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RESEARCH NOTE

Influence of integrated weed management practices on weeds, physiology, quality and yield of direct sown ragi (*Eleusine coracana* L. Gaertn)

S.R. Sneha[1], Sheeja K Raj[1*], D. Jacob[2], G.V. Kavitha[3], N.V. Radhakrishnan[1] and Shalini P. Pillai[1]

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ABSTRACT

Field experiment was conducted at Coconut Research Station, Balaramapuram during January 2022 to April 2022 to assess the effect of weed management on weeds, physiology, quality and yield of direct sown ragi. The experiment was conducted in randomized block design with twelve treatments. The percentage reduction in weed density at 60 DAS due to weed management ranged from 45.4% to 81.8%. The lowest weed dry weight at 60 DAS was observed in PE pyrazosulfuron-ethyl 20 g/ha on the day sowing *fb* WHW at 25 DAS. The treatments, wheel hoe weeding (WHW) at 15 and 30 DAS, pre-emergence (PE) pyrazosulfuron-ethyl 20 g/ha on the day of sowing *fb* WHW or post directed application of penoxsulam + cyhalofop-butyl 135g/ha at 25 DAS recorded higher values for crop growth rate, relative growth rate, leaf area index and chlorophyll content. The treatment, PE pyrazosulfuron-ethyl 20g/ha on the day of sowing *fb* WHW at 25 DAS recorded higher protein content while PE pyrazosulfuron-ethyl 20 g/ha on the day of sowing *fb* post directed application of penoxsulam + cyhalofop-butyl 135 g/ha at 25 DAS recorded the highest starch content and these two treatments also recorded higher grain yield compared to other treatments.

Key words: Bensulfuron-methyl + pretilachlor, Bispyribac-sodium, Pyrazosulfuron-ethyl, Penoxsulam + cyhalofop-butyl, Oxyfluorfen, Wheel hoe weeding

Finger millet (*Eleusine coracana* L. Gaertn.), commonly known as ragi, is one of India's important staple food crops. In India, it covers an area of 0.97 million ha with an average yield of 1.62 t/ha, during 2019-20 (Tonapi 2020). Inclusion of finger millets in the diet provides health benefits through their anti-diabetic, anti-tumorigenic, anti-diarrheal, anti-inflammatory, antioxidant, and antimicrobial properties.

In India the production and productivity of finger millet is low and weed infestation is found to be the major constraints in finger millet cultivation. Since the crop is having slower initial growth, weeds dominate over the crop easily and remove the soil nutrients, moisture, and other growth factors at a faster rate and affect crop growth and development. Patil *et al*. (2013) also reported heavy weed infestation during initial growth period of finger millet which ultimately led to higher crop weed competition and drastic reduction in yield. Presence of weeds not only causes yield loss but also affect the quality of the produce and intensify the disease and pest incidence by serving as an alternate host. Kujur *et al.* (2019) reported that weed management practices had significant impact on physiological parameters of finger millet, which was evident from the higher values of crop growth rate (CGR), relative growth rate (RGR) and LAI, recorded in the weed control treatments. Post emergence application of bispyribac-sodium 20 g/ha recorded significantly higher leaf area per hill compared to weedy check in finger millet (Banu *et al*. 2016*)*. With this back ground, the present investigation was carried out to study the effect of weed management practices on weed parameters, physiological parameters, yield and quality of direct seeded finger millet.

Field study was conducted at Coconut Research Station, Balaramapuram, Thiruvananthapuram, Kerala, Kerala, located at 8° 22' 52'' North latitude and 77° 1' 47'' East longitude and at an altitude of 9 m above MSL during January 2022 to April 2022 with an objective to assess the effect of weed management practices on physiological parameters, weed parameters, yield and quality of direct seeded finger millet. The variety *PPR 2700* (*Vakula*) was used as

[1] Kerala Agricultural University, College of Agriculture Vellayani, Kerala 695522, India

[2] Kerala Agricultural University, Onattukara Regional Agricultural Research Station, Kayamkulam, Kerala, India

