The Effect of Cattle Manure Enriched With ERP Fertilizer on Seed Yield of Soybean (*Glycine max*) in Sandy Regosol

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ABSTRACT

The experiment was carried out in the Eastern region of Sri Lanka to evaluate the effect of cattle manure with different levels of rock phosphate application on seed yield of soybean (*Glycine max*) in sandy regosol. The air dried cattle manure (CM) (10 t/ha) with ERP fertilizer (eppawela rock phosphate) at 0-100 kg/ha and also recommended chemical fertilizers as a control were applied two weeks and two days before sowing respectively as a basal fertilizer application. The six treatments were arranged in a randomized complete block design with four replications. The yield response to each treatment was observed at the harvesting stage. The results revealed that significant differences ($P<0.01$) were noted in the pod number as well as dry weights of pods and seeds among the treatments. The number of effective nodules was significantly increased with increasing rate of phosphate application after 6 weeks of sowing. Highest mean values of pod number (41.9) and dry weights of pods (16.92 g) and seeds (11.67 g) per plant were significantly ($P<0.05$) recorded in CM with ERP at 50 kg/ha. Maximum seed yield (4.21 t/ha) was remarkably achieved by cattle manure (10 t/ha) with ERP at 50 kg/ha followed by the control treatment (4.10 t/ha). Thus, it was significantly ($P<0.01$) resulted the high value of economical yield of soybean with the application of locally available cattle manure plus naturally occurring ERP fertilizer at the moderate level.

KEYWORDS: Cattle manure, Rock phosphate, Sandy soil, Seed yield, Soybean

INTRODUCTION

In conventional agriculture, farmers generally use inorganic fertilizer to improve crop production but most of the inorganic fertilizers contain NPK elements. On the contrary, organic fertilizers enhance the macro and micronutrient contents of the soil, soil water holding capacity, pH and soil structure (Agricola, 1978; Lekasi et al., 2000) and plant grown with biological sources of nutrients is less susceptible to insects than conventionally grown plants (Lotter, 2003). Moreover application of organic manure in crop cultivation give organic products and has comparatively long term beneficial residual effect than inorganic fertilizers its residual benefit do not last beyond one season (Rutunga and Neel, 2006) may be due to leaching of nutrients.

In Sri Lanka, inorganic fertilizers are used to increase crop yield per unit area because of limited land for cultivation and increasing demand for food however they cause for environmental and health problems in addition to the drawbacks stated above. Hence, organic agriculture is an alternative farming practice being done in crop production but organic manures need in a large quantities and also release nutrients slowly. As a result, the use of organic fertilizers together with chemical fertilizers, compared to the addition of organic fertilizers alone, had a higher positive effect on microbial biomass and hence soil health (Dutta *et al.*, 2003).

Addition of manures has been used for improving physical and chemical properties of soil (Tennakoon et al., 1995; Miller, 2009) for better plant root system however farm manures are generally deficient in phosphorus in comparison with nitrogen and potassium but phosphorus is an important nutrient for plant growth and their development (Van Slyke, 2001). Hence, phosphorus is incorporated to cultivated soil as inorganic or organic fertilizers and it is an important element for the uptake of other elements (Kan'ankuk'a, 1999). Naturally available rock phosphate can be used as phosphorus fertilizer in crop production. Wijewardena (1998) stated that application of phosphorus at 25 kg/ha is required to obtain high yields from potato

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and pole bean while yield increment in cabbage and tomato showed significant positive response upto maximum level of 100 kg/ha among the three levels (25, 50, 100 kg/ha) of various sources of phosphate applied. Mineral fertilizers usually consist of relatively simple chemical compounds and provide a gradual release of plant available P and residual effect for several years (Sanchez et al., 1997). Cattle manure contains macro and micro nutrients and it is a locally available organic fertilizer. Effectiveness of cattle manure depends on manure quality, climate, soil type, crop types, soil management and other factors (Sui et al., 2009). Therefore, this experiment was designed to studying the effect of cattle manure with different levels of eppawela rock phosphate (ERP fertilizer) on seed yield of soybean in sandy regosol.

