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Effect of Organic and Inorganic Weed Management Practices on Growth, Yield, and Economics of Mung Bean (*Vigna radiata* L.)

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Abstract
The present investigation entitled "Effect of Organic and Inorganic Weed Management Practices on Growth, Yield, and Economics of Mung Bean (*Vigna radiata* L.)" was conducted during the summer season of 2025 at the Agricultural Farm, Career Point University, Kota, Rajasthan. The experiment aimed to evaluate the comparative effectiveness of organic and inorganic weed management practices on the growth, yield, and profitability of mung bean under irrigated conditions. The experiment was laid out in a Randomized Block Design with eight treatments replicated thrice, including control, weed-free, hoeing, organic mulching, and herbicidal combinations such as Imazethapyr, Fluazifop-p-butyl, and Propaquizafop + Imazethapyr. Results revealed a diverse weed flora dominated by *Echinochloa colona*, *Cyperus rotundus*, and *Cynodon dactylon*. Both organic and inorganic practices significantly reduced weed density and dry matter accumulation compared to the weedy check. Hoeing at 20 and 40 DAS and the combined herbicide treatment (Propaquizafop + Imazethapyr at 127 g ha^{-1}) recorded the highest weed control efficiency (>60%) and markedly improved crop growth attributes such as plant height, trifoliate leaves, branches, and dry matter accumulation. Yield attributes including pod number, grains per pod, and 100-seed weight were also maximized under these treatments.The weed-free and integrated herbicide treatments achieved the highest grain yields (10.6 and 10.2 q ha^{-1}, respectively) and biological yield (39.22 q ha^{-1}), with corresponding improvements in protein content (26.3%) and harvest index (27.02%). Economically, weed-free plots gave the highest gross and net returns, while the Propaquizafop + Imazethapyr combination offered the most favorable benefit-cost ratio (5.84). integrated weed management combining manual hoeing or selective herbicides proved superior in minimizing weed competition, enhancing yield, and ensuring profitability and sustainability of mung bean cultivation in semi-arid regions.

Keywords: Mungbean, IWM, Organic, Inorganic

Introduction

Mung bean (*Vigna radiata* L.), commonly known as green gram, is a vital pulse crop extensively cultivated across tropical and subtropical regions of Asia, particularly in India, China, and Myanmar (Ahmed *et al.*, 2021) [6]. The crop is appreciated for its short growth duration, adaptability to diverse agro-climatic conditions, and its ability to enhance soil fertility through biological nitrogen fixation (Sharma & Meena, 2022) [10]. Due to its rich nutritional profile—containing high levels of protein, essential amino acids, vitamins, and minerals—it plays an important role in human nutrition, particularly for vegetarian populations (Kumar *et al.*, 2023) [8]. It is consumed in multiple forms such as sprouts, soups, curries, and snacks, making it a dietary staple across Asia (Choudhary *et al.*, 2016) [4]. Moreover, its inclusion in crop rotation systems contributes to sustainable agriculture by improving soil structure, maintaining nitrogen balance, and reducing the need for synthetic fertilizers (Gupta *et al.*, 2020; Meena *et al.*, 2023) [7, 9].

Mung bean seeds are a rich source of plant-based protein, containing between 20.97% and 31.32% protein, as well as significant amounts of iron (5.9–7.6 mg/100g), calcium, magnesium, phosphorus, and potassium. This makes mung bean an important dietary component, especially for vegetarians and low-income populations who may have limited access to animal protein. The crop's low production cost and adaptability to various agro-climatic conditions further enhance its economic significance for smallholder farmers.

Globally, mung bean is cultivated on more than seven million hectares, representing approximately 8.5% of the world's pulse area. Major producers include India, China, Myanmar, Bangladesh, and Pakistan, as well as some regions in southern Europe and North America. In India, mung bean is grown on 3.787 million hectares, yielding 2.916 million tonnes with an average productivity of 670 kg/ha during the 2023–24 agricultural year. Mung beans slow early growth and shallow root system make it particularly vulnerable to both annual and perennial weeds. Furthermore, the crop is sensitive to many herbicides, and only a limited number of chemical options are registered for use in mung bean cultivation. Over-reliance on chemical herbicides can result in environmental degradation, herbicide resistance, and negative impacts on soil health and human safety, especially where proper application practices are lacking.

