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Efficacy and economic feasibility of different weed management practices in pearl millet [*Pennisetum glaucum* (L.) R. Br.]

Surendra Kumar and Rakesh Choudhary

Abstract
The field investigation was conducted at the Instructional farm, College of Agriculture, Jodhpur, during the *Kharif* season of 2019 on pearl millet. Twelve treatments were undertaken and replicated thrice. Amongst weed management treatments, weed-free recorded significantly higher growth attributes as compared to other treatments, but it was equally effective with the application of atrazine 50% WP @ 500 g *a.i.* ha^{-1} (PE) followed by one hand weeding at 30 DAS showed significantly greater efficacy in reducing weeds count, total weed density and weed dry weight, which resulted in higher weed control efficiency at all stages of crop growth as well as fetched the highest gross return (₹75573 ha^{-1}), net return (₹54620 ha^{-1}) but atrazine 50% WP @ 400 g *a.i.* ha^{-1} (PE) *fb* tembotrione 42% SC @ 90 g *a.i.* ha^{-1} at 25 DAS achieved higher profitability level in respect of B: C ratio (3.75) over rest of the treatments.

Keywords: Pearl millet, weed control efficiency, B: C ratio

Introduction
Pearl millet is a C_4 species, it is endowed with very high photo-synthetic efficiency and more ability for dry matter production. It is the world's hardiest warm season crop (Reddy *et al*., 2013) [10] and drought tolerant cereal having the maximum potentiality for grain production in adverse conditions (Acharya *et al.,* 2017) [1]. The nutritional value of pearl millet is high and unique, providing vital micronutrients such as iron (3.0 mg) and zinc (1.7 mg) making it a nutri-cereal. It contains 11.6% protein, 5% fat, 67% carbohydrates, 12.4% moisture 2.7% minerals and 100 g of grains providing 360 calories of energy. It is also rich of vitamin-A, thiamine and riboflavin content and imparts substantial energy to the body with easy digestibility (Pal *et al*., 1996) [7]. Further, the nutritional value of this crop offers much scope for development of value added products in new health conscious consumer segments (Yadav *et al*., 2011) [18] as it contains more fibre so good for diabetic and heart patients.
Weed management is one of the main constraints in achieving the desired yield as the weeds have better competing ability than the main crop and they can survive in adverse conditions too. A heavy infestation of weed in pearl millet may reduce the yield by 40-55% (Banga, 2000 [2]; Sharma and Jain, 2003) [13]. The nutrient depletion by weeds in pearl millet is up to 61.8 kg N, 5.6 kg P and 57.6 kg K per hectare (Ram *et al.,* 2004) [9]. The critical period for weed competition in pearl millet is up to 30-45 days after sowing (Bhan *et al*., 1998) [3]. The predominant methods of weed management are inter-culturing and hand weeding. These are found effective, but they have certain limitations like unavailability of laborers during peak periods under intensive farming and high labor cost herbicides as an effective tool for weed management and replacing conventional methods of weed management.

Materials and Methods
Field experiment was laid out in randomized block design (RBD) with sixteen treatments and replicated thrice. The treatments taken in the investigation were T_1- Tembotrione 42% SC @ 90 g *a.i.* ha^{-1} at 20 DAS, T_2 - Tembotrione 42% SC @ 100 g *a.i.* ha^{-1} at 20 DAS, T_3- Tembotrione 42% SC @ 110 g *a.i.* ha^{-1} at 20 DAS, T_4 - Tembotrione 42% SC @ 120 g *a.i.* ha^{-1} at 20 DAS, T_5- Tembotrione 42% SC @ 90 g *a.i.* ha^{-1} at 25 DAS, T_6 - Tembotrione 42% SC @ 100 g *a.i.* ha^{-1} at 25 DAS, T_7 - Tembotrione 42% SC @ 110 g *a.i.* ha^{-1} at 25 DAS, T_8 - Tembotrione 42% SC @ 120 g *a.i.* ha^{-1} at 25 DAS, T_9 - Atrazine 50% WP @ 400 g *a.i.* ha^{-1} (PE) *fb* Tembotrione 42% SC @ 90 g *a.i.* ha^{-1} at 25 DAS, T_{10} - Atrazine 50% WP @ 400 g *a.i.* ha^{-1} at 20 DAS *fb* one hand weeding at 35 DAS, T_{11} - Atrazine 50% WP @ 500 g *a.i.* ha^{-1} (PE)

