

Impact of Vermiwash on the Growth and Yield of Green Gram (*Vigna radiata*) MI6

ABSTRACT

Green gram (*Vigna radiata*) cultivation in Sri Lanka heavily relies on inorganic fertilizers, leading to environmental and health issues that necessitate the exploration of alternatives; therefore, a field experiment was conducted at the Adaptive Research Centre in Vavuniya, Sri Lanka, to evaluate the impact of vermiwash on the growth and yield of the green gram variety MI6. Vermiwash was prepared using cow dung, banana fruit waste, mold leaves, and red worms (*Eisenia fetida*). Six treatments were established in a Randomized Complete Block Design (RCBD), including controls such as no fertilizer (T1) and 100% recommended inorganic fertilizer (T2). The remaining treatments combined half-doses of inorganic fertilizer with varying concentrations of vermiwash as a foliar spray: 25% (T3), 50% (T4), 75% (T5), and 100% (T6). The prepared vermiwash had a pH of 7.63 and contained total available nitrogen, phosphorus, and potassium at 0.014%, 0.355%, and 1.500%, respectively. The highest plant height, leaf area index, and number of branches were recorded in T5 (42.13±0.21 cm, 10.48±0.28, and 3.67±0.31, respectively), showing no significant difference ($P>0.05$) from T2. The lowest days for 50% of flowering were observed in T5 (42±0). The highest number of pods per plant, pod length, pod girth, seeds per pod, 100 seeds weight, and total yield (27.17±0.78, 11.27±0.17, 2.29±0.02, 12±0.22, 7.18±0.10 g, and 212±1.49 g) were observed in T5, significantly different ($P<0.05$) from T2. This study suggests reducing inorganic fertilizer by half and combining it with 75% vermiwash (T5) for optimal growth and yield.

Keywords: Green gram, Growth, Inorganic fertilizer, Vermiwash, Yield

1. INTRODUCTION

The green gram (*Vigna radiata*) is a crucial pulse crop in Sri Lanka, providing essential protein for its vegetarian population [1]. It contains antioxidants that may lower the risk of chronic diseases, such as diabetes and heart disease [2]. In 2020, 2021, and 2022, Sri Lanka produced 13497, 18931, and 12544 tons of green gram, respectively (DoA (2022, 2023), AgStat, Dept. of Agriculture of Sri Lanka). The Department of Agriculture (DoA) recommends the MI6 variety for cultivation in dry and intermediate zones (Department of Agriculture Sri Lanka, 2023).

However, excessive use of inorganic fertilizers threatens the sustainability of agroecosystems [4]. For the MI6 variety, the DoA advises applying, per hectare: 35 kg of urea (46% N), 100 kg of triple super phosphate (TSP) (46% P₂O₅), and 75 kg of muriate of potash (MOP) (60% K₂O) (Department of Agriculture Sri Lanka, 2023). Solutions are needed to mitigate the environmental harm caused by inorganic fertilizers, which can degrade soil structure and lead to nutrient loss through leaching and gas emissions [5]. Overusing these fertilizers can harm soil organisms, disrupt ecosystems, and hinder mycorrhizal colonization [6]. Additionally, salt buildup from chemical fertilizers can impair water absorption, resulting in stunted plant growth [7]. Excessive fertilizer use may cause nutrient imbalances, low yields, and increased soil acidity [7]. Increased nitrogen levels can cause crop browning, yellowing leaves, and lodging, while root burn may occur due to salt

accumulation. Furthermore, biodiversity declines due to ammonia buildup from over-fertilization [5]. Thus, effective, eco-friendly alternatives are essential.

Alternatives to chemical fertilizers include organic, slow-release, and bio-fertilizers [8]. Vermiwash, an organic liquid fertilizer produced with earthworms, contains growth-promoting hormones and nutrients [9]. Foliar application of vermiwash is preferred for achieving sustainable yields [10]. Studies show that a 75% concentration of vermiwash increases leaf count in cowpeas, and boosts yield in okra and black gram [11, 12, 13]. While vermiwash is widely used in developed countries, it should also be accessible to developing nations [10].

This study aimed to assess the **impact** of various vermiwash application rates on the growth and yield of the green gram MI6. The research involved analyzing the composition of produced vermiwash and investigating its combined **impact** with half the recommended inorganic fertilizer on MI6 growth. The experiment was conducted as a field study, identifying the best combined treatment based on growth and yield outcomes.

2. MATERIAL AND METHODS

2.1 Study location

The study was conducted at the Adaptive Research Centre, Vavuniya, Northern Province, Sri Lanka, during the 2022 Maha season. The district, characterized by a tropical climate with an average temperature of 28 °C and annual rainfall under 1750 mm [14], is situated between 08°83'N and 80°50'E, with elevations ranging from 100 to 300 feet above mean sea level (Ministry of Lands, 2016).

2.2 Production of vermiwash

A vermiwash production unit was created using a barrel with one open side and a tap at the bottom. A 25 cm layer of broken bricks was placed at the bottom, with the tap open. This was followed by 25 cm of coarse sand and another layer of bricks. Afterward, a 30 cm layer of loam soil was added and moistened. Finally, Red earthworms (*Eisenia fetida*) were introduced, and organic materials like cow dung, leaf litter, and rotten banana waste were added, keeping the contents moist daily. The tap was open for the first week to allow vermiwash to flow out. On the 8th day, the tap was closed, and the collected vermiwash was poured back in. This process continued for two weeks, with the tap opened on alternate days to collect vermiwash. After two weeks, the mature vermiwash was collected through the tap [10].

