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VERMICOMPOST – A BETTER ORGANIC MANURE IN INTEGRATED PLANT NUTRIENT SYSTEM FOR *Vigna radiata* (MUNG BEAN)

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ABSTRACT

The mung bean (Vigna radiata L.) is a member of the Fabaceae family. It is a major grain legume widely farmed in tropical and subtropical regions worldwide. Mung bean is a versatile crop that responds well to fertilizers and low nitrogen requirements due to its leguminous nature. The present experiment evaluated the effects of different types of organic manure on mung bean growth, yield, and physicochemical properties to identify the best integrated plant nutrient management system. There were five treatments; T_1 application of inorganic fertilizer (DOAR), T_2– application of compost (10 mt/ha) and ¼ DOAR, T_3 – application of vermicompost (8 mt/ha) + ¼ DOAR, T_4 – application of cow dung (4 mt/ha) + ¼ DOAR and T_5 – no application of any fertilizers. Mung bean variety MI-06 was used as genetic material (raw seeding), and organic manure was added at the land preparation, and synthetic fertilizer was added as a split application. The variables such as plant height, number of pods per plant, seed yield, thousand seed weight, moisture content, protein content, and bulk density of the flour were varied among treatments. It was found that there were significant differences among treatments on all parameters except plant height and pH of the flour.. The highest number of seeds per pod, thousand seed weights, and total grain yield were recorded from vermicompost, which was not significantly different from inorganic fertilizer. Significantly lowest bulk density of flour was recorded from inorganic fertilizer, whereas others did not show a statistical difference. Interestingly, the significantly highest protein content was recorded from vermicompost, followed by the inorganic fertilizer. The present study suggested that applying a vermicompos to the integrated plant nutrient mixture could increase the quality and quantity of mung beans, especially yield and protein content.

Keywords: Mung bean, Physiochemical properties, Vermicompost

INTRODUCTION

Mung bean (*Vigna radiata L.*), also known as, green gram, is one of the most important pulse crops and an excellent source of high-quality protein (Patel et al., 2018; Mahalingam et al., 2018). It consists of about 25 % protein, almost 2.5-3.0 times more than cereals. Sprouted mung bean whole seed is used in South India for preparing curry or a savoury dish. India is the largest producer and consumer of pulses in the world. India primarily produces Bengal gram (chickpea), red gram (tur), lentil (Masur), mung bean (green gram), and black gram (urad). Pulses are the major source of protein for vegetarians, and crop residues are a major source of high-quality livestock feed. Mung bean has the edge over other pulses because of its high nutritive value, digestibility, and non-flatulent behaviour. It is grown principally for protein-rich edible seeds, which contain 24% crude protein, 56.7% carbohydrates, 1.3% fats, 3.5% minerals, 0.43% lysine, 0.1% methionine and 0.04% tryptophan (Kachroo, 1970).

Mung bean is one of the most important grain legumes in the traditional farming systems of Sri Lanka. It is one of the principal but cheapest protein sources and its importance as a component of the Sri Lankan diet has grown over the years. Mung bean contains a high percentage of easily digestible protein, and its essential amino acid composition is also complementary to the staple food, rice. In addition to being an essential source of human food and animal feed, mung bean also plays an important role in sustaining soil fertility by improving physical properties and fixing atmospheric nitrogen in the soil (Kumara et al., 2021).

The local production of mung beans has declined over the last two decades, and 49.8% of the total mung bean requirement is still being imported (Department of Customs, 2019). In this context, it is clear that increasing the production of mung beans is a must to achieve the government's target. However, in Sri Lanka, there is a large gap between the actual yield and the potential yield of mung bean due to various issues—i.e., unavailability of nutrient-rich soil, lack of quality seeds, unsuitable climatic factors, traditional cultivating practices, improper weed management, etc. Yield loss due to weed competition can significantly hinder achieving potential yield in most crops, including mung bean (Kumara et al., 2021).

