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Effect of Different Weed Management Methods on Growth and Yield of Finger Millet (*Eleusine coracana* (L.) Gaertn) Cultivars under the Foot Hill Conditions of Nagaland

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Abstract

Investigation entitled "Effect of different weed management methods on growth and yield of finger millet (*Eleusine coracana* (L.) Gaertn) cultivars under the foot hill conditions of Nagaland" was undertaken at the Experimental Farm, Department of Agronomy, SASRD, Nagaland University during *Kharif* season, June to October 2019. The experiment was laid out in Split Plot Design with three replications including five finger millet varieties viz.,V_1-GPU 66, V_2 -GPU 67, V_3-VL 352 ,V_4-VL 376 and V_5-VR 847 and four weed management practices viz., W_1: Weedy check, W_2: PE of pendimethalin @ 1 kg ha^{-1} fb one hoeing at 30 DAS, W_3: PE of pendimethalin @ 1 kg ha^{-1} fb mulching at 10-15 DAS and W_4: PE of pendimethalin @ 1 kg ha^{-1} fb 2,4-D @ 0.75 kg ha^{-1} at 25-30 DAS. Results revealed that growth parameters such as plant height (cm), CGR (g m^{-2} day^{-1}), RGR (g g^{-1} day^{-1}) etc., and yield attributes viz., grain yield (1789.8 kg ha^{-1}), straw yield (4959.0 kg ha^{-1}) and harvest index (27.0%) were higher with the variety V4-VL 376. Among different weed management practices treatment W_4: PE of pendimethalin @ 1 kg ha^{-1}fb 2,4-D @ 0.75 kg ha^{-1} at 25-30 DAS recorded higher growth attributes, yield attributes and yield at all stages of crop. Among weed observations *Cynodon dactylon, Digitaria sanguinalis* etc., were dominant lower weed density (2.5 no m^{-2} at 40 DAS) higher weed control efficiency (84.9% at 40 DAS) were recorded with the treatment W_4 - pendimethalin @ 1 kg ha^{-1}fb 2,4-D @ 0.75 kg ha^{-1} at 25-30 DAS. Lower weed index (16.1%) was recorded with the treatment W_2: PE of pendimethalin @ 1 kg ha^{-1}fb hoeing at 30 DAS.

***Key words*:** *Eleusine coracana*, Varieties, Growth, Yield attributes, Weed management practices

Finger millet (*Eleusine coracana* (L.) Gaertn) is also referred as African millet or ragi or bird's foot millet is the 3rd most important millet crop in India after pearl millet and sorghum. Finger millet has the pride place in having the highest production per unit area among all the millets [1]. Finger millet is one of the most important staple food crops for many people in the hilly regions of the country and it is grown both for fodder and grain purposes and cultivated up to 3000 mts above MSL. The crop is widely adapted to low fertile soil conditions and marginal uplands [2]. Ragi belongs to the family Gramineae or Poaceae. *Eleusine* the generic was derived from the Greek word meaning "goddess of cereals". Because of its finger like branching of peduncle it is commonly known as finger millet [3]. Finger millet is native to Ethiopian highlands of Central Africa and the crop was introduced to India around 3000 years ago. India is considered as secondary Centre of origin and diversity of finger millet. Finger millet grains contain ash (3.9%), protein (19.2%), minerals (2.24%), fat (1.29%), carbohydrates (76.32%) and besides the grains also contains vitamin A and B. Grains are rich in methionine (amino acid), potassium phosphorous and calcium (410 mg 100 g^{-1} grains) [4]. Finger millet grains contain 2 times more phosphorous, 4 times more minerals and 10 times more calcium than rice and wheat [5]. In our country finger millet is widely grown in about 1.14 M ha area with the production of 1.82 MT and productivity of 1601 kg ha^{-1} [6]. In Nagaland finger millet is grown in an area of about 300 ha with the production of 310 MT with the productivity of 970 kg ha^{-1} [6].

