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RESEARCH ARTICLE

Weed dynamics and integrated management in finger millet [*Eleusine coracana* (L.) Gaertn]

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Abstract

Weed management plays a crucial role in enhancing the productivity and sustainability of finger millet cultivation, particularly under diverse agro-ecological conditions. A field experiment was conducted at Agricultural Research Station, Bhubaneswar, Odisha to study the effect of weed management practices on weed growth, crop growth and productivity of finger millet during the *kharif* season of 2023. The experiment included eight treatments combining stale seedbed, closer row spacing, bispyribac-Na, two hand weedings and a weedy check. These were arranged in a randomised block design with three replications. Twice-hand weeding recorded the lowest weed density (14.0 No./m^2) and dry weight (8.0 g/m^2), comparable to the stale seedbed method followed by closer spacing (21.8 No./m^2, 12.9 g/m^2). The maximum tiller number, dry matter accumulation and ear count per square meter were achieved with the two-hand weeding treatment performed at 20 and 40 days after sowing (DAS). This was closely followed by the stale seedbed method combined with closer spacing, as well as closer spacing combined with bispyribac-sodium application. In terms of productivity, the highest yield of 2217 kg/ha was recorded under the two-hand weeding treatment. This yield was statistically comparable to the yields obtained from the stale seedbed technique followed by (*fb)* closer spacing (2060 kg/ha) and closer spacing *fb* bispyribac-sodium at 15 g/ha at 15 DAS (1884 kg/ha). In terms of grain yield, twice hand weeding was 7.62% higher than stale seedbed technique *fb* closer spacing. The next best treatment in maximization of yield was the integrated application of stale seedbed *fb* bispyribac-sodium (1645 kg ha^{-1}) treatment in finger millet. Economic analysis of finger millet exhibited the highest return per rupee invested (2.45) under stale seedbed *fb* closer row spacing. Integrated weed management using the stale seedbed technique 10 days before sowing followed by 15 cm row spacing proved most effective, offering practical benefits for farmers by ensuring better weed control, enhanced crop growth, higher yields and improved profitability in finger millet during the *kharif* season.

Keywords: closer row spacing; finger millet; herbicide; integrated weed management; stale seedbed

Introduction

Finger millet, valued for its rich nutritional profile - is an important millet in India. It is known for its resilience to adverse conditions and adaptability to poor soils and harsh weather conditions. It is rich in fibres, proteins and carbohydrates, as well as a good source of minerals like calcium, iron and potassium. Its gluten-free nature makes suitable for individuals with gluten intolerance (1). It can withstand drought, low soil fertility and high temperature better than other crops and this adaptability makes it a valuable crop in erratic rainfall areas. Finger millet production faces several constraints including low yield potential, limited access to improved varieties and vulnerability to climate change. Additional challenges such as disease and pest incidence, soil degradation and weed infestation further hinder its productivity. Diverse weed flora in finger millet leads to competition for nutrients, water, sunlight and hampers their availability to plants resulting in reduction of tiller, stunted growth and poor development. Further it also complicates harvesting and post-harvesting operations. Weed infestation during the first developmental stage of finger millet can result in increased competition and lower production (2, 3).

Among grasses, *Digitaria sanguinalis* (L.) Scop., *Echinochloa colona* (L.) Link., *Echinochloa crus-galli* (L.) Beauv., *Eleusine indica* (L.) Gaertn.; among broad-leaved, *Amaranthus palmeri* S. Wats, *A. retroflexus* L., *Celosia argentea* L., *Melochia corchorifolia* L., *Ludwigia parviflora* Roxb., *Tribulus terrestris* L.; among sedges, *Cyperus rotundus* L., *Cyperus iria L.*, were the most common weeds found in millets (4, 5). Under uncontrolled weed infestations, finger millet experiences severe competition, resulting in yield losses between 5% to 70%. The extent of loss varies based on agro-climatic conditions, the types of weed species present and the cropping systems practiced (6). To boost crop output, it's crucial to reduce weed competition, especially during important growth periods. Crop-associated weeds can be handled via cultural, mechanical, or chemical strategies or by combining several methods (7, 8). Hand weeding is effective but requires time and effort. Hand weeding is helpful in reducing infestations but might be challenging to implement during wet seasons (9, 10). Weed management with herbicides such as butachlor, bensulfuron-methyl + pretilachlor, isoproturon and bispyribac sodium are the cost-effective and efficient approach to reduce a wide range of weeds quickly (11, 12). The growing labor

