بسم الله الرحمن الرحيم

In The Name Of

Allah

The Most Beneficent,

The Most Merciful

Potential of bioslurry and compost at different levels of inorganic nitrogen to improve growth and yield of okra (*Hibiscus esculetus* L.)

By

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Declaration

I hereby declare that the contents of the thesis " Potential of bioslurry and compost at different levels of inorganic Nitrogen to improve growth and yield of okra" are product of my own research and no part has been copied from any published source (except the references, standard mathematical or biochemical models/equations/formulae/protocols etc.). I further declare that this work has not been submitted for award of any other diploma/degree. The university may take action if the information provided is found inaccurate at any stage.

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To,

The Controller of Examinations,
University of Agriculture,
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We, the Supervisory Committee members, certify that the contents and form of the thesis submitted by **Mr. Muhammad Shahbaz (Regd. No. 2005-ag-1600),** have been found satisfactory and recommend that it be processed for evaluation by the External Examiner(s) for the award of degree.

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Dedicated to

◆ *My Loving Father*

A symbol of success for me

Always behaved me like a friend

Whose valuable and mature guidance and financial assistance enabled me to perceive and pursue high ideas of life.

◆ *My Adorable Mother*

A minerate of love, affection and kindness

Who enlightened me

A learning spirit

Whose love and prayers helped me to get this status.

◆ *My Sweet Siblings*

For their good wishes and sincere prayers for my success.

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CHAPTER-1

INTRODUCTION

Vegetables are a great significance source of vitamins, minerals and plant proteins in human diet all over the world. Vegetable cultivation is one of the more efficient and major branches of agriculture and of economic value as well. At the same time, vegetable cultivation is becoming more costly due to the increasing use of purchased inputs such as pesticides and fertilizers to sustain production levels (Salim, 1999).

Okra (*Hibiscus esculentus* L.) is one of the most well known and utilized species of the family Malvaceae. It is also a chief vegetable crop grown for its immature pods that can be consumed as a fried or boiled vegetable or may be added to salads, soups and stews (Kashif *et al.*, 2008). Although okra finds its origin in South-Africa, India stands top in area and production. (Anon., 2006)

Okra plays a significant role in human nutrition by providing carbohydrates, protein, fat, minerals and vitamins that are generally deficient in basic foods. Mature okra seeds are good sources of protein and oil (Oyelade *et al.*, 2003) and it has been known to be very important in nutritional quality. Okra oil is rich in unsaturated fatty acids such as linoleic acid (Savelli *et al.*, 1980), which is essential for human nutritionIt has good nutritional value, especially high in vitamin C (30 mg/100 g), Ca (90 mg/100 g), Fe (1.5 mg/100 g) and other minerals such as magnesium and potassium, vitamin A and B, fat and carbohydrates (Aykroud, 1963). Its ripe fruit and stems contain crude fiber, which is used in the paper industry. It is also revived the importance of food for the okra pod interest in crop nutrition in commercial production. Although the nutritional value of okra, did not achieve better returns with (2-3 tons ha^{-1}) and quality in tropical countries, due in part to a continuing decline in soil fertility. Okra plant requires warm temperatures and is unable to withstand low temperatures for long or tolerate any threat of frost. Optimum temperature is in the range of 21 to 30 degrees Celsius, with temperatures less than 18 degrees Celsius and 35 degrees Celsius maximum (Abd El - Kader *et al*., 2010)

In Pakistan, okra (locally known as “bhindi”) is represented by one species: *Hibiscus esculentus*. Is well grown in the plain areas of the country, particularly in the provinces of Punjab and Sindh, and is valued as a source of good income for the growers. Total area under okra cultivation in Pakistan is estimated to be 2.21×105 hectares yielding about 2.86×106 tons of green pods (Kashif *et al.,* 2008). The last five-year statistics show that there is a decreasing trend in yield per unit area and production as compared to the last 10 years. A number of factors are considered to cause reduction in yield and production and it is stated that the limiting availability of soil fertility is a key factor for its reduction.

Lack of adequate nutrient supply and poor soil structure are the main constraints to agricultural production systems in low-input agriculture. Chemical fertilizers are not the most appropriate solution to overcome these constraints, especially for vegetables that have increasingly short time and are consumed fresh. Use of chemical fertilizers are also expensive and a threat to human health (Weltzein, 1990). So, it is suggested that there should be an emphasis on finding alternatives to chemical fertilizers such as compost and bioslurry, which are cheaper than other sources of nutrients and relatively safe (Rindle, 1997) . The use of these organic sources has a role in the management of plant diseases and soil fertility in field and greenhouse.

With the downward trend observed in the rate of application of farm manure (FM), the soils are not restored for more than 70 percent of the nutrients extracted every year in terms of agricultural production Thus, soil productivity is declining because of the continuous mining off (Karki and Joshi, 1997; Karki, 1996).

When we apply the organic based fertilizer alone or with chemical fertilizer these organic sources besides supplying plant nutrients, also plays an important role because of its beneficial effects in enhancing the cation exchange capacity (CEC), improving soils aggregation, increasing water holding capacity of the soils, stabilizing its humid content, and preventing the leaching of nutrients (Swift and Woolmer, 1993; Dudal and Decker, 1993).

1.1 Bioslurry

Biogas dregs and slurry are by-products of biogas production generated from cattle dung. These residues, especially biogas slurry, are a good source of plant nutrients and can improve soil properties (Garg *et al.,* 2005). The farmer needs to use chemical fertilizer to increase his crop production. However, if only mineral fertilizers are continuously applied to the soil without adding organic manure, productivity of land will decline.

In countries where biogas technology is well developed, for example in China, there is evidence supporting the fact that the productivity of agricultural land can be increased dramatically with the use of manure produced from biogas (Krishna, 2001). However, in Nepal, little attention has been paid by the biogas farmers have on the proper use of digested sludge as organic fertilizer. In China, digested sludge was used to supplement the diet of cattle, pigs, poultry and fish (FAO, 1977). Because of rich nitrogen source, biogas slurry can improve the power quality of crop residues and grass silage of poor quality. Digested sludge, when used as fertilizer, showed significant effects on plant tolerance to diseases such as potato blight, mildew, etc. cauliflower mosaic and can be used as bio-chemical pesticide. Soak the seeds with digested manure can lead to the seed germinate faster and resist diseases. Similarly, foliar application of sludge has many beneficial effects on field crops, fruits and vegetables in relation to growth, quality and disease resistance

Biogas slurry proved to be of high quality organic manure compared to the FM, digested sludge tends to have more nutrients. However, nutrients, especially nitrogen, are lost by volatilization when exposed to sunlight (heat) and by leaching due to rain (Karki and Joshi, 1997). Digested sludge contains organic nitrogen (mainly amino acids), minerals in abundance, and low molecular weight bioactive substances (hormones, for example, humic acids, vitamins, etc.) and could be used as organic fertilizer in seedlings. Use of the slurry also inhibits disease and increase yields (Liu *et al*., 2008).

Bio slurry beside its use as soil amendment for crop growth also offers a promising win-win opportunity as at the same time it prevents adverse environmental impacts of waste disposal. Application of digested bioslurry increases the crop yield, quality of vegetables like size and shapes. It also helps in reduction of dependence on mineral fertilizer (Karki, 1996). Yield increase due to bio-slurry application has been reported in many crops. Vegetable crops produced with bio-slurry have better quality as compared to those produced with chemical fertilizer (Krishna, 2001).

1.2 Compost.

Compost is an aerobically decomposed organic material derived from plants and animal source. It is rich in nutrients, used in gardens, landscaping, horticulture and agricultural field crops. (Martens, 2000) Compost is suggested that it is an alternative to chemical fertilizers, which is cheaper than other sources of nutrients and relatively safe (Rindle, 1997). The use of compost has a role in plant disease management and soil fertility in greenhouse. Huge work has been done to seeks and assess the ability of compost to increase crop production beside its other beneficial effect on soil and environment. The benefit of compost application in commercial agriculture for the purpose of securing markets for municipally derived compost has proved by different scientists work. Using compost in sustainable agriculture manner preserves agro-ecosystems and environmental quality (Tafaghodinia, 2008). It is a key ingredient in organic farming and is one of nature's best mulches and soil amendments, and can be used instead of commercial fertilizers. It also improves soil structure and aeration and increases the water-holding capacity of soil (Morgan, 2007).

For agricultural markets, to develop and use the compost to become standard practice and with the passage of time will increase to its request (Weltzein, 1989). Compost is a rich source of nutrients with high organic matter content and use of compost can be beneficial to improve the organic matter. Physical and chemical properties of soil can be improved by the use of compost, which can ultimately increase crop yields. Thus the use of compost is the need of the time. Physical properties such as bulk density, porosity, water permeability and hydraulic conductivity were significantly improved when compost was applied in combination with chemical fertilizer (Hussain *et al.*, 2001).

The use of compost will not only supplement the chemical fertilizers, but also reduce environmental pollution. In this strategy, the production cost is also reduced. Thus, a higher yield with higher incomes resultantly is expected by the farming community in this culture system (Sarwar *et al.*, 2007).

Compost is particularly effective when added with fertilizer at the time of planting. Not only do seeds germinate faster when compost is present, but a higher percentage of seeds germinate. Compost becomes a source of phosphate and carbon by stimulating micro flora populations (Martens, 2000).

1.3 Main Objective

The main objective of this experiment was to examine the effect of bio-slurry and compost on okra vegetable. It had the following specific objectives:

1. To generate reliable data information on the effect of biogas slurry and compost on crops and soil.
2. To compare the effect of bio-slurry and compost in combination with the chemical fertilizer on okra growth/ yield.
3. To assess the quality of bioslurry and compost.

1.4 Expected Outputs.

The expected outputs of the study are the following:

1. Generating reliable data on the effect of slurry and compost on okra.
2. Supplementing costly mineral fertilizer with locally produced biogas slurry and compost.
3. Quality of bioslurry and compost with regard to the plant nutrients.
4. Residual effects of bioslurry and compost in the soil.

CHAPTER-2

REVIEW OF LITERATURE

2.1 Effect of organic based fertilizers on crop and soil.

From present agriculture system it was noted that growing populations and the increasing use of existing resources has led to growth in organic waste emissions. Therefore, a sustainable approach to managing this waste has become a major concern in densely populated areas. Biological treatment is an efficient method for reducing the amount of organic waste, and for producing energy. A large number of biogas plants and compost facilities that use organic waste as a substrate for electricity and fuel production are being built around the world. The biological treatment process in these plants produces large amounts of organic waste, and there is therefore a growing need to find a sustainable use for this material. Organic waste, such as biogas residues and compost can be a valuable fertilizer for agricultural soils. They can serve as a source of plant nutrients and can also improve soil structure and water holding capacity. However, as organic residues are known to contain both heavy metals and organic contaminants there is a need for long term field experiments to ensure that soil and plant quality is maintained. In different experiments under realistic conditions, compost and biogas residues from source-separated household waste were compared with traditional mineral fertilizer. It was concluded that crop yield and soil chemical and microbiological properties has increased by application of such resources to soil. The main conclusion from the field experiment was that biogas residues resulted in crop yields almost as high as the mineral fertilizer. In addition, several important soil microbiological properties, such as substrate induced respiration, potential ammonium oxidation and nitrogen mineralization were improved after application of both biogas residues and compost. Moreover, no negative effects could be detected from using either of the organic wastes. In particular the genetic structure of the soil bacterial community appeared to resist changes caused by addition of organic waste **(**Oldare *et al.,* 2011).

Karanatsidis and Berova (2009) carried out research on pepper of “Buketen 50” and “Gorogled 6” cultivars, by using different organic and inorganic source of fertilizers, intended for production of red pepper for grinding. Pepper plants were grown in a phytostatic chamber under controller conditions. The experiment was carried out with scheme as control – soil (no organic fertilizer application); Soil and organic-N fertilizer application. The indicated variants were formed during the pricking of the plants in phase 2-4 true leaf. Their results indicates that, applying organic-N fertilizer gave the vigorous plants expressed as plant height, leaves size as well as dry weight in both cultivars. The increase of dry biomass was mainly for the account of the increased mass of the above the ground organs. There was a positive effect of the fertilizer along with organic amendments upon the functional activity of the photosynthetic apparatus /increased content of photosynthetic pigments, improved leaf gas exchange.