The low production and productivity of finger millet is due to imbalance nutrient management, insufficient irrigation, heavy weed infestation, use of local varieties and incidence of blast disease etc. Among all these constraints, the serious threat for the low production and productivity is heavy weed infestation. The uncontrolled weed growth during critical periods of crop growth reduced the grain yield of finger millet ranging from 34 to 61% [7]. During the initial stage the crop growth is very slow and this condition favors the weeds to grow faster and thus, reduces the grain yield [8]. Intensive application of various weed management practices should be optimized for reduce the cost of finger millet production.

In the view to increase the area, production and productivity of finger millet in the North – Eastern states it is important to increase the area, use of improved varieties and to reduce the competition of weeds mainly during the critical period. Hence, to ensure the optimum grain yield determining efficient weed control method and the best performed variety is essential. Therefore, the present field investigation entitled "Effect of different weed management methods on growth and

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yield of finger millet (*Eleusine coracana* (L.) Gaertn) cultivars under the foot hill conditions of Nagaland" was conducted.

MATERIALS AND METHODS

A filed investigation entitled "Effect of different weed management methods on growth and yield of finger millet (*Eleusine coracana* (L.) Gaertn) cultivars under the foot hill conditions of Nagaland" was conducted at Research farm, Department of Agronomy, School of Agriculture Sciences and Rural Development, Medziphema Campus, Nagaland University during *Kharif*, 2019 from June – October. The site of the experiment was located at 25° 45' 43" North latitude and 95° 53' 04" East longitude with elevation of 310 m above mean sea level (MSL). The experimental site falls under tropical sub-humid climate with relatively high humidity, moderate to high rainfall and moderate temperature. The average temperature of the region during summer ranges between 21°C to 30°C. Due to high relative humidity during winter temperature rarely goes below 8°C. Annually, the rainfall of the region varies between 2000-2500 mm. The soil of the experimental field was found to be well drained and sandy loam in texture. The experiment was laid out in Split Plot Design (SPD) with 3 replications and 20 treatments [5 varieties (main plot) and 4 weed management practices including untreated weedy check (sub plot)].

RESULTS AND DISCUSSION

Plant height (cm)

It has been observed that the plant height was increased up to 90 DAS, in the time period between 30 to 60 DAS (days after sowing) increase in plant height was rapid. Generally, as compared to 90 DAS the plant height was slightly decreased at harvest. Similar line of work was reported by Kajur *et al*. [9]. Among the different varieties used the highest value of plant height was recorded from variety VL 376 i.e. (47.7cm, 87.9cm, 105.2cm, 104.5cm at 30, 60, 90 DAS and at harvest respectively). The lowest value of plant height was obtained from variety VR 847 i.e. (44.1cm, 81.0 cm, 93.7 cm and 93.5 cm at 30, 60, 90 DAS and at harvest respectively. In finger millet different weed management practices significantly effects the plant height where the highest plant height at all stages of observation (52.0 cm, 95.3 cm, 110.9 cm and 106.6 cm at 30, 60, 90 and at harvest respectively) were obtained by treatment W4 - PE application of pendimethalin @ 1.0 kg a.i ha^{-1}fb POE application of 2, 4-D @ 1.0 kg a.i ha^{-1} at 30 DAS. The increased plant height in W4 treatment might be due to effective control of weeds. The lowest plant height was obtained by weedy check plot (38.0 cm, 73.6 cm, 86.7 cm and 86.2 cm respectively) [10-11].

Crop growth rate (g m^{-2} day)

Among the different varieties used significantly highest crop growth rate was recorded by variety V4 – VL 376 at both 30 – 60 DAS and 60 – 90 DAS i.e. 3.70 g m^{-2} day^{-1} and 10.54 g m^{-2} day^{-1} while the lowest crop growth was recorded by variety V5 – VR 847 at 30 – 60 DAS with 2.88 g m^{-2} day^{-1} and at 60 – 90 DAS lowest crop growth rate was recorded by variety V3 – VL 352 with 9.08 g m^{-2} day^{-1} [12-13]. It is evident from the data that among all weed management practices the significantly highest value of crop growth rate was recorded by treatment W4 – PE application of pendimethalin @ 1 kg a.i ha^{-1}fb POE application of 2, 4–D @ 1 kg a.i ha^{-1} with 3.57 g m^{-2} day^{-1} and 10.38 g $^{-2}$ day^{-1}. While the lowest value of crop growth rate was recorded with W1 – weedy check with 2.9 g m^{-2} day^{-1} and 8.9 g m^{-2} day^{-1} at 30 – 60 DAS and 60 – 90 DAS.