shortages during critical crop growth stages, coupled with rising labor costs, have made herbicides an increasingly vital tool for weed control in field crop production (13, 14).

Agronomic practices like as soil application of nutrients rates, nitrogen fertiliser delivery schedules and spacing require careful consideration for yield enhancement (15). Plant geometry can impact weed development in the crop. To control weeds, closer row spacing may be beneficial. Closer row spacing suppress weed growth by quickly forming a dense canopy, which reduces the amount of sunlight reaching the soil surface - limiting weed germination and growth. This technique requires rigorous scientific validation to improve productivity. Research suggests that finger millet planting in rows produces higher yields than spread planting. The stale seedbed technique serves as an effective preventive strategy for weed control. This method involves irrigating the field before sowing to encourage weed germination, followed by the removal of emerged weeds using shallow cultivation or non-selective herbicide application (16). Integrated weed management (IWM) focuses on long-term solutions by combining various approaches such as cultural, mechanical, thermal, biological and chemical methods (17, 18). These strategies are designed to suppress weed emergence, reduce weed seed banks and limit competition with crops (19, 20). IWM is a cornerstone of sustainable agriculture, aiming to manage weeds efficiently while preserving environmental health and ensuring crop productivity. It aligns with sustainability goals by minimizing reliance on any single method-especially chemical herbicides-thereby reducing environmental pollution, herbicide resistance and harm to non-target organisms. Therefore, a field trial was conducted to explore the effective weed management practices to reduce weed growth and enhance the growth, productivity and profitability of finger millet.

Materials and methods

The present study took place at Agricultural Research Station, Faculty of Agricultural Sciences, Siksha 'O' Anusandhan (Deemed to be University), Bhubaneswar, Odisha during *kharif*, 2023. The research station is situated at 20^0 15′ N latitude and 85^0 40′ E longitude with an altitude of 58m above MSL. The climate of the area is warm sub-humid with mild winter and hot summer. Rainfall is mainly due to south-west monsoon and usually stays in around mid-June and recedes by October**.** Mean annual rainfall is 1542 mm during the month of June to September. The mean monthly temperature ranges from 24.8^0C to 37.7^0C. The experimental plot exhibited acidic soil characteristics, with a pH value of 6.07. The soil profile revealed low organic carbon levels at 0.35%, which may affect the nutrient availability and microbial activity in the soil. Additionally, the available nitrogen content was measured at 179.4 kg/ha, classifying it as low, while the levels of phosphorus (P_2O_5) and potassium (K_2O) were found to be moderate, registering at 12.42 kg/ha and 129.5 kg/ha, respectively. Eight treatments such as - stale seedbed (SSB) technique at 10 days before sowing (DBS), closer row (CS) spacing of 15 cm, bispyribac-sodium (BS) @ 15 g/ha at 15 days after sowing (DAS), SSB followed by (*fb*) CS, SSB *fb* BS, CS *fb* BS, twice hand weeding and weedy check were replicated thrice in the randomized complete block design. Arjun variety was sown at the rate of 10 kg/ha on 3rd July, 2023 in the north south direction. The net plot size is 5m x 4 m.

