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PERFORMANCE OF VARIOUS INTEGRATED WEED MANAGEMENT PRACTICES IN TRANSPLANTED FINGER MILLET [*ELEUSINE CORACANA* (L.) GAERTN.] FOR THE COASTAL REGION OF KARAIKAL, INDIA

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ABSTRACT

A field experiment was conducted at Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal to evaluate the performance of various integrated weed management practices in transplanted Finger millet. The experiment involving ten treatments with different weed control combinations were evaluated in a Randomised Block Design and replicated thrice. Among all treatments, Pendimethalin markedly suppressed the total weed density. Hand weeding twice at 15 and 30 DAT (T_9) and Pendimethalin@750g ha^{-1} at 3 DAT + one hand weeding at 30 DAT (T_2) resulted in lowest dry weight of weeds throughout the crop growth period and also registered the highest WCE. Integrated weed control with pre-emergence application of Pendimethalin @ 750g ha^{-1} at 3 DAT + one hand weeding at 30 DAT (T_2) registered higher values of yield components, which was followed by hand weeding twice at 15 and 30 DAT (T_9). It is concluded that Pendimethalin @ 750g ha^{-1} at 3 DAT + one hand weeding at 30 DAT is the most effective weed management practice for achieving higher grain yield and net returns through effective control of weeds in transplanted finger millet.

Key words : Weeds, Herbicide, Finger millet, Weed control efficiency, Pendimethalin, *Eleusine coracana*.

Introduction

Small millets are drought hardy crops and make an important contribution to the national food basket. Small millets offer enormous advantages such as early maturity, wider adaptability, low input cost and high nutritious value of both grain and fodder. These millets constitute to be a part of subsistence agriculture. They are high in folic acid, minerals, iron, fibre and have higher vitamin levels than rice. Small millets not only have been less researched but also have received negligible developmental support (Rao, 1986). Finger millet or Ragi has the pride of place in having the highest productivity among small millets. It is the main food grain for many people, especially in dry areas of India and Sri Lanka. It is the most important small millet grown in India in an area of 1.03 Million ha with a production of 1.89 Million tonnes and a productivity of 1.48 t ha^{-1} (Bellundagi *et al*., 2016). In Tamilnadu the area of finger millet is 1.14 lakh ha with a production of 3.08 lakh tonnes and a productivity of 2.58t ha^{-1} (DES and MoAFW, 2014-15).

Grain is higher in protein, fat and minerals than rice, corn, or sorghum. Finger millet is also known as Ragi or locally Kezhvaragu, valued as staple food and first important crop among small millets. It contains 9.2 % protein, 1.29% fat, 76.32% carbohydrate, 2.24% minerals and 3.9% ash besides vitamin A and B. The grains are rich in phosphorus, potassium and amino acid. It is also rich source of calcium (410mg/100g grain) for growing

children and aged people (Tomar *et al*., 2011). Finger millet grains are more nutritious and provide eight times more calcium, four times more minerals and two times more phosphorus per unit of grain consumed as compared to rice. Protein content of finger millet is more than that of rice with well-balanced amino acid profile. It is a good source of methionine and lysine and is also rich in important vitamins such as thiamine, riboflavin, folic acid and niacin. It is ideal food as it lowers the incidence of cardio-vascular diseases, duodenal ulcers and diabetes among population consuming millets (MSSRF, 2002). The grain is utilized as human staple food and straw for cattle feed. The production and productivity of finger millet is low because of inefficient irrigation and nutrient management, heavy weed infestation, incidence of blast disease etc. Part of the terrible toil is weeding the fields, part in handling the harvest, and part in processing the grain. Among these, weed infestation is a serious threat to its production. Uncontrolled weed growth during crop period has significantly reduced the grain yield ranging from 34 to 61 per cent (Prasad *et al*., 1991).