Table 1 Effect of varieties and weed control methods on growth attributes of finger millet

Treatments	Plant height (cm)				Plant population (m^{-2}) and number of tillers m^{-2} at 60 and 90 DAS			Number of green leaves $hill^{-1}$		
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Varieties										
V_1: GPU 66	45.8	89.6	100.4	98.5	30.28	74.29	83.69	6.5	11.8	20.5
V_2: GPU 67	47.1	87.5	102.1	99.6	33.99	83.90	93.22	6.7	12.1	20.3
V_3: VL 352	46.4	82.9	97.5	90.5	30.42	75.93	87.41	6.4	13.4	20.6
V_4: VL 376	47.7	87.9	105.2	104.5	37.55	78.84	94.06	6.8	13.9	21.3
V_5: VR 847	44.1	81.0	93.7	93.5	30.98	73.63	86.58	6.0	13.8	20.1
SEm±	2.17	1.61	2.23	1.68	0.52	1.40	1.45	0.25	0.32	0.46
CD(P=0.05)	6.94	5.26	7.27	5.48	1.71	4.56	4.73	NS	1.24	NS
Weed management practices										
W_1	38.0	73.6	86.7	86.2	28.61	67.16	77.99	4.9	8.5	13.9
W_2	49.0	89.8	103.7	101.4	33.90	79.50	91.61	7.1	14.4	22.7
W_3	45.9	84.5	97.9	94.2	31.21	75.20	85.58	6.1	12.9	20.5
W_4	52.0	95.3	110.9	106.6	36.85	87.42	100.80	7.8	16.2	25.0
SEm±	1.02	0.94	1.29	1.70	0.51	0.84	0.99	0.20	0.39	0.41
CD(P=0.05)	2.95	2.71	3.73	4.90	1.48	2.42	2.87	0.67	1.29	1.37

Relative growth rate (g g^{-1} day^{-1})

Among the different varieties used significantly all the varieties recorded almost same value of relative growth rate at all the growth stages of crop. It is evident from the data that there was significant increase in relative growth rate from 30 – 60 DAS and 60 – 90 DAS. Highest relative growth rate at 30 – 60 DAS was recorded by variety V4 – VL 376 (0.56 g g^{-1} day^{-1}) followed by GPU 66, GPU 67, VL 352, VR 847 (0.5, 0.5, 0.5 g g^{-1} day^{-1}). At 60 – 90 DAS all varieties recorded the same value of relative growth rate (1.0 g g^{-1} day^{-1}) [12-13]. Weed management practices significantly influenced the value of relative growth rate at all stages of crop growth. Higher value of relative growth rate was obtained by treatment W4 - PE application of pendimethalin @ 1 kg a.i ha^{-1}fb POE application of 2,4 – D @ 1 kg a.i ha^{-1} which recorded 0.6 g g^{-1} day^{-1} and 1.0 g g^{-1} day^{-1} at 30 – 60 DAS and 60 – 90 DAS. This might be due to effective control of weeds which was responsible for better utilization of available nutrients, moisture and solar radiation.

Number of green leaves $hill^{-1}$ at 30, 60 and 90 DAS

Different varieties of finger millet did not show any significant effect on finger millet at 30 and 90 DAS (days after sowing). Maximum number of green leaves $hill^{-1}$ was recorded with the variety V4 – VL 376 (6.8 and 21.3 leaves $hill^{-1}$) at 30

and 90 DAS. At 60 DAS there was a significant difference between number of green leaves hill^{-1}. Highest number of green leaves hill^{-1} (13.9 leaves hill^{-1}) was recorded by variety V4 – VL 376. Whereas minimum leaves hill^{-1} at all the growth stages was recorded by the variety V5 – VR 847 (6.0, 11.8, and 20.1) at 30, 60 and 90 DAS. Maximum number of leaves hill^{-1} (7.8, 16.2 and 25.0 leaves hill^{-1}) at 30, 60 and 90 DAS was obtained by treatment W4 – PE application of pendimethalin @ 1 kg a.i ha-1fb POE application of 2,4 – D @ 1 kg a.i ha-1. However minimum number of leaves hill^{-1} (4.9, 8.5 and 13.9 leaves hill^{-1}) was recorded by treatment W1 – weedy check. Kumar *et al.* [14] reported that leaves of finger millet increase up to 90 DAS and decreases at harvest.