Fertilizers were applied at a rate of 60 kg of N, 30 kg of P_2O_5 and 30 kg of K_2O per hectare. Prior to planting, an initial application of one-quarter of the nitrogen, the complete dose of phosphorus and potassium was incorporated into the furrows. The remaining nitrogen was distributed in two stages: half of the nitrogen was applied at 20 DAS, followed by the last quarter of the nitrogen (15 kg N per hectare) at 40 DAS. In stale seedbed plots, irrigation was given and after 10 days plots weeds were destroyed by giving shallow tillage within a depth of 5-10 cm. In general, the seeds were sown at a 20 cm row to row spacing in the experiment. The spacing of 15 cm between the rows was maintained in the closer row spacing treatments as a weed control method in finger millet. Bispyribac-sodium was applied at the rate of 500 lt/ha spray volume by using a knapsack sprayer with a flat fan nozzle. The sprayer was calibrated before being used to spray in the experimental plots. Calibration of the sprayer is important to ensure accurate and uniform application of herbicides, preventing underdosing or overdosing.

Total weed density was recorded by placing the quadrat of 0.25 m^2 randomly as diagonal method in the sampling area of each plot. The collected weed samples were first cleaned and air-dried under sunlight for a few hours. They were then placed in a hot air oven set at 70°C and dried for 72 hours (21). Observations regarding growth characteristics, including plant height, number of tillers per square meter, dry matter accumulation and leaf area index, were recorded 50 days after sowing. The area of fresh green leaves for each treatment was recorded by using leaf area meter (LICOR Model LI 3000C). Parameters related to yield were assessed at the time of harvest and the yield (kg/ha) was measured following appropriate drying, threshing and winnowing processes. Weed control efficiency and weed index were calculated by using the weed dry weight and yield of finger millet, respectively (22). Dividing the gross return by cost of cultivation, return per rupee invested was obtained. F test was used at the probability level 0.05. ANOVA was used for data analysis (23). The data was analysed after checking the normality. The square root transformation was made to normalise the data as and when required. The statistical analysis was carried out using the GRAPES in the R software.

Results and Discussions

Weed flora

The experimental field was infested with ten different weed species, six of them being grasses, three broad-leaved weeds and one sedge belonging to five different families in finger millet during *kharif* season (Table 1). The grasses and sedge were monocotyledonous, while the broad-leaved weeds were dicotyledonous. Weed flora in the weedy check plots comprised of all ten species. The experimental field was mostly dominated by grasses like *Digitaria sanguinalis* and *Echinochloa colona* and broad-leaved weeds like *Melochia corchorifolia* and *Ludwigia parviflora* throughout the crop-growing period of finger millet (Table 1). The experimental field of finger millet was primarily infested with a diverse range of weed species. Among the grasses, common species included *Echinochloa crusgalli, Dactyloctenium aegyptium, Digitaria marginata* and *Eleusine indica.* Broad-leaved weeds included *Commelina benghalensis, Commelina nodiflora, Oldenlandia corymbosa, Ageratum*

Table 1. Floristic composition of weeds in the experimental field.

Scientific Name	Family	English Name
Grasses		
Digitaria sanguinalis (L.) Scop.	Poaceae	Large crab grass
Echinochloa colona (L.) Link.		Jungle rice
Chloris barbata Swartz.		Swollen finger grass
Poa annua L.		Annual bluegrass
Setaria viridis (L.) Beauv.		Green bristle grass
Eleusine indica (L.) Gaertn		Crow foot grass
Broadleaved		
Melochia corchorifolia L.	Sterculiaceae	Red weed
Ludwigia parviflora Roxb.	Onagraceae	Water primrose
Alternanthera philoxeroides (Mart.) Griseb	Amaranthaceae	Alligator weed
Sedge		
Cyperus iria L.	Cyperaceae	Umbrella sedge

conyzoides and *Spilanthes acmella*. Among the sedges, *Cyperus rotundus* was predominant (3, 24).

