SCIENCE LETTERS 2014 | Volume 2 | Issue 1 | Pages 56-59

Integrated use of biogas slurry and chemical fertilizer to improve growth and yield of okra

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Abstract

Biogas slurry is not only the environment friendly organic fertilizer, but it is also efficient utilization of waste material, in this era of dire need of sustainable agriculture. A study was conducted to evaluate the integrated effect of biogas slurry and chemical fertilizer on growth, yield and quality of okra. Fresh and 30 days old biogas slurry was used 400 and 800 kg ha^{-1} as soil conditioners along with 100% recommended nitrogen (N) , and applied to obtain 25, 50, 75 and 100% N from biogas slurry, while rest of N from chemical fertilizer. These treatments were compared with recommended dose of NPK. The results indicated that maximum yield of okra was obtained with treatment which received 50% N from recommended chemical NPK and 50% N from fresh biogas slurry. Similarly, plant height (15%), root length (23%), number of fruits per plant (25%) and fruit fresh weight (36%) were also significantly higher in this treatment compared with control where only recommended dose of chemical NPK fertilizers was applied. Comparing with other treatments the yield was significantly lower in the sole application of biogas slurry. It was concluded that application of biogas slurry in combination with chemical fertilizer could boost up the yield of Okra.

Key words: Biogas slurry, chemical fertilizer, growth, integrated use, okra.

Received April 12, 2014; **Revised** June 01, 2014; **Accepted** June 02, 2014
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To cite this manuscript: Maqbool S, ul Hassan A, Akhtar MJ, Tahir M. Integrated use of biogas slurry and chemical fertilizer to improve growth and yield of okra. Sci Lett 2014;2(2):56-59.

Introduction

Agriculture is the major sector for the economic development of most developing countries. There are chemical fertilizers used by the farmers to fulfill the crop nutritional requirements, but presently, chemical fertilizers are much expensive and, in certain cases, not available in time. This situation demands to explore other supplement sources of nutrients. The integrated use of organic and chemical fertilizers can reduce dependence on expensive chemical inputs. To sustain high crop yields without deterioration of soil fertility, it is important to work out the optimal combination of fertilizers and manures in the cropping system [1]. There are a number of types of organic and inorganic fertilizers to improve plant growth and yield. Among those, biogas slurry is not only the environment friendly organic fertilizer, but it is also efficient utilization of waste material. In many Asian countries, including China, the amount of biogas slurry has drastically increased [2]. Nowadays, there are approximately 16 million households using anaerobic digesters in China and the output of slurry was more than 450 million tons in 2008.

The use of organic wastes such as crop residues, manures and compost has large potential for improving soil productivity and crop yield through improvement of the physical, chemical and microbiological properties of the soil as well as nutrient supply [3]. The fermented slurry, sometimes called bio-slurry, as a product of anaerobic fermentation of animal excrement in the biogas digester is an excellent organic fertilizer, which can make an important contribution to better crop yields and soil fertility. The fermented slurry which contains a relatively high percentage of readily available nutrients can be directly applied as a liquid or dried form to the plants both for basal and top dressing [4]. The wet slurry is reported to contain around 1.6% and the dry slurry contains <0.5% nitrogen as the readily available form ammonia [5]. Maximum benefits are obtained when slurry is used in liquid form as it comes out of manufacturing plant [6]. Palm et al. [7] reported that the organic fertilizer cannot meet crop nutrient demands over large areas because of limited availability, low nutrient composition, and high labor requirements. The integrated soil fertility management is the most feasible options to resource poor farmers to sustain the productivity of maize/bean in intercropping system. The integrated use of organic wastes and chemical fertilizers is beneficial in improving crop yield, soil pH, organic carbon and available N, P and K in sandy loam soil [8].

Okra (*Abelmoschus esculentus L.*) commenly known as ladyfinger belongs to the family *Malvaceae*. It is an important summer vegetable crop, which is grown in tropical and subtropical regions of the world. It is a rich source of vitamin A, B, thiamine riboflavin and niacin, which are found at rate of 0.1 mg, 0.1 mg and 0.7 mg/100 gm of edible fruit [9]. It's black or white eyed seeds are roasted, ground and used as a substitute for coffee in Turkey [10].