Organic farming preserves the ecosystem. Symbiotic life forms are cultured ensuring weed and pest control and optimum soil biological activity, maintaining fertility. Organic farming neither demands synthetic fertilizers nor harmful chemicals (pesticides & fungicides) for controlling weeds, insects and pests. Synthetic fertilizers only are harmful to soil and the aerial environment because the inorganic fertilizers mainly contain major nutrients NPK in large quantities and neglect the use of organic manures and bio-fertilizers; hence have paved the way for deterioration of soil health and, in turn, ill-effects on plants, human being and livestock (Choudhry, 2005).

Using organic manures alone as a substitute for chemical fertilizers is not profitable and will not be adequate to produce the potential yields of of high-yielding varieties. The use of organic manures and inorganic fertilizers leads to increased productivity and sustains soil health for a more extended period (Alley et al., 2009). Although not useful as sole sources of nutrients, organic manures act as good complementary nutrient sources with inorganic fertilizers (Chaudhary et al., 2004), which have carried over to succeeding crops. Using organic manures alone or combined with chemical fertilizers will help improve the soils' physicochemical properties and efficiently use applied fertilizers to improve seed quality and quantity. Organic manures provide a suitable substrate for the growth of microorganisms and maintain a favourable nutritional balance and soil physical properties. It is recognized that combined sources of organic matter and chemical fertilizers play a key role in increasing soil productivity. Mung bean yield and quality can be improved by the balanced use of fertilizers and by properly managing the organic manures.

Currently, Sri Lankan agriculture policy focuses on minimizing synthetic fertilizer usage as much as possible, especially for field crops. The present research addressed such an objective under low synthetic fertilizer application with integrated plant nutrient management systems (IPNS). In this context, farmers have to face some difficulties in finding the correct type of organic manure in appropriate quantities to adopt the IPNS systems for mung bean cultivation. Considering the above facts, the present investigation was carried out to determine the effect of three types of organic manures and inorganic fertilizers in an integrated manner on the yield and physiochemical properties of the mung bean.

METHODOLOGY

Experimental site

The experiment was conducted in the field at Sri Lanka School of Agriculture, Vavuniya, and the study was conducted from September 2021 to February 2022.

Experimental procedure

Mung bean MI-06 was used as the genetic material of the study, and practised raw seeding. All the agronomic practices were carried out as recommended by the Department of Agriculture, Sri Lanka, except for fertilization. The field experiment was laid out in Randomized Complete Block design (RCBD) with five treatments and four replications. Each plot size was 2 m^2 and separated each other 1.0 m space within the blocks. Each plot contained 16 plants as experimental units. The experimental site was divided into four blocks based on the slope of the land. Each treatment was randomized for every block as four replicates. Different treatments and its description are mentioned in table 1.

Table 1: The treatment combination of the experiment

Treatment	Treatment Description
T1- IPNS Compost	Application of compost at 10 MT/ha and Urea – 8.75 kg/ha, TSP – 25 kg/ha and MOP – 18.75 kg/ha
T2 – DOAR	Application of Urea – 35 kg/ha, TSP – 100 kg/ha and MOP 7. kg/ha
T3- IPNS Vermicompost	Application of vermicompost at 8 MT/ha and Urea – 8.75 kg/ha, TSP – 25 kg/ha and MOP – 18.75 kg/ha
T4- IPNS Cow dung	Application of cow dung at 4 MT/ha and Urea – 8.75 kg/ha, TSP – 25 kg/ha and MOP – 18.75 kg/ha
T5- Control	Without any external fertilization

The compost rate was selected based on the DOAR. Cow dung and vermicompost rates were selected based on the N% (Alidadi et al., 2014), which was proportionate to maintain similar N% availability.

Data collection

Data were collected mainly on two aspects as growth/yield parameters and postharvest parameters. Growth and yield parameters include plant height, number of pods and grain yield. Postharvest parameters include both the physical and chemical properties of grains.

