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Weed Management through Combined Herbicides and its Influence on Soil fertility, Nutrient Content and Uptake of Summer Green gram (*Vigna radiata* L.)

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Abstract

A field experiment with the objectives to understand the “Weed management through combined herbicides and its influence on soil fertility, nutrient content and uptake of summer green gram (*Vigna radiata* L.)” was conducted during the summer season of 2018 at the Instructional Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat, India. The experiment comprised ten weed management treatments laid out in a RBD with three replications. The treatments included: T₁ - pendimethalin at 900 g ha⁻¹ as pre-emergence followed by one hand weeding at 30 days after sowing (DAS); T₂ - sodium acifluorfen + clodinafop-propargyl (RM) at 250 g ha⁻¹ applied as post-emergence at 20 DAS; T₃ - imazethapyr + pendimethalin (RM) at 750 g ha⁻¹ as pre-emergence; T₄ - imazethapyr + imazamox (RM) at 70 g ha⁻¹ as pre-emergence; T₅ - imazethapyr + proquazafop (RM) at 125 g ha⁻¹ applied as post-emergence at 20 DAS; T₆ - quizalofop-p-ethyl at 100 g ha⁻¹ applied as post-emergence at 20 DAS; T₇ - fenoxaprop-p-ethyl at 100 g ha⁻¹ applied as post-emergence at 20 DAS; T₈ - two hand weedings at 20 and 40 DAS; T₉ - unweeded control; and T₁₀ - weed-free were evaluated on green gram cv. Meha. The weed-free treatment (T₁₀) resulted in significantly higher nutrient concentration and uptake in seed and straw and improved soil nutrient status after harvest the crop which was at par with T₈. Conversely, unweeded control (T₉) recorded maximum nutrient accumulation in weeds, whereas minimum nutrient removal by weeds was observed under T₈.

Keywords: Weed, Green gram, Herbicides, Nutrient content and uptake, Unweeded

Introduction

Green gram (*Vigna radiata* L.), commonly known as mung bean, is a short-duration, protein-rich pulse crop of considerable agronomic and nutritional importance in India. Being a legume, it enhances soil fertility through biological nitrogen fixation and plays a key role in sustainable cropping systems, particularly in rotations with cereals such as rice and wheat. India contributes over 70 per cent of the global production of green gram, making it the largest producer and consumer of this crop (Agricultural Market Intelligence Centre, PJTAU, 2025). At the national level, the area and production of green gram have increased in recent years. According to the 3rd advance estimates of the Ministry of Agriculture and Farmers Welfare, the crop occupied about 35.27 lakh hectares in India during 2024-25, with an estimated production of 3.82 million tonnes (Agricultural Market Intelligence Centre, PJTAU, 2025). In Gujarat, green gram represents a smaller but growing component of the pulse sector. During 2024-25, the crop covered approximately 1.38 lakh hectares with a production of about 1.26 lakh tonnes, indicating gradual expansion and stable productivity (Gujarat Agriculture Department, 2026). The increasing area, production and yield of green gram highlight its growing importance in Indian agriculture. Understanding production trends and associated constraints is essential for improving productivity and strengthening diversified cropping systems. Among the major production constraints, weed competition is particularly severe during the early growth stages of green gram. Yield losses due to uncontrolled weeds have been reported to range from 65.4 to 79.0 per cent, depending on weed flora, intensity of infestation and duration of crop-weed competition (Dungarwal *et al.*, 2003) [4].

Weeds compete with crop plants for vital resources such as nutrients, moisture, light and space especially during the critical early growth period, leading to substantial yield reduction if not effectively controlled. In recent years, herbicide mixtures or combinations have been increasingly adopted for efficient weed management. Since a single herbicide often fails to control diverse weed species effectively, herbicide combinations broaden the spectrum of weed control by targeting both grassy and broad-leaved weeds while minimizing the risk of crop injury. Therefore, effective weed management during the critical period of crop-weed competition is essential to achieve higher productivity in green gram.

