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5 authors, including:

Atif Muhmood
Aarhus University

Shahid Javid
provincial reference fertilizer testing laboratory Punjab, Lahore

Abdul Majeed
Ayub Agricultural Research Institute

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INTEGRATED USE OF BIOSLURRY AND CHEMICAL FERTILIZERS FOR VEGETABLE PRODUCTION

A. Muhmood*, S. Javid, Z.A. Ahmad, A. Majeed and R.A. Rafique

Soil Chemistry Section, Institute of Soil Chemistry and Environmental Sciences
Ayub Agricultural Research Institute Faisalabad, Pakistan
***Corresponding author's e-mail: atif_1534@yahoo.com**

Low organic matter content is one of the most important contributing factors for poor fertility status of Pakistani soils. Bioslurry, a by-product from the biogas plant, can successfully be used to improve crop productivity and soil health. A study was conducted to assess the integrated use of bioslurry and chemical fertilizers for improving the yield of vegetables. For this purpose, seven treatments i.e., control (recommended dose of NPK@ 55-76-0 kg ha^{-1} for spinach, and NPK @ 125-75-60 kg ha^{-1} for chilli), liquid slurry on the basis of recommended dose (RD) of N, dried slurry on the basis of RD of N , farm yard manure on the basis of RD of N, Half of the RD of N from chemical fertilizer and half from liquid slurry, Half of the RD of N from chemical fertilizer and half from dried slurry, Half of the RD of N from chemical fertilizer and half from farm yard manure, were applied before sowing of spinach and chilli and all the organic material was well mixed with soil. The results revealed that the highest yield (56.0 t ha^{-1}) of spinach (total two cuttings) and chilli (3.06 t ha^{-1}) was obtained with chemical fertilizer which was at par where half of the RD of N from chemical fertilizers and half from liquid slurry was applied. The results of the combined use of liquid slurry and chemical fertilizers were significantly better than those of liquid slurry alone. The plant analysis showed that total N, P, K, Zn, Cu, Fe and Mn contents were improved significantly by integrated use of bio-slurry with fertilizers.
Keywords: Bio-slurry, farm yard manure, spinach, chilli, yield, soil health

INTRODUCTION

The increasing population and limited land forced our farmers to maximize crop yields per unit area through intensive cultivation. The organic matter, an indicator of soil fertility, is low in our soils (less than 1%). This is due to less rainfall and high temperature. The continuous mining of nutrients from soil ultimately decreases its productivity. Organic manure can serve as a substitute to mineral fertilizers. Organic fertilizers supply required nutrients, improve soil structure, increase microbial population and maintain the quality of crop produce (Suresh *et al*., 2004; Dauda *et al*., 2008; Ejaz *et al*., 2012; Munir *et al*., 2012; Khan *et al*., 2012; Unal, 2013; Muhammad *et al*., 2013). Despite the large quantities of plant nutrients in inorganic fertilizers as compared to organic fertilizers, the presence of growth promoting agents in organic fertilizers make them important for the enhancement of soil fertility and productivity (Sanwal *et al*., 2007; Adeleye *et al*., 2010). Bio-slurry, a by-product from biogas production plant, is a good quality organic fertilizer (Islam, 2006). During anaerobic fermentation process, about 25 to 30% of organic matter is transformed into biogas, while the rest is converted into bio-slurry. This residual manure is normally rich in macro and micro nutrients (Islam, 2006). Biogas slurry has the ability to improve the physical and biological quality of soil besides providing both macro and micro-nutrients to crops. So, bioslurry could be one of the best organic fertilizers to revitalize soils since it is a rich source of both plant nutrients and organic matter. The use of bio-slurry can reduce the application of chemical fertilizers to a great extent. It is possible to reduce the use of the chemical fertilizers up to 50% which will benefit the farmers in their production costs and the soil will be high in fertility and productivity (Islam, 2006). Keeping in view the above facts, a study was conducted to evaluate the effect of integrated use of chemical fertilizer and bio-slurry for improving vegetable productivity and soil health.

