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Monu

M.Sc. Student, Department of
Agronomy, School of Agriculture,
Suresh Gyan Vihar University,
Jaipur, Rajasthan, India

Sidra Qidwai

Assistant Professor, Department of
Agronomy, School of Agriculture,
Suresh Gyan Vihar University,
Jaipur, Rajasthan, India

Hansraj Shivran

Assistant Professor, Department of
Agronomy, School of Agriculture,
Suresh Gyan Vihar University,
Jaipur, Rajasthan, India

Manish Yadav

Assistant Professor, Department of
Soil Science, School of Agriculture,
Suresh Gyan Vihar University,
Jaipur, Rajasthan, India

Usha Shukla

Assistant Professor, Department of
Horticulture, School of
Agriculture, Suresh Gyan Vihar
University, Jaipur, Rajasthan,
India

LS Dhayal

Professor, Department of Genetics
& Plant Breeding, School of
Agriculture, Suresh Gyan Vihar
University, Jaipur, Rajasthan,
India

Corresponding Author:

Monu

M.Sc. Student, Department of
Agronomy, School of Agriculture,
Suresh Gyan Vihar University,
Jaipur, Rajasthan, India

Effect of weed management on weed dynamics and yield of fenugreek (*Trigonella foenum-graecum* L.)

Monu, Sidra Qidwai, Hansraj Shivran, Manish Yadav, Usha Shukla and LS
Dhayal

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Abstract

A field experiment entitled “Effect of Weed Management on Weed Dynamics and Yield of Fenugreek (*Trigonella foenum-graecum* L.)” was conducted during the *Rabi* season of 2025–26 at the Agricultural Research Farm, Department of Agronomy, School of Agriculture, Suresh Gyan Vihar University, Jaipur, Rajasthan. The experiment was laid out in a Randomized Block Design (RBD) with three replications and seven weed management treatments, comprising weedy check, weed-free condition, pendimethalin, fluazifop-p-butyl, sodium acifluorfen + clodinafop-propargyl, imazethapyr + imazamox and imazethapyr followed by hand weeding. Weed management practices significantly influenced weed dynamics, growth, yield attributes, nutrient uptake and economics of fenugreek. All weed management treatments substantially reduced weed density and weed dry matter and improved weed control efficiency compared with the weedy check. Among the herbicidal treatments, pendimethalin @ 750 g ha⁻¹ as pre-emergence (T₂) proved most effective, recording the lowest weed density and dry matter, highest weed control efficiency and lowest weed index. It also significantly improved plant height, dry matter accumulation and number of root nodules per plant. The treatment produced superior yield attributes, including pods plant⁻¹, seeds pod⁻¹, pod length and test weight, resulting in higher grain yield (14.25 q ha⁻¹), straw yield (33.33 q ha⁻¹) and biological yield (47.58 q ha⁻¹). Improved weed control also enhanced N, P and K concentration and uptake in grain and straw. Economically, pendimethalin @ 750 g ha⁻¹ recorded the highest gross return (₹88,833 ha⁻¹), net return (₹64,833 ha⁻¹) and benefit ratio (3.70). Thus, pre-emergence application of pendimethalin @ 750 g ha⁻¹ was found to be an effective and economical weed management practice for improving productivity and profitability of fenugreek under the agro-climatic conditions of Jaipur, Rajasthan

Keywords: Weed dynamics, yield, fenugreek, productivity

1. Introduction

Fenugreek (*Trigonella foenum-graecum* L.), locally known as ‘Methi’, is an important seed spice and leafy vegetable belonging to the family Fabaceae. It is mainly cultivated during the *rabi* season under cool and dry climatic conditions. Fenugreek is a multipurpose crop whose leaves and seeds are widely used as vegetables, spices, condiments and for medicinal purposes. Its seeds are nutritionally rich in protein, carbohydrates, minerals, vitamins, gums, mucilage and bioactive compounds such as trigonelline and saponins.

India is one of the major producers of fenugreek, with Rajasthan being the leading producing state. However, the productivity of fenugreek remains below its potential, largely because of severe weed competition during the early stages of crop growth. Weeds compete with fenugreek for moisture, nutrients, light and space and may cause substantial yield losses. The first 25–32 days after sowing are particularly critical for weed management (Malunjkar *et al.*, 2022; Singh *et al.*, 2022) [3, 10].