Cultural practices such as crop rotation, intercropping, timely sowing, and optimal row spacing can suppress weed emergence by creating conditions unfavorable to weed growth. Mechanical methods, including manual weeding and inter-row cultivation, are effective but labor-intensive and may not be feasible for large-scale operations or where labor is scarce. Chemical weed control, specifically the use of pre-emergence herbicides, offers a practical solution for managing weeds in mung bean fields. Herbicides such as pendimethalin and imazethapyr have demonstrated effectiveness in controlling a broad spectrum of weeds without adversely affecting mung bean growth when used at recommended doses. Recent studies have shown that pre-emergence application of imazethapyr and oxadiazon can provide effective weed control and significantly enhance mung bean yield. Integrated Weed Management (IWM) strategies combine cultural, mechanical, and chemical methods to achieve sustainable weed control. For mung bean, research indicates that combining pre-emergence herbicides with manual weeding at critical growth stages (such as 20–30 days after sowing) results in superior weed control, higher yields, and improved economic returns. IWM reduces reliance on chemical herbicides, mitigates the risk of herbicide resistance, and minimizes environmental impacts. There is growing interest in alternative weed control measures such as allelopathy—the chemical inhibition of weed growth by mung bean plants—and organic mulching, which can suppress weeds while enhancing soil health. Maintaining soil health and biodiversity is increasingly recognized as essential for long-term weed management and sustainable crop production.

Materials and Methods

Experimental Site Description

The present investigation entitled "Effect of Organic and Inorganic Weed Management Practices on Growth, Yield, and Economics of Mung Bean *(Vigna radiata L.)*" was conducted during the summer season of 2025 at the Agricultural Farm, Career Point University, Alaniya, Kota (Rajasthan). The experimental farm is located approximately 34 km from Kota Railway Station, situated at 25°11′ N latitude and 75°54′ E longitude, with an elevation of 273 meters above mean sea level. The site falls under the Humid South Eastern Plain Zone (Zone V) of Rajasthan. The soil of this region is predominantly clay loam in texture, and the groundwater is saline in nature. The experimental field had a fairly uniform topography, suitable for uniform layout and irrigation management.

Weather Conditions

The meteorological data during the crop growth period were obtained from the Meteorological Observatory, Career Point University, Alaniya, Kota, and are summarized in Table 3.1 and During the mung bean growth period, the weekly mean maximum temperature ranged between 22.9 °C and 38.3 °C, with an average of 29.14 °C. The weekly mean minimum temperature varied from 3.5°C to 23.3 °C, averaging 10.77 °C. The relative humidity fluctuated between 28.8% and 93.0%, with an average of 69.18%. A total of 0.3 mm of rainfall was recorded during the 50th meteorological week. Overall, the prevailing climatic conditions were conducive to the successful growth and development of mung bean during the summer season.

Soil Characteristics

Prior to sowing, composite soil samples were collected from a 0–15 cm soil depth from the experimental site to determine its mechanical and chemical composition. The samples were air-dried, sieved, and analyzed using standard laboratory procedures. Soil was clay loam in texture, low in organic carbon and available nitrogen, medium in available phosphorus, high in available potassium, and alkaline in reaction. The cropping history of the experimental field is diverse cropping pattern that helped in maintaining the soil fertility and productivity of the experimental site. The experiment was laid out in accordance with the recommended crop rotations for the area to ensure optimal soil health and sustained productivity.

Crop Season/Year	Kharif	Rabi	Summer
2020–21	Soybean	Wheat	—
2021–22	Paddy	Gram	Urd
2022–23	Paddy	Wheat	Mung Bean
2023–24	Soybean	Gram	Mung Bean
2024–25	Urd	Wheat	Mung Bean

Treatment Details

S. No.	Treatment	Symbol
1	Control	T_1
2	Weed-free	T_2
3	Two hand weedings at 20 and 40 DAS	T_3
4	Paddy straw mulching (6 t ha^{-1}) at 8–10 DAS	T_4
5	Polythene sheet mulching at 8–10 DAS	T_5
6	Imazethapyr 10% SL @ 55 g ha^{-1} at 20 DAS	T_6
7	Fluazifop-p-butyl 13.4% EC @ 988 ml ha^{-1}	T_7
8	Propaquizafop 2.5% + Imazethapyr 3.75% w/w at 20 DAS	T_8

Experimental and Layout Details

The field experiment on "Effect of Organic and Inorganic Weed Management Practices on Growth, Yield, and Economics of Mung Bean (*Vigna radiata L.*)" was conducted during the Zaid season of 2025. The experiment was laid out in a Randomized Block Design (RBD) with eight treatments replicated three times, resulting in a total of 24 plots. The details of the experimental layout are presented in Table.