Materials and Methods

A field experiment was conducted during the summer season of 2018 at the College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat. The experimental soil was clayey in texture with low, medium and high levels of available N, P₂O₅ and K₂O, respectively. The soil was slightly alkaline in reaction (pH 8.1) with normal electrical conductivity. Green gram variety 'Meha' was used as the test crop. Prior to sowing, seeds were treated with Ceresan at 3.0 g kg⁻¹ seed to prevent seed-borne fungal diseases, followed by inoculation with *Rhizobium* culture to enhance biological N fixation. The treated seeds were shade-dried before sowing. Sowing was performed on 5th February 2018 by the line sowing method with a spacing of 30 cm × 10 cm between rows and plants, respectively, using a seed rate of 20 kg ha⁻¹. A basal fertilizer dose of 20-40-00 NPK kg ha⁻¹ was applied at sowing through urea and single superphosphate (SSP), respectively, while no potassium fertilizer was applied. The herbicides evaluated in the study included pendimethalin; imazethapyr + pendimethalin (RM); imazethapyr + imazamox (RM); sodium acifluorfen + clodinafop-propargyl (RM); imazethapyr + propaquizafop (RM); quizalofop-p-ethyl; and fenoxaprop-p-ethyl. The required quantity of each herbicide was measured using a graduated cylinder according to the treatment specifications. Herbicide application was performed using a knapsack sprayer fitted with a flat-fan nozzle, delivering a spray volume of 500 L ha⁻¹ to ensure uniform coverage. Pendimethalin, imazethapyr + pendimethalin (RM), and imazethapyr + imazamox (RM) were applied as pre-emergence (PE) treatments, whereas sodium acifluorfen +

clodinafop-propargyl (RM), imazethapyr + propaquizafop (RM), quizalofop-p-ethyl, and fenoxaprop-p-ethyl were applied as post-emergence (PoE) treatments. Pre-emergence herbicides were applied two days after sowing, following irrigation. The quantity of commercial formulation required for each treatment was calculated based on the active ingredient concentration using the following formula:

$$Rh = \frac{Ai \times At}{Ci} \times 100$$

Where,

Rh = Required quantity of trade formulation of herbicide (ha⁻¹),

Ai = Quantity of active ingredient to be applied (kg),

At = Area to be treated (ha), and

Ci = Concentration of active ingredient (%) in the commercial formulation.

Total uptake of N, P₂O₅ and K₂O by crop and weeds was calculated by using the following formula.

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content in crop or weeds (\%)} \times \text{Crop yield or dry weight of weed (kg ha}^{-1}\text{)}}{100}$$

Results and Discussion

Available Nutrient Status of Soil after Crop Harvest (kg ha⁻¹)

Available N, P₂O₅ and K₂O were estimated from soil samples collected from the experimental plots after harvest of green gram. The data pertaining to the available nutrients as influenced by different weed management treatments are presented in Table 1. The residual nutrient status in the soil was found to be significantly higher under the weed-free treatment (T₁₀), which recorded 238.1 kg ha⁻¹ N, 62.7 kg ha⁻¹ P₂O₅ and 329.6 kg ha⁻¹ K₂O. This treatment was found to be statistically at par with treatments T₁, T₂, T₆ and T₈ in respect of available N, P₂O₅ and K₂O. The significantly lower values of available N, P₂O₅ and K₂O were recorded under the unweeded control treatment (T₉), which registered 174.4 kg ha⁻¹ N, 38.2 kg ha⁻¹ P₂O₅ and 294.6 kg ha⁻¹ K₂O. The higher availability of nutrients under weed-free conditions might be attributed to reduced crop-weed competition and better nutrient utilization by the crop, whereas lower nutrient availability in the unweeded control could be due to higher nutrient removal by weeds. Similar observations have also been reported by Ganapathi *et al.* (2024) and Patel *et al.* (2024) [5, 6].

