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Efficient non chemical weed management strategy for irrigated finer millet (*Eleusine coracana* L.)

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Abstract
Non chemical weed management practices are gaining significance in the recent past due to their scope in organic farming. A field experiment was conducted at the Department of Agronomy, Agricultural College and Research Institute, Killikulam to study the efficiency of non chemical weed management practices in irrigated finger millet. The experiment was laid out in factorial randomized block design (FRBD). The treatments consisted of mulching as main factor which included rice straw, shredded coconut waste and a control as treatments. The sub factor included intercrops *viz*., black gram, small onion, palak, coriander and a control without intercrops. Non chemical weed management treatments lowered total weed density and weed dry weight significantly as compared to unweeded control. Mulching with rice straw mulch at 30 and 45 DAS significantly lowered the total weed density as well as weed dry weight and was on par with shredded coconut waste mulch. The lowest weed density was recorded under small onion intercropping (I_3) and was on par with palak (I_4) and balack gram (I_1) treatments. The combination of rice straw mulch with small onion intercrop had effective control over the weeds. Apart from small onion, rice straw mulch with palak and rice straw mulch with black gram were found to record reduced weed densities with their broad leaved canopy structure.

Keywords: Rice straw mulch, shredded coconut waste mulch, intercropping, weed control efficiency (WCE)

Introduction
Finger millet, the most important small millet crop is grown in India in an area of 1.14 million hectare with a production of 1.82 million tonnes and a productivity of 1601 kg ha^{-1} (Anonymous, 2016) [1]. Apart from its excellent nutritional value, its ability to tolerate various abiotic stresses and resist pest and diseases make it an alternate crop for upland ecosystems. Among biotic stresses, weeds are serious threat to its production. Uncontrolled weed growth during crop period reduces the grain yield ranging from 34 to 61 per cent. The critical period for crop-weed competition differs from one week to five weeks after planting depending upon whether it is transplanted or direct sown. In order to increase the productivity, it is necessary to minimize weed competition particularly during the critical period of the crop. It is known that finger millet is a high statured crop, still the slower initial growth of the crop and heavy infestation of weeds at early stages make the crops' growth diminished.
Cultivation of crops like finger millet organically and at the same time maintaining higher production levels is a big challenge since chemical intervention is not permitted in organic weed management. The increase in weed population under organic farming due to non use of herbicides is a serious problem (Bond and Grundy 2001) [4]. Growing of intercrops and crop residue mulching as a tool in integrated weed management strategy in organic farming not only reduce the intensity of weeds but also gives additional yield and returns. Weeding through non-chemical methods have to be undertaken within the critical period of the crop. Information on non-chemical weed management in finger millet is limited and therefore, present experiment was carried out to evolve an effective weed management through practices intercropping and mulching in irrigated finger millet.

Materials and Methods
Field experiment was conducted at the 'B' block of Department of Agronomy, Agricultural College and Research Institute, Killikulam during *rabi* season of 2018-2019. The soil of the experimental field was sandy loam with pH of 7.04 and EC of 0.02 ds/m. It was low in available nitrogen (242 kg/ha), medium in phosphorus (21 kg/ha) and medium in potassium (236 kg/ha). The experiment was laid out in Factorial Randomized Block Design (FRBD) and replicated thrice. Main factor consisted of rice straw mulching (M_1), shredded coconut waste mulching (M_2) and without mulch (M_0) as control whereas sub factor included four intercrops

viz., blackgram (I_1), coriander (I_2), small onion (I_3) and palak (I_4) and a control (I_0). Finger millet variety CO-15 was used in this experiment with 30cm x 10cm spacing. Intercrops were grown in 1:1 row ratio in additive series. Data on weed density and weed dry matter were recorded at 30 and 45 DAS. The data on weed density was subjected to square root transformations before statistical analysis for normalization.

Results and Discussion

Weed flora

Among the identified weeds, *Echinochloa colona* (L.), *Cynodon dactylon* (L.) Pers and *Digitaria marginata* (L.) were the dominant grasses. *Cyperus iria* (L.) was the only sedge recorded in the experiment. Among the broad leaved weeds, *Celosia argentea* (L.), *Corchorus olitorius* (L.), *Boerhavia erecta* (L.), *Cleome gynandra* (L.), *Trianthema portulacastrum* (L.), and *Portulaca oleracea* (L.) were predominant. Similar findings had earlier been reported by Dhanapal *et al.* (2015) [5]. The narrow spectrum of weed flora might be due to the fact that the experimental field was prepared thoroughly to obtain a fine tilth. Due care was taken to remove the stubbles of crop and weeds of previous season which are the basic pre requisites of organic weed management.