Weed growth

Twice hand weeding registered the least grassy, broad-leaved, sedge and total weed count and biomass, which were closely followed by SSB at 10 DBS followed by (*fb)* CS of 15 cm (Table 2). The stale seedbed technique minimized the initial weed flush by encouraging weed germination before sowing, followed by their removal through shallow tillage. Similarly, closer spacing led to faster canopy cover which blocked the sunlight and decreased the weed seedling emergence between the rows. Grasses, broad-leaved, sedges and total weed density in the stale seedbed at 10 DBS *fb* closer spacing of 15 cm (T_4) were around 28.57, 18.13, 1.7 and 25.26% higher than two-handed weeding treatment (T_7), respectively. Similarly, grasses, broad-leaved, sedges and total weed biomass were 26.93, 13.52, 7.59 and 24.65% higher in T_4 than T_7 treatment, respectively. The slow initial development and larger spacing were the primary causes of severe crop weed competition in millets (5). Instead of depending on a single approach of weed control, all possible strategies must be combined for successful and long-term weed management in millets. IWM is a practical approach to tackle weed flora shifts and resistance development while reducing the weed seed bank and keeping weed populations below the economic threshold, thereby preventing economic losses. Integrated weed management, having the stale seedbed technique as a component of it, significantly lowered the total weed density (23.9 no./m^2) and biomass (10.3 g/m^2) (25). The next best treatment in reducing all categories of weeds and total weed growth (both in terms of population and biomass) was CS of 15 cm *fb* bispyribac-sodium at 15 g/ha at 15 DAS (T_6) (Table 2). The highest weed biomass was recorded in the weedy check treatment.

Crop growth

Among the weed management treatments, the tallest plant height was attained under two-hand weeding at 20 and 40 DAS (T_7), which was significantly at par with all the IWM practices (T_4, $T_5$and T_6) throughout the growing period (Table 2). Plant height reflected the growth of finger millet and was inversely proportional to the infestation of weed. Finger millet planted at a 10 cm inter-row spacing produced significantly taller plants compared to those planted at 20 cm spacing (26). The tallest plants were observed in treatments involving integrated weed management, particularly with the early post-emergence application of bispyribac sodium in finger millet. That was comparable with the plant height achieved through hand weeding performed at 15 and 30 days after transplanting (27).

The maximum tiller number and dry matter accumulation were achieved with the two-hand weeding treatment performed at 20 and 40 days after sowing (DAS). This was closely followed by the stale seedbed method combined with closer spacing, as well as closer spacing combined with bispyribac-sodium application. (Table 2). The plant population increased with closer spacing and double seedlings per hill, leading to more tillers and higher dry matter output (28). Enhanced finger millet leaves may improve photosynthetic efficiency and lead to improved plant dry matter output. The maximum LAI was recorded in two hand weeding treatment (4.00) followed by T_4 treatment (3.71) during *kharif* season. Hand weeding twice, at 20 and 30 DAT, resulted in significantly enhanced growth parameters. These included taller plants (110.13 cm), a higher leaf area index (LAI) of 3.3, an increased number of tillers per hill (6.00) and greater DMA (36.4 g per plant). These were comparable to those achieved through integrated weed management practices (25). However, in the present study, weedy check (T_8) recorded significantly lower plant height, tiller number, DMA and LAI than all other treatments in the direct seeded finger millet during the *kharif* season (Table 2).

Weed control efficiency

At 50 DAS, the maximum weed control efficiency (WCE) in grasses, broad-leaved, sedge and total weed were documented in two-hand weeding (T_7), which was followed by stale seedbed at 10 DBS *fb* closer spacing of 15 cm (T_4) treatment (Fig. 1). Twice hand weeding was 5.69% more efficient in reducing the diverse weed flora than stale seedbed at 10 DBS *fb* closer spacing of 15 cm. The next best treatment in grasses, broad-leaved and total weed was the closer spacing *fb* bispyribac-sodium (T_6) but in the case of sedge stale seedbed *fb* bispyribac-sodium (T_5) was found to be the most efficient method for weed control (Fig. 1). Integrated weed management comprising hand weeding

Table 2. Weed and crop growth under weed management practices in finger millet at 50 DAS.