The effects of slurry and other organic manures and chemical fertilizers on yields of a number of crops have been proved. However, for the potential benefits to the farmers, the percent nutrient contents of different biogas slurry sources, and its application at different rates along with different levels of combinations with chemical fertilizer is needed to be tested [11]. Okra responds well to the dressing of organic manure applied in combination with inorganic fertilizer. Palm et al. [12] depicted the importance of integrated application of organic and inorganic fertilizer as an essential technique in okra production and concluded that okra can also be given a combination of organic and inorganic fertilizers to improve the growth and yield and to supply balance nutrient to the crop. Keeping in view the above discussion a pot experiment was conducted to study the effect of biogas slurry by applying alone and in combination with chemical fertilizer on growth and yield of okra crop to improve the soil health and conserve the environment.

Materials and methods

A pot experiment was conducted in the glasshouse of Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad. The biogas slurry (BGS) samples were collected from the biogas plant located at Resalpur area of Punjab, Pakistan. Samples were taken as wet slurry, air-dried and then analyzed for NPK by following standard protocols as described by US Salinity Laboratory Staff [13]. The soil was collected, sieved and biogas slurry and chemical NPK fertilizers were mixed. The pots were filled with 12 kg of soil. Five seeds were sown in each pot which were thinned to one plant 15 days after germination. Pots were placed in the wire house under ambient light and temperature conditions. Ground water was used for irrigations. Treatments were arranged in a Completely Randomized Design (CRD).

Treatments will be as follows:

T1 = Recommended NPK @ 150:120:60 kg ha^{-1} (control)
T2 = Fresh BGS @ 400 kg ha^{-1} + 100% recommended N from chemical fertilizer
T3 = Fresh BGS @ 800 kg ha^{-1} + 100% recommended N from chemical fertilizer
T4 = 100% N from fresh BGS
T5 = 75% N from fresh BGS + 25% N from chemical fertilizer
T6 = 50% N from fresh BGS + 50% N from chemical fertilizer
T7 = 25% N from fresh BGS + 75% N from chemical fertilizer
T8 = 30 days old BGS @ 400 kg ha^{-1} + 100% recommended N from chemical fertilizer
T9 = 30 days old BGS @ 800 kg ha^{-1} + 100% recommended N from chemical fertilizer
T10 = 100% N from 30 days old BGS
T11 = 75% N from 30 days old BGS + 25% N from chemical fertilizer
T12 = 50% N from 30 days old BGS + 50% N from chemical fertilizer
T13 = 25% N from 30 days old BGS + 75% N from chemical fertilizer

The recommended doses of phosphorus and potassium were applied @ 120 and 60 kg ha^{-1}, respectively. The sources of N, P and K were urea, di-ammonium phosphate (DAP) and sulphate of potash (SOP), respectively. Plants were harvested at maturity and the following parameters were studied: plant height, root length, number of fruits per plant and fruit fresh weight.

Statistical analysis

The data were statistically analyzed for significance by ANOVA and means were compared by LSD (least significant difference) test at $p \leq 0.05$ [14]. The software packages STATISTIX 8.1 (StatSoft, Inc., 2001), was used for statistical analysis.

Results and discussion

Integrated use of biogas slurry and chemical fertilizer could be successfully used in agricultural crops. The results regarding the effect of biogas slurry and chemical fertilizer on plant growth and yield of okra were outstanding. The data regarding plant height depicted that maximum plant height, i.e. 59.6 cm (15.7% increase over control) was observed in treatment T_6 where 50% recommended dose of chemical N was applied in combination with biogas slurry (Fig. 1). The application of 100% recommended chemical N and fresh biogas slurry @ 800 kg ha^{-1} applied as soil conditioner was the second best treatment which showed a 7% increase in plant height over control (Fig. 1). The application of 100% recommended chemical N along with 30 days old biogas slurry @ 800 and 400 kg ha^{-1} as soil conditioner showed 4 and 3% increase in plant height, over control, respectively. Statistically similar plant height was observed in T_2, T_3, T_6, T_7, T_8, T_9, T_{11}, T_{12} and control treatments (T_1).