Manual weeding is labour-intensive and costly; therefore, herbicides provide an effective alternative for timely weed management. Pendimethalin has been reported to provide effective pre-emergence control of several annual weeds in fenugreek (Sharma, 2009; Singh *et al.*, 2014) [9, 10]. However, its effectiveness is mainly restricted to early crop growth. Imazethapyr, a systemic herbicide with pre- and post-emergence activity, offers broader-spectrum weed control and has been widely used in leguminous crops (Dixit and Varshney, 2007) [1]. Hence, evaluating suitable herbicides and their application strategies is essential for effective weed management and

improving the productivity of fenugreek.

2. Materials and Methods

A field experiment was conducted during the *Rabi* season of 2025–26 at the Agricultural Research Farm, Department of Agronomy, School of Agriculture, Suresh Gyan Vihar University, Jaipur, Rajasthan, to assess the “Effect of Weed Management on Weed Dynamics and Yield of Fenugreek (*Trigonella foenum-graecum* L.)”. The experimental site is located in a semi-arid, subtropical climate characterized by extreme temperature variations, with hot and dry summers (maximum temperature up to 45 °C) and cold winters (minimum temperature as low as 2.8 °C). The area receives an average annual rainfall of 500–800 mm, mostly concentrated during the monsoon season. The soil of the experimental field was sandy loam in texture, saline in reaction, with the following initial characteristics: Soil of the experimental field was sandy loam in texture, saline in reaction with a pH value of 7.62, EC (0.48 dSm⁻¹), poor in organic carbon (0.34%), low in available nitrogen (134.25 kg/ha), phosphorus (13.25 kg/ha) and (178.15 kg/ha) but medium in available potassium (320 kg/ha). The chickpea variety ‘RMT-1’ was used in the experiment. The experiment comprised seven treatments with randomized block design with three replications. The collected data were statistically analysed using analysis of variance (ANOVA) appropriate for the RBD design to determine the significance of treatment effects.

3. Results and Discussion

3.1 Weed dynamics

3.1.1 Weed density

Weed management practices significantly reduced weed density at 30, 60 DAS and at harvest compared with the weedy check. The minimum weed density was recorded with T₂: pendimethalin @ 750 g ha⁻¹ (PE), with 6.52, 11.45 and 2.45 weeds m⁻² at 30, 60 DAS and harvest, respectively. It was followed by T₆: imazethapyr @ 70 g ha⁻¹ (PoE) followed by one hand weeding at 40 DAS, which recorded 12.36, 19.48 and 4.85 weeds m⁻², respectively. In contrast, the maximum weed density was observed under T₀: weedy check (32.35, 38.35 and 17.32 weeds m⁻²).

The superior performance of pendimethalin may be attributed to its pre-emergence activity, which effectively suppressed the emergence of annual grasses and broad-leaved weeds during the critical early growth period of fenugreek. Similar results were reported by Mehta *et al.* (2010) [7], who observed effective weed suppression with pendimethalin @ 0.75 kg ha⁻¹ in fenugreek. Dungarwal *et al.* (2002) [2] also reported that pre-emergence pendimethalin was highly effective in controlling weeds in fenugreek and improved crop growth and seed yield.

3.1.2 Weed dry matter

Weed dry matter followed a trend similar to weed density. Pendimethalin @ 750 g ha⁻¹ recorded the lowest weed dry matter of 12.06, 20.04 and 17.24 g m⁻² at 30, 60 DAS and harvest, respectively, whereas the highest weed dry matter was recorded under the weedy check. T₆ was the next best treatment, with 22.87, 33.57 and 21.20 g m⁻², respectively.

Reduced weed biomass under pendimethalin indicates effective suppression of weed emergence and subsequent weed growth. Similar findings were reported by Meena *et al.* (2024) [4], who found that pendimethalin-based treatments significantly reduced weed density and weed dry matter in fenugreek under western Rajasthan conditions. Malunjar *et al.* also reported that effective weed management substantially reduced weed density and dry

matter while increasing crop yield and nutrient uptake in fenugreek.

3.1.3 Weed control efficiency and weed index

Weed control efficiency was significantly influenced by weed management treatments. T₂ recorded the highest weed control efficiency of 54.39, 44.86 and 35.20% at 30, 60 DAS and harvest, respectively, followed by T₆ with 37.78, 28.99 and 28.33%. The lowest efficiency was observed with T₄. Weed index was also lowest under T₂ (10.09%) compared with 37.85% under the weedy check.

The higher weed control efficiency and lower weed index under pendimethalin demonstrate its effectiveness in reducing crop–weed competition. Earlier studies have similarly established the superiority of pendimethalin and integrated herbicide-based approaches for reducing weed interference and improving fenugreek productivity.