Michael *et al.* (2010) conducted a field experiment to evaluate the effects of farm manure (FM) and inorganic fertilizer application on the productivity of horticultural crops. Two rates of FM selected (2 and 6 Mg ha^{-1} on dry weight basis) were combined with three rates of nitrogen (N) and phosphorus (P) fertilizer (0, 0), (61, 31) and (92, 46) kg ha^{-1} to six treatments. Four crops (onion, tomatoes, cabbage and potatoes, respectively) were planted in rotation on permanent plots. The treatments have a significant effect on biomass and yield of economic crops. In addition to the recommended inorganic fertilizer only 2 Mg ha^{-1} FM resulted in a significant increase in performance on the recommended rates. In addition, it was found that the reduction of fertilizer recommended by one third did not significantly reduce performance, if accompanied by two Mg ha^{-1} FM. It is not only to reduce the cost of production due to reduced use of fertilizer, but also improves soil quality leading to sustainability.

Masarirambi *et al.* (2010) conducted a study to assess the effects of organic fertilizers on the yield and quality of lettuce (*Lactuca sativa* L.) grown in river sand to assess. The organic fertilizers were returned compost, manure and chicken manure. The rates applied were 40 tones per hectare (t / ha) for cattle and chicken manure, 1.5 t / ha basal dressing and 1.0 tons / ha side dressing of compost bounce back. Inorganic fertilizers 2:03:02 (22) + 0.5 % zinc (Zn) and limestone ammonium nitrate (LAN 28 %) were recorded at specific application rates of 955 kg / ha basal dressing and 100 kg / ha as a side dressing control. The results showed that kind of fertilizer significantly ($P < 0.05$) affected growth, yield and nutritional value of lettuce. A trend to superiority of the different types of organic fertilizer was observed as the chicken relatively higher values exhibited in the number of leaves, plant height, marketable yield and average leaf dry mass. Cattle manure was second, and then bounce back compost and finally the inorganic fertilizers. However, plants produced by Bounce back compost were higher in calcium, iron and Zn content on fresh weight basis, while plants from cattle manure followed, and then finally inorganic fertilizers and manure. Organoleptic tests showed no significant (P> 0.05) differences in appearance and taste between treatments. Results of this experiment showed that inorganic fertilizers are less suitable for lettuce production in river sand compared to organic fertilizers. It is recommended that the lettuce can be grown successfully using organic fertilizers

2.2 Effect of bioslurry on crop growth.

Maskey (1978) conducted several field and laboratory studies using manure, in which slurry was compared to dry slurry and the mineral fertilizer. In the treatment plan it was also included use of 50 % of dry slurry plus mineral fertilizer. Wheat was taken as a reference crop. The mineral fertilizer treatment resulted highest yield followed by M) percent of dry slurry and wet slurry. Biogas slurry (dry) yielded two percent higher than control whereas wet slurry yielded even 55.4 percent higher than control.

In another experiment Maskey (1978) reported that biogas slurry as "directly depressed 'wheat yield in Bhairahawa Agricultural Station, while such'" depressing "effect was not observed in Khumaltar. She pointed out that in the earlier case the effluent was probably not fully digested to look at these issues, an experiment was designed to be irrigated and rainfed condition of five treatments (control, wet slurry, dry manure, dry manure N + 50 percent 50 percent chemicals and chemical fertilizers (usual dose). The reference crop is wheat (Variety: RR21)

Earlier it was reported that wet biogas slurry is higher than the mammalian value of the dry slurry was as long as the wheat crop was (Maskey, 1978). But the manorial value of slurry was reported to be lower than those of his compost. It is due to higher dilution of the wastewater. Dry manure gave better returns than wheat wet slurry under irrigated condition. In irrigated there arc opportunities in the soil pores are filled with soil moisture and anaerobic conditions develop, resulting in that a strong chance that hydrogen is produced, which acts as toxic to plants and therefore lower yields.

Acharya (1983) reported that the use of fertilizer and the combination of fertilizer and organic manure much higher returns than bio-slurry in wet and dry form given. The incorporation of compost, as a treatment in the experimental design would have a realistic picture, the goal was generally not yield comparable to fertilizer, but other sources of organic manure. also in another study (van Barkel, 1980) found that there is no definitive superiority of the manure after fermentation methane over ordinary manure.

In the Philippines, Maramba (1978) conducted a pot experiment with biogas slurry that was mixed with raw materials with a high percentage of phosphorus than nitrogen or potassium zither. Effluent applied to the rate of 388 mL / pot produced higher returns than other counterparts, in particular 5714 mL of the same materials. Despite potive effect of slurry on a wheat plant, there are some negative effects of higher amount of wastewater may be due to the production of H_2S gas could have acted as toxic to wheat plants.

Dhussa (1985) compiled the results of some of the experiments performed until the mid-eighties to study the effects on the discharge of biogas yield of rice, wheat, corn, cotton, cucumber, tomato, mongbeen and sunflower. The result is 15 and 16 percent indicated that wheat and cotton yields, while corn and rice increased by 9 and 7 percent. Another report states that did double cucumber than control, the application of biogas slurry @ 15 t ha^{-1}, the amount exceeds 15 tons / ha less cucumber yield. The same author stated that the application of manure @ 10 tonnes / ha in combination of N, P, K on 45, 60 and 30 kg ha^{-1} respectively produced the best results, and both N and P content of the soil increased after slurry application. The results indicated that wheat and cotton yields were increased by 15 percent and 16 that the maize and rice increased by 9 and 7 percent.

In another report (Dhussa, 1985) stated that yielded double cucumber than monitoring the application of biogas slurry at a rate of 15 t / ha over control. Amount higher than I5t/ha reduced revenue cucumber. The same report Dhusha (1986) stated that application of NPK bioslurry with (a) 45:60:30 produced the best results. Reports of the studies from Thailand indicated that slurry use in crop production which was digested pig manure compared with fertilizer on the yield performance of vegetable, corn, mungbean and morning glory can be as effective as chemical fertilizers. The digested pig slurry containing 0.4 percent of the total nitrogen. Effluent was applied as top dressing during growth. The amount of nitrogen from the effluent was 50 percent. 100 percent and 200 percent of the nitrogen in fertilizers. Fertilizer was applied at the rate of 124-52-124 kg / ha for maize crop, mungbeans, and morning glory, respectively. The treatment delivers 100 percent effluent as N gave significantly better performance was on par with fertilizer. Increasing demand for mungbeans has no significant increase in yield (Tentscher, 1986). The yield performance of treatment with 50 percent N was as good as fertilizer, along with bioslurry source of N.

Gupta (1991) also reported the results of demonstrations launched 15 trials in Kharif. The total percentage increase in yield of crops treated with biogas slurry was about 40 percent. The application of biogas slurry gave best results in vegetables such as tomato and eggplant, followed by crops like maize and pigeonpea percentage increase in crops such as bajra, rice, groundnut records were found. Other crops such as chilli, showed no effect widespread demonstrations using biogas slurry were carried out over the central, eastern and northeastern states of India. Grains on the rise in yields was considered significant, since no additional costs for materials used in fertilizer. The response was better in dry areas with low soil fertility level that the doses of fertilizer used were low. Average increase of control over due to slurry application was found on 2.3 percent. Average yield of Rabi crops in Kharif crops as compared to the previously reported modest. Because Kharif crops are generally grown in fertile soil under irrigated conditions, the reaction is less impressive than Rabi crops. It is still a substantial increase (Singh, 1990). The response was moderate in irrigated wet areas with higher doses of fertilizers, as the state of Punjab, Madhya Pradesh, Haryana and North Bihar and found that bioslurry increaes fertilizer and plant growth, ie root length, plant height and dry shoot weight (Gupta, 1991).

On the other hand, Singh (I991) noted that biogas slurry is not a very scientific demonstration, and should be easy on the farm participatory processes in which the participating farmers were able to see and judge the performance of the returns. In addition to some of the experimental results been reviewed. Sun-dried slurry out-performed control.

Tripathi (1993) conducted various slurry demonstrations across India on two plots of equal size with the same crop sown. In a plot biogas slurry was applied at the rate of 10 tones per hectare in irrigated land and non-irrigated land @ 5 tones per hectare. At maturity, crops were harvested from both the land and revenue compared. The crops were grown on various agro-climatic zones and soil types. Four to forty percent of the proceeds from the different 12 different cereals and vegetable crops were observed. In addition to crop yields, were the quality of vegetables, such as size and shape also observed. There were fewer weeds, low number of diseases and pests attack, including improvements in soil physical and chemical properties, where biogas slurry was applied. It also helped in reducing the use of mineral fertilizers.

Kanthaswamy (1993) reported that the investigation into the use of slurry and mineral fertilizers to the proper attention. The studies on the effect of biogas slurry on rice were conducted in farmers' fields and on wet black loamy soil and data on grain and straw yield for different treatments follow. The results showed that application of the beam Biogas Slurry (BGDS) applied only @ I5t / ha recorded maximum yield (5316 / ha) and it was on par with yields obtained from applied@12.5t FYM / ha along with 75 percent NPK (4874 kg / ha). BGDS10 t / ha NPK + 75 percent (5000 kg / ha) BGDS and 10 t / ha 25 percent NPK (5000 kg / ha). Minimum yield of rice (3446 kg / ha) was recorded by monitoring the same trend of results was also reported by Laura and Idnani (1992).

Singh (1995a) reported that the combination of fertilizer and digested effluent significantly the yield of rice, corn, soybeans and okra. It was concluded that based on the analysis of these results and depending on the crops, soils and agro-climatic conditions, 20-100 fertilizer can be replaced by bio-slurry.

Singh (1995b) in another study reported that a lower yield of crops were produced probably by 12.5 tons per hectare of the digested manure as a result of unavailability of N to crops at critical stages due to slow release rate. He also concluded that biogas slurry was better than organic manure FM for obtaining a higher yield in pea, okra, corn and soybeans. In comparison with FM, the use of biogas slurry in combination with the recommended dose of fertilizer gave better yields. Thus, biogas slurry sealed to be superior to FM for increasing crop.

Singh *et al.* (1995b) reported that the combination of fertilizer and digester effluent significantly the yield of both rice and corn. Based on the analysis of these results and depending on the crops, soils and agro-climatic conditions. 25 to 100 percent replacement of chemical fertilizers in India is recommended bioslurry.

Banik and Nandi (2004) concluded that the popularity of oyster mushroom by biosluur applies increasingly to the ease of cultivation, high yield potential and its high nutritional value. Laboratory experiments, followed by farm trial with an oyster mushroom Pleurotus sajor Caju typically showed that the potential yield of these mushrooms can be significantly increased when grown on a lignocellulosic crop residue supplemented rice straw with biogas residual slurry in a 1:1 ratio as a substrate. In addition to increased yield, the above treatments caused significant increase in the protein content, reducing carbohydrates and increasing essential mineral nutrients in mushroom sporophores. Thus it is concluded from the study that supplementation of rice straw with biogas residual slurry strong influence in improving the yield potential and mineral nutrients protein content of mushroom in Indian subcontinent or similar climatic conditions.

Yu *et al.* (2005) suggested that the application of biogas slurry can lead to nitrate accumulation reduction in fruit compared with fertilizer, the biological breakdown of organic matter in manure is a slow process that is better for nutrient uptake by the plant, and this organic matter may accelerate of the soil nitrification process that nitrate accumulation in soils and the further reduction of NO_3-N uptake will decrease.

Tani *et al.* (2006) concluded an experiment and concluded that anaerobic digestion method is a powerful and useful technique for dairy manure into a source of energy, but the practical use of digested dairy manure as a soil source remains unclear. They studied the combination of digested dairy slurry with recycled dry chemical extinguisher, which was sold as an industrial waste, but are rich in nitrogen and phosphate. We also tried to digest dairy slurry combined with animal bone ash (hydroxyapatite), which is rich in calcium and phosphate. The addition of fertilizer efficiency of dairy cattle slurry by dissolving the soil dry chemicals proved very effective, because it provides sustained nearly equal or even with the application of fertilizer in the pasture exceeded. The combination of hydroxyapatite and rotted manure also resulted in higher yields of maize dent than the application of chemical fertilizers. The results suggest that not only the direct effects of macronutritional components in the digested slurry as fertilizer zuivel, but also the effects of other ingredients such as fertilizers and soil amendments should be considered.

Matsunaka *et al.* (2006) conducted a lysimeter experiment about three years to the efficient use of cattle consumed anaerobic slurry (ADCS) on the basis of a biogas plant based on the efficiency of its nitrogen (N) to clarify. Timothy (*Phleum pratense* L.) was the test crop, ADCS applied in different rates and times. Nitrogen by the grass ranged from 18 to 30% of total N (TN) in the ADCS, with spring application (late April) to increase efficiency compared with autumn application (late October). The N leaching losses were also investigated and concluded that the lowest leaching loss was associated with the standard application rate of the spring, making a total of 32 gm-2 (320 kg ha-1) in three years as ammonium N (NH_4-N) derived from the ADCS. N oxide (N_2O-N), emission from the soil loss was less than 0.1% of the total nitrogen of the ADCS. The standard rate of spring application of the ADCS gave the maximum N efficiency in end use (for dry matter production) of the ADCS and the minimal N loss. He concluded that under the experimental conditions, the standard rate ADCS application in early spring, the highest N-efficiency in grass dry matter production, and reduced environmental risks indicated.