Growth and yield parameters

Plant height was measured using a meter ruler and recorded in centimetres. The plant height was taken from ground level to the tip of the shoot. The number of pods was counted per treatment.

Fully matured pods were harvested from 8 plants of each plot to avoid the border effect. Then grains were separated from the plant, and the dry weight of the grains was measured. All the weight measurements were taken using an analytical balance (0.1 grams).

Physical properties

Moisture content

Seed moisture content (SMC) is the amount of water in a seed. SMC is expressed in terms of the weight of water contained in the seed as a percentage of the total weight of the seed before drying, known as the wet-weight (wb) or fresh-weight basis (International Seed-Testing Association [ISTA] 2005).

$$SMC\ (\%\ wb) = \left\{\frac{wet\ weight - dry\ weight}{wet\ weight}\right\} \times 100$$

Weight

The fresh weight of 20 randomly selected seeds was recorded, and the mean values were computed. Dry weight: 20 randomly selected seeds were kept in a hot air oven at 105 °C overnight and their dry weight was recorded using electric balance. And the mean values were recorded.

1000 seeds weight

Collected seeds from the pods were counted and took the weight of the seeds and that weight was calculated for 100 seeds.

$$1000\ seeds\ weight = \{(weight\ of\ X\ number\ of\ seeds) \div X\} \times 1000$$

Number of seeds per pod

Seeds grow in groups, nestled within a pod or a several-seeded dehiscent fruit called a pod, and the number of seeds in the pods was collected and counted manually.

Bulk density

The bulk density of a powder is determined by measuring the volume of a known mass of powder sample, which may have been passed through a sieve into a graduated cylinder.

Pass a quantity of powder sufficient to complete the test through a sieve with apertures greater than or equal to 1.0 mm, if necessary, to break up agglomerates that may have formed during storage; this must be done gently to avoid changing the nature of the material. Into a dry graduated cylinder of 250 mL (readable to 2 mL), gently introduce, without compacting, approximately 100 g of the test sample (m) weighed with 0.1 percent accuracy. Carefully level the powder without compacting, and read the apparent unsettled volume (V_0) to the nearest graduated unit. Calculate the bulk density in g per mL by the formula. Generally, replicate determinations are desirable for the determination of this property. If the powder density is too low or too high, such that the test sample has an apparent untapped volume of either more than 250 mL or less than 150 mL, it is not possible to use 100 g of powder sample. Therefore, a different amount of powder has to be selected as a test sample, such that its apparent untapped volume is 150 mL to 250 mL (apparent volume greater than or equal to 60 percent of the total volume of the cylinder); the mass of the test sample is specified in the expression of results. For test samples having an apparent volume between 50 mL and 100 mL, a 100 mL cylinder readable to 1 mL can be used; the volume of the cylinder is specified in the expression of results.

Chemical properties

Proteins

30 mg of samples were weighed into Kjeldhal digestion flasks. 1.3g of K_2SO_4 and 40mg of HgO were added as a catalyst mixture, followed by 25 ml of concentrated H_2SO_4. The samples (in 27 Kjeldhal digestion flasks) were left to digest in a heating digester for 4 hours after connecting to the fume trap and attached to the pump. Flasks were left to cool for one hour.

Samples were dissolved in the minimum amount of ammonia-free distilled water and transferred to a semi-micro Kjeldhal distillation apparatus that had been previously conditioned by slowly passing steam for several minutes. 8 ml of NaOH solution was added to the flask. The indicator was prepared by mixing 2 mL of methyl red solution with 1 ml of methylene blue solution. 5ml of 4% Boric acid solution and three drops of the indicator were taken into a titration flask and kept at the end of the digestion apparatus to trap the ammonia. Steam was passed through the flask until about 20ml of distillate was recovered.

