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Effect of planting techniques and weed management practices on yield and economics of finger millet (*Eleusine coracana* (L.) Gaertn.)

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Abstract
The field experiment was conducted to study the effect of planting techniques and weed management practices on yield and economics of finger millet (*Eleusine coracana* (L.) Gaertn.). The experiment was carried out at the instructional farm of Dr. Sharadchandra Pawar College of Agriculture, Baramati, Maharashtra, India during *kharif* season of 2024-25 with 4 planting techniques (direct seeding at 30 × 10 cm and 30 × 10 cm and transplanting at 30 × 10 cm and 30 × 10 cm) and 5 weed management practices (PE application Oxyfluorfen *fb* hand weeding at 40 DAS/DAT, PoE application of Bispyribac sodium *fb* hand weeding at 40 DAS/DAT, Two hand weeding at 20 and 40 DAS/DAT, Weed free check, Weedy check). Results revealed that among planting techniques transplanting at 30 × 30 cm to finger millet recorded significantly highest number of earheads plant-1 (7.15), number of fingers earhead-1 (8.66), grain weight plant-1 (44.24 g) test weight (5.71 g), grain yield (23.51 q ha^{-1}), straw yield (49.00 q ha^{-1}) and biological yield (72.50 q ha^{-1}) with a harvest index of 32.29%. In economic studies transplanting at 30 × 30 cm gross returns of ₹1,22,542.79 ha^{-1}, net returns of ₹57,806.33 ha^{-1} and a B:C ratio of 1.88. Among weed management practices result revealed that weed free check recorded higher number of earheads plant-1 (4.84), number of fingers earhead-1 (8.51), grain weight plant-1 (36.63 g) test weight (5.77 g), grain yield (24.11q ha^{-1}), straw yield (48.81 q ha^{-1}), biological yield (72.92 q ha^{-1}) and harvest index of 33.03%, this treatment was at par with two hand weeding at 20 and 40 DAS/ DAT. However, highest net returns (₹55344.14 ha^{-1}) and B:C ratio (1.90) was recorded in treatment pre-emergence application of Oxyfluorfen 23.5% EC at 80 g ha-1 *fb* one hand weeding at 40 DAS/ DAT.

Keywords: Finger millet, transplanting, weed management, planting techniques, herbicides, spacing

Introduction
Finger millet (*Eleusine coracana* L.), also known as ragi, is a hardy, climate-resilient millet crop widely grown in India and Africa for grain and fodder (Kumar and Paramasivan, 2020) [4]. It is nutritionally superior, rich in calcium (344 mg/100 g), dietary fiber (15–20%), and essential amino acids (Gull *et al*., 2014) [5], making it valuable in managing lifestyle diseases (Gurung *et al.,* 2023) [6]. Karnataka leads in cultivation, contributing over 60% to national production (Shubhashree *et al.*, 2023) [9]. Despite its potential, yields remain low due to poor agronomic practices (Gavit *et al.,* 2017) [7]. Planting methods like broadcasting and random transplanting result in uneven spacing and reduced productivity (Bhatta *et al.*, 2017) [8]. Proper spacing improves nutrient use and crop growth (Bhowmik *et al.*, 2012) [12]. Additionally, finger millet is highly susceptible to early weed competition, causing 34–62% yield losses if not controlled timely (Prasad *et al.,* 1991; Manjunath and Muniyappa, 1990) [11, 10]. Labour-intensive hand weeding is costly and often delayed (Nyende, 2001) [13], prompting the need for efficient weed management. Herbicides, especially low-dose formulations, offer effective and economical weed control with minimal environmental impact (Guruprasanna *et al.,* 2004; Devi *et al.,* 2024) [14, 15]. To boost productivity and profitability in finger millet, scientific evaluation of planting techniques and integrated weed management is essential, especially under rainfed and resource-limited conditions (Pradhan *et al*., 2014) [2].

Materials and Methods

A field experiment was undertaken during *Kharif* 2024-25 season at the instructional farm, Dr. Sharadchandra Pawar College of Agriculture, Baramati, District Pune, Maharashtra, India. Geographically, the area was situated between 18o13' North latitude and 74o54' East longitude.