2.3 Analysis of the chemical composition of vermiwash

Composition analysis was conducted on 100% raw vermiwash samples. Electrical conductivity (EC) and pH were measured using conductivity and pH meters (Model: S-610L). Total nitrogen (N) was estimated using the Kjeldahl method [15]. Total phosphorus (P) was determined using the colorimetric method [40]. Total potassium (K) was measured with a flame photometer. Total organic carbon was assessed using the Walkley-Black method described in Sri Lanka Standard 1702:2021.

2.4 Research design and layout

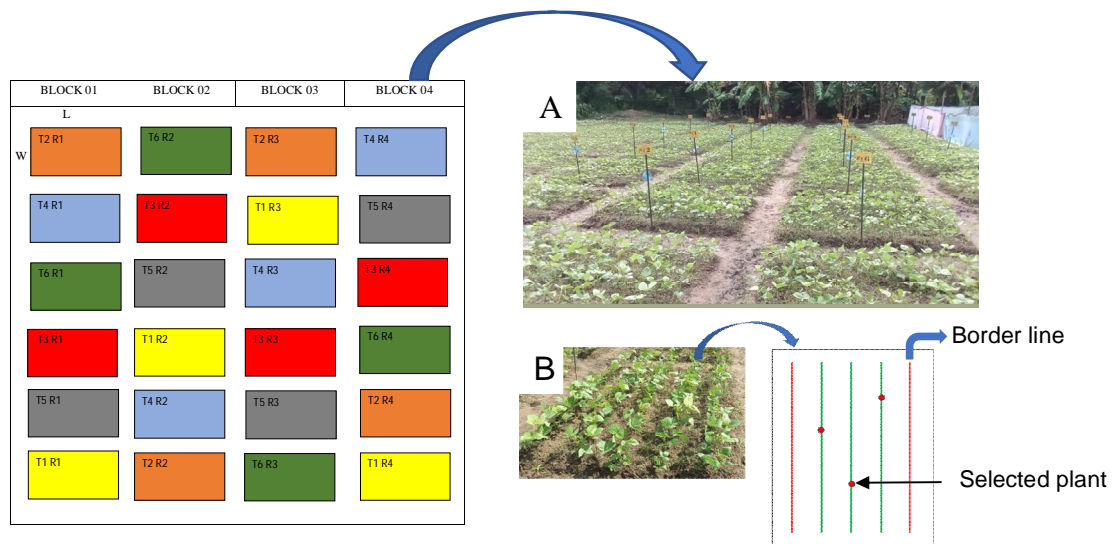


Fig. 1. Field layout of experiment. A: Experimental field; B, Single plot.

The experiment was carried out under RCBD design with four replicated plots in four blocks (Fig 1; Table 1). The Length (L) and the width (W) of each plot were 2 m and 1.5 m respectively. The total area was 208 m², with 1 m between blocks and treatments. Field preparation, planting, and watering followed DoA (Department of Agriculture Sri Lanka, 2023) recommendations.

2.5 Field preparation and planting

The experimental site was plowed and harrowed, and flatbeds were made manually based on the water supply. Two seeds per hill were planted 2 cm deep, and weaker plants were thinned after 10-12 days. Planting space was 30 cm × 10 cm (Department of Agriculture Sri Lanka, 2023).

2.6 Implementation of treatments

Table 1. Different combinations of inorganic fertilizer and vermiwash were used in the study.

Treatments	Basal dressing			Top dressing (after 30 days)	Top dressing
	Inorganic fertilizer (kg/ha)			Inorganic fertilizer (kg/ha)	Vermiwash concentration (%)
	Urea	TSP	MOP		
T1	No	No	No	No	No
T2	35	100	75	30	No
T3	17.5	50	37.5	15	25%
T4	17.5	50	37.5	15	50%
T5	17.5	50	37.5	15	75%
T6	17.5	50	37.5	15	100%

T-Treatment; TSP -Triple Super Phosphate; MOP-Muriate of Potash

Basal dressings included inorganic fertilizers like urea, TSP, and MOP applied before sowing, with urea top dressing 4 weeks after planting. Vermiwash concentrations (25%, 50%, 75%, 100%) indicated dilution rates. The experiment featured six treatments with four combinations of inorganic fertilizers and vermiwash (Table 1). Controls included no fertilizer (T1) and 100% inorganic application (T2). Vermiwash was applied as a foliar spray at the 1st, 3rd, 5th, and 7th weeks after planting (WAP). The vermiwash solution sprayed per plant for each treatment during every application was 10 ml.

Harvesting occurred 60 days after planting when pods turned brown [1]. Three randomly chosen plants from the middle lines in a plot (one from each line) were used to measure plant height, Leaf Area Index (LAI), and number of branches per plant. LAI was calculated using the following formula.

$$LAI = \frac{\text{Length (m)} \times \text{Width of leaves (m)} \times \text{N of leaves on the plant}}{\text{Area covered (m}^2\text{)}}$$

Where; L = Length (m), W = Width of leaves (m), N = Number of leaves

[39]

Five plants were randomly uprooted from each plot at flowering, and the average tap root length was measured. The days to 50% flowering were counted by noting flowered plants. Yield parameters included number of pods per plant, pod length, pod girth, seeds per pod, 100 seeds weight, and total yield.

2.7 Data analysis

The data were analyzed using statistical software SAS. One-way ANOVA was used to find out the significant differences among the treatments for each parameter [10].