All distillates were titrated with the standard HCl solution (0.02M HCl). Three replicates were done. Plate 3.4 shows the colour changes (green) during distillation, and plate 3.5 shows the colour changes (from green to purple) after being titrated with HCl solution. Protein percentage was calculated using the following equation protein (%) = Nitrogen percentage x 5.70 (Source: Modification of AOAC official method 920.87)

$$\text{Nitrogen (\%)} = \frac{\text{(Sample tite-Blank titer)}\times\text{Molarity of HCl*14}}{\text{Weight of the sample}} \times 100\text{N (\%)}$$

PH

The pH was measured by making a 10% (w/v) flour suspension of each sample in distilled water. Each sample was then mixed thoroughly in a plastic beaker, and the pH was recorded with an electronic pH meter.

Data Analysis

Collected data were analyzed using analysis of variance (ANOVA) procedures by using the statistical package Minitab 18 version. The difference between the treatments was compared using Duncan's multiple range test (DMRT) at a 5% significance level.

RESULTS AND DISCUSSION

Vegetative parameters

The results showed no significant differences between the treatments on plant height during the entire growth period. The plant height at 30 days after sowing (DAS) differed significantly due to the combined application of organic and inorganic fertilizers. It was revealed that there were significant differences between the treatments on pod number. The highest and similar average number of pods were recorded from compost, vermicompost and DOAR (12 pods), whereas the lowest was observed from cow dung (11.7) and control (12.2), respectively (Table 2).

The number of pods per plant of Mungbam is influenced by organic and inorganic fertilizers, as reported by Armin et al. (2016). Because of the diverse combinations of organic and inorganic fertilizer doses, the number of pods per plant varied significantly. A combination of vermicompost and inorganic fertilizers produced the highest number of pods per plant. When organic and inorganic fertilizers were used together, the number of pods per plant grew more than when inorganic fertilizer was used alone. This could be resulted by combining organic and inorganic fertilizers enhances soil's physical qualities, resulting in improved soil health and nutrient utilization efficiency.

Higher gain yield in mung bean was obtained in the treatments where vermicompost (312.5 ± 24.9 g) and was not significantly different from DOAR (300.0 ± 18.1 g) (Table 2). Both treatment compost and cow dung had similar grain yields of 262.5 g, which were not significantly different from DOAR (Table 2). Armin *et al.* (2016) mentioned that the seed yield of mung bean per plant showed significant variation due to the different combinations of organic and inorganic fertilizer doses. That study showed significant performance from vermicompost-based integrated fertilization compared to poultry manure-based integrated fertilization. Furthermore, Patil (1998) reported that in groundnut, the maximum seed yield plant^{-1} was recorded with the application of vermicompost at 2.50 t per ha + inorganic fertilizer, the application of inorganic fertilizer alone. The results of the present study and literature confirm that combining vermicompost and inorganic fertilizers increased the seed yield of plant-1 than using inorganic fertilizers alone.

Organic fertilizers aid in increasing the organic matter content of the soil, lowering bulk density and minimizing compaction. Plants are provided with an appropriate growing environment, allowing for improved growth and development. Many scientists discovered similar results while trying various crops. Channaveerswami (2005) observed that a combination of organic and inorganic fertilizers performed better in groundnut, while Rajkhowa et al. (2002) indicated that inorganic fertilizers performed better in mung beans.

Physiochemical parameters

The study showed a significant difference in all the tested physiochemical properties against different treatments (Table 2). The 100 seed weight varied from 45.2 g to 52.0 g among treatments. The higher values in thousand seed weights were obtained in the treatment DOAR as 52.0 g, but that does not significantly different from the vermicompost (52,7 g). Cow dung, compost and control did not significantly differ in 1000 seed weight (Table 3). Karpagam and Rajesh (2014) mentioned that 1000 seed weight is mainly affected by grain shape, grain size and the filling of kernels. In this regard, grain size and shape are similar since the same variety was used. The possible reason for having variation in 1000 seed weights could be the N utilization and availability. Significantly lowest moisture content was recorded from compost (9.8 %) treatment, whereas it was highest in cow dung (12.32 %). The samples' bulk density varied between 0.55 to 0.66 g/cm^3. Significantly lowest bulk density was recorded from the treatment DOAR. All the other treatments did not significantly differ in bulk density (Table 3).

