AATCC Review

03 October 2025: Received
12 December 2025: Revised
16 December 2025: Accepted
04 January 2026: Available Online

https://aatcc.peerjournals.net/

Review Article Open Access

Effect of integrated weed management on growth parameters and yield performance of spinach beet (*Beta vulgaris* var. *bengalensis* L.)

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ABSTRACT

The present study was carried out during 2021-2022 at Krishi Vigyan Kendra, Samba, of Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu. The experiment comprised of 12 treatments,viz. Oxyfluorfen @ 150 g/ha (Pre-emergence), Oxyfluorfen @ 150 g/ha (Pre-emergence) + 1 handweeding (40 DAS), Pendimethalin @ 750 g/ha (Pre-emergence), Pendimethalin @ 750 g/ha (Pre-emergence) + 1 hand weeding (40 DAS),Imazethpyr @ 70 g/ha (Pre-emergence), Imazethpyr @ 70 g/ha + 1 handweeding (40DAS), Oxadiargyl @ 100 g/ha (Pre-emergence),Oxadiargyl @ 100 g/ha) + 1 handweeding (40DAS), Two hand weeding at 20and 40 DAS, Mulching with paddy straw, Weedy check, andWeed Free. The experiment was laid out ina randomized block design with three replications. The variety used for this experiment was "Jammu Spinach beet-07". The results revealed that weed weed-free treatment recorded the highest plant height, leaf length, leaf width, leaf area index, and yield(232.77 q/ha), and the weedy check recordedthe minimum yield (113.66 q/ha). Whereas among herbicidal treatments, the Pendimethalin @ 750 g/ha (Pre-emergence) with one hand weeding (40 DAS) outperformed the other treatments.

Keywords: *Spinach beet, Pendimethlin, Growth, Yield.*

INTRODUCTION

Spinach beet (*Beta vulgaris* var. *bengalensis* L.) is a leafy vegetable typically grown in winter. It belongs to the "Chenopodiaceae" family and is native to the Indo-Chinese region [3]. As a leafy green, it is highly nutritious, rich in fiber, which aids in providing essential roughage to the diet, promoting digestive health, and preventing constipation. Additionally, it is an excellent source of vitamin K, magnesium, calcium, folate (which supports heart health), potassium, and vitamin B6 [1]. This makes it an essential part of the human diet. In every 100 grams of its leaves, it contains 86.6% moisture, 3.4 g of protein, 0.8 g of fat, 6.6 g of carbohydrates, 5863 IU of vitamin A, 0.26 mg of thiamine, 0.56 mg of riboflavin, 3.3 mg of niacin, 70 mg of ascorbic acid, 380 mg of calcium, 30 mg of phosphorus and 16 mg of iron [9]. Its high productivity in terms of green leaves and tender stems makes it a valuable crop for vegetable production [8].

The productivity of spinach beet is influenced by various biotic and abiotic factors. Among the biotic factors, weeds are a significant barrier to achieving higher yields. Weeds not only decrease the yield but also lower input efficiency, disrupt agricultural activities, affect quality, and act as alternate hosts for a range of insect pests and diseases [11]. Common weeds found in spinach beet include Rumex dentatus (toothed dock), Poa annua (annual bluegrass), and Cynodondactylon (Bermuda grass), Coronopusdidymus (Lesser swine cress), Cannabis sativus (Cannabis), Anagallis arvensis (Pimperrnel), Argemone mexicana (Mexican prickly poppy), and Silybum marianum (Milk thistle). Integrated weed management is a science-driven decision-making process that combines environmental data, weed biology, and ecology, along with available technologies, to control weeds in the most efficient manner [12]. Since spinach beet is a fast-growing leafy vegetable, the early stages of growth are critical for effective weed control. In this context, pre-emergence herbicides play a crucial role in managing weeds. Based on these considerations, an experiment was designed to evaluate the effectiveness of herbicides and their impact on the growth and yield of the crop.