Leaf area index

Among the different varieties used higher leaf area index was recorded with the variety V4 – VL 376 (0.9, 2.3, 3.4, 1.7) at 30, 60, 90 DAS and at harvest when compared with other varieties. Leaf area index gradually increased and reached maximum at 90 DAS and decreased at harvest. Variation in the leaf area index were found significant at 30, 60, 90 DAS and at harvest among different varieties. With respect to weed management practices, significantly higher value of leaf area index was obtained with treatment W4 - PE application of pendimethalin @ 1 kg a.i ha^{-1}fb POE application of 2,4 – D @ 1 kg a.i ha^{-1} at all stages of crop with 0.9, 2.4, 3.2, 1.7 at 30, 60, 90 DAS and at harvest. However, lower value of leaf area index was recorded in weedy check. Leaf area index is one of the most important growth parameters which indicates the number of leaves per unit area and it involves indirectly in photosynthesis.

Plant population (m^{-2})

There is significant difference between plant population m^{-2} of different varieties. Higher plant population was observed by variety V4 – VL 376 (37.55 m-2) at 30DAS. With respect to different weed management practices at 30 DAS of finger millet higher plant population m^{-2} (36.85 m^{-2}) at 30 DAS by treatment W4 – PE application of pendimethalin @ 1 kg a.i ha^{-1}fb POE application of 2,4 – D @ 1 kg a.i ha^{-1}. This might be due to application of herbicides and less crop weed competition during the critical period of growth reported by Kisic *et al.* [15].

Number of tillers m^{-2} at 60 and 90 DAS

It is evident from the data that no of tillers m^{-2} increases with increase in the crop age of finger millet. At 60 DAS higher number of tillers m^{-2} was observed in the variety VL 376 (78.84 m^{-2}). At 90 DAS maximum number of tillers m^{-2} was observed in variety V4 – VL 376 (94.06 m^{-2}) which was superior to all other varieties. The highest number of tillers m^{-2} at 60 and 90 DAS of finger millet variety V4 - VL 376 might be due to its genetic potential over other varieties [16-17]. With respect to weed management practices at all the growth stages of finger millet maximum number of tillers m-2 (87.42 m^{-2} and 100.80 m^{-2}) at 60 and 90 DAS was observed with treatment W4 - PE application of pendimethalin @ 1 kg a.i ha^{-1}fb POE application of 2,4 – D @ 1 kg a.i ha^{-1}.

Table 2 Effect of varieties and weed control methods on growth attributes of finger millet

Treatments	Leaf area index				CGR (g m^{-2} day^{-1})		RGR (g g^{-1} day^{-1})		Days to 50% flowering	Days to maturity
	30 DAS	60 DAS	90 DAS	At harvest	30-60 DAS	60-90 DAS	30-60 DAS	60-90 DAS		
Varieties										
V_1: GPU 66	0.7	1.9	2.3	1.4	3.13	9.13	0.49	0.96	72.9	110.1
V_2: GPU 67	0.8	2.3	3.2	1.6	3.45	9.92	0.54	1.02	72.2	102.6
V_3: VL 352	0.8	2.0	3.1	1.5	3.00	9.08	0.48	0.86	71.7	101.0
V_4: VL 376	0.91	2.3	3.4	1.7	3.70	10.54	0.57	1.07	74.8	113.6
V_5: VR 847	0.6	1.6	2.3	1.2	2.88	9.75	0.46	0.99	72.5	107.9
SEm±	0.01	0.08	0.02	0.07	0.04	0.06	0.01	0.00	0.59	1.19
CD(P=0.05)	0.04	0.30	0.07	0.16	0.13	0.21	0.02	0.01	2.29	4.64
Weed management practices										
W_1	0.7	1.9	2.7	1.4	2.95	8.95	0.47	0.95	87.8	112.9
W_2	0.8	2.1	3.0	1.6	3.28	9.89	0.51	0.99	67.6	104.7
W_3	0.8	2.0	2.9	1.5	3.13	9.52	0.49	0.98	70.4	106.3
W_4	0.9	2.4	3.2	1.7	3.57	10.38	0.55	1.06	65.5	104.3
SEm±	0.003	0.01	0.01	0.02	0.02	0.03	0.00	0.00	0.75	0.97
CD(P=0.05)	0.01	0.05	0.04	0.07	0.06	0.09	0.01	0.00	2.50	3.23