The critical period for crop-weed competition is initial five weeks' period from planting (Sundaresh *et al*., 1975 and Nanjappa, 1980). Effective weed management is needed for accomplishment of higher yield. It warrants for timely weeding and Inter cultivation within the critical period. Although, manual weeding is effective, it is time consuming and labour intensive. By the time, it is practiced, the crop would have been sufficiently damaged by weed competition. So, controlling weeds by use of herbicides is receiving attention due to shortage of labour and increased labour wages. There is a considerable dearth of knowledge concerning the feasibility of chemical weed control in Ragi. There is also a demand from farmers for the selective pre or post emergence herbicides, which became cheaper when compared to manual weeding for timely control of weeds in Ragi crop. However, increased consciousness about the chemical pollution of soil and water had widened the scope for an integrated approach to control weeds. Keeping the above context under consideration, various integrated weed management practices have been practiced in transplanted Finger millet to identify the best combination, which will ultimately benefit the farming community.

Materials and Methods

The present investigation was undertaken to know the influence of weeds in combination with various integrated weed management practices on the performance of Finger millet for growth and yield characters at A22 field at Agronomy farms of PAJANCOA&RI, Karaikal during December to April 2017-18. Karaikal is situated at 10° 55'N latitude and 79°49'E longitude with an altitude of four meters above MSL. Location comes under coastal deltaic alluvial plain zone which has a tropical climate with the mean maximum and minimum temperatures of 30.6^{0}C and 21.1^{0}C, respectively. The mean annual total rainfall is 1112mm. The total annual evaporation is 438.5 mm and the annual total bright sun shine hours are 699.2. The mean annual morning and evening relative humidity are 93% and 67% respectively, while the mean annual wind speed is 5 kmph.

The experiment was laid out in a Randomized Block Design with ten treatments *viz*. T_1 (Application of Pendimethalin @ 750g ha^{-1} at 3 DAT), T_2 (T_1 + one hand weeding at 30 DAT), T_3 (T_1 + one weeding by peg type weeder at 30 DAT), T_4 (T_1 + Bispyribac sodium @ 25g ha^{-1} at 25 DAT), T_5 (Application of Bispyribac sodium @ 25g ha^{-1} at 15 DAT), T_6 (T_5 + one hand weeding at 30 DAT), T_7 (T_5 + one weeding by peg type weeder at 30 DAT), T_8 (Weeding twice by peg type weeder at15 and 30 DAT), T_9 (Hand weeding twice at15 and 30 DAT) and T_{10} (Unweeded control) with three replications. The finger millet seeds of the variety TRY-1 were used with all the crop management practices pertaining to finger millet were followed as per crop production guide.

Weed control efficiency

Weed control efficiency (WCE) denotes the magnitude of reduction in weed dry weight due to imposed weed control treatment. It was calculated by using the formula given by Mani *et al*. (1973) and expressed in percentage

$$WCE\ (\%) = \frac{DM_C - DM_T}{DM_C} \times 100$$

Where,

WCE = Weed control efficiency (%)

DM_C = Dry matter of weeds in Unweeded control plot (g m^{-2})

DM_T = Dry matter of weeds in treated plot (g m^{-2})

Weed Index

Competition offered by weeds in terms of per cent yield reduction expressed as weed index was calculated using the formula suggested by Gill and Vijaykumar (1969).

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

Where,

X = Yield from minimum weed competition plot

Y = Yield from treated plot for which WI is to be worked out.

Results and Discussion

Effect of weed control treatments on weeds

Weed dry weight

Hand weeding twice at 15 and 30 DAT (T_9) and Pendimethalin @ 750g ha^{-1} at 3 DAT + one hand weeding at 30 DAT (T_2) resulted in lowest dry weight of weeds The lower weed dry weight in twice hand weeding (T_9) might be due to reduced soil seed bank as well as the poor emergence of weeds after second hand weeding (Table 1, Fig. 1). Hand weeding controlled the emerged weeds and those that emerged later on might have failed to accumulate sufficient dry matter owing to the competition offered by the crop plants. Moreover, the weed seeds under depleted soil seed bank shall have been brought to the upper soil layer by hand weeding, though germinated and emerged later they were in their initial growth stage thus accumulating less dry weight. Effective reduction in weed density by Pendimethalin during initial period and by hand weeding at later periods was the reason for lower dry weight of weeds in treatment T_2. This is in confirmation with the results of Singh *et al*. (2016), Tuti *et al*. (2016) and Haindavi *et al*. (2018).

