E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
www.agronomyjournals.com
2024; 7(12): 233-236
Received: 06-10-2024
Accepted: 05-11-2024

Shafna PH
PG Scholar, Department of Agronomy, College of Agriculture, Vellanikkara, Kerala Agricultural University, Thrissur, Kerala, India

Syama S Menon
Assistant Professor, Department of Agronomy, Agronomic Research Station, Chalakkudy, Kerala Agricultural University, Thrissur, Kerala, India

Corresponding Author:
Shafna PH
PG Scholar, Department of Agronomy, College of Agriculture, Vellanikkara, Kerala Agricultural University, Thrissur, Kerala, India

Sustainable weed management in foxtail millet

Shafna PH and Syama S Menon

DOI: https://doi.org/10.33545/2618060X.2024.v7.i12c.2141

Abstract
A study to evaluate the effect of different weed management strategies on growth and yield of foxtail millet was conducted at the Kerala Agricultural University, Vellanikkara from January to April, 2024. The experiment followed Randomized Block Design (RBD) with eight treatments and three replications. The treatments included, T_1- stale seedbed technique, T_2- straw mulching in the interspaces, T_3- pre-emergence application of oxyfluorfen @0.10 kgha^{-1} (at 0-3 DAS) followed by hand weeding at 25-30 DAS, T_4- pre-emergence application of pretilachlor 30% + pyrazosulfuron ethyl 0.75% WG (premix) @ 0.10 kg ha^{-1} (at 0-3 DAS) followed by hand weeding at 25-30 DAS, T_5- live mulching with green gram, T_6- brown manuring with green gram, T_7- hand weeding at 25 and 45 DAS, T_8- unweeded control. Results showed that highest grain yield in foxtail millet (3.26 kg plot^{-1}) was realized in hand weeding at 25 and 45 DAS. Though hand weeding twice was better in terms of yield, the treatment brown manuring with green gram was found to be economically viable in foxtail millet. Herbicides applied treatments caused phytotoxicity to crop which resulted in poor germination and thereby poor crop stand, leading to very low grain yield comparable to unweeded control.

Keywords: Oxyfluorfen, Pretilachlor, Pyrazosulfuron ethyl, SSB, Live mulch

Introduction
Foxtail millet (*Setaria italica* (L.) *P. Beauv.*), one of the oldest cultivated millet grains, characterized by its climate resilience and nutritional value has gained increasing attention in agriculture due to its adaptability to dry conditions and poor management practices. Despite the hardiness of the crop, its a nutritional powerhouse rich in proteins, vitamins, minerals, such as iron, calcium, and phosphorus, making it a vital component in combating malnutrition, especially in developing countries. In addition to its nutritional benefits, foxtail millet plays a crucial role in sustainable agriculture by restoring soil health by way of reducing erosion and improving nutrient cycling. Increased water use efficiency of foxtail millet makes it suitable for water-scarce regions, aligning with current needs for sustainable food systems in the context of climate change.

However, the successful cultivation of foxtail millet faces significant challenges, particularly from weeds that compete for vital resources, reduce the yield, and compromise the quality of the crop. Effective weed management strategies are essential not only to enhance the productivity of foxtail millet but also to ensure the economic viability of farmers and to reduce the weed seed bank. To address these challenges, the present research study was carried out to develop an economically viable integrated weed management practices for foxtail millet.

Materials and Methods
A study to assess the efficiency of various integrated weed management practices for foxtail millet (*Setaria italica* (L.) P. Beauv) was carried out at Department of Agronomy, Kerala Agricultural University, Thrissur, Kerala, during January to April, 2024. The field was situated at 10°31'N latitude and 76°13'E longitude with an altitude of 40.3 m above Mean Sea Level. The soil was sandy loam texture with acidic in reaction. The experiment was laid out in Randomized Block Design (RBD) with eight treatments and three replications. The foxtail millet variety DHFT-109-3, released from UAS, Dharwad was used for the experiment. The treatments included, T_1- stale seedbed technique, T_2- straw mulching in the interspaces, T_3- pre-emergence application of oxyfluorfen @ 0.10 kg ha^{-1} (at 0-3 DAS) followed by hand weeding at 25-30

