Combined effect of municipal sewage sludge and inorganic fertilizers on marketable pod yield of vegetable cowpea in sandy regosol soil

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Abstract

Vegetable cowpea (Vigna unguiculata L.) is one of the leguminous crops which can fix atmospheric nitrogen to improve soil nutrients. For obtaining high crop yield, fertilizers are applied effectively to provide the required plant nutrients with minimizing environmental problems. This study was conducted to determine the combined effect of municipal sewage sludge and inorganic fertilizers on pod yield of vegetable cowpea. The eight treatments were designed in a Completely Randomized Design with five replicates. Treatments included T1- no fertilizer, T2- 100% inorganic fertilizers (urea, TSP, MOP), T3- 10 t/ha sewage sludge alone, T4 - 20 t/ha sewage sludge alone, T5- 10 t/ha sewage sludge + 50% inorganic fertilizers (TSP, MOP), T6- 20 t/ha sewage sludge + 50% inorganic fertilizers (TSP, MOP), T7- 10 t/ha sewage sludge + 100% inorganic fertilizers (TSP, MOP), T8- 20 t/ha sewage sludge + 100% inorganic fertilizers (TSP, MOP). One- way Analysis of variance test was used to determine the significance level of the treatments. The results confirmed that sewage sludge with phosphorous and potassium inorganic fertilizers had significant differences ($P<0.05$) in yield parameters. According to the statistically analyzed results, 20 t/ha sewage sludge with 100% TSP and 100% MOP treatment (T8) showed the best treatment for the yield of vegetable cowpea in terms of marketable pod yield. But T5 (10 t/ha sewage sludge + 50% TSP + 50% MOP) and T8 (20 t/ha sewage sludge + 100% TSP + 100% MOP) did not show a significant difference of marketable pod yield produced (1029.83 g/m^2 and 1221.17 g/m^2 respectively). Based on the results of this study, it can be concluded that combined application of 10 t/ha sewage sludge with 50% phosphorous and potassium inorganic fertilizers could be used for environmentally friendly manner cultivation of vegetable cowpea in sandy regosol soil conditions.

Keywords: Inorganic fertilizers, organic manure, pod yield, sewage sludge, vegetable cowpea

Introduction

The vegetable cowpea (Vigna unguiculata L. Walp) is a legume crop that belongs to the Family Fabaceae (Department of Agriculture, 2023). In Sri Lanka, it is a very popular edible crop. It plays a vital role as a source of high-quality protein in the diet of the people who live in the developing world. Shahardeen and Seran (2013) stated that the vegetable cowpea is an excellent source of calcium, magnesium, potassium, iron and other minerals. The plant can fix atmospheric nitrogen, which assists for maintaining soil nutrients. Cowpea is a drought-tolerant crop since it needs less amount of water than other legume species, and it can give high yields even under conditions of terminal drought (Gomes et al., 2020). This crop is heavily cultivated in the low country wet zone, intermediate zone and dry zone of Sri Lanka.

In conventional crop cultivation, inorganic fertilizers are used because they generally release nutrients rapidly however it is available for a short time in the soil particularly in the sandy soil condition (Samarakoon and Seran 2023). Hence, in recent years, farmers have applied organic manures to the soil to increase soil fertility and cultivate these crops in an environmentally and eco-friendly manner (Archana & Seran 2023; Fernando & Seran 2023). Effective application of organic manure can substitute inorganic fertilizers without affecting crop yields. The regular addition of organic fertilizer is necessary for maintaining soil productivity in crop-cultivating land. Sewage sludge as an organic fertilizer is one of the commonly used organic wastes for increasing soil fertility and helping in the partial solution to the issue of an increasing number of waste and byproducts (Kominko et al., 2017). Sludge results from the treatment of domestic and industrial wastewater at wastewater treatment plants linked to the sewerage system and the composition of sewage sludge in rural and urban areas can differ considerably (Qadir et al., 2020).