Weed control efficiency

Among the management practices studied WCE ranged between 47.39% to 92.65% at 60 DAT and at harvest. However, higher WCE was observed in Pendimethalin @ 750g ha^{-1} at 3 DAT + one hand weeding at 30 DAT (T_2) and hand weeding twice at 15 and 30 DAT (T_9) (Table 2, Fig. 2). This is because, pre-emergence application of Pendimethalin prevents emergence of monocot and grassy weeds by inhibiting root and shoot growth, while remaining weeds were controlled by hand weeding. Such results were also supported by Anil *et al*. (2015), Rao *et al*. (2015), Geetha *et al*. (2016) and Haindavi *et al*. (2018). Spraying of herbicides, Pendimethalin @ 750g ha^{-1} at 3 DAT,

Table 1 : Total dry weight of weeds (g m^{-2}) at different growth stages as influenced by weed control treatments in Finger millet.

Treatments	30 DAT	60 DAT	Harvest
T_1 :Application of Pendimethalin @750g ha^{-1} at 3 DAT.	5.5(30.08)	4.8(22.36)	4.0(15.96)
T_2 :T_1 + one hand weeding at 30 DAT.	5.7(32.04)	2.5(5.35)	2.5(6.1)
T_3 :T_1 + one weeding by peg type weeder at 30 DAT.	4.7(22.12)	3.6(13.21)	3.1(9.07)
T_4 :T_1 + Bispyribac sodium @ 25g ha^{-1} at 25 DAT.	5.7(32.15)	3.9(14.83)	3.9(16.14)
T_5 :Application of Bispyribac sodium @ 25g ha^{-1} at 15 DAT.	6.6(43.91)	5.4(29.27)	5.4(29.35)
T_6 :T_5 + one hand weeding at 30 DAT.	6.7(45.64)	3.2(10.12)	2.7(7.13)
T_7 :T_5 + one weeding by peg type weeder at 30 DAT.	7.1(50.26)	4.7(21.5)	4.9(24.65)
T_8 :Weeding twice by peg type weeder at15 & 30 DAT	5.2(30.17)	3.9(15.22)	4.8(25.61)
T_9 :Hand weeding twice at15 & 30 DAT.	4.7(21.61)	2.4(5.5)	2.4(5.55)
T_{10} :Unweeded control.	8.6(74.12)	7.7(59.45)	9.1(83.3)
SEd	**0.87**	**0.64**	**0.90**
CD (p=0.05)	**1.83**	**1.35**	**1.9**

*Figures in parenthesis indicate original values. *Observation were recorded prior to imposing of HW for all treatments.

Table 2 : Weed control efficiency (%) at different growth stages as influenced by weed control treatments in Finger millet.

Treatments	30 DAT	60 DAT	Harvest
T_1 :Application of Pendimethalin @ 750g ha^{-1} at 3 DAT.	61.75	60.35	77.80
T_2 :T_1 + one hand weeding at 30 DAT.	65.59	89.35	92.65
T_3 :T_1 + one weeding by peg type weeder at 30 DAT.	72.96	77.85	88.06
T_4 :T_1 + Bispyribac sodium @ 25g ha^{-1} at 25 DAT.	64.90	72.33	78.74
T_5 :Application of Bispyribac sodium @ 25g ha^{-1} at 15 DAT.	40.32	47.39	61.49
T_6 :T_5 + one hand weeding at 30 DAT.	43.82	80.49	91.43
T_7 :T_5 + one weeding by peg type weeder at 30 DAT.	37.64	58.43	70.69
T_8 :Weeding twice by peg type weeder at15 & 30 DAT	55.92	75.65	71.30
T_9 :Hand weeding twice at15 & 30 DAT.	69.74	88.86	92.46
T_{10} :Unweeded control.	—	—	—

#(Data statistically not analyzed). *Observations were recorded prior to imposing of HW for all treatments.

