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EFFECT OF COMBINED APPLICATION OF CATTLE MANURE AND EM ON THE YIELD AND YIELD COMPONENTS OF GROUNDNUT (*Arachis hypogaea* L.)

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Abstract

The field experiment was conducted at the Eastern Region of Sri Lanka to evaluate the effects of cattle manure with EM soil application on the yield and yield components of groundnut (*Arachis hypogaea* L.) *cv Indi*. It consisted of 10 treatments replicated four times in a randomized complete block design. Treatments were five levels (0, 5, 10, 15 and 20 t/ha) of cattle manure (CM) with and without EM soil application. Air dry cattle manure was incorporated into soil two weeks before sowing and EM solution was sprayed to soil at two week intervals from flowering to maturity of the crop. All other agronomic practices were followed according to the recommendation. The results showed that the increase of cattle manure (up to 15 t/ha) combined with EM increased the number of pods, weight of pods and kernels per plant, 100-kernel weight, shelling % and total yield. Higher kernel yield (3.42 t/ha) was obtained from 15 t/ha CM + EM application. The kernel yield in the control treatment (chemical fertilizer only) was 2.78 t/ha, which was comparable to 2.81 t/ha of kernel with 15 t/ha CM application alone. This study revealed that cattle manure at the rate of 15 t/ha coupled with EM would give better yield of groundnut and it can replace chemical fertilizer use.

Keywords: Combined application of manure and EM, yield, yield components of groundnut.

Introduction

Groundnut (*Arachis hypogaea* L.) is an important oil seed crop. It's a good source of protein and contributes to satisfy protein requirement mainly in developing nations (Eapen, 2003). Groundnut seeds contain 40-50% fat, 20-50% protein, and 10-20% carbohydrate depending on the variety (Okello *et al*., 2010) and some essential minerals and vitamins. It is commonly grown in the tropical and warm temperate countries. In Sri Lanka, groundnut is demanded as snacks and confectionaries. It has a unique ability to fix atmospheric nitrogen to soil which reduces the application of nitrogen fertilizer.

Agrochemicals are the main inputs in conventional agriculture where chemical fertilizers and pesticides are used to increase crop yield and control pests, respectively. Consequently it affects not only soil environment and also

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human health. Thereafter, the organic farming is becoming popular and their products have higher demand round the world. Because of this, many types of locally available organic manures are widely used in Sri Lanka. Addition of organic manure improves the soil fertility. However, they contain relatively low amount of nutrients as compared to chemical fertilizers.

Cattle manure is commonly used in agriculture. Effects of cattle manure on crop growth and yield has been studied (Jahan *et al*., 2008; Dada and Fayinminnu, 2010; Abul-Soud *et al*., 2010. Sangakkara and Higa (1992) reported that use of effective microorganisms (EM) resulted in higher yield in the organic farming system over that of traditional organic farming. EM enhances nutrient availability, suppresses weeds, controls diseases and improves yield (Wang *et al*., 2000; Javaid, 2009; Jilani *et al.,* 2010).

Inoculation of EM with organic manure or EM application during the vegetative phase of crop improves the nutrient status of soil via stimulates the decomposition rate, speed up the nutrient releasing rate and enhance crop production (Sangakkara and Higa, 1992; Sangakkara, 1994; Sangakkara, 1996). However, studies with organic manures integrated with EM application in leguminous crops are limited in Sri Lanka. Cattle manure is the most common manure used in organic farming and groundnut is one among the several crops which are cultivated organically hence this study was done to evaluate the yield performance of groundnut cultivated with cattle manure integrated with EM application.

Materials and Method

A field experiment was carried out in 2010 at the Experimental station of the Eastern University of Sri Lanka. The soil is sandy regosol with 6.4 pH, 0.013% N, 0.12% K, 0.06% P, and 0.65% organic matter. Treatments (T_1-T_{10}) included applications of recommended chemical fertilizer as a control (T_1) and the different levels of cattle manure with and without EM soil application (T_2-T_{10}) as indicated in Table 1. Treatment T_2, T_3, T_5, T_7, and T_9 were cattle manure at the rates 0, 5, 10, 15, and 20 t/ha, respectively and T_4, T_6, T_8, and T_{10} were cattle manure at the rates 5, 10, 15, and 20 t/ha with EM soil application, respectively. Cattle manure was applied to the experimental plots (T_2-T_{10}) two weeks before sowing. To the control treatment (T_1), recommended level of chemical fertilizer (35 kg/ha urea, 140 kg/ha triple superphosphate, and 75 kg/ha muriate of potash) was applied two days before sowing as basal application and 30 kg/ha urea was top dressed after four weeks of sowing. Treatments were replicated four times in randomized complete block design.