3. RESULTS AND DISCUSSION

3.1 Vermiwash Composition Analysis

The vermiwash used in the experiment had the following composition: pH 7.63, EC 9.66 mS/cm, total organic carbon 0.239%, nitrogen 0.014%, phosphorus 0.355%, and potassium 1.5%. The vermiwash pH was neutral due to CO₂ and organic acid production from microbial decomposition, which lowered the substrate pH [41, 42, 43]. The high electrical conductivity (EC) might be due to organic matter loss and the release of mineral salts [44, 45]. During vermicomposting, 20–43% of organic matter is lost as CO₂, explaining the nitrogen levels [46, 47]. Nitrogen addition may also come from earthworm excretory substances, mucus, and growth hormones [47, 48]. The increased total phosphorus level in the final vermiwash is because of the physical breakdown of the earthworms [49]. It was studied that the leachates collected during vermicomposting process had higher K concentrations [50]. Macronutrients like nitrogen, phosphorus, and potassium are crucial for plant growth, aiding in leaf, stem, flower formation, disease resistance, and water efficiency [16].

3.2 The impact of vermiwash and recommended inorganic fertilizer on the growth of Green Gram M16.

3.2.1 Plant height

The study evaluated the impact of varying rates of vermiwash with 50% of the recommended inorganic fertilizer by DoA (Table 1). T2 was maintained as the full dose of inorganic fertilizer recommendation and T1 without any sort of fertilizer application. At the 2nd and 3rd WAP, there was no significant difference in average plant height among all treatments ($p > 0.05$) (Table 2). From the fourth week onwards T1 started giving significantly the lowest plant height of all the other treatments. However, a significant difference in plant height was not observed among T2 or other treatments. From the 5th WAP to the 8th WAP, the T2 and T5 had the maximum plant heights in the range of 31.38 ± 0.70 cm and 56.08 ± 0.72 cm. At the 7th and 8th WAP, T5 had the significantly highest plant height even compared to T2, the full dose of inorganic fertilizer recommendation (Table 2). T5 included 75% vermiwash and 50% inorganic fertilizer. Similar results were reported in tomato studies [17]. Undiluted vermiwash can significantly reduce plant height, causing phytotoxicity to *Vigna radiata* [18]. In this study, T6 was treated with undiluted vermiwash every two weeks, possibly explaining the reduced height in T6. According to these findings, reducing inorganic fertilizer by 50% and substituting by 75% vermiwash increased the height of green gram plants.

Table 2. Average plant heights (cm) of green gram MI6

Treatments	Average Plant Height (cm)						
	At 2 nd WAP	At 3 rd WAP	At 4 th WAP	At 5 th WAP	At 6 th WAP	At 7 th WAP	At 8 th WAP
T ₁	12.76±0.28 ^a	17.13±0.80 ^a	21.46±0.81 ^b	27.14±0.48 ^c	36.79±0.29 ^c	44.77±0.51 ^c	46.48±0.44 ^d
T ₂	14.58±0.16 ^a	19.42±0.56 ^a	26.33±0.30 ^a	31.38±0.70 ^a	41.92±0.63 ^a	49.75±1.17 ^b	50.58±0.57 ^{bc}
T ₃	12.92±0.76 ^a	17.46±0.80 ^a	23.21±0.92 ^{ab}	29.13±0.53 ^{ab}	37.79±0.36 ^{bc}	46.36±0.55 ^c	49.47±0.61 ^{bcd}
T ₄	13.21±0.95 ^a	17.67±1.03 ^a	23.50±1.00 ^{ab}	30.21±0.97 ^{ab}	38.54±0.21 ^b	47.13±0.35 ^{bc}	52.33±0.83 ^b
T ₅	13.54±0.35 ^a	18.77±0.91 ^a	25.96±0.65 ^a	32.00±1.12 ^a	42.13±0.21 ^a	54.30±0.69 ^a	56.08±0.72 ^a
T ₆	13.33±1.19 ^a	17.93±1.19 ^a	23.42±0.73 ^{ab}	30.58±1.27 ^{ab}	38.54±0.26 ^b	46.15±0.81 ^c	49.08±0.93 ^{cd}

Values are means ± standard deviation (n = 4). *Means with the same letters are not significantly different at P > .05 within the treatments. T1 - No vermiwash or inorganic fertilizers applications, T2 - full doses of recommended inorganic fertilizer–Control, T3 - ½ doses of recommended inorganic fertilizer + 25% vermiwash, T4 - ½ doses of recommended inorganic fertilizer + 50% vermiwash, T5 - ½ doses of recommended inorganic fertilizer + 75% vermiwash, T6 - ½ doses of recommended inorganic fertilizer + 100% vermiwash.

3.2.2 Leaf area index

The Leaf Area Index (LAI) represents the total leaf surface area per unit ground area, reflecting plant canopy structure [19]. Key material and energy exchanges in plants stem from the canopy's surface area, mainly leaves. In this study, LAI remained consistent among treatments until the 4th WAP. Green gram leaves responded better to 100% vermiwash for development, but regular use of undiluted vermiwash resulted in stunted growth of the leaves. The highest LAI values such as 5.28 ± 0.46 , 10.48 ± 0.28 , 12.94 ± 0.43 , and 13.11 ± 0.43 were observed in T5 at the 5th, 6th, 7th, and 8th WAPs, respectively (Table 3). At 7th WAP, T2 and T5 had the highest LAI values (49.75 ± 1.17 and 54.30 ± 0.69), which were not significantly different (Table 3). Higher leaf area correlates with a crop's ability to accumulate dry matter [20]. Similar results showed that 75% of vermiwash increased leaf count in cowpeas [11]. Comparable findings were reported for tomato, Ber seeds, okra, and Black gram [21, 22, 23, 24]. Our results indicate that reducing inorganic fertilizer by 50% and substituting with 75% vermiwash enhanced the LAI of green gram.

