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Effect of weed management methods on growth and yield of finger millet (*Eleusine coracana* (L.) Gaertn) cultivars

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ABSTRACT

A field experiment was carried out during kharif - 2019, at Experimental Farm, Department of Agronomy, School of Agricultural Sciences, Nagaland University, Medziphema to evaluate the effect of different weed management practices on growth and yield of finger millet varieties. The experiment was laid out in split plot design with five main plot treatments (V_1 - GPU 66, V_2 - GPU 67, V_3 - VL 352, V_4 - VL 376 and V_5 - VR 847) and four sub-plot treatments (W_1 - Control, W_2 - Pre-emergence application of Pendimethalin 30 EC @ 1 kg a.i ha^{-1} at 2-3 DAS + one hoeing at 25-30 DAS, W_3 - Pre-emergence application of Pendimethalin 30 EC @ 1 kg a.i ha^{-1} at 2-3 DAS + plastic mulching at 10-15 DAS and W_4 - Pre-emergence application of Pendimethalin 30 EC @ 1 kg a.i ha^{-1} at 2-3 DAS + 2, 4-D 80 WP @ 0.75 kg a.i ha^{-1} at 25-30 DAS) each replicated thrice. Results revealed that among varieties V_4 - VL 376 recorded significantly higher growth parameters, yield parameters, grain yield (1789.82 kg ha^{-1}) and straw yield (4959.00 kg ha^{-1}). Among weed management practices treatment W_4 - Pre-emergence application of Pendimethalin 30 EC @ 1 kg a.i ha^{-1} at 2-3 DAS + 2, 4-D 80 WP @ 0.75 kg a.i ha^{-1} at 25-30 DAS, recorded higher growth, grain yield (1619.30 kg ha^{-1}) and straw yield (4099.62 kg ha^{-1}) with minimum weed density (2.51 and 12.40 m^{-2} at 40 and 60 DAS) and maximum weed control efficiency (84.93 and 83.42% at 40 and 60 DAS). Predominant weed flora found in the experimental plot were Amaranthus viridis, Ageratum haustorianum, Cyperus rotundus, Cynodon dactylon, Euphorbia hirta and Digetaria Sanguinalis. While, the lowest weed index was noticed under the treatment W_2 - Pre-emergence application of Pendimethalin 30 EC @ 1 kg a.i ha^{-1} at 2-3 DAS + one hoeing at 25-30 DAS.

Keywords: finger millet, varieties, growth, yield, weed density, weed index

INTRODUCTION

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 (Seetharam and Gowda, 2007). Ragi belongs to the family graminae 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 (Gull *et al.,* 2014). Finger millet grains contain 2 times more phosphorous, 4 times more minerals and 10 times more calcium than rice and wheat (Stanly and Shanmugam, 2013; Aparna and Rekha, 2023). 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 (AICSMIP, 2014). 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} (Anonymous, 2018). 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} (Anonymous, 2018). Finger millet is mostly grown as rainfed crop under dry land conditions with low natural resources and it can be intercropped with various pulses and oil seeds by which land and other resources can be utilized efficiently as ascribed by (Aravazhi *et al.,* 1997), (Natrajan, 1992) and (Sadashiv and Nemgouda, 2004).

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.* (Swain *et al.,* 2021). 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

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yield of finger millet ranging from 34 to 61 % (Prasad *et al.,* 1991). 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 (Kushwaha *et al.,* 2002). First five weeks after planting is considered as most critical period for CWC in finger millet (Nanjappa, 1980). Intensive application of various weed management practices should be optimized for reduce the cost of finger millet production (Fryer and Peace, 1997). 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. Keeping this in backdrop a field experiment was conducted with varieties and weed management practices for improved performance of finger millet in terms of growth, yield and better weed control in the foot hill conditions of Nagaland.

