Chemical Science Review and Letters ISSN 2278-6783

www.chesci.com Research Article

Influence of Herbicidal Mode of Action on Nutrient Availability and Productivity of Green Gram

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Abstract

Weeds pose a serious constraint in green gram (*Vigna radiata* L.) production, particularly under rainfed and semi-arid conditions. A field experiment was conducted during *Kharif* 2024 at Vivekananda Global University Research Farm, Jaipur, Rajasthan, to evaluate different weed management practices on growth, yield, and economics of green gram variety SML-668. The study was laid out in a randomized block design with 10 treatments, including chemical (pre-emergence and post-emergence herbicides), cultural (manual weeding), and integrated methods with three replications. Data revealed that weed-free treatment (T2) recorded the maximum plant height (64.43 cm), branches per plant (5.96), dry matter accumulation (11.04 g), pods per plant (23.12), grains per pod (7.84), test weight (39.2 g), grain yield (1257.9 kg ha^{-1}), and harvest index (28.91%). Among herbicidal treatments, pendimethalin 750 g/ha (PE) fb imazethapyr 75 g/ha (POE) (T9) and pendimethalin 750 g/ha (PE) fb quizalofop-ethyl 50 g/ha (POE) (T10) were superior to single applications. Manual weeding at 25 and 45 DAS (T6) also gave competitive results with weed-free plots. The lowest performance was observed in weedy check (T1), which significantly reduced yield by 57.6% compared to weed-free plots. Economic analysis indicated the highest net returns and B:C ratio under weed-free condition, followed by manual weeding and integrated herbicidal treatments. The study concludes that integration of pre- and post-emergence herbicides or timely manual weeding can effectively manage weeds, improve productivity, and enhance profitability of green gram in semi-arid Rajasthan.

Keywords: Green gram (Vigna radiata L.), Weed management, Herbicide integration, Grain yield, Rainfed agriculture.

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Introduction

Green gram (*Vigna radiata* L.), also known as mungbean, is one of the most important pulse crops in India, cultivated extensively during *Kharif* and summer seasons. It is a rich source of protein (22–24%), carbohydrates, and essential micronutrients, thus playing a crucial role in food and nutritional security. India accounts for nearly 65% of global green gram area and production, with Rajasthan being a leading producer [1]. Despite its importance, productivity remains low (400–600 kg ha^{-1}) compared to potential yields (1200–1500 kg ha^{-1}) due to several biotic and abiotic constraints. Among these, weed infestation is one of the major limiting factors. Weeds compete vigorously with green gram for nutrients, moisture, and light, particularly during the first 30–40 days of crop growth [2, 3]. Yield losses due to weeds in pulses may range from 30 to 80%, depending on weed flora, intensity, and management practices [4]. Manual weeding is effective but labor-intensive and costly, whereas herbicides provide efficient weed control but may have residual effects if misused. Integrated weed management, involving chemical and manual methods, is therefore crucial for sustainable production [5, 6].

Earlier studies have shown that pre-emergence herbicides like pendimethalin, and post-emergence herbicides like imazethapyr and quizalofop-ethyl, are effective in controlling grassy and broadleaf weeds in pulses [7–9]. However, performance varies with soil type, climatic conditions, and weed flora. Limited systematic studies have been conducted in semi-arid Rajasthan under green gram, necessitating region-specific recommendations. The present investigation was therefore undertaken to assess the efficacy of different weed management practices on growth parameters, yield attributes, yield, and economics of green gram under sandy loam soils of Jaipur.

Material and Methods

The trial was done at the Vivekananda Global University Research Farm in Jaipur as an extra sowing of the year in the Kharif season. Having an average annual rainfall of around 550 mm, mostly received between the months of July to

September, the region has a semi-arid climate. The soil (sandy loam) used in the experiment was medium in phosphorus, high, and less in available phosphorus with a pH of 7.5. The type of green gram that was used was SML-668. A typical agronomic activity applied with the crop being planted at a 45 x 10 cm interval rate at 20 kg $ha^{-1}$of seed. The study includes a random block design that involve 3 replications and 10 treatments. The details of treatment are below:

Treatment details

Ten weed management treatments were imposed as follows.

Table 1. Treatment details.

