Anaerobic Digested Slurry -An Input For Sustainable Agriculture

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Abstract : Anaerobic digestion of agro residues and cattle waste produces bio-gas which is used as domestic fuel and the digested slurry can be used as manure for crop production. The present study aimed to evaluate the effectiveness of the nitrogen through chemical fertilizer and bio-gas spent slurry in different proportion on production of soybean-wheat rotation. Study reveals that soybean crop showed maximum grain yield (21.05+0.1q/ha) in year 2005 with the combination of T-3(($N_{75}S_{25}$) while the maximum grain yield of 21.19+0.1 q/ha was found with the combination of T-4($N_{50}S_{50}$) in second year of field trial (2006). Similarly in rabi season with wheat crop in 2005-2006, maximum grain yield of 41.84+0.1q/ha was recorded with T-3 (($N_{75}S_{25}$) and in 2006-2007 maximum grain yield of 43.41+0.1 q/ha was observed with the combination T-4($N_{50}S_{50}$) which may be due to improvement in soil health. Integration of chemical fertilizer along with bio-gas slurry proved beneficial and economical as it not only saved chemical fertilizer but also maintained soil health.

Key words : Chemical fertilizer, Biogas slurry, Soybean, Wheat, Grain yield, Soil health.

Introduction

Crop cultivation requires supplementation of available nutrients to the plant for achieving yield potentialities. The supplementation is generally achieved through application of chemical fertilizer in the soil at different stages of crop life. These chemical fertilizers have hazardous effect. It is unanimously accepted that chemical fertilizer alone can not be used for achieving higher and continued productivity of the crops to meet the growing food requirement. Intensive agriculture with the use of agro-chemicals in large quantity has increased the land productivity. Nambiar and Abrol (1989) suggested that continuous application of higher amount of only inorganic fertilizer had deleterious effect leading to decline in productivity due to limitation of one or more micronutrients. Organic manuring is becoming an important component of environmentally sound sustainable agriculture. Residual nature of organic sources makes them more value based for the whole system compared to individual crops (Pathak *et al.*, 2002). Anaerobic digestion of agro-residues in biogas plant produces clean fuel and nutrient rich slurry. The slurry contains considerable amount of plant nutrient (Wang *et al.*, 2008).Their use as soil amendment may offer a promising win-win opportunity to crop productivity and at the same time preventing adverse environmental impact of waste disposal. Experiments were, therefore, conducted to study the effect of integrated plant nutrients (inorganic fertilizer + biogas spent slurry) on grain yield and on soil health with soybean – wheat system.

Materials and Methods

Bio-gas spent slurry

The slurry coming out of the biogas plant is referred to as biogas spent slurry (BSS) or biogas residue. Biogas slurry resulting from anaerobic digestion of organic waste has significant potential as a crop fertilizer and soil conditioner. Anaerobic microorganisms degrade the organic fractions of feedstock to CH_4, CO_2 and digested residue. Essential nutrients N, P, K, Mg, including trace elements required by plants, are conserved in the residue (Marinari *et al.*, 2000; Field *et al.*, 1984; Kirchmann and Witter, 1992).

Biogas plant is fed with cattle dung and water in 1:1 ratio. Decomposition takes about 45 days. The liquid slurry used in this experiment contained 1.53% nitrogen, 0.82% phosphorous, 0.9% potassium and 28.21% organic carbon.

Field-Trial

A. Soybean: Experiments were conducted on a commercial field during Kharif season for consecutive two years 2005 & 2006 in the village Ratibarh of district Bhopal (India). The soil was clay loam having p^H 6.8, organic carbon 0.58%, EC- 0.178 mmhos/cum; available

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nitrogen226kg/ha, phosphorous 21.08 kg/ha and potassium 187 kg/ha (Jackson, 1973). The experiments were laid out in randomized block design with four replications. Soil cultivation, sowing, weed management, which are not part of the experimental design were identical among all treatments and were performed on similar dates and in a similar manner.

Following treatments were applied to the experimental plots:-

1. Soil only –Control (N_0S_0)
2. Soil + Recommended dose of nitrogen fertilizer ($N_{100}S_0$)
3. Soil +N_{75}+ BSS_{25} ($N_{75}S_{25}$)
4. Soil + N_{50} + BSS_{50} ($N_{50}S_{50}$)
5. Soil + N_{25} + BSS_{75} (($N_{25}S_{75}$)
6. Soil +N_0 + BSS_{100} (N_0S_{100})

Moist soybean seeds of variety JS-335 were mixed with 2 gm thiram and 1 gm carbendazim seeds per kg. Recommended dose 25:50:30 kg/ha of N: P: K was used. Soybean seed were planted at approximately 35 seeds per meter of row in a depth of 2.5- 3.0 cm. Thinning was done evenly to 27 plants per meter. After 90 days of sowing harvesting was done. Seeds were collected from the pods after 1 week of harvesting and their yield was noted.

B. Wheat : A field experiment was also performed with the integrated use of urea and Biogas spent slurry after harvesting of soybean during rabi season in 2005-2006 & 2006-2007 with wheat variety Lok–1. The recommended dose of nitrogen (120 kg/ha) was applied as BSS or chemical fertilizer and also with their mixture in different proportion to study their influence on grain yield. Results are summarized in table 2.

Soil were analyzed for available nitrogen and percent organic carbon after harvesting in 2007 by standard method of analysis (Jackson, 1973). Statistical analysis was done by ANOVA one way analysis (Tukey HSD) by eznova software.