Phenological parameters

Days to 50% flowering

It is evident from the data that variation in the different varieties used significantly affected the days to 50 % flowering. Significantly early flowering was recorded with variety V3 - VL 352 (71.7 days) and delayed flowering is observed in variety V4- VL 376 (74.8 days). A range of high variability in days to 50 % flowering is desirable for selecting the genotypes for earliness. Variability in days to 50% flowering has also been reported by Bishit *et al.* [18] from 54.5 days to 90.9 days. It was noticed that among different weed management practices significantly early flowering was recorded by W4 – PE application of pendimethalin @ 1 kg a.i ha^{-1}fb POE application of 2,4 – D @ 1 kg a.i ha^{-1} (65.5 days) and delayed flowering was recorded with W1 – Weedy check (87.8 days) [19-20].

Days to maturity

Early maturity was attained by variety V3 – VL 352 (101.0 days) and late maturity was recorded with variety V4 – VL 376 (113.6 days). Variation in days to maturity might be due to their different genetic constitution. A Difference in days to maturity has also been reported by Ganapathy *et al.* [12] from 95 days to 135 days and Haradari *et al.* [21] from 84 to 128 days. It was noticed that among different weed management practices significantly early maturity was recorded with W4 – PE application of pendimethalin @ 1 kg a.i ha^{-1}fb POE application of 2,4 – D @ 1 kg a.i ha^{-1} (104.3 days) which is statistically at par with W2 – PE application of pendimethalin fb one hoeing at 25 – 30 DAS (104.7 days). Late maturity was recorded with W1 – Weedy check (112.9 days).

Yield attributes

Number of productive tillers m^{-2}

Maximum number of tillers was recorded by variety V4 – VL 376 with 81.60 tillers m^{-2} and low number of tillers was recorded by variety V1 – GPU 66 with 71.32 tillers m-2. There is significant effect on number of productive tillers m^{-2} due to different weed management practices. Maximum number of productive tillers m-2 was recorded from W4 – PE application of pendimethalin @ 1 kg a.i ha^{-1} fb POE application of 2,4, - D @ 1 kg a.i ha^{-1} with 87.46 tillers m-2 while low number of tillers were recorded with W1 – Weedy check with 63.45 tillers m^{-2}. Effect of weed management practices on yield attributes of finger millet was also reported by Ramamoorthy *et al*. [22].

Number of ear heads m^{-2}

Variety V4- VL 376 recorded a highest and significant value of 77.23 ear heads m^{-2} and lower number of ear heads m-2 was recorded from variety V1 – GPU 66 with 67.42 ear heads m^{-2}. Various weed management practices had significant variation in number of ear heads m^{-2}. From the data it is evident that W4 – PE application of pendimethalin @ 1 kg a.i ha^{-1}fb POE application of 2,4 – D @ 1 kg a.i ha^{-1} recorded significantly highest number with 81.87 ear heads m^{-2} while low number of ear heads m^{-2} were recorded by W1 – weedy check with 57.68 ear heads m^{-2} [9].

