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Marketable Pod Yield of Vegetable Cowpea (*Vigna unguiculata*) as Influenced by Organic Manures Fermented with EM Solution

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Abstract: An experiment was conducted at a net house in the Eastern region of Sri Lanka to study the influence of organic manures with EM (effective microorganisms) on marketable yield of vegetable cowpea (*Vigna unguiculata*) *cv BS1*. The treatments included different fertilizer applications from three sources of animal manures viz: cattle, goat and poultry manures separately mixed with rice bran and paddy husk then fermented with EM solution (EM-Bokashi fertilizers) while unfertilized plot and application of recommended chemical fertilizer both served as first and second controls respectively. Each EM-Bokashi fertilizer was applied as basal and top dressing applications at rate of 300 g/m^2 which was applied 14 days before planting and 30 days after planting respectively. The results revealed that EM-Bokashi significantly ($p<0.05$) increased the number of nodules, length and number of marketable (green) pods, dry weight of plant parts, marketable pod yield and harvest index compared to chemical and non-fertilizer applications. Plants fertilized with goat manure EM-Bokashi had highest number of nodules (31), fresh (174.3 g) and dry (22.8 g) weights of marketable pods per plant and harvest index (70.2%) compared to those with cattle or poultry manure EM-Bokashi. In summary, application of organic manures fermented with EM solution especially goat manure EM-Bokashi fertilizer was more effective in improving growth and marketable pod yield of vegetable cowpea compared to chemical fertilizer and unfertilized plots in vegetable cowpea cultivation.

Keywords: Effective microorganisms, marketable yield, organic manure, vegetable cowpea.

INTRODUCTION

Vegetable cowpea (*Vigna unguiculata*) is grown by poor farmers those have insufficient resources and information on the agronomic practices for crop cultivation [1]. It is a good quality protein source and an important component of the human diet in developing counties. The pods of vegetable cowpea are good source of calcium, magnesium, potassium and iron and also contain high in nutrients as a result most of the people use for consumption [2]. It is usually cultivated as an intercrop with major cereals mainly in developing world [3]. The increase in the world's population leads to greater need to increase the produce yield therefore farmers have adopted the strategy of increasing crop yields by applying large amounts of chemical fertilizers and pesticides however the excess applications of chemical inputs are being a negative effect on environment and crop quality and also reduced crop yield [4]. In addition, the increasing cost of agricultural chemicals has direct impact on farmer's profit. To overcome these problems, researchers suggest alternatives to chemical based conventional agriculture. Effective use of organic fertilizers can lead to significantly reduce the application of chemical inputs without affecting crop yields in a sustainable way [5].

Organic fertilizers are prepared from animal waste or green waste with the other ingredients such as paddy husk and rice bran [4]. Paddy husk is added to compost as a carbon-rich substance and as a porous material which increases the nutrient holding capacity, improves soil structure and acts as harboring place for the microorganisms [6]. Rice bran is a good stimulant for the fermentation and contains excellent nutrients for microorganisms [7]. Generally the use of at least three types of organic matters is employed in preparing organic fertilizers in order to increase microbial diversity [8]. Microbial fertilizers can be efficiently used by farmers to increase yield and quality of crops and this practice can more or less clean the environment and lead to be productive land [9]. EM application showed beneficial effects on crop growth and yield of rice [10] wheat [11] mungbean and vegetables [12]. Therefore in this study, an attempt was made to study the effect of organic manures fermented with EM solution (EM-Bokashi) on marketable pod yield of vegetable cowpea in the Eastern region of Sri Lanka. The objectives include to study the response of animal manures EM-Bokashi in cowpea cultivation and to select most suitable organic manure for better green pod yield of vegetable cowpea.

MATERIALS AND METHODS

The experiment was carried out in 2009-2010 as a net house trial in the Eastern region of Sri Lanka which locates in the latitude of 7^o 43' and the longitude of 81^o 42'. It comes under the agro-ecological zone of the low country dry zone. The annual mean temperature is 30±2^{o}C and average rainfall is around 1600 mm. The relative humidity is 70±10%. The chemical and physical properties of soil used in this experiment are 6.3 pH, 31.8 µs/cm electrical conductivity, 0.65% organic matter content, 0.014% N, 0.12% K, 0.06% P,

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26.4% water holding capacity and 43.4% porosity. EM (effective micro-organisms) solution was prepared by mixing 240 ml EM super^{TM} (SEEDS Ltd, Sri Lanka), 240 ml molasses and 24 L distilled water at a ratio of 1:1:100 (v/v/v) as recommended by Kyan *et al.* [8]. This mixture was fermented under air tight condition for two days, before being used for preparation of EM-Bokashi (organic manures fermented with EM solution). Three different types of EM-Bokashi were prepared using different animal manures such as cattle; poultry and goat manures but other materials (rice bran and paddy husk) used were same. Each EM-Bokashi was separately prepared using 5 kg animal manure, 2.5 kg rice bran and 2.5 kg paddy husk at a ratio of 2:1:1 (w/w/w) and EM solution (6 L) as recommended by Kyan *et al.* [8].