Treatments	Weed growth		Crop growth			
	Density (no./m^2)	Biomass (g/m^2)	Plant height (cm)	No. of tiller per m^2	DMA (g/m^2)	LAI
T_1- SSB @ 10 DBS	6.96 (48.1)	5.74 (32.6)	54.8	196	210.92	3.03
T_2- CS of 15 cm	7.39 (55.0)	6.13 (37.4)	54.4	211	211.48	3.10
T_3- Bispyribac-Na @ 15 g/ha	7.63 (57.9)	6.26 (39.0)	54.2	202	214.93	3.09
T_4- SSB *fb* CS	4.71 (21.8)	3.64 (12.9)	65.4	293	285.32	3.71
T_5- SSB *fb* bispyribac-Na	6.41 (41.0)	5.36 (28.3)	62.9	252	246.60	3.33
T_6- CS *fb* bispyribac-Na	5.20 (26.3)	3.97 (15.3)	64.8	279	265.22	3.36
T_7- Two HW	3.76 (14.0)	2.92 (8.0)	66.3	296	289.25	4.00
T_8-Weedy check	9.98 (101.3)	8.44 (72.0)	45.3	97	144.28	1.86
CD(P=0.05)	1.179	0.883	7.19	34.74	30.126	0.550

Values in the parenthesis are original and data was made square root transformation before analysis. **SSB**: Stale seedbed, **DBS**: Days before sowing, **CS**: Closer row spacing, **HW**: Hand weeding, **DMA**: Dry matter accumulation, **LAI**: Leaf area index.

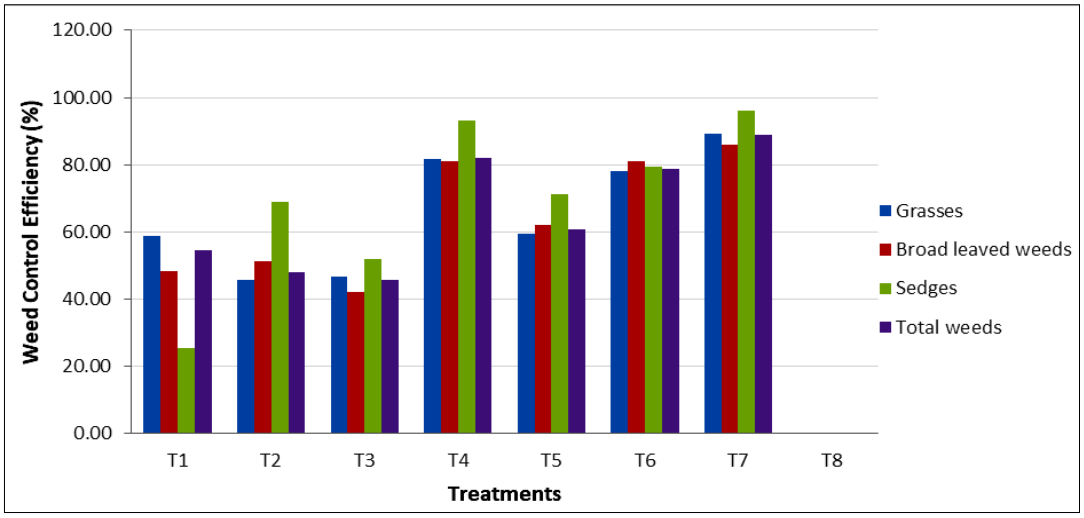

Fig. 1. Effect of weed management on weed control efficiency (%) of finger millet at 50 DAS. **T_1**- SSB @ 10 DBS, **T_2**- CS of 15 cm, **T_3**- Bispyribac-Na @ 15 g/ha, **T_4**- SSB *fb* CS, **T_5**- SSB *fb* bispyribac-Na, **T_6**- CS *fb* bispyribac-Na, **T_7**- Two HW, **T_8**-Weedy check, **SSB**: Stale seedbed, **DBS**: Days before sowing, **CS**: Closer row spacing, **HW**: Hand weeding.

resulted in better WCE (83%) (29). Similarly, the maximum WCE was found in manual weeding (93.2 %), followed by integrated weed management involving stale seedbed (91.6 %) (25).