Table 1: Yield and available nutrients status in soil after crop harvest as influenced by different weed management treatments

Treatments	Yield		Dry weed weight (kg ha ⁻¹)	Available nutrients (kg ha ⁻¹)		
	Seed	Straw		N	P ₂ O ₅	K ₂ O
T ₁ = Pendimethalin 900 g /ha as pre emergence + 1 HW at 30 DAS	1121	1367	437	228.1	56.7	322.4
T ₂ = Sodium acifluorfen + clodinafop-propargyl (RM) 250 g /ha as post emergence at 20 DAS	1099	1376	493	223.3	53.7	321.1
T ₃ = Imazethapyr + pendimethalin (RM) 750 g /ha as pre emergence	1030	1314	501	217.8	51.1	316.0
T ₄ = Imazethapyr + imazamox (RM) 70 g /ha as pre emergence	976	1198	556	205.9	50.7	309.5
T ₅ = Imazethapyr + propaquizafop (RM) 125 g /ha as post emergence at 20 DAS	932	1144	569	196.9	47.4	303.8
T ₆ = Quizalofop-p-ethyl 100 g /ha post emergence at 20 DAS	995	1256	539	221.1	54.7	313.0
T ₇ = Fenoxaprop-p-ethyl 100 g /ha post emergence at 20 DAS	882	1113	603	198.4	43.8	307.0
T ₈ = 2 HW at 20 and 40 DAS	1184	1453	315	232.3	57.0	324.7
T ₉ = Unweeded control	687	932	2062	174.4	38.2	294.6
T ₁₀ = Weed free	1319	1632	-	238.1	62.7	329.6
S.Em. ±	77.24	90.26	51.68	7.63	3.23	6.08
C.D at 5 %	229.48	268.18	153.54	22.66	9.61	18.07
C.V. %	13.08	12.23	14.72	6.18	10.85	3.35

Nutrient Content in Seed and Straw

The data presented in Table 2 clearly demonstrate that different weed management practices exerted a significant influence on the concentration of N, P₂O₅ and K₂O in seed and straw of green gram. The highest N, P₂O₅ and K₂O content in seed was recorded under the weed-free treatment (T₁₀) (3.70, 0.47 and 2.11 %, respectively), which was

statistically at par with T₈ (3.65, 0.45 and 2.00 %). Treatments T₁ and T₂ were also at par with respect to N and P₂O₅ content. Similarly, the maximum N, P₂O₅ and K₂O content in straw was observed under T₁₀ (1.19, 0.26 and 1.11 %, respectively), which was at par with T₈, T₁ and T₂. The lowest nutrient content in both seed and straw was recorded under the unweeded control (T₉).

Table 2: Nutrient content in seed and straw of green gram as influenced by different weed management treatments

Treatments	Nutrient content (%)					
	Seed			Straw		
	N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O
T ₁ = Pendimethalin 900 g /ha as pre emergence + 1 HW at 30 DAS	3.60	0.44	1.89	1.15	0.22	1.08
T ₂ = Sodium acifluorfen +clodinafop-propargyl (RM) 250 g /ha as post emergence at 20 DAS	3.65	0.44	1.82	1.16	0.22	1.07
T ₃ = Imazethapyr + pendimethalin (RM) 750 g /ha as pre emergence	3.35	0.41	1.79	1.05	0.19	1.01
T ₄ = Imazethapyr + imazamox (RM) 70 g /ha as pre emergence	3.40	0.39	1.72	0.97	0.16	0.92
T ₅ = Imazethapyr + propaquizafop (RM) 125 g /ha as post emergence at 20 DAS	3.27	0.33	1.68	0.93	0.14	0.89
T ₆ = Quizalofop-p-ethyl 100 g /ha post emergence at 20 DAS	3.39	0.38	1.75	1.01	0.20	0.95
T ₇ = Fenoxaprop-p-ethyl 100 g /ha post emergence at 20 DAS	3.42	0.39	1.69	0.83	0.15	0.84
T ₈ = 2 HW at 20 and 40 DAS	3.65	0.45	2.00	1.16	0.24	1.08
T ₉ = Unweeded control	3.10	0.32	1.22	0.64	0.13	0.55
T ₁₀ = Weed free	3.70	0.47	2.11	1.19	0.26	1.11
S.Em. ±	0.05	0.01	0.06	0.02	0.01	0.01
C.D at 5 %	0.16	0.03	0.18	0.05	0.03	0.04
C.V. %	2.66	4.62	6.01	2.77	10.06	2.63

Nutrient Uptake by Seed and Straw

The results presented in Table 3 showed that weed management practices significantly influenced the uptake of N, P₂O₅ and K₂O by seed and straw of green gram. The highest uptake of N (48.9 and 19.4 kg ha⁻¹), P₂O₅ (6.2 and 4.3 kg ha⁻¹) and K₂O (27.9 and 18.1 kg ha⁻¹) by seed and straw, respectively, was recorded under the weed-free treatment (T₁₀), which was statistically at par with T₈.