The experiment was conducted in a split plot design with 4 main plot treatments (planting techniques) and 5 sub-plot treatments (weed management practices), comprised a total of 20 treatment combinations, replicated 3 times. The main plot treatments included: S1 – Direct seeding at 30 cm × 10 cm spacing, S2 – Direct seeding at 30 cm × 30 cm spacing, S3 – Transplanting at 30 cm × 10 cm spacing and S4 – Transplanting at 30 cm × 30 cm spacing. The sub-plot treatments comprised different weed management strategies, which were: T1 – Pre-emergence application of Oxyfluorfen 23.5% EC at 80 g ha^{-1} followed by one hand weeding at 40 DAS/DAT, T2 – Post-emergence application of Bispyribac-sodium 10% SC at 20 g ha^{-1} followed by one hand weeding at 40 DAS/DAT, T3 – Hand weeding on 20 DAS/DAT followed by one hand weeding at 40 DAS/DAT, T4 – Weed free check and T5 – Weedy check. Pre-emergence herbicide spray done on 2 DAS and post emergence on 20 DAS.

Result and discussion Yield attributes and yield Effect of planting techniques

The data (Table 1, Fig. 1) on yield-attributing characters and yield of finger millet as influenced by different planting techniques revealed significant variations. Among all the planting techniques, transplanting at 30 cm × 30 cm spacing (S4) treatment recorded the highest number of earheads plant-1 (7.15), maximum number of fingers earhead-1 (8.66), highest grain weight plant-1 (44.24 g) and test weight (5.71 g). The better performance under wider spaced transplanting is likely due to improved air circulation, better light penetration, and less competition between plants. This allowed each plant to grow more vigorously and utilize available resources more efficiently. These observations are in line with the findings of Ahiwale *et al.,* (2011) [1] and Bhatta *et al.,* (2017) [8] reported similar improvements in yield attributes under transplanting methods with wider spacing.

Similarly in the yield (Table 2, Fig. 2) transplanting at 30 cm × 30 cm produced the highest grain yield (23.51 q ha^{-1}), straw yield (49.00 q ha^{-1}), biological yield (72.50 q ha^{-1}) and also recorded a harvest index (32.29%). The lowest grain yield (15.49 q ha^{-1}), straw yield (33.79 q ha^{-1}), biological yield (49.28 q ha^{-1}) and lower harvest index (30.98%) were recorded under direct seeding at 30 cm × 10 cm. The overall improvement in yield under transplanting may be due to better plant establishment, healthier tillering, and more effective use of nutrients and moisture. These results are strongly supported by earlier studies from Pradhan *et al.,* (2014) [2] and Hebbal *et al.,* (2018) [16].

Effect of weed management practices

Weed management practices significantly influenced the yield attributes and yield of finger millet (Table 1, Fig. 1). Among all treatments, the weed-free check (T4) recorded the highest number of earheads plant-1 (4.84), number of fingers earhead-1 (8.51), grain weight plant-1 (36.63 g) and test weight (5.77 g). While this was statistically similar to two hand weeding at 20 and 40 DAS/DAT and PE application of PE application of oxyfluorfen *fb* hand weeding at 40 DAS/ DAT. The weedy check (T5) produced the lowest values across all yield traits, indicating the severe negative impact of unchecked weed competition during the early growth phase of the crop. Weeds not only compete for essential resources like light, water, and nutrients but also create an unfavorable microenvironment that hampers crop development. This is in agreement with earlier findings by Prasad *et al.,* (1991) [11] and Manjunath and Muniyappa (1990) [10], who reported yield losses up to 60% in finger millet under severe weed infestation.

The yield data (Table 2, Fig. 2) followed a similar trend. The weed-free check gave the highest grain yield (24.11 q ha^{-1}), straw yield (48.81 q ha^{-1}), and biological yield (72.92 q ha^{-1}), with a harvest index of 33.03%. However, these values were statistically at par with two other effective treatments hand weeding at 20 and 40 DAS/DAT (T3) and pre-emergence application of oxyfluorfen followed by hand weeding at 40 DAS/DAT (T1). These results highlight the efficiency of combining herbicides with manual weeding, as both treatments provided a relatively weed-free environment during the crop's critical growth stages. Similar results were reported by Bhargavi *et al.,* (2016) [17] found that integrated weed management strategies, especially those combining chemical and manual methods, significantly improved the yield of finger millet. Additionally, Shubhashree *et al.,* (2023) [9] emphasized that early and timely weed control is essential for achieving optimum productivity, particularly in slow-growing crops like finger millet.

Interaction effect

Significantly highest grain weight plant-1 (53.81 g), grain yield (27.91 q ha^{-1}), straw yield (56.90 q ha^{-1}) and biological yield (84.81 q ha^{-1}) recorded under treatment combination transplanting at 30 × 30 cm with weed free check recorded minimum weed dry matter. This treatment was closely followed by transplanting at 30 × 30 cm with two hand weeding at 20 and 40 DAS/ DAT and transplanting at 30 × 30 cm with PE application of oxyfluorfen *fb* hand weeding at 40 DAS/ DAT.