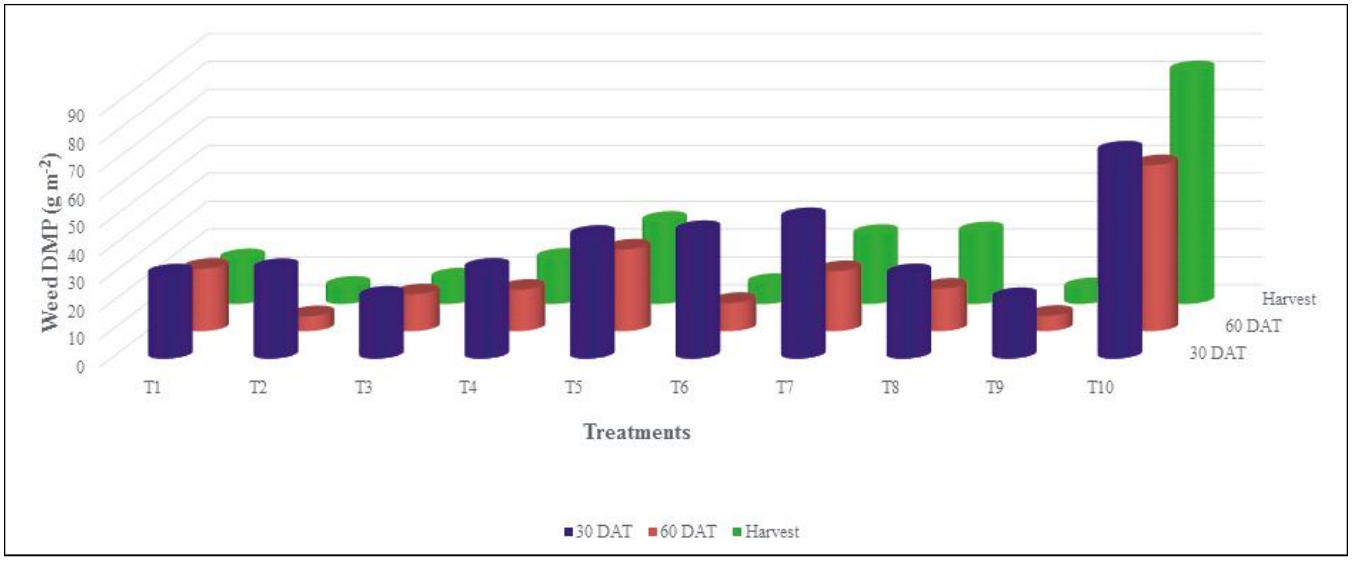

Fig. 1 : Total dry weight of weeds (g m^{-2}) at different growth stages as influenced by weed control treatments in Finger millet. $\mathbf{T_1}$- Pendimethalin @ 750g ha^{-1} at 3 DAT; $\mathbf{T_2}$- T_1 + one HW at 30 DAT; $\mathbf{T_3}$- T_1 + one weeding by peg type weeder at 30 DAT; $\mathbf{T_4}$- T_1 + Bispyribac sodium @ 25g ha^{-1} at 25 DAT; $\mathbf{T_5}$- Bispyribac sodium @ 25g ha^{-1} at 15 DAT; $\mathbf{T_6}$- T_5 + one HW at 30 DAT; $\mathbf{T_7}$- T_5 + one weeding by peg type weeder at 30 DAT; $\mathbf{T_8}$- Peg weeding twice at 15 and 30 DAT; $\mathbf{T_9}$- HW twice at 15 and 30 DAT; $\mathbf{T_{10}}$- Unweeded control.