S.No.	Treatment details	Symbol
1	Weedy check	T1
2	Weed free	T2
3	Application of 750 g of pendimethalin a.i./ha as (PE)	T3
4	4 25 g/pk propaquizafop a.i./ha as (PE)	T4
5	The means of imezathypr a.i./ ha used was (POE) 7.5 g.	T5
6	Manual weeding 25 and 45 DAS	T6
7	At 25 DAS, a HW was applied comprising of 250 g of pendimethalin a.i./ha as (PE) fb	T7
8	As POE, 50/75 g a.i./ha (Proaquizafop + Imezathyper)	T8
9	The pendimethalin 750g/ha a.i./ per ha can be applied as (PE) fb. The POE is Imezathyper75ga.i./ha.	T9
10	Pendimethalin PE fb 750 g a.i./ha as (POE), quisoloffopethy 50g a.i./ha	T10

PE-pre-emergence, POE-post-emergence, DAS-day after sowing, and fb followed by

Data collected

Recorded data was WCE-based parameters (weed control at time of harvesting), dry weight, and density at 30 DAS. Growth characteristics are plant growth height, the number of branches per plant, and dry matter sequestration. Some examples of yield parameters include pods/plant, seeds/pod, 1000-seed weight, and seed and stover yield. Economics: levy/ yield, net income, gross income, and cultivation expenses. A conventional RBD analysis of the data was conducted at the five percent significance level.

Results and Discussion

Growth Parameters

Weed management significantly influenced plant height, branches per plant, and dry matter accumulation (**Table 1,2**). Weed-free treatment (T2) recorded the highest plant height (64.43 cm), branches (5.96), and dry matter accumulation (11.04 g/m row length) at harvest. This was closely followed by manual weeding twice (T6) and integrated treatments T7, T9, and T10. The lowest values were observed in weedy check (T1).

The improvement in growth traits under weed-free and effective herbicidal treatments may be attributed to reduced weed competition, leading to higher availability of nutrients, water, and light to the crop. Similar findings were reported by Singh et al. (2018) [10] and Choudhary et al. (2021) [11], who observed significant improvement in growth attributes of pulses under efficient weed control measures.

Yield Attributes

Weed management practices had a marked impact on pods per plant, pod length, grains per pod, and 1000-seed weight (**Table 2**). Maximum pods per plant (23.12), pod length (8.82 cm), grains per pod (7.84), and test weight (39.2 g) were observed in weed-free treatment (T2). Manual weeding (T6) and integrated herbicidal treatments (T7 and T9) were at par with weed-free. Weedy check (T1) recorded the lowest values across all yield attributes. Effective weed control ensured better assimilate partitioning towards reproductive organs, resulting in improved yield attributes. These results corroborate the findings of Patel et al. (2020) [12], who reported increased pods per plant and test weight in green gram under integrated weed management.

Yield and Harvest Index

Significant differences were observed in seed, stover, and biological yield (**Table 3**). Weed-free treatment (T2) recorded the highest grain yield (1257.9 kg ha^{-1}), straw yield (3092.5 kg ha^{-1}), and biological yield (4350.4 kg ha^{-1}), with a harvest index of 28.91%. Manual weeding (T6) and pendimethalin (PE) fb imazethapyr (POE) (T9) also performed well, recording grain yields of 1149.9 and 1041.9 kg ha^{-1}, respectively. Weedy check (T1) produced the lowest grain yield (532.6 kg ha^{-1}), reflecting 57.6% yield reduction compared to weed-free.