Economics

Effect of planting techniques

The economic analysis revealed that transplanting at 30 × 30 cm spacing emerged as the most profitable planting technique, recording the highest gross returns of ₹1,22,542.79 ha^{-1}, net returns of ₹57,806.33 ha^{-1}, and a B:C ratio of 1.88. This was closely followed by the transplanting technique at 30 × 10 cm, which also showed favourable economic outcomes. On the contrary, direct seeding at 30 × 10 cm spacing resulted in the lowest economic performance, with gross returns of ₹80,983.26 ha^{-1}, net returns of ₹14,969.49 ha^{-1}, and a B:C ratio of 1.21. However, the lowest cost of cultivation was observed in direct seeding at 30 × 30 cm, likely due to reduced labour and input requirements. (Table 3, Fig. 3)

The superior economic returns in transplanting can be attributed to better crop establishment, reduced intra-plant competition, and enhanced nutrient uptake, ultimately resulting in higher yield and profit margins. These results align with the findings of Hebbel *et al.,* (2018).

Effect of weed management practices

Among the weed management practices, the weed free check recorded the highest gross returns of ₹1,25,451.69 ha^{-1}, which was statistically comparable with two hand weeding at 20 and 40 DAS/DAT. However, the pre-emergence application of oxyfluorfen followed by one hand weeding at 40 DAS/DAT emerged as the most economical treatment, generating net returns of ₹55,344.14 ha^{-1} and the highest B:C ratio of 1.90

(Table 3, Fig. 3). These results were at par with the treatment involving two hand weeding at 20 and 40 DAS/DAT indicating that both approaches were effective in improving profitability. In contrast, the weedy check resulted in the lowest economic returns, with a gross income of only ₹52,329.81 ha^{-1} and net returns of ₹1,939.71 ha^{-1}, despite incurring the lowest cost of cultivation (₹50,390.11 ha^{-1}). The poor performance of this treatment was largely due to heavy weed infestation, which severely impacted crop growth and yield. These findings are supported by Pradhan *et al.,* (2010) [2] and Kunjur *et al.,* (2019) [3].

Interaction effect

Treatment transplanting at 30 × 30 cm with weed free check recorded highest gross returns (₹1,45,292.92 ha^{-1}). Whereas, transplanting at 30 × 30 cm with pre-emergence application of oxyfluorfen followed by one hand weeding at 40 DAS/DAT recorded highest net returns (₹72,826.93 ha^{-1}). This interaction proved superior in maximizing profitability.

Table 1: Effect of planting techniques and weed management practices on number of earheads plant-1, number of fingers earhead-1, grain weight plant-1 (g), test weight (g) of finger millet

Sr. No.	Treatments	Number of earheads (plant-1)	Number of fingers (earhead-1)	Grain weight plant-1 (g)	Test weight (g)
A. Main plot (Planting techniques)					
S1	Direct seeding (30 cm × 10 cm)	2.46	7.95	17.67	4.55
S2	Direct seeding (30 cm × 30 cm)	4.77	8.36	35.38	5.25
S3	Transplanting (30 cm × 10 cm)	3.07	8.14	25.38	4.97
S4	Transplanting (30 cm × 30 cm)	7.15	8.66	44.24	5.71
	S.Em. ±	0.14	0.14	0.58	0.10
	C.D. at 5%	0.50	0.47	2.01	0.33
B. Sub plot (Weed management practices)					
T1	Pre-emergence application of Oxyfluorfen 23.5% EC at 80 g ha-1 *fb* one hand weeding at 40 DAS/ DAT	4.72	8.40	35.84	4.99
T2	Post emergence application of Bispyribac-sodium 10% SC at 20 g ha-1 *fb* one hand weeding at 40 DAS/ DAT	4.48	8.27	32.95	4.77
T3	Hand weeding on 20 DAS/ DAT *fb* one hand weeding at 40 DAS/ DAT	4.76	8.39	36.04	5.37
T4	Weed free check (Hand weeding at 15 days interval)	4.84	8.51	36.63	5.77
T5	Weedy check	3.01	7.82	12.26	4.71
	S.Em. +	0.15	0.13	0.60	0.13
	C.D. at 5%	0.42	0.36	1.73	0.39
C. Interaction effect					
	S.Em. +	0.29	0.25	1.20	0.27
	C.D. at 5%	NS	NS	3.46	NS

Table 2: Effect of planting techniques and weed management practices on grain, straw, biological yield (q ha-1) and HI (%) of finger millet