Amir et al. (2016) found that organic and inorganic fertilizers influenced data on mungbean's 1000-seed weight (g) in a Mungbam experiment. The diverse combinations of organic and inorganic fertilizer doses resulted in significant variance in 1000-seed weight. The results show that using organic and inorganic fertilizers raised the 1000-seed weight more than using only inorganic fertilizers. This could result from IPNS systems, which include plant nutrients, growth-promoting chemicals, and beneficial microorganisms, which provide favourable soil conditions that improve nutrient utilization efficiency when combined with inorganic fertilizers.

The protein content of the treatments varied from 20.84 to 26 28 g/100g (Table 3) The highest value for protein content was recorded from vermicompost followed by cow dung (25.40 g/100g), DOAR (22.91 g/100g), compost (22.42 g/100g) and control. The pH value did not change much among the treatments, ranging from 6.38 to 6.61 (Table 3).

Overall, the integrated nutrient management treatment with vermicompost had a high 1000 seed weight, bulk density and protein content competitive with only inorganic fertilizer treatment (Table 3). And further yield and the number of pods also had a similar observation (Table 2).

Table 2: Effect of integrated nutrient management on plant height, pod number and yield attributes of mung bean

Treatment	Plant Height (cm)				Pod Number	Grain Yield (g) (MT/ha)
	2nd week	4th week	6th week	8th week		
IPNS Compost	11.9 ± 1.1 [a]	14.6±1.6 [a]	17.7±1.5 [a]	18.2±1.3 [a]	12.0 ± 0.0 [a]	262.5 ± 17.5[bc] (1.32 MT/Ha)
DOAR	10.4± 0.7 [a]	13.6±0.6 [a]	16.4±0.9 [a]	18.1±0.7 [a]	12.0 ± 0.0 [a]	300.0 ± 18.1 [ab] (1.50 MT/Ha)
IPNS Vermicompost	11.1±0.9 [a]	15.0±1.3 [a]	18.5± 1.1[a]	19.7±0.4 [a]	12.0±0.0 [a]	312.5 ± 24.9 [a] (1.56 MT/Ha)
IPNS Cow dung	10.1± 0.2 [a]	12.9±0.5 [a]	16.6±1.3 [a]	17.7±1.2 [a]	11.7± 0.2 [a]	262.5 ± 18.5 [bc] (1.32 MT/Ha)
Control	9.5± 0.4 [a]	12.1±0.1 [a]	14.4±0.5 [a]	17.7±0.4 [a]	11.2± 0.2 [b]	237.5 ± 11.0 [c] (1.18 MT/Ha)

Values represent the mean ± standard error of four replicates. Means followed by the same superscripts in the same column are not significantly different at 0.05 probability level according to DMRT. Yield values in MT per hectare were mentioned within bracket.

Table 3: Effect of integrated nutrient management on physiochemical properties of mung bean grains

Treatment	Physical parameters			Chemical parameters	
	Moisture (%)	Thousand seed weight (g)	Bulk density (g/cm3)	pH	Protein content (g per 100g)
IPNS Compost	9.80 ± 0.03 [e]	46.2 ± 0.75[b]	0.66 ± 0.01[a]	6.61 ± 0.08[d]	22.42 ± 0.13[c]
DOAR	10.47 ± 0.07[c]	52.0 ± 1.23[a]	0.55 ± 0.01[d]	6.52 ± 0.06[e]	22.91 ± 0.16[c]
IPNS Vermicompost	10.27 ± 0.06 [d]	51.7 ± 1.03 [a]	0.65 ± 0.01[a]	6.39 ± 0.09[b]	26.28 ± 0.15[a]
IPNS Cow dung	12.32 ± 0.13 [a]	44.5 ± 0.29[b]	0.66 ± 0.01[a]	6.38 ± 0.06[c]	25.40 ± 0.18[b]
Control	10.90 ± 0.05 [b]	45.5 ± 0.29[b]	0.65 ± 0.01[a]	6.51 ± 0.03[a]	20.84 ± 0.17[d]