MATERIALS AND METHODS

Two field trials were conducted at Institute of Soil Chemistry & Environmental Sciences, Ayub Agricultural Research Institute during 2010 and 2011, to study the integrated effect of fertilizers and bio-slurry on vegetables (spinach and chilli) and soil health. The experiments were designed in a randomized complete block design (RCBD) with three replications.
The following treatments were applied in the experiment:
T1 = Recommended dose (RD) of NPK
T2 = Liquid slurry (LS) on the basis of RD of N
T3 = Dried slurry (DS) on the basis of RD of N

T4 = Farm manure (FM) on the basis of RD of N
T5 = Half of the RD of N from fertilizer and half from liquid slurry
T6 = Half of the RD of N from fertilizer and half from dry slurry
T7 = Half of the RD of N from fertilizer and half from FYM

***Soil sampling and analysis*:** Soil samples were taken before sowing of crop for assessing the fertility status of the soil and were air dried, crushed and sieved through a 2 mm stainless steel sieve for physical and chemical characteristics (Table 1). Soil particle distribution was measured by hydrometer method (Blake and Hartge, 1986). About 250 g soil was saturated with distilled water for determining pH of soil. The paste was allowed to stand for one hour and pH was recorded by pH meter with glass electrodes using buffer of pH 4.0 and 9.0 as standard (Mclean, 1982). For determining EC_e, extract of each soil paste was obtained by using vacuum pump and EC_e was noted with conductivity meter (Corning 220). Soil organic carbon (SOC) content was estimated following the method as described by Ryan *et al*. (2001), and available phosphorus was estimated by Olsen's method (Jackson, 1962). While for potassium, soil extraction was done with ammonium acetate (1 N of pH 7.0) and potassium was determined by using PFP-7 Janway Flame photometer (Rowell, 1994).

Plant samples (0.5 g) were digested with sulphuric acid and hydrogen peroxide according to the method of Wolf (1982). Total nitrogen was determined by Kjeldhal method (Jackson, 1962). Phosphorus in plant samples was determined by using yellow color method. 10 mL of digested liquid was taken into 50 mL volumetric flask + 10 mL of colored reagent (Molybdate Vanadate solution) + 30 mL of distilled water and it was left for 30 minutes to develop color. After that samples were run on spectrophotometer No. 410 (at 420 nm wavelength) reading were noted (Chapman and Pratt, 1961). Potassium was analyzed by Flame photometer (Jenway PFP-7). Zn, Cu, Fe and Mn in plant and organic sources were carried out by the standard procedures given by Rashid *et al*. (1986) using Atomic Absorption Spectrophotometer (AA-7000 Shimaszu). The data collected from the experiment regarding different parameters were subjected to analysis of variance to test the significance of treatments and treatment means were compared using least significant difference (LSD) (Steel *et al*., 1997).

***Characterization of organic materials*:** Liquid and dried slurry was taken from biogas plant at Chak No. 254 RB Faisalabad. Liquid slurry, dried slurry and farm manure samples were analysed for their chemical constituents.

RESULTS AND DISCUSSION

Vegetables are a source of vitamins, minerals and plant proteins in human diet all over the world. The maximum spinach and chilli yield (Table 3) was recorded where recommended dose of chemical fertilizer was applied alone and it was statistically at par with treatment where half of the RD of N from chemical fertilizer and half from liquid slurry was used. The spinach yield was low in treatment where liquid slurry was applied through fertigation and it was statistically significant with treatment containing recommended dose of chemical fertilizers. The highest yield in chemical fertilizer treatment is due to rapid supply and release of nutrients from inorganic fertilizers. The greater yield in treatment with combination of chemical fertilizer and bioslurry than combination of farm yard manure and chemical fertilizer may be due to the fact that bioslurry have narrow C:N ratio than farm yard manure That's why the mean yield of both vegetables that is more in combination of bioslurry and chemical fertilizers than farm yard manure and fertilizer integration due to supplying of more readily available nutrients. In addition to this soil applied organic matter not only served as a reservoir of all the required plant nutrients, but it also gave better structure to the soil, provided energy for the microbial activity which is essential for recycling of nutrients, affected the nutrient availability like N, P, K and S. These arguments were supported by Stevenson (1986) that application of organic amendments along with chemical fertilizers resulting in improving soil and water conservation, buffering capacity, exchange capacity of the soil. Due to this bioslurry showed better

Table 1. Basic soil analysis

Depth cm	pH -	ECe dS m^{-1}	O.M -%-	P mg kg^{-1}	K	Sand	Silt -%-	Clay	Texture
0-15	8.12	1.98	0.72	8.63	180	53.2	20.4	26.4	Sandy clay loam
15-30	8.03	1.88	0.63	7.69	160				

