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Yield performance of groundnut (*Arachis hypogaea* L) grown with different levels of cattle manure as a substitute of inorganic fertilizer on sandy regosol

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Abstract

The effect of different levels of cattle manure on yield of groundnut (Arachis hypogaea L) was determined on sandy regosol. Increase of cattle manure level had significant effect on groundnut yield. Gradual increase upto 15 tons/ha lead to improve yield parameters such as number of pods, weights of pods and kernels, 100 kernals weight, shelling percentage and total dry matter yield per plant. Cattle manure application influenced the nodulation of groundnut and it was positively correlated with yield components. High kernel yield (17.49 g per plant) was achieved with 20 tons/ha cattle manure among the treatments. However, air dry kernel yield of plant fertilized with15 tons/ha (17.20 g per plant) was statistically on par (P>0.05) with 20 tons/ha manure (17.49 g per plant) and inorganic fertilizer application (16.98 g per plant). This study conclude that use of cattle manure at the rate of 15 tons/ha is the optimal level in organic cultivation of groundnut both economically and environmentally giving an optimum yield equivalent to inorganic fertilizer.

Keywords: chemical fertilizer, cattle manure, groundnut, kernel yield, sandy regosol

1. Introduction

Safety and health of food is a major concern due to over usage of chemicals for crop production [1] and the use of chemical fertilizers is not only costly but also cause environmental and health hazards. Therefore, Crop is cultivated organically and organic product has high demand worldwide. The synthetic fertilizers, pesticides and plant hormones are not used in organic farming. Organic manure can be an important source of nutrients especially nitrogen (N), phosphorus (P) and potassium (K) [2]. The manures improve soil aeration, increase water holding capacity and also contain essential macro and micro elements for plant growth and development. It restores humus to the soil, gives cohesion to sandy soil and renders resistant to drought [3]. Animal manure has been traditionally utilized as a source of nutrients and can improve yield considerably

[4]. Cattle manure is commonly used by the farmers to improve soil fertility during their cultivation. But problems encountered with high rate of manure application to crop field are excess growth of weed, nitrogen immobilization due to high C:N ratio of cattle manure [5] and induction of root disease because of high water holding capacity of manure.

Groundnut is mainly grown for its kernels (seeds) which contain 40-50% fat and 20-50 % protein depending on the variety [6]. Kernels are consumed directly or oil extracted from the kernels and also used as animal feed and industrial raw material. Further, crop residues of leguminous crop conserve the soil moisture, improve soil fertility and control the weed growth. Groundnut fixes atmospheric nitrogen with the help of *Rhizobium* in the root nodules however it takes around 25-30 days to develop root nodules therefore nitrogen is required in the early stages of plant growth [7]. Organic crop production with cattle manure was reported with crops such as okra [8] and squash [9]. The research studies related to organic cultivation of legume crops are limited and there is a scope to cultivate groundnut with cattle manure because of its capability to fix atmospheric nitrogen into soil that helps to fulfill nitrogen requirement for plant growth and development. Therefore, this experiment was done to study the effects of different levels of cattle manure on the yield of groundnut on sandy regosol and to suggest an economically feasible quantity of cattle manure to cultivate groundnut organically.

2. Materials and Methods

This study was conducted at the Agronomy farm, Eastern University of Sri Lanka in 2010-2011. The mean annual rainfall ranges from 1600 to 1800 mm, annual mean temperature is from 28 °C to 32 °C and humidity ranges from 60% to 90%. The experiment was laid out in a Randomized Complete block Design with six treatments and four replications. Treatments had five levels (0, 5, 10, 15, 20 tons/ha) of cattle manure and application of chemical fertilizer [35 kg/ha urea, 140 kg/ha triple super phosphate and 75 kg/ha muriate of potash as basal and 30 kg/ha as top dressing] recommended by the Department of Agriculture of Sri Lanka was kept as control. Well dried, powdered cattle manure was incorporated into soil two weeks prior to sowing to allow decomposition. Groundnut (*cv. Indi*) seeds were sown at the spacing of 45 cm x 15 cm and other agronomic practices were followed according to the recommendation. No chemical pesticide or herbicide was applied and weeding was done manually at four and eight weeks after sowing. The plants were uprooted at maturity and agronomic parameters were recorded.

Number of pods of ten randomly selected plants recorded separately was from each experimental plot and the pods were allowed to air dry for a week. After drying, the pod yield per plant was taken as the mean weight of harvested pods of ten randomly selected plants and seed yield per plant was estimated in each treatment. Weight of hundred seeds was measured from the bulk of harvested seeds in each treatment. Shelling percentage was calculated using weights of dry pods and seeds. Further, at the time of harvest, plant height, number of nodules per plant and number of branches were also recorded. Data were statistically analyzed and the mean separation was done using Duncan's Multiple Range Test at 5% level by using Statistical Analysis System (SAS). Finally correlation between yield and yield attributes developed in both control and optimal level cattle manure applied treatments.