Table 3. Average plant LAIs of green gram MI6

Treatments	Plant Leaf Area Index (LAI)						
	At 2 nd WAP	At 3 rd WAP	At 4 th WAP	At 5 th WAP	At 6 th WAP	At 7 th WAP	At 8 th WAP
T ₁	0.11±0.01 ^a	0.64±0.05 ^a	1.33±0.27 ^a	2.89±0.46 ^b	5.49±0.77 ^c	6.52±0.81 ^b	6.57±0.82 ^b
T ₂	0.18±0.04 ^a	0.91±0.10 ^a	2.73±0.43 ^a	4.78±0.63 ^{ab}	8.76±1.09 ^{ab}	9.99±1.10 ^{ab}	10.11±1.10 ^{ab}
T ₃	0.12±0.02 ^a	0.70±0.11 ^a	1.78±0.45 ^a	4.18±0.55 ^{ab}	6.56±0.47 ^{bc}	8.06±0.56 ^b	8.14±0.55 ^b
T ₄	0.14±0.01 ^a	0.77±0.08 ^a	2.15±0.33 ^a	4.24±0.38 ^{ab}	7.87±1.02 ^{abc}	9.01±1.31 ^b	9.00±1.22 ^b
T ₅	0.17±0.02 ^a	0.88±0.08 ^a	2.71±0.28 ^a	5.28±0.46 ^a	10.48±0.28 ^a	12.94±0.43 ^a	13.11±0.43 ^a
T ₆	0.14±0.02 ^a	0.82±0.09 ^a	2.23±0.32 ^a	4.59±0.65 ^{ab}	7.38±0.49 ^{abc}	8.56±0.93 ^b	8.66±0.92 ^b

Values are means ± standard deviation (n = 4). *Means with the same letters are not significantly different at P > .05 within the treatments. T1 - No vermiwash or inorganic fertilizers applications, T2 - full doses of recommended inorganic fertilizer–Control, T3 - ½ doses of recommended inorganic fertilizer + 25% vermiwash, T4 - ½ doses of recommended inorganic fertilizer + 50% vermiwash, T5 - ½ doses of recommended inorganic fertilizer + 75% vermiwash, T6 - ½ doses of recommended inorganic fertilizer + 100% vermiwash.

3.2.3 Number of branches

In this study, the highest number of branches was in T5 (3.67±0.31), followed by T2 (3.58±0.18), T4 (3.42±0.18), T6 (3.33±0.54), T3 (2.75±0.10), and T1 (2.67±0.27) at 6th WAP (Table 4). Ranjan and Murugesan (2012) found that 75% of vermiwash yielded the most branches in cowpea (*Vigna unguiculata*). At all-time points, T2 and T5 had significantly more branches than other treatments. There was no significant difference between T5 and T2 in the number of branches.

Table 4. Average plant number of branches of green gram MI6

Treatments	Average Number of Branches		
	At 6 th WAP	At 7 th WAP	At 8 th WAP
T ₁	2.67±0.27 ^c	2.83±0.25 ^c	3.17±0.19 ^d
T ₂	3.58±0.18 ^a	4.50±0.11 ^a	5.25±0.33 ^{ab}
T ₃	2.75±0.10 ^{bc}	3.20±0.16 ^{bc}	4.17±0.11 ^{cd}
T ₄	3.42±0.18 ^{bc}	3.67±0.16 ^{abc}	4.50±0.19 ^{bc}
T ₅	3.67±0.31 ^a	4.58±0.29 ^a	5.75±0.18 ^a
T ₆	3.33±0.54 ^{bc}	4.17±0.40 ^{ab}	5.25±0.40 ^{ab}

Values are means ± standard deviation (n = 4). *Means with the same letters are not significantly different at P > .05 within the treatments

3.2.4 Tap root length

Plant growth depends on root system design, facilitating nutrient and water absorption [25]. Foliar application of vermiwash increased taproot length at 50% flowering: T6 (16.06±0.11 cm), T5 (15.17±0.14 cm), T4 (14.25±0.23 cm), T3 (13.93±0.30 cm), T2 (14.04±0.27 cm), and T1 (13.78±0.21 cm) (Table 5). Applying 100% vermiwash at two-week intervals with 50% inorganic fertilizer produced the longest taproot in T6, not significantly different from T5. Ranjan and Murugesan (2012) also found the longest cowpea root with 100% vermiwash, aligning with this result. Vermiwash contains high levels of macro- and micronutrients, and plant growth regulators, enhancing crop development [26]. It was noted that vermiwash extracts can increase root tip length [27].

Table 5. Average plant tap root lengths of green gram MI6

Treatments	Average Tap Root Length (cm)
	At 50% of flowering
T ₁	13.78±0.21 ^d
T ₂	14.06±0.27 ^c
T ₃	13.93±0.30 ^{cd}
T ₄	14.25±0.23 ^{bc}
T ₅	15.17±0.14 ^{ab}
T ₆	16.06±0.11 ^{ab}

Values are means ± standard deviation (n = 4). *Means with the same letters are not significantly different at P > .05 within the treatments

3.3 The **impact** of vermiwash and 1/2 the level of recommended inorganic fertilizer on the yield of Mung bean MI6.

3.3.1 Days for 50% of flowering

Vermiwash application significantly decreased ($p < 0.05$) the days to 50% flowering. T5 and T2 had the minimum days (42 ± 0), while T1 had the maximum (48 ± 0). Applying vermiwash at 75% concentration biweekly with half the inorganic fertilizer dose reduced the time to 50% flowering. This may be due to increased auxin and available N and P in the flowering shoots [28]. A study on the foliar application of vermiwash and KNO_3 showed significant improvements in flower yield and tuberosity quality, affecting floret length and diameter [29].