Nevertheless, organic manures generally contain low amounts of plant nutrients. The incorporation of organic manures into the soil increases the water-holding capacity of the soil and provides both macro and micro plant nutrients for attaining better crop yield (Nadeeka and Seran, 2020). Although the excessive application of inorganic fertilizers contributes to increasing crop yield, it enhances the incidence of insects and diseases and also gives negative effects on the environment (Seran, 2018). Hence, the combined use of organic and inorganic fertilizers boosts soil nutrients, which are available to the plants for achieving the optimum seed yield of cowpeas (Iwantika and Seran,2023)

Sustainable farming aims to maximize the use of natural resources while minimising environmental harm (Viharnaa and Seran, 2013). The majority of the nitrogen and phosphorus requirements for many crops might be met by the soil amendment with processed sewage sludge (Lamastra et al., 2018). Legume crop has the ability to fix atmospheric nitrogen to enrich the nitrogen content in the soil. Fernando and Seran (2023) stated that phosphorus and Potassium are responsible for physiological processes to enhance the seed weight of legume crop. The objective of this study was to determine the combined effect of sewage sludge and inorganic fertilizers incorporated with phosphorous and potassium on the marketable pod yield of vegetable cowpeas. The null hypothesis is that the combined use of sewage sludge and inorganic fertilizers in vegetable cowpea cultivation did not affect pod yield, and the alternative hypothesis is that it had an effect on pod yield in sandy regosol soil conditions.

Methodology

Study site

The study was carried out to determine the effect of sewage sludge and inorganic fertilizers incorporated with phosphorus and potassium on the yield performances of vegetable cowpea. A polybag experiment was conducted at the Faculty of Agriculture, Eastern University, Sri Lanka, from August 2023 to November 2023. The study site was located at a latitude of 7°48’36.64” N and a longitude of 81°35’30.76” E. The annual mean temperature and rainfall in the study area varied from 26.36 ^{o}C to 36.98 ^{o}C and from 1400 mm to 1680 mm respectively (Department of Meteorology, 2023). The soil type is sandy regosol in this location (Seran and Imthiyas, 2016).

Experimental design

The experiment was carried out in a completely randomized design with eight treatments and five replicates. Treatments in this experiment is given in Table 1.

Table 1: Treatments used in this study

Treatment codes	Treatments (Fertilizer application)
T1	No fertilizer
T2	100% recommended inorganic fertilizers (urea, TSP, MOP)
T3	10 t/ha sewage sludge alone
T4	20 t/ha sewage sludge alone
T5	10 t/ha sewage sludge and 50% recommended inorganic fertilizers (TSP, MOP)
T6	20 t/ha sewage sludge and 50% recommended inorganic fertilizers (TSP, MOP)
T7	10 t/ha sewage sludge and 100% recommended inorganic fertilizers (TSP, MOP)
T8	20 t/ha sewage sludge and 100% recommended inorganic fertilizers (TSP, MOP)
TSP – Triple Super Phosphate; MOP – Muriate of Potash	

Agronomic practices

Seeds of the vegetable cowpea (yard long bean), BS-1 variety were collected from the Seed and Planting Material Development Centre, Department of Agriculture (DOA), Karadiyanaru, Batticaloa. Black polythenes were used to prepare the poly bags (30 cm height and 30 cm diameter) in this experiment. Holes were made in each polybag's bottom to drain the excess water. All of the bags were arranged in the experiment area at a spacing of 60 cm between rows and 20 cm within rows (DOA, 2023). The sewage sludge (4.20% N, 11.52% P_2O_5, 1.20% K_2O, 4.84 mg/kg Ca, pH 6.43 and Electrical conductivity 3.73) used in this study was collected from the Municipal Solid Waste Management Centre at Thirupperunthurai, Batticaloa. Sewage sludge at the rates of 10 t/ha and 20 t/ha were applied two weeks before planting while phosphorus and potassium inorganic fertilizers at different amounts (0-100%) were applied two days before planting for the treatments T3-T8. In this experiment, 100 % inorganic fertilizers as basal (35 kg/ha urea + 130 kg/ha TSP + 35 kg/ha MOP) and top dressing (55 kg/ha urea + 35 kg/ha MOP after one month of planting) were added only to the T2 treatment as recommended by DOA (2023) and any fertilizer was not applied to the T1 treatment as a control.

Two seeds were planted in each bag at a depth of 3 cm and then thinning out was practiced to maintain one plant per polybag. Irrigation was done twice a day in the early morning and late evening at the early stage of plant growth then once a day in the evening using a watering can until pod development (Dananjana and Seran, 2022). Weeding was done manually at two-week intervals in and around the polybags. Leaf miner attack was found at the early vegetative stage. Hence, Admire insecticide (1 mL insecticide mixed with 10 L water) was applied to control the Leaf miner attack in the experiment area.