Bo *et al.* (2006) concluded that the growth of seedlings of sweet corn, treated with biogas slurry is strengthened. The dry weight of roots and seedling increased by 15.71% and 6.37% respectively. The yield rose 5.37-11.75% compared with a treatment where bioslurry was applied. Biogas slurry can improve quality, the sugar / acid and solid / acid increased 74.0% and 52.7%, respectively, compared with the treatment, which bioslurry was applied. The content of iron and calcium from sweet corn was decreased, while phosphorus, magnesium and manganese increased. Immersing biogas slurry can help to seed more elements to absorb.

Somasundaram *et al.* (2007) conducted field tests with biological sources of nutrients and spray Panchagavya evaluate the yield and economics of crops in the maize - sunflower - green gram cropping system. They concluded that higher yields of maize and sunflower was included in biogas slurry (BGS) with Panchagavya. Grain Yield of green grams was higher among the recommended fertilizer treatments, but it was similar to BGS Panchagavya. The economic analysis showed that BGS was Panchagavya with commercially viable because it is the seat of the highest net returns and BCR than the recommended dose of fertilizers and foliar sprays for years.

Okoroigwe (2007) examined the improved soil nutrient levels from biomass techonology use of bio-fertilizer. He studied the effect of the biofertilizer produced by anaerobic digestion of piggery waste at non-digested material and non-application of biofertilizer. Nsuka yellow pepper (*Capsicum year* L) was used as test plant. The results showed that application of the biofertilizer papper yield in terms of increased plant height, number of fruit, branches and mass of fruit from planted without fertilizer.

Sharma *et al.* (2007) suggested that the preservation of the organic pools of nitrogen (N) in soil is important for providing a constant flux of N in the soil solution. Bioslurry, that is the product obtained from anaerobically digested (methanised) farm manure (FM), is an efficient source of organic manure with ability to deliver nutrients, especially N to crops. A study was conducted to the balance between inorganic and organic N fractions as affected by the application of fertilizer N and bioslurry maize (*Zea mays* L.), mustard (*Brassica campestris*) crop sequence shown. Obtained results showed that 75.7 percent of the total soil N was in the hydrolyzable N fraction. The application of bioslurry maintain higher status of N in both organic and inorganic N fractions. Linear regression relationship between N content in different fractions and bioslurry used both under fertilized and unfertilized conditions helped in the development of prediction models of the speed of bioslurry be applied to the desired N content in different fractions. The significant inter-correlation coefficients (r^2) between the different groups indicated free mobility between the N-N fractions under limited circumstances indicate a dynamic equilibrium between them. Path coefficient analysis showed that exchangeable NH_4^+ and NO_3-N had significant direct positive effect on N uptake by mustard bioslurry application. Under untreated conditions, exchangeable NH_4^+ and hydrolyzable hexosamine NH_4^+ groups had a higher direct contributions to mustard N requirement. Most of the hydrolysable N fractions contributed to the N uptake by mustard by first transforming into exchangeable NH_4^+ and NO_3-N and thereby establish an equilibrium condition for maintaining the steady flow of N for plants.

Herrmann *et al.* (2007) the purpose of their study was to evaluate the residual N effect of cattle slurry in maize quantified using the mechanistic model SPN. Calibration of the model was based on a 5-year field experiment (1997-2001) performed on a sandy soil in northern Germany. Fertilization treatments consisted of three cows slurry fertilization rates (0, 20, 40 m^3 ha^{-1}) with four mineral N rates (0, 50, 100, 150 kg N ha^{-1}). Corn yield and N content were the two weeks throughout the growing season. Soil mineral N (00-90 cm) was measured in spring and autumn, were estimated by leaching from ceramic cups. The SPN model was used to simulate N dynamics in soil-crop system. Results of a 5-year simulation were compared with field data, and a 36-year simulation (1966-2001) was conducted to assess the residual N effect and the corresponding N-balances to quantify. Periods of 3-9 years with manure were interrupted by periods without any, and the predicted plant N uptake was compared to that predicted for plants receiving mineral fertilizers alone. Three years of application by ha^{-1} y^{-1} (100 kg N ha^{-1} y^{-1}, 50% as ammonium), plus 50 kg mineral N ≥ about

30 m ha^{-1} y^{-1} increased the crop N uptake in the next three years by about 30 kg N ha^{-1} (i.e. 20% of organic N in applied manure) compared with mineral fertilization alone. Impact assessment for N fertilizer and N budgets are discussed.

Rahman *et al*. (2008) conducted an experiment to study the effect of cattle slurry on forage maize (*Zea mays*) production to study. Feed corn was produced on 4 cattle slurry levels T0 (0 t / ha), T1 (10 tons / ha), T2 (12 tons / ha) and T3 (14 tons / ha) in a randomized block design. Agronomic characteristics, plant height, circumference of the tribes, the number of leaves, leaf area and dry matter yield of forage maize were measured. Corn plant height and trunk circumference were significantly ($p < 0.01$) influenced by the increasing rate of cattle manure at 15, 30, 45 and 56 days after sowing. Some leaves of forage was not significant, but leaf area was significantly ($P < 0.05$) between treatment groups. The highest biomass yield ($P < 0.01$) of maize fodder was observed in [T2] (44.0 tons / ha). For crude protein content, a significant difference ($p < 0.01$) was observed in the treated groups and the highest value was observed in [T2] (11.99%). Organic matter content of the feed corn showed a significant difference, but ash, ADF and NDF content did not differ significantly between the treatment groups. This study can be concluded that application of 12 tons of cattle manure / ha was optimal for biomass production and nutritional value of corn feed.

Urselmans *et al.* (2009) performed a work with the aim to investigate the impacts of bioslurry obtained from biogas plant on soil microbial biomass to investigate the mineralization in the field and on the related crop yield. The experiment was conducted by following four treatments: (1) fallow, (2) fallow + biogas slurry, (3) spring barley, and (4) barley + biogas slurry. The CO_2 evolution rates ranged between 15 and 120 mg C m^{-2} h^{-1} in both fallow treatments and showed a significant exponential relationship with soil temperature at 5 cm depth. According to the extrapolation of the CO_2 evolution rates in amounts per hectare, 200 kg C ha^{-1} or 27 % of the biogas slurry derived C was mineralized to CO_2 during a 50 days' period to 18 June in the fallow treatment with biogas slurry. An additional amount of up to 29.5 kg inorganic N ha^{-1} can be calculated as the sum of NH_4-N in all biogas slurry at the time of change and the amount of biogas slurry mineralized in the soil NO_3-N. A good agreement between measured and modeled stocks of inorganic N at 00 to 60 cm depth was obtained after five-fold increased content of organic C turnover compared to the default values of the model DNDC. The mineralization data are in line with a maximum of 21 kg ha^{-1} more N transferred by the barley plants to their aboveground biomass into biogas slurry treatment. The N not paid by the aboveground biomass can be explained by the underground plant-derived N. CO_2 evolution from the soil surface, inorganic N content at 00-60 cm depth and N into barley aboveground biomass leads apparently to comparable results after the application of biogas slurry. The soil ATP content after harvest of barley was significantly greater in the two treatments with biogas slurry, especially in the fallow treatment indicates a positive effect on soil microbial community.

Moler and Stinner (2009) worked for sustaining of nitrogen (N) in the soil by using soil applied biogas digested material. They concluded that use of stable wastes and other residues for biogas digestion may reduce N losses. The purpose of this work was to assess the effects of biogas digestion on soil mineral N (SMN) content in spring and autumn, to compare NH_3 volatilization following superficial application of different manures to a cereal crop, to compare greenhouse gas emissions of differently treated liquid slurry after its application via injection into closed slots, and to compare greenhouse gas emissions of differing manuring treatments within a whole organic stockless cropping system. Ammonia volatilization after application from digested slurry was higher than the volatilization from undigested slurry, likely due to the effect of the higher ammonia content and higher pH. Organic manuring by application of liquid effluents of the biogas digester, by incorporation of green manures with a narrow C/N ratio or by mulching aboveground biomass of a clover/grass-ley, resulted in a strong increase in N_2O emission. The results of their study prove that biogas digestion of field residues resulted in a win-win situation, with additional energy yields, a lower nitrate leaching risk and lower nitrous oxide emissions. However, the propensity to ammonia volatilization was higher in digested manures

Wenke *et al.* (2009) concluded that biogas slurry is an important byproduct of biogas fermentation, containing abundant nutrient element and bioactive substances. It has proved that biogas slurry could significantly improve the vegetable quality and resistances to biotic and a biotic stresses. They studied the review on effect of bioslurry on vegetables and soil, the results were focusing on effects of biogas slurry on vegetables were summarized, highlighting the yield, hygienic quality, nutritional quality and disease resistance in addition to soil quality. They have found the satisfactory and efficient results, particularly to protect vegetables.

Zhou (2009) conducted an experiment to quantitatively study the effect of application of biogas slurry on yield, nutrition quality of purple cabbage and soil quality. The results showed that the application of biogas slurry could remarkably improve yield. The biogas slurry application could not only increase the content of vitamin C and decrease the content of reducing sugar, nitrate and heavy metals in purple cabbage, but also increase the organic matter content in the soil. Applying 120 kg biogas slurry per unit area as basal fertilizer and 0.6 kg chemical fertilizer and 75 kg biogas slurry as top dressing could increase the yield and vitamin C content by 16.06 % and 16.21 %, respectively, decrease the content of nitrate, Cd, Pd and Cr in the vegetable by 13.12 %, 25.49 %,18.48 % and 17.86 %, respectively, increase soil pH-value and organic matter content to 6.64 and 17.45 g/kg, respectively and decrease the content of Cd, Pd and Cr in the soil by 12.31 %, 5.70 % and 1.18 %, respectively. Under this experiment conditions, the above coordinative application rate of biogas slurry and chemical fertilizer is the best for purple cabbage.

Weiping *et al.* (2010) studied the influence of biogas slurry of different concentrations on the soil environment and quality of radish through experiments of biogas slurry as supply fertilizer with water at different ratios. Results of their experiment showed that under equal to nitrogen's condition the biogas slurry irrigating were helpful to improve quality of radish, had promoted soil quality compared with general chemical fertilizer, and decreased chemical fertilizer quantity.

Islam *et al.* (2010) conducted an experiment to examine the effectiveness of biogas slurry as nitrogen source for the production of maize fodder (*Zea mays*). Maize fodder was cultivated as a control (T0: 0 kg of slurry N ha^{-1}) and with 3 different levels of biogas slurry T_1 (60 kg of slurry N ha^{-1}), T_2 (70 kg of slurry N ha^{-1}), and T_3 (82 kg of slurry N ha^{-1}) in a randomized block design. The parameters studied were plant height, stem circumference, number of leaves, leaf area, dry matter yield, and nutrient contents in maize fodder. Maize plant height and stem circumference were significantly influenced by increasing the rate of biogas slurry 14, 28, 42, and 56 days after sowing. The number of leaves in fodder plants did not differ significantly, but leaf area significantly differed between the treatment groups. The highest maize fodder biomass yield was observed in T2 (54.12 t ha^{-1}). In the case of crude protein, a significant difference was observed between the treatment groups and the highest value was also observed in T2 (11.91 %). A significant difference was also observed in dry matter and ash content between the treatment groups, but not in acid detergent fiber or neutral detergent fiber. Based on these results they had concluded that the application of approximately 70 kg of biogas slurry N ha^{-1} will improve the production of biomass and nutrient content in maize fodder.

Yu *et al.* (2010) worked on bioslurry effect on soil and tomato crop, they concluded that biogas slurry is a cheap source of plant nutrients and can offer extra benefits to soil fertility and fruit quality. However, its current utilization mode and low content of active ingredients limit its further development. They conducted a one-season field study, to assess the effects of concentrated biogas slurry on soil property, tomato fruit quality, and composition of microflora in both nonrhizosphere and rhizosphere soils. They recorded that the application of concentrated slurry could bring significant changes to tomato cultivation, including increases in organic matter, available N, P, and K, total N and P, electrical conductivity, and fruit contents of amino acids, protein, soluble sugar, β-carotene, tannins, and vitamin C, together with the R/S ratios and the culture able counts of bacteria, actinomycetes, and fungi in soils. They also concluded that the application is a practicable means in tomato production and will better service in the area of sustainable agriculture.