MATERIALS AND METHODS

This field experiment was conducted in 2010-2011 to assess the effect of cattle manure with different levels of ERP fertilizer (eppawela rock phosphate) on seed yield of soybean in the Eastern region of Sri Lanka. It is located at the latitude of $7^{o}43'$ and longitude of $81^{o}42'$. Mean annual rainfall is about 1600 mm and average annual temperature is around 32°C. It is classified under the low country dry zone and soil type is sandy regosol. The experiment was designed in a Randomized Complete Block Design and there were six treatments (T_1-T_6) with four replications. The treatments included applications of recommended chemical fertilizer as a control (T_1) and cattle manure (10 t/ha) with different levels (0, 25, 50, 75, 100 kg/ha) of ERP fertilizer (T_2-T_6). The experimental area was ploughed and leveled thereafter air dried cattle manure (10 t/ha) and EMP fertilizer at 0-100 kg/ha were applied to the experimental plots (T_2-T_6) except control treatment (T_1) two weeks before sowing and also recommended chemical fertilizers (50 kg/ha urea, 150 kg/ha triple super phosphate and 75 kg/ha muriate of potash) were applied two days before sowing to the control treatment (T_1) as a basal fertilizer application. Seeds of soybean *cv* PB1 were sown at 3 cm depth as one plant per hill with a spacing of 40 cm between rows and 7 cm within row. Plot size was 1.6 m x 0.9 m and there were 52 plants per experimental plot. Four weeks after sowing, 50 kg/ha urea was applied as topdressing to all experimental plots. The other agronomic practices were done as recommended. Plants were uprooted at the harvesting stage in each treatment and agronomic parameters were measured such as fresh and dry weights of stem, root, pods and seeds per plant by electric balance. Nodules exhibited pink or reddish in colour inside were considered as effective nodules and they were counted in each plant at various growing periods. In each treatment, harvest index was calculated. It is a ratio of economic yield to biological yield and expressed as percentage. Collected data was analyzed with the statistical package of SAS. The treatment means were compared by using Tukey's Studentized Range (HSD) Test at P=0.05.

RESULTS AND DISCUSSION

Effective Nodules

Table 1 shows the effective influence of cattle manure with different levels of rock phosphate application. The number of effective nodules was showed no remarkable variation ($P>0.05$) among the treatments at early stages. Highly significant ($P<0.01$) differences were observed after 6^{th} week onwards. The number of effective nodules slightly increased with the increasing rate of phosphate application after 6^{th} week of sowing and significantly higher number (20.0) was recorded in T_6 and lower number (13.5) in T_1 at the 12^{th} week. This result is agreed with the finding by Hossein et al. (2010) reported that rock phosphate application as a phosphate fertilizer increase the effectiveness of soil microorganism which support to the N_2 fixation and Setiyo et al. (2004) found that phosphate application stimulate growth and function of the nodules in soybean.

Table 1: Effect of cattle manure with different levels of rock phosphate in the number of effective nodules per plant

	Number of effective nodules per plant at the growing periods				
Treatments	**4 weeks**	**6 weeks**	**8 weeks**	**10 weeks**	**12 weeks**
T_1 (control)	1.25	3.00	09.75 a	16.50 c	13.50 b
T_2	1.50	2.75	18.50 b	21.75 b	16.50 ab
T_3	1.50	3.00	18.75 b	24.00 b	17.25 ab
T_4	1.50	2.50	24.75 a	24.00 b	18.00 a
T_5	1.50	2.00	25.00 a	24.25 b	18.25 a
T_6	1.25	2.00	26.00 a	28.75 a	20.00 a
F test	ns	ns	**	**	**

Means with the same letter in each column are not significantly different at 5% level using Tukey's Studentized Range (HSD) Test. F test: ns – non significant, **-highly significant

A significant difference ($P<0.05$) was observed between control treatment and cattle manure with or without rock phosphate application at the 10^{th} week. Cattle manure is a good source of organic matter which not only supplies the food material to the growth of microorganisms but also provides favourable conditions for increasing activity of some desirable soil organisms (Van Slyke, 2001). As a result, microbial activity is generally more in cattle manure that was applied to the soil. This may be the reason for the variation of nodule number between control treatment and other treatments. And also cattle manure may release micronutrients for the nodulation. Solely applied cattle manure did not result highest value at any growing stages because there may be a low availability of phosphate when cattle manure applied lonely. Cassman et al. (1981) found that N fixating soybean plants required more P than N supplied and Beck and Munns (1984) found that growth rate of rhizobium reduced by low levels of phosphate application.