Table 2. Chemical composition of bio- slurry and farm yard manure

Organic Material	N	P	K	Fe	Zn	Cu	Mn
		-%-			-ppm-		
LS	0.98	0.68	1.09	1910	74.4	28.6	484
DS	1.00	0.79	1.17	2000	81.1	36.0	464
FYM	0.67	0.56	1.13	1560	73.6	22.6	396

results than farmyard manure application. The decline in yield in organic fertilizer treated plants may be due to slow rate of mineralization and nutrient uptake. The findings of this study are in accordance with Devi *et al.* (2002). Shahbaz (2011) conducted a study on okra and found maximum okra fruit yield with the application of bioslurry @ 600 kg/ha and half of recommended nitrogenous fertilizer.

Table 3. Effect of bioslurry on yield of spinach and chilli ($t\ ha^{-1}$)

Treatments	Spinach yield ($t\ ha^{-1}$)	Chilli yield ($t\ ha^{-1}$)
Recommended dose of NPK	56.06 A	3.06 A
Liquid slurry on the basis of RD of N	39.33 C	1.86 C
Dried slurry on the basis of RD of N	49.63 B	1.87 C
Farm yard manure on the basis of RD of N	47.26 B	1.73 C
Half of the RD of N from chemical fertilizer and half from liquid slurry	52.73 AB	2.60 AB
Half of the RD of N from chemical fertilizer and half from dried slurry	48.90 B	2.07 BC
Half of the RD of N from chemical fertilizer and half from farm yard manure	49.97 B	2.03 BC
LSD	5.50	0.55

***Effect of bioslurry and fertilizer integration on macronutrient concentration of spinach and chilli*:** The application of bioslurry and farm yard manure increased organic matter content, available phosphorus and exchangeable potassium of soil and improved the porosity and water holding capacity of the soil and it also reduced soil temperature fluctuations, reduced evaporation of soil water, and influenced the levels of some nutrients measured in plant. The maximum macronutrient contents (Fig.1 and 2) in leaves of both vegetables (i.e. spinach and chilli) were obtained in treatment with recommended dose of chemical fertilizer followed by treatment where ½ N from chemical fertilizer and ½ N from liquid slurry were applied. These treatments were statistically at par with each other but significantly differed from all other treatments. The higher concentration of nutrients by the application of chemical fertilizers is due to quick release of nutrients from fertilizers. The minimum macronutrient contents were obtained in the treatment where farm yard manure alone was used; this might be due to the gradual release of nutrients from its slow rate of decomposition. Bioslurry provides readily available nutrients to the growth media and plant flourish more rapidly and chlorophyll contents also increased. Due to more staying nature of bioslurry in soil and holding and supplying nutrients more efficiently, bioslurry showed better results than farm yard manure application regarding N, P and K uptake by plant (Yu *et al*., 2010). Similar results were also found by Liu *et al.* (2008) and Desuki *et al.* (2010).

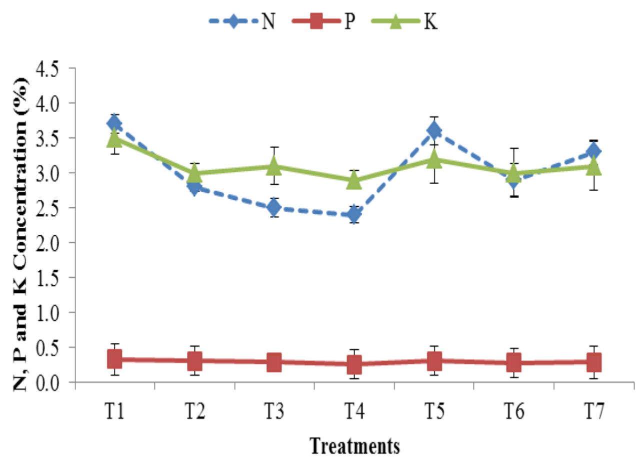

Figure 1. Effect of bio-slurry and fertilizer integration macronutrient concentration (%) in spinach leaf (T1 = RD of NPK, T2 = LS on the basis of RD of N T3 = DS on the basis of RD of N, T4 = FM on the basis of RD of N, T5 = ½ N from fertilizer and ½ N from LS, T6 = ½ N from fertilizer and ½ N from DS, T7 = ½ N from fertilizer and ½ N from FM).