MATERIALS AND METHODS

The field experiment was carried out during the winter season of 2021-22 at Krishi Vigyan Kendra Samba. Samba is situated at a latitude of 32°-34°N and a longitude of 70°-83°E, with an elevation of 400 meters above sea level in the subtropical region of Jammu. During the summer, the maximum temperature can reach up to 45°C, while in winter, the minimum temperature can drop to 10°C. The soil of the experimental field was sandy loam in texture, neutral in reaction (pH 7.0), and was low in organic carbon and available nitrogen, but medium in phosphorus and potassium levels. The experiment was laid out in a randomized block design with three replications. There were twelve treatment including Oxyfluorfen @ 150 g/ha (pre-emergence), Oxyfluorfen @ 150 g/ha (pre-emergence) + one hand weeding at 40 DAS, Pendimethalin @ 750 g/ha (pre-emergence), Pendimethalin @ 750 g/ha (pre-emergence) + one hand weeding at 40 DAS, Imazethpyr @ 70 g/ha (pre-emergence),

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DOI: https://doi.org/10.21276/AATCCReview.2026.14.01.14

Imazethpyr @ 70 g/ha + one hand weeding at 40 DAS, Oxadiargyl @ 100 g/ha (pre-emergence), Oxadiargyl @ 100 g/ha + one hand weeding at 40 DAS, two hand weedings at 20 and 40 DAS, mulching with paddy straw, a weedy check, and a weed-free treatment. In Spinach Beet, growth and yield parameters were noted at 20, 40, and 60 Days after sowing. The plot size was 3x3 meters. The variety used in this study was "Jammu Spinach Beet – 07". The calculated doses of herbicides were applied as pre-emergence sprays using 600 liters of water per hectare. Hand weeding was carried out according to the schedule using a hand hoe in the respective plots. Fertilizer nutrients, including full doses of P_2O_5 and K_2O, along with ¼ of nitrogen, were applied before sowing. The remaining nitrogen was applied in split doses after each harvest, followed by irrigation. The data collected for growth and yield parameters were statistically analyzed to determine the its theirsignificance.

RESULTS AND DISCUSSION

Growth Parameters

Plant Height

The data presented in the tTable 1 indicated that all weed management practices resulted in a significant increase in plant height, except at 60 DAS, which was influenced by the first cutting at 40 DAS. The maximum plant height was shown in T_{12} (weed weed-free treatment), about 8.13 cm, 20.65 cm, and 19.99 cm, and the minimum was recorded in T_{11} (weedy check), about 5.00 cm, 14.21 cm, and 11.02 cm, respectively, at 20, 40, and 60 DAS respectively. This could be attributed to the improved availability of moisture and nutrients to the crop in the absence of competition from weeds, which likely enhanced the rate of photosynthesis. This, in turn, may have stimulated cell division, multiplication, and elongation, leading to increased growth. Similar findings regarding plant height in coriander were reported by [10] and [7]. T_{10} (mulching with paddy straw) (7.90 cm, 20.37 cm, 18.87 cm) at 20, 40 and 60 days after sowing also found significant over T3 (Pendimethalin @ 750 g/ha as pre-emergence) (7.87 cm), T_4 (Pendimethalin @ 750 g/ha as pre-emergence + one hand weeding at 40 DAS) (7.85 cm) at 20 DAS and T_9 (Two hand weeding at 20 and 40 DAS)(20.37cm) followed by T_4 (Pendimethalin @ 750 g/ha as pre-emergence + one hand weeding at 40 DAS)(18.87 cm) at 60 DAS.