Table 6. Days for 50% of flowering of green gram MI6

Days for 50% of Flowering	
Treatments	Days
T ₁	$48 \pm 0^{\text{a}}$
T ₂	$42 \pm 0^{\text{d}}$
T ₃	$45 \pm 0^{\text{b}}$
T ₄	$43 \pm 0^{\text{c}}$
T ₅	$42 \pm 0^{\text{d}}$
T ₆	$45 \pm 0^{\text{b}}$

Values are means \pm standard deviation ($n = 4$). *Means with the same letters are not significantly different at $P > .05$ within the treatments

3.3.2 Number of pods per plant

The application of vermiwash significantly increased ($p < 0.05$) pods per plant. The highest number was in T5 (27.17 ± 0.78), followed by T2 (22.5 ± 0.25), T4 (21.42 ± 0.29), T3 (19.50 ± 0.25), T1 (16.17 ± 0.60), and T6 (15.75 ± 0.43) (Table 7). A study found that vermiwash enhanced pods and yield of *Abelmoschus esculentus* [12]. These findings suggest reducing inorganic fertilizer by 50% and replacing it with 75% vermiwash can increase green gram pod numbers.

Table 7. The average number of pods per plant of green gram MI6

Average Number of Pods per Plant	
Treatments	Pods
T ₁	$16.17 \pm 0.6^{\text{d}}$
T ₂	$22.50 \pm 0.25^{\text{b}}$
T ₃	$19.50 \pm 0.25^{\text{c}}$
T ₄	$21.42 \pm 0.29^{\text{bc}}$
T ₅	$27.17 \pm 0.78^{\text{a}}$
T ₆	$15.75 \pm 0.43^{\text{d}}$

Values are means \pm standard deviation ($n = 4$). *Means with the same letters are not significantly different at $P > .05$ within the treatments

3.3.3 Pod length and pod girth

The use of vermiwash significantly impacted pod length and girth. The longest pods were in T5, likely due to micronutrients enhancing fruit size [30]. The minimum pod length in T6 was

9.26±0.06 cm, and the minimum girth in T1 was 2.03±0.01 cm (Tables 8 and 9). The high salt content in 100% vermiwash may inhibit growth and lead to malformed pods [31]. This aligns with the finding that 100% vermiwash reduced potato yield [32]. T5 had the highest ($P<0.05$) pod length and girth at 11.27±0.17 cm and 2.29±0.02 cm, respectively. Applying vermiwash as a foliar spray at 75% with ½ inorganic fertilizer increased pod girth by 1.08 times compared to control T1 (Table 9). Thus, foliar application of vermiwash at this rate biweekly is optimal for greater pod length and girth.

Table 8. Average pod lengths of green gram MI6

Average Pod Length	
Treatments	Pod length (cm)
T ₁	9.95±0.08 ^c
T ₂	10.45±0.02 ^b
T ₃	10.54±0.02 ^b
T ₄	10.77±0.1 ^b
T ₅	11.27±0.17 ^a
T ₆	9.26±0.06 ^d

*Values are means ± standard deviation (n = 4). *Means with the same letters are not significantly different at P > .05 within the treatments*

Table 9. Average pod girths of green gram MI6

Average Pod Girth	
Treatments	Pod Girth (cm)
T ₁	2.03±0.01 ^d
T ₂	2.13±0.01 ^c
T ₃	2.17±0.01 ^c
T ₄	2.23±0.02 ^b
T ₅	2.29±0.02 ^a
T ₆	2.06±0.01 ^d

*Values are means ± standard deviation (n = 4). *Means with the same letters are not significantly different at P > .05 within the treatments*

3.3.4 Number of seeds per pod

There was a significant increase ($p<0.05$) in seeds per pod. The highest was in T5 (12±0.22), with 75% vermiwash and ½ dose of inorganic fertilizer (Table 10). Jaybhaye and Bhalerao (2015) reported similar findings, noting that vermiwash increased seeds per pod in black gram. Vermiwash from 100% cow dung significantly impacted growth and yield, leading to the highest seed yield [33]. Foliar application of vermiwash at a rate of 75% with half the dose of inorganic fertilizer at two-week intervals would be the best method to obtain a higher number of seeds.

Table 10. Average number of seeds per pod of green gram MI6

Number of Seeds per Pod	
Treatments	Number of Seeds per Pod
T ₁	9.78±0.1 ^d
T ₂	10.93±0.06 ^c
T ₃	11.05±0.06 ^{bc}
T ₄	11.50±0.09 ^b
T ₅	12.00±0.22 ^a
T ₆	9.53±0.09 ^d

Values are means ± standard deviation (n = 4). *Means with the same letters are not significantly different at P > .05 within the treatments

3.3.5 Weight of 100 seeds

There was a significant increase in 100-seed weight in T5 (7.18±0.10 g), 1.2 times higher than control T2 (6.05±0.07 g), which had full inorganic fertilizer (Table 11). However, a 100% vermiwash rate reduced 100-seed weight in green gram. Thus, 75% vermiwash with 50% inorganic fertilizer is optimal. This is likely due to essential and trace nutrients and growth regulators enhancing photosynthesis and bio-physiological conditions. These findings align with Krishnaveni *et al.* (2021), Ansari *et al.* (2024), and Joshi *et al.* (2022) [34, 35, 36]. Kumar and Pandey (2020) noted that nutrition supplementation is crucial for improving pulse seed yield [37].