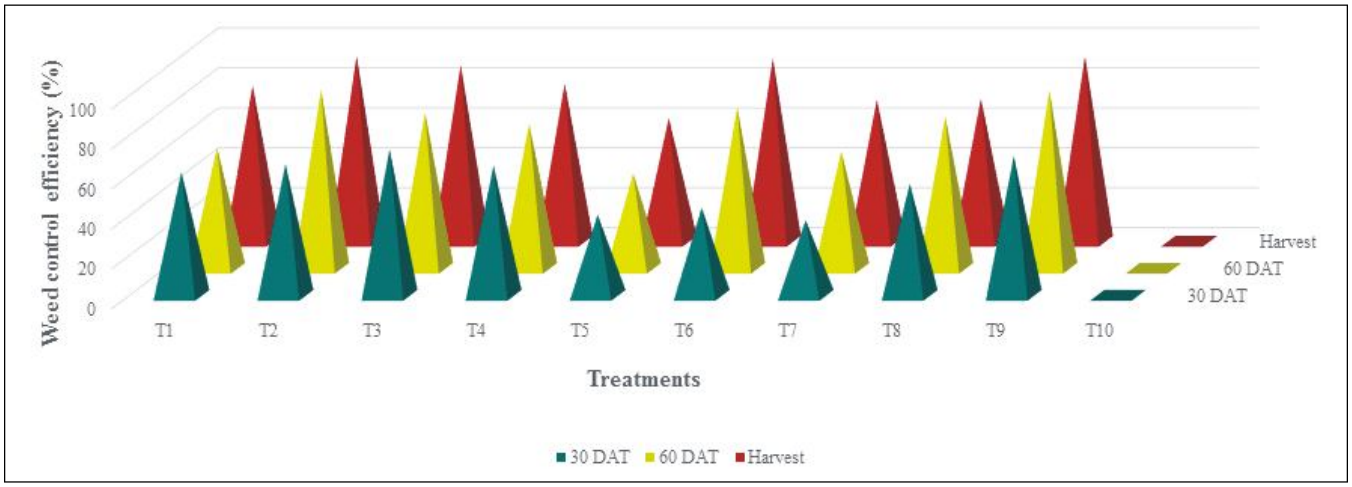

Fig. 2 : Weed control efficiency (%) at different growth stages as influenced by weed control treatments in Finger millet. $\mathbf{T_1}$- Pendimethalin @ 750g ha^{-1} at 3 DAT; $\mathbf{T_2}$- T_1 + one HW at 30 DAT; $\mathbf{T_3}$- T_1 + one weeding by peg type weeder at 30 DAT; $\mathbf{T_4}$- T_1 + Bispyribac sodium @ 25g ha^{-1} at 25 DAT; $\mathbf{T_5}$- Bispyribac sodium @ 25g ha^{-1} at 15 DAT; $\mathbf{T_6}$- T_5 + one HW at 30 DAT; $\mathbf{T_7}$- T_5 + one weeding by peg type weeder at 30 DAT; $\mathbf{T_8}$- Peg weeding twice at 15 and 30 DAT; $\mathbf{T_9}$- HW twice at 15 and 30 DAT; $\mathbf{T_{10}}$- Unweeded control.

Bispyribacsodium @ 25g ha^{-1} as early post emergence application and Bispyribacsodium 25 g ha^{-1} as post-emergence application showed slight to moderate crop toxicity. However, at later stages plant recovered from the effect. The excellent control of weeds was noticed with T_2, T_6, followed by T_4. These results were comparable with T_9. The highest weed control efficiency and lowest weed index was recorded with T_2.

Weed index

Competition offered by weeds in terms of per cent yield reduction was expressed as weed index. It is the ultimate parameter towards appraisal of superiority or inferiority of weed control treatments. In the present study, unweeded control recorded the largest yield reduction, which was reflected by maximum weed index (Table 3). This is due to poor management of weeds in this plot that enhanced the weed growth and it in turn effected to reduce yield components compared to all other treatments. The results were in confirm with Kumara *et al*. (2007), Vinothini and Arthanari (2017).