fb one hand weeding at 30 DAS, T_{12} - Weedy check, T_{13} - Weed free. The data on weed counts and dry matter were recorded with the help of a quadrate (0.5 m x 0.5 m) at two places per plot and then converted into per square meter. The data on weeds were subjected to square root transformation. In order to evaluate the economic viability of different treatments and to ascertain the most remunerative treatment, economics of different treatment were worked out in terms of net return (₹ ha^{-1}), B:C ratio and profitability (₹day^{-1}).

Result and Discussion

Weed flora

Weed flora of the experimental plot consisted of mixed flora of narrow and broad-leaved weeds *viz*., *Digera arvensis, Tribulus terristris, Corchorus trilocularis Phyllanthus niruri, Amaranthus viridis, Celosia argentea and Portulaca oleracea* among broad-leaved weeds and *Eragrostis minor, Cyperus rotundus, Cynodon dactylon* and *Dactyloctenium aegyptium* were among narrow-leaved weeds. However, broad-leaved weeds were dominated over narrow-leaved weeds.

Effect on weeds

The susceptibility and tolerance of different kinds of weeds to different applications of herbicides depend on their size and shape. There was a progressive increase in the population of individual weed species as well as total weeds up to 40 DAS then decreased onward and recorded the lowest during the investigation at the harvest stage. After 40 DAS, the declining trend in the weed population can be attributed to the completion of the life cycle of some of the weeds that emerged at the very beginning of the crop, combined with the suppression of late weed flushes by luxurious crop growth leading to death (Yadav, 2018) [19].

Under the present analysis, weed density was substantially reduced as opposed to weedy test due to specific weed management practices. At 20 DAS the individual counts of weeds (narrow leaved weeds) were significantly lesser with the application of atrazine 50% WP @ 500 g *a.i.* ha^{-1} (PE) *fb* one hand weeding at 30 DAS whereas, lower broad-leaved weeds were found in atrazine 50% WP @ 400 g *a.i.* ha^{-1} (PE) *fb* tembotrione 42% SC @ 90 g *a.i.* ha^{-1} at 25 DAS. The minimum total weed count (narrow and broad-leaved weeds) was found in treatment with atrazine 50% WP @ 400 g *a.i.* ha^{-1} (PE) *fb* tembotrione 42% SC @ 90 g *a.i.* ha^{-1} at 25 DAS, similar results were reported by Sunitha and Kalyani (2012) [16] in maize and Guggari and mallappa (2017) [6] in pearl millet. At 40 DAS and harvest stage, the lowest density of weeds (narrow leaved) and total count of weeds (narrow and broad-leaved) were recorded under application of atrazine 50% WP @ 400 g *a.i.* ha^{-1} at 20 DAS *fb* one hand weeding at 35 DAS but lower broad leaved weed density was recorded with atrazine 50% WP @ 500 g *a.i.* ha^{-1} (PE) *fb* one hand weeding at 30 DAS. This might be due to effective control of the first flush of weeds by atrazine and subsequent flushes by hand weeding, which was found effective against all kinds of weeds resulting in reduced particular weed density and ultimately reduced total density of weeds. The results of the present investigation are similar to earlier findings of Bhuva and Detroja (2018) [4] and Samota (2019) [12] in pearl millet. The overall weed dry matter was also substantially and dramatically reduced in the same way as in the case of plant count due to different weeding activities relative to weed management. It was commonly found that total weed dry matter increased dramatically before harvest irrespective of treatments. It could be due to favorable micro-climate in the field, such as adequate availability of soil moisture and congenial temperature for higher production of weed bio-mass resulting in greater accumulation of dry matter by weeds. Previously, the gradual increase in dry matter of weed till harvest in pearl millet has also been reported by Das *et al.* (2013) [5].