[3] Kerala Agricultural University, Coconut Research Station, Balaramapuram, Kerala 695501, India

* Corresponding author email: sheeja.raj@kau.in

the test crop. The crop was grown as an intercrop in 60-year-old coconut palms that were spaced 7.6 m apart and had 70% light transmission rate. The textural class of soil in the experimental site was sandy loam with acidic character (soil pH 5.19), and was very low in organic carbon (0.25%), low in N (275.96 kg/ha), medium in P (17.23 kg/ha), and high in K (324.8 kg/ha). Total rainfall during the experimental period was found to be 129.8 mm. The experiment was carried out in randomized completely block design with 12 treatments (**Table 1**) in three replications. The method of sowing adopted was direct seeding with the help of a seed cum fertilizer drill. The seed rate adopted was 5 kg/ha and seeds were sown at a spacing of 25 x 15 cm. Farm yard manure 5 t/ha was uniformly applied to the plots. The crop was fertilized with NPK 45: 22.5: 22.5 kg/ha. At the time of seeding, full doses of P and K and half of the N were applied, and top-dressing was done with the remaining N at 21 DAS. The spray fluid adopted for the experiment was 500 L/ha. Pre-emergence herbicides were applied with the help of hand-operated knapsack sprayer with a flat fan nozzle on the day of sowing, and post emergence herbicides were applied with the aid of a crop protective herbicide applicator on 25 DAS. Weed density at 20 DAS, 40 DAS and 60 DAS were determined by randomly placing quadrat of 0.25 m^2 area in each plot and weeds present within the quadrant were counted and expressed in no./m^2. Weed dry weight was determined by recording the dry weight of uprooted weeds and expressed as g/m^2. The leaf area index was calculated by the formula proposed by Watson (1952). The leaf chlorophyll content was determined by the method suggested by Yoshida *et al.* (1976). The crop growth rate was calculated at three-time intervals, 20-40 DAS, 40-60 DAS, and 60 DAS to harvest using the formula suggested by Watson (1958). The relative growth rate was calculated at time intervals, 20-40 DAS, 40-60 DAS, and from 60 DAS to harvest using the formula proposed by Evans (1972). The grain harvested from the net plot area was sun dried and the grain weight was expressed in kg/ha. The nitrogen content of the finger millet grain was multiplied by a factor 6.25 to compute the crude protein content (Simpson *et al.* 1965) and expressed as percentage on dry weight basis. The starch content of the finger millet grain was estimated by titrimetric method (Aminoff *et al.* 1970) and the values were expressed in percentage. Analysis of variance technique for RBD was used for the statistical analysis of the experimental data and the significance was tested using F test. Wherever the F values were found significant, the critical difference was calculated at five per cent probability level.

Effect of weed management on total weed density and weed dry weight

The major weed flora in the experimental field were *Panicum maximum* Jacq., *Setaria barbata* (Lam.) Kunth, and *Digitaria sanguinalis* (L.) Scop., *Mimosa pudica* L., *Phyllanthus niruri* L., *Boerhavia diffusa* L. and *Synedrella nodiflora* (L.) Gaertn.

Weedy check recorded the highest weed density at 20 DAS (100 no./m^2), 40 DAS (65.33 no. /m^2), and 60 DAS (44 no. /m^2) (**Table 1**). The treatment PE oxyfluorfen 50 g/ha on 0 DAS *fb* WHW at 25 DAS recorded significantly lower weed density (12 no. / m^2) at 20 DAS. At 40 DAS, the lowest weed density was noted in PE pretilachlor + bensulfuron-methyl 495 g/ha 0 DAS *fb* WHW at 25 DAS (12 no./m^2). However, at 60 DAS, PE pretilachlor + bensulfuron-methyl 495 g/ha 0 DAS *fb* bispyribac-sodium 20 g/ha at 25 DAS recorded the lowest weed density which was statistically identical with PE pyrazosulfuron-ethyl 20 g/ha 0 DAS *fb* penoxsulam+ cyhalofop-butyl