Total weed density (Table 1)

At 45 DAS, the lowest weed density was registered in all the weed management treatments over weedy check (Table 1). On 30 and 45 DAS, lower total weed density was recorded in rice straw mulch (M_1) (38.1 and 37.5 m^{-2}) and shredded coconut waste mulch (M_2) (40.1 and 40.5 m^{-2}) than in un-mulched (M_0) (65.4 and 46.9 m^{-2}). Irrespective of sources, mulching either with rice straw or shredded coconut waste mulch resulted in better control of weeds. But, in the un-mulched plot, as the day progressed the density reduced which may be due the heavy competition among the weeds among themselves and with the crop. Similar findings were reported by Mohtisham *et al*. (2013) [7] wherein straw mulch reduced the number of germinating weeds by half, compared to the non-mulched control.

Among the intercropping treatments, the lowest weed density was recorded under small onion intercropping (I_3) and was on par with palak (I_4) and balack gram (I_1) treatments but significantly superior to other weed management treatments on 30 and 45 DAS. Higher weed density was recorded in the non-intercropped treatment (I_0) at 15, 30 and 45 DAS recording 58.4, 51.8 and 52.9 m^{-2} respectively. The interaction effect between organic mulches and intercropping weed management practices was significant on 30 and 45 DAS, the combination of M_1I_3 registered lowest weed population (35.6 g m^{-2} on 30 DAS and 30.8 g m^{-2} on 45 DAS). Unlike mulching, it was observed the total weed density increased on 30 DAS than on 15 DAS and then declined on 45 DAS, revealing that there existed a suppression ability for the intercrops over the weeds ensuring weed free situation upto 45 DAS. Though, a narrow leaved crop, small onion with its ability to germinate at the earliest than the weeds, hindered the germination and growth of weeds. Thus, the combination of rice straw mulch with small onion intercrop had effective control over the weeds. Apart from small onion, rice straw mulch with palak and rice straw mulch with black gram were found to record reduced weed densities with their broad leaved canopy structure. Similar results of reduced weed density due to intercropping were observed in pearl millet intercropping with black gram (1: 1) by Mathukia *et al.* (2015) [6].

Total weed dry matter (g m^{-2}) (Table 1)

The data on total weed dry matter followed a similar trend as of weed density at all stages of observation (Table 2). Organic mulching influenced the weed dry matter production on 30 and 45 DAS and the highest weed dry matter was recorded in M_0 (without organic mulches) (73.1 and 74.5 g m^{-2}), while lower weed dry matter at rice straw mulch (M_1) (44.4 and 46.2 g m^{-2}). Among the intercropping, small onion intercropping was significantly superior over other weed management practices on reducing weed dry matter production on 30 and 45 DAS recording 42.1 and 43.7 g m^{-2} respectively which was on par with palak intercrop (I_4). Among the organic mulching practices, rice straw mulch had a greater influence on weed dry weight when compared with un-mulched plot. The lowest weed biomass was recorded under rice straw mulching as observed by Ahmed *et al.* (2007) [2], where minimum total weed biomass was recorded under wheat straw mulched treatment. Combination of rice straw mulch with small onion intercrop reduced the weed dry matter production on 30 and 45 DAS recording 34.3 and 35.9 g m^{-2} respectively.

Weed control efficiency (WCE)

Weed control efficiency (WCE) measures the magnitude of reduction in weed dry matter by weed control treatments and was found to be influenced by mulching and intercropping practices. Higher weed control efficiency was recorded under mulching than un-mulched treatment. Though, rice straw mulching recorded higher weed control efficiency on 30 and 45 DAS, the differences were only numerical with shredded coconut waste mulch (Munnoli *et al*., 2018) [8]. Among the intercropping treatments, small onion intercrop drastically reduced weed dry matter thus recording higher WCE. Similar result was reported by (Arbhanvi *et al.*, 2017) [3] in maize + cowpea (1: 5) intercropping systems that recorded highest WCE. The least weed control efficiency was observed in coriander intercropping, since it took 7-10 days for germination by the time the weed seeds germinated ahead of finger millet and grow luxuriously with higher weed dry weight and hence recorded diminished WCE (40.4 and 46.7 per cent on 30 and 45 DAS). Similarly, in palak intercropping also the canopy coverage was obvious still, it lacked early germination and recorded WCE of 53.2 and 51.2 per cent on 30 and 45 DAS. Though canopy coverage is an important criterion in mulching for preventing weed germination and growth, earliness and height of the canopy to harness the light interception effectively by achieving higher relative growth rate is remarkable as observed in small onion which proved its superiority over other intercrops (Hollander *et al*., 2007).