A significant increase in root length was obtained with combined application of biogas slurry and chemical fertilizer (Fig. 2). The maximum root length (23 cm) was observed with the application of 50% of the recommended N as chemical fertilizer in combination with 50% N from fresh biogas slurry (T_6) and this increase was 23% over control where only chemical fertilizers was applied (Fig. 2). This treatment was followed in descending order by the treatments T_3 and T_9 where 100% recommended dose of N as chemical fertilizer was applied in combination with 800 kg ha^{-1} fresh and 30 days old biogas slurry and it increased the root length by 7 and 2% respectively, over control. Our results concur with the findings of the Islam et al. [15] who also reported that maize plant height and stem circumference were significantly (p< 0.01) influenced by the application of 50% N from biogas slurry. In another report, mean plant height was highest with the application of NPK along with cattle manure treatment [16]. Increase in plant height is due to nitrogen fertilizers. Nitrogen fertilizer, either organic or inorganic, always affects vegetative growth of the fodder plants [17]. In our study, maximum root length (23 cm) was observed with the application of 50% of the recommended chemical N in combination with 50% biogas slurry (T_6) which was 23% higher than the control. Baldi et al. [18] also reported that the application of compost increased the production of new roots compared with the treatment in which alone chemical fertilizers were applied.

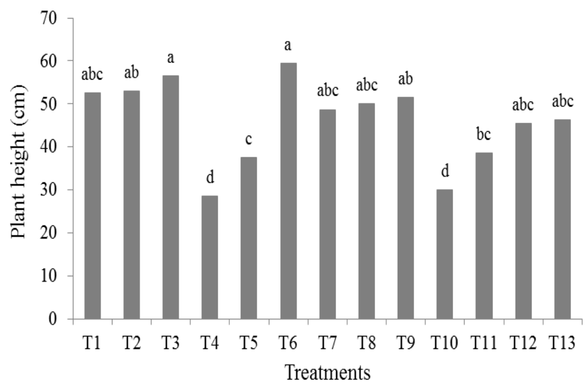

Fig. 1: Effect of integrated use of biogas slurry and chemical fertilizer on plant height of okra. Means sharing the same letter (s) don't differ significantly at $p \leq 0.05$.

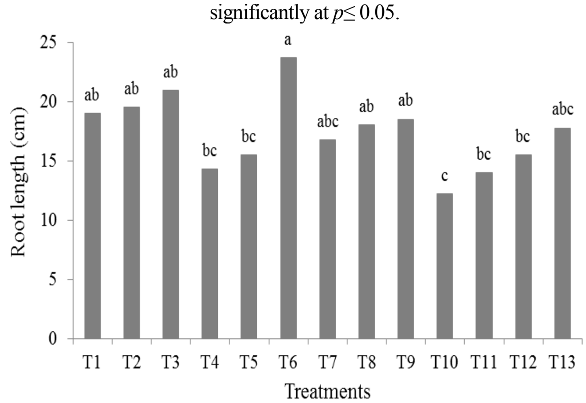

Fig. 2: Effect of integrated use of biogas slurry and chemical fertilizer on root length of okra. Means sharing the same letter (s) don't differ significantly at $p \leq 0.05$.

Results revealed that some of treatments showed positive while others showed negative results regarding number of fruit per plant (Fig. 3). The maximum increase of 25% was recorded in treatment T_6, followed by increase of 21% in T_3 treatment compared with control. Moreover, a 17% increase was observed in T_2 where 100% of recommended chemical N in combination with fresh biogas slurry as soil conditioner @ 400 kg per ha was applied. While 14% increase was recorded in treatment T_8 where 100% of recommended chemical N in combination with 30 days old biogas slurry as soil conditioner @ 400 kg per ha was applied.