Table 1. Effect of weed management on total weed density

Treatment	Total density of weeds (no./m^2)		
	20 DAS	40 DAS	60 DAS
PE pretilachlor + bensulfuron-methyl 495 g/ha 0 DAS *fb* WHW at 25 DAS	4.79 (22.0)	3.54 (12.0)	3.60 (12.0)
PE pretilachlor + bensulfuron-methyl 495 g/ha 0 DAS *fb* bispyribac-sodium 20 g/ha at 25 DAS	4.12 (16.0)	4.43 (18.7)	2.95 (8.0)
PE pretilachlor + bensulfuron-methyl 495 g/ha 0 DAS *fb* penoxsulam + cyhalofop-butyl 125g/ha at 25 DAS	5.25 (26.7)	3.95 (14.7)	5.00 (24.0)
PE pyrazosulfuron-ethyl 20 g/ha 0 DAS *fb* WHW at 25 DAS	6.71 (44.0)	5.00 (24.0)	3.78 (13.3)
PE pyrazosulfuron-ethyl 20 g/ha 0 DAS *fb* bispyribac-sodium 20 g/ha at 25 DAS	8.19 (66.0)	4.43 (18.7)	3.40 (10.7)
PE pyrazosulfuron-ethyl 20 g/ha 0 DAS *fb* penoxsulam+ cyhalofop-butyl 125 g/ha at 25 DAS	6.40 (40.0)	4.96 (24.0)	3.00 (8.0)
PE oxyfluorfen 50 g/ha 0 DAS *fb* WHW at 25 DAS	3.61 (12.0)	4.43 (18.7)	4.12 (16.0)
PE oxyfluorfen 50 g/ha 0 DAS *fb* bispyribac-sodium 20 g/ha at 25 DAS	4.36 (18.0)	4.04 (15.3)	3.61 (12.0)
PE oxyfluorfen 50 g/ha 0 DAS *fb* penoxsulam + cyhalofop-butyl 125 g/ha at 25 DAS	5.75 (32.0)	3.76 (13.3)	3.75 (13.3)
WHW 15 and 30 DAS	5.38 (28.0)	3.78 (13.3)	3.78 (13.3)
HW 15 and 30 DAS	6.55 (42.0)	4.57 (20.0)	4.58 (20.0)
Weedy check	10.05 (100.0)	8.14 (65.3)	6.71 (44.0)
LSD (p=0.05)	0.474	0.756	0.556

DAS- Days after sowing; *fb*- followed by; HW- hand weeding; WHW- wheel hoe weeding

125 g/ha at 25 DAS and PE pyrazosulfuron-ethyl 20 g/ha 0 DAS *fb* bispyribac-sodium 20 g/ha at 25 DAS.

Weedy check resulted in significantly higher weed dry weight at 20 DAS, 40 DAS and 60 DAS (14.4 g/m^2, 90.13 g/m^2, and 393.73 g/m^2, respectively) (**Figure 1**). At 20 DAS, PE oxyfluorfen 50 g/ha on 0 DAS *fb* bispyribac-sodium 20 g/ha at 25 DAS resulted in the lowest weed dry weight (1.04 g/m^2). At 40 DAS, significantly lower weed dry weight was observed in HW at 15 and 30 DAS which was *fb* PE pyrazosulfuron-ethyl 20 g/ha on 0 DAS *fb* penoxsulam+ cyhalofop-butyl 125 g/ha at 25 DAS and at 60 DAS, the lowest weed dry weight was observed in PE pyrazosulfuron-ethyl 20 g/ha on 0 DAS *fb* WHW at 25 DAS. Pandey *et al*. (2018) also came to similar conclusion that uncontrolled weed growth in weedy check resulted in higher weed density and weed dry weight.