DAS, T_4- pre-emergence application of Pretilachlor 30% + Pyrazosulfuron ethyl 0.75% WG (Premix) @ 0.10 kg ha^{-1} (at 0-3 DAS) followed by hand weeding at 25-30 DAS, T_5- live mulching with green gram, T_6- brown manuring with green gram, T_7- hand weeding at 25 and 45 DAS, T_8- Unweeded control.

In stale seedbed technique, after land preparation weeds were allowed to germinate for 15 days before sowing the crop and the emerged weeds were destroyed using non-selective herbicide, glufosinate ammonium @ 0.5 kg ha^{-1}. In straw mulching (T_2) rice straw (@ 5 t ha^{-1}) was spread in the interspaces of crop to prevent weed germination. Herbicides, oxyfluorfen (Goal®) (T_3) and Pretilachlor 30% + Pyrazosulfuron ethyl 0.75% WG (premix- Eros Gold®) (T_4) were applied @ 0.10 kg ha^{-1} on the day of sowing. In live mulched treatments (T_5), green gram @ 25 kg ha^{-1}, sown in the interspaces was uprooted at 15 DAS and spread in between rows of foxtail millet. In brown manuring (T_6), herbicide 2, 4-D @ 0.5 kg ha^{-1} was sprayed at 15 days after the establishment of green gram.

The land was ploughed, clods were broken, levelled and a fine seedbed was prepared. Lime was incorporated uniformly @ 600 kg ha^{-1} at the time of ploughing. Plots of 4.8 m x 4 m were made and FYM @ 5 t ha^{-1} was incorporated in all the plots. The seeds were line sown at a spacing of 30 cm x 10 cm and the seed rate followed was 10 kg ha^{-1}. The crop was fertilized @ 40: 20: 20 kg N_2, P_2O_5 and K_2O per hectare respectively. Entire dose of fertilizers were applied basally. Irrigation was given twice daily for uniform germination as it is a summer crop.

Five plants were randomly selected and tagged from each of the treatments and height was measured in cm from ground level to the tip of the longest leaf at 30 DAS, whereas it was measured from the base to the tip of the ear at heading and at harvest. Observations on weed dry matter production was taken using a 0.5 m^2 quadrat which was placed randomly within each plot and samples were taken at 15, 25, 45 and 75 DAS. Weeds collected were oven dried and expressed in kg ha^{-1}. The crop was harvested at 90 DAS.

Results and Discussion

Plant height (cm)

At the time of harvest, plant height ranged from 49 to 67 cm, and all weed management approaches resulted in improved plant height compared to Unweeded control (Table 1). Implementing effective weed management during critical periods of weed competition alleviated competitive pressure, enabling the crop for better utilization of available resources, thereby enhancing the overall growth of foxtail millet. These results was in line with findings reported by Shanmugapriya *et al*. (2019) [9] in finger millet. Different weed management practices did not influenced test weight of the crop and it was approximately 3g irrespective of treatments.

Yield per plot (kg plot^{-1})

The highest grain and straw yields per plot were recorded in hand weeding (at 25 and 45 days after sowing), as indicated in Table 1, which was on par with straw mulching (T_2). The increased yield from the hand weeding can be due to the lower weed density and biomass during critical crop-weed competition phases, which resulted from the periodic weeding. This practice fostered favorable conditions for crop development, leading to enhanced grain and straw production (Patil *et al*., 2013) [8]. The improved grain yield from straw mulching (T_2) was due to greater moisture retention for the crop and effective weed control in the interspaces, due to limited sunlight exposure for weed germination, which in turn supported healthy growth of crop, ultimately increasing grain yield. Asif *et al*. (2020) [1] reported similar outcomes in maize.