Dong (2010) studied the effect of the application of the biogas slurry and chemical fertilizer on Chinese cabbage (*Brassica chinensis* L.) yield and quality was studied. Under the condition of soilless cultivation, the orthogonal test in the biogas slurry as a nutrient liquid based solution affecting Chinese cabbage was conducted. The Chinese cabbage yield was the highest with the weight of 10.6 g/plant in the treatment of biogas slurry of 250 mL as nutrient liquid fertilizer mixed with 3 g urea, 2 g potassium dihydrogen phosphate and 1g calcium chloride, 2 g magnesium sulfate and 2 mL trace element. Compared with the CK that contained the chemical fertilizer, its good-quality index: the content of nitrate nitrogen, soluble sugar and chlorophyll did not vary; the content of Fe, Zn, Cu and Mn was significantly increased, while the content of Cd and As was significantly lower than the value required in the national standard on the green leafy vegetable. He concluded that rational application of biogas slurry in cabbage cultivation had a positive effect on the improvement of its yield and quality.

Ding *et al*. (2011) also studied the effects of biogas slurry on the growth and quality of tabe bean, and soil fertility. The results showed that biogas slurry could not only increase the tabe bean production, but also improve the nutrition quality of the bean. In addition, the physical and chemical characters of soil were also improved with increase of soil organic matter, N, K and other trace elements.

Yu *et al.* (2010) conducted a field study to assess the effects of concentrated biogas slurry on soil properties, tomato fruit quality, and composition of micro flora in both non rhizosphere and rhizosphere soils. The results showed that application of concentrated slurry could bring significant changes to tomato cultivation, including increases in organic matter, available N, P, and K, total N and P, electrical conductivity, and fruit contents of amino acids, protein, soluble sugar, b-carotene, tannins, and vitamin C, together with the R/S ratios and the culturable counts of bacteria, actinomycetes and fungi in soils. It was concluded that the biogas slurry application is a practicable means in tomato production and will be better for sustainable agriculture.

2.3 Effect of Compost application on crop.

Duggan and Wieles (1976) studied the effects of different amounts and rates of application of municipal compost and chemical fertilizers on plant yield and on soil properties. Plots were also monitored for crop yield, uptake of heavy metals, soil bulk density, and soil moisture. The compost was fortified with sewage sludge and nitrogen fertilizer, and applied at rates of 200 tons and 160 pounds per acre respectively. Results from their experiments indicated that corn grain yields were increased and soil physical properties improved with annual compost application of 200 tons per year for five years. It was also reported that after compost application residual corn crops still registered positive responses. No adverse effects were observed from the presence of heavy metals, but other crops might be less tolerant to them.

Marchesini *et al.* (1988) studied the effects of the addition of compost prepared from vegetable market waste, in soil contained in pots and kept in a greenhouse. A comparison was made between the treatments with fertilizer only pots with soil mixed with four treatments in which fertilizer made from the same batch homogeneous have been integrated with mineral NPK fertilizer nutrients to match available as an untreated control other crops, sunflower was sown. The yield was approximately doubled in the case of compost treated with chemical fertilizer control. The other four treatments also resulted in increases in production compared to the untreated control. The improvement in soil chemistry and microbiology, suggests that the increase in crop production can be attributed to a general improvement in all components involved in soil fertility status used.

Vogtmann *et al*. (1993) evaluated the absorption of micronutrients by garden vegetables from applications of compost in three successive years, as expected, the vegetables have responded differently to compost treatments describe the effects of compost on the yield and quality some vegetables in Germany. Compared to chemical fertilizers, compost treatments reduced yields of vegetables the first two years, but yields did not differ after the third year of fertility. Generally, composts food quality positively affected and storage performance while reducing nitrate and nitrate improved for vitamin C ratio.

Bevacqua and Mellano (1994) conducted an experiment on onion (*Allium cepa*), lettuce (*Lactuca sativa*), snapdragon (*Antirrhinum majus*), and grass (*Festuca arundinacea*), which were grown twice a year (spring and fall) of San Emigdio sandy loam (coarse-loamy, mixed calcareous, thermic, *Typic Xerorthents*) from the floor for two years which was treated with a cumulative total of 0, 37 and 74 of sludge compost TM / ha of San Diego's wastewater. The soil received two treatments of compost each year and crops were planted in the week of the incorporation of compost. Crop growth was monitored and the results of the fourth or final planting are described here. Seedlings of onions, lettuce and snapdragon transplanted to plots treated with compost facility displayed more vigorous than those in control plots. It was revealed by the findings that treatment of compost produced higher yields of lettuce as the control. Analysis of soil compost treated plots also showed a lowered pH and increased levels of organic matter, primary nutrients, soluble salts and heavy metals.

Mcsorley and Gallaher (1995) have determined the effects of compost garden waste on the densities of plant parasitic nematodes and crop yields in two out of four sites in northern Florida. Separate experiments were conducted with sweet corn (*Zea mays*), cowpea (*Vigna unguiculata*), yellow squash (*Cucurbita pepo*) and okra (*Hibiscus esculentus*). In each experiment three treatments: 269 tonnes / ha yard-waste composting applied to the soil surface as mulch, 269 tonnes / ha of compost into the soil and unamended controls were used. Final population densities Criconemeua spp. and Meloidogyne incognita were lower in plots receiving compost treatment than in the unamended control plots in one of the eight tests. Final densities of Paratrichodorus minor, Pratylenchus spp. and Xiphinema spp. were not affected by treatment of the compost in all tests. Vegetable yields were not affected by either the treatment or, in some trials, were lower after treatment of mulch. The results indicate that the garden waste compost used has little effect on the density of plant parasitic nematodes associated with short-term and vegetable crops have a greater effect on performance. For China as a whole Karki *et al.* (1995) had previously reported, the average growth rate of various crops and vegetables. On an average increase of 10-20 percent yield was reported for China.

Pinamonti (1997) conducted a field experiment to evaluate the effect of compost on soil fertility, nutritional status and performance of the vine. He concluded that the application of compost increases the organic matter content, phosphorus and exchangeable potassium of soil and improve the water holding capacity and porosity of the soil and it also reduces the temperature fluctuations soil, reducing evaporation of water in the soil and influenced the levels of certain nutrients measured in leaf samples. The data showed that nutrient uptake was more influenced by soil physical conditions (temperature, water) and by the availability of nutrients in the soil. Compost materials have significant benefits for land management on the rows of vines, reducing the chemical control of weeds and allow the substitution of chemical fertilizers, no loss of strength, performance or quality of the vine

Jagadeeswari and Kumaraswamy (2000) noted that use of composts with mineral fertilizer increased yield and production of wheat, green beans, gram and rice. Grain and straw yields of rice were significantly higher in treatments that received compost application with N, P and K than in no compost with NPK treatments, thereby highlighting the beneficial effects of compost to increase the crop yield.

Warman (2002) conducted a comparative study of combined conventional compost over vegetable gardens fertilized for 11 years in a sandy soil. Fertility treatments were applied each year to six rotation plots planted with six to eight different vegetable crops. Applications of compost and fertilizer were based on the results of soil sampling and recommendations in Nova Scotia soil test, and assuming that 50 or 100 % availability of total nitrogen in compost mature or fertilizers, respectively. The compost consisted of animal manure, food waste, yard waste and straw bedding or manure racecourse. He said the response of crop yields was inconsistent between the two amendments, the yields of tomatoes and broccoli varied from year to year. Fertilized plots, however, produced higher yields of beans and carrots and numerically higher yields of pepper, while the compost amended plots yields higher onions within two years. There were few significant effects of treatments on the content of plant tissues, that Fe and B were higher in plant bio-modified leaves in 1999. Of the 19 soil parameters measured, the cation exchange capacity (CEC) and the Mehlich-3 extractable Ca, Mn and Pb contents of soil-compost were amended to harvest more than two years of study. Many authors from various countries discussed the different characteristics of vegetable crops where soils were amended with compost and / or fertilizer.

Ozores-Hampton (2002) studied the residual effects of compost on snap beans "Opus" (*Phaseolus vulgaris* L.) and soil nutrient concentration was evaluated from compost applied in the fall 1995 and winter 1996. Compost treatments applied eight months at the beginning were considered the two main plots and fertilizer at the sub-plots (0 vs. 100 kg ha^{-1} N). This study concluded that marketable yield and yield per plant was increased linearly with increasing rates of compost. Plant growth is increased linearly as compost increased, however settlement, marketable yield, and yield per plant is higher in the fertilized plots than unfertilized plots in the middle-aged compost. Soil pH, OM, P, Ca, Zn and Mn increased linearly as the rate of compost has increased. There was no difference in K, Mg, Fe and between treatments of compost and control treatments of compost. Positive residual effect of compost on the production of snap beans can be expected in the normal irrigation practice.

Adediran *et al.* (2003) had conducted a field experiment to evaluate the effect of compost prepared from organic waste material on two vegetable crops, tomato (*Lycopercicum esculentum* Mill*) and* Amaranthus (*Ameranthus cruentus*) were planted as test crops. The results from the field evaluation indicated that the effectiveness of compost on both crops productivity rated in ascending order and it was concluded that compost could be used as high quality growing media and soil conditioner.

Gutser *et al.* (2005) studied the effect of bio-compost with and without mineral nitrogen fertilizer applied to barley optimized corn, winter wheat and summer (crop rotation) in a randomized field experiment on a Luvisol in southwestern Germany. The purpose of their experiment was to evaluate the effect of bio-compost application on crop yield and N-net mineralization in soil. In the treatment of bio-compost application (100 kg total N ha^{-1}, which is about 7.5 t DM) with optimized performance mineral N fertilization of spring barley (1999) and maize (2000) was higher than in the mineral N treatment without optimized bio-compost application. Similar results were obtained with the rate of application of bio-compost higher (400 kg total N ha^{-1}, which is about 30 t MS) without additional mineral N fertilization. The yield increase can be attributed to improved soil structure in the Luvisols. During the growing season of summer barley net-N-mineralization of the plots of bio-compost treatments with minerals additional nitrogen fertilizer was lower than in plots without additional mineral N application.

Shiralipour and Epstein (2005) concluded that although there is some use of municipal compost on farms, the use of compost is not a common practice in commercial agriculture. For agricultural markets to develop and make compost to use a common practice, the agronomic benefits of unsafe application of compost must be demonstrated and a cost-benefit analysis developed. Because of high transportation costs relative to the value of the product, the compost should not only address concerns agricultural, but also be adapted to regional specificities.

Wei and Liu (2005) conducted a field experiment of three years on the compost can be applied to cropland to supply nutrients and improve soil physical properties and yield of barley and Chinese cabbage which was compared with conventional mineral fertilization. However, farmers are more concerned about the accumulation of heavy metals in cultivated land and the availability of heavy metals to crops. From the results over the availability of heavy metals for barley and Chinese cabbage was examined. The experimental results showed that application of compost produced little effect on the germination of rapeseed and stimulated the development Plumelets rape lower application rates (<150 ton ha^{-1}). The yields of barley and Chinese cabbage generated positive response to the application of the SSC. The addition of mineral N fertilizer in compost-PK could further increase crop yields. Considering the accumulation of heavy metals in farmland soils and their availability for crops, the SSC should be applied to agricultural land at a rate of application limited (<150 ton ha^{-1}).

Srikanth *et al.* (2006) study to investigate the possibility of converting agricultural wastes, municipal and industrial compost enriched and assess their nutritional value in the field of experience. All treatments receiving compost enriched with phosphate and microbial inoculants showed superiority in relation to the values were compared to other drugs with a low C / N and increased total phosphorus. In this experiment, carried out under the protection of irrigation of a raga is a test of culture, all treatments were found to be enriched with compost, compost enriched with a better return parameters. Among the treatments compost, humus enriched pressmud yeast and sediment from increased nutritional value compared to other compost treatments. Organic carbon and major nutrients and high levels of nutrients in the soil after harvest of the first harvest increased due to the addition of compost.

In another study, Ghorbani *et al.* (2006). Studied the effect of different fertilizers and compost extracts at different plant health and yield of tomato experiments at two locations in Iran. Treatments included different fertilizers (cattle, sheep and poultry manure, green waste and household composts and fertilizers) and five aqueous extracts (from cattle manure, chicken manure, green waste and house-hold compost and water as a control). Effect of type of fertilizer on the yield of tomato in both places significant ($p < 0.05$) the use of organic fertilizer does not get higher yields compared to the use of fertilizers. Overall, chicken manure and green waste composting led to an increase in production of tomatoes and among various organic fertilizers, respectively. They concluded that the effect of aqueous extracts was not essential to plant health or performance, or tomatoes from these results were very limited and inconsistent. Improving the effectiveness of the adoption of alternatives to agrochemicals, especially in organic farming is necessary

Kostov *et al.* (2007) found that Vine branches, rice husks, flax and residues were composted and dynamics of biomass carbon, C / N ratios and nitrification was studied. The highest quality and most stable composts with the highest values of total N (1.3-1.6%) and lowest C / N ratios (8.0-9.0) was found with wine industry composts. Application of compost significantly increased tomato yield (24.0 - 61.1%) and fruit quality in comparison with soil treated with mineral fertilizers and manure. Inoculation of the branches of the vine with compost Cephalosporium Sp. had a positive impact on productivity and quality of both ryegrass and tomatoes. Stabilization of the level of bacterial C biomass in composts coincided with the beginning of intensive nitrification. Vaccination reduced the value of the conductivity and nitrate in all composts. They found that when concentrations of nitrate N in the composts more than 5% of total N, NO_3 accumulation in the fruits may cause. However, the results can be used in similar substrates and conditions for composting.