Yield attributing

Weed management practices significantly affected number of ear/m^2 and number of grains/finger parameters. Whereas, the number of fingers/ ear and 1000 grain weight were not affected by the changes in weed management methods in finger millet (Table 3). The maximum number of ears/m^2, a key yield-attributing character, was recorded under the two-hand weeding treatment, which was statistically comparable to stale seedbed *fb* closer row spacing and closer spacing *fb* bispyribac-sodium treatments. Similarly, the best treatment recorded for the number of grains/finger was under two hand weeding, which was not significantly different from stale seedbed *fb* closer row spacing (Table 3). In direct seeded finger millet, the highest grains per head (1032), grain yield (3496 kg/ha) and straw yield (6164 kg/ha) were obtained with a management practice combining one hand weeding at 20 DAS and two intercultural operations at 30 and 45 DAS (24).

Yield

The impact of weed management practices on the yield of finger millet was significantly evident. All the treatments procured higher yields as compared to the weedy check (Table 3). Among the weed management practices, twice hand weeding at 20 and 40 DAS (T_7) recorded significantly higher yield (2217 kg grain/ha and 3217 kg straw/ha) than all other treatments (Table 3). The twice-hand weeding treatment resulted in the highest productivity. Its yield was statistically comparable to that of the treatment with SSB at 10 DBS followed by conoweeding at 15 cm spacing (T_4), which recorded 2060 kg grain/ha and 3086 kg straw/ ha. It was also similar to the treatment with closer spacing of 15 cm followed by bispyribac-sodium at 15 g/ha applied at 15 DAS (T_6), which yielded 1884 kg grain/ha and 2733 kg straw/ha during the *kharif* season (Table 3). In terms of grain and straw yield, twice-hand weeding was 7.62% and 4.24% higher over stale seedbed *fb* closer spacing, respectively. The important aspect that contributed to the increase in grain production was the absence of weed competition for growth factors. Herbicide alone was insufficient for prolonged weed control, necessitating integrated approaches. Thus, integration of herbicide or stale seedbed technique along with closer row spacing effectively reduced the weed infestations, which led to better growth of direct seeded finger millet along with higher grain and straw yield. Here, the stale seedbed created a weed-free environment, whereas closer row spacing reduced the weed seed germination and seedling emergence. An increased yield of 72% was recorded with integrated weed management involving twice hand weeding treatment (30). Closer row spacing reduced the space between rows during the initial crop growth period, supressing weed emergence. The application of post-emergence herbicide further controlled weeds at a later stages, facilitating optimal growth and ultimately enhancing yield. The treatment with spacing 20 cm × 10 cm recorded maximum grain yield (2680 kg/ha) (28). Wider spacing resulted in lower grain yields due to a significantly reduced population compared to closer planting. Establishing an optimal planting pattern is essential for the effective use of resources and maximizing the productivity of field crops. A higher plant population associated with closer

Table 3. Effect of weed management on yield attributing parameters and yield of finger millet.

Treatments	No. of ear /m^2	No. of fingers/ ear	No. of grains/ finger	1000 grain weight	Grain yield (kg/ha)	Straw yield (kg/ha)
T_1- SSB @ 10 DBS	182	4.00	155	2.32	1236	1474
T_2- CS of 15 cm	198	4.40	163	2.58	1306	1806
T_3- Bispyribac-Na @ 15 g/ha	189	4.00	157	2.23	1249	1556
T_4- SSB *fb* CS	282	4.67	206	2.65	2060	3086
T_5- SSB *fb* bispyribac-Na	241	4.33	180	2.86	1645	2159
T_6- CS *fb* bispyribac-Na	274	4.67	190	2.83	1884	2733
T_7- Two HW	286	5.00	214	2.57	2217	3217
T_8-Weedy check	84	3.00	127	2.20	866	1068
CD(P=0.05)	33.2	NS	20.5	NS	335.5	304.7