3. Results and Discussion

Plant height and number of branches

There was remarkable difference ($P<0.05$) in plant height among the treatments (Table 1). Plant height at control (T_1) differed significantly ($P<0.05$) from others while the height corresponding to the different levels of cattle manure was not significantly differed ($P>0.05$) at harvest. The difference in plant height between cattle manure and inorganic fertilizer may be due to the variation in nutrient levels because inorganic fertilizers are water soluble and provide nutrients readily to the plants than cattle manure during the vegetative growth. Plant growth depends largely on the development of root system. The average plant height ranged from 34.50 cm to 42.38 cm.

Table 1: The plant height and number of branches per groundnut plant at harvest.

Treatments	Treatment Code	Plant height (cm)	Number of branches
Inorganic fertilizer	T_1 (control)	42.38 ± 2.96 a	6.00 ± 0.41
No fertilizer	T_2	34.50 ± 0.64 b	5.25 ± 0.48
CM (5 tons/ha)	T_3	35.25 ± 0.77 b	5.25 ± 0.25
CM (10 tons/ha)	T_4	36.12 ± 1.00 b	5.25 ± 0.25
CM (15 tons/ha)	T_5	37.42 ± 0.67 b	5.75 ± 0.25
CM (20 tons/ha)	T_6	37.00 ± 0.54 b	5.75 ± 0.48
F test		*	ns
CV%		7.47%	13.28%

CM- Cattle manure

Value represents mean ± standard error of four replicates.

F test: - * $P< 0.05$; ns: not significant.

Means followed by the same letter are not significantly different according to Duncan's Multiple Range Test at 5% level.

Effect of manure on nodulation

Effect of different levels of cattle manure application on nodulation (Table 2) was significantly ($P<0.01$) varied among the treatments. Effective nodulation depends on the number of bacteria present, the kind of legume, the supply of N fertilizer, soil condition and availability of micronutrients [10]. Tropical grain legumes have the capacity to fix substantial amount of nitrogen (N) under favourable condition, but the majority of this N is stored in grain [2]. In this study, number of nodules formed was comparatively high (131) in organic manure as compared to inorganic fertilizer application (T_1).

Moreover, it was observed that increase in cattle manure application to 15 tons/ha improves nodulation however further increase in application decrease it. Generally legume prefers to use readily available nitrogen rather than fix atmospheric nitrogen with *Rhizobia*. This result is in agreement with Gowariker [10] who stated that the constant supply of N fertilizer discourage N- fixation because the plant does not need excess nitrogen.

Table 2 : The number of nodules and number of pods per groundnut plant at harvest.

Treatments	Number of nodules	Number of pods
T_1 (control)	113.75 ± 2.21 b	22.00 ± 0.41 a
T_2	83.25 ± 5.15 b	9.75 ± 0.48 e
T_3	117.00 ± 2.64 b	13.75 ± 0.63 d
T_4	131.50 ± 3.12 a	16.50 ± 0.29 c
T_5	130.50 ± 2.74 a	20.50 ± 0.64 b
T_6	128.50 ± 3.52 a	21.75 ± 0.25 ab
F test	**	**
CV%	5.74%	5.47%

Value represents mean ± standard error of four replicates.

F test: - **: $P < 0.01$.

Means followed by the same letter in each column are not significantly different according to Duncan's Multiple Range Test at 5% level.

Number of harvested pods

The results (Table 2) revealed that the effect of different levels of organic manure application on number of pods per plant was significant ($P<0.01$). With increasing application of cattle manure upto 20 tons/ha an increasing trend was observed in the number of pods per plant (Table 2). Increase in application of manure increases the amount of nutrient release as a result the plants can easily absorb the nutrients thus enhance dry matter production. Proper use of fertilizers plays an important role in sustainable crop production and cattle manure contains macro as well as micro nutrients for the improvement of pod yield.

Groundnut can fix 33 kg nitrogen per hectare [11] and organic manure application improved nodulation in groundnut (Table 2), as a result it increased pod formation responding to additional nitrogen and other required nutrients. The number of matured pods per plant increased from 9.75 to 21.75 with increasing rate of application from zero to 20 tons/ha. It is due to macro and micronutrients available in the manure and also its beneficial effect on soil environment. In this study, the number of pods per plant in both T_1 and T_6 was not significantly varied ($P>0.05$). Further, the result revealed that inadequate amount of nutrients in soil creates nutrients deficiency to plant as a result reduction in the pod yield (T_2). The results were in accordance with Hossaini and Hamid [12] who reported that increase in N and P application increase number of pods in groundnut.