Measurements

Harvesting started in the 7th week of planting in the harvesting stage of vegetable cowpea. Three pickings of immature green (marketable) pods were done. The total number of green pods per plant, pod length (cm), number of green seeds per pod, fresh weight of a single green pod (g) and fresh weight of seeds per pod (g) were measured after harvest. Marketable pod yield (g/m^2) was calculated based on the fresh weight of green pods.

Statistical Analysis

Statistical analysis system (SAS 9.1 version) was used to analyze the collected data for statistical analysis. One-way Analysis of variance (ANOVA) test was used to determine the significance level of the treatments. Turkey’s test was used to compare treatment means at a 5% significance level.

Results and Discussion

The number of green pods per plant, pod length, number of seeds per pod and fresh weight of seeds per pod against different treatments are given in Table 2.

Number of green pods per plant

In the total number of green (marketable) pods per plant, there were significant differences ($P<0.001$) among the treatments (Table 2). The highest number of green pods was observed in T8 (11.8) followed by T5 (11.2) but there was no significant variation between T5 and T8. The lowest number of green pods was observed in T1 (3.4) which was remarkably different from other treatments. Further, it was noted that there was considerable variation ($P<0.05$) in number of pods between T2 and T4 treatments. Jalilian (2015) reported that a remarkable effect on yield was noted in cereal crops with the use of sewage sludge compost. Berecz et al. (2005) stated that the combined application of synthetic fertilizers and organic manure has the potential to boost soil biological activity and enhance the soil’s chemical and physical properties. This enhanced soil condition, in turn, contributes to increased yields of cultivated plants.

Table 2: The number of green pods per plant, pod length, number of seeds per pod and fresh weight of seeds per pod against different treatments

Treatments	Number of green pods per plant	Pod length (cm)	Number of seeds per pod	Fresh weight of seeds per pod (g)
T1	$3.4±0.2^{d}$	$18.56±0.66^{bc}$	8.8±0.9	$0.76±0.05^{d}$
T2	$6.2±0.4^{c}$	$17.42±1.37^{c}$	9.6±1.6	$1.04±0.19^{dc}$
T3	$6.8±0.5^{c}$	$22.22±1.16^{ab}$	10.6±1.4	$1.74±0.10^{abc}$
T4	$9.0±0.4^{b}$	$21.62±0.35^{ab}$	9.8±0.9	$1.66±0.22^{abc}$
T5	$11.2±0.9^{a}$	$21.68±0.66^{ab}$	11.1±0.4	$2.04±0.29^{ab}$
T6	$9.8±0.4^{ab}$	$20.26±0.75^{abc}$	10.6±0.5	$1.38±0.04^{abcd}$
T7	$10.2±0.4^{ab}$	$19.48±0.68^{bc}$	10.4±1.1	$1.26±0.17^{bcd}$
T8	$11.8±0.4^{a}$	$23.88±0.62^{a}$	12.4±0.7	$2.18±0.31^{a}$
F test	$P<0.001$	$P<0.001$	$P>0.05$	$P<0.001$

Value represents mean ± SEM. Means followed by the same letter in each column are not significantly different according to the Tukey’s Test at 5% significant level.

Pod Length

Table 2 shows that there were significant differences ($P<0.001$) in pod length. The highest pod length was recorded in T8 (23.88 cm) and it was considerably ($P<0.05$) differed from T1, T2 and T7. The lowest pod number was observed in T2 (17.42 cm) which was statically similar in T1, T6 and T7. According to Ozdemir (2005), the application of municipal solid waste compost enhanced growth and improved yield parameters for chickpeas. A positive response in the growth of dwarf beans was also observed with the addition of sewage sludge (Theodoratos et al., 2000).

Number of seeds per pod

There were no significant variations ($P > 0.05$) in number of seeds per green pod (Table 2). The highest number of seeds was recorded in T8 (12.4) and the lowest number of seeds was observed in T1 (8.8). According to Ozyazici (2013) finding, the application of sludge enhanced crop yields by supplying an adequate amount of available nitrogen to the plants. The low number of seed formation in each pod might be ascribed to an inadequate amount of Nitrogen, Phosphorus, and Potassium (NPK) nutrients during the flowering and seed-setting stages of the plant (Naeem et al., 2006). Pasqualone et al. (2017) stated that the combined use of sewage sludge and mineral fertilization gave crop seed yield that was equal to that achieved with mineral fertilization alone. This suggests that the potential efficacy of sewage sludge leads to reducing the use of chemical fertilizers.