Table 3 Effect of varieties and weed control methods on yield attributes of finger millet

Treatments	No of productive tillers m^{-2}	No of ear heads m^{-2}	Number of fingers earhead^{-1}	Finger length (cm)	Weight of grains ear head^{-1}	Test weight (gm)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)
Varieties									
V_1: GPU 66	71.32	67.42	6.2	7.2	6.6	2.1	1644.3	4462.1	26.3
V_2: GPU 67	77.50	71.97	6.6	7.1	6.5	2.1	1783.4	4933.2	26.4
V_3: VL 352	73.42	68.69	6.5	7.2	6.8	1.7	1732.6	4638.6	26.7
V_4: VL 376	81.61	77.23	7.9	7.5	6.9	2.2	1789.8	4959.0	27.0
V_5: VR 847	74.25	67.96	6.5	7.1	5.5	1.8	1703.5	4821.5	26.0
SEm±	2.39	1.86	0.14	0.22	0.16	0.11	42.48	52.96	0.49
CD(P=0.05)	7.78	6.08	0.53	0.70	0.51	0.43	138.53	172.70	NS
Weed management practices									
W_1	63.45	57.68	5.1	5.4	4.3	1.4	1034.0	3127.2	24.5
W_2	78.63	74.68	7.0	7.8	7.1	2.7	1343.8	3660.6	27.2
W_3	72.94	68.38	6.3	6.9	6.6	2.4	1220.5	3466.9	26.0
W_4	87.46	81.87	7.4	8.6	7.7	3.2	1619.3	4099.6	28.3
SEm±	1.00	0.96	0.05	0.15	0.11	0.12	17.35	50.64	0.23
CD(P=0.05)	2.88	2.78	0.18	0.43	0.33	0.39	50.12	146.25	0.66

Number of fingers per ear head^{-1}

Among the varieties highest number of fingers earhead^{-1} was recorded from variety V4 – VL 376 with 7.95 fingers ear head^{-1} while less number of fingers ear head^{-1} was noticed in V1 – GPU 66 with 6.20 fingers ear head^{-1}. Among weed management practices W4 – PE application of pendimethalin @ 1 kg a.i ha^{-1} fb POE application of 2,4 – D @ 1 kg a.i ha^{-1} recorded significantly the highest value with 7.4 fingers ear head^{-1} while lowest number of fingers were recorded from W1 – Weedy check with 5.17 fingers ear head^{-1} [23].

Finger length (cm)

The maximum finger length was recorded by variety V4–VL 376 with 7.5 cm while the lowest finger length was recorded by variety V2–GPU 67 with 7.14 cm which is statistically at par with variety V5–VR 847 with 7.10 cm. Variability in finger length of finger millet have also been reported by Ulaganathan *et al.* [24] from 7.00 cm to 12.45 cm and Bishit *et al*. [18] from 3.3 cm to 12.16 cm. Maximum finger length is noticed from treatment W4–PE application of pendimethalin @ 1 kg a.i ha^{-1}fb POE application of 2, 4–D @ 1 kg a.i ha^{-1} with finger length of 8.6 cm while lowest finger length was observed from W1–Weedy check with 5.4 cm [9], [19].

Weight of grains ear head^{-1}

Among the different varieties of finger millet significantly higher weight of grain ear head^{-1} was recorded with the variety V4–VL 376 (6.9 gm) which was statistically at par with the variety V3–VL 352 (6.8 gm). Variation in weight of grains ear head^{-1} was also reported by [12-13]. With respect to weed management practices significantly higher weight of grains ear head^{-1} (7.7 gm) was obtained with the treatment W4–PE application of pendimethalin @ 1 kg a.i ha^{-1} fb POE application of 2,4 – D @ 1 kg a.i ha^{-1}. Whereas, lower weight of grains ear head^{-1} (4.3) was noticed in treatment W1 – weedy check.

Test weight (gm)

A close scrutiny of the data regarding varieties reveals that there was significant effect on varieties highest test weight was recorded by variety V4 – VL 376 with 2.2 g and lower test weight were recorded by variety V3 – VL 352 with 1.7 g. Wide range of variability in 1000 seed weight also noticed by Bishit *et al*. [18] from 1.98 g to 3.30 g in finger millet. Among the weed management practices highest weight is obtained by W4 – PE application of pendimethalin @ 1 kg a.i ha^{-1}fb POE application of 2, 4–D @ 1 kg a.i ha^{-1} which recorded 3.2 gm. While low test weight is recorded by W1 – weedy check with 1.4 gm. Different weed management practices significantly affects the test weight of finger millet was also reported by Kajur *et al*. [13], Gohain *et al*. [11].