Weights of pods and kernals

Significant variations ($P<0.01$) were observed in both pod and kernal weights per plant with different levels of cattle manure application (Table 3). It was observed that the highest pod weight (26.58 g) and kernal weight (17.49 g) per plant were recorded in 20 kg/ha cattle manure followed by the second highest values (25.55 g and 17.20 g) in 15 kg/ha cattle manure however, those two treatments were not significantly differed ($P>0.05$). Studies with different rate of cattle manure in some crops showed that increase in the rate of cattle manure upto certain limit increase crop yield and further increment cause yield reduction in okra [8], squash [9] and sweet potato [13]. The optimal level varies with crop due to the nutrient requirements.

The yield reduction in crop under high fertilizer application is due to the nitrogen immobilization which causes nitrogen deficiency to crop because of high C: N ratio (30:1) of cattle manure [5]. In groundnut kernel, protein and lipids are major components and found in higher percentage than carbohydrate [6]. It consists most of amino acids including cysteine and methionine [14] and N is one of major element of amino acid. We also found that a linear relationship with positive slope is developed between different levels of cattle manure application and kernal yield per plant (Figure 1). The kernal yield per plant was significantly influenced ($P<0.01$) by the application of cattle manure (Table 3). With a gradual increase in cattle manure rate increase the kernal yield per plant. The effect of cattle manure at 20 tons/ha was not significant ($P<0.05$) from that of 15 tons/ha (Table 3).

Table 3: The dry weights of pods and kernals per groundnut plant at harvest.

Treatments	Pod weight (g)	Kernal weight (g)
T_1 (control)	25.77 ± 1.34 a	16.98 ± 0.40 a
T_2	12.40 ± 0.80 c	06.42 ± 0.30 d
T_3	14.56 ± 1.68 c	08.92 ± 0.51 c
T_4	20.62 ± 1.20 b	13.13 ± 0.35 b
T_5	25.55 ± 1.15 a	17.20 ± 0.31 a
T_6	26.58 ± 1.00 a	17.49 ± 0.26 a
F test	**	**
CV%	11.74%	10.96%

Value represents mean ± standard error of four replicates.

F test: - **: P< 0.01.

Means followed by the same letter in each column are not significantly different according to Duncan's Multiple Range Test at 5% level.

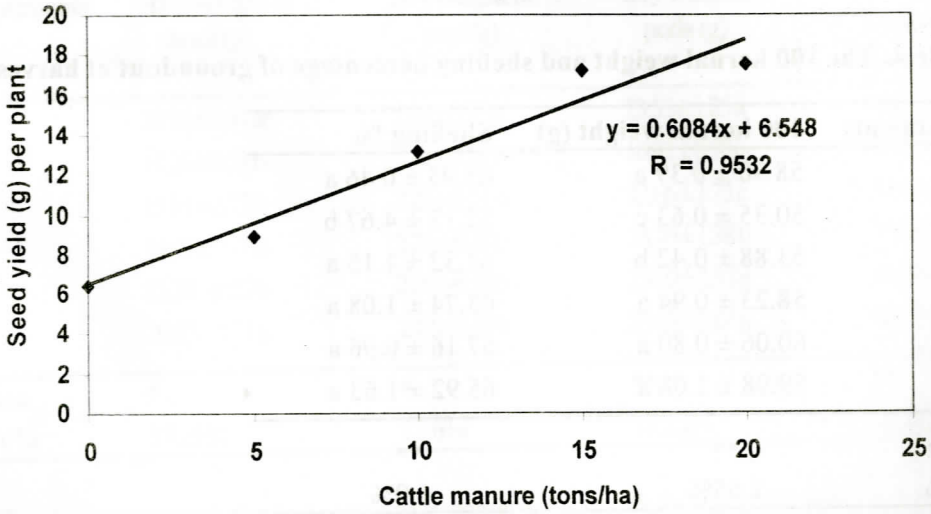

Figure 1: The linear relationship between applied cattle manure and kernal yield per groundnut plant.

100 kernal weight

The hundred kernal weight of groundnut was significantly (P<0.01) influenced by the rate of cattle manure application (Table 4) among the treatments. The highest average 100 kernal weight (60.06 g) was recorded in 15 tons/ha cattle manure, in contrast plant grown under no application of nutrients gave very lowest value (50.35 g). There was not remarkable (P>0.05) variation between organic manure (15 tons/ha) and inorganic fertilizer application. Further, it was noted that increase in cattle manure to the certain limit i.e., nutrient increment improved the 100 seeds weight. These results are in conformity with observation of Hassaini and Hamid [12]; Gohari and Niyaki [15] in groundnut.