MATERIALS AND METHODS

The field experiment was carried out at Research farm, Department of Agronomy, School of Agriculture Sciences, Medziphema, Nagaland University during *Kharif*, 2019 from June – October. The experimental site was located at 310 m above mean sea level (msl) with north latitude of 25° 45' 43'' and east longitude of 95° 53' 04''. The experimental site falls under tropical humid climate with average annual rainfall of 2000 - 2500 mm. The soil of the research plot was sandy loam in texture with acidic pH (4.60), high organic carbon (1.06 %), medium in nitrogen (222.80 kg ha^{-1}), phosphorous (19.86 kg ha^{-1}) and potassium (217.26 kg ha^{-1}). The experiment was laid out in split plot design with five main plot treatments (V_1 - GPU 66, V_2 - GPU 67, V_3 - VL 352, V_4 - VL 376 and V_5 - VR 847) and four sub-plot treatments (W_1 - Control, W_2 - Pre-emergence application of Pendimethalin 30 EC @ 1 kg a.i ha^{-1} at 2-3 DAS + one hoeing at 25-30 DAS, W_3 - Pre-emergence application of Pendimethalin 30 EC @ 1 kg a.i ha^{-1} at 2-3 DAS + plastic mulching at 10-15 DAS and W_4 - Pre-emergence application of Pendimethalin 30 EC @ 1 kg a.i ha^{-1} at 2-3 DAS + 2, 4-D 80 WP @ 0.75 kg a.i ha^{-1} at 25-30 DAS) each replicated thrice. The size of each experimental plot was 1.9 m × 2.0 m. Finger millet varieties were collected from All India Coordinated Research Project on Small Millets, ZARS, GKVK (PC Unit), Bangalore. Seeds were sown manually in lines maintaining row spacing of 30 cm, with the seed rate of 10 kg ha^{-1}. Fertilizers were applied as per the recommended dose of 40: 20: 20 N: P_2O_5: K_2O kg ha^{-1} using urea, SSP and MOP. Half of the nitrogen and entire dose of phosphorous and potassium were applied as basal. Remaining amount of nitrogen was applied as top dressing at 30 DAS. Pre-emergence application of Pendimethalin was sprayed at 2 DAS with spray volume of 500 L ha^{-1}, however post emergence application of 2, 4-D was sprayed at 25 DAS with spray volume of 750 L ha^{-1} with the help of knap sack sprayer. Hoeing and plastic mulching was performed with the help of manual labour according to the treatment. The data on growth parameters like plant height, plant population m^{-2} were recorded at harvest. The data on growth parameters like plant height, plant population m^{-2} were recorded at harvest; while leaf area index was recorded at periodically at 30 days interval. Yield parameters like effective tillers m^{-2}, fingers ear $head^{-1}$, finger length (cm) and 1000-grain weight (g) were recorded at harvest. For estimation of grain and straw yield the entire produce from net plot area of 1 m^2 (from demarcated area, excluding border rows) was harvested manually. After threshing grain were sun dried to bring the moisture of grain to 12% and then samples were weighed separately and obtained value was expressed in kg ha^{-1}. Harvest Index was calculated by taking the ratio of economic yield to biological yield. Data on weed density m^{-2} was recorded periodically at 20 days interval using a quadrate (0.5 m × 0.5 m) and then the original values were transformed to log (X + 2) and subjected to statistical analysis. Analysis of variance (ANOVA) method for split plot design was used to analyze the data. The significance of varieties and weed management practices were tested by using mean square error (MSE) as suggested by (Gomez and Gomez, 1984) at 5 % level of probability. The weed control efficiency was computed using the methodology as suggested by Mani *et al.* (1973) and weed index was calculated by following the procedure given by Gill and Vijaykumar (1969), respectively. The formulas used for computing weed control efficiency (WCE) and weed index (WI) were given below.

$$WCE = \frac{WDC - WDT}{WDC} \times 100$$

Where,
WCE = Weed Control Efficiency
WDC = weed dry weight in control plot (g)
WDT = weed dry weight in treated plot (g)

$$WI = \frac{(X - Y)}{X} \times 100$$

Where,
WI = Weed index
X = Yield of the crop from uncontrolled plot (weedy check)
Y = Yield of the crop from treated plot

RESULTS AND DISCUSSION

Growth attributes

From the results it was clearly observed that both varieties and weed management practices had a significant effect with respect to the growth attributes (Table 1). Among the five varieties, significantly maximum plant height (104.50 cm), better plant population m^{-2} (94.06 m^{-2}), higher leaf area index (0.90, 2.36 and 3.42 at 30, 60 and 90 DAS) was recorded with the variety V_4 (VL-376). This variety was statistically at par with the variety V_2 (GPU 66) where it recorded plant height (99.62 cm), plant population m^{-2} (93.22 m^{-2}), leaf area index (0.82, 2.30 and 3.22 at 30, 60 and 90 DAS), respectively. Variation in growth attributes among different varieties might be attributed to inherent genetic difference of the crop (Yadav *et al.,* 2010; Triveni *et al.,* 2017). Ali *et al.* (2013) claimed that as plant reproductive phase depends on vegetative growth, maximum values of growth attributes, increased supply of photosynthetates and leaf area index and higher tiller number might have resulted in enhanced crop growth thereby better yield attributes and yield.