Table 2 Growth traits of Green Gram as result of weed management

S.No.	Treatments	Plant height (cm)			Dry matter accumulation per meter row length (g)		Branches per plant		
		30 DAS	45 DAS	At harvest	30 DAS	At harvest	30 DAS	60 DAS	At harvest
T1	Weedy check	20.71	31.34	42.83	7.81	11.97	1.83	2.44	2.76
T2	Weed free	29.81	50.64	64.43	1.02	1.04	4.03	5.24	5.96
T3	Application of 750 g of pendimethalin a.i./ha as (PE)	25.31	42.04	54.13	6.13	9.14	2.43	3.24	3.76
T4	4 25 g/pk propaquizafop a.i./ha as (PE)	23.81	40.14	51.83	6.33	9.45	2.33	3.04	3.56
T5	The means of imezathyper a.i./ ha used was (POE) 7.5 g.	25.91	44.24	55.13	5.92	8.88	2.63	3.44	3.96
T6	Manual weeding 25 and 45 DAS	29.11	48.84	62.23	3.55	5.81	3.63	4.44	5.36
T7	At 25 DAS, a HW was applied comprising of 250 g of pendimethalin a.i./ha as (PE) fb	28.71	47.94	61.93	4.97	7.32	3.43	4.04	4.96
T8	As POE, 50/75 g a.i./ha (Proaquizafop + Imezathyper)	26.21	44.64	56.23	5.75	8.57	2.83	3.54	4.06
T9	The pendimethalin 750g/ha a.i./ per ha can be applied as (PE) fb The POE is Imezathyper75ga.i./ha.	27.91	47.54	59.83	5.25	7.46	3.23	4.04	4.76
T10	Pendimethalin PE fb 750 g a.i./ha as (POE), quisoloffopethy 50g a.i./ha	27.31	46.14	58.63	5.51	8.15	3.03	3.84	4.56
	CD (P=0.05)	1.249	1.754	3.042	0.238	0.331	0.146	0.179	0.239
	SEm+	0.417	0.586	1.016	0.08	0.11	0.049	0.06	0.08
	CV (%)	2.728	2.288	3.102	2.638	2.46	2.875	2.777	3.17

Table 3 Impact of weed management on yield attributes of green gram

Symbol	Treatment	Yield attributes				
		No. of Pods plant-	Pod length (cm)	No. of Grains per pod	Grain yield g per plant	Test weight(g)
T1	Weedy check	17.92	4.72	5.04	2.95	32.1
T2	Weed free	23.12	8.82	7.84	6.75	39.2
T3	Application of 750 g of pendimethalin a.i./ha as (PE)	19.52	6.62	5.94	4.05	35.2
T4	4 25 g/pk propaquizafop a.i./ha as (PE)	18.52	6.32	5.84	3.75	34.5
T5	The means of imezathyper a.i./ ha used was (POE) 7.5 g.	20.72	6.92	6.54	4.75	35.6
T6	Manual weeding 25 and 45 DAS	22.42	8.62	7.64	6.35	38.4
T7	At 25 DAS, a HW was applied comprising of 250 g of pendimethalin a.i./ha as (PE) fb	21.22	8.52	7.54	5.85	38.4
T8	As POE, 50/75 g a.i./ha (Proaquizafop + Imezathyper)	20.82	7.12	6.74	4.95	36.7
T9	The pendimethalin 750g/ha a.i./ per ha can be applied as (PE) fb The POE is Imezathyper75ga.i./ha.	21.12	8.22	7.44	5.75	38.1
T10	Pendimethalin PE fb 750 g a.i./ha as (POE), quisoloffopethy 50g a.i./ha	20.92	7.82	7.24	5.45	37.3
	C.D. (P=0.05)	1.032	0.443	0.243	0.153	1.452
	SEm (±)	0.345	0.148	0.081	0.051	0.485
	C.V.	2.895	3.475	2.07	1.744	2.299