Leaf Length (cm)

The results of the experiment regarding leaf length at 20, 40, and 60 DAS, was shown in Table 1, indicate that all weed management practices significantly influenced leaf length, which continued to increase with the growth of the crop, except at 60 DAS. The maximum leaf length was recorded in T_{12} (weed weed-free treatment), about 7.09 cm, 18.83 cm, and 18.83 cm, and the lowest value was shown in T_{11} (weedy check), about 4.63 cm, 12.61 cm, and 10.47 cm at 20, 40, and 60 DAS, respectively, due to ongoing competition with weeds. This competition limited plant growth by reducing exposure to sunlight and creating competition for nutrients and water [13]. Application of T_{10} (mulching with paddy straw) at 20, 40 and 60 days after sowing also significantly increased the leaf length (6.98 cm, 18.77 cm, 17.93 cm) over T_3 (Pendimethalin @ 750 g/ha as pre-emergence) (6.95 cm), T_4 (Pendimethalin @ 750 g/ha as pre-emergence + one hand weeding at 40 DAS) (6.94 cm) at 20 DAS.and And T_9 (Two hand weeding at 20 and 40 DAS)showed leaf length of 17.80cm,followed by T_4 (Pendimethalin @ 750 g/ha as pre-emergence + one hand weeding at 40 DAS) 17.72 cm at 60 DAS.

3.1.3 Leaf Width (cm)

The data on leaf width presented in Table 1 shows a continuous increase in leaf width with the progression of crop growth, except at 60 DAS. At 20, 40, and 60 DAS, T_{12} (weed-free treatment) recorded the highest leaf width, measuring 4.39, 10.23, and 8.95 cm, respectively. In contrast, the lowest leaf width (2.27, 5.16, and 4.50 cm) was observed in T_{11} (weedy check) during the respective days. Leaf width recorded in T_{10} (mulching with paddy straw) (4.35 cm, 10.19 cm, 8.88 cm) at 20, 40 and 60 days after sowing was significantly higher than T_3 (Pendimethalin @ 750 g/ha as pre-emergence) (4.32 cm), T_4 (Pendimethalin @ 750 g/ha as pre-emergence + one hand weeding at 40 DAS) (4.30 cm) at 20 DAS andT_9 (Two hand weeding at 20 and 40 DAS) leaf width (8.80 cm) succeeded by T_4 (Pendimethalin @ 750 g/ha as pre-emergence + one hand weeding at 40 DAS) (8.72 cm) at 60 DAS.

Number of Leaves/Plant

The data presented in Table 1 showed that weed management practices significantly affected the number of leaves per plant. The highest number of leaves per plant was observed in T_{12} (weed-free treatment) (5.33, 11.30, 13.12) and the lowest number of leaves was observed in T_{11}i.e weedy check 2.67, 7.00, 7.50 at 20, 40 and 60 DAS respectively as it had the highest weed intensity, which likely disturbed the spectral photon distribution within the canopy, thus affecting plant development [6]. However T_{10} (mulching with paddy straw) (5.30, 11.23, 13.00) at 20, 40 and 60 days after sowing also produced significantly higher no. of leaves than T_3 (Pendimethalin @ 750 g/ha as pre-emergence) (5.30), T_4 (Pendimethalin @ 750 g/ha as pre-emergence + one hand weeding at 40 DAS) (5.27) at 20 DAS and T_9 (Two hand weeding at 20 and 40 DAS) (12.93) followed by T_4 (Pendimethalin @ 750 g/ha as pre-emergence + one hand weeding at 40 DAS) (12.87) at 60 DAS.

Leaf Area Index (LAI)

The leaf area index, which indicates the amount of solar energy absorbed by the crop canopy and utilized for the plant's metabolic activities, was significantly influenced by different weed management practices, as shown in the tTable 2. At 20, 40, and 60 DAS, the highest leaf area index of 1.16, 15.23, and 14.79, respectively, was recorded in T12 (weed-free treatment). On the other hand, the lowest leaf area index (0.20, 3.18, and 2.47,)was observed in T11 (weedy check). Crops with no weed competition are better able to capture maximum sunlight, which can improve leaf area, photosynthetic efficiency, and overall growth, as noted by [4]. T_{10} (mulching with paddy straw) at20, 40 and 60 days after sowing showed the leaf area index of1.13, 15.03, 14.48 respectively andalso found significant over T_3 (Pendimethalin @ 750 g/ha as pre-emergence) (1.11), T_4 (Pendimethalin @ 750 g/ha as pre-emergence + one hand weeding at 40 DAS) (1.10) at 20 DAS and T_9 (Two hand weeding at 20 and 40 DAS) showed leaf area index of14.17 followed by T_4 (Pendimethalin @ 750 g/ha as pre-emergence + one hand weeding at 40 DAS) (13.92) at 60 DAS respectively.

