of November sowing with 48 and 1667 kg ha^{-1}, respectively. However, at 30, 60 and at harvest accumulation of drymatter in proso millet was on par between I and II FN of October sowing and significantly superior over I FN of November sowing due to the early sowing and favourable weather conditions, leading to increased photosynthesis and dry matter production. This supports the observations of Swathi *et al*. (2021).

Sowing in the I FN of October (D_1) resulted in a greater number of days to 50% flowering (42 days) compared to the II FN of October (D_2) (38 days) and the I FN of November (D_3) (36 days). The prolonged flowering period in D_1 is likely due to extended vegetative growth associated with more rainy days. These results align with Reager *et al.* (2023). The first fortnight of October sowing (D_1) took significantly more days (76) to mature compared to the first fortnight of November sowing (D_3) (69 days) and was comparable to the second fortnight of October sowing (D_2) (73 days). The extended maturity period for D_1 is associated with the prolonged vegetative phase. Reddy *et al*. (1991) also noted that delayed sowing results in earley flowering and reduced vegetative growth, leading to earley maturity.

Table 1. Plant height (cm) of proso millet varieties at 15, 30, 45, 60 DAS and at harvest as influenced by dates of sowing

Treatments	15 DAS	30 DAS	45 DAS	60 DAS	At harvest
Varieties (V)					
(V_1) TNAU 164	28	51.5	67.5	83.3	94.5
(V_2) TNPm 230	31.6	55.9	75.2	89.8	100.6
(V_3) CO 4	27.8	42.2	61.2	75	85.9
SEm±	1.09	1.55	2.51	2.78	2.99
CD (P=0.05)	3.3	4.6	7.5	8.3	9
Dates of sowing (D)					
(D_1) I FN of October	32.7	55.7	75	90.3	103.6
(D_2) II FN of October	28.8	52.1	67.3	84.9	96.4
(D_3) I FN of November	25.9	41.7	61.6	72.8	80.9
SEm±	1.09	1.55	2.51	2.78	2.99
CD (P=0.05)	3.3	4.6	7.5	8.3	9
Interaction (V x D)					
V_1D_1	31.8	55.7	75.3	91	105.9
V_1D_2	28.1	54.8	65.2	83.7	94.3
V_1D_3	24.1	44	61.8	75.1	83.3
V_2D_1	36.4	62.7	82.2	98.7	111.7
V_2D_2	30	58	73.7	92.6	103.3
V_2D_3	28.4	47	69.6	78	86.7
V_3D_1	29.9	48.7	67.4	81.2	93.3
V_3D_2	28.3	43.7	62.9	78.3	91.7
V_3D_3	25.3	34.2	53.2	65.4	72.7
SEm±	1.89	2.68	4.36	4.81	5.18
CD (P=0.05)	NS	NS	NS	NS	NS
CV%	11.2	9.3	11.1	10	9.6

Table 2. Drymatter production (kg ha^{-1}) of proso millet varieties at 15, 30, 45, 60 DAS and at harvest as influenced by dates of sowing

Treatments	15 DAS	30 DAS	45 DAS	60 DAS	At harvest
Varieties (V)					
(V_1) TNAU 164	49	515	2089	3437	3837
(V_2) TNPm 230	54	563	2346	3526	4013
(V_3) CO 4	48	476	1667	2570	2989
SEm±	1.43	16.7	78.1	143.5	148.0
CD (P=0.05)	4	50	234	430	444
Dates of sowing (D)					
(D_1) I FN of October	55	568	2444	3526	4132
(D_2) II FN of October	50	521	2131	3341	3744
(D_3) I FN of November	46	466	1526	2667	2963
SEm±	1.43	16.7	78.1	143.5	148.0
CD (P=0.05)	4	50	234	430	444
Interaction (V x D)					
V_1D_1	54	557	2489	3844	4489
V_1D_2	50	521	2222	3600	3933
V_1D_3	44	468	1556	2867	3089
V_2D_1	60	607	2889	3845	4662
V_2D_2	51	571	2506	3733	4078
V_2D_3	50	512	1644	3000	3300
V_3D_1	51	540	1956	2889	3244
V_3D_2	50	470	1667	2689	3222
V_3D_3	44	419	1378	2133	2500
SEm±	2.5	29.0	135.4	143.5	256.4
CD (P=0.05)	NS	NS	NS	NS	NS
CV%	8.6	10.0	11.5	14.0	12.3

Table 3. Days to 50% flowering and maturity of proso millet varieties as influenced by dates of sowing

Treatments	Days to 50% flowering	Days to maturity
Varieties (V)		
(V_1) TNAU 164	37	70
(V_2) TNPm 230	38	72
(V_3) CO 4	41	76
SEm±	0.7	1.5
CD (P=0.05)	2	5
Dates of sowing (D)		
(D_1) I FN of October	42	76
(D_2) II FN of October	38	73
(D_3) I FN of November	36	69
SEm±	0.7	1.5
CD (P=0.05)	2	5
Interaction (V x D)		
V_1D_1	40	73
V_1D_2	36	70
V_1D_3	34	67
V_2D_1	42	76
V_2D_2	39	72
V_2D_3	36	69
V_3D_1	45	80
V_3D_2	40	76
V_3D_3	38	72
SEm±	1.2	2.6
CD (P=0.05)	NS	NS
CV%	5.3	6.2

Table 4. Grain yield, stover yield and harvest index of proso millet varieties as influenced by dates of sowing

Treatments	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest Index (%)
Varieties (V)			
(V_1) TNAU 164	1356	2309	36.6
(V_2) TNPm 230	1551	2422	39.0
(V_3) CO 4	1128	1989	35.7
SEm±	64.1	88.0	1.01
CD (P=0.05)	192	264	NS
Dates of sowing (D)			
(D_1) I FN of October	1619	2545	38.7
(D_2) II FN of October	1387	2287	37.7
(D_3) I FN of November	1029	1887	34.9
SEm±	64.1	88.0	1.01
CD (P=0.05)	192	264	3.0
Interaction (V x D)			
V_1D_1	1659	2600	38.8
V_1D_2	1389	2374	36.8
V_1D_3	1022	1952	34.2
V_2D_1	1803	2769	39.4
V_2D_2	1585	2472	39.2
V_2D_3	1265	2024	38.3
V_3D_1	1394	2265	38.0
V_3D_2	1188	2016	37.0
V_3D_3	802	1686	32.0
SEm±	111.1	134.8	1.76
CD (P=0.05)	NS	NS	NS
CV%	14.3	11.8	8.2

Early sowing in October (I FN) yielded 14.32% more than late October sowing and 36.44% more than early November sowing. Delayed sowing led to reduced temperatures and shorter day lengths, affecting growth and yield, consistent with Swathi *et al*. (2021). Early sowing in October (I FN) resulted in the highest stover yield (2545 kg ha^{-1}), with better growth conditions leading to increased yields, as noted by Lokesh *et al*. (2023). Sowing in October (I FN) produced a higher harvest index than sowing in November, due to better resource utilization leading to greater dry matter accumulation and yield.

CONCLUSION

The present study highlighted the superior performance of TNPm 230 (V_2) in terms of plant height, dry matter accumulation, days to maturity, and grain and stover yields compared to TNAU 164 (V_1) and CO 4 (V_3). Early October sowing (D_1) facilitated optimal growth conditions, maximizing biomass production and yield potential. Varietal differences in growth parameters underscore the importance of genetic characteristics in crop development. These findings emphasize the need for selecting suitable varieties and sowing dates tailored to local conditions to enhance proso millet production effectively.

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