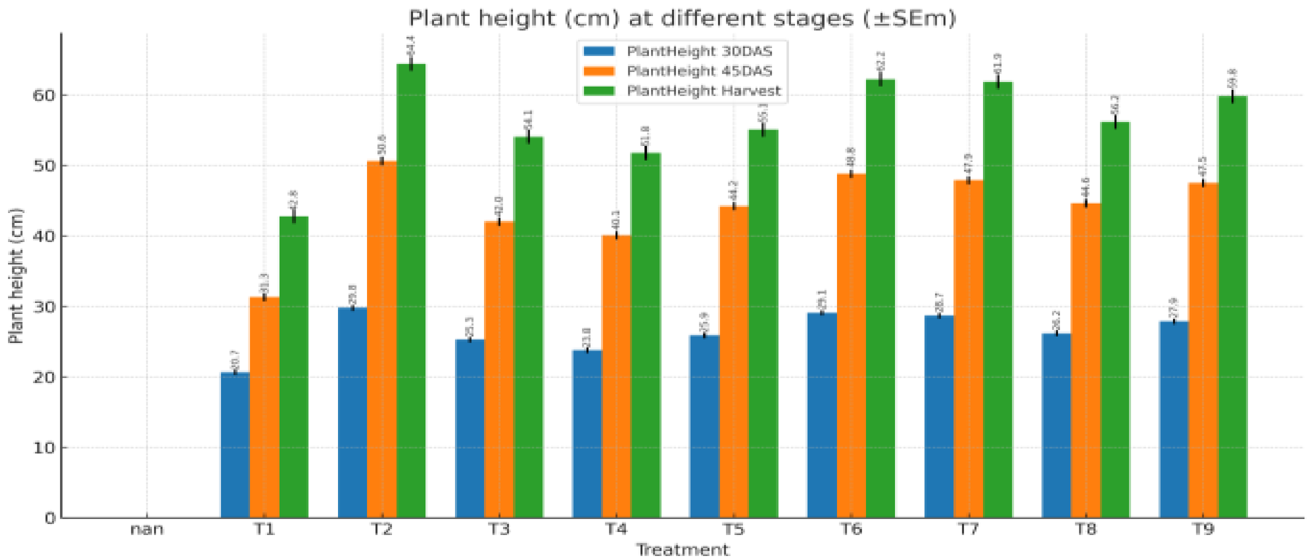

Figure 1 Plant height at different stages.

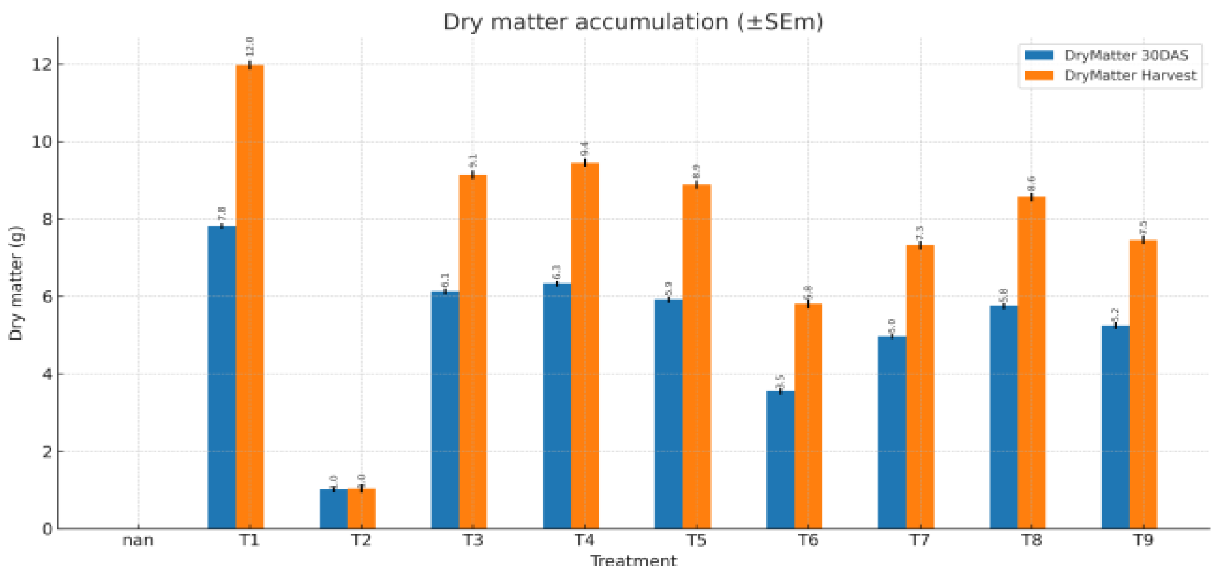

Figure 2 Dry matter accumulation.