Effect of weed management on total chlorophyll content

Total chlorophyll content was significantly influenced by weed management at 20 DAS and 60 DAS (**Table 2**). At 20 DAS, the highest chlorophyll content was recorded in WHW at 15 and 30 DAS (2.654 mg/g) and it was statistically on par with HW at 15 and 30 DAS. However, at 60 DAS the treatment PE pyrazosulfuron-ethyl 20 g/ha *fb* penoxsulam + cyhalofop-butyl 125 g/ha at 25 DAS recorded the highest chlorophyll content (4.027 mg/g) and it was statistically on par with all treatments except weedy check. At 60 DAS, weed management treatments recorded significantly higher chlorophyll content than that of weedy check. This was mainly attributed to higher nutrient uptake due to significant reduction in the nutrient removal of weeds.

Effect of weed management on leaf area index

At 20 DAS the treatment WHW at 15 DAS and 30 DAS recorded higher LAI (**Table 2**). However, at 40 DAS, the treatment PE pyrazosulfuron-ethyl 20 g/ha *fb* WHW at 25 DAS resulted in the highest LAI. The treatments, PE pyrazosulfuron-ethyl 20 g/ha *fb* WHW or penoxsulam+ cyhalofop-butyl 125 g/ha at 25 DAS, and PE pyrazosulfuron-ethyl 20 g/ha *fb* bispyribac-sodium 20 g/ha at 25 DAS recorded higher LAI at 60 DAS. The reason was due to the production of a greater number of tillers per m^2 and higher leaf area resulting from longer and wider leaves. Muhammadi *et al.* (2016) reported higher values of LAI at 90 DAS in hand-weeded plots (4.07), wheel hoe weeded plots (3.96), and herbicide-treated plots (3.68), compared to weedy check (3.28) in dry direct seeded rice.

Effect of weed management on crop growth rate and relative growth rate

Crop growth rate and relative growth rate was also significantly influenced by weed management at time intervals 20 DAS - 40 DAS and at 40 DAS - 60 DAS (**Table 3**). At 20 DAS - 40 DAS, PE pyrazosulfuron-ethyl 20 g/ha *fb* penoxsulam + cyhalofop-butyl 125 g/ha resulted in the highest CGR and RGR. At 40 DAS-60 DAS, WHW at 15 DAS and 30 DAS recorded the highest CGR. At 20 DAS - 40 DAS, the RGR was higher in PE pyrazosulfuron-ethyl 20 g/ha *fb* penoxsulam+ cyhalofop-butyl 125 g/ha at 25 DAS and 40 DAS - 60 DAS, PE pyrazosulfuron-ethyl 20 g/ha *fb* WHW at 25 DAS recorded higher RGR. Higher CGR and RGR in these treatments might be due to significant reduction in weed density and weed biomass, which enabled the crop to utilize the resources more efficiently. Increased N uptake

Table 2. Effect of weed management on total chlorophyll content and leaf area index (LAI) of direct sown finger millet

Treatment	Total chlorophyll content (mg/g)			LAI	
	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS
PE pretilachlor + bensulfuron-methyl 495 g/ha 0 DAS *fb* WHW at 25 DAS	1.860	3.626	3.901	0.216	2.466
PE pretilachlor + bensulfuron-methyl 495 g/ha 0 DAS *fb* bispyribac-sodium 20 g/ha at 25 DAS	1.863	3.910	3.745	0.276	2.621
PE pretilachlor + bensulfuron-methyl 495 g/ha 0 DAS *fb* penoxsulam + cyhalofop-butyl 125 g/ha at 25 DAS	1.778	3.886	3.920	0.243	2.646
PE pyrazosulfuron-ethyl 20 g/ha 0 DAS *fb* WHW at 25 DAS	1.978	3.922	3.986	0.755	3.251
PE pyrazosulfuron-ethyl 20 g/ha 0 DAS *fb* bispyribac-sodium 20 g/ha at 25 DAS	1.935	3.870	3.939	0.648	2.755
PE pyrazosulfuron-ethyl 20 g/ha 0 DAS *fb* penoxsulam+ cyhalofop-butyl 125 g/ha at 25 DAS	1.863	3.917	4.027	0.728	2.808
PE oxyfluorfen 50 g/ha 0 DAS *fb* WHW at 25 DAS	1.832	3.893	3.947	0.617	2.713
PE oxyfluorfen 50 g/ha 0 DAS *fb* bispyribac-sodium 20 g/ha at 25 DAS	1.783	3.795	3.895	0.541	2.378
PE oxyfluorfen 50 g/ha 0 DAS *fb* penoxsulam + cyhalofop-butyl 125 g/ha at 25 DAS	1.792	3.865	3.897	0.613	2.678
WHW 15 and 30 DAS	2.654	3.923	3.950	0.858	2.656
HW 15 and 30 DAS	2.593	3.906	3.900	0.810	2.543
Weedy check	2.469	3.562	3.032	0.782	2.056
LSD (p=0.05)	0.0870	NS	0.4710	0.0880	0.5070