Sr. No.	Treatments	Grain yield (q ha-1)	Straw yield (q ha-1)	Biological yield (q ha-1)	HI (%)
A. Main plot (Planting techniques)					
S1	Direct seeding (30 cm × 10 cm)	15.49	33.79	49.28	30.98
S2	Direct seeding (30 cm × 30 cm)	18.74	39.51	58.25	31.79
S3	Transplanting (30 cm × 10 cm)	21.30	44.48	65.78	32.18
S4	Transplanting (30 cm × 30 cm)	23.51	49.00	72.50	32.29
	S.Em. +	0.50	1.22	1.71	-
	C.D. at 5%	1.72	4.23	5.91	-
B. Sub plot (Weed management practices)					
T1	Pre-emergence application of Oxyfluorfen 23.5% EC at 80 g ha-1 *fb* one hand weeding at 40 DAS/ DAT	22.50	47.09	69.59	32.27
T2	Post emergence application of Bispyribac-sodium 10% SC at 20 g ha-1 *fb* one hand weeding at 40 DAS/DAT	19.29	42.09	61.37	31.27
T3	Hand weeding on 20 DAS/ DAT *fb* one hand weeding at 40 DAS/ DAT	22.94	47.36	70.30	32.62
T4	Weed free check (Hand weeding at 15 days interval)	24.11	48.81	72.92	33.03
T5	Weedy check	9.97	23.11	33.09	29.86
	S.Em. +	0.51	1.01	1.49	-
	C.D. at 5%	1.47	2.92	4.30	-
C. Interaction effect					
	S.Em. +	1.02	2.03	2.98	-
	C.D. at 5%	2.94	5.84	8.60	-

Table 3: Effect of planting techniques and weed management practices on economics of finger millet cultivation

Sr. No.	Treatments	Gross returns (₹ ha-1)	Cost of Cultivation (₹ ha-1)	Net returns (₹ ha-1)	B:C ratio
A. Main plot (Planting techniques)					
S1	Direct seeding (30 cm × 10 cm)	80983.26	66013.76	14969.49	1.21
S2	Direct seeding (30 cm × 30 cm)	97757.46	63045.76	34711.70	1.51
S3	Transplanting (30 cm × 10 cm)	111043.38	69421.66	41621.71	1.59
S4	Transplanting (30 cm × 30 cm)	122542.79	64736.46	57806.33	1.88
	S.Em. +	2619.04	-	2619.04	-
	C.D. at 5%	9063.09	-	9063.09	-
B. Sub plot (Weed management practices)					
T1	Pre-emergence application of Oxyfluorfen 23.5% EC at 80 g ha-1 *fb* one hand weeding at 40 DAS/ DAT	117297.79	61953.65	55344.14	1.90
T2	Post emergence application of Bispyribac-sodium 10% SC at 20 g ha-1 *fb* one hand weeding at 40 DAS/ DAT	100818.93	62474.11	38344.83	1.61
T3	Hand weeding on 20 DAS/ DAT *fb* one hand weeding at 40 DAS/ DAT	119510.39	70742.11	48768.28	1.69
T4	Weed free check (Hand weeding at 15 days interval)	125451.69	83462.11	41989.58	1.51
T5	Weedy check	52329.81	50390.11	1939.71	1.03
	S.Em. +	2642.56	-	2642.56	-
	C.D. at 5%	7612.30	-	7612.30	-
C. Interaction effect					
	S.Em. +	5285.11	-	5285.11	-
	C.D. at 5%	15224.61	-	15224.61	-