Table 1: Effect of organic weed management practices on weed density (no. m^{-2}) and weed dry weight (g m^{-2}) in irrigated Finger millet

Treatments	Weed density (no. m^{-2})								Weed dry weight (g m^{-2})							
	30 DAS				45 DAS				30 DAS				45 DAS			
	M_0	M_1	M_2	Mean	M_0	M_1	M_2	Mean	M_0	M_1	M_2	Mean	M_0	M_1	M_2	Mean
I_0	16.0 (87.0)	12.0 (51.8)	10.7 (56.7)	13.5 (65.2)	13.8 (90.5)	11.6 (47.5)	12.3 (54.0)	12.5 (64.0)	17.1 (99.4)	12.9 (58.3)	13.4 (62.9)	14.5 (73.5)	17.0 (100.6)	12.5 (60.1)	12.9 (63.4)	14.1 (74.7)
I_1	13.8 (63.5)	10.2 (37.3)	10.4 (38.8)	11.5 (46.5)	11.7 (48.4)	10.2 (37.6)	10.5 (40.0)	10.8 (42.0)	14.5 (70.5)	11.1 (43.0)	11.4 (45.1)	12.3 (52.9)	14.5 (72.2)	10.4 (45.2)	10.3 (47.0)	11.8 (54.8)
I_2	14.6 (71.4)	10.8 (41.7)	11.0 (42.9)	12.1 (52.0)	12.4 (54.7)	10.7 (41.0)	11.1 (44.7)	11.4 (46.8)	15.2 (77.5)	11.8 (48.2)	12.0 (49.3)	13.0 (58.3)	15.5 (78.6)	10.9 (49.9)	11.1 (51.4)	12.5 (60.0)
I_3	12.3 (50.5)	8.9 (27.9)	9.0 (28.6)	10.0 (35.6)	9.9 (34.9)	9.0 (28.6)	8.9 (28.9)	9.3 (30.8)	13.0 (56.7)	10.0 (34.4)	10.1 (35.1)	11.1 (42.1)	12.6 (58.3)	9.1 (35.9)	9.0 (36.9)	10.2 (43.7)
I_4	12.8 (54.6)	9.5 (31.8)	9.7 (33.7)	10.7 (40.1)	10.5 (39.7)	9.6 (32.7)	9.9 (34.9)	10.0 (35.8)	13.6 (61.5)	10.5 (37.9)	10.8 (40.2)	11.6 (46.5)	13.3 (62.7)	9.4 (39.8)	9.6 (41.7)	10.7 (48.0)
Mean	13.9 (65.4)	10.3 (38.1)	10.6 (40.1)		11.7 (45.0)	10.2 (37.5)	10.5 (40.5)		14.7 (73.1)	11.3 (44.4)	11.6 (46.5)		14.6 (74.5)	10.5 (46.2)	10.6 (48.1)	
		SEd	CD (0.05)			SEd	CD (0.05)			SEd	CD (0.05)			SEd	CD (0.05)	
	M	0.064	0.132		M	0.091	0.187		M	0.055	0.112		M	0.148	0.304	
	I	0.083	0.170		I	0.118	0.242		I	0.071	0.145		I	0.191	0.392	
	M x I	0.144	0.294		M x I	0.204	0.418		M x I	0.122	0.251		M x I	0.331	NS	

(Figures in parenthesis are original values; data subjected to square root transformation $\sqrt{X + 0.5}$

Table 2: Effect of organic weed management practices on weed control efficiency (%) in irrigated Finger millet

Treatments	30 DAS				45 DAS			
	M_0	M_1	M_2	Mean	M_0	M_1	M_2	Mean
I_0	0.00	41.3	36.7	26.0	0.00	40.3	36.9	25.7
I_1	29.1	56.7	54.6	46.8	28.2	55.1	53.3	45.5
I_2	22.0	51.5	50.4	41.3	21.9	50.4	48.9	40.4
I_3	43.0	65.4	64.6	57.7	42.0	64.3	63.3	56.5
I_4	38.1	61.8	59.6	53.2	34.6	60.4	58.5	51.2
Mean	26.4	55.4	53.2		25.3	54.1	52.2	

Conclusion

Mulching with rice straw and shredded coconut waste is the best efficient method for achieving higher weed control efficiency through lower weed density and dry matter. Similarly, the combination of mulching with intercropping onion recorded higher weed control efficiency.

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