Among weed management treatments, at 20 DAS, a significantly lower quantity of weeds dry weight of narrow leaved was recorded under atrazine 50% WP @ 500 g *a.i.* ha^{-1} (PE) *fb* one hand weeding at 30 DAS and broad leaved as well as total weeds (narrow and broad leaved weeds) under atrazine 50% WP @ 400 g *a.i.* ha^{-1} (PE) *fb* tembotrione 42% SC @ 90 g *a.i.* ha^{-1} at 25 DAS which were statistically at par with atrazine 50% WP @ 400 g *a.i.* ha^{-1} (PE) *fb* tembotrione 42% SC @ 90 g *a.i.* ha^{-1} at 25 DAS and atrazine 50% WP @ 500 g *a.i.* ha^{-1} (PE) *fb* one hand weeding at 30 DAS. Earlier, similar results were recorded by Sivamurugan *et al*. (2017) [15] in maize crop. At 40 DAS and harvest stage, the minimum amount of narrow leaved weed dry matter was recorded in treatment including atrazine 50% WP @ 400 g *a.i.* ha^{-1} at 20 DAS *fb* one hand weeding at 35 DAS followed by atrazine 50% WP @ 500 g *a.i.* ha^{-1} (PE) *fb* one hand weeding at 30 DAS and both these treatments were statistically at par with each other. While, application of atrazine 50% WP @ 500 g *a.i.* ha^{-1} (PE) *fb* one hand weeding at 30 DAS had lower broad-leaved weed dry matter followed by atrazine 50% WP @ 400 g *a.i.* ha^{-1} at 20 DAS *fb* one hand weeding at 35 DAS. Dry matter of total weeds was minimum in atrazine 50% WP @ 400 g *a.i.* ha^{-1} at 20 DAS *fb* one hand weeding at 35 DAS and also showed significant superiority over rest of the treatments including weedy check. Primule or cotyledon of weeds when in contact with pre-emergence herbicides during germination capable of stopping the emergence of weeds above ground growth, but the latter ontogenic flushes minimized due to post-emergence application of herbicides or hand weeding resulted in lower weed density per unit area and ultimately reduced weed weight. Similarly, these findings were parallel with the findings of Singh *et al.* (2008) [14] and Samanth *et al*. (2015) [11] while working on pearl millet and maize, respectively. The efficacy of herbicides can only be measured by measuring the weed control efficiency of a particular treatment and contrasting it with weedy check in terms of weed control. It was estimated using weed dry matter production data at 20, 40 DAS and at harvest time. The marked differences were obtained in weed control efficiency due to different weed management treatments. Among herbicidal treatments, maximum weed control efficiency was achieved at 20 DAS by the sequential application of pre- and post-emergence herbicides *i.e.*, atrazine 50% WP @ 400 g *a.i.* ha^{-1} (PE) *fb* tembotrione 42% SC @ 90 g *a.i.* ha^{-1} at 25 DAS. The present results were similar to the earlier finding of Sivamurugan *et al*. (2017) [15] in maize. The maximum weed control efficiency at 40 DAS was recorded with atrazine 50% WP @ 400 g *a.i.* ha^{-1} at 20 DAS *fb* one hand weeding at 35 DAS however, application of pre-emergence atrazine 50% WP @ 500 g *a.i.* ha^{-1} (PE) *fb* one hand weeding at 30 DAS showed at harvest stage. The results were in close conformity with the findings of Bhuva and Detroja (2018) [4] and Samota (2019) [12] in pearl millet. This might be due to broad spectrum nature of atrazine which killed weed by inhibiting electron transfer during photosynthesis, thereafter coinciding with tembotrione which acted as an inhibitor of inhibition of the enzyme 4-hydroxyphenylpyruvate dioxygenase (HPPD), resulted in lesser weed counts and ultimately produced lower weed dry weight. The performance of this herbicide and manual hand weeding could be attributed to reasonable suppression of weeds and its selectivity to pearl millet crop as well. Weed index is the indicator of crop yield reduction as