Grain yield and straw yield were on par in treatments T_5 (live mulching) and T_6 (brown manuring). This similarity may be attributed to the early smothering cum suppressive effect of green gram on weed growth. These results was in line with the observations made by Kumar *et al.* (1995) [4] in bajra. Herbicide applied treatments (T_3 and T_4), resulted in significantly lower grain yields when compared to other treatments, and it was on par with unweeded control. This reduction in yield was caused by the phytotoxic effects of the herbicides, which inhibited germination of crop due to its small sized seeds, leading to reduced crop stand, despite achieving a weed control efficiency (WCE) of 91 per cent. Phytotoxicity of oxyfluorfen in little millet was reported by Bai *et al*. (2021) [2], Pretilachlor by Shim *et al*. (1990) [10] and pyrazosulfuron-ethyl by Ma *et al*. (2021) [5] in foxtail millet. The unweeded control (T_8) resulted in higher weed dry matter production which inturn caused resource competition with foxtail millet and thereby reduction in both grain and straw yields, consistent with findings by Banu *et al*. (2016) [3] in ragi.

Table 1: Effect of integrated weed management practices on plant height and yield of foxtail millet

	Treatments	Plant height At Harvest (cm)	Grain yield (kg plot^{-1})	Straw yield (kg plot^{-1})
T_1	Stale seedbed technique	65.83^a	2.16^c	4.95^c
T_2	Straw mulching	66.9^a	3.13^a	6.36^a
T_3	Oxyfluorfen *fb* hand weeding	66.3^a	1.18^e	3.04^e
T_4	Pretilachlor 30%+Pyrazosulfuron ethyl 0.75% *fb* hand weeding	66.13^a	1.64^d	4.08^d
T_5	Live mulching	65.03^a	2.77^b	5.61^b
T_6	Brown manuring	65.56^a	2.53^b	5.14^b
T_7	Hand weeding @25 and 45 DAS	67.01^a	3.26^a	6.63^a
T_8	Unweeded control	49.1^b	1.22^e	3.13^e

In a column, means followed by common letters do not differ significantly at 5% level in Turkey's Test.

Weed dry matter production (kg ha^{-1})

The findings indicated that, treatments with herbicide applications (T_3 and T_4) resulted in lowest levels of weed dry matter production at 15 days after sowing (DAS), whereas unweeded control and hand weeding treatments exhibited higher weed dry matter production (Table 2). The reduced dry matter in herbicide-treated plots can be attributed to their efficacy in suppressing the germination and growth of weed seeds. Additionally, the use of straw mulching contributed to a decrease in weed dry matter, as mulch inhibited sunlight for emerging weed seeds, thereby impeding their germination by covering the spaces between crops. This observation is in line with the findings of Mohtisham *et al*. (2013) [7] in rice. The reduction in weed dry matter associated with live mulching is primarily due to the smothering effect of green gram, in accordance with the results reported by Kumar *et al*. (1995) [4] in

bajra. At 25 DAS, the application of hand weeding twice resulted in significantly reduced weed dry weight, on par to the herbicide treatments (T_3 and T_4), followed by straw mulching (T_2). At 45 and 75 DAS, the hand weeding treatment again recorded the lowest weed dry weight, succeeded by T_3 and T_4. Implementing hand weeding during the critical period of crop-weed competition in foxtail millet proved effective in controlling weeds and minimizing weed dry matter accumulation. The integration of various pre-emergence herbicides with a single hand weeding at 25 DAS successfully reduced weed populations up to 75 DAS. Conversely, the stale seedbed technique (T_1) was ineffective in lowering total weed counts due to subsequent weed germination from the soil's weed seed bank, which adversely affected crop yield.