Uniform seeds of groundnut *cv Indi* were sown with spacing of 45cm x 15cm. The plot size was 2.2m x 2.0m. EM solution was prepared two hours before spraying by diluting EM stock solution [EM super^{TM}, SEEDS Ltd, Sri Lanka] with molasses and water (1:1:1000) as recommended in EM application manual (Anon., 1995). This solution was sprayed at 4^{th}, 6^{th}, 8^{th}, and 10^{th} weeks after sowing of groundnut to soil and application rate of EM solution to soil was 10 L/ha. Irrigation was done whenever required. Other agronomic practices were followed according to the recommendation of Department of Agriculture of Sri Lanka. No chemical pesticide or herbicide was applied. The plants were uprooted separately at maturity for recording the agronomic parameters.

The pod numbers were counted from randomly selected plants from each experimental plot and then air dried for one-week subsequently pod and seed weights were recorded. Hundred uniform seed weight were taken from each treatment. Shelling percentage was also calculated. At the time of harvest, number of nodules per plant was recorded and plant samples were oven dried at 105°C over night to determine the total dry matter per plant. All data were statistically analyzed by analysis of variance and the mean separation was done using Tukey's studentized range test at 5% level.

Results and Discussion

Effects of manure and EM on nodulation

Manure application significantly ($P<0.01$) influenced the nodulation of groundnut (Table 1). The number of nodules was remarkably ($P<0.05$) higher in the treatments T_6-T_{10} as compared to chemical fertilizer application (T_1). Effectiveness of nitrogen fixation by legume depends on many factors, such as supply of N fertilizer, soil condition and availability of nutrients (Gowariker *et al*., 2009). It was observed that the nodule formation was improved with increasing rates of CM up to 15 t/ha with or without EM application. The finding is supported by Ihejirika (2007) who reported that organic manure significantly influenced the nodulation of groundnut.

The lowest number (84.4) of nodules per plant was recorded with no fertilizer (T_2) application which was significantly ($P>0.05$) lower than the other treatments except T_3. The highest number (148.8) was found with T_{10} but failed to produce significant vitiation with T_8 at $P>0.05$ level of probability. It was clearly indicated that application of EM with cattle manure had great influence the nodule formation of groundnut. EM enhances the microbial diversity in soil (Higa and Parr, 1994) and thus improves soil nutrients. The present result agrees with the findings of Sangakkara (1996) who reported that nodulation of bush bean was enhanced by the application of EM with organic manures.

Table 1. Effects of cattle manure and EM on nodule and pod formation of groundnut.

Code	Treatments	No. of nodules/plant	No. of pods/ plant
T_1	Control	113.8±2.7 c	22.3±0.3 b
T_2	No fertilizer + no CM	84.4±5.9 d	10.3±0.5 f
T_3	5 t/ha CM	91.9±2.8 d	14.3±0.5 e
T_4	5 t/ha CM + EM	105.9±3.0 c	16.7±0.1 d
T_5	10 t/ha CM	118.3±1.5 c	16.4±0.2 d
T_6	10 t/ha CM + EM	135.8±2.6 b	20.3±0.3 bc
T_7	15 t/ha CM	130.0±2.0 b	20.1±0.3 bc
T_8	15 t/ha CM + EM	147.5±1.7 a	24.5±0.4 a
T_9	20 t/ha CM	138.0±2.3 b	22.0±0.4 b
T_{10}	20 t/ha CM + EM	148.8±1.8 a	24.1±0.2 a
F value		**	**
CV (%)		4.6	3.4

Control: Recommended level of chemical fertilizer
CM: Cattle manure, EM: Effective microorganisms
Value represents mean ± standard error of four replicates.
F test: - **: P< 0.01.
Means followed by the same letter are not significantly different according to Tukey's studentized range test at 5% level.