DAS- Days after sowing; *fb*- followed by; HW- hand weeding; WHW- wheel hoe weeding enhanced the vegetative growth and hence larger assimilatory area for intercepting solar radiation and this in turn resulted in higher CGR and RGR. Significant reduction in crop weed competition for the resources resulted in better expression of growth and yield attributes which also contributed to higher CGR and RGR in weed management treatments compared to weedy check. Shanmugapriya *et al*. (2022) reported remarkable improvement in CGR and RGR due to weed management in finger millet.

Effect of weed management on yield

Among the weed management treatments, the highest grain yield (2072 kg/ha) was recorded in treatment PE pyrazosulfuron-ethyl 20 g/ha *fb* WHW at 25 DAS which was statistically on par with PE pyrazosulfuron-ethyl 20 g/ha *fb* penoxsulam + cyhalofop-butyl 125 g/ha at 25 DAS (**Figure 2**). The yield enhancement observed in these treatments was due to significant reduction in weed density and dry weight, higher leaf area index, chlorophyll content, crop growth and relative growth rate. Satish *et al*. (2018) revealed that PE application of bensulfuron-methyl + pretilachlor *fb* one intercultivation resulted in higher yield compared to PE application of bensulfuron-methyl + pretilachlor alone. Weedy check recorded the lowest grain yield.

Effect on NPK uptake by grain

Nutrient uptake by grain was significantly influenced by weed management (**Table 3**). Compared to weedy check, an increase in NPK uptake by grain was observed in the weed management treatments. Better control of weeds provided a competition-free environment for crop growth. It was found that nutrient uptake was directly related to the nutrient content and dry matter

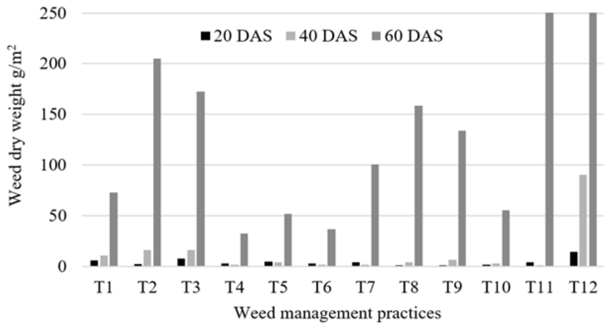

Figure 1. Effect of weed management practices on weed dry weight in finger millet