opposed to weed free due to weed competition. Weed index indicates the yield loss caused by weeds under different treatment as opposed to weed free plot. Reduction in losses of grain yield due to successful weed management practices is known to increase crop weed index. On average, weed index was minimum under atrazine 50% WP @ 500 g *a.i.* ha^{-1} (PE) *fb* one hand weeding at 30 DAS followed by atrazine 50% WP @ 400 g *a.i.* ha^{-1} (PE) *fb* tembotrione 42% SC @ 90 g *a.i.* ha^{-1} at 25 DAS. This may have been due to lower weed competition combined with herbicide pre- and post-emergence combined action that could lead to comparatively higher yield attributes and yield of pearl millet. Weedy check registered the highest weed index during the entire crop growth period due to heavy flushes of weeds and thus caused extreme weed competition due to uncontrolled weed growth, resulting in increased yield losses. Such findings are in line with the recommendations of Sunitha and Kalyani (2012) [16] and Triveni *et al*. (2017) [17] in maize

Economic stability is a function of losses and profits. In modern agriculture, the introduction of any technology can only be feasible and reasonable to farmers if it is economically viable. Owing to various procedures, the gross return received by crop yield varies, which eventually affects net return and benefit: cost ratio. Maximum cultivation costs were incurred under weed-free control and were primarily due to labor costs involved in the regular weeding of the hands. While, weedy check showed minimal cost since no additional costs were involved other than common crop cultivation costs.

It is evident from data that the highest gross return (₹75573 ha^{-1} and ₹73270 ha^{-1}) and net return (₹77919 ha^{-1} and ₹74856 ha^{-1}) were recorded under the application of pre-emergence herbicide atrazine 50% WP @ 500 g *a.i.* ha^{-1} (PE) *fb* one hand weeding at 30 DAS followed by combined application of pre and post-emergence herbicides *i.e.* atrazine 50% WP @ 400 g *a.i.* ha^{-1} (PE) *fb* tembotrione 42% SC @ 90 g *a.i.* ha^{-1} at 25 DAS respectively as compared to rest of the treatments including weedy check, but both the treatments stand next to weed free in this respect and showed less monetary differences. The highest net return (₹54620 ha^{-1} and ₹53719 ha^{-1}) and productivity (₹658 day^{-1} and ₹647 day^{-1}) were recorded under the application of pre -emergence herbicide atrazine 50% WP @ 500 g *a.i.* ha^{-1} (PE) *fb* one hand weeding at 30 DAS followed by combined application of pre and post-emergence herbicides *i.e.* atrazine 50% WP @ 400 g *a.i.* ha^{-1} (PE) *fb* tembotrione 42% SC @ 90 g *a.i.* ha^{-1} at 25 DAS, respectively. Under various treatments, economics measurement dependent on the respective market price of grain and stover yield was expressed as monetary gain. Under T_{11} and T_9 treatments, the seed and stover yield was higher, which gained more value and showed higher gross and net monetary advantages. However, Gross return was higher in weed-free treatment, but their higher costs included regular weeding by hand that reduced net returns as compared to atrazine 50% WP @ 500 g *a.i.* ha^{-1} (PE) *fb* one hand weeding at 30 DAS. These results were supported by Patel (2012) [8], Samota (2019) [12] and Bhuva and Detroja (2018) [4] in pearl millet.

Table 1: Weed flora of the experimental plot observed during experimentation

Botanical name	Category of weed	Family	Common name
Digera arvensis	BLW	Amaranthaceae	False amaranth
Tribulus terristris	BLW	Zygophyllaceae	Puncture vine
Corchorus trilocularis	BLW	Tiliaceae	Wild jute
Phyllanthus niruri	BLW	Euphorbiaceae	Gale of the wind
Portulaca oleracea	BLW	Portulacaceae	Common purslane
Amaranthus viridis	BLW	Amaranthaceae	Pigweed
Celosia argentea	BLW	Amaranthaceae	Cock's comb
Dactyloctenium aegyptium	NLW	Poaceae	Crow foot grass
Cyperus rotundus	NLW	Cyperaceae	Common nut sedge
Eragrostis minor	NLW	Poaceae	Small love grass
Cynodon dactylon	NLW	Poaceae	Bermuda grass