Sarwar *et al.* (2007) conducted an experiment to assess possible impact on the cultivation of compost from different organic substrates such as plant residues, tree leaves, fruit and vegetable waste. Decomposition of organic matter was used in rice, wheat crop production in normal soil. Compost was applied without and with fertilizer (Rice and wheat 100-70-70: 140-110-70 NPK kg ha-1) to examine the likely effects of compost on crop yields. Grain yield and yield components (plant height, number of fertile tillers and 1000 grain weight) of rice and wheat increased significantly with the use of organic material in the form of compost, both at the level. Combining compost with fertilizer enhanced biomass and grain yield of both crops. This treatment was cost-effective over the other. On the basis of experimental results, a recommendation for farmers has been formulated that should compost plant residues for use in the soil on the growth of sustainable crop production. In this way you can improve soil fertility improvement in net productivity of land.

Zaller and Kopke (2007) studied the impact of using traditional composting manure (FYM) and two types of composted FYM biodynamically over 9 years on soil chemical properties, microbial biomass and respiration, decomposition rates of grass and clover root production, activity and biomass of earthworms in the wheat, and gives the grass-clover, potatoes, winter wheat, field beans, spring wheat, winter rye crop marketing. Their results showed that plots which received prepared or not prepared FM (30 Mg ha^{-1} $year^{-1}$) had significantly increased soil pH, P and K concentrations than plots without FYM application. Application of FM also affect the soil C / N ratio, root length density, the activity of sucrose, the basic microbial respiration, metabolic quotient and crop yields. Biodynamic preparation of FM with fermented residues of six plant species (6 g Mg^{-1} FM) significantly decreased soil microbial respiration and basic metabolism ratio compared to other prepared FM prepared with Achillea. Furthermore, the use of fully prepared FM led to significantly higher biomass and abundance of earthworms or anecic endogeic than plots where FYM prepared not been applied.

Vaccaro *et al.* (2009) investigated the need to develop management strategies to preserve and protect soil resources, especially soil organic matter (SOM). Among these, the composting process allows both the increasing amount of recycling organic waste and restoration of organic matter in soil. Sequential chemical fractionation in the unbound structure of weakly bound and strongly bound compounds used for bulk compost and its soluble fractions extracted in water or compost suspension after oxidation of the stream of oxygen or without oxidation. Such chemically characterized compost in bulk and fractions were tested on maize seedlings grown in sand and hydroponic conditions and the impact on plant growth and nitrogen metabolism were measured. The use of organic substances in soil showed a large positive impact of growth and enzymatic activity of plants. These results suggest that composting of organic matter may become useful in order to stimulate plant growth.

Branson *et al.* (2009) found that by improving the quality of soil, compost increases the earthworm habitat and allows for greater spread of root. The aim of this study was to determine whether there is a correlation between the amount of compost added, and the number of roots and earthworms in the ecological system row crops. Eight plots (2 reps) received 0, 22, 66, or 110 kg of compost after a cover crop of rye. Plots were then cut government in tomatoes. 18 "x 18" x 6 "sample was removed from each plot. The samples were sieved to remove earthworms and roots. The highest number of roots were extracted in 66 kg parcels composted. The population of earthworms were comparable in the plot receiving 22 or 66 kg of compost. Higher levels of compost did not significantly increase neither root nor amount of earthworms.

Oluwatoyinbo *et al.* (2009) conducted pot and field experiments to determine the effect of lime and compost application on growth and yield of okra. Treatment includes three levels of compost (0, 2.5 and 5.0 Mt ha^{-1}) and two levels of lime (0, 250 kg ha^{-1}) used only in conjunction with compost. Okra has the most growth with the use of 5 Mt ha^{-1} compost. Adding compost to the lime gave lower, but comparable to the growth and seed yield and reduced soil acidity greater than only compost applications of lime or salt. The combined use of compost and lime increases the available P and exchangeable K, Ca and Mg.

In another experiment Kader *et al.* (2010) studied the effect of two organic fertilizers (composted plant residues and chicken manure at the rate of 6 m^3/ acre) on growth and yield response for okra crop, using split block designing with different irrigation level. The results of drip irrigation in conjunction with two types of organic fertilizers were evaluated in terms of growth yield, water use efficiency and nutrients uptake of the crop. They said that it can be seen that the plant growth and yield were greater in drip system with chicken manure as compared to plant residues. The obtained results showed that NPK uptake were significantly affected by water levels and both plant residues and chicken manure. The additional more of irrigation water caused on increase in the uptake of N P K and if compared to the lowest level of irrigation water it increased the growth parameters in expense of okra yield.

Tafaghodinia *et al.* (2010) had studied that compost application was very effective in improving the physical and chemical properties of the soil and has a role in plant disease management and soil fertility in greenhouse, resulting in great improvements of vegetative parts of cress plants as compared to non-amended plots. In addition to improvement of soil's physical and chemical properties, incorporation of compost into the soil added a considerable amount of available soil nutrients for cress. The utilization of compost could be a replacement for chemical fertilizers while growing vegetables like cress which need short time for growth and consume freshly. The goal of their project was to demonstrate the benefits of compost application in commercial agriculture for the purpose of securing markets for municipally derived compost.

Ghaly and Alkoaik (2010) reported that municipal solid waste (MSW) has traditionally dealt with the practice of land filling and incineration. However, the detrimental environmental impact of municipalities Canada promoted the recycling of waste is not putrescible putrescible and compost them. This study aimed at assessing the impact of MSW compost on the development and production of three vegetables (potatoes, corn and squash). Approach: Each crop received 5 treatments: MSW1, MSW2, MSW3, NPK and NPK 0.5, 0.5 MSW1. MSW3 MSW2 and were twice and three times MSW1 respectively. MSW1 was established in the case of corn and potatoes, based on the requirements of phosphorus by the plants and the phosphorus content of MSW compost and the squash was determined based on the requirement of nitrogen by plants and nitrogen content of MSW compost. The choice of fertilizer and application rate based on the optimum NPK ratio for each plant. Samples were taken from plants at different stages of growth and health during harvest and dry the visual analysis of the case. Results: yield of each crop, following the same patterns as in the case of visual observations in the ranking of health and dry. Results showed that 0.5 NPK + 0.5 MSW1 gave best plant growth, health and productivity for potatoes and corn, while NPK gave the best plant growth, health and productivity of the squash. Squash does not seem to respond well to compost MSW. Conclusion: The plots that received MSW2 were healthier than those reserved MSW1 and MSW3. The high rate of MSW can provide a higher level of heavy metals than plants tolerate low levels of the Ministry of the Interior may not include all other required micro-nutrients. Long-term effects of MSW compost on chemical and microbiological properties of soil and plant characteristics such as taste, appearance, ability to store, susceptibility to bugs and disease should be evaluated.

Hernandez *et al*. (2010) conducted a greenhouse study to evaluate the impact of different types of fertilizer in the compost from the total growth and leaf nutrition in lettuce (*Lactuca sativa* L.). Three types of fertilization treatments were analyzed: two organic and one conventional or inorganic. Both the resulting vermicompost and compost from cattle manure in 25-wk trial. The study included 12 experimental units consists of lettuce seedlings var. Great Lakes. The linear model was fitted with a statistical analysis using a completely random experience. ANOVA was performed and means were compared by orthogonal contrasts. The results showed differences in weight and content of the leaves on the N and K variables, and the highest average values for these variables were in the treatment of urea. The content of leaf Ca, Mg and Mn showed higher values in organic fertilization treatments. Treatment of vermicompost showed a higher contribution of Mg, Fe, Zn and Cu and lower in the body of the leaf of lettuce compared to the use of compost.

Sarwar *et al*. (2010) conducted a pot experiment to see the effect of compost, which is prepared from green waste such as garden and agricultural waste on the grass *Lolium perenne*. Compost was analyzed (pH 7.3 and C: N ratio = 10.19:1) before its application to the soil. Three types of soils were used for this purpose. Green compost was applied to each type of soil at 5 and 10% of the volume of soil. *Lolium perenne* grass grown on all these vessels was repeated four times arranged in a CRD factorial. After harvesting grass and soil samples from all vessels and analyzed for pH, EC, organic matter, N, C, C / N and minerals (Ca, Mg, K, P, Cl). The results showed that the use of green compost, both at the level (5 and 10 %) increase in soil pH and EC. Organic matter, N and %age C have been enhanced by a net decrease in C / N ratio and increase the mineral content in the soil.

Desuki *et al*. (2010) conducted a experiment to study the effect of different rates of organic fertilizer (compost) application (100, 120 and 140 kg N/fed.) and biofertilizer (biogen) at 0, 1 and 2 kg/fed. on growth, yield and pods quality of pea (*Pisum sativum* L.) cv. Little Marvel. Obtained results proved that all the tested vegetative growth parameters (plant length, number of leaves and branches as well as fresh and dry weight of leaves and branches), green pods yield and pod quality (pod length, weight and seed weight per pods as well as pods content of N, P, K, Mn, Fe, total protein and total carbohydrate) were significantly increased by increasing the applied compost @ of 100, 120 up to 140 kg N. It was also observed that biofertilizer (biogen) improved previously mentioned parameters and the highest values were recorded with using the highest level of biogen-application (2 kg/fed.). Moreover obtained data proved that the vegetative growth, pods yield as well as pod quality were improved due to the use of the interaction between compost and biogen The highest values were recorded when using the highest levels of compost (140 kg N/fed) and biogen (2 kg/fed).

Abedi *et al*. (2010) evaluated the effects of different levels of inorganic (0, 80, 160 and 240 kg nitrogen ha^{-1}) and organic (0, 30 and 60 Mg municipal waste compost ha^{-1}) fertilizers on wheat grain yield, gluten content, protein variability and protein banding pattern on polyacrylamide gel in different growth stages of irrigated wheat. Their experiment results indicate that the highest wheat grain yield was achieved when the plants were fertilized with 160 kg N ha^{-1} and 30 Mg compost ha^{-1}. Among yield components, spikes $plant^{-1}$, seeds $spike^{-1}$ and 1000 kernels weight were significantly increased with increasing the level of nitrogen. However, there was no significant difference between 160 and 240 kg N ha^{-1}. There was no significant effect of N fertilization on seed protein and gluten content, however the highest amount of seed protein was obtained in 60 Mg compost ha^{-1} at all levels of nitrogen. The SDS-PAGE was performed to investigate differences between proteins banding pattern in different growth stages under different levels of N and compost. Protein banding pattern showed no polymorphism in tillering and stem elongation stages. However, in ear emergence in 160 kg N ha^{-1} and in the all compost levels, density of a 50 k Da band was increased specifically in 60 Mg compost ha^{-1}. Furthermore, seed water soluble proteins, Albumin and Globulin, showed no polymorphism. All in all, it is possible to obtain maximum grain yield, protein and gluten, just in 160 kg ha^{-1} nitrogen level. Thus, it showed the positive impact of compost application on reduction of chemical fertilizer use.

Zhang (2011) reported that high transportation cost is a barrier which prevents land application of compost far away from where the compost is produced. As a result, use of compost in lawns is becoming a popular alternative in municipalities where compost is produced from municipal solid/biosolid waste. A four-year field experiment was conducted on turfgrass, grown on a Black Chernozem soil near Edmonton, Alberta, Canada, to determine the effect of rate and frequency of spring application of compost (prepared from soild/biosolid waste of city of Edmonton) on biomass, sward color, concentration and uptake of nutrients of sward, and soil chemical properties. After four growing seasons, there was no residual mineral N in soil from both compost and NPKS fertilizer, and no residual sulfate-S in soil from NPKS fertilizer treatments. The amounts of extractable P and exchangeable K in soil were greater in compost treatments than in the NPKS fertilizer treatment. There was downward movement of extractable P into the 15-30 cm soil depth in one-time initial and split compost and NPKS fertilizer treatments, and of sulfate-S in all compost treatments. In conclusion, annual application of compost in spring at 50 Mg ha^{-1} is recommended for sustainable color and growth of turfgrass.