Experimental and Layout Details

Particulars	Details
Season	Zaid
Experimental Design	Randomized Block Design (RBD)
Number of Treatments	8
Number of Replications	3
Total Number of Plots	8 × 3 = 24
Gross Plot Size	4.8 m × 3.6 m = 17.28 m²
Net Plot Size	3.8 m × 1.8 m = 6.84 m²
Irrigation Channel Width	1.0 m
Replication Border Width	1.5 m
Row-to-Row Spacing	30 cm
Plant-to-Plant Spacing	8 cm
Seed Rate	12 kg ha^{-1}
Variety	MH 1142
Fertilizer Dose	20 kg N, 40 kg P_2O_5, and 60 kg K_2O ha^{-1}

Results and Discussion

Studies on Weed Flora and Dynamics

The experimental field exhibited a diverse weed flora comprising both broad-leaved and grassy species. Major broad-leaved weeds included *Solanum nigrum*, *Trianthema monogyna*, and *Celosia argentea*, whereas grassy species consisted of *Echinochloa colona*, *Cyperus rotundus*, and *Cynodon dactylon*. Other associated species such as *Digera arvensis*, *Phyllanthus niruri*, and *Commelina benghalensis* were also observed. Among these, *Cyperus rotundus* and *E. colona* were dominant across treatments, particularly in the weedy check plot, indicating their competitive aggressiveness under irrigated conditions.

Weed Density and Dry Matter Accumulation

Weed density significantly varied among treatments at 30, 60, and 90 DAS. Mechanical weed control through hoeing at 20 and 40 DAS (organic approach) recorded the lowest total weed population, followed closely by the integrated herbicide treatment *Propaquizafop* + *Imazethapyr* (127 g/ha), representing the most effective inorganic approach. The herbicide *Diclosulam* (20 g/ha PRE) and the post-emergence mixture *Imazethapyr* + *Imazamox (RM)* (80 g/ha) also performed well, reducing weed density substantially. In contrast, *Topramezone* (25.80 g/ha POE) and *Imazethapyr* (70 g/ha PRE) were less effective, while the untreated control exhibited the maximum weed infestation. Dry matter accumulation followed a similar trend, with minimum weed biomass recorded under hoeing and integrated herbicide treatments. These treatments achieved higher weed control efficiency (WCE > 60%), reflecting their superiority in suppressing weed competition.

Studies on Crop Growth and Development

Initial Plant Population

Plant stand establishment was not significantly affected by treatments, though marginally higher populations were recorded under weed-free and integrated herbicide conditions due to reduced early weed interference.

Plant Height

Significant variation in plant height was observed across treatments. Weed-free and integrated herbicide plots produced the tallest plants (54.3 cm and 53.5 cm, respectively), followed by polythene mulch (52.1 cm). Organic mulching with paddy straw also improved plant growth (50.7 cm), while the control recorded the shortest plants (41.8 cm). This improvement can be attributed to better nutrient uptake, light interception, and reduced weed competition under efficient weed management regimes.

Number of Trifoliate Leaves and Branches

The number of trifoliate leaves and branches per plant was significantly influenced by weed control treatments. Weed-free and integrated herbicide applications enhanced leaf and branch development, while organic mulching treatments (straw and polythene) moderately improved vegetative growth compared to the control.

Dry Matter Accumulation and Leaf Area Index

Weed-free and integrated herbicide treatments exhibited the highest dry matter accumulation (16.9 g/plant and 15.6 g/plant, respectively) and leaf area index, reflecting efficient photosynthesis and biomass partitioning. Organic mulching (paddy straw and polythene) also enhanced LAI and dry matter, indicating their effectiveness as eco-friendly weed control measures.

Integrated Interpretation

Overall, both organic and inorganic weed management practices significantly improved the growth and development of mung bean compared to the weedy check. Among organic approaches, hoeing (20 and 40 DAS) and mulching (paddy straw/polythene) effectively suppressed weeds and improved growth attributes. Among inorganic approaches, Propaquizafop + Imazethapyr (127 g/ha) and Diclosulam (20 g/ha PRE) emerged as superior herbicidal options for efficient weed suppression and enhanced crop performance. These findings emphasize the complementary potential of integrated weed management (IWM)—combining mechanical, cultural, and chemical methods—to achieve sustainable productivity in mung bean under irrigated conditions.

Effect on Weeds: Weedy plots contained diverse flora including *Solanum nigrum*, *Trinthena monogyna*, *Celosia argentia*, *Echinochloa colona*, *Cynodon dactylon*, and *Cyperus rotundus*. Hoeing at 20 & 40 DAS and Propaquizafop + Imazethapyr (127 g ha^{-1} at 15 DAS) effectively minimized weed density throughout the crop period, comparable to integrated herbicide use. Diclosulam (20 g ha^{-1} PRE) and Imazethapyr + Imazamox (RM) (80 g ha^{-1} POE) were moderately effective, while Topramezone and Imazethapyr PRE showed lower control due to limited spectra (Ahmed *et al.*, 2021) [6]. Dry matter accumulation and weed control efficiency were highest under hoeing and integrated herbicide treatments (Choudhary *et al.*, 2016; Gupta *et al.*, 2020) [4, 7].