The lowest uptake of N (21.3 and 5.9 kg ha⁻¹), P₂O₅ (2.2 and 1.3 kg ha⁻¹) and K₂O (8.4 and 5.2 kg ha⁻¹) by seed and straw, respectively, was recorded under the unweeded control (T₉).

Total Nutrient Uptake by Crop

Total uptake of N, P₂O₅ and K₂O by green gram crop was significantly influenced by different weed management treatments. The highest total uptake of N, P₂O₅ and K₂O

(68.3, 10.5 and 45.9 kg ha⁻¹, respectively) was recorded under the weed-free treatment (T₁₀), which remained statistically at par with T₈ (60.0, 8.8 and 39.4 kg ha⁻¹, respectively). The lowest total uptake of N, P₂O₅ and K₂O (27.2, 3.5 and 13.6 kg ha⁻¹, respectively) was observed under the unweeded control (T₉).

The higher content and uptake of nutrients by seed and straw due to lesser crop weed competition, resulted in better development of crop growth. Further, the higher nutrients content in seed and straw and more biomass production under these treatments boosted the nutrient uptake by the crop. The finding for the nutrient uptake was followed the pattern of those were reported by Chhodavadia *et al.* (2013), Choudhary *et al.* (2012), Kumar *et al.* (2007), Kumar *et al.* (2024), Modak *et al.* (1995) and Singh *et al.* (2015)^[2, 3, 6, 7, 8, 12] in green gram.

Table 3: Nutrient uptake in seed and straw of green gram as influenced by different weed management treatments

Treatments	Nutrient uptake (kg ha ⁻¹)						Total nutrient uptake (kg ha ⁻¹)		
	Seed			Straw					
	N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O
T ₁ = Pendimethalin 900 g /ha as pre emergence + 1 HW at 30 DAS	40.4	4.9	21.3	15.7	3.0	14.8	56.1	7.9	36.1
T ₂ = Sodium acifluorfen +clodinafop-propargyl (RM) 250 g /ha as post emergence at 20 DAS	39.9	4.8	20.0	15.9	3.0	14.7	55.8	7.8	34.7
T ₃ = Imazethapyr + pendimethalin (RM) 750 g /ha as pre emergence	34.6	4.2	18.4	13.8	2.4	13.3	48.3	6.7	31.7
T ₄ = Imazethapyr + imazamox (RM) 70 g /ha as pre emergence	33.2	3.8	16.8	11.6	1.9	11.0	44.9	5.7	27.8
T ₅ = Imazethapyr + propaquizafop (RM) 125 g /ha as post emergence at 20 DAS	30.5	3.1	15.6	10.7	1.6	10.2	41.2	4.7	25.8
T ₆ = Quizalofop-p-ethyl 100 g /ha post emergence at 20 DAS	33.8	3.8	17.4	12.7	2.5	12.0	46.5	6.3	29.4
T ₇ = Fenoxaprop-p-ethyl 100 g /ha post emergence at 20 DAS	30.2	3.5	15.0	9.3	1.7	9.4	39.4	5.1	24.3
T ₈ = 2 HW at 20 and 40 DAS	43.2	5.3	23.7	16.8	3.5	15.7	60.0	8.8	39.4
T ₉ = Unweeded control	21.3	2.2	8.4	5.9	1.3	5.2	27.2	3.5	13.6

T ₁₀ = Weed free	48.9	6.2	27.9	19.4	4.3	18.1	68.3	10.5	45.9
S.Em. ±	2.56	0.36	1.56	1.01	0.28	0.94	3.46	0.61	2.43
C.D at 5 %	7.60	1.08	4.63	3.00	0.83	2.78	10.29	1.81	7.21
C.V. %	12.44	15.06	14.63	13.29	19.24	13.06	12.29	15.74	13.62