Effects of manure and EM on pod formation

Significant difference (P<0.01) was observed in number of pods per plant due to the treatments (Table 1). Increasing trend was observed in the number of pods per plant with increasing rates of cattle manure (CM) up to 15 t/ha. Treatment T_8 produced to highest number of pods (24.5) however significantly no variation was found with T_{10} where manure was applied at the rate of 20 t/ha along with EM. Significant effect was observed with or without the application of fertilizer. Application of chemical fertilizer (T_1) produced statistically similar number of pods with T_9 but lower than T_8 where manure was applied at the rate of 15 t/ha along with EM. Similar results were reported by Chandrasekaran *et al*. (2007) the positive effect of farm yard manure on the number of pods per plant in groundnut.

Addition of EM with CM (15-20 t/ha) produced significantly better yield compared to chemical fertilizer. Balanced use of fertilizers plays an important role in sustainable crop production (Afridi *et al*., 2002) and cattle manure contains both macro (NPK) and micro (Mg, Ca, S, etc.) nutrients. The groundnut requires large quantities of phosphorous, calcium, and sulphur for seed,

development and oil quality (Bala *et al*., 2011). Application of CM and EM enhances the microbial activity in soil (Higa and Parr, 1994). Sangakkara (1996) reported that combination of manure with EM increased the total nitrogen and potassium content of soil.

Effects of manure and EM on pod and kernel weight

Application of EM with cattle manure (CM) produced significant (P<0.01) effects on both pod and kernel weights (Table 2). Pod and kernel weights (30.5 g and 21.0 g) were significantly higher in T_8 but similar with T_{10}. Recommended chemical fertilizer (T_1) produced yield (25.8 g and 17.0 g) which is statistically similar with T_9. The lowest pod and kernel weights (12.5 g and 6.5 g) were obtained with T_2 where no fertilizer was applied.

Table 2. Effects of cattle manure and EM on dry weight of pods and kernels of groundnut.

Treatment	Air dry wt of pods/plan (g)	Air dry wt of kernels/plant (g)	100-kernel wt/plant (g)
T_1	25.8±0.6 b	17.0±0.4 b	60.0±1.1 ab
T_2	12.5±0.9 d	6.5±0.3 e	50.4±0.6 e
T_3	14.9±1.1 d	9.0±0.5 d	53.9±0.4 d
T_4	20.2±0.6 c	13.0±0.7 c	57.5±0.6 c
T_5	20.1±0.8 c	12.7±0.7 c	59.2±0.8 bc
T_6	25.8±0.8 b	16.6±0.5 b	59.6±0.5 ab
T_7	25.4±1.2 b	17.2±0.7 b	60.3±0.9 ab
T_8	30.5±0.8 a	21.0±0.6 a	60.9±0.6 ab
T_9	26.5±0.7 b	17.4±0.5 b	59.3±0.4 abc
T_{10}	29.9±1.1 a	20.2±0.9 a	61.2±0.5 a
F value	**	**	**
CV (%)	7.6	8.2	2.2

Value represents mean ± standard error of four replicates.
F test: - **: P< 0.01.
Means followed by the same letter are not significantly different according to Tukey's studentized range test Duncan's Multiple Range Test at 5% level.

The 100-kernel weight of groundnut was significantly (P<0.01) influenced by the application of manure (Table 2) among the treatments. The highest average 100 kernel weight (61.2 g) was recorded in T_{10} followed by T_8 (60.9 g). It was observed that plant grown with chemical fertilizer (T_1) gave 60.0 g but no significant variation was obtained among them. In contrast, remarkably (P<0.05) low value (50.4 g) was recorded in T_2. Further, it was noted that increase in CM rate with or without EM increased the 100-kernel weight in the present study.

Effects of manure and EM on plant biomass

The maximum plant biomass (49.4 g) was obtained in T_8 and the minimum amount (27.3 g) in T_2. The total dry matter per plant increased with the increase in cattle manure level (up to 15 t/ha). Photosynthetic microorganisms are one constituent of EM which enhances photosynthesis (Wang *et al.,* 2000) and it may lead to high dry matter accumulation in plant parts. The results revealed that optimum rate of cattle manure either alone or combined with EM is required to plants for its optimum dry matter production. It has been reported that increase in cattle manure rate increased the total dry matter yield per plant in okra (Dada and Fayinminnu, 2010 and Chandrasekaran *et al*., 2007).