Fresh weight of green pod and seeds

Considerable differences ($P<0.001$) in the fresh weight of a single green pod (Table 3) and the fresh weight of seeds per green pod were recorded (Table 2). The fresh weight of single green pod was high in T8 (12.48 g), followed by T5 (10.98 g) and the lowest mean value was noted in T1 (6.26 g). It was also observed that green pod weight in T3 (11.16 g) was varied from that in T2 (8.10 g). In fresh weight of seeds per pod, high seed weight was observed in T8 (2.18 g), followed by T5 (2.04 g) while T1 (0.76 g) had the fewest. Outhman and Firdous (2016) reported that the application of sewage sludge at 12 t/ha significantly increased the grain yield of wheat and barley. The increased yield characteristics can be attributed to the increased levels of soil nutrients by the addition of organic manures to plants, which promote the vegetative and reproductive growth in cowpea plants Ahamed and Elzaawely (2010). In this experiment, 20 t/ha sewage sludge and 100% P and K inorganic fertilizers (T8) gave the highest results. It might be due to the combined application of sewage sludge with P and K inorganic fertilizers. When compared to the T2 treatment, the application of 10 t/ha sewage sludge without inorganic fertilizer significantly increased the fresh weight of a single green pod.

Marketable pod yield

The effect of different combinations of sewage sludge with P and K inorganic fertilizers on green (marketable) pod yield per square meter at 8 weeks after planting is shown in Table 3. In the fresh weight of green pods per plant, the substantial difference ($P<0.001$) was noted among the treatments. The highest fresh weight of green pods per plant was observed in T8 (146.54 g), followed by T5 (123.58 g), both were statistically similar. The lowest fresh weight of green pods per plant was observed in the T1 (21.00 g) control treatment, which significantly varied from the other treatments. Moreover, this study showed that fresh weight of green pods in T3 (10 t/ha sewage sludge alone) was statically on a par ($P<0.05$) with T2 (inorganic fertilizers alone) and T4 (20 t/ha sewage sludge alone). Still, there was considerable disparity between T2 and T4. Nutrient availability resulting from the appropriate amount of sewage sludge amendment in the soil is the major factor for increasing pod weight.

Table 3: Effect of sewage sludge with P and K inorganic fertilizers on fresh weight of single pod, green pods per plant and marketable pod yield of vegetable cowpea.

Treatments	Fresh weight of single green pod (g)	Fresh weight of green pods per plant (g)	Marketable Pod yield (g/m^2)
T1	6.26 ± 0.33^{d}	21.00 ± 0.75^{e}	175.00 ± 6.26^{e}
T2	8.10 ± 0.16^{dc}	50.06 ± 2.45^{d}	417.17 ± 20.44^{d}
T3	11.16 ± 0.33^{ab}	$75.66\pm5.24d^{c}$	630.50 ± 43.65^{cd}
T4	10.10 ± 0.61^{bc}	89.98 ± 2.91^{c}	749.83 ± 24.24^{c}
T5	10.98 ± 0.88^{ab}	123.58 ± 14.1^{ab}	1029.83 ± 117.31^{ab}
T6	10.28 ± 0.43^{abc}	100.98 ± 6.44^{bc}	841.50 ± 120.04^{bc}
T7	9.36 ± 0.37^{bc}	95.24 ± 3.94^{c}	793.67 ± 32.84^{c}
T8	12.48 ± 0.54^{a}	146.54 ± 2.90^{a}	1221.17 ± 24.16^{a}
F test	$P<0.001$	$P<0.001$	$P<0.001$

Value represents mean ± SEM. Means followed by the same letter in each column are not significantly different according to the Tukey's Test at 5% significant level.