Nutrient Content in Weeds

Data presented in 4 indicated that weed management practices significantly influenced the N, P₂O₅ and K₂O content in weeds. The highest nutrient content was recorded under the unweeded control (T₉), registering 1.82, 0.47 and

1.17 % N, P₂O₅ and K₂O, respectively. The lowest nutrient content was observed under the weed-free treatment (T₁₀) (1.28, 0.22 and 0.65 %, respectively), which remained statistically at par with T₁, T₂ and T₈ with respect to N and P₂O₅ content in weeds.

Table 4: Nutrient content and uptake by weeds as influenced by different weed management treatments

Treatments	Nutrient content (%)			Nutrient uptake (kg ha ⁻¹)		
	Seed			Straw		
	N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O
T ₁ = Pendimethalin 900 g /ha as pre emergence + 1 HW at 30 DAS	1.34	0.25	0.76	5.9	1.1	3.3
T ₂ = Sodium acifluorfen +clodinafop-propargyl (RM) 250 g /ha as post emergence at 20 DAS	1.33	0.26	0.74	6.6	1.3	3.7
T ₃ = Imazathapyr + pendimethalin (RM) 750 g /ha as pre emergence	1.39	0.31	0.79	7.0	1.5	3.9
T ₄ = Imazathapyr + imazamox (RM) 70 g /ha as pre emergence	1.42	0.33	0.85	7.9	1.8	4.8
T ₅ = Imazethapyr + propaquizafop (RM) 125 g /ha as post emergence at 20 DAS	1.46	0.40	0.83	8.3	2.2	4.8
T ₆ = Quizalofop-p-ethyl 100 g /ha post emergence at 20 DAS	1.40	0.30	0.86	7.5	1.6	4.6
T ₇ = Fenoxaprop-p-ethyl 100 g /ha post emergence at 20 DAS	1.49	0.38	1.14	9.0	2.4	6.9
T ₈ = 2 HW at 20 and 40 DAS	1.29	0.24	0.71	4.1	0.8	2.2
T ₉ = Unweeded control	1.82	0.47	1.17	37.5	9.8	24.1
T ₁₀ = Weed free	1.28	0.22	0.65	0.0	0.0	0.0
S.Em. ±	0.02	0.02	0.02	0.74	0.25	0.50
C.D at 5 %	0.06	0.06	0.05	2.21	0.73	1.49
C.V. %	2.37	10.36	3.60	13.72	18.93	14.88

Nutrient Uptake by Weeds

Data revealed that nutrient uptake by weeds was significantly affected by weed management treatments. The weed-free treatment (T₁₀) recorded almost negligible nutrient removal by weeds. Significantly lower nutrient uptake by weeds was observed under T₈ (two hand weedings at 20 and 40 DAS), recording 4.1, 0.8 and 2.2 kg ha⁻¹ of N, P₂O₅ and K₂O, respectively, which remained at par with T₁. The maximum uptake of N, P₂O₅ and K₂O by weeds was recorded under the unweeded control (T₉).

The significantly lowest uptake of nutrients by weeds under weed free condition due to minimum weeds population, which indirectly increase the availability of soil nutrients for plant growth. The results are in close vicinity with those reported by Choudhary *et al.* (2012), Chhodavadia *et al.* (2013), Kumar *et al.* (2024) and Vivek *et al.* (2008) [2, 3, 6, 13].

Conclusion

Field experimentation indicated that post-emergence application of sodium acifluorfen + clodinafop-propargyl (RM) @ 250 g ha⁻¹ at 20 DAS proved most effective for yield, profitability, and weed control in summer green gram. Manual weeding (weed-free or two hand weedings at 20 and 40 DAS) was equally effective when labour was available. Weed-free treatment (T₁₀) recorded maximum yield, nutrient uptake, and soil fertility, while unweeded control (T₉) showed the lowest performance. Overall, effective weed management reduced nutrient competition and improved productivity and soil health.

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