Adhikari and Chen (2011) collected data from one cabbage growing season to compare nitrogen (N) and phosphorus (P) recovery and leaching between independent and combined application of composted manure and urea in the greenhouse. Treatments included chemical-fertilizer NPK at 250:80:150 kg ha^{-1}, respectively, organic-fertilizer (250 kg N from 16 Mg ha^{-1} of compost), low-combination (125 kg N from urea and 125 kg N from 8 Mg ha^{-1} of compost), high-combination (double of low-combination), and a blank control. Nitrate-N (NO_3) and inorganic water soluble P (WSP) leaching were monitored fortnightly. Organic and chemical fertilizer treatments suffered from demerits of low N recovery (9.34 %) and high NO_3 leaching (27 %), respectively. While cumulative NO_3 leaching loads in both low-, and high-combination treatments were low, high-combination treatment demonstrated greater numismatic quality by outperforming low combination treatment by higher retention and uptake of N and P. Taking into account the prevailing environment the soil represents to, 16 Mg ha^{-1} of compost co-applied with 250 kg urea-N appeared to be more appropriate combination for cabbage growth.

CHAPTER-3

MATERIALS AND METHODS

A field experiment was conducted at Experimental Area of the Institute of Horticultural Sciences, University of Agriculture, Faisalabad to evaluate the potential of biogas slurry and compost at different levels of inorganic N to improve growth and yield of okra. The experiment was laid down according to Randomized Complete Block Design (RCBD) keeping row to row distance 45 cm and plant to plant distance 20 cm. The dimension of each plot was 600 x 210 cm. The following treatments were tested with three replications:

3.1 Treatment plan

T_1 = Control (Recommended NPK @ 180: 90: 40 kg ha^{-1})

T_2 = Biogas slurry @ 600 kg ha^{-1} + Recommended NPK ha^{-1}

T_3 = Biogas slurry @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}

T_4 = Biogas slurry @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}

T_5 = Compost @ 600 kg ha^{-1} + Recommended NPK ha^{-1}

T_6 = Compost @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}

T_7 = Compost @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}

3.2 Preparation of field and sowing of seeds

The soil was at field capacity condition when the seed bed was prepared. Three plowing was done with two planking, experimental design was followed according to plan and seed bed was prepared of 600 by 210 cm for each treatment and seed was directly sown on beds.

3.3 Fertilizers sources used

The NPK was applied @ 180, 90 and 40 kg ha^{-1} as urea, diammonium phosphate (DAP) and sulphate of potash (SOP), respectively. Full dose of P, K and one third dose of N was applied after at the time of seed sown while remaining N was applied after two weeks and five weeks of germination, respectively.

3.4 Procedure for Obtaining Bioslurry and Compost

Bioslurry was obtained through the outlet of biogas plant of cattle dung, which was already installed in a village named, Rissala Wala near Faisalabad city. Fine grained compost was taken from University of Agriculture, Faisalabad which was prepared from fruit and vegetable waste. Then both bioslurry and compost were weighed according to treatment plan and applied to the soil before seed sowing.

3.5 Application of bioslurry, compost and Inorganic fertilizer.

Biogas slurry and compost each was applied at time of seed bed preparation. Before soil application compost and bioslurry was chemically analyzed as shown in Table 2. According to treatment plan one third of recommended chemical N and full dose of P and K in all plots was applied as urea, DAP and SOP at the time of seed bed preparation. Remaining chemical N was applied at flowering and fruit setting stage. Before sowing crop, composite soil sample from 0-15 cm depth was taken for chemical analysis. After the seed bed preparation, seeds of okra were sown on beds and recommended plant protection measures were carried out. The crop was irrigated with canal water as and when required.

3.6 Data collection

Following data was recorded during crop growth and at harvesting time.

1. Plant height
2. Number of branches per plant
3. Number of fruit sets per plot
4. Fruit yield per plot
5. Root fresh weight
6. Root dry weight
7. Root length
8. 1000 grain weight
9. Nitrogen uptake by root, shoot and fruit

10. Phosphorus uptake by root, shoot and fruit

11. Potassium uptake by root, shoot and fruit

12. NPK contents in soil

13. Organic matter contents in soil

Plant height (cm)

Plant height was measured in centimeter (cm) with the help of measuring tape from soil surface to the top of plants. Average plant height of all three replications was calculated.

Total number of flowers

Total number of flowers per plant was counted directly.

Number of fruits per plant

Number of fruits per plant was counted for each replication directly and mean was calculated.

Number of branches per plant

Total numbers of branches were counted directly per plot and then mean was calculated of each plot

Root length

After the completion of harvesting, each plant roots was dug out, washed with tap water and length of each root was recorded in centimeter (cm). All the plants were cut from the base of the stem and then length was measured with the help of a scale.

Root fresh weight

After the completion of harvesting, roots were dug out, washed with tap water and its fresh weight was recorded with the help of electrical balance for each replication and mean was calculated

Root dry weight

After the completion of harvesting, roots were dug out. These roots were dried under shade and weight was recorded with the help of electrical balance, and mean was calculated.

Okra fruit yield (g plant^{-1})

Okra fruit yield per plant in grams was measured with the help of electrical top load balance for each replication and mean was calculated.

1000 Grain weight (g)

When the whole fruit was harvested, fruit of each replication were dried in sunlight and their 1000 seed weight was recorded with the help of electrical balance

Nitrogen, potassium and phosphorus concentration in plant

Nitrogen, potassium and phosphorus concentration in root shoot and fruit was determined by chemical analysis of plant root, shoot and fruit and these concentration were used to determine the uptake of N, P and K by root, shoot and fruit.

NPK uptake in root, shoot and fruits

Nitrogen uptake by fruit was calculated by multiplying fruit dry weight with nitrogen concentration (%) in fruit. Similarly nitrogen uptake by shoot was calculated by multiplying dry shoot weight with nitrogen concentration (%) in shoot. And also similarly nitrogen uptake by root was calculated by multiplying dry root weight with nitrogen concentration (%) in root. The formula used is as follows:

N uptake (g pot^{-1}) = Yield (g pot^{-1}) x N concentration (%)/100

3.7 ANALITICAL METHODS

The analytical methods followed were from Hand Book No. 60 (U.S. Salinity Lab. Staff, 1954) unless otherwise mentioned.

3.7.1 SOIL ANALYSIS

Before sowing plants, composite soil sample was taken from 0-15 cm depth and was analyzed for physical and chemical soil characteristics. The analytical methods employed were those described in Hand Book No. 60. of USDA (U.S. Salinity Laboratory Staff, 1954) unless otherwise mentioned.

3.7.1.1 Mechanical analysis

To 400 g of soil, 40 mL of 1% sodium hexametaphosphate solution and 150 mL of distilled water were added and kept for over night. Soil was stirred with a mechanical stirred and reading was recorded with Bouyoucos hydrometer (Moodie *et al*., 1959). Soil textural class was established by triangle used in international textural classification system.

3.7.1.2 Saturation percentage (SP)

A portion of saturated paste was transferred to a tarred china dish. It was weighed, dried to constant weight at 105^{o}C and weighed again. Saturation percentage was calculated by using (Method 27a) formula:

$$SP = \frac{\text{Mass of wet soil} - \text{Mass of oven dry soil}}{\text{Mass of oven dry soil}} \times 100$$

3.7.1.3 pH of the saturated soil paste (pHs)

About 250 g of soil was saturated with distilled water. Paste was prepared and allowed to stand for at least one hour and pH was recorded by pH meter (JENCO Model-671 P) with glass electrodes using buffer solutions having pH of 4.1 and 9.2 for standardizing the instrument (U.S. Salinity Laboratory Staff, 1954; Method 21a).

3.7.1.4 Electrical conductivity (EC_e)

Clear extract of above mentioned paste was obtained by using vacuum pump. Electrical conductivity was noted with digital Jenway conductivity meter model 4070 (Method 3a and 4b).

3.7.1.5 Organic matter

1g of soil sample was mixed thoroughly with 10 mL 1 N potassium dichromate solution and 20 mL concentrated sulphuric acid. Then 150 mL of distilled water and 25 mL of 0.5 N ferrous sulphate solution were added and the excess was titrated with 0.1 N potassium permanganate solutions to pink end point (Moodie *et al*., 1959).

3.7.1.6 Total Nitrogen

Total nitrogen was estimated by Gunning and Hibbard's method of sulphuric acid digestion and distillation of ammonia into 4% boric acid by micro Kjeldhal apparatus (Jackson, 1962). In this procedure, 10 grams of soil was added in 30 mL of concentrated H_2SO_4 and 10 grams of digestion mixture (K_2SO_4: $FeSO_4$: $CuSO_4$ = 10:1:0.5) and then the material was digested using Kjeldahl's digestion tubes, cooled and volume made to 250 mL. 10 mL aliquot was taken from this for distillation of ammonia, into a receiver containing 4% boric acid solution and mixed indicator (boromocresol green and methyl red). Sodium hydroxide was added to the distillation flask to make the contents alkaline. After distillation the material in the receiver was titrated against 0.1N H_2SO_4.

3.7.1.7 Available phosphorus

Soil weighing 5g was extracted with 0.5 M $NaHCO_3$ solution adjusted to pH 8.56. Five mL of clear filtrate was taken in 100 mL volumetric flask and then added 5 mL color developing regent (ascorbic acid).Volume was made up to the mark. Reading was recorded on spectrometer (Milton Roy Company) using 880 nm wave length and with the help of standard curve. Available phosphorus was calculated by Olsen's extraction method (Jackson, 1962).

3.7.1.8 Extractable potassium

The extraction was done by ammonium acetate (1 N of pH 7.0) and potassium was determined by Jenway PFP-7 flame photometer (U.S. Salinity Lab. Staff, 1954; Method, 1).

Table 1: Physico-chemical characteristics of soil

Parameter	Unit	Values
Sand	%	47.98
Silt (%)	%	29.52
Clay (%)	%	22.50
Textural class	---	Sandy Clay Loam
Saturation percentage	---	30
ECe	dS m^{-1}	1.16
pH	---	7.7
Organic matter	%	0.72
Total nitrogen	%	0.06
Available P	ppm	6.01
Extractable K	ppm	310

Table 2. Analysis of bioslurry and compost.

Characteristics	Unit	Bioslurry	Compost
EC	dS m^{-1}	3.12	3.20
pH	--	7.30	7.05
Organic matter	%	49.9	55.5
Total nitrogen	%	1.59	1.96
Potassium	%	1.32	1.54
Total phosphorus	%	1.75	1.98
C/N ratio	--	39.5	11.0

3.8 PLANT ANALYSIS

3.8.1 Wet digestion

The dried and ground fruit shoot or root material (0.5 g) was digested with sulphuric acid and hydrogen peroxide according to the method of Wolf (1982). For this purpose the dried ground material (0.5 g) was placed in digestion tubes, 2 mL of conc. H_2SO_4 was added and incubated over night at room temperature. Then 1 mL of H_2O_2 (35%) A. R. grade extra pure was poured down through the sides of the digestion tubes and was rotated. Tubes were ported in a digestion block and heated up to 350 ^{0}C until fumes were produced and continued to heat for another 30 min, digestion tubes were removed from the block and cooled. Then 1 mL of H_2O_2 was slowly added and tubes were placed back into the digestion block until fumes were produced for 20 min. Again digestion tubes were removed. Above step was repeated until the cooled material became colourless. The volume of extracts was made up to 50 mL with distilled water. Then it was filtered and used for determination of mineral elements.

3.8.2 Nitrogen determination

Total nitrogen was determined by Kjeldhal method. Ten mL of aliquot was taken in Kjeldhal flask and it was placed on the Kjeldhal ammonium distillation unit, 10 mL of 40 % sodium hydroxide solution was added and the flask was immediately connected to the distillation apparatus. Ten mL of 2 % boric acid solution were taken with few drops of mixed indicator (bromocresol green methylene red) in 100 mL conical flask. When the distillate was approximately 40-50 mL, the conical flask was removed and distillation was turned off. The distillate was cooled for few minutes and titrated with 0.01 N standard sulphuric acid up to pink end point. A blank was run for complete procedure (Jackson, 1962).

3.8.3 Phosphorus determination

Dissolved 22.5 g ammonium heptamolybedate in 400 mL DI water. (a) Dissolved 1.25g ammonium metavanadate in 300 mL hot DI water. (b) Added (b) to (a) in a 1 L volumetric flask and let the mixture to cool at room temperature. Slowly added 250 mL concentrated nitric acid to the mixture, cooled at room temperature and brought to 1 L volume. Standard solution was also run on the Spectrophotometer to develop standard curve.

For this purpose, oven-dried KH_2PO_4 at 105 C° for 1 hour. Took 2.156 g KH_2P0_4 and made 1 L volume (1000 ppm solution). Took 25 mL of stock solution and made 250 mL volume (100 ppm solution). Made standards of 1, 2, 3, 4, 5 ppm solution from 100 ppm solution in 100 mL volumetric flask.