Yield (kg/ha)

Yield parameters were significantly affected by different herbicide treatments. The highest yield attributes, such as yield per plot and yield per hectare, were observed in the weed-free

plots (232.77q/ha), which benefitted from effective weed control, leading to better nutrient uptake and improved growth. All weed management practices resulted in a considerable increase in leaf yield compared to T11 (weedy check), i.e.,113.66 q/ha, likely due to the intense competition with weeds. Weeds compete with crops for water, nutrients,and sunlight, which reduces leaf area and photosynthetic efficiency. Among the various herbicidal treatments, the pre-emergence application of Pendimethalin @ 750 g/ha combined with one hand weeding at 40 days was found to be the most effective, with a yield of 220.11 q/ha. Pendimethalin was rapidly absorbed by germinating weeds, inhibiting both cell division and elongation in the root and shoot meristem [5], disrupting microtubule formation [2],causing the weeds to die shortly after germination or emergence. These findings align with [14] study on fenugreek, which reported similar results for yield parameters, while the weedy check had the lowest yield attributes.

Economics

All the weed management practices fetched significantly higher net returns and B: C ratio over weedy cheek (Table 3). Weed Weed-free treatment gave the maximum net returns (2,38,971 ₹/ha), followed by Pendimethalin 1.0 kg/ha+hand weeding at 40 DAS(2,34181 ₹/ha). This might be owing to higher weed control efficiency. Whereas the lowest net returns and B: C ratio were recorded under the weedy check. Among all the treatments maximum benefit cost ratio (2.43) was recorded with pendimethalin @ 750 g/ha as pre-emergence with one hand weeding at 40 days.

Table 1. Effect of integrated weed management on growth parameters at 20, 40, and 60 DAS

Treatment	Plant height (cm)	Leaf length (cm)	Leaf width (cm)	No. Of leaves/plant
	20	40	60	20
T1	6.68	17.31	14.23	5.85
T2	6.72	17.39	16.07	5.88
T3	7.87	19.57	16.50	6.95
T4	7.85	19.43	18.50	6.94
T5	6.58	16.41	13.61	5.76
T6	6.60	16.70	15.43	5.78
T7	6.77	17.43	14.50	5.89
T8	6.80	17.47	16.44	5.92
T9	5.12	19.67	18.68	4.67
T10	7.90	20.37	18.87	6.98
T11	5.00	14.21	11.02	4.63
T12	8.13	20.65	19.99	7.09
SEm±	0.26	0.65	0.60	0.22
CD(5%)	0.78	1.90	1.76	0.65
CV%	6.75	6.24	6.44	6.45

T_1:Oxyfluorfen@150g/ha(Pre-emergence), T_2:Oxyfluorfen @ 150 g/ha (Pre- emergence) + 1 hand weeding (40 DAS), T_3:Pendimethalin @ 750 g/ha (Pre emergence), T_4:Pendimethalin @ 750 g/ha (Pre emergence) +1 hand weeding(40DAS), T_5: Imazethapyr @ 70 g/ha (Pre-emergence), T_6: Imazethapyr @ 70 g/ha (Pre-emergence) + 1 hand weeding (40 DAS), T_7:Oxadiargyl @ 100 g/ha (Pre-emergence), T_8: Oxadiargyl @ 100 g/ha (Pre-emergence) + 1 hand weeding (40 DAS), T_9: Two hand weeding at 20 and 40 DAS, T_{10}: Mulching with paddy straw, T_{11}:Weedy check, T_{12}:Weed free.