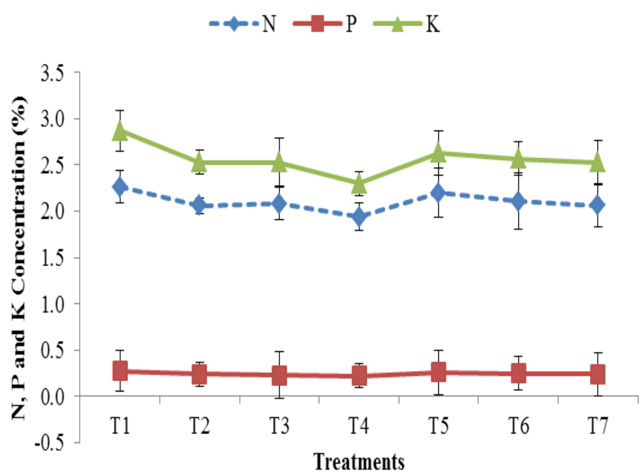

Figure 2. Effect of bio-slurry and fertilizer integration on macronutrient concentration (%) in chilli leaf (T1 = RD of NPK, T2 = LS on the basis of RD of N, T3 = DS on the basis of RD of N, T4 = FM on the basis of RD of N, T5 = ½ N from fertilizer and ½ N from LS, T6 = ½ N from fertilizer and ½ N from DS, T7 = ½ N from fertilizer and ½ N from FM).

***Effect of bioslurry and fertilizer integration on micronutrient concentration of spinach and chilli*:** The maximum micronutrient contents (Figs.3 & 4) in leaves of both vegetables (spinach and chilli) were obtained in treatment with recommended dose of chemical fertilizer followed by treatment where ½ N from chemical fertilizer and ½ N from liquid slurry were applied. These treatments are statistically at par with each other but significantly differed from all other treatments. The maximum micronutrient concentration with the application of chemical fertilizers might be due to extensive root growth. Bioslurry affected the nutrient uptake to the plant in more consistent manner because its mineralization was occurred on later stages and provide nutrients to the plants along with mineral fertilizer. Whereas the minimum micronutrient contents were obtained in the treatments where organic materials were used alone, this might be due to the gradual release of nutrients from their slow rate of mineralization. High uptake of nutrients by soil applied bioslurry and farmyard manure along with chemical fertilizers might be due to the fact that it beside improving soil quality also supplied micro, macro nutrient to soil, increase uptake of nutrients to plant that flourish the plant growth that was observed in bioslurry application and due to supplying of more readily available nutrients while farm yard manure has wider C:N ratio than bioslurry. Therefore bioslurry shows better results on early stages of its application in soil on nutrients availability while farm yard manure affected the nutrient uptake to the plant in more consistent manner because its mineralization was occurred on later stages and provides nutrients to the plants along with mineral fertilizer (Sarwar *et al.*, 2007). The results of this study are in accordance with Sarwar *et al.* (2010).

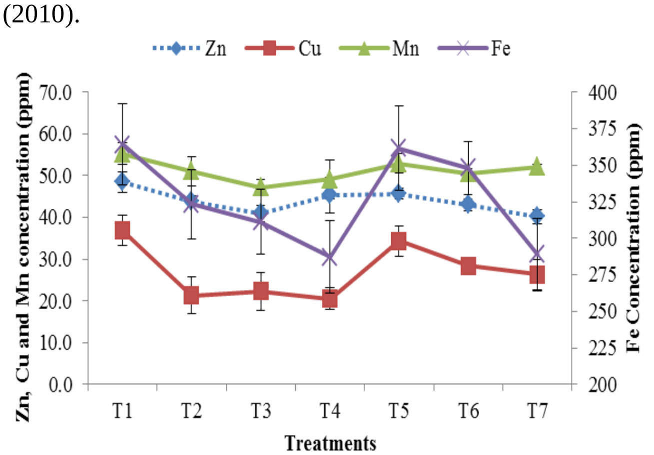

Figure 3. Effect of bio-slurry and fertilizer integration on micronutrient concentration (ppm) in spinach (T1 = RD of NPK, T2 = LS on the basis of RD of N, T3 = DS on the basis of RD of N, T4 = FM on the basis of RD of N, T5 = ½ N from fertilizer and ½ N from LS, T6 = ½ N from fertilizer and ½ N from DS, T7 = ½ N from fertilizer and ½ N from FM).