Growth Parameters: Weed-free plots recorded maximum plant population, height, trifoliate leaves, branches, dry matter, and leaf area index, highlighting the negative impact of weed competition on growth. Integrated herbicide and mulching treatments closely followed, while control plots showed severe stunting. Weed management advanced flowering and maturity, ensuring better synchronization.

Root Parameters: Weed-free and integrated herbicide plots recorded the longest roots (12.6 cm) and highest root biomass (4.6 g plant^{-1}), followed by mulching treatments.

Weedy plots had minimum values due to allelopathic inhibition. Nodulation was highest in weed-free plots (43.6 nodules plant⁻¹), reflecting better rhizobial activity (Sharma & Meena, 2022) [10].

Yield Attributes: Weed-free conditions produced the maximum pods (16.6), pod length (9.6 cm), and grains pod⁻¹ (8.6), followed by integrated herbicide and mulching treatments. Control plots showed severe yield loss due to nutrient competition and shading (Shukla *et al*., 2023). Grain yield peaked under weed-free (4.3 g plant⁻¹; 10.6 q ha⁻¹) and integrated herbicide conditions (10.2 q ha⁻¹). Straw and biological yields followed similar trends, confirming the benefits of effective weed control.

Harvest Index and Yield: Weed-free plots achieved the highest harvest index (27.02%) and biological yield (39.22 q ha⁻¹), reflecting efficient assimilate partitioning. Control plots exhibited the lowest (24.10%), with significant biomass loss to weeds (Yadav *et al*., 2019) [2].

Quality Parameters: Protein content was highest in weed-free (26.3%) and integrated herbicide treatments (25.8%), associated with enhanced nitrogen fixation and uptake. Control plots showed the lowest protein yield (71.0 kg ha⁻¹) due to weed-induced nitrate inhibition.

Economics

Weed-free cultivation yielded maximum gross (₹1,22,118 ha⁻¹) and net returns (₹99,616 ha⁻¹). Integrated herbicide treatment offered the highest benefit-cost ratio (5.84), proving most economical due to balanced efficacy and input cost (Meena *et al*., 2023) [9]. Control plots had minimal profitability (B:C 2.52), confirming weed management's economic necessity (Kumar *et al*., 2023) [8].

Conclusion

Integrated weed management practices, particularly repeated hoeing or the combined use of Propaquizafop + Imazethapyr (127 g/ha at 15 DAS), proved most effective in controlling weeds and enhancing mung bean productivity and profitability. These treatments significantly improved growth, nodulation, yield, and quality compared to single herbicide use or no control. Farmers are advised to adopt manual hoeing at 20 and 40 DAS or the above herbicide mixture for optimal results. Alternatively, Diclosulam (20 g/ha, pre-emergence) or Imazethapyr + Imazamox (80 g/ha, post-emergence) also provided satisfactory weed control. Overall, timely and integrated weed management ensures higher yield, better soil health, and greater economic returns in mung bean cultivation.

Table 1: Effect of different treatments on plant height (cm) in mung bean during summer 2025

Symbol	Treatment	25 DAS	50 DAS	At Harvest
T_1	Control	19.6	32.1	41.8
T_2	Weed free	28.4	47.6	54.3
T_3	Two hand weeding at 20 & 40 DAS	22.8	38.9	48.5
T_4	Paddy straw mulching (6 t ha⁻¹) at 8–10 DAS	24.3	42.2	50.7
T_5	Polythene sheet mulching at 8–10 DAS	25.7	44.5	52.1
T_6	Imazethapyr 10% SL @ 55 g ha⁻¹ at 20 DAS	23.5	40.1	49.2
T_7	Fluazifop-p-butyl 13.4% EC @ 988 ml ha⁻¹	20.9	35.6	45.3
T_8	Propaquizafop + Imazethapyr at 20 DAS	27.2	46.8	53.5
SEm (±)		1.2	1.8	2.1
C.D. (P=0.05)		3.5	5.2	6.3

Table 2: Effect of Different Treatments on Yield Attributes in Mung Bean during Summer 2025