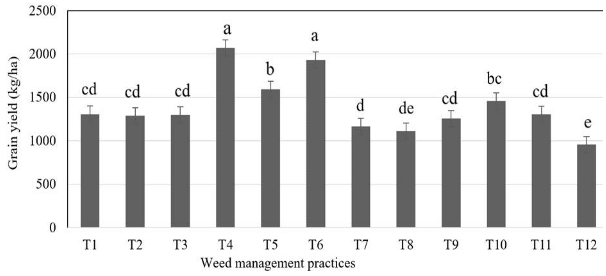

Figure 2. Effect of weed management on grain yield in finger millet

Note: T_1: PE pretilachlor + bensulfuron-methyl 495 g/ha 0 DAS *fb* WHW at 25 DAS; T_2: PE pretilachlor + bensulfuron-methyl 495 g/ha 0 DAS *fb* bispyribac-sodium 20 g/ha at 25 DAS; T_3: PE pretilachlor + bensulfuron-methyl 495 g/ha 0 DAS *fb* penoxsulam+ cyhalofop-butyl 125g/ha at 25 DAS; T_4: PE pyrazosulfuron-ethyl 20 g/ha 0 DAS *fb* WHW at 25 DAS; T_5: PE pyrazosulfuron-ethyl 20 g/ha 0 DAS *fb* bispyribac-sodium 20 g/ha at 25 DAS; T_6: PE pyrazosulfuron-ethyl 20 g/ha 0 DAS *fb* penoxsulam+ cyhalofop-butyl 125 g/ha at 25 DAS; T_7: PE oxyfluorfen 50 g/ha 0 DAS *fb* WHW at 25 DAS; T_8: PE oxyfluorfen 50 g/ha 0 DAS *fb* bispyribac-sodium 20 g/ha at 25 DAS; T_9: PE oxyfluorfen 50 g/ha 0 DAS *fb* penoxsulam+ cyhalofop-butyl 125 g/ha at 25 DAS; T_{10}: WHW 15 and 30 DAS; T_{11}: HW 15 and 30 DAS; T_{12}: Weedy check

Table 3. Effect of weed management on crop growth rate (CGR) and relative growth rate (RGR) of direct sown finger millet

Treatment	CGR (g/m²/day)			RGR (g/g/day)		
	20-40 DAS	40-60 DAS	60 DAS-Harvest	20-40 DAS	40-60 DAS	60 DAS-Harvest
PE pretilachlor + bensulfuron-methyl 495 g/ha 0 DAS *fb* WHW at 25 DAS	6.82	6.34	11.93	0.080	0.089	0.090
PE pretilachlor + bensulfuron-methyl 495 g/ha 0 DAS *fb* bispyribac-sodium 20 g/ha at 25 DAS	6.15	5.96	12.74	0.076	0.088	0.093
PE pretilachlor + bensulfuron-methyl 495 g/ha 0 DAS *fb* penoxsulam + cyhalofop-butyl 125 g/ha at 25 DAS	6.64	8.35	11.35	0.080	0.100	0.088
PE pyrazosulfuron-ethyl 20 g/ha 0 DAS *fb* WHW at 25 DAS	7.44	9.01	12.54	0.086	0.105	0.092
PE pyrazosulfuron-ethyl 20 g/ha 0 DAS *fb* bispyribac-sodium 20 g/ha at 25 DAS	7.12	7.94	12.07	0.084	0.099	0.090
PE pyrazosulfuron-ethyl 20 g/ha 0 DAS *fb* penoxsulam+ cyhalofop-butyl 125 g/ha at 25 DAS	9.23	6.92	11.39	0.097	0.093	0.088
PE oxyfluorfen 50 g/ha 0 DAS *fb* WHW at 25 DAS	7.72	6.66	9.92	0.088	0.085	0.083
PE oxyfluorfen 50 g/ha 0 DAS *fb* bispyribac-sodium 20 g/ha at 25 DAS	7.09	5.63	9.48	0.083	0.082	0.082
PE oxyfluorfen 50 g/ha 0 DAS *fb* penoxsulam + cyhalofop-butyl 125 g/ha at 25 DAS	6.70	5.55	11.27	0.081	0.073	0.088
WHW 15 and 30 DAS	8.53	9.04	11.25	0.093	0.102	0.088
HW 15 and 30 DAS	7.26	8.19	10.41	0.085	0.100	0.085
Weedy check	5.19	5.43	9.13	0.068	0.076	0.081
LSD (p=0.05)	1.156	1.197	NS	0.0090	0.0120	NS

DAS- Days after sowing; *fb*- followed by; HW- hand weeding; WHW- wheel hoe weeding; NS- not significant