Effects of manure and EM on shelling percentage

The shelling % ranged from 52.1% to 68.8% (Table 3) and it agrees with the findings of Maruthi and Srinivas (2006) who stated that the shelling % of groundnut is nearly 60-70%. The highest shelling % (68.8%) was recorded in 15 t/ha cattle manure combined with EM (T_8). T_1 was not significantly different ($P>0.05$) in shelling % with other treatments except T_2 and T_3. Similar trend in shelling % was cited by Gohari and Niyaki (2010) tested with different levels of N fertilizer with groundnut.

Table 3. Effects of cattle manure and EM on pod and kernel yield of groundnut.

Treatment	Plant biomass (g)	Shelling (%)	Pod yield (t/ha)	Kernel yield (t/ha)
T_1	43.0±2.5 abc	65.9±1.6 ab	4.22±0.10 bc	2.78±0.06 c
T_2	27.3±1.1 d	52.1±2.6 d	2.04±0.15 e	1.06±0.04 e
T_3	30.0±1.3 d	60.5±1.9 c	2.44±1.78 e	1.47±0.08 e
T_4	33.8±1.36 cd	64.2±2.3 abc	3.31±0.09 d	2.12±0.12 d
T_5	34.1±1.2 cd	63.2±3.1 bc	3.28±0.13 d	2.07±0.12 d
T_6	38.8±2.1 bcd	64.2±0.8 abc	4.21±0.13 bc	2.70±0.09 c
T_7	42.0±3.3 abc	67.9±0.6 ab	4.14±0.19 c	2.81±0.11 bc
T_8	49.4±2.0 ab	68.8±0.3 a	4.98±0.13 a	3.42±0.10 a
T_9	44.2±2.1 abc	65.5±2.3 abc	4.33±0.11 abc	2.84±0.08 bd
T_{10}	48.6±3.5 a	67.6±0.8 ab	4.88±0.18 ab	3.30±0.14 ab
F value	**	**	**	**
CV (%)	11.3	6.0	7.6	8.2

Value represents mean ± standard error of four replicates.
F test: - **: P< 0.01.
Means followed by the same letter are not significantly different according to Tukey's studentized range test Duncan's Multiple Range Test at 5% level.

Effects of manure and EM on pod and kernel yields

Pod and kernel yields per hectare ranged from 2.04 t/ha to 4.98 t/ha and 1.06 to 3.42 t/ha, respectively (Table 3). The highest values were recorded in T_8 (15 t/ha CM with EM), the lowest values in T_2. Treatment T_1 (chemical fertilizer) gave 4.22 t/ha pod and 2.78 t/ha kernel yield. There was a remarkable ($P>0.05$) variation between T_1 and T_8. Further, it was noted that there was no significant difference ($P>0.05$) between T_8 and T_{10} indicated that when a crop fertilized with CM (15 t/ha) and EM, it resulted better yield. Studies with different rates of cattle manure in some crops showed that increase in the rate of cattle manure up to 15 t/ha increased crop yield and further increment caused yield reduction in okra (Dada and Fayinminnu, 2010) and squash (Jahan *et al*., 2008; Abul-Soud *et al*., 2010). Moreover, shelling % (Table 3) indicates that there was an efficient pod filling process for better pod and seed yields by the application of CM combined with EM. The results were supported by previous studies that EM showed the either EM spray or combination with organic manure addition to soil improved the crop yield (Sangakkara, 1994; Wang *et al*., 2000; Ncube *et al*., 2011).

Conclusion

Two things can be concluded from this finding, first increase in the manure application up to 15 t/ha had significant effect on nodulation, total dry matter production, yield and yield attributes. Secondly, combination of cattle manure with EM application during crop growth led to significant improvement over sole application of manure, resulted in better performance of crop in organic farming system. Analyses result showed that the yield performance of crop was significantly similar with 15 t/ha and 20 t/ha cattle manure integrated with EM application. From this result, it can be concluded that 15 t/ha cattle manure with EM application is important for groundnut to obtain better yield of groundnut in organic farming system.

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