In pod yield per square meter, there was remarkable variation ($P<0.001$) among the treatments. The significantly highest value (1221.17 g/m^2) was recorded ($P<0.05$) in T8 (20 t/ha Sewage sludge + 100% PK inorganic fertilizers) than those in other treatments except T5 (1029.83 g/m^2). Further, it was noticed that there was no considerable difference in pod yield between the T5 (10 t/ha Sewage sludge + 50% PK inorganic fertilizers) and T6 (20 t/ha Sewage sludge + 50% PK inorganic fertilizers) however, pod yield in T5 differed from that in T7 (10 t/ha Sewage sludge + 100% PK inorganic fertilizers). Compared to other treatments, T1 treatment had significantly lowest pod yield (175.00 g/m^2) which was not treated with sewage sludge or inorganic fertilizers. The combination of sewage sludge and P and K inorganic fertilizer had a cumulative effect on improving crop yield. Due to sewage sludge's effectiveness as a source of organic matter, nitrogen, phosphorus, and various micronutrients, the combined use of sewage sludge and fertilizer resulted in an increased dry matter yield (Bedwal et al., 2022). The incorporation of sewage sludge as a soil amendment exhibits the beneficial of increasing crop production and nurturing the nutrient and organic matter in the soil (Muter et al., 2022).

Conclusion

Based on the findings, the highest value of marketable pod yield was obtained in T8 (1221.17 g/m^2), followed by T5 (1029.83 g/m^2). However, the application of 10 t/ha or 20 t/ha sewage sludge without inorganic fertilizers (T3 or T4) showed a positive effect on most of the measured parameters. The combined application of sewage sludge with inorganic fertilizer increased pod yield of vegetable cowpea in sandy regosol compared to the T1 (control) and T2 (inorganic fertilizers alone) treatments. Further, it was noted that the usage of sewage sludge and inorganic fertilizers either at full capacity (T8 - 20 t/ha sewage sludge + 100% P and K) or at half (T5-10 t/ha sewage sludge + 50% P and K) resulted in higher marketable pod yield while T6 (20 t/ha sewage sludge + 50% P and K) and T7 (10 t/ha sewage sludge + 100% P and K) notably reduced pod yield than T5 and T8 treatments. In this study, there was no significant difference in pod yield between T5 and T8 treatments. Therefore, 10 t/ha municipal sewage sludge with 50% of P and K inorganic fertilizers (T5) could be used for the cultivation of vegetable cowpea to increase marketable pod yield in sandy regosol soil with reduced usage of inorganic fertilizers.

List of References

Ahmed, M. S. and Elzaawely, A. (2010). Growth and yield of cowpea plants in response to organic fertilization. Australian Journal of Basic and Applied Sciences, 4(8), pp 3244-3249.

Archana, K. and Seran, T. H. (2023). Growth and yield of shallot (*Allium ascalonicum* L.) as influenced by soil application of liquid urea and cow urine. *AGRIEAST, 17*(1), pp 1-13.

Bedwal, S., Kuldeep, Kumar, S. and Singh, C. (2022). Impact of sewage sludge on crop growth, soil quality and nutrient dynamics in system-based approach. The Pharma Innovation Journal, 11(3), pp 1399-1406.

Berecz, K., Kismányoky, T. and Debreczeni, K. (2005). Effect of organic matter recycling in long- term fertilization trials and model pot experiments. Communications in Soil Science and Plant Analysis, 36(1-3), pp 191-202.

Dananjana, G. A. N and Seran, T. H. (2022). Effect of foliar application of red large onion (*Allium cepa* L.) peel solution on growth and yield of cowpea (*Vigna unguiculata* L. WALP). Tropical Agricultural Research and Extension, 25(3), pp 318-326.

Department of Agriculture (DOA) (2023). Vegetable cowpea varieties. Available in https://doa.gov.lk/hordi-crop-yard-long-bean (Accessed on 20th November 2023).

Fernando, W. K. M. B. and Seran, T. H. (2023). Effect of compost with banana peel and moringa leaf powders on seed yield and yield components of green gram (*Vigna radiata* L. WILCZEK). Journal of Agricultural Sciences (Belgrade), 68(2), pp 171-186.

Gomes, A. M.F., Rodrigues, A. P., António, C., Rodrigues, A. M., Leitão, A. E., Batista-Santos, P., Nhantumbo, N., Massinga, R., Ribeiro-Barros, A. I. and Ramalho, J. C. (2020). Drought response of cowpea (*Vigna unguiculata* (L.) Walp.) landraces at leaf physiological and metabolite profile levels. Environmental and Experimental Botany, 175, article 104060. https://doi.org/10.1016/j.envexpbot.2020.104060

Jalilian, J. (2015). The effect of farm slope and application of different fertilizer sources on wheat yield. In: Proceeding of Sixth International Scientific Agricultural Symposium “Agrosym 2015", Jahorina, Bosnia and Herzegovina, University of East Sarajevo during 15th -18th October 2015. pp 209-213.