Soil was filled into each polythene bag (40 cm height and 25 cm diameter) and arranged in a completely randomized design with 15 replications for each treatment at spacing of 60 cm × 20 cm. The treatments were non-fertilizer (T_1), chemical fertilizer (T_2), cattle manure EM-Bokashi (T_3), goat manure EM-Bokashi (T_4) and poultry manure EM-Bokashi (T_5). Two vegetable cowpea seeds of high yielding variety, BS1 which is an annual herb, were seeded in each bag. As a basal application, recommended chemical fertilizer (0.54 g of urea, 1.56 g of triple super phosphate and 0.76 g of muriate of potash applied to each bag) was applied two days before seeding while 0.54 g of urea as top dressing was applied at the 30 days after seeding to T_2 treatment. As recommended by Kyan *et al.* [8] for field crop in the tropical regions, each animal manure EM-Bokashi at the rate of 300 g/m^2 was applied 14 days before seeding and 30 days after seeding as basal and top dressing applications to T_3, T_4 and T_5 treatments, respectively.

Plants from each treatment were uprooted at 3rd, 6th and 9th weeks after planting to count the number of nodules and also to measure leaf area (cm^2) which was measured using portable leaf area meter (LI 3100, LI-COR inc., USA). At harvesting time, plants along with marketable (green) pods were uprooted thereafter number, length and fresh weight of green pods were recorded. Subsequently leaves, stem, roots, nodules and pods were separated and their dry weights were recorded after drying in oven at 105 ^{o}C over night. Finally harvest index described as the cumulative edible biomass expressed as a percent of total plant biomass was calculated. The collected data were analyzed statistically using SAS package. Data were first subjected to Shaio-Wilk test at p=0.05 for normality before the analysis of variance and log and square root transformation techniques were subjected on data when necessary. The means were compared using Duncan's Multiple Range Test at 5% significant level.

RESULTS AND DISCUSSION

Leaf Area

The result revealed that plants fertilized with goat manure EM-Bokashi had significantly (P<0.05) higher leaf area (330.4 cm^2) compared to other treatments at 3rd week (Table **1**) but there was no significant difference in leaf area between T_4 (goat manure EM-Bokashi) and T_5 (EM-poultry manure) at 6th and 9th weeks while lower values were remarkably recorded in other treatments. However, all animal manure EM-Bokashi fertilizers gave relatively higher leaf area than non-fertilizer (T_1) and chemical fertilizer (T_2). This is supported by Sahain *et al.* [13] who stated that in general EM biostimulant significantly increased leaf area in radish.

Number of Nodules

Significant differences (P<0.05) were found in a numbers of nodules recorded at different weeks (Table **2**). Goat manure EM-Bokashi (T_4) showed remarkably (P<0.05) higher number of nodules compared to other treatments at 6th weeks but at 9th week, T_4 significantly differed from other treatments except T_5. This result is endorsed by Yan and Xu [14] and Javaid *et al.* [15] who found that EM-bokashi fertilizer remarkably enhanced the nodule numbers in groundnut. Degree of atmospheric nitrogen fixation in legume crop depends on quantity of rhizobia available in the soil [16]. EM application boosted rhizobial population subsequently it increased nodule number in bush bean and mung bean [12].

The results indicated that number of nodules in T_4 was recorded higher mean value compared to other treatments at each growth period of vegetable cowpea. This is strengthen with the previous report [7] that poultry manure has a higher amount of nitrogen than cow and goat manures but goat

Table 1. Effect of Different Organic Manures with EM on Leaf Area of Vegetable Cowpea

	Leaf area (cm^2)		
Treatments	**3 weeks**	**6 weeks**	**9 weeks**
Unfertilized plot (T_1)	138.7 ± 8.0c	470.3 ± 3.5c	473.7 ± 17.0b
Chemical fertilizer (T_2)	153.5 ± 6.4c	651.8 ±5.0b	666.1 ± 12.1b
Cattle manure EM (T_3)	202.3 ± 0.6b	709.2 ± 1.2b	700.0 ± 04.8b
Goat manure EM (T_4)	330.4 ± 0.8a	972.1 ± 8.5a	904.7 ± 12.7a
Poultry manure EM (T_5)	228.4 ± 6.8b	909.6 ± 0.7a	895.1 ± 15.1a
F test	*	*	*
CV%	5.7	4.5	11.1

Value represents mean ± standard error of three replicates. F test:-*: P<0.05; Means followed by the same letter in each column are not significantly different according to DMRT at 5% level.