Where DAS: Days after sowing

Table 2: Effect of integrated weed management on growth parameter at 20, 40 and 60 DAS and Yield

NO.	Leaf area index (LAI) 20	Leaf area index (LAI) 40	Leaf area index (LAI) 60	Yield (Kg/ha)
T1	0.66	7.97	5.23	181.11
T2	0.67	8.22	7.49	190.50
T3	1.11	14.29	9.90	198.43
T4	1.10	14.12	13.92	220.11
T5	0.64	7.61	4.60	157.55
T6	0.65	7.73	7.04	176.11
T7	0.67	8.56	5.52	186.39
T8	0.68	8.74	7.97	197.57
T9	0.21	14.84	14.48	213.44
T10	1.13	15.03	14.48	221.34
T11	0.20	3.18	2.47	113.66
T12	1.16	15.23	14.79	232.77
SEm±	0.02	0.39	0.32	7.14
CD (5%)	0.07	1.16	0.94	20.94
CV %	6.21	6.57	6.21	6.48

T_1:Oxyfluorfen@150g/ha(Pre-emergence), T_2:Oxyfluorfen @ 150 g/ha (Pre- emergence) + 1 hand weeding (40 DAS), T_3:Pendimethalin @ 750 g/ha (Pre emergence), T_4:Pendimethalin @ 750 g/ha (Pre emergence) +1 hand weeding(40DAS), T_5: Imazethapyr @ 70 g/ha (Pre-emergence), T_6: Imazethapyr @ 70 g/ha (Pre-emergence) + 1 hand weeding (40 DAS), T_7:Oxadiargyl @ 100 g/ha (Pre-emergence), T_8: Oxadiargyl @ 100 g/ha (Pre-emergence) + 1 hand weeding (40 DAS), T_9: Two hand weeding at 20 and 40 DAS, T_{10}: Mulching with paddy straw, T_{11}:Weedy check, T_{12}:Weed free.

Where DAS: Days after sowing

Table 3: Economics of different treatmentsin spinach beet

No.	Cost of Cultivation (₹/ha)	Gross Returns (₹/ha)	Net Returns (₹/ha)	B:C Ratio
T1	90,824	2,71,665	1,80,841	1.99
T2	95,699	2,85,750	1,90,051	1.98
T3	91,109	2,97,645	2,06,536	2.26
T4	95,984	3,30,165	2,34,181	2.43
T5	90,471	2,36,325	1,45,854	1.61
T6	95,346	2,64,165	1,68,819	1.77
T7	91,381	2,79,585	1,88,204	2.05
T8	96,359	2,96,355	1,99,996	2.07
T9	1,02,059	3,20,160	2,18,101	2.13
T10	1,13,059	3,32,010	2,18,096	1.93
T11	89,059	1,70,490	81,431	0.91
T12	1,10,184	3,49,155	2,38,971	2.16

T_1:Oxyfluorfen@150g/ha(Pre-emergence), T_2:Oxyfluorfen @ 150 g/ha (Pre- emergence) + 1 hand weeding (40 DAS), T_3:Pendimethalin @ 750 g/ha (Pre emergence), T_4:Pendimethalin @ 750 g/ha (Pre emergence) +1 hand weeding(40DAS), T_5: Imazethapyr @ 70 g/ha (Pre-emergence), T_6: Imazethapyr @ 70 g/ha (Pre-emergence) + 1 hand weeding (40 DAS), T_7:Oxadiargyl @ 100 g/ha (Pre-emergence), T_8: Oxadiargyl @ 100 g/ha (Pre-emergence) + 1 hand weeding (40 DAS), T_9: Two hand weeding at 20 and 40 DAS, T_{10}: Mulching with paddy straw, T_{11}:Weedy check, T_{12}:Weed free.

4. Summary

Based on the one-year study, it can be concluded that the pre-emergence application of Pendimethalin @ 750 g/ha, combined with one hand weeding at 40 days after sowing, outperformed the other herbicidal treatments in terms of all growth attributes, including plant height, leaf length, leaf width, number of leaves per plant, leaf area index, and yield. Therefore, this treatment could be the most profitable option for effective weed control in spinach beet.

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