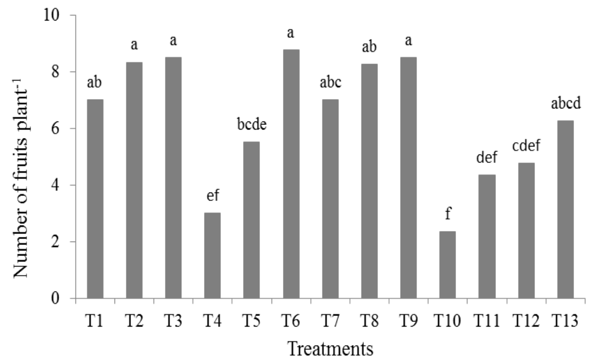

Fig. 3: Effect of integrated use of biogas slurry and chemical fertilizer on number of fruits per plant of okra. Means sharing the same letter (s) don't differ significantly at $p \leq 0.05$.

The results regarding the effect of integrated use of chemical N fertilizer and different aged biogas slurry showed that (Fig. 4) treatment where 50% of recommended chemical nitrogen was applied in combination with 50% of the recommended N as fresh biogas slurry (T_6) resulted in 36% increase in fruit fresh weight over control. It was followed by 19 and 13% increase in treatment where 30 days old biogas slurry @ 800 and 400 kg per ha as a soil conditioner in combination with 100% recommended chemical NPK was applied, respectively. The minimum increase of 7% in fruit fresh weight was observed in treatment T_2 and T_3. Our results were in line with the findings of Parvathy and Vaishnavy [19] who also reported the significant effect of biogas slurry supplemented with chemical fertilizers on number of fruits per plant. Dhussa [20] compiled the results of some of the experiments conducted on the effects of biogas effluent on the yield of rice, wheat, maize, cotton, cucumber, tomato, mung bean, and sunflower. They also concluded that wheat and cotton yield was increased by 15 and 16%, whereas the yield of maize and rice was increased by 9 and 7%, respectively. The increase in yield is due to the application of fresh biogas slurry because the wet biogas slurry had higher mammal value than that of dry slurry. The wet slurry is reported to contain around 1.6% of the nitrogen in the form of readily available ammonia and the dry slurry less than 0.5% [5]. The wet slurry is proved to be better than the dry slurry. It is due to mineralization of organic nitrogen in liquid form. The nitrogen in liquid slurry is also reported to be superior to that in sun-dried slurry and farmyard manure [21, 22, 23, 24]. Olaniyi and Akanbi [24] and Pandey et al. [25] also reported that the integrated use of organic and inorganic N fertilizer enhance the yield of crops.

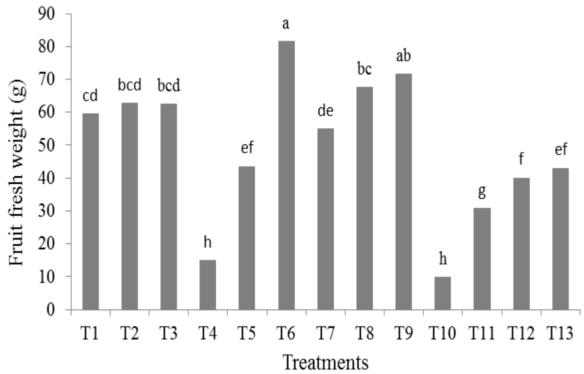

Fig. 4: Effect of integrated use of biogas slurry and chemical fertilizer on fruit fresh weight of okra. Means sharing the same letter (s) don't differ significantly at $p \leq 0.05$.

Conclusion

Due to the changing scenario of soil fertility management through an integrated plant nutrition system that combines the use of organic and chemical fertilizers, the biogas slurry organic fertilizers plays a vital role in restoring fertility as well as organic matter status of the soils. Biogas slurry is considered as a good quality organic fertilizer in Pakistan agriculture. Biogas slurry organic fertilizer is environmentally friendly, has no toxic or harmful effects and can easily reduce the use of chemical fertilizers up to 50%. Nutrients from organic sources are more efficient than those from chemical sources. It was concluded that the application of biogas slurry in combination with chemical fertilizer with each source providing 50% N, could boost up the yield of okra, and it is a better choice than applying the recommended NPK alone.

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