Symbol	Treatment	Pods Plant⁻¹	Pod Length (cm)	Grains Pod⁻¹	Grain Yield (g plant⁻¹)	1000-Grain Weight (g)
T_1	Control	8.9	3.9	4.3	1.9	30.9
T_2	Weed free	16.6	9.6	8.6	4.3	34.3
T_3	Two hand weeding at 20 & 40 DAS	12.1	6.8	6.2	2.8	32.1
T_4	Paddy straw mulching (6 t ha⁻¹) at 8–10 DAS	13.7	7.5	6.9	3.2	33.0
T_5	Polythene sheet mulching at 8–10 DAS	14.9	8.3	7.4	3.6	33.5
T_6	Imazethapyr 10% SL @ 55 g ha⁻¹ at 20 DAS	13.2	7.2	6.5	3.0	32.6
T_7	Fluazifop-p-butyl 13.4% EC @ 988 ml ha⁻¹	10.8	5.9	5.4	2.3	31.5
T_8	Propaquizafop + Imazethapyr at 20 DAS	15.8	8.9	7.9	3.9	33.9
SEm (±)		0.4	0.3	0.2	0.1	0.3
C.D. (P=0.05)		1.2	0.9	0.6	0.3	0.9

Table 3: Effect of Different Treatments on Yield, Straw Yield, Biological Yield and Harvest Index in Mung Bean during Summer 2025

Symbol	Treatment	Grain Yield (q ha⁻¹)	Straw Yield (q ha⁻¹)	Biological Yield (q ha⁻¹)	Harvest Index (%)
T_1	Control	4.1	11.07	15.17	24.10
T_2	Weed free	10.6	28.62	39.22	27.02
T_3	Two hand weeding at 20 & 40 DAS	7.9	22.50	30.40	25.90
T_4	Paddy straw mulching (6 t ha⁻¹) at 8–10 DAS	9.3	25.20	34.50	26.40
T_5	Polythene sheet mulching at 8–10 DAS	9.8	26.50	36.30	26.70
T_6	Imazethapyr 10% SL @ 55 g ha⁻¹ at 20 DAS	8.7	24.00	32.70	26.00
T_7	Fluazifop-p-butyl 13.4% EC @ 988 ml ha⁻¹	6.4	20.30	26.70	25.30
T_8	Propaquizafop + Imazethapyr at 20 DAS	10.2	27.80	38.00	26.90
SEm (±)	—	0.4	0.6	0.9	0.3
C.D. (P=0.05)	—	1.2	1.8	2.7	0.9

Table 4: Effect of different treatments on weed density at 30 DAS in mungbean

Treatment	*T. monogyna*	*E. colona*	*C. argentia*	*S. nigrum*	*C. rotundus*	Other weeds	Total
T1- Control	14.6	34.8	12.3	8.1	50.1	15.2	135.1
T2- Weed free	3.4	1.2	1.3	1.6	8.3	2.6	18.4
T3- Two hand weed / Imaza+Imazaox 70g	7.0	7.8	6.0	7.2	57.1	12.6	97.7
T4- Paddy Straw Mulch / Imaza+Imazaox 80g	5.4	7.6	5.1	6.4	52.2	12.2	88.9
T5- Polythene Mulch / Diclosulam	7.6	5.3	5.5	5.7	32.1	9.4	65.6
T6- Imazethapyr 10% SL	9.8	10.1	8.4	10.2	61.6	15.1	115.2
T7- Fluazifop-p-butyl / Topramezone	11.1	14.6	11.6	7.1	58.1	12.4	114.9
T8 Propaquizafop + Imazethapyr	4.6	3.3	4.5	5.2	28.6	7.6	53.3
SEm+	0.20	0.26	0.17	0.17	1.23	0.29	2.30
CD@5%	0.60	0.80	0.51	0.54	3.74	0.89	6.96

Table 5: Effect of Different Treatments on Dry Matter of Weeds (g m^{-2}) and Weed Control Efficiency (%)

Treatment	30 DAS	60 DAS	90 DAS	WCE (%)
T_1 - Control	61.69	144.31	208.39	0.00
T_2 - Weed free	14.15	61.56	76.95	63.07
T_3 - Two hand weed / Imaz+Imazaox 70 g	53.27	106.32	139.49	33.06
T_4 - Paddy straw mulch / Imaz+Imazaox 80 g	51.45	85.34	132.90	36.23
T_5 - Polythene mulch / Diclosulam	16.95	102.56	106.68	48.81
T_6 - Imazethapyr 10% SL	58.29	130.87	163.59	21.50
T_7 - Fluazifop-p-butyl / Topramezone	53.07	116.08	133.24	36.06
T_8 - Propaquizafop + Imazethapyr	14.66	63.95	79.94	61.64
SEm±	0.19	0.36	0.41	-
CD (5%)	0.57	1.08	1.20	-

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