Table 11. 100 seeds weight of green gram MI6

100 Seeds Weight	
Treatments	100 Seeds Weight (g)
T ₁	5.13±0.06 ^c
T ₂	6.05±0.07 ^b
T ₃	6.40±0.11 ^b
T ₄	6.90±0.09 ^a
T ₅	7.18±0.10 ^a
T ₆	5.30±0.18 ^c

Values are means ± standard deviation (n = 4). *Means with the same letters are not significantly different at P > .05 within the treatments

3.3.6 Total yield

Sun-dried total seed weight of green gram significantly increased (p<0.05) with foliar vermiwash application. The highest weight was in T5 (212±1.49 g) with ½ doses of basal and top dressings plus 75% vermiwash. The lowest was in T6 (94.2±0.82 g) with ½ doses and 100% vermiwash (Figure 2). Thus, 75% vermiwash at two-week intervals was the best for maximizing dry weight. This likely resulted from enhanced photo-assimilation and translocation, producing larger, higher-quality seeds [38].

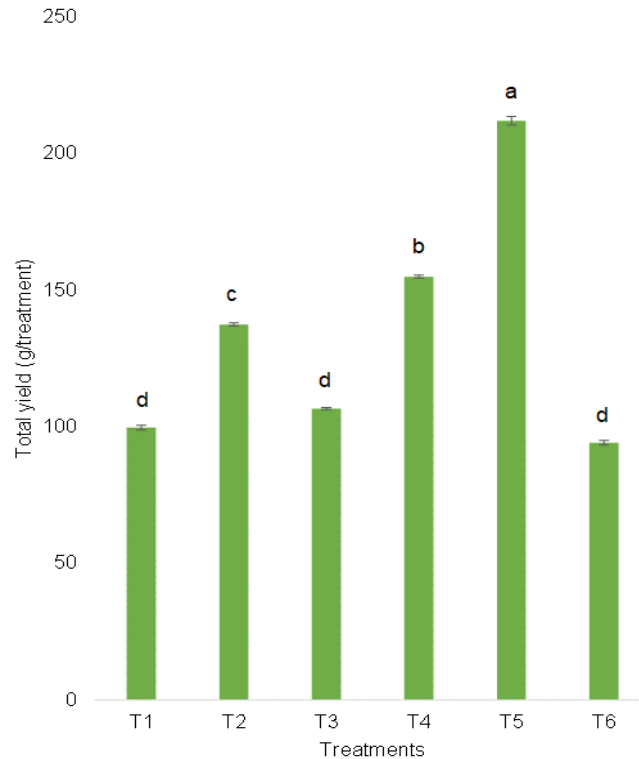


Fig. 2. Total weight of green gram MI6 (*Vigna radiata*) under different fertilizer treatments. Error bars indicate \pm standard deviation (n=4). Means with the same letters are not significantly different at $P > 0.05$ within the treatments.

4. CONCLUSIONS

This study suggests that the application of 75% vermiwash in combination with a 50% dosage of the recommended inorganic fertilizer enhances both vegetative and yield parameters in the green gram variety MI6. Alternatively, 75% vermiwash as a foliar application, along with half the dosage of inorganic fertilizer, can reduce the DoA-recommended inorganic fertilizer dosage while maintaining the same growth and yield in the green gram variety MI6.

REFERENCES

1. KamannavarPY, VijayakumarAG, Revanappa SB, Ganajaxi M, ArunkumarKPH, Salimath PM. Genotype and environment interaction in mung bean *Vigna radiata* cultivars grown in different agro-climatic zones of Karnataka. *Electronic Journal of Plant Breeding*. 2011;2(4):501-505.
2. DzudieT, HardyJ. Properties of flours prepared from common beans and mung beans. *Journal of Agricultural and Food Chemistry*. 1996;44(10):3029-3032. Available: <https://doi.org/10.1021/jf9504632>