Weight of Stem and Root

The results of the influence of cattle manure with different levels of rock phosphate application on weights of stem and root at harvesting stage is shown in Table 2. Fresh and dry weights of stem showed significant variations ($P<0.01$) among the treatments. Significantly ($P<0.05$) highest values of fresh (6.97 g) and dry (1.91 g) weights of stem were recorded in cattle manure with rock phosphate at the rate of 50 kg/ha (T_4). Fresh weight of root showed significant variation ($P<0.05$) among the treatment but not in dry weight. The control treatment exhibited lowest values of dry weight of root (0.84) than other treatments. Dry weight of stem was increased with ERP application upto a certain level. Tsvetkova and Georgiev (2003) stated phosphorus deficiency affected the whole plant fresh and dry mass at the harvesting stage.

Pod Parameters

The response of pods and seeds to the combined application of cattle manure with rock phosphate is shown in Table 3. Pod length ranged from 3.39 to 3.44 cm and higher value was obtained in T_6. There were significant differences ($P<0.01$) observed among the treatments in pod number and pod dry weight. Significantly ($P<0.05$) highest values of pod number (41.9) and air dry weight of pods (16.92 g) per plant were recorded in T_4. There was no remarkable ($P<0.05$) variation in oven dry weight of pods between T_1 and T_4. In the present study, applied phosphate in excess did not increase pod yield of soybean as reported by Jones et al. (1997). Yield response was high at the optimum level of phosphate application (Cassman et al., 1981; Tanwar and Shaktawat, 2003).

Table 2: Effect of different levels of rock phosphate with cattle manure in the weights of stem and root at harvest

Weight of stem and root at harvest (g)				
Stem weight per plant			Root weight per plant	
Treatments	**Fresh weight**	**Treatments**	**Fresh weight**	**Treatments**
T_1 (control)	6.52 ± 0.13 b	T_1 (control)	6.52 ± 0.13 b	T_1 (control)
T_2	6.37 ± 0.12 b	T_2	6.37 ± 0.12 b	T_2
T_3	6.78 ± 0.22 b	T_3	6.78 ± 0.22 b	T_3
T_4	6.97 ± 0.01 a	T_4	6.97 ± 0.01 a	T_4
T_5	6.40 ± 0.19 b	T_5	6.40 ± 0.19 b	T_5
T_6	6.61 ± 0.26 b	T_6	6.61 ± 0.26 b	T_6
F test	**	F test	**	F test

Means with the same letter in each column are not significantly different at 5% level using Tukey's Studentized Range (HSD) Test. F test: ns – non significant, *-significant, **-highly significant.

Table 3: Effect of cattle manure with different levels of rock phosphate in soybean pod parameters at harvest.

Treatments	Pod length (cm)	Number of pods per plant	Air dry weight of pods per plant (g)	Oven dry weight of pods per plant (g)
T_1 (control)	3.40 ± 0.11	39.50 ± 0.50 c	16.28 ± 0.03 b	11.59 ± 0.03 a
T_2	3.39 ± 0.09	39.97 ± 0.15 bc	15.13 ± 0.04 d	10.60 ± 0.03 c
T_3	3.41 ± 0.03	40.08 ± 0.04 bc	15.55 ± 0.01 c	10.94 ± 0.03 b
T_4	3.41 ± 0.11	41.90 ± 0.05 a	16.92 ± 0.01 a	11.70 ± 0.03 a
T_5	3.42 ± 0.02	40.00 ± 0.09 bc	15.29 ± 0.02 d	10.75 ± 0.03 bc
T_6	3.44 ± 0.08	40.65 ± 0.12 b	15.16 ± 0.07 d	10.66 ± 0.03 c
F test	ns	**	**	**

Means with the same letter in each column are not significantly different at 5% level using Tukey's Studentized Range (HSD) Test. F test: ns – non significant, **-highly significant

Seed Yield

The combined effect of cattle manure and rock phosphate on the yield of seeds is shown in Table 4. It was highly significant ($P<0.01$) among the treatments. The seed yield ranged from 4.21 t/ha to 3.69 t/ha. Highest mean value of seed yield (4.21 t/ha) was significantly recorded ($P<0.05$) in cattle manure with rock phosphate at the rate of 50 kg/ha and control treatment gave 4.10 t/ha. Kimani et al. (2004) reported that when cattle manure and mineral fertilizers are applied together in the field there is greater improvement in crop yields than when they applied separately. Sridhar et al. (2000) stated that rate of phosphate application for obtaining high yield of soybean may be from 50 kg/ha to 56.25 kg/ha in hill zone of India. Phosphate application increased the yield as reported by the several researchers (Cassman et al., 1981; Jones et al., 1997; Sridhar et al., 2000; Magani and Kuchinda, 2009).