3.2 Growth attributes

Plant population was not significantly affected by weed management at 30 DAS or harvest, although numerically higher plant population was observed in weed-free and pendimethalin treatments. In contrast, plant height and dry matter accumulation were significantly influenced. Pendimethalin @ 750 g ha⁻¹ recorded plant height of 16.89, 39.25 and 53.75 cm at 30, 60 DAS and harvest, respectively, compared with 13.35, 28.36 and 38.45 cm under the weedy check. Dry matter accumulation under T₂ was 4.15, 8.45 and 17.88 g plant⁻¹, compared with 2.75, 5.78 and 12.36 g plant⁻¹ in the weedy check.

The improvement in growth under effective weed management may be due to reduced competition for moisture, nutrients, light and growing space, allowing fenugreek plants to utilize available resources more efficiently. Meena *et al.* (2024) [5] similarly reported improved plant height and dry matter accumulation with effective herbicidal weed management in fenugreek.

The number of root nodules also increased significantly. T₂ recorded 32.08 nodules plant⁻¹, compared with only 20.32 nodules plant⁻¹ under the weedy check. T₆ recorded 30.28 nodules plant⁻¹. Reduced weed competition probably promoted better root development and rhizobial activity, thereby favouring nodulation.

3.3 Yield attributes and yield

Weed management significantly improved yield attributes. Pendimethalin @ 750 g ha⁻¹ recorded 34.58 pods plant⁻¹, 11.95 seeds pod⁻¹ and 12.28 cm pod length, compared with 25.32 pods plant⁻¹, 10.32 seeds pod⁻¹ and 11.36 cm pod length under the weedy check. Test weight was also higher with T₂ (12.25 g) than the weedy check (11.25 g).

The improvement in yield attributes can be explained by better vegetative growth, greater nodulation and reduced competition during the critical crop establishment period. Similar results were obtained by Mehta *et al.* (2010) [7], who reported higher pod length, pods plant⁻¹, seeds pod⁻¹ and seed yield with pendimethalin-based weed management in fenugreek. Grain yield was highest under T₂ at 14.25 q ha⁻¹, followed by T₆ (13.65 q ha⁻¹) and T₃ (12.85 q ha⁻¹), whereas the weedy check produced only 9.85 q ha⁻¹. Straw yield was also highest with T₂ (33.33 q ha⁻¹) compared with 23.65 q ha⁻¹ under the weedy check. Biological yield reached 47.58 q ha⁻¹ under T₂ compared with 33.50 q ha⁻¹ under T₀, while harvest index remained statistically non-significant.

These results agree with Meena *et al.* (2025) [6], who reported substantial improvement in fenugreek seed and straw yields through effective herbicide-based weed management under

western Rajasthan conditions. Malunjar *et al.* also demonstrated that effective weed control markedly improved yield attributes and seed yield of fenugreek compared with weedy conditions.

3.4 Nutrient content and uptake

Weed management significantly affected nutrient concentration in grain and straw. Under T₂, nitrogen content reached 3.18% in grain and 0.95% in straw, compared with 2.85 and 0.91%, respectively, under the weedy check. Phosphorus content under T₂ was 0.43% in grain and 0.16% in straw, compared with 0.29 and 0.09% under T₀. Potassium content was also maximum under T₂, with 0.80% in grain and 0.97% in straw, compared with 0.68

and 0.88% under the weedy check.

Higher nutrient concentration under effective weed control indicates reduced competition for available soil nutrients and improved crop nutrient acquisition. Nitrogen uptake by grain and straw under T₂ was 45.32 and 31.66 kg ha⁻¹, respectively, compared with 28.07 and 19.16 kg ha⁻¹ under the weedy check. Similarly, P uptake was 6.13 and 5.33 kg ha⁻¹, while K uptake was 11.40 and 32.33 kg ha⁻¹ in grain and straw, respectively. The higher nutrient uptake was mainly a consequence of improved plant growth and greater biomass and grain production under efficient weed control.

Table 1: Effect of weed management on weed density and dry matter accumulation at 30, 60 DAS and at harvest