Table 2: Density of narrow and broad-leaved weeds at 20, 40 DAS and at harvest

Treatments	Weed density (numbers m^{-2})								
	20 DAS			40 DAS			At harvest		
	NLW	BLW	Total	NLW	BLW	Total	NLW	BLW	Total
T_1	3.68 (13.04*)	7.89 (61.82)	8.68 (74.86)	2.35 (5.01)	3.60 (12.45)	4.24 (17.46)	2.34 (4.99)	3.23 (9.96)	3.93 (14.95)
T_2	3.65 (12.83)	7.81 (60.50)	8.65 (74.33)	2.19 (4.30)	3.54 (12.08)	4.15 (16.71)	2.20 (4.35)	3.22 (9.89)	3.84 (14.24)
T_3	3.58 (12.32)	7.65 (58.35)	8.42 (70.67)	2.21 (4.37)	3.35 (10.75)	3.95 (15.12)	2.16 (4.18)	3.13 (9.30)	3.74 (13.48)
T_4	3.51 (11.88)	8.00 (63.45)	8.70 (75.33)	2.18 (4.25)	3.31 (10.54)	3.91 (14.79)	2.14 (4.08)	3.12 (9.21)	3.71 (13.29)
T_5	3.74 (13.52)	8.04 (64.19)	8.84 (77.71)	2.61 (6.35)	3.87 (14.49)	4.62 (20.84)	2.49 (5.72)	3.71 (13.24)	4.41 (18.96)
T_6	3.74 (13.53)	8.05 (64.40)	8.85 (77.93)	2.54 (5.95)	3.85 (14.44)	4.57 (20.39)	2.46 (5.54)	3.66 (12.88)	4.35 (18.41)
T_7	3.78 (13.77)	8.10 (65.09)	8.91 (78.86)	2.47 (5.62)	3.84 (14.22)	4.51 (19.84)	2.42 (5.38)	3.66 (12.90)	4.32 (18.28)
T_8	3.83 (14.20)	7.89 (57.08)	8.47 (71.28)	2.47 (5.58)	3.09 (9.05)	3.89 (14.63)	2.35 (5.04)	3.65 (12.88)	4.28 (17.92)
T_9	1.90 (3.10)	3.54 (12.12)	3.96 (15.22)	2.00 (3.52)	2.00 (3.53)	2.75 (7.08)	1.84 (2.93)	1.95 (3.49)	2.60 (6.43)
T_{10}	3.71 (13.27)	8.07 (64.66)	8.85 (77.93)	1.59 (2.03)	1.93 (3.24)	2.40 (5.27)	1.70 (2.38)	1.98 (3.42)	2.50 (5.80)
T_{11}	1.84 (2.90)	3.68 (13.23)	4.08 (16.13)	1.69 (2.38)	1.87 (3.01)	2.42 (5.38)	1.78 (2.66)	1.91 (3.18)	2.51 (5.84)
T_{12}	3.82 (14.12)	8.12 (65.45)	8.95 (79.57)	4.21 (17.24)	8.89 (78.47)	9.8 (96.04)	3.74 (13.51)	8.59 (73.28)	9.34 (86.79)
T_{13}	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.7 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
SEm±	0.08	0.18	0.16	0.05	0.16	0.07	0.05	0.11	0.14
C.D. (*P*=0.05)	0.25	0.53	0.48	0.16	0.34	0.22	0.15	0.32	0.41

*Figures in parentheses are the original value; NLW = Narrow-leaved weeds; BLW = Broad-leaved weeds

Table 3: Dry matter of narrow and broad-leaved weeds at 20, 40 DAS and at harvest