Values represent the mean ± standard error of four replicates. Means followed by the same superscripts in the same column are not significantly different at 0.05 probability level according to DMRT.

Interestingly high protein content was recorded from vermicompost treatment could result from high nutrient utilization. The two kinds' distinct responses to fertilizer treatment in terms of vegetative and physiochemical characteristics demonstrate that the fertilization method is a major factor in determining cowpea output. According to an experiment conducted by Abedi et al. (2010), nitrogen fertilizer has no significant impact on wheat seed protein content. However, compost had a substantial effect on seed protein, with the 60 MT compost ha $^{-1}$ treatment yielding the highest amount of seed protein. According to the findings, there were no significant variations in seed gluten concentration between the nitrogen and compost treatments. The results on seed water-soluble protein and gluten contents were unaffected by the N approach, according to Abedi et al. (2010).

These findings are consistent with previous researchers who discovered that N feeding has a considerable effect on the albumin-globulin amount (Dupont and Altenbach 2003; Pedersen and Jorgensen 2007;). As previously stated, wheat grain protein content is influenced by genotype, growing system, and environmental circumstances. In other words, while increasing nitrogen availability boosted all protein components significantly, the effect on grain protein varies on the cultivar seeded, due to various utilization of available soil nitrogen, particularly during stem elongation. One of the most important findings was a considerable increase in grain protein content when organic material was utilized in conjunction with nitrogen fertilizer.

The study results reveal that vermicompost-based IPNS perfume is better than the other IPNS in mung bean crops cultivated in the Jaffna area. Senarathne (2017) investigated the feasibility of producing vermicompost in low-country dry zone areas in Sri Lanka. In that study, problematic aquatic weeds were used for the preparation of compost and vermicompost. The results showed that vermicompost was superior in all the properties compared to compost in the same substrate. Further, the study revealed that aquatic weeds such as *Salvinia molesta*, *Eichhornia crassipes* and *Lagenandra toxicaria* , which are readily available in the low country dry zone, can be successfully used to produce vermicompost under the low cost of production (Senarathne 2017).

The literature confirms that vermicompost is better because it contains most macronutrients, and its nutrient composition is often greater than the regular garden soil and compost. Vermicomposting increases soil fertility and water resistance and helps in germination, plant growth, and crop yield (Olle, 2019). Vermicompost contains beneficial bacteria (102-106 per gram of vermicompost of Actinomycetes, Azotobacter, Rhizobium, Nitrobacter, and Phosphate Solubilizing Bacteria) and plant growth regulators (auxins, cytokinins, and gibberellins). (Chaulagain et al., 2017).

The present combination showed competitive performances against fully inorganic cultivation and could be replaced by the vermicompost-based IPNS system. The reason for such an observation could result from improving soil properties and increasing N fertilizer use efficiency. Moreover, which may create a healthy microenvironment in the root zone where habitat for beneficial microorganisms and support for the symbiotic relationship in root nodules. Further, the present study suggests assessing the effect of continuous application of vermicompost-based IPNS on soil properties (physical, chemical and biological) and yield and postharvest properties.

CONCLUSIONS

The present study on integrated plant nutrient system (IPNS) on mung bean has proved that it caused significant effects on pod number, grain yield, 1000-seed weight, grain pH, bulk density, moisture content and bulk density except for plant height. Based on the results, it could be concluded that the application of vermicompost-based IPNS can be replaced fully inorganic without affecting yield and physicochemical properties.

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