SSB: Stale seedbed, **DBS**: Days before sowing, **CS**: Closer row spacing, **HW**: Hand weeding.

spacing is likely to have increased dry matter production and leaf count, ultimately leading to enhanced yields. Similarly, integrated weed management with hand weeding resulted in better grain yield (3303 kg ha^{-1}) (29). The next best treatment in maximization of yield was the integrated application of SSB *fb* bispyribac-sodium (T_5) (1645 kg grain/ha and 2159 kg straw/ha) treatment (Table 3). The maximum yield was found in IWM involving the application of bispyribac-sodium in transplanted finger millet and it was on par with hand weeding treatment (27).

Compared to integrated weed management practices, the sole adoption of SSB resulted in reduced grain yield, recording 1236 kg grain/ha and 1474 kg straw/ha. This was closely followed by the bispyribac-sodium treatment, which yielded 1249 kg grain/ha and 1556 kg straw/ha and the closer row spacing of 15 cm, which produced 1306 kg grain/ha and 1806 kg straw/ha. These treatments were less effective in controlling weed growth, leading to poor crop growth and vigour and consequently lower grain yield. Whereas the weedy plot (T_8) recorded the lowest yield (866 kg grain/ha and 1068 kg straw/ha) due to high crop-weed-competition during *kharif*, 2023. In direct-seeded finger millet, weed infestation was found to be the most important factor. Without any weed control measure, the growth and development of finger millet were reduced, which eventually led to severe yield reduction.

Weed index

The weed index determined how much a weed management practice affected the productivity compared to a weed-free plot. Hand weeding resulted in the minimum values in weed index which was followed by the execution of stale seedbed *fb* closer row spacing of 15 cm (T_4) (Fig. 2). To effectively and sustainably manage weeds in millets, it is essential to integrate all feasible methods of weed control rather than relying on a single approach to reduce both the weed seed bank and weed growth (31).

Return per rupee invested

The stale seedbed treatment at 10 DBS *fb* closer row spacing of 15 cm achieved the highest return of 2.45 per rupee invested. The next best treatment in higher return rupee^{-1} invested (2.36) was recorded under the application of closer spacing of 15 cm *fb* bispyribac- sodium during *kharif* season (Fig. 3). The highest return rupee^{-1} invested of 2.72 was associated with the treatment (20 days old seedlings with 15 x 10 cm) in transplanted kodo millet. Various spacing options significantly enhanced the economic viability of finger millet (32). The treatment combination of 20 cm × 10 cm spacing yielded the highest benefit-cost ratio of 2.32 (28).