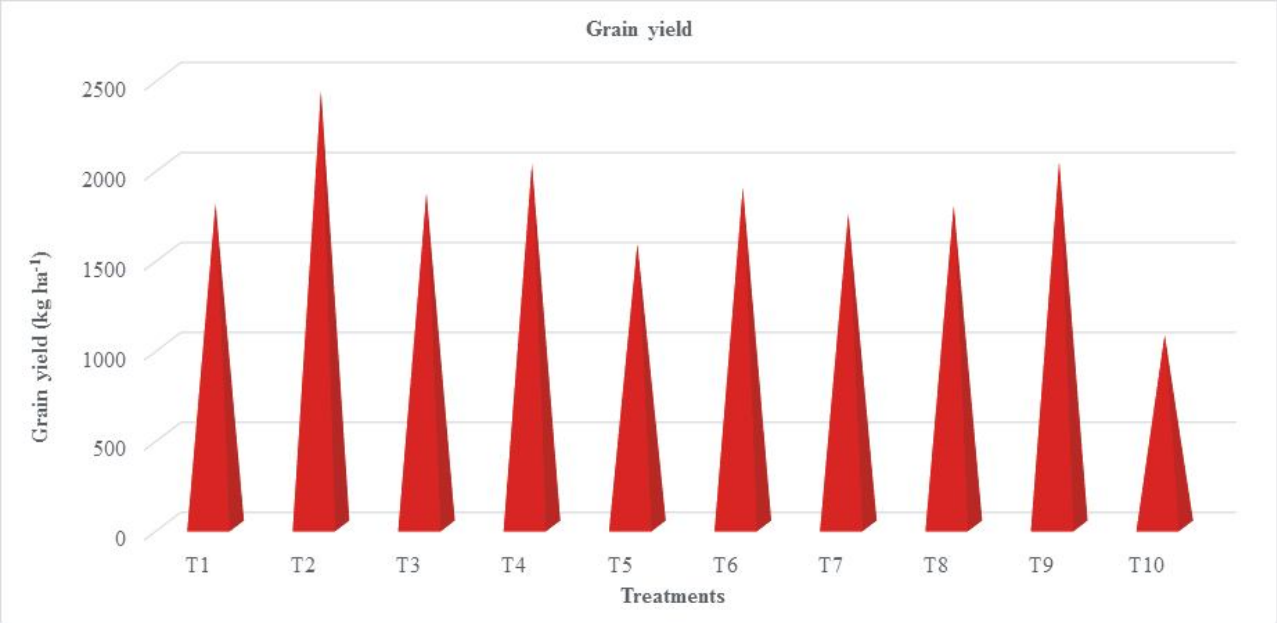

Fig. 3 : Grain yield (kg ha^{-1}) as influenced by weed control treatments in Finger millet. **T_1**- Pendimethalin @ 750g ha^{-1} at 3 DAT; **T_2**- T_1 + one HW at 30 DAT; **T_3**- T_1 + one weeding by peg type weeder at 30 DAT; **T_4**- T_1 + Bispyribac sodium @ 25g ha^{-1} at 25 DAT; **T_5**- Bispyribac sodium @ 25g ha^{-1} at 15 DAT; **T_6**- T_5 + one HW at 30 DAT; **T_7**- T_5 + one weeding by peg type weeder at 30 DAT; **T_8**- Peg weeding twice at 15 and 30 DAT; **T_9**- HW twice at 15 and 30 DAT; **T_{10}**- Unweeded control.

Table 3 : Yield contributing characters, yield and WI as influenced by weed control treatments in Finger millet.