Harvest Index

Effective influence of combined application of cattle manure with rock phosphate in biological yield, economical yield and harvest index (HI) is shown in Table 5. Significantly highest values ($P<0.01$) of biological (0.763 kg per plot) and economical yields (0.431 kg per plot) were observed in the application of cattle manure with rock phosphate at the rate of 50 kg/ha (T_4). HI was exhibited a significant variation ($P<0.05$) among the treatments and there was remarkable ($P<0.05$) difference between T_1 (chemical fertilizer) and T_4. Higher economic yield was obtained in cattle manure with rock phosphate at 50 kg/ha among the treatments. Thus plant biomass was increased by the application of manure with phosphate upto moderate level.

Table 4: Effect of cattle manure with different levels of rock phosphate on seed yield at harvest

Treatment	Air dry weight (g) of seeds per plant	Oven dry weight (g) of seeds per plant	Seed yield (air dry basis) kg/plot	t/ha
T_1 (control)	11.36 ± 0.17 b	7.95 ± 0.11 b	0.591 ± 0.009 b	T_1 (control)
T_2	10.22 ± 0.12 d	7.25 ± 0.08 d	0.531 ± 0.006 d	T_2
T_3	10.73 ± 0.19 c	7.67 ± 0.12 c	0.558 ± 0.010 c	T_3
T_4	11.67 ± 0.02 a	8.28 ± 0.01 a	0.607 ± 0.012 a	T_4
T_5	10.97 ± 0.04 bc	7.66 ± 0.03 bc	0.570 ± 0.015bc	T_5
T_6	10.76 ± 0.01 c	7.63 ± 0.02 c	0.559 ± 0.001 c	T_6
F test	**	**	**	F test

Means with the same letter in each column are not significantly different at 5% level using Tukey's Studentized Range (HSD) Test. F test: **-highly significant.

Table 5: Effect of cattle manure with different levels of rock phosphate in yield and harvest index of soybean plant at harvest

	Yield of soybean plant (kg/plot)		
Treatments	Biological yield	Economical yield	Harvest Index (%)
T_1 (control)	0.744 ± 0.004 b	0.413 ± 0.009 b	55.51 ± 1.1 c
T_2	0.683 ± 0.004 d	0.377 ± 0.006 d	55.20 ± 0.9 c
T_3	0.713 ± 0.006 c	0.399 ± 0.010 c	55.96 ± 1.0 bc
T_4	0.763 ± 0.000 a	0.431 ± 0.012 a	56.49 ± 1.1 ab
T_5	0.695 ± 0.009 d	0.398 ± 0.015 bc	57.27 ± 1.9 a
T	0.691 ± 0.007 d	0.397 ± 0.001 c	57.45 ± 1.0 a
F test	**	**	*

Means with the same letter in each column are not significantly different at 5% level using Tukey's Studentized Range (HSD) Test. F test: *-significant, **– highly significant

CONCLUSION

The results revealed weights of pods and seeds per plant were not increased with increasing level of phosphate in this experiment. The biological and economical yields exhibited significantly ($P<0.05$) higher values (0.763 kg per plot and 0.431 kg per plot respectively) in cattle manure with 50 kg/ha rock phosphate than other treatments. This may be due to adequate supply of plant nutrient from both cattle manure and rock phosphate. From this finding, it can be concluded that the air dried cattle manure with 50 kg/ha eppawela rock phosphate gave significantly higher seed yield (4.21 t/ha) of soybean than other tested treatments and it was 4.10 t/ha in chemical fertilizer treatment. This

experiment would provide information to farmers to improve the seed yield of soybean with low input and less environmental impact in sandy regosol.

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