Table 1: Growth of finger millet as influenced by different varieties and weed management practices

Treatments	Plant height (cm)	Plant population m^{-2}	Leaf Area Index		
	At harvest	At harvest	30 DAS	60 DAS	90 DAS
Varieties (V)					
V_1 : GPU 66	98.50	83.69	0.71	1.94	2.30
V_2 : GPU 67	99.62	93.22	0.82	2.30	3.22
V_3 : VL 352	90.51	87.41	0.83	2.06	3.10
V_4 : VL 376	104.50	94.06	0.91	2.36	3.42
V_5 : VR 847	93.53	86.58	0.61	1.62	2.31
SEm±	1.68	1.45	0.01	0.08	0.02
CD(P=0.05)	5.48	4.73	0.04	0.30	0.07
Weed management practices (W)					
W_1 : Control (Weedy check)	86.21	77.99	0.72	1.90	2.72
W_2 : Pendimethalin 30 EC @ 1 kg a.i ha^{-1} + one hoeing	101.40	91.61	0.84	2.14	3.00
W_3 : Pendimethalin 30 EC @ 1 kg a.i ha^{-1} + plastic mulching	94.20	85.58	0.82	2.06	2.96
W_4 : Pendimethalin 30 EC @ 1 kg a.i ha^{-1} + 2, 4-D 80 WP @ 0.75 kg a.i ha^{-1}	106.64	100.80	0.91	2.45	3.24
SEm±	1.70	0.99	0.003	0.01	0.01
CD(P=0.05)	4.90	2.87	0.01	0.05	0.04

As far as the weed management options were concerned, significantly higher plant height (106.64 cm), maximum plant population m^{-2} (100.80 m^{-2}) and leaf area index (0.91, 2.45 and 3.24 at 30, 60 and 90 DAS) was noticed under the treatment W_4 (Pendimethalin 30 EC @ 1 kg a.i ha^{-1} + 2, 4-D 80 WP @ 0.75 kg a.i ha^{-1}) which is being statistically at par with the treatment W_2 (Pendimethalin 30 EC @ 1 kg a.i ha^{-1} + one hoeing) where the recorded plant height (101.40 cm), plant population m^{-2} (91.61 m^{-2}), leaf area index (0.84, 2.14 and 3.00 at 30, 60 and 90 DAS), respectively. Higher growth attributes under W_4 and W_2 might be due to better utilization of resources and better control of weeds. It was also noticed that treatment W_1 (Control) recorded lowest values of all the growth attributes which reflects huge crop weed competition for various resources. Results were in conformity with the findings reported by Linganagouda *et al.* (2019); Pawar *et al.* (2021); Shubhshree *et al.* (2023).

Table 2: Yield attributes and yield of finger millet as affected by various cultivars and weed management practices

Treatments	Effective tillers m^{-2}	Fingers ear $head^{-1}$	Finger length (cm)	1000 - grain weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)
Varieties (V)							
V_1 : GPU 66	71.32	6.20	7.22	2.12	1644.30	4462.13	26.3
V_2 : GPU 67	77.50	6.62	7.14	2.18	1783.44	4933.21	26.4
V_3 : VL 352	73.42	6.56	7.20	1.74	1732.60	4638.64	26.7
V_4 : VL 376	81.61	7.94	7.54	2.20	1789.82	4959.00	27.0
V_5 : VR 847	74.25	6.52	7.11	1.84	1703.54	4821.52	26.0
SEm±	2.39	0.14	0.22	0.11	42.48	52.96	-
CD(P=0.05)	7.78	0.53	0.70	0.43	138.53	172.70	-
Weed management practices (W)							
W_1 : Control (Weedy check)	63.45	5.12	5.46	1.41	1034.00	3127.22	24.5
W_2 : Pendimethalin 30 EC @ 1 kg a.i ha^{-1} + one hoeing	78.63	7.02	7.80	2.74	1343.84	3660.64	27.2
W_3 : Pendimethalin 30 EC @ 1 kg a.i ha^{-1} + plastic mulching	72.94	6.36	6.92	2.48	1220.56	3466.92	26.0
W_4 : Pendimethalin 30 EC @ 1 kg a.i ha^{-1} + 2, 4-D 80 WP @ 0.75 kg a.i ha^{-1}	87.46	7.42	8.67	3.26	1619.30	4099.62	28.3
SEm±	1.00	0.05	0.15	0.12	17.35	50.64	-
CD(P=0.05)	2.88	0.18	0.43	0.39	50.12	146.25	-