Treatments	Weed density (m ²)			Weed dry matter (g/m ²)		
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest
T ₀ -Weedy check	5.73 (32.35)	6.23 (38.35)	4.22 (17.32)	7.77 (59.85)	8.22 (67.11)	6.50 (41.78)
T ₁ -Weed free	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
T ₂ -Pendimethalin @750 g/ha (PE)	2.65 (6.52)	3.46 (11.45)	1.72 (2.45)	3.54 (12.06)	4.53 (20.04)	4.21 (17.24)
T ₃ -Fluazifop -p-butyl @250 g/ha (20 DAS)	4.12 (16.45)	4.83 (22.85)	2.82 (7.44)	5.56 (30.43)	6.36 (39.99)	5.10 (25.48)
T ₄ -Sodium acifluorfen + Clodinafop propargyl @210 g/ha (20 DAS)	4.95 (24.05)	5.55 (30.32)	4.02 (15.65)	6.71 (44.49)	7.32 (53.06)	6.29 (39.02)
T ₅ -Imazethapyr + Imazamox @50 g/ha (PoE)	4.56 (20.25)	5.26 (27.22)	3.60 (12.48)	6.16 (37.46)	6.94 (47.64)	5.86 (33.79)
T ₆ -Imazethapyr 70 g/ha PoE fb one hand weeding (40 DAS)	3.59 (12.36)	4.44 (19.18)	2.31 (4.85)	4.83 (22.87)	5.84 (33.57)	4.66 (21.20)
S.E.m.±	0.23	0.24	0.12	0.23	0.23	0.23
CD%	0.70	0.73	0.38	0.71	0.71	0.71
CV%	10.53	9.47	7.72	0.97	7.05	8.44

Table 2: Effect of weed management on weed control efficiency at 30, 60 DAS and at harvest

Treatments	Weed control efficiency (%)			Weed index (%)
	30 DAS	60 DAS	At harvest	
T ₀ -Weedy check	0.00	0.00	0.00	37.85
T ₁ -Weed free	100	100	100	0.00
T ₂ -Pendimethalin @750 g/ha (PE)	54.39	44.86	35.20	10.09
T ₃ -Fluazifop -p-butyl @250 g/ha (20 DAS)	28.42	22.59	21.58	18.93
T ₄ -Sodium acifluorfen + Clodinafop propargyl @210 g/ha (20 DAS)	13.67	10.97	3.28	29.02
T ₅ -Imazethapyr + Imazamox @50 g/ha (PoE)	20.71	15.59	9.91	24.29
T ₆ -Imazethapyr 70 g/ha PoE fb one hand weeding (40 DAS)	37.78	28.99	28.33	13.88

Table 3: Effect of weed management on growth attributes

Treatments	Plant stand of per m row length		Plant height (cm)			Dry matter accumulation (g/plant)			Number of root nodules per plant at 50 DAS
	30 DAS	At harvest	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest	
T ₀ -Weedy check	8.32	7.44	13.35	28.36	38.45	2.75	5.78	12.36	20.32
T ₁ -Weed free	9.75	8.87	18.02	41.08	57.25	4.58	9.02	18.68	35.63
T ₂ -Pendimethalin @750 g/ha (PE)	9.25	8.37	16.89	39.25	53.75	4.15	8.45	17.88	32.08
T ₃ -Fluazifop -p-butyl @250 g/ha (20 DAS)	8.78	7.9	15.65	35.75	49.52	3.85	7.75	16.25	28.25
T ₄ -Sodium acifluorfen + Clodinafop propargyl @210 g/ha (20 DAS)	8.45	7.57	14.25	32.36	44.25	3.08	6.85	14.32	24.32
T ₅ -Imazethapyr + Imazamox @50 g/ha (PoE)	8.65	7.77	14.85	33.85	47.32	3.65	7.25	15.45	26.15
T ₆ -Imazethapyr 70 g/ha PoE fb one hand weeding (40 DAS)	8.92	8.04	16.15	37.63	51.36	4.00	8.05	17.02	30.28
S.E.m.±	0.36	0.33	0.72	1.49	1.82	0.15	0.32	0.66	1.18
CD%	NS	NS	2.23	4.59	5.61	0.47	0.99	2.03	3.62
CV%	7.04	1.02	8.04	7.28	6.46	6.25	7.35	6.78	7.23

Table 4: Effect of weed management on yield attributes and yield

Treatments	Number of pods per plant	Number of seeds per pod	Pod length (cm)	Test weight (g)	Grain yield (q/ha)	Straw yield (q/ha)	Biological yield (q/ha)	Harvest index (%)
T ₀ -Weedy check	25.32	10.32	11.36	11.25	9.85	23.65	33.50	29.40
T ₁ -Weed free	37.85	12.75	12.45	12.68	15.85	27.45	43.30	36.61
T ₂ -Pendimethalin @750 g/ha (PE)	34.58	11.95	12.28	12.25	14.25	33.33	47.58	29.95
T ₃ -Fluazifop -p-butyl @250 g/ha (20 DAS)	31.39	11.25	11.85	11.80	12.85	30.15	43.00	29.88
T ₄ -Sodium acifluorfen + Clodinafop propargyl @210 g/ha (20 DAS)	28.45	10.85	11.45	11.45	11.25	26.78	38.03	29.58
T ₅ -Imazethapyr + Imazamox @50 g/ha (PoE)	30.25	11.00	11.65	11.68	12.00	28.45	40.45	29.67
T ₆ -Imazethapyr 70 g/ha PoE fb one hand weeding (40 DAS)	32.65	11.65	12.02	11.95	13.65	32.25	45.90	29.74
S.E.m.±	1.23	0.44	0.22	0.28	0.47	1.23	1.59	1.23
CD%	3.80	1.34	0.67	0.85	1.45	3.80	4.91	3.80
CV%	6.78	6.61	3.18	4.04	6.35	7.40	6.60	NS