Table 2. Effect of Different Organic Manures with EM on Nodulation of Vegetable Cowpea

Treatments	Number of nodules		
	3 weeks	6 weeks	9 weeks
Unfertilized plot (T_1)	06.7 ± 0.6b	12.0 ± 1.1c	08.7 ± 0.9c
Chemical fertilizer (T_2)	08.3 ± 0.6ab	13.7 ± 0.8c	12.3 ± 1.2c
Cattle manure EM (T_3)	10.3 ± 0.4ab	17.0 ± 1.7c	16.0 ± 0.6bc
Goat manure EM (T_4)	11.7 ± 0.4a	33.7 ± 0.8a	31.0 ± 3.0a
Poultry manure EM (T_5)	08.7 ± 0.8ab	25.7 ± 1.4b	24.3 ± 2.1a
F test	*	*	*
CV%	14.6	11.8	15.9

Value represents mean ± standard error of three replicates. F test:-*: P<0.05. Means followed by the same letter in each column are not significantly different according to DMRT at 5% level.

manure had high amount of potassium than cow and poultry manures. K fertilization enhanced the number of effective nodules per plant in most of legume crops tested [17] and the dry matter yield of soybean [18].

Marketable Pods

All three animal manure EM-Bokashi fertilizers gave similar results in length and number of harvested marketable pods (Fig. **1**) and significant varied (P<0.05) from the chemical and non-fertilizer treatments. There were remarkable variations (P<0.01) in fresh and dry weights of marketable pods per plant among the treatments. Yan and Xu [14] reported that the pod dry weight of groundnut fertilized with EM-bokashi was significantly higher than that with chemical fertilizer. In the present study, T_4 exhibited greater mean fresh (174.3 g) and dry (22.8 g) weights of green pods than other treatments. This may be due to the high amount of potassium presented in the goat manure as reported by Inckel *et al.* [7].

Plant Biomass

Biomass is an important parameter that has direct influences on crop yield. The EM-Bokashi treatments (T_3, T_4 and T_5) significantly increased (P<0.05) dry weight of pods than those in chemical and non-fertilizer application (Table **3**). This result proved with the findings of Yan and Xu [14] who

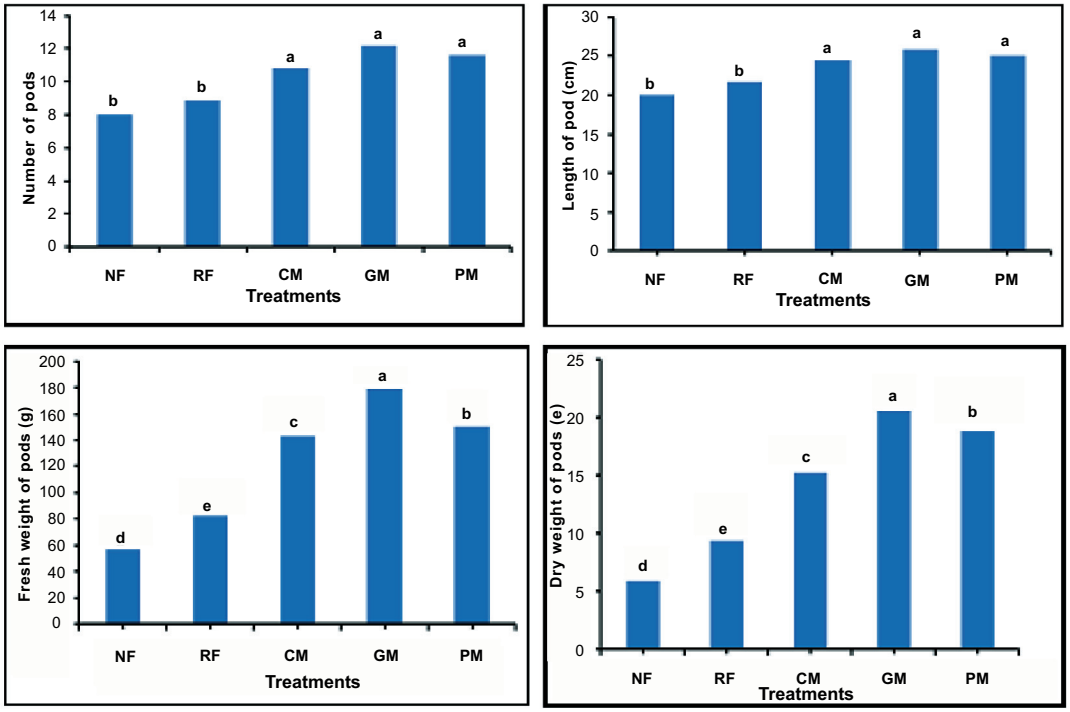

Fig. (1). Effect of different animal manure EM-Bokashi fertilizers on marketable pods of vegetable cowpea. Vertical bars show standard error of means. Values with different letters at their top show significant difference (P = 0.05) between treatments according to DMRT. NF: Non-fertilizer application, RF: Chemical fertilizer, CM: EM-cattle manure, GM: EM -goat manure, PM: EM-poultry manure.