Wet digestion procedure

Procedure is same as in case of nitrogen.

Procedure:

P in plant samples was determined by using yellow color method. Ten 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).

% P = ppm P (from calibration curve) x R/Wt x 100/ 10000

R = Ratio between total volume of digest

Wt = Weight of total dry plant (g)

3.8.4 Potassium determination:

Wet digestion procedure

Procedure is same as in nitrogen.

Procedure:

Analysed the digested liquid by Flame photometer Jenway PFP-7 (Method 8).

K (ppm) = (ppm in extract - blank) x A/ Wt

A = Total volume of the extract (mL)

Wt = Weight of dry plant (g)

3.9 Statistical analysis

The data collected for various characteristics were analyzed statistically using Fisher's technique (Steel *et al*., 1997). The treatment means were compared by Duncan Multiple Range Test (DMR test) at 5 % probability level.

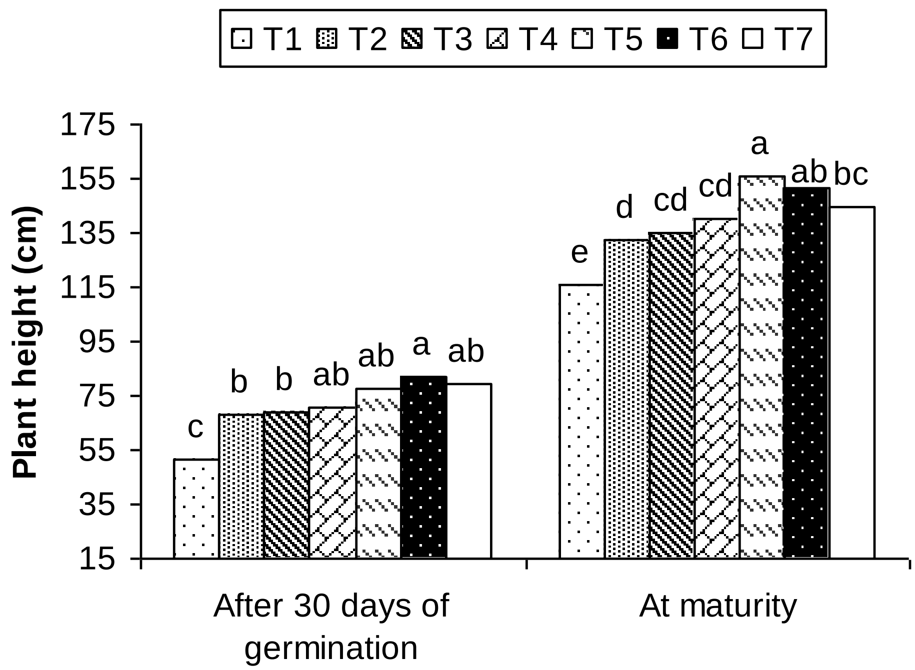
CHAPTER-4

RESULTS AND DISCUSSIONS

The research work presented in this manuscript was carried out at field area of Institute of Horticultural Sciences, University of Agriculture, Faisalabad. The study was planned to evaluate the potential of bioslurry and compost at different levels of inorganic nitrogen to improve the growth and yield of okra. The soil, bioslurry and compost used for this experiment were physically and chemically analyzed for various physico-chemical characteristics given in Table 1 and 2. It was sandy clay loam in texture, alkaline in reaction with normal EC value and low in organic matter. Results regarding growth, yield and chemical composition of plants and their explanations are being discussed here.

4.1 Plant height (cm)

Response of bioslurry and compost applied along with different rates of inorganic nitrogen and recommended dose of inorganic phosphoric and potassic fertilizer on plant height after 30 days of germination and at plant maturity are shown in Figure1. Data clearly indicated that application of bioslurry and compost with different level of N significantly affected the plant height. Minimum plant height (51 cm) 30 days after germination was observed in control where only recommended dose of NPK was applied while minimum plant height (116 cm) at maturity was also observed in T_1. All treatments containing compost and bioslurry caused an increase in plant height ranging from 32 to 59 % over control 30 days after germination and 14 to 31% at maturity. The maximum plant height (82 cm) 30 days after germination was observed on the application of compost @ 600 kg ha^{-1} along with 25 % less N of the recommended dose (T_6) and the increase was 59 % more than that of control. The maximum plant height (156 cm) at maturity was observed on the application of compost @ 600 kg ha^{-1} along with recommended dose of chemical N (T_5) fertilizer which was 34 % more than that of control, This was followed by 152 cm in compost @ 600 kg ha^{-1} along with 25 % less N of the recommended dose, 144 cm length in plant height was observed where compost @ 600 kg ha^{-1} along with 50 % less N of recommended N dose was applied. Comparative analysis of compost and bioslurry indicates that effect of compost with fertilizer showed better results on plant height than control and even than bioslurry treatment.



Values sharing same letters do not differ significantly at $P = 0.05$, accordingly to DMR test.
I) LSD PH1, 12.33
II) LSD PH2. 11.55

Figure 1: Effect of bio-slurry and compost on plant height of okra in the presence of different levels of inorganic nitrogen under field conditions

T_1 = Control (Recommended NPK @ 180: 90: 40 kg ha^{-1})

T_2 = Biogas slurry @ 600 kg ha^{-1} + Recommended NPK ha^{-1}

T_3 = Biogas slurry @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}

T_4 = Biogas slurry @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}

T_5 = Compost @ 600 kg ha^{-1} + Recommended NPK ha^{-1}

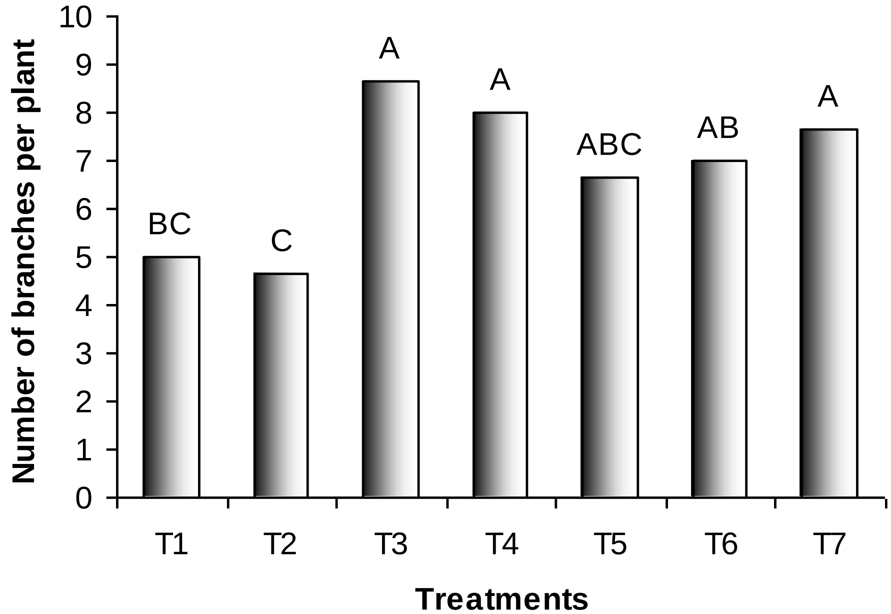
T_6 = Compost @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}

T_7 = Compost @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}

The data also showed that compost containing treatments significantly (0.05) caused up to 61% more plant height than that of bioslurry containing treatments. The reason is that compost had more narrow C:N ratio than that of bioslurry and supplied more quickly nutrients than bioslurry. That's why the mean plant height that was observed more in compost application than bioslurry 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 compost overall showed better results than bioslurry application and control in plant height. The increase in plant height on the application of compost in combination with inorganic N fertilizer was in line with the results reported by Sarwar *et al.* (2007) and Sarwar *et al.* (2010).

4.2 Number of branches per plant

The response of bioslurry and compost at different levels of inorganic nitrogen on number of branches per plant is shown in Figure 2. The data clearly showed that application of bioslurry and compost with different level of N and recommended doses of P and K significantly affected the number of branches per plant at significant level of 0.05 according to DMR test. Maximum number of branches 73 % more than control were observed in T_3, , where bioslurry @ 600 kg ha^{-1} was applied in combination with 75 % of recommended nitrogen and full dose of P and K while minimum mean number of branches per plant was observed in T_2 where bioslurry @ 600 kg ha^{-1} was applied along with recommended dose of NPK. The bioslurry application in treatments with T_3 and T_4 showed the best result than all other treatment where compost was applied along with different levels of chemical N and recommended P and K fertilizer. However compost application along with different level of inorganic nitrogen increased number of branches from 33 to 53 % over control. Statistical analysis showed that overall effect of bioslurry gave best results regarding number of branches than control and compost treatments. The data also showed that bioslurry produced



Values sharing same letters do not differ significantly at $P = 0.05$, accordingly to DMR test.

LSD: 2.2946

Figure 2: Effect of bio-slurry and compost on number of branches per plant in the presence of different levels of inorganic nitrogen under field conditions

T_1 = Control (Recommended NPK @ 180: 90: 40 kg ha^{-1})

T_2 = Biogas slurry @ 600 kg ha^{-1} + Recommended NPK ha^{-1}

T_3 = Biogas slurry @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}

T_4 = Biogas slurry @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}

T_5 = Compost @ 600 kg ha^{-1} + Recommended NPK ha^{-1}

T_6 = Compost @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}

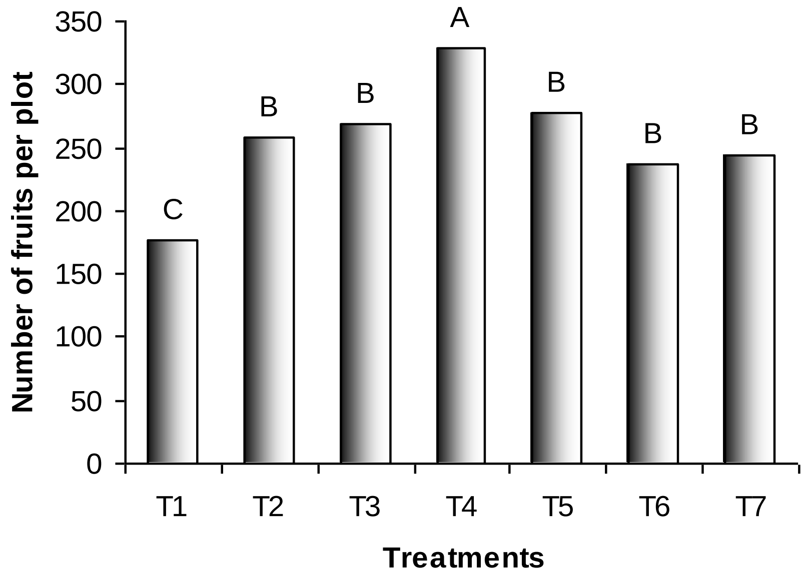
T_7 = Compost @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}

37 % number of branches than compost treatments at significant level of 0.05 according to DMR tests. The reason is that compost and bioslurry beside improving soil quality also supplied micro, macro nutrients and improved the plant growth, while mean number of branches that was observed more in bioslurry application than compost due to more staying and persistent nature of nutrients in the soil. That's why bioslurry overall showed better results than compost application and control in number of branches. Rehman *et al*. (2008) also reported the similar results.

4.3 Number of fruits per plant

Effect of bioslurry and compost in the presence of variable rates of N and full rates of P and K fertilizers on number of fruits per plot is shown in Figure 3. The data clearly indicated that the application of bioslurry and compost with different levels of N significantly affected the number of fruits per plot. Minimum number of fruits per plot (176) was observed in control where only recommended doses of NPK fertilizers were applied. All the treatments containing compost and bioslurry caused an increase in number of fruits per plot ranging from 37 to 89 % over control. Because bioslurry and compost improved physical and chemical properties of soil and resulted to supplied micro, macro nutrients and improve the plant growth but maximum number of fruit per plot (328) was observed on the application of bioslurry @ 600 kg ha^{-1} along with 50 % less N of recommended N (T_4) fertilizers which was 89 % more than that of control. This was followed by T_5 (278) where compost @ 600 kg ha^{-1} along with recommended dose of NPK, and T_3 (269) where bioslurry @ 600 kg ha^{-1} along with 25 % less N of recommended N fertilizer.