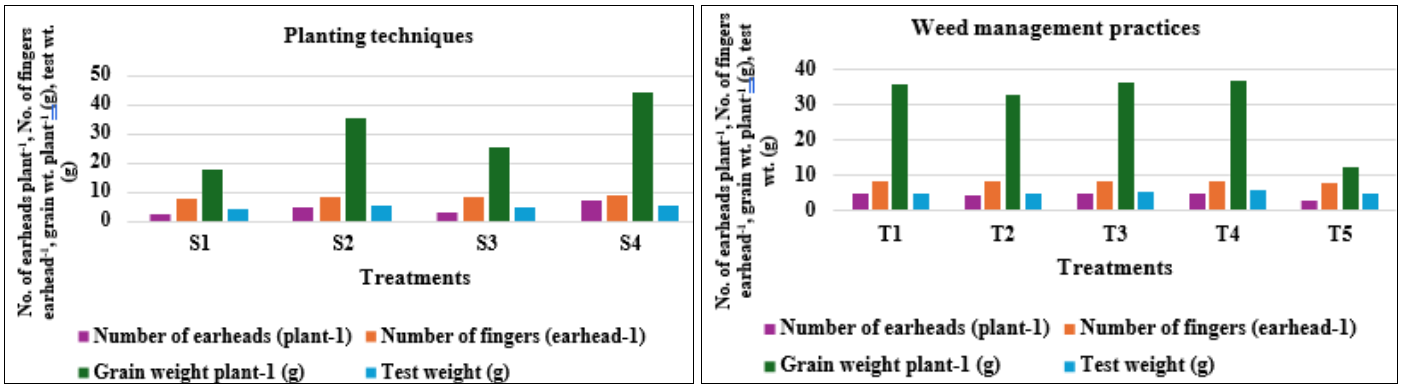

Fig 1: Effect of planting techniques and weed management practices on number of earheads plant-1, number of fingers earhead-1, grain weight plant-1 (g), test weight (g) of finger millet

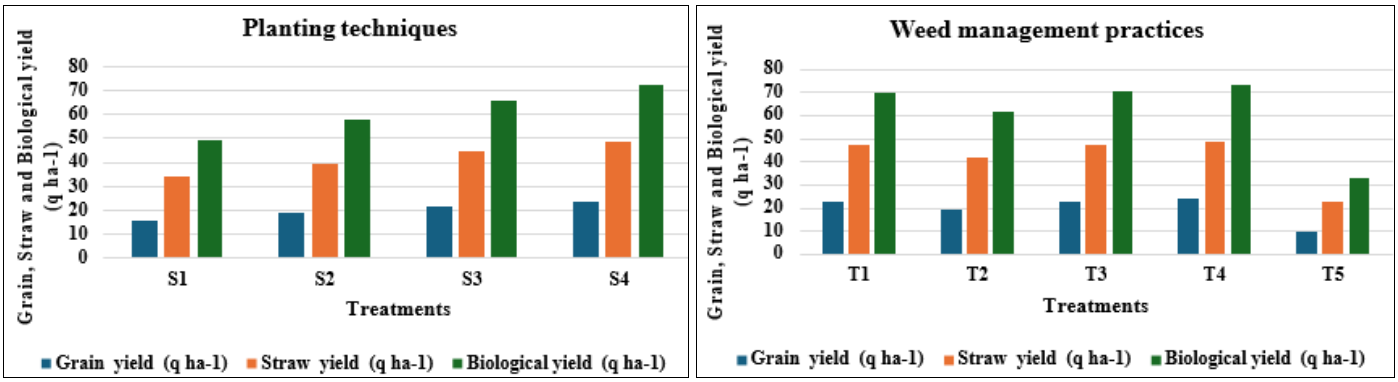

Fig 2: Effect of planting techniques and weed management practices on grain, straw and biological yield (q ha-1) of finger millet

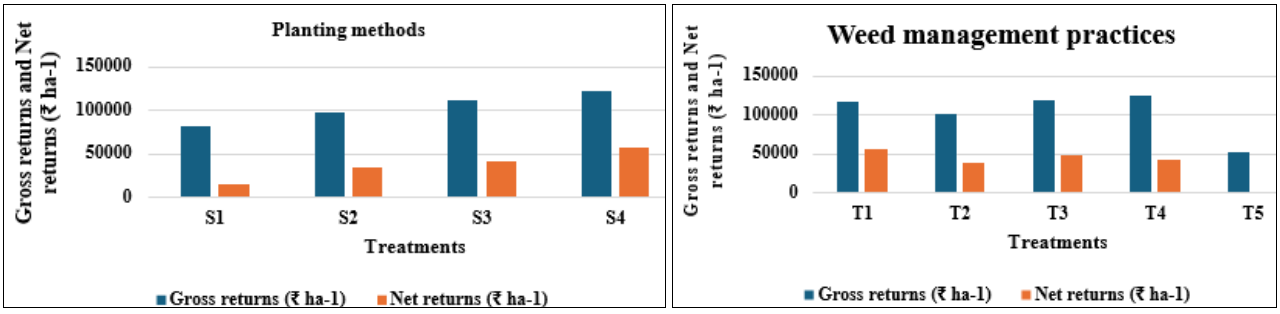

Fig 3: Effect of planting techniques and weed management practices on economics of finger millet cultivation

Conclusion

It is concluded that transplanting at 30 × 30 cm with weed free found superior in terms of yield attributes and yield, Whereas, transplanting at 30 × 30 cm with pre-emergence application of oxyfluorfen 23.5% EC at 80 g ha-1 *fb* one hand weeding at 40 DAS/ DAT observed best economics returns.

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