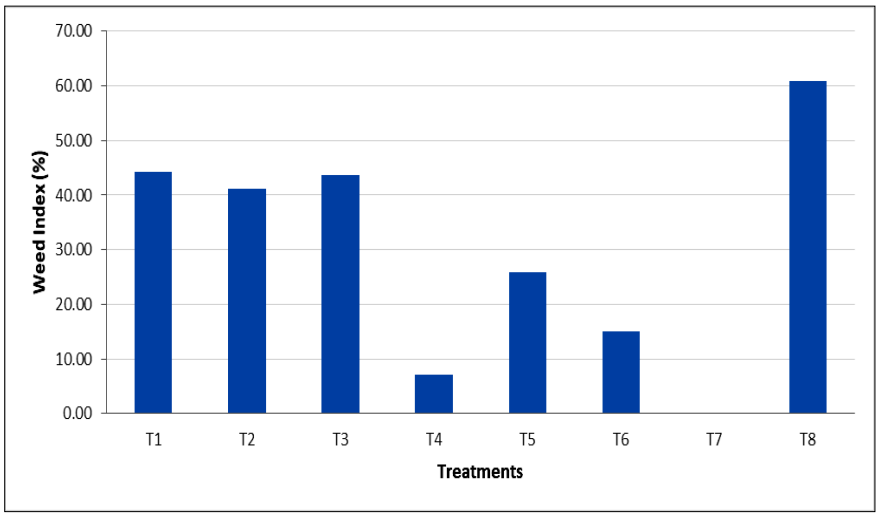

Fig. 2. Weed index (%) of finger millet under various weed management practices. **T_1**- SSB @ 10 DBS, **T_2**- CS of 15 cm, **T_3**- Bispyribac-Na @ 15 g/ha, **T_4**- SSB *fb* CS, **T_5**- SSB *fb* bispyribac-Na, **T_6**- CS *fb* bispyribac-Na, **T_7**- Two HW, **T_8**-Weedy check, **SSB**: Stale seedbed, **DBS**: Days before sowing, **CS**: Closer row spacing, **HW**: Hand weeding.

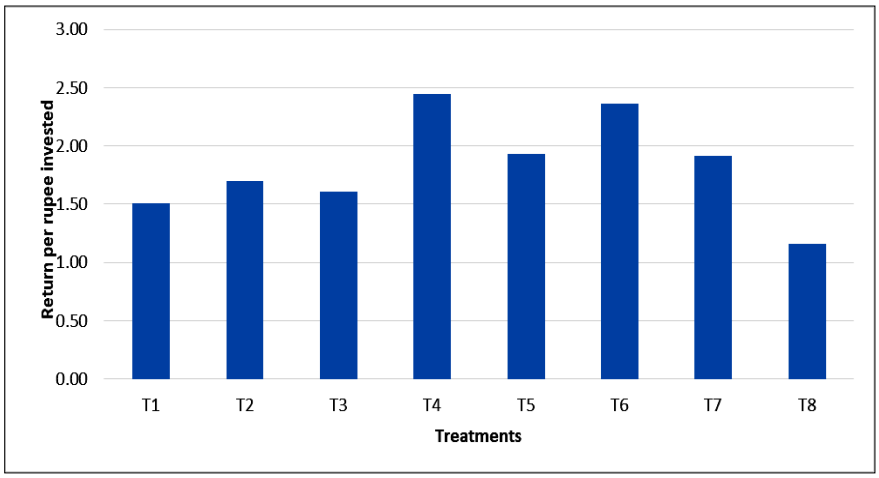

Fig. 3. Return per rupee invested of finger mille. **T_1**- SSB @ 10 DBS, **T_2**- CS of 15 cm, **T_3**- Bispyribac-Na @ 15 g/ha, **T_4**- SSB *fb* CS, **T_5**- SSB *fb* bispyribac-Na, **T_6**- CS *fb* bispyribac-Na, **T_7**- Two HW, **T_8**-Weedy check, **SSB**: Stale seedbed, **DBS**: Days before sowing, **CS**: Closer row spacing, **HW**: Hand weeding.

Conclusion

Execution of stale seedbed *fb* closer spacing was found comparable with twice hand weeding treatment in reducing the growth of all the categories as well as total weed infestation during the crop growing period of finger millet. The growth, yield attributes and yield of finger millet was recorded maximum under twice hand weeding, which was found to be comparable with the stale seedbed *fb* closer spacing. Economic analysis of finger millet exhibited the highest return rupee^{-1} invested (2.45) under stale seedbed *fb* closer row spacing during *kharif* season. Integrated weed management using the stale seedbed technique at 10 DBS *fb* closer row spacing of 15 cm effectively managed weeds, improving growth, productivity and profitability in finger millet during the *kharif* season. Future research should explore the long-term effectiveness of integrated weed management strategies on soil health and productivity. Additionally, studies should focus on the farmer adoption and perceptions, which will also be essential to identify barriers and promote the implementation of sustainable weed management practices.

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Authors' contributions

SKB executed the experiment and collected the data. SD conceptualised and supervised the experiment, analysed the data and prepared the manuscript. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interest to declare.

Ethical issues: None

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