Table 2: Effect of integrated weed management practices on weed dry matter in foxtail millet

Treatments		Weed Dry Matter Production (Kg Ha^{-1})			
		15 Das	25 Das	45 Das	75 Das
T_1	Stale seedbed technique	14.35^{b} (206.67)	20.28^{b} (411.67)	33.63^{b} (1129)	54.99^{b} (3023.66)
T_2	Straw mulching	6.83^{c} (46.33)	9.99^{d} (100)	21.83^{d} (476.67)	29.72^{d} (883.33)
T_3	Oxyflourfen *fb* hand weeding	0.71^{d} (0)	0.71^{e} (0)	7.85^{e} (610)	15.89^{e} (252.66)
T_4	Pretilachlor 30%+ Pyrazosulfuron ethyl 0.75% *fb* hand weeding	0.71^{d} (0)	0.71^{e} (0)	10.45^{e} (1090)	17.28^{e} (298.67)
T_5	Live mulching	10.87^{bc} (120)	14.33^{c} (206.67)	26.68^{c} (712)	33.09^{c} (1095.33)
T_6	Brown manuring	11.15^{b} (126.67)	14.63^{c} (215)	26.85^{c} (720.66)	33.06^{c} (1093.33)
T_7	Handweeding @25 and 45 DAS	19.05^{a} (363.33)	0.71^{e} (0)	0.71^{f} (0)	11.57^{f} (134)
T_8	Unweeded control	19.11^{a} (366.76)	26.17^{a} (685)	43.78^{a} (1916.66)	59.27^{a} (3512.77)

$\sqrt{(x+0.5)}$ transformed values, original values in parenthesis. In a column, means followed by common letters do not differ significantly at 5% level in Turkey's Test.

Weed control efficiency (%)

Hand weeding (T_7) exhibited the most effective weed control efficiency (WCE), as detailed in Table 3, primarily due to its successful management of weed density and dry matter accumulation. This was in line with the findings by Mishra (2016) [6]. The use of pre-emergence herbicides followed by hand weeding, achieved a WCE of over 90 percent. This high efficiency was due to prevention of weed germination by conducting timely manual weeding during the critical competition phase; but overall crop yield was reduced due to reduced crop stand. Furthermore, straw mulching in the interspaces resulted in WCE of 74 percent. Initially, at 15 days after sowing (DAS), the stale seed bed (T_1) recorded a WCE of 43 percent, but it was reduced to 13 percent by 75 DAS, indicating its inadequacy for weed control in foxtail millet. Patil *et al.* (2013) [8] also observed that stale seed beds alone led to an increase in weed density in finger millet, while its combination with inter-cultivation markedly enhanced weed control efficiency.

Table 3: Effect of integrated weed management practices on weed control efficiency in foxtail millet

Treatments		Weed Control Efficiency (%)			
		15 Das	25 Das	45 Das	75 Das
T_1	Stale seedbed technique	43	39	41	13
T_2	Straw mulching	87	85	75	74
T_3	Oxyfluorfen *fb* hand weeding	100	100	96	92
T_4	Pretilachlor 30%+ Pyrazosulfuron ethyl 0.75% *fb* hand weeding	100	100	94	91
T_5	Live mulching	67	69	62	68
T_6	Brown manuring	65	68	62	68
T_7	Hand weeding @25 and 45 DAS	0.92	100	100	96
T_8	Unweeded control	0	0	0	0

Table 4: Effect of treatments on economics of production in foxtail millet

Treatments		Cost and Returns (Rs Ha-1)			
		Total Cost	Gross Returns	Net Returns	B: C Ratio
T_1	Stale seedbed technique	58071	64998	6926	1.11
T_2	Straw mulching in the interspaces	79071	91002	13330	1.17
T_3	Oxyflourfen @0.10kg/ha at 0-3 DAS followed by hand weeding at 25-30DAS	59971	27400	-32571	0.45
T_4	Pretilachlor 30% +Pyrazosulfuron ethyl 0.75% (Premix) @0.10kg/ha at 0-3 DAS followed by hand weeding at 25-30DAS	60281	30499	-29781	0.50
T_5	Live mulching with green gram	75357	82200	6143	1.08
T_6	Brown manuring with green gram	65371	82002	17330	1.26
T_7	Hand weeding @25 and 45 DAS	86871	99300	12428	1.14
T_8	Unweeded control	47671	33000	-14671	0.69