Table 3. Effect of Animal Manure EM-Bokashi on Dry Weights of Plant Parts of Vegetable Cowpea

Dry weight (g) per plant				
Treatments	**Stem**	**Leaves**	**Root**	**Pods**
Unfertilized plot (T_1)	2.5 ± 0.6b	1.3 ± 0.3b	0.4 ± 0.1b	07.1 ± 0.1e
Chemical fertilizer (T_2)	3.4 ± 0.6b	1.7 ± 0.1b	0.4 ± 0.1b	07.1 ± 0.1e
Cattle manure EM(T_3)	4.9 ± 0.2ab	2.2 ± 0.2ab	0.8 ± 0.1ab	16.8 ± 0.3c
Goat manure EM (T_4)	5.4 ± 0.6a	2.9 ± 0.2a	1.1 ± 0.2a	22.8 ± 0.2a
Poultry manure EM (T_5)	5.1 ± 0.2a	2.2 ± 0.1ab	0.7 ± 0.1ab	20.7 ± 0.4b
F test	*	*	*	**
CV%	17.8	14.1	6.7	5.4

Value represents mean ± standard error of four replicates. F test:-**: P<0.01; *: p<0.05. Means followed by the same letter are not significantly different according to DMRS at 5% level

noted that dry weights of stem, leaves, root and pods of groundnut grown in EM-bokashi were significantly higher than those in chemical fertilizer. Zhao [19] reported that the EM-bokashi treatment increased germination, yield and total biomass of groundnut as compared to control. The results observed in the present study showed that increase of biomass was higher in goat manure EM-Bokashi than that in cow or poultry manure EM Bokashi fertilizers. This effect may be due to high level of potassium available in goat manure as stated by Inckel *et al.* [7]. Potassium is needed for the production of the energy carbohydrate, protein and lipid which express the higher plant biomass [20].

Marketable Yield

The pod yield response showed that T4 gave significantly higher pod yield followed by the T_5 and T_3 (Table **4**). The lowest yield was recorded in T_1. The result indicated that animal manure EM-Bokashi fertilizers produced more pod yield in plants than obtainable with chemical and non-fertilizer application. This result is confirmed by previous research worker who reported that commercial fruit yield per plant increased with increasing rate of potassium application [21-23]. Higa [24] reported that EM has the ability to accelerate the decomposition of organic materials thereby released additional available nutrients which provided favourable conditions of rhizophere for significantly increased crop yield in EM-Bokashi fertilized plants than in those with chemical and control treatments.

Harvest Index

The highest harvest index was recorded in the application of goat manure EM-Bokashi (T_4), followed by poultry manure EM-Bokashi (T_5) (Table **4**), while unfertilized treatment showed the lowest harvest index. Harvest index described as stated earlier. The application of EM and organic manures increased crop yield and improved physical characteristics of soil on rice-wheat rotation [25]. Also Bokashi with EM or Farm Yard Manure (FYM) with EM produced more yield and yield components comparable to those of chemical fertilizer treatment [26].

Table 4. Effect of Animal Manure EM-Bokashi on Marketable Yield and Harvest Index of Vegetable Cowpea

Treatments	Pod yield (kg/m^2)	Harvest index (%)
Unfertilized plot (T_1)	0.44 e	60.0e
Chemical fertilizer (T_2)	0.67 d	63.0d
Cattle manure EM (T_3)	1.11 c	66.2c
Goat manure EM (T_4)	1.45 a	70.2a
Poultry manure EM (T_5)	1.31 b	69.2b
F test	**	**
CV%	4.1	1.1

F test:-**: P<0.01.Means followed by the same letter are not significantly different according to DMRS at 5% level.

CONCLUSION

The results revealed that the plants fertilized with animal manure EM-Bokashi had significant improvement in leaf area, number of nodules, length and numbers of green pods, fresh and dry weights of marketable (green) pods, plant biomass, marketable pod yield and harvest index compared to chemical and non-fertilizer treatments. Among the different types of organic manures with EM, plants treated with goat manure EM-Bokashi recorded highest marketable pod yield and harvest index. According to the results obtained, it can be concluded that application of organic manure treated with EM solution was an effective organic fertilizer than chemical and non fertilizer application. However, among the EM-Bokashi fertilizers, goat manure EM-Bokashi gave better marketable (green) pod yield of vegetable cowpea grown on sandy regosol.

CONFLICT OF INTEREST

The author(s) confirm that this article content has no conflicts of interest.

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