3. Marasinghe Irosha. Analysis of productivity of green gram and cowpea in Sri Lanka: 2000-2018 Prepared by Analysis of Productivity of Green gram and Cowpea in Sri Lanka:2000- 2018. 2021.
4. JandaikS, KumarV, ThakurP. Vermiwash Plant growth enhancer and antifungal agent. International Journal of Extensive Research. 2015;2:38-41.
5. AlimiT, AjewoleOC, AwosolaO, IdowuEO.Organic and inorganic fertilizer for vegetable production under tropical conditions. Journal of Agricultural and Rural Development. 2007;1: 120-136.
6. GruhnP, GolettiF, YudelmanM.Integrated Nutrient Management, Soil Fertility and Sustainable Agriculture: Current Issues and Future Challenges. International Food Policy Research Institute, Washington DC, USA. 2000.
7. OjeniyiSO.Effect of long-term NPK application on secondary and micronutrient content of coffee carephora. Plant and Soil. 1981; 60:477-480.
Available: <https://doi.org/10.1007/B F02149644>
8. UsmanM, MaduVU, AlkaliG. The Combined Use of Organic and Inorganic Fertilizers for Improving Maize Crop Productivity in Nigeria. International Journal of Scientific and Research Publications. 2015; 5(10).
9. SharmaS, Pradhank, SatyaS, VasudevanP. Potentiality of earthworms for waste management and in other uses. Journal of American Science. 2005;1(1):4-16.
10. RajasooriyaAPS, KarunarathnaB. Application of vermiwash on growth and yield of green gram (*Vigna radiate*) in sandy regosol. AGRIEAST. Journal of Agricultural Sciences. 2020;14(2):31–42.
Available: <http://doi.org/10.4038/agriest.v14i2.95>
11. Murugesan,Rajan MR. Influence of Vermiwash on Germination and Growth of Cow Pea *Vigna Ungiculata* and Rice *Oryza Sativa*. IOSR Journal of Pharmacy (IOSRPHR). 2012;2. 31-34.
Available: 10.9790/3013-26403134.
12. VijayaKS, Seethalakshmi S. Contribution of Parthenium vermicompost in altering growth, yield and quality of *Ablelmoschus esculentus*. Advanced Biotechnology. 2011;11(2):44-47.
13. JaybhayeMM, BhaleraoSA.Influence of vermiwash on germination and growth parameters of seedlings of green gram (*Vigna radiata* L.) and Black gram (*Vigna mungo* L.). International Journal of Current Microbiology and Applied Science. 2015; 4(9):635-643.
14. VijitharanS, SasakiN, VenkatappaM, TripathiNK, Abel, TsusakaTW. Assessment of Forest Cover Changes in Vavuniya District, Sri Lanka: Implications for the Establishment of Subnational Forest Reference Emission Level. Land. 2022;11(7):1061.
Available: <https://doi.org/10.3390/land11071061>
15. BremnerJM, MulvaneyCS.Methods of Soil Analysis. Part 2. Agronomy, 2nd Edition. American Journal of Soil Science. Society, Madison, WI. 9:595-624.1982.
16. ToorMD, AdnanM, RehmanFU, Tahir R, Saeed MS, Khan AU, PareekV. Nutrients and their importance in agriculture crop production; A review. Indian Journal of Pure and Applied Bioscience. 2021; 9(1):1-6.
Available: <http://dx.doi.org/10.18782/2 582-2845.8527>

17. AwadhpersadVR, Ori L, Adil Ansari A. Production and effect of vermiwash and vermicompost on plant growth parameters of tomato (*Lycopersicon esculentum* Mill.) in Suriname. International Journal of recycling organic waste in agriculture. 2021; 10(4):397-413.
Available: <https://doi.org/10.30486/ijrowa.2021.1911898.1148>
18. ChattopadhyayA. Effect of vermiwash of *Eisenia fetida* produced by different methods on seed germination of green mung, *Vigna radiata*. International Journal of Recycle Organic Waste Agriculture. 2015; 4(4):233-237.
Available: <https://doi.org/10.1007/s40093-015-0103-5>
19. ParkerGG. Tamm review: Leaf Area Index (LAI) is both a determinant and a consequence of important processes in vegetation canopies. Forest Ecology and Management. 2020; 477:118-496.
Available: <https://doi.org/10.1016/j.foreco.2020.118496>
20. RasheedM, AbidH, TariqM. Growth analysis of hybrid maize as influenced by planting techniques and nutrient management. International Journal of Agriculture and Biology.2004; 5(2):169-171.
21. AwadhpersadVRR, OriL, AnsariA.Production and effect of vermiwash singly and in combination with vermicompost on the growth, development and productivity of tomato in the greenhouse in Suriname.Asian Journal of Agriculture. 2021; 5(1).
Available: <https://doi.org/10.13057/asianjagric/q050105>
22. JoshiD, YadavLR, RatoreBS, SrivastavaH, VermaRS, GurjarBS, YadavM, SharmaC, KarolA.Growth and Yield of Urdbean Influenced by Vermicompost and Vermiwash. International Journal of Plant & Soil Science.2023; 35(18):1831-1837. Available: <https://doi.org/10.9734/ijpss/2023/v35i183465>
23. SamirajaDSMMSM, Harris KD, AttanayakaAMKDM.Some Agronomic Factors as Influenced by the Application of Cattle and Poultry Manures along with Foliar Application of Vermiwash in Okra (*Abelmoschus Esculentus* L. Moench) Cv. P-11. World Journal of Current Scientific Research.2021; 1(1):1-6.
24. VardhanAV, SinghD, YadavA, BahadurV, ShuklaPK, LawrenceR.Effects of Vermiwash and different growing media on germination, seedling growth & longevity of BER seeds. The Pharma Innovation International Journal.2022; 11(8):1781-1784.
25. SinghV, BellM.Genotypic variability in architectural development of mungbean (*Vigna radiata* L.) root systems and physiological relationships with shoot growth dynamics. Frontiers in Plant Science.2021; 12:725-915.
Available: <https://doi.org/10.3389/fpls.2021.725915>
26. ManyuchiMM, PhiriA, MuredziP.Effect of vermicompost, vermiwash and application time on soil micronutrient composition. International Journal of Engineering and Advanced Technology. 2013;2(5):90-98.
27. SundararasuK, JeyasankarA.Effect of vermiwash on growth and yield of brinjal (*Solanum melongena*). Asian Journal of Science Technology. 2014;5(3):171-173.
28. TaleshiK, ShokohfarA, RafeeM, NoormahamadiG, SakinejhadT. Effect of vermicompost and nitrogen levels on yield and yield component of safflower (*Carthamus tinctorius* L.) under late season drought stress. International Journal of Agronomy and Plant Production.2011; 2:15-22.