Grain yield (kg ha^{-1})

Highest grain yield was recorded in V4 – VL 376 with 1789.8 kg ha^{-1}. While the lowest grain yield was recorded in variety V1 – GPU 66 with 1644.3 kg ha^{-1}. Higher grain yield of finger millet varieties might be due to the effective weed management practices, improved vegetative growth and yield attributing characters such as number of productive tillers, number of fingers ear head^{-1}, total number of grains finger^{-1} and test weight of crop that resulted in higher grain yield [11], [17], [25]. Among different weed management practices highest grain yield was recorded by treatment W4–PE application of pendimethalin @ 1 kg a.i ha^{-1}fb POE application of 2, 4 – D @ 1 kg a.i ha^{-1} with 1943 kg ha^{-1}. While the lowest yield was recorded with W1–Weedy check with 1240.8 kg ha^{-1}.

Straw yield (kg ha^{-1})

Highest straw yield was recorded from variety V4 – VL 376 with 4959.2 kg ha^{-1} which is statistically at par with variety V2 – GPU 67 with 4933.0 kg ha^{-1}. The higher straw yield of finger millet varieties was attributed due to increased total number of tillers and dry matter production [11], [26]. Different weed management practices significantly influenced the straw yield of finger millet. Higher straw yield (4099.6 kg ha^{-1}) was obtained with the treatment W4 - PE application of pendimethalin @ 1 kg a.i ha^{-1}fb POE application of 2, 4 – D @ 1 kg a.i ha^{-1} and lower straw yield (3127.2 kg ha^{-1}) was recorded with W1 – weedy check. Among different weed management practices maximum straw yield was recorded by the interaction of with V4 – VL 376 and treatment W4 - PE application of pendimethalin @ 1 kg a.i ha^{-1}fb POE application of 2,4 – D @ 1 kg a.i ha^{-1} with 5696.0 kg ha^{-1}.

Harvest index (%)

Among the different varieties higher harvest index was recorded by variety V4 – VL 376 with 27.0% and the harvest index of remaining varieties were statistically at par with the values of 26.4%, 26.4%, 26.7%, 26.0% from the varieties GPU 66, GPU 67, VL 352 and VR 847. The results are in conformity with the findings of Aparna and Bhargavi [25], Triveni *et al.* [27]. Different weed management practices significantly affected the harvest index of finger millet. Higher harvest index (28.3%) was noticed with treatment W4 - PE application of pendimethalin @ 1 kg a.i ha^{-1} fb POE application of 2,4 – D @ 1 kg a.i ha^{-1} and lower harvest index (24.5%) was recorded with W1 – weedy check. Bishit *et al.* [18] have also reported the variability in harvest index of finger millet genotypes ranges from 14.2% to 36.05%.

Weed observations

Weed flora

During the course of investigation, the predominant weeds found in the plot were *Amaranthus viridis*, *Ageratum haustorianum*, *Cyperus rotundus*, *Cynodon dactylon*, *Euphorbia hirta*, *Digetaria Sanguinalis*, *Eleusine indica*, *Mimosa pudica*, *Emilia sanchifolia*, *Eclipta alba* and *Spilanthus asmella* [28-29].

Table 4 Effect of varieties and weed control methods on weed density (no m^{-2}), Weed control efficiency (%) and weed index (%) of finger millet