Yield attributes and yield

Yield attributes of finger millet viz., effective tillers m^{-2}, fingers ear $head^{-1}$, finger length (cm) and 1000-grain weight (g) were significantly influenced by different varieties (Table 2). Significantly higher number of effective tillers m^{-2} (81.61 m^{-2}), fingers ear $head^{-1}$ (7.94), finger length (7.54 cm), 1000-grain weight (2.20 g), grain yield (1789.82 kg ha^{-1}), straw yield (4959.00 kg ha^{-1}) were noted with the variety V_4 (VL-376) over other varieties. Higher yield attributes and yield with the respective variety might be due to different genetic makeup of the genotypes, different area of adaption that coupled with environmental interaction (Bishit *et al.,* 2015). Studies reported by Aparna and Bharvai (2017); Triveni *et al.* (2017); Gohain and Reddy (2020) concluded that improved vegetative growth and better yield attributing characters resulted in higher grain yield of finger millet. Results are also in conformity with the findings reported by Nigade and More (2013) noticed that higher tiller number and dry matter accumulation is the major reason for obtaining higher straw yield.

Among weed management strategies significantly higher number of effective tillers m^{-2} (87.46 m^{-2}), fingers ear $head^{-1}$ (7.42), finger length (8.67 cm), 1000-grain weight (3.26 g), grain yield (1619.30 kg ha^{-1}), straw yield (4099.62 kg ha^{-1}) were obtained under the treatment W_4 (Pendimethalin 30 EC @ 1 kg a.i ha^{-1} + 2, 4-D 80 WP @ 0.75 kg a.i ha^{-1}) which is being statistically at par with the treatment W_2 (Pendimethalin 30 EC @ 1 kg a.i ha^{-1} + one hoeing). Improved yield attributes is the consequence of rapid and effective weed management, that resulted in minimum crop weed competition along with enhanced growth parameters and yield attributes owing to higher grain and straw yield by effective utilization of sunlight, moisture and nutrients by the crop. Results are in close conformity with the findings reported by Kamble *et al.* (2015); Kumar and Chawla (2019); Pawar *et al.* (2021). It was also noticed that lower yield attributes and yield were observed with the treatment W_1 (Control), which is due to higher weed competition that resulted in reduced growth, yield attributes and yield. Harvest index of finger millet did not varied much with respect to different varieties and weed management practices.

Effect on weeds

During the course of investigation the predominant weeds found in the plot were Amaranthus viridis (Slender amaranth),

Table 3: Effect of varieties and weed control methods on WCE (%) 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	60 DAS	
Varieties (V)							
V_1 : GPU 66	5.61 (33.0)	4.84 (31.8)	5.87 (41.4)	49.32	51.64	50.40	17.60
V_2 : GPU 67	6.30 (38.3)	4.16 (31.0)	5.69 (39.9)	50.54	53.70	52.56	21.21
V_3 : VL 352	6.11 (40.9)	4.76 (27.6)	5.96 (39.6)	45.61	48.32	47.09	20.10
V_4 : VL 376	6.17 (38.0)	4.37 (32.3)	5.70 (42.08)	54.10	56.51	55.67	19.42
V_5 : VR 847	6.36 (41.0)	4.65 (32.0)	5.81 (40.9)	44.26	47.06	46.09	16.90
SEm±	0.68	0.84	0.89	-	-	-	-
CD(P=0.05)	2.66	3.26	3.47	-	-	-	-
Weed management practices (W)							
W_1 : Control (Weedy check)	8.22 (67.81)	10.09 (100.94)	10.61 (111.50)	43.92	47.30	46.13	36.00
W_2 : Pendimethalin 30 EC @ 1 kg a.i ha^{-1} + one hoeing	5.54 (30.10)	2.63 (6.62)	4.05 (15.62)	54.24	66.91	65.53	16.16
W_3 : Pendimethalin 30 EC @ 1 kg a.i ha^{-1} + plastic mulching	4.90 (24.12)	3.82 (13.73)	4.95 (23.61)	81.71	58.10	56.60	24.12
W_4 : Pendimethalin 30 EC @ 1 kg a.i ha^{-1} + 2, 4-D 80 WP @ 0.75 kg a.i ha^{-1}	5.63 (31.00)	1.69 (2.51)	3.63 (12.40)	63.74	84.93	83.42	0.0
SEm±	0.69	0.58	0.80	-	-	-	-
CD(P=0.05)	2.31	1.95	2.67	-	-	-	-