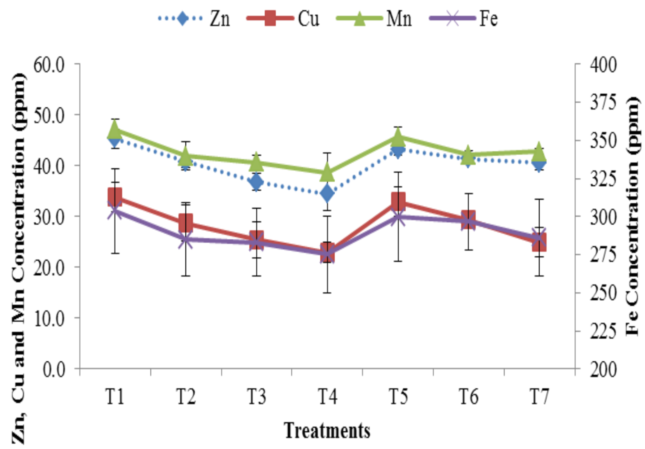

Figure 4. Effect of bio-slurry and fertilizer integration on micronutrient concentration (ppm) in chilli leaf (T1 = RD of NPK, T2 = LS on the basis of RD of N, T3 = DS on the basis of RD of N, T4 = FM on the basis of RD of N, T5 = ½ N from fertilizer and ½ N from LS, T6 = ½ N from fertilizer and ½ N from DS, T7 = ½ N from fertilizer and ½ N from FM).

***Postharvest soil analysis*:** Post harvest soil analysis depicted that there is a little difference of pH and ECe of the soil before and after the experiment. Despite the fact that well decomposed bioslurry and farm yard manure act as the buffering agent no significant improvement in pH was found in this experiment. This may be due to the slow rate of mineralization. There is a definite trend on the content of organic matter in the soil after the crop. For the noticeable change in organic matter content long-term observation is required. It is too short period to notice the changes on the soil properties brought about by the application of bioslurry and farm yard manure along with different doses of inorganic N fertilizer. Application of mineral fertilizer along with farm yard manure and bioslurry has showed positive contribution on the availability of K content in soil, whereas the available phosphorus content in the soil has shown no definite trend. This is mainly due to alkaline soil pH property. Soil phosphorus in high soil pH environment becomes deficit even if it is present in plentiful amount Shahbaz (2011) conducted a study on okra and using different combinations of bioslurry and chemical fertilizer and he found the similar trend in soil property after harvest of crop as observed in this study.

***Economic analysis of the study*:** The economic analysis of the study depicted that maximum benefit was obtained in case integration of chemical fertilizers and liquid slurry where as minimum benefit was obtained where only organic sources were used without integration. So, it is economical to use integration of chemical fertilizers and fresh slurry instead of using organic or inorganic fertilizers alone.

Table 4. Post harvest soil analysis

Treatment	pH	ECe (dS/m)	O.M (%)	Av. P (mg/kg)	Av. K (mg/kg)
Recommended dose of NPK	8.11	1.95	0.71	8.42	195
Liquid slurry on the basis of RD of N	8.15	1.81	0.82	8.71	204
Dried slurry on the basis of RD of N	8.15	1.88	0.79	8.76	208
Farm yard manure on the basis of RD of N	8.16	1.89	0.80	8.73	213
Half of the RD of N from chemical fertilizer and half from liquid slurry	8.14	1.80	0.76	8.62	200
Half of the RD of N from chemical fertilizer and half from dried slurry	8.15	1.83	0.78	8.50	202
Half of the RD of N from chemical fertilizer and half from farm yard manure	8.16	1.85	0.74	8.55	209

Table 5. Economic analysis

Treatments	Spinach	Chilli
	Benefit cost ratio (BCR)	
Recommended dose of NPK	8.34	8.01
Liquid slurry on the basis of RD of N	7.80	6.16
Dried slurry on the basis of RD of N	7.10	5.79
Farm yard manure on the basis of RD of N	6.61	5.41
½ N from chemical fertilizer and ½ N from liquid slurry	9.26	8.10
½ N from chemical fertilizer and ½ N from dried slurry	8.45	6.62
½ N from chemical fertilizer and ½ N from farm manure	8.23	6.54

***Conclusion*:** The combination of inorganic and organic fertilizers (liquid slurry) proved cost effective and produced the maximum yield compared with other combinations but at par with treatment where chemical fertilizer was applied alone. This best combination also saved half nitrogenous fertilizer. So, this combination may be recommended to farmers for better production of vegetables

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