Table 5: Effect of weed management on nitrogen, phosphorus content in grain and straw

Treatments	N content (%)		P content (%)		K content (%)	
	Grain	Straw	Grain	Straw	Grain	Straw
T ₀ -Weedy check	2.85	0.81	0.29	0.09	0.68	0.88
T ₁ -Weed free	3.24	0.98	0.46	0.18	0.84	0.99
T ₂ -Pendimethalin @750 g/ha (PE)	3.18	0.95	0.43	0.16	0.80	0.97
T ₃ -Fluazifop -p-butyl @250 g/ha (20 DAS)	3.05	0.91	0.37	0.13	0.76	0.93
T ₄ -Sodium acifluorfen + Clodinafop propargyl @210 g/ha (20 DAS)	2.92	0.85	0.32	0.10	0.72	0.90
T ₅ -Imazethapyr + Imazamox @50 g/ha (PoE)	3.00	0.88	0.34	0.12	0.74	0.92
T ₆ -Imazethapyr 70 g/ha PoE fb one hand weeding (40 DAS)	3.12	0.93	0.41	0.15	0.78	0.95
S.E.m.±	0.06	0.02	0.01	0.003	0.01	0.02
CD%	0.18	0.06	0.04	0.010	0.04	0.06
CV%	3.33	3.46	5.71	4.02	3.29	3.43

Table 6: Effect of weed management on nitrogen, phosphorus uptake by grain and straw

Treatments	N uptake (kg/ha)		N uptake (kg/ha)		N uptake (kg/ha)	
	Grain	Straw	Grain	Straw	Grain	Straw
T ₀ -Weedy check	28.07	19.16	2.86	2.13	6.70	20.81
T ₁ -Weed free	51.35	26.90	7.29	4.94	13.31	27.18
T ₂ -Pendimethalin @750 g/ha (PE)	45.32	31.66	6.13	5.33	11.40	32.33
T ₃ -Fluazifop -p-butyl @250 g/ha (20 DAS)	39.19	27.44	4.75	3.92	9.77	28.04
T ₄ -Sodium acifluorfen + Clodinafop propargyl @210 g/ha (20 DAS)	32.85	22.76	3.60	2.68	8.10	24.10
T ₅ -Imazethapyr + Imazamox @50 g/ha (PoE)	36.00	25.04	4.08	3.41	8.88	26.17
T ₆ -Imazethapyr 70 g/ha PoE fb one hand weeding (40 DAS)	42.59	29.99	5.60	4.84	10.65	30.64
S.E.m.±	1.23	0.81	0.10	0.10	0.17	0.56
CD%	3.80	2.49	0.32	0.30	0.52	1.74
CV%	5.43	5.34	3.69	4.35	3.00	3.60

Table 7: Effect of weed management on economics

Treatments	Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B:C ratio
T ₀ -Weedy check	22500	61465	38965	2.73
T ₁ -Weed free	30500	97845	69345	3.43
T ₂ -Pendimethalin @750 g/ha (PE)	24000	88833	64833	3.70
T ₃ -Fluazifop -p-butyl @250 g/ha (20 DAS)	23500	80115	56615	3.41
T ₄ -Sodium acifluorfen + Clodinafop propargyl @210 g/ha (20 DAS)	24500	70178	45678	2.86
T ₅ -Imazethapyr + Imazamox @50 g/ha (PoE)	25500	74845	49345	2.94
T ₆ -Imazethapyr 70 g/ha PoE fb one hand weeding (40 DAS)	26000	85125	59125	3.27

4. Conclusion

The results clearly demonstrate that early and effective suppression of weeds is essential for obtaining higher productivity in fenugreek. Pendimethalin @ 750 g ha⁻¹ as pre-emergence (T₂) consistently performed better than the other herbicidal treatments by reducing weed density and dry matter, increasing weed control efficiency and minimizing weed index. Consequently, crop growth, nodulation, yield attributes, grain and straw yield, nutrient concentration and nutrient uptake were improved. The findings are supported by earlier research demonstrating the effectiveness of pendimethalin and integrated herbicide-based approaches in fenugreek.

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