29. HarikaV, GajbhiyeRP, ThakreS, FusherR. Effect of foliar application of vermiwash and potassium nitrate on flower yield and quality of tuberose var. Prajwal. The Pharma Innovation Journal. 2023; 12(11):1190-1192.
30. PolaraKB, PonkiaHP, SakarvadiaHL, VekariaLC, BabariaNB. Effect of multi-micronutrient fertilizers on yield and micronutrient uptake by okra (*Abelmoschus esculentus* L.) grown on medium black calcareous soils of Saurashtra region of Gujarat. International Journal of Pure and Applied Bioscience. 2017; 5(6):258-264. Available: <http://dx.doi.org/10.18782/2320-7051.5350>
31. FernandezFL, ReyesVV, MartinezSC, HernandezSG, MenesesYJ, Ceballos JMR, DendoovenL. Effect of different nitrogen sources on plant characteristics and yield of common bean (*Phaseolus vulgaris* L.). Bioresource Technology. 2010; 101(1):396-403. Available: <https://doi.org/10.1016/j.biortech.2009.07.058>
32. AlamMN, JahanMS, AliMK, IslamMS, KhandakerSMAT. Effect of vermicompost and N P K S fertilizers on growth, yield and yield components of red amaranthus. Australian Journal of Basic and Applied Sciences. 2007; 1(4): 706-716.
33. KumarD, MasseyJX, SharmaSK, MundraSL, YadavSK. Vermiwash prepared from different combination of organic sources to improve growth and yield of blackgram (*Vigna mungo* (L.) hepper) for organic agriculture. Indian Journal of Agricultural Research. 2023; 57(5):630-634. Available: <https://doi.org/10.18805/IJARE.A-5630>
34. KrishnaveniSA, SupriyaC, SridharSM. Impact of foliar nutrition on the yield and economics of green gram (*Vigna radiata*). International Journal of Chemical Studies. 2021; 9(2):11-13. Available: <https://doi.org/10.22271/chemi.2021.v9.i2a.11843>
35. AnsariAA, AwadhpersadV, OriL. Use of vermicompost and vermiwash for the growth and production of tomatoes (*Lycopersicon esculentum* Mill.): A case study in Suriname. Earthworm Technology in Organic Waste Management, Elsevier. 2024; 135-162.
36. JoshiN, JoshiS, SinghS, SharmaJK, ShekhawatHS, SutaliyaR. Impact of organic nutrient management practices on growth and yield of mungbean. International Journal of Bio-resource and Stress Management. 2022; 13(12):1367-1373. Available: <https://doi.org/10.23910/1.2022.3253a>
37. KumarS, PandeyG. Biofortification of pulses and legumes to enhance nutrition. Heliyon. 2020; 6(3). Available: <https://doi.org/10.1016/j.heliyon.2020.e03682>
38. KunduR, MandalJ, MajumderA. Growth and production potential of green gram (*Vigna radiata*) influenced by rhizobium inoculation with different nutrient sources. International Journal of Agriculture Environment and Biotechnology. 2013; 6(3):344-350. Available: <https://doi.org/10.5958/j.2230-732X.6.3.012>
39. Ngwu Oliver. Effect of organic and inorganic fertilizers on the growth and yield of physic nut (*Jatropha curcas*). International Journal of advances in agricultural and environmental engineering. 2016; 3: 131- 135. Available: <http://dx.doi.org/10.15242/IJAAEE.U0316217>

40. OlsenSR, ColeCV, WatanabeFS,DeanLA. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. USDA Cir. No. 939.1954.
41. GargVK, KaushikP. Dynamics of biological and chemical parameter during vermicomposting of solid textile mill sludge mixed with cow dung and agricultural residues. *Bioresource Technol.*2004; 94: 203-209.
42. HaimiJ,HuthaV. Capacity of various organic residues to support adequate earthworm biomass in vermicomposting *Biology Fertilized Soil.*1986; 2: 23-27.
43. ElviraCA,SampedroL,BenitezE, NogalesR. Vermicomposting of sludges from paper mill and dairy industries with *Eisenia Andrei*: Apiolet scale study. *Biores. Technol.*1998; 63: 205-211.
44. WongJMC, Li. FangGX, WongMH. Feasibility of using ash residues composting materials for sewage sludge. *Environ. Technol.*1997; 18: 563-568.
45. Kaviraj, SharmaS. Municipal solid wastes management through vermicomposting employing exotic and local species of earthworm. *Biores. Technol.*2003; 90: 169-173.
46. ElviraCA, L.SampedroE, Benitez, NogalesR. Vermicomposting of sludges from paper mill and dairy industries with *Eisenia Andrei*: Apiolet scale study. *Biores. Technol.*1998; 63: 205-211.
47. TripathiG, BhardwajP. Comparative study on Biomass Production, Life Cycle and Efficiency of *Eisenia foetida* (Savigny) and *Lampitomaureitii* (Kingberg), *Biores. Technol.*2004; 92: 275-283.
48. VielM,SayangD,AndreL. Optimization of Agricultural, Industrial Wastes Management through In –vessel Composting, in: M. de Bertoldi, (ed.) *Compost: Production, Quality and Use.* Elseiver Appl. Sci. Essex.1987; 230-237.
49. MansellGP,SyersJK, GreggPEH. Plant availability of phosphorus in dead herbage ingested by surface casting earth worm *Soil Biol. Biochem.*1981; 13: 163 -167.
50. BenitezE,NogalesR,ElviraC,MasciandaroG, CeccantiB. Enzyme activity as indicators of the stabilization of sewage sludge composting with *Eisenia foetida*. *Biores Technol.*1999; 67: 297-303.