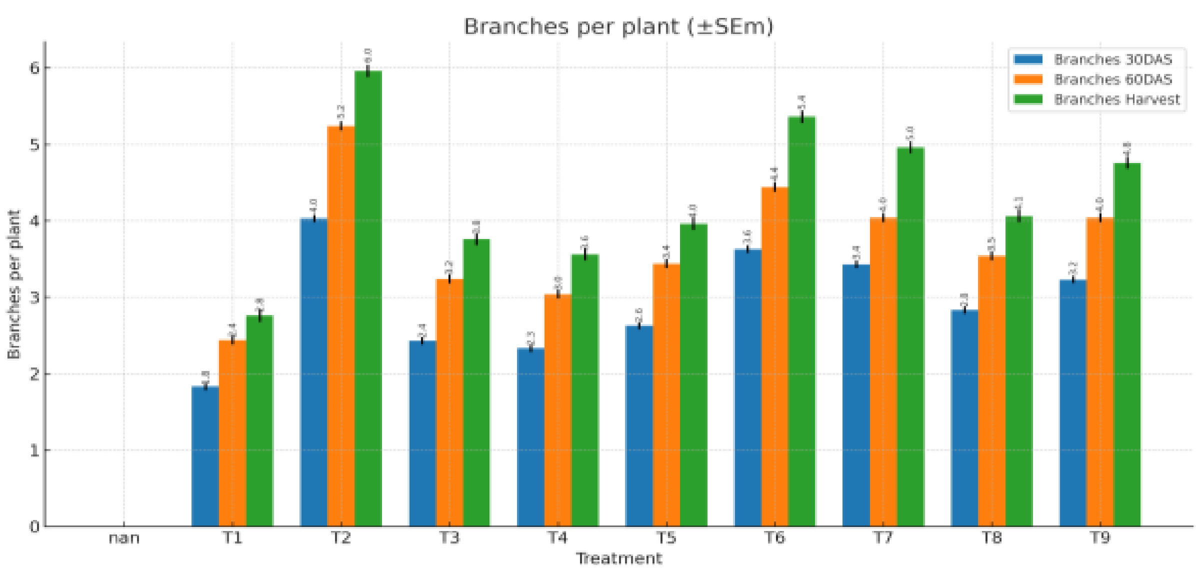

Figure 3 Branches per plant vs treatments.

The superiority of weed-free and integrated treatments is consistent with previous reports in pulses [13, 14]. It is evident that the critical period of weed competition in green gram lies within 20–40 DAS, and timely weed management during this phase is vital for maximizing productivity.

Herbicide chemistry influences weed physiology by targeting specific metabolic pathways; for example, ALS inhibitors like imazethapyr block acetolactate synthase, halting the synthesis of branched-chain amino acids (valine, leucine, isoleucine), which disrupts protein formation and cell division. This biochemical arrest leads to stunted weed growth, chlorosis, and eventual death, reducing nutrient competition with the crop. Consequently, nutrient dynamics shift in favor of green gram, enhancing uptake efficiency of N, P, and K and supporting higher growth and yield.