Treatments	Dry matter of weeds (g m^{-2})								
	20 DAS			40 DAS			At harvest		
	NLW	BLW	Total	NLW	BLW	Total	NLW	BLW	Total
T_1	1.72 (2.45*)	3.36 (10.79)	3.71 (13.33)	1.86 (2.96)	2.78 (7.23)	3.27 (10.19)	2.08 (3.84)	4.28 (17.80)	4.70 (21.64)
T_2	1.69 (2.38)	3.36 (10.81)	3.70 (13.19)	1.77 (2.64)	2.75 (7.09)	3.20 (9.72)	1.96 (3.34)	4.25 (17.53)	4.60 (20.88)
T_3	1.66 (2.25)	3.36 (10.77)	3.68 (13.02)	1.75 (2.57)	2.62 (6.34)	3.07 (8.91)	1.93 (3.22)	4.15 (16.73)	4.51 (19.94)
T_4	1.68 (2.34)	3.38 (10.93)	3.71 (13.27)	1.73 (2.50)	2.59 (6.19)	3.03 (8.68)	1.92 (3.19)	4.12 (16.50)	4.49 (19.66)
T_5	1.67 (2.28)	3.40 (11.06)	3.72 (13.34)	1.98 (3.45)	2.89 (7.86)	3.44 (11.30)	2.21 (4.42)	4.43 (19.13)	4.90 (23.55)
T_6	1.63 (2.14)	3.42 (11.21)	3.72 (13.35)	1.96 (3.33)	2.85 (7.72)	3.40 (11.05)	2.19 (4.30)	4.32 (18.17)	4.79 (22.48)
T_7	1.70 (2.39)	3.40 (11.05)	3.73 (13.44)	1.91 (3.17)	2.84 (7.56)	3.35 (10.73)	2.16 (4.16)	4.36 (18.55)	4.79 (22.68)
T_8	1.66 (2.24)	3.36 (10.82)	3.68 (13.06)	1.88 (3.05)	2.83 (7.51)	3.32 (10.56)	2.09 (3.86)	4.31 (18.05)	4.73 (21.91)
T_9	1.01(0.53)	1.62 (2.12)	1.77 (2.65)	1.54 (1.87)	1.51 (1.77)	2.03 (3.64)	1.67 (2.30)	2.33 (4.94)	2.78 (7.24)
T_{10}	1.65 (2.21)	3.41 (11.19)	3.73 (13.40)	1.30 (1.20)	1.38 (1.42)	1.76 (2.61)	1.53 (1.83)	2.29 (4.90)	2.68 (6.73)
T_{11}	0.99 (0.47)	1.65 (2.23)	1.79 (2.70)	1.38 (1.41)	1.35 (1.32)	1.80 (2.73)	1.59 (2.03)	2.13 (4.04)	2.56 (6.08)
T_{12}	1.78 (2.69)	3.42 (11.22)	3.79 (13.91)	3.12 (9.24)	8.14 (65.84)	8.69 (75.08)	3.29 (10.32)	10.63 (112.46)	11.10 (122.78)
T_{13}	0.71 (0.00)	0..71 (0..00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
SEm±	0.03	0.05	0.06	0.03	0.06	0.06	0.03	0.12	0.16
C.D. (*P*=0.05)	0.10	0.16	0.19	0.10	0.18	0.18	0.0.10	0.37	0.48

*Figures in parentheses are the original value; NLW = Narrow-leaved weeds; BLW = Broad-leaved weed

Table 4: Weed control efficiency and weed index as influenced by various weed management treatments

Treatments	Weed control efficiency (%)			Weed index (%)
	20 DAS	40 DAS	At harvest	
Tembotrione 42% SC @ 90 g *a.i.* ha^{-1} at 20 DAS	4.82	86.43	82.35	24.09
Tembotrione 42% SC @ 100 g *a.i.* ha^{-1} at 20 DAS	5.18	87.05	82.97	22.16
Tembotrione 42% SC @ 110 g *a.i.* ha^{-1} at 20 DAS	6.40	88.13	83.74	20.60
Tembotrione 42% SC @ 120 g *a.i.* ha^{-1} at 20 DAS	4.60	88.44	83.97	21.40
Tembotrione 42% SC @ 90 g *a.i.* ha^{-1} at 25 DAS	4.10	84.95	80.80	29.00
Tembotrione 42% SC @ 100 g *a.i.* ha^{-1} at 25 DAS	4.02	85.28	81.67	27.65
Tembotrione 42% SC @ 110 g *a.i.* ha^{-1} at 25 DAS	3.38	85.71	81.51	26.52
Tembotrione 42% SC @ 120 g *a.i.* ha^{-1} at 25 DAS	6.11	85.94	82.13	27.57
Atrazine 50% WP @ 400 g *a.i.* ha^{-1} (PE) *fb* Tembotrione 42% SC @ 90 g *a.i.* ha^{-1} at 25 DAS	80.94	95.15	94.10	11.04
Atrazine 50% WP @ 400 g *a.i.* ha^{-1} at 20 DAS *fb* one hand weeding at 35 DAS	3.67	96.52	94.51	18.59
Atrazine 50% WP @ 500 g *a.i.* ha^{-1} (PE) *fb* one hand weeding at 30 DAS	80.59	96.36	95.04	7.93
Weedy check	0.00	0.00	0.00	63.70
Weed free	—	—	—	0.00