Iwanthika, G. M. S. and Seran T. H. (2023). Yield response of cowpea (*Vigna unguiculata* L.) to poultry waste application with different rates of potassium and phosphorus inorganic fertilizers. International Journal of Environment, 12(2), pp 71-82.

Kominko, H., Gorazde, K. and Wzorek, Z. (2017). The possibility of organo-mineral fertilizer production from sewage sludge. Waste and Biomass Valorization, 8, pp 1781-1791. https://doi.org/10.1007/s12649-016-9805-9

Lamastra, L., Suciu, N. A. and Trevisan, M. (2018). Sewage sludge for sustainable agriculture: contaminants' contents and potential use as fertilizer. Chemical and Biological Technologies in Agriculture 5,10. https://doi.org/10.1186/s40538-018-0122-3

Muter, O., Dubova, L., Kassien, O., Cakane, J. and Alsina, I. (2022). Application of the Sewage Sludge in Agriculture: Soil Fertility, Techno-economic and Life-Cycle Assessment. In: Hazardous Waste Management, IntechOpen, London. http://dx.doi.org/10.5772/intechopen.10426

Nadeeka, P. W. M. and Seran, T. H. (2020). The effects of goat manure and sugarcane molasses on the growth and yield of beetroot (*Beta vulgaris* L). Journal of Agricultural Sciences (Belgrade), 65(4), pp 321-335.

Naeem, M., Iqbal, J. and Bakhsh, M. (2006). Comparative study of inorganic fertilizers and organic manures on yield and yield components of mungbean (*Vigna radiata* L.). Journal of Agriculture and Soil Science, 2(4), pp 227-229.

Outhman, A.M. and Firdous. F. (2016). The impact of the use of sludge in agriculture on the vegetative growth of cereal crops. International Journal of Advanced Science and Engineering 4, pp 1-9.

Ozdemir, S. (2005). Effects of municipal solid waste (MSW) compost on nodulation, plant growth and mineral composition of chickpea in marginal land. Fresenius Environmental Bulletin, 14, 599- 604.

Ozyazici, M. A. (2013). Effects of sewage sludge on the yield of plants in the rotation system of wheat-white head cabbage-tomato. Eurasian Journal of Soil Science, 2(1), pp 35-44.

Pasqualone, A., Summo, C., Centomani, I., Lacolla, G., Caranfa, G. and Cucci, G. (2017). Effect of composted sewage sludge on morpho-physiological growth parameters, grain yield and selected functional compounds of barley. Journal of the Science of Food and Agriculture, 97(5), pp 1502- 1508.

Qadir, M., Drechsel, P., Cisneros, J. B., Kim, Y., Pramanik, A., Mehta, P. and Olaniyan, O. (2020). Global and regional potential of wastewater as a water, nutrient and energy source. Natural Resource Forum, 44, pp 40 -51.

Samarakoon, S. G. N. D. and Seran, T. H. (2023). Yield response of Abelmoschus esculentus as influenced by compost with Tithonia leaves. International Journal of Environment, 12(2), pp 56- 70.

Seran, T. H. and Imthiyas, M. S. M. (2016). Effect of Different Doses of NK Chemical Fertilizers and Compost on Growth and Yield Attributes of Tomato (Lycopersicon esculentum Mill.). Turkish Journal of Agriculture - Food Science and Technology, 4(6), pp 481-486.

Seran, T. H. (2018). Effects of inorganic and organic nutrients combindly used on yield and quality of groundnut (Arachis hypogaea L.). Bangladesh Journal of Scientific and Industrial Research, 53(4), pp 289-296.

Shahardeen R. N. M and Seran T. H (2013). Impact of animal manure EM-bokashi on seed yield and quality of vegetable cowpea (*Vigna unguiculata* L.). Bangladesh Journal of Scientific and Industrial Research, 48(1), pp 33-38.

Theodoratos, P., Moirou, A., Xenidis, A. and Paspaiaris, I. (2000). The use of municipal sewage sludge for the stabilization of soil contaminated by mining activities. Journal of Hazardous Materials, 77, pp 177-191.

Viharnaa, S. and Seran, T. H. (2013). Effect of cow and poultry manures as basal fertilizers on marketable fruit yield of okra (*Abelmoschus esculentus* L). Tropical Agricultural Research and Extension, 16(1), pp 31-33.