Shelling percentage

The shelling % of groundnut is nearly 60-70 % i.e. of the total pod shelled, 60-70% is the seeds and 30 - 40% is the shells [16]. The obtained shelling percentage ranges from 52.13 % to 67.16 % and it was agreed with the typical value. The highest shelling percentage (67.16) was obtained in 15 tons/ha cattle manure. There was no significant difference (P>0.05) in shelling percentage with increasing rate from 10 to 20 tons/ha and in control treatment. Similar trend in shelling percentage was cited by Gohari and Niyaki [15] tested with different levels of N fertilizer for groundnut.

Table 4: The 100 kernal weight and shelling percentage of groundnut at harvest.

Treatments	100 kernal weight (g)	Shelling %
T_1	58.90 ± 0.39 a	65.93 ± 0.46 a
T_2	50.35 ± 0.63 c	52.13 ± 4.67 b
T_3	53.88 ± 0.42 b	61.32 ± 1.15 a
T_4	58.23 ± 0.94 a	63.74 ± 1.08 a
T_5	60.06 ± 0.80 a	67.16 ± 0.96 a
T_6	59.98 ± 1.08 a	65.92 ± 1.63 a
F test	**	**
CV%	2.65%	6.9%

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

Total dry matter yield

Total dry matter yield per plant was significantly influenced ($P<0.01$) by the applied rate of cattle manure (Table 5). During the early stage of plant growth, it utilizes photosynthesized food for their vegetative growth however at the later stage, majority of synthesized food transport to sink. Pods are the sink for dry matter accumulation in groundnut thereby prominent variation was exhibited in oven dry weight of pods per plant than other plant parts such as shoot and root at the time of harvesting. The significant ($P<0.05$) variations were noted in both oven dry weights of shoot and root per plant among the treatments. The total dry matter yield per plant increased with a gradual increase in cattle manure level upto 20 tons/ha. Similar trend was recorded by Chandrasekaran [17]. Increase in cattle manure rate increase the total dry matter yield per plant in okra [8]. However, the total dry matter yield per plant in T_1, T_5 and T_6 were not significantly differed ($P>0.05$). The average total dry matter yield per plant ranges from 27.38 g to 46.45g. The highest and lowest total dry matter yield per plant 27.38 g and 46.45g were recorded in T_2 and T_6 respectively.

Table 5: The total dry matter yield per groundnut plant at harvest.

Treatments	Dry weight of shoot (g)	Dry weight of root (g)	Dry weightof pods (g)	Total dry matter yield per plant (g)
T_1	18.16±2.34ab	3.38±0.35a	23.55±1.25a	45.08±3.06a
T_2	14.26±0.53b	2.20±0.14b	10.92±0.70c	27.38±1.24d
T_3	15.14±2.12b	2.22±0.19b	12.66±1.73c	30.14±3.14cd
T_4	14.99±0.77b	2.24±0.18b	18.70±1.38b	35.93±1.72bc
T_5	15.74±0.83b	2.26±0.19b	23.09±1.37a	40.85±1.10ab
T_6	20.63±0.74a	2.42±0.18b	23.69±0.64a	46.45±0.98a
F test	*	*	**	**
CV%	17.26%	17.6%	13.22%	11.05%

Value represents mean ± standard error of four replicates. F test: - **: $P<0.01$; * $P<0.05$.
Means followed by the same letter in each column are not significantly different according to Duncan's Multiple Range Test at 5% level.

Correlation analysis in yield parameters

The correlation coefficients of yield parameters of groundnut in organically (15 tons/ha cattle manure) and inorganically fertilized plants revealed that there were positive correlation between yield parameters such as number of pods per plant and weights of air dry pods kernels per plant The number of pods was positively correlated with the weights of air dry pods (r=0.46) and kernals (r=0.49) in cattle manure (15 tons/ha) fertilized groundnut which gave the optimal kernal yield in the present study. The air dry weight of pods was also positively and highly correlated with the weight of air dry kernals (r=0.98). In case of inorganically fertilized groundnut, the number of pods was positively correlated with the air dry weights of pods (r=0.75) and kernals (r=0.80). And also air dry weight was positively and highly correlated with kernal weight (r=0.94).

4. Conclusion

The results reveals that there was no significant (P>0.05) variation in yield between organic manure (15 tons/ha) and inorganic fertilizer application on sandy regosol. The pod weight (26.58 g) and kernal weight (17.49 g) per plant were higher in plots receiving 20 kg/ha cattle manure than those values (25.55 g and 17.20 g) in plants treated with 15 kg/ha cattle manure but they were not significantly different (P>0.05). And also highest shelling percentage (67.16) and 100 kernal weight (60.06 g) were recorded in 15 tons/ha cattle manure treatment. Based on this result, the cattle manure rate of 15 tons/ha is optimal level to achieve optimal pod and kernal yield of groundnut economically and soil environmentally.

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