Economics of cultivation

The cost of cultivation in foxtail millet was lowest (Rs. 47671/- per ha) in Unweeded control, whereas the highest was in hand weeded control (Rs. 86871/- per ha) (Table 4) due to more number of labours required for hand weeding. Even though hand weeding was found to be the best and efficient method of weed control in foxtail millet, it is economically not feasible for farmers. Greater net returns and benefit-cost (B: C) ratio were obtained in brown manuring with green gram (1.26), followed by straw mulching in the interspaces of the crop (1.17). The greater net returns and B: C ratio in brown manuring with green gram was due to less labour compared to other treatments and it

was lower in straw mulching due to the increased cost of straw. Oxyfluorfen followed by hand weeding recorded the lowest B: C ratio of 0.45 due to less crop population and thereby less yield. The decreased B: C ratio in other treatments was due to the increased cost of cultivation.

Conclusion

Even though hand weeding at 25 and 45 DAS was found to be the best and efficient method of weed control in foxtail millet, it is economically not feasible for farmers. Brown manuring with green gram with greater net returns and benefit-cost (B: C) ratio of 1.26 is the economically viable integrated weed management practice for foxtail millet cultivation. But straw mulching in the interspaces of foxtail millet was economic and suitable for summer rice fallows in terms of soil moisture conservation in areas where there is straw availability. Pre-emergence application of herbicides (oxyfluorfen, Pretilachlor + Pyrazosulfuron ethyl) is not suitable for weed management in foxtail millet due to the small grain size and non-selective action of the herbicides, which inhibited the germination of the crop in sandy loam soils.

References

1. Asif M, Nadeem MA, Aziz A, Safdar ME, Adnan M, Ali A, *et al*. Mulching improves weeds management, soil carbon and productivity of spring planted maize (*Zea mays* L.). Int J Botany Stud. 2020;5(2):57-61.
2. Bai SK, Geetha KN, Sindhu KK, Dhanapal GN. Screening of herbicides for weed control in little millet (*Panicum sumatrense*) under South Karnataka. Mysore J Agric Sci. 2021;55(4):150-155.
3. Banu A, Fathima PS, Denesh GR, Suni CM. Pre- and post-emergence herbicides for weed management in finger millet. Indian J Weed Sci. 2016;48(4):447-449.
4. Kumar D, Kallshik SK, Galltam RC. Effect of moisture conservation and weed control on pearl millet (*Pennisetum glaucum*) under rainfed conditions. Indian J Agron. 1995;425-430.
5. Ma K, Zhang K, Zhang W, He LX, Fan Y, Alam S, Yuan X. Effect of pyrazosulfuron-ethyl on the photosynthetic characteristics and antioxidant systems of foxtail millet. Front Plant Sci. 2021;12:696169.
6. Mishra JS. Weed problem in millets and its management. In: Das IK, Padmaja PK, editors. Biotic Stress Resistance in Millets. Cambridge: Academic Press, 2016, p. 205-20.
7. Mohtisham A, Ahmad R, Ahmad Z, Aslam MR. Effect of different mulches techniques on weed infestation in aerobic rice (*Oryza sativa* L.). Am Eurasian J Agric Environ Sci. 2013;13(2):153-157.
8. Patil B, Reddy VC, Prasad TVR, Shankaralingappa BC, Devendra R, Kalyanamurthy KN. Weed management in irrigated organic finger millet. Indian J Weed Sci. 2013;45(2):143-145.
9. Shanmugapriya P, Rathika S, Ramesh T, Janaki P. Evaluation of weed management practices on weed control and yield of transplanted finger millet. J Pharm Innov. 2019;8(5):276-278.
10. Shim IS, Usui K, Ishizuka K. Studies relation on the selective of glutathione to pretilachlor mechanism of pretilachlor content and glutathione S-transferase selectivity in several plant species. Weed Res. 1990;35(1):25-35.