Treatments	Weed density (no m^{-2})			Weed control efficiency (%)		Weed index (%)
	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	
			Varieties			
V_1: GPU 66	5.61 (33.0)	4.84 (31.8)	5.873 (41.4)	49.3	51.6	17.6
V_2: GPU 67	6.30 (38.3)	4.16 (31.0)	5.693 (39.9)	50.5	53.7	21.2
V_3: VL 352	6.11 (40.9)	4.76 (27.6)	5.969 (39.6)	45.6	48.32	20.1
V_4: VL 376	6.17 (38.0)	4.37 (32.3)	5.703 (42.08)	54.1	56.5	19.4
V_5: VR 847	6.36 (41.0)	4.65 (32.0)	5.812 (40.9)	44.2	47.0	16.9
SEm±	0.68	0.84	0.89	0.67	0.73	0.87
CD(P=0.05)	2.66	3.26	3.47	2.59	2.84	3.37
			Weed management practices			
W_1	8.2 (67.8)	10.09 (100.9)	10.6 (111.5)	43.9	47.3	36.0
W_2	5.5 (30.1)	2.63 (6.6)	4.05 (15.6)	54.2	66.9	16.1
W_3	4.9 (24.1)	3.82 (13.7)	4.95 (23.6)	81.7	58.1	24.1
W_4	5.6 (31.0)	1.69 (2.5)	3.63 (12.4)	63.7	84.9	0.0
SEm±	0.69	0.58	0.80	0.40	0.38	0.65
CD(P=0.05)	2.31	1.95	2.67	1.32	1.27	2.16

Weed density (m^{-2}) at 20, 40 and 60 DAS

Weed control treatments showed significant effect on total weed population. At 20 DAS minimum weed population (24.9 m^{-2}) was recorded under PE application of pendimethalin @ 1.0 kg a.i. ha^{-1} fb mulching at 10 – 15 DAS compared to other treatments due to covering of soil completely in between the rows. However, higher weed density was observed in weedy check (67.8 m^{-2}) compared to all other treatments. At 40 DAS PE application of pendimethalin @ 1.0 kg a.i. ha^{-1} fb POE application of 2,4 – D @ 1.0 kg a.i. ha^{-1} registered significantly lower density of weeds (2.5 m-2) which was at par with PE application of pendimethalin @ 1.0 kg a.i. ha^{-1} fb one hoeing at 20 – 25 DAS (3.0 m^{-2}). At 60 DAS pendimethalin @ 1.0 kg a.i. ha^{-1} fb POE application of 2,4 – D @ 1.0 kg a.i. ha^{-1} was significantly superior in controlling total weed density (12.4 m^{-2}) as compared to rest of the weed management practices. Weedy check registered significantly higher weed density (111.5 m^{-2}).

Weed control efficiency (%) at 20, 40 and 60 DAS

Effect of different weed management practices on weed control efficiency was found significant. At 20 DAS highest weed control efficiency (81.7 %) was recorded with treatment W3 - PE application of pendimethalin @ kg a.i ha^{-1}fb mulching at 10 – 15 DAS. This might be due to complete cover of inter rows of crop with mulching material. At 40 and 60 DAS highest WCE (84.9% and 83.4%) was recorded with treatment W4 – PE application of pendimethalin @ 1.0 kg a.i ha^{-1} fb POE application of 2,4 – D @ 1.0 kg a.i ha^{-1}. This might be due to effective control of weeds at 20 and 40 DAS which results in lower weed population and lower weed dry matter accumulation of weeds in these treatments [30-31].

Weed index (%)

Weed index is a measure of yield loss caused due to varying degree of competition compared to the relatively weed free condition throughout the crop period leading to higher productivity. It is one of the important parameters towards appraisal of the superiority or inferiority of different weed management practices. Among the different weed management methods lowest weed index (16.0%) was recorded under treatment W2 – PE application of pendimethalin @ 1.0 kg a.i ha^{-1} fb one hoeing at 30 DAS. Whereas, maximum weed index (36.0%) was registered with W1 – weedy check. Control of weeds during critical periods results in lower weed density which leads to higher WCE, grain yield and straw yield and lower weed index was reported by Kashid *et al.* [30], Gohain *et al.* [11].

CONCLUSION

Overall, it can be concluded that finger millet variety V4 - VL 376 performed better under the weed treatment i.e. PE application of pendimethalin @ 1.0 kg a.i ha^{-1}fb POE application of 2, 4-D @ 1.0 kg a.i ha^{-1} at 30 DAS (days after sowing) with respect to grain yield, straw yield and net returns. Hence this practice can be suggested to farming community to achieve optimum yields and good profits under rainfed conditions of Nagaland.

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