Table 4. Effect of weed management on nutrient uptake by finger millet grain

Treatment	Nutrient uptake by grain (kg/ha)		
	N uptake by grain	P uptake by grain	K uptake by grain
PE pretilachlor + bensulfuron-methyl 495 g/ha 0 DAS *fb* WHW at 25 DAS	10.91	11.95	22.86
PE pretilachlor + bensulfuron-methyl 495 g/ha 0 DAS *fb* bispyribac-sodium 20 g/ha at 25 DAS	10.86	11.98	22.84
PE pretilachlor + bensulfuron-methyl 495 g/ha 0 DAS *fb* penoxsulam + cyhalofop-butyl 125g/ha at 25 DAS	11.00	12.14	23.14
PE pyrazosulfuron-ethyl 20 g/ha 0 DAS *fb* WHW at 25 DAS	10.96	13.00	23.96
PE pyrazosulfuron-ethyl 20 g/ha 0 DAS *fb* bispyribac-sodium 20 g/ha at 25 DAS	11.84	12.41	24.25
PE pyrazosulfuron-ethyl 20 g/ha 0 DAS *fb* penoxsulam+ cyhalofop-butyl 125 g/ha at 25 DAS	10.86	13.32	24.18
PE oxyfluorfen 50 g/ha 0 DAS *fb* WHW at 25 DAS	11.49	10.76	22.25
PE oxyfluorfen 50 g/ha 0 DAS *fb* bispyribac-sodium 20 g/ha at 25 DAS	11.88	12.20	24.08
PE oxyfluorfen 50 g/ha 0 DAS *fb* penoxsulam + cyhalofop-butyl 125 g/ha at 25 DAS	13.50	11.21	24.71
WHW 15 and 30 DAS	13.44	11.78	25.22
HW 15 and 30 DAS	10.73	12.80	23.53
Weedy check	11.05	10.49	21.55
LSD (p=0.05)	0.386	0.347	0.532

DAS- Days after sowing; *fb*- followed by; HW- hand weeding; WHW- wheel hoe weeding

Table 5. Effect of weed management on crude protein and starch content of finger millet grain

Treatment	Crude protein content (%)	Starch content (%)
PE pretilachlor + bensulfuron-methyl 495 g/ha 0 DAS *fb* WHW at 25 DAS	8.05	55.70
PE pretilachlor + bensulfuron-methyl 495 g/ha 0 DAS *fb* bispyribac-sodium 20 g/ha at 25 DAS	7.00	54.89
PE pretilachlor + bensulfuron-methyl 495 g/ha 0 DAS *fb* penoxsulam + cyhalofop-butyl 125g/ha at 25 DAS	8.05	56.25
PE pyrazosulfuron-ethyl 20 g/ha 0 DAS *fb* WHW at 25 DAS	9.69	61.82
PE pyrazosulfuron-ethyl 20 g/ha 0 DAS *fb* bispyribac-sodium 20 g/ha at 25 DAS	8.75	60.93
PE pyrazosulfuron-ethyl 20 g/ha 0 DAS *fb* penoxsulam+ cyhalofop-butyl 125 g/ha at 25 DAS	7.88	64.85
PE oxyfluorfen 50 g/ha 0 DAS *fb* WHW at 25 DAS	6.96	58.86
PE oxyfluorfen 50 g/ha 0 DAS *fb* bispyribac-sodium 20 g/ha at 25 DAS	8.75	62.51
PE oxyfluorfen 50 g/ha 0 DAS *fb* penoxsulam + cyhalofop-butyl 125 g/ha at 25 DAS	6.30	59.99
WHW 15 and 30 DAS	9.43	61.21
HW 15 and 30 DAS	7.70	57.42
Weedy check	4.55	50.77
LSD (p=0.05)	1.003	6.188

DAS- Days after sowing; *fb*- followed by; HW- hand weeding; WHW- wheel hoe weeding

production. Higher N, P, K uptake by the grain in weed management treatments were due to higher dry matter accumulation by the crop and also due to higher N, P, and K content. The treatment PE pyrazosulfuron-ethyl 20 g/ha 0 DAS *fb* WHW at 25 DAS recorded the highest total N uptake by grain. Whereas, the highest total P uptake by crop was recorded in PE pyrazosulfuron-ethyl 20 g/ha 0 DAS *fb* penoxsulam+ cyhalofop-butyl 125 g/ha at 25 DAS which was statistically on par with PE pyrazosulfuron-ethyl 20 g/ha 0 DAS *fb* WHW at 25 DAS. Similar to P uptake, the highest K uptake was also recorded in PE pyrazosulfuron-ethyl 20 g/ha 0 DAS *fb* penoxsulam+ cyhalofop-butyl 125 g/ha at 25 DAS. Sunil *et al*. (2011) also came to similar conclusion that higher nutrient uptake by crop was mainly due to reduction in weed population and weed dry weight which helped the crop to grow vigorously and absorb more nutrients from the soil.