Treatments	Productive tillers per hill (No. hill^{-1})	No. of ear heads m^{-2}	No. of fingers ear^{-1}	No. of grains ear^{-1}	Test weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Weed Index
T_1 :Application of Pendimethalin @750g ha^{-1} at 3 DAT.	4	103.0	6	1284.8	2.77	1791.4	5244.4	23.00
T_2 :T_1 + one hand weeding at 30 DAT.	5	127.0	7	1462.7	3.31	2416.5	6176.2	0.00
T_3 :T_1 + One weeding by peg type weeder at 30 DAT.	4	112.0	6	1364.7	2.77	1847.3	5563.5	22.82
T_4 :T_1 + Bispyribac sodium @ 25g ha^{-1} at 25 DAT.	4	114.0	6	1307.1	2.87	2010.8	5612.7	15.98
T_5 :Application of Bispyribac sodium @ 25g ha^{-1} at 15 DAT.	4	102.0	6	1215.5	2.62	1567.0	4355.6	34.16
T_6 :T_5 + one hand weeding at 30 DAT.	4	116.0	6	1290.7	2.94	1880.0	5507.9	22.71
T_7 :T_5 + one weeding by peg type weeder at 30 DAT.	4	112.7	6	1284.6	2.69	1736.5	5131.7	27.71
T_8 :Weeding twice by peg type weeder at15 & 30 DAT	4	110.7	6	1275.9	2.79	1782.2	5452.4	26.36
T_9 :Hand weeding twice at15 & 30 DAT.	4	123.3	6	1415.9	2.86	2023.2	6293.7	16.08
T_{10} :Unweeded control.	2	88.0	5	987.0	2.44	1061.0	4181.6	55.37
SEd	**0.38**	**7.81**	**0.23**	**110.42**	**0.18**	**211.09**	**496.5**	**-**
CD (p=0.05)	**0.81**	**16.4**	**0.49**	**232.0**	**0.39**	**443.5**	**1043.3**	**-**

Effect of weed control treatments on finger millet

Yield components

The yield components of finger millet *viz*., productive tillers, number of ear heads m^{-2}, number of fingers ear^{-1}, number of grains ear^{-1} and test weight were studied in the present investigation in relation to the weed management practices, which revealed that number of ear heads m^{-2} played a dominant role in deciding the yield of the crop (Table 3). Similar results were also reported by Kumara *et al*. (2007) in finger millet. The values of yield components were found to be superior in Pendimethalin @ 750g ha^{-1} at 3 DAT + one hand weeding at 30 DAT (T_2) followed by hand weeding twice at 15 and 30 DAT (T_9). It was due to reduced crop weed competition for nutrients, light, moisture and space and provided better environment for crop growth and development. Unweeded check treatment recorded poor yield components due to poor control of weeds, which resulted in severe crop weed competition. This is in confirmation with the results of Kumara *et al*. (2007), Patil *et al*. (2014) and Kumar *et al*. (2015). The variation in number of grains ear^{-1}, test weight and harvest index was not much among the treatments in present in investigation due to the reason that these characters were genetic makeup of the plant which could not be influenced much by the weed management practices. Such results were also supported by Ganapathy *et al*. (2011).

Yield

The grain yield of finger millet was significantly higher in Pendimethalin @ 750g ha^{-1} at 3 DAT + one hand weeding at 30 DAT (T_2) followed by hand weeding twice at 15 and 30 DAT (T_9) (Table 3, Fig. 3). The higher grain yield may be owing to significantly lower weed dry weight, higher weed control efficiency which reflected in higher values of plant height, number of effective tillers $plant^{-1}$, ear head m^{-2} and 1,000 grain weight. This was in line with the findings of Pradhan *et al*. (2010), Patil *et al*. (2014) and Kumar *et al*. (2015). Similar to that of grain yield, straw yield was also influenced by different weed management practices. The higher straw yield was recorded in hand weeding twice at 15 and 30 DAT (T_9) followed by Pendimethalin @ 750g ha^{-1} at 3 DAT + one hand weeding at 30 DAT (T_2). This higher yield might be due to better control of weeds at tillering stage of the crop which was also visualised by Pandey *et al*. (2014) and Dhanapal *et al*. (2015). The study also reveals that early competition of the weeds must be avoided to make the crop in utilizing the inputs such as water, nutrients and light to produce superior yield. Similar reports on the importance of early weed control option were made by Naik *et al*. (2001).

Conclusion

To enhance income for finger millet farmers, implementing enhanced crop management techniques, particularly in weed control, can reduce cultivation costs and increase earnings. It can be concluded from the present investigation that application of Pendimethalin @ 750g ha^{-1} at 3 DAT + one hand weeding at 30 DAT had lower weed dry weight, good weed control efficiency, lower weed index during the critical period of crop weed competition and increased grain yield as compared to other weed management practices in transplanted finger millet.

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