Note: Data within parentheses are original value

Ageratum haustorianum (Goat weed), Cyperus rotundus (Purple nut sedge), Cynodon dactylon (Bermuda grass), Euphorbia hirta (Hairy spunge), Digetaria Sanguinalis (Crab grass), Eleusine indica (Goose grass), Mimosa pudica (Touch-me-not) and Emilia sanchifolia (Tassel flower). Similar weeds in finger millet are also reported by Pradhan *et al.* (2010), Banu *et al.* (2016) and Kajur *et al.* (2018).

Data on weed density is presented in Table 3. Data clearly reflected that among varieties even though there was a significant difference with respect to total weed density, weed control efficiency and weed index but it did not show much difference at all the periodical growth stages. It was also observed that some varieties showed quite higher weed density as compared to others, which could be due to lower plant population there by higher weed density.

As far as weed management practices are concerned, weed density different significantly at all the growth stages. At 20 DAS, minimum weed population (24. 12 m^{-2}) was recorded under W_3 (Pendimethalin 30 EC @ 1 kg a.i ha^{-1} + plastic mulching), which might be due to effective control of weeds during initial stages. However, at 40 and 60 DAS lower weed density (2.51 and 12.40 m^{-2} at 40 and 60 DAS) was noticed under the treatment W_4 (Pendimethalin 30 EC @ 1 kg a.i ha^{-1} + 2, 4-D 80 WP @ 0.75 kg a.i ha^{-1}), respectively. Minimum weed population at 20 DAS was recorded with the treatment where the inter rows are covered with plastic sheet, this might be the reason for low weed density during the initial period. However, at 40 and 60 DAS minimum weed density was observed under chemical weed control treatments which is attributed to effective weed control at critical crop weed competition period. Results are in conformity with the findings reported by Kujur *et al.* (2018); Yathisha *et al.* (2020). Significantly higher weed density was noticed under control treatment due to increased number of weed seeds from the earlier season during period and complete avoidance of weed control measures under specific treatment resulted in higher weed density (Dhanapal *et al.,* 2015).

Weed management practices significantly influenced weed control efficiency and weed index (Table 3). Among weed management practices maximum weed control efficiency at 20 DAS (81.71%) was noticed under the treatment W_3 (Pendimethalin 30 EC @ 1 kg a.i ha^{-1} + plastic mulching). In contrast, at 40 and 60 DAS maximum weed control efficiency (84.93 and 83.42% at 40 and 60 DAS) was observed with the treatment W_4 (Pendimethalin 30 EC @ 1 kg a.i ha^{-1} + 2, 4-D 80 WP @ 0.75 kg a.i ha^{-1}), respectively. Higher weed control efficiency under the respective treatment might be attributed to minimum total weed dry weight due to effective control of weeds by plastic mulching and combination of herbicides. Results are in conformity with the findings reported by Siddarooda (2016); Nagarjun (2018) who noticed maximum weed control efficiency with lower weed competition.

Among weed management methods lowest weed index (16.0 %) was recorded under treatment W_2 (Pre-emergence application of Pendimethalin 30 EC @ 1 kg a.i ha^{-1} at 2-3 DAS + one hoeing at 25-30 DAS) 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.* (2015). However, maximum weed index (36.0 %) was registered with treatment W_1 (Control), respectively.

CONCLUSION

It can be concluded from this trial that finger millet variety VL 376 performed better and among weed management practices pre-emergence application of Pendimethalin @ 1.0 kg a.i ha^{-1} at 2-3 DAS + post-emergence application of 2, 4-D @ 1.0 kg a.i ha^{-1} at 25-30 DAS with respect to growth, yield and weed control. Hence this practice can be suggested to farming community to achieve optimum yields and good profits of finger millet under rainfed conditions of Nagaland.

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