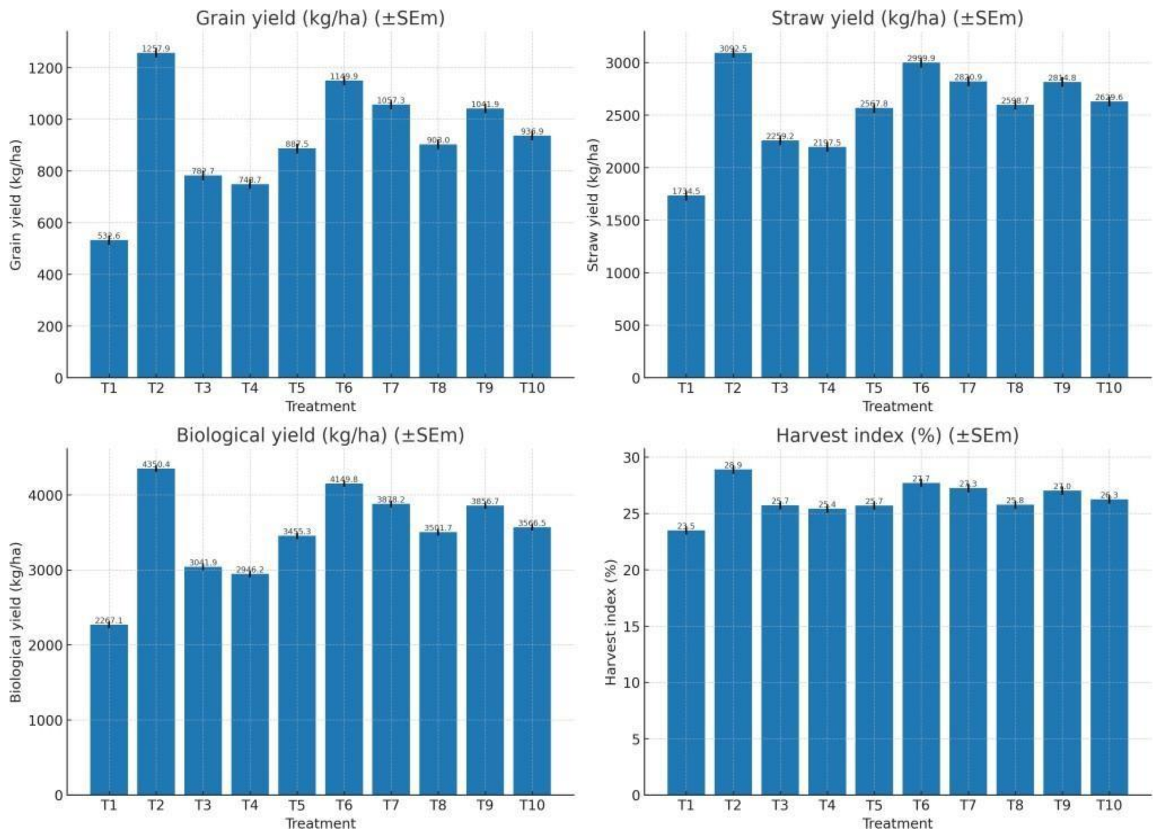

Figure 4. Treatments vs grain yield, straw yield, biological yield, harvest index.

Table 4 integrated nutrient management results on Grains, straw, biological yield, and harvest index of green gram

Symbol	Treatments	Yield (kg ha^{-1})			Harvest index (%)
		Grains	Straw	Biological	
T1	Weedy check	532.6	1734.5	2267.1	23.49
T2	Weed free	1257.9	3092.5	4350.4	28.91
T3	Application of 750 g of pendimethalin a.i./ha as (PE)	782.7	2259.2	3041.9	25.73
T4	4 25 g/pk propaquizafop a.i./ha as (PE)	748.7	2197.5	2946.2	25.41
T5	The means of imezathyper a.i./ ha used was (POE) 7.5 g.	887.5	2567.8	3455.3	25.687
T6	Manual weeding 25 and 45 DAS	1149.9	2999.9	4149.8	27.7
T7	At 25 DAS, a HW was applied comprising of 250 g of pendimethalin a.i./ha as (PE) fb	1057.3	2820.9	3878.2	27.26
T8	As POE, 50/75 g a.i./ha (Proaquizafop + Imezathyper)	903	2598.7	3501.7	25.78
T9	The pendimethalin 750g/ha a.i./ per ha can be applied as (PE) fb The POE is Imezathyper75ga.i./ha.	1041.9	2814.8	3856.7	27.015
T10	Pendimethalin PE fb 750 g a.i./ha as (POE), quisoloffopethy 50g a.i./ha	936.9	2629.6	3566.5	26.26
	C.D. (P=0.05)	56.092	140.763	136.305	1.127
	SEm (±)	18.734	47.012	45.524	0.376
	C.V.	3.49	3.166	2.252	2.476

Economics

Economic analysis revealed that weed-free plots recorded the highest gross return (Rs. 87,940/ha), net return (₹55,320/ha), and B:C ratio (2.7), followed by manual weeding and integrated herbicide treatments. In contrast, the weedy check registered the lowest net returns and B:C ratio. Similar economic advantages of integrated weed management in pulses have been reported by Meena et al. (2022) [15].

Conclusion

The study clearly demonstrated that weed infestation caused significant yield losses in green gram under semi-arid conditions of Rajasthan. Among the treatments, weed-free condition recorded the best growth, yield, and economic performance, but manual weeding at 25 and 45 DAS (T6) and integrated herbicidal treatments (pendimethalin PE fb imazethapyr POE) provided comparable results. Considering labor scarcity and cost-effectiveness, integrated herbicidal approaches are recommended as a sustainable weed practice.

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Publication History

Received	31.08.2025
Revised	15.09.2025
Accepted	18.09.2025
Online	30.10.2025