Table 5: Cost of cultivation, gross return, net return, B:C ratio and profitability of pearl millet as influenced by various weed management treatments

Treatments	Cost of cultivation (`ha^{-1})	Gross return (`ha^{-1})	Net return (` ha^{-1})	B:C ratio	Profitability (`day^{-1})
T_1	18877	63248	44371	3.35	535
T_2	19196	64652	45456	3.37	548
T_3	19515	65618	46102	3.36	555
T_4	19835	65247	45413	3.29	547
T_5	18877	59844	40967	3.17	494
T_6	19196	60778	41582	3.17	501
T_7	19515	62434	42919	3.20	517
T_8	19835	61297	41462	3.09	500
T_9	19551	73270	53719	3.75	647
T_{10}	21447	68072	46624	3.17	562
T_{11}	20953	75573	54620	3.61	658
T_{12}	15473	36213	20740	2.34	250
T_{13}	24748	81681	56933	3.30	686

*Sale price of pearl millet seed 20 kg^{-1} and stover 7.00 kg^{-1} in 2019-20.

Summary and Conclusion

Among thirteen weed management treatments, atrazine 50% WP @ 400 g *a.i.* ha^{-1} (PE) *fb* tembotrione 42% SC @ 90 g *a.i.* ha^{-1} at 25 DAS showed the lowest weed density (3.96 m^{-2}) and weed dry weight (1.79 g m^{-2}) at 20 DAS. But lower weed density of total weeds (broad and narrow leaved) at 40 DAS and at harvest stage were found in atrazine 50% WP @ 400 g *a.i.* ha^{-1} at 20 DAS *fb* one hand weeding at 35 DAS (2.40 m^{-2} & 2.50 m^{-2}). The lowest dry matter at 40 DAS (1.76 g m^{-2}) and harvest stage (2.56 g m^{-2}) were found in atrazine 50% WP @ 400 g *a.i.* ha^{-1} at 20 DAS *fb* one hand weeding at 35 DAS and atrazine 50% WP @ 500 g *a.i.* ha^{-1} (PE) *fb* one hand weeding at 30 DAS over weedy check, respectively.

The higher weed control efficiency was recorded by application of pre and post-emergence herbicides *i.e.* atrazine 50% WP @ 400 g *a.i.* ha^{-1} (PE) *fb* tembotrione 42% SC @ 90 g *a.i.* ha^{-1} at 25 DAS (80.94%) at 20 DAS. At 40 DAS atrazine 50% WP @ 400 g *a.i.* ha^{-1} at 20 DAS *fb* one hand weeding at 35 DAS was found superior with weed control efficiency of 96.52% but the application of pre-emergence

atrazine 50% WP @ 500 g *a.i.* ha^{-1} (PE) *fb* one hand weeding at 30 DAS showed maximum control efficiency (95.04%) at the harvest stage. The lowest weed index was found with atrazine 50% WP @ 500 g *a.i.* ha^{-1} (PE) *fb* one hand weeding at 30 DAS (7.93%).

An economic evaluation of treatment weed free fetched the highest gross return (₹81681 ha^{-1}) and net return (₹56933 ha^{-1}) followed by atrazine 50% WP @ 500 g *a.i.* ha^{-1} (PE) *fb* one hand weeding at 30 DAS fetched the highest gross return (₹75573 ha^{-1}) and net return (₹54620 ha^{-1}) however, atrazine 50% WP @ 400 g *a.i.* ha^{-1} (PE) *fb* tembotrione 42% SC @ 90 g *a.i.* ha^{-1} at 25 DAS depicted higher profitability level in respect of B: C ratio (3.75).

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