Results

Grain yield

Data in table - 2 reveals that application of biogas slurry enhanced the crop yield over control in both the crops soybean and wheat. Maximum grain yield of 21.05+0.1q/ha was recorded with the combination T-3 (($N_{75}S_{25}$) with soybean in year 2005 while in 2006 the maximum grain yield of 21.19+0.1 q/ha was found with T-4($N_{50}S_{50}$).Similar improvement in grain yield was noticed in succeeding wheat crop. In 2005-2006 maximum grain yield of 41.84+0.1q/ha was recorded with T-3 (($N_{75}S_{25}$) and in 2006-2007 maximum grain yield of 43.41+0.1 q/ha was observed with T-4($N_{50}S_{50}$). Results were significant at $p<0.01$ and $p<0.05$ level of significance.

Soil Health

Perusal of table – 3 reveals that available nitrogen content was improved under integrated nutrient management practices with treatment T-4($N_{50}S_{50}$) and T-5 ($N_{75}S_{25)}$ compared to its initial soil fertility while increase in percent organic carbon content was found with treatment T-4($N_{50}S_{50}$), T-5 ($N_{75}S_{25)}$ and T-6 ($N_0S_{100)}$. All the results were significant at $p<0.01$ and $p<0.05$ level of significance.

Table 1: Details of treatment applied in Soybean- Wheat cropping system

Treatment	Soybean	Wheat
T-1	No fertilizer, No BSS (N_0S_0)	No fertilizer, No BSS (N_0S_0)
T-2	100% recommended N through fertilizer,No BSS($N_{100}S_0$)	100% recommended N through fertilizer,No BSS($N_{100}S_0$)
T-3	75% recommended N through fertilizer,25% through BSS($N_{75}S_{25}$)	75% recommended N through fertilizer,25% through BSS($N_{75}S_{25}$)
T-4	50% recommended N through fertilizer,50% through BSS($N_{50}S_{50}$)	50% recommended N through fertilizer,50% through BSS($N_{50}S_{50}$)
T-5	25% recommended N through fertilizer,75% through BSS($N_{25}S_{75}$)	25% recommended N through fertilizer,75% through BSS($N_{25}S_{75}$)
T-6	100% recommended N through BSS, No fertilizer(N_0S_{100})	100% recommended N through BSS, No fertilizer(N_0S_{100})

Table 2: Effect of mixture of biogas spent slurry and chemical fertilizer on soybean and wheat grain yield in q/ha

S.No.	Treatment	Soybean grain Yield in q/ha		Wheat grain Yield in q/ha	
		2005	2006	2005-06	2006-07
1	T-1 (N_0S_0)	16.64+0.1	15.36+0.1	34.15+0.1	32.24+0.2
2	T-2($N_{100}S_0$)	20.45+0.1	19.78+0.2	41.54+0.2	40.36+0.1
3	T-3($N_{75}S_{25}$)	21.05+0.1	20.67+0.1	41.84+0.1	41.93+0.2
4	T-4($N_{50}S_{50}$)	19.89+0.2	21.19+0.1	41.19+0.1	43.41+0.1
5	T-5($N_{25}S_{75}$)	19.45+0.1	20.72+0.1	40.88+0.2	42.59+0.1
6	T-6(N_0S_{100})	18.86+0.2	19.16+0.1	39.26+0.1	39.12+0.1

Replicates-4
All results are expressed as Mean + SE
Results are statistically significant at $p<0.05$ & $p<0.001$

Table 3: Effect of mixture of biogas spent slurry and chemical fertilizer on Soil Health

S.No.	Treatment	%Organic Carbon	Available Nitrogen kg/ha
1	T-1 (N_0S_0)	0.56±0.01	218±0.1
2	T-2 ($N_{100}S_0$)	0.55±0.01	219±0.2
3	T-3 ($N_{75}S_{25}$)	0.58±0.01	225±0.1
4	T-4 ($N_{50}S_{50}$)	0.61±0.02	232±0.2
5	T-5 ($N_{25}S_{75}$)	0.62±0.01	228±0.1
6	T-6 (N_0S_{100})	0.63±0.02	223±0.2
7	Initial	0.58±0.01	226±0.1

Replicates-4
All results are expressed as Mean + SE
Results are statistically significant at $p<0.05$ & $p<0.001$

Discussion

Singh *et al*. (2002) stated that the continuous application of the recommended dose of chemical fertilizer alone causes rapid mineralization, resulting in higher losses of nutrient by way of leaching, denitrification and ammonia volatilization responsible for the lower yield. Tiwari *et al*. (2000) showed that significant amounts of mineral N could be substituted with biogas slurries in cropping of wheat. Kocar (2008) obtained higher yields of safflower with biogas residue than commercial organic and chemical fertilizers. Garg *et al*. (2005) reported that fertilization of soil with biogas slurry generated from cattle dung improved the yield of wheat over non-modified control. In the present investigation, significant increase in grain yield was recorded with treatment T-3($N_{75}S_{25}$), T-4 ($N_{50}S_{50}$) and T-5 ($N_{75}S_{25}$) as compared to control in both soybean and wheat crops. The enhancement in grain yield is due to the supplementation of chemical fertilizer with biogas slurry. This may be due to slow and prolonged availability of nutrients as also suggested by Singh *et al*. (2002). Biogas residue is an efficient nitrogen source for plants with the potential to improve soil properties also (Pathak *et al.*, 1992; Bath and Ramert, 2000; Svensson *et al*., 2004). In the present study a significant increase in percent organic carbon and available N content in soil was found due to the supplementation with biogas slurry which causes better root growth and more plant residue after harvest of the crop. This indirectly influences the physico-chemical characteristics of soil as reported by the earlier workers (Bhandari *et al*., 1992; Selvi *et al*., 2003).

Conclusion

Integration of chemical fertilizer along with biogas spent slurry proved beneficial and economical as it not only saved chemical fertilizer but also maintained soil health.

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