Effect on quality

The treatment PE pyrazosulfuron-ethyl 20 g/ha 0 DAS *fb* WHW at 25 DAS resulted in the highest protein content (9.69 (**Table 4**). Whereas, the highest starch content was observed in PE pyrazosulfuron-ethyl 20 g/ha 0 DAS *fb* penoxsulam+ cyhalofop-butyl 125 g/ha at 25 DAS (64.85%). Higher N content of the grain resulted in higher protein content of grain. Since N is regarded as the building block of amino acids, an enhancement in N uptake in turn increased the protein content of grain. Jagtap *et al.* (2018) also reported lower protein content in rice grain under unweeded conditions compared to other treatments. Higher starch content was observed in weed management treatments compared to weedy check. Shaban *et al.* (2016) also reported higher carbohydrate content in maize in weed control plots compared to the weedy check. Among the treatments the lowest crude protein (4.55%) and starch content

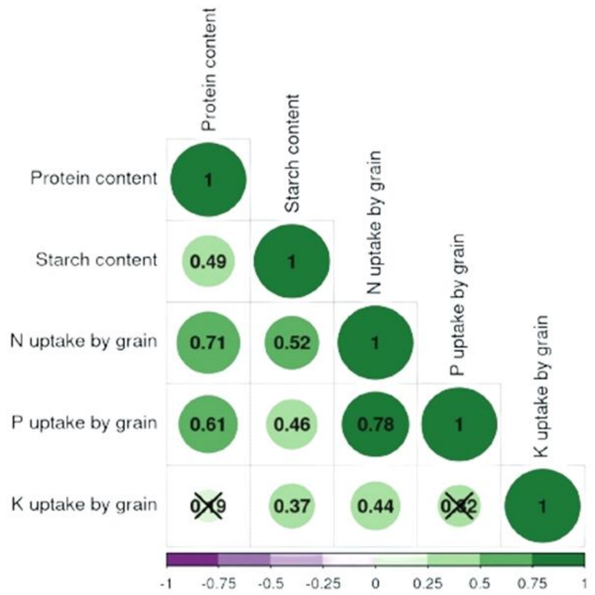

Figure 3. Correlation between NPK uptake by grain and protein and starch content of finger millet grain

(50.77%) was recorded in weedy check. From the correlation data, it was evident that the protein content was positively correlated with N and P uptake by grain and at the same time, starch content was positively correlated with N, P, and K uptake by grain (**Figure 3**).

Weed management had significant effect on weed, physiology, nutrient uptake by grain, quality and grain yield of direct seeded finger millet. Among the treatments, PE pyrazosulfuron-ethyl 20 g/ha on the day sowing *fb* penoxsulam+ cyhalofop-butyl 125 g/ha or WHW at 25 DAS recorded higher values of CGR, RGR, LAI chlorophyll content and lower values for weed density and dry weight. These treatments also recorded higher protein and starch content. The highest yield was recorded in PE pyrazosulfuron-ethyl 20 g/ha on the day of sowing *fb* WHW at 25 DAS and it was on par with PE pyrazosulfuron-ethyl 20 g/ha *fb* penoxsulam + cyhalofop-butyl 125 g/ha at 25 DAS. Hence it can be concluded that, PE pyrazosulfuron-ethyl 20 g/ha *fb* WHW at 25 DAS or post directed application of penoxsulam + cyhalofop-butyl at 25 DAS could be recommended as the best integrated weed management practices for higher yield and quality in direct sown finger millet.

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