Comparative analysis of compost and bioslurry indicated that the effect of bioslurry along with fertilizer showed better results on number of fruits per plot than control and even compost treatments. The data also showed that bioslurry containing treatments caused upto 48 % more number of fruits than that of compost containing treatments at significant level of 0.05 according to DMR test. The results showed that bioslurry had more efficiency over compost because it released nutrients with the passage of time to the plants more efficiently than compost. That effect on the number of fruits per plot observed was more in bioslurry application than compost. These sources application increased organic matter content, available phosphorus and exchangeable potassium of soil, influenced the levels of some



Values sharing same letters do not differ significantly at *P* = 0.05, accordingly to DMR test.
LSD 41.01

Figure 3: Effect of bio-slurry and compost on number of fruits per plant in the presence of different levels of inorganic nitrogen under field conditions

T_1 = Control (Recommended NPK @ 180: 90: 40 kg ha^{-1})

T_2 = Biogas slurry @ 600 kg ha^{-1} + Recommended NPK ha^{-1}

T_3 = Biogas slurry @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}

T_4 = Biogas slurry @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}

T_5 = Compost @ 600 kg ha^{-1} + Recommended NPK ha^{-1}

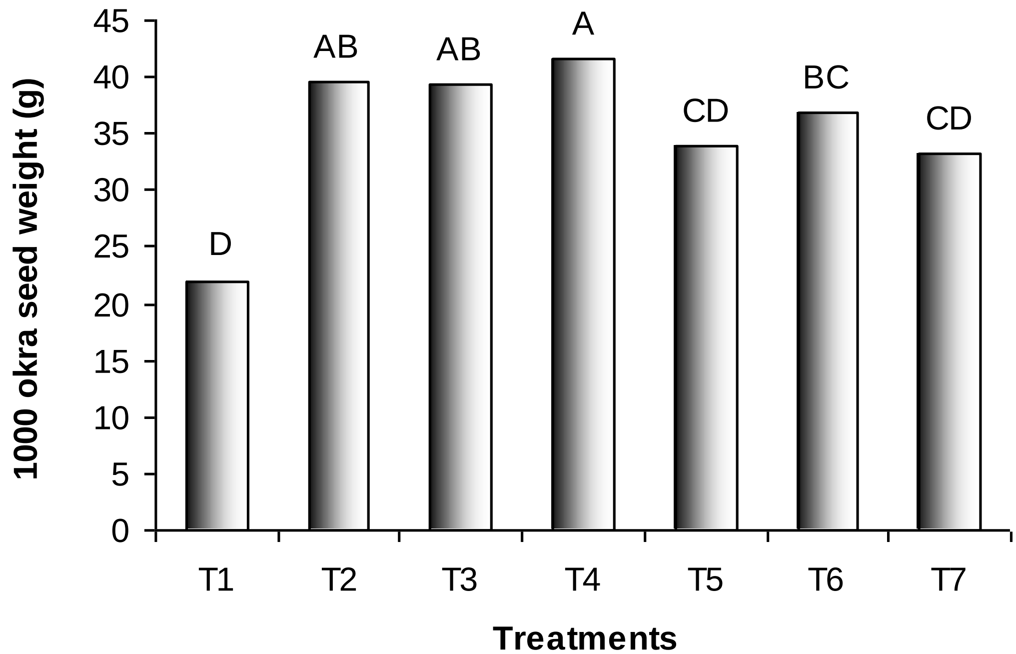
T_6 = Compost @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}

T_7 = Compost @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}

nutrients measured in plant. Because physical conditions of soil has been improved that's why nutrient uptake was more in plant that effect crop yield similar study was also found by Pinamonti (1997).

4.4 Weight of 1000 seeds (g)

Means concerning the comparative effect of bioslurry and compost with different levels of N and recommended dose of P and K on 1000 seeds weight is explored by Figure 4. The data clearly indicated that the application of bioslurry and compost along with different levels of N and recommended doses of P and K significantly affected the 1000 seeds weight. Maximum 1000 okra seed weight (42 g) was observed in T_3, 30 % more than control, where bioslurry was applied @ 600 kg ha^{-1} along with 75 % of recommended nitrogen and full dose of P and K. While minimum mean weight of 1000 okra seed 22 g was observed in (T_1) where only recommended dose of NPK fertilizer was applied. Except T_7 bioslurry and compost application showed the best results in all treatments where applied in combination with different levels of chemical N and recommended P and K fertilizer. The increase in 1000 seed weight over control recorded with the application of compost along with different level of inorganic N ranged from 15 to 52 % over control. Statistical analysis showed that overall bioslurry showed significantly positive results on number of branches than control and compost treatments. The data also showed that bioslurry gave 35 % better results in 1000 okra seed weight than compost treatments at significant level of 0.05 according to DMR test. The reason is that compost and bioslurry besides improving soil quality also supplied micro, macro nutrient and improved the plant growth, bioslurry and compost treatments also affected the pH and organic matter status of the soil which helps to release of indigenous nutrients of soil and soil applied NPK. The mean seed weight was observed more in bioslurry application than compost because bioslurry had more potential to supply nutrients to plant more efficiently than compost. That's why bioslurry overall showed better results than compost application and control in 1000 seed weight. Similar results were also found by Rehman *et al*. (2008).



Values sharing same letters do not differ significantly at $P = 0.05$, accordingly to DMR test.
LSD: 3.9590

Figure 4: Effect of bio-slurry and compost on 1000 okra seeds weight in the presence of different levels of inorganic nitrogen under field conditions

T_1 = Control (Recommended NPK @ 180: 90: 40 kg ha^{-1})

T_2 = Biogas slurry @ 600 kg ha^{-1} + Recommended NPK ha^{-1}

T_3 = Biogas slurry @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}

T_4 = Biogas slurry @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}

T_5 = Compost @ 600 kg ha^{-1} + Recommended NPK ha^{-1}

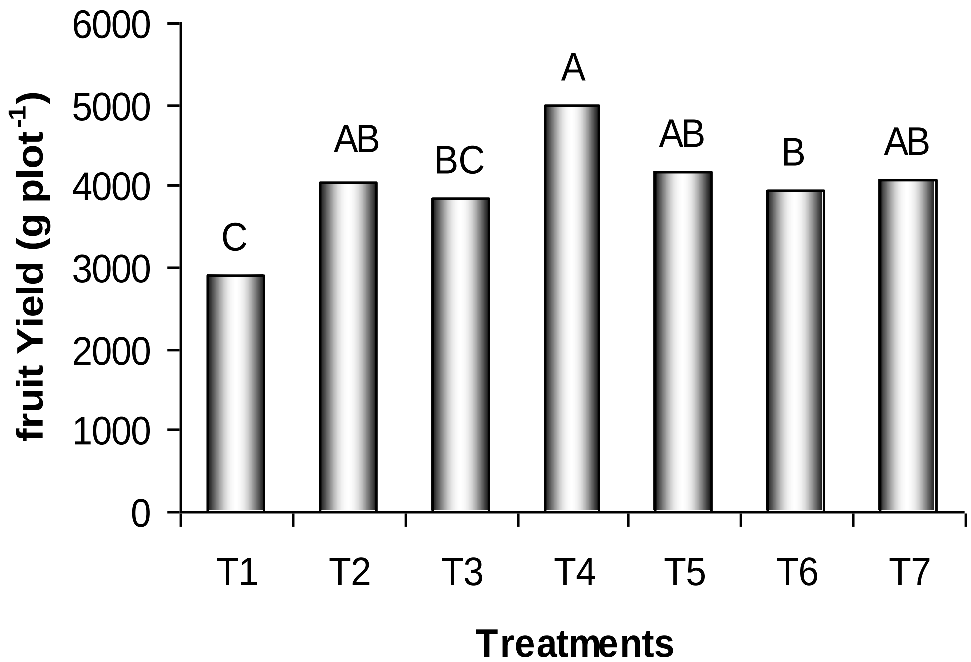
T_6 = Compost @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}

T_7 = Compost @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}

4.5 Fruit yield per plot (g)

Effect of bioslurry as well as compost along different rates of inorganic nitrogen and with full dose of recommended P and K fertilizers on number of fruits of okra is shown in Figure 5. The data clearly indicated that the application of bioslurry and compost with different levels of N significantly affected the fruit weight per plot. Minimum fruits weight per plot (2910 g) was observed in control (T_1) where only recommended dose of NPK was applied. All treatments containing compost and bioslurry caused an increase in fruits weight per plot ranging from 35 to 72 % over control. The maximum fruit yield per plot (4995 g) was observed on the application of bioslurry @ 600 kg ha^{-1} along with 50 % less N of recommended inorganic N (T4) fertilizers which was 72 % more than that of control. This yield was followed by 4170 and 4058 g per plot recorded with the application of compost @ 600 kg ha^{-1} along with 100 and 75 % recommended dose of chemical N, respectively.

Comparative analysis of compost and bioslurry indicated that effect of bioslurry along with fertilizer showed best results on fruit weight per plot than control and even than compost treatments. The data also showed that bioslurry containing treatments caused upto 67% more number of fruits per plot than that of compost containing treatments at significant level of 0.05 according to DMR test. The reason is that bioslurry application slowly releases nutrients than compost, because compost provides readily available nutrients to the soil and number of fruits improved more rapidly due to more staying nature of bioslurry in soil and holding and supplying of nutrients more efficiently, bioslurry performed better in fruit yield than compost. That’s why bioslurry overall showed better results than compost application and control in fruit yield. The increase in fruit yield on the application of bioslurry in combination of N inorganic fertilizer was in line with the results reported by Yu *et al.* (2010).



Values sharing same letters do not differ significantly at $P = 0.05$, accordingly to DMR test.
LSD: 986.81

Figure 5: Effect of bio-slurry and compost on okra fruit yield in the presence of different levels of inorganic nitrogen under field conditions.

T_1 = Control (Recommended NPK @ 180: 90: 40 kg ha^{-1})

T_2 = Biogas slurry @ 600 kg ha^{-1} + Recommended NPK ha^{-1}

T_3 = Biogas slurry @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}

T_4 = Biogas slurry @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}

T_5 = Compost @ 600 kg ha^{-1} + Recommended NPK ha^{-1}

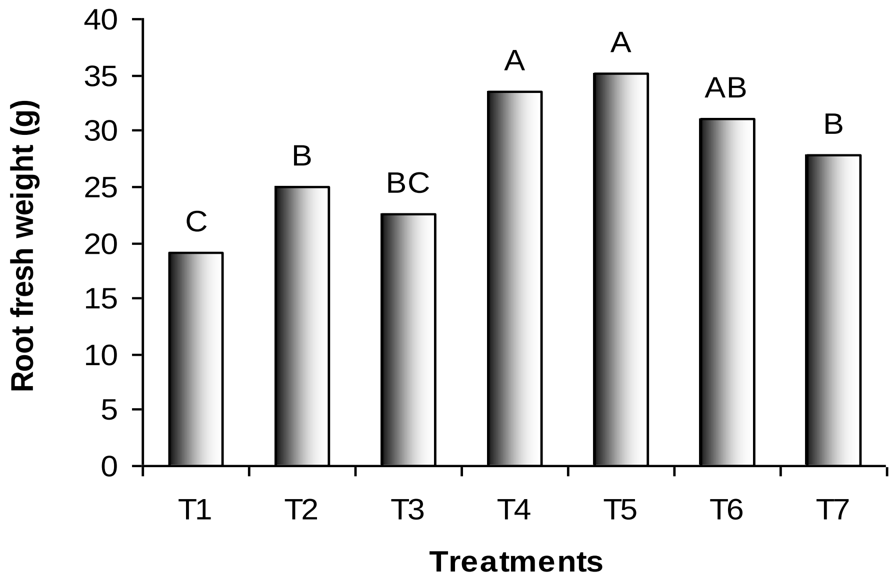
T_6 = Compost @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}

T_7 = Compost @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}

4.6 Root fresh weight (g plant^{-1})

Effect of bioslurry and compost in the presence of variable rates of N and full rates of P and K fertilizers on root fresh weight is graphically shown in Figure 6. The data clearly depicted that the application of bioslurry and compost with different level of N significantly affected the root fresh weight. Minimum root fresh weight (19 g) was observed in control where only recommended dose of NPK fertilizers was applied. All treatments containing compost and bioslurry caused an increase in root fresh weight ranging from 18-85 % over control. The maximum root fresh weight (35 g) was achieved with the application of compost @ 600 kg ha^{-1} along with full dose of recommended inorganic N fertilizer and this increase was 85 % more than that of control. This increase was followed by plot (32 g) where compost was applied @ 600 kg ha^{-1} along with 25 % less of recommended inorganic N and 30 g achieved with the use of in compost @ 600 kg ha^{-1} along with 50 % less N of recommended N fertilizer.

Comparative analysis of compost and bioslurry indicated that the application of compost along with fertilizer showed significantly positive results on root fresh weight per plant than control and bioslurry treatment applications. The data also showed that compost containing treatments increase root fresh weight from 46-85 % more than control and bioslurry containing treatments increased root fresh weight from 18-76 % over control. It is also clear from the data that compost performed 17 % relatively more better on root fresh weight than bioslurry at significant level of 0.05 according to DMR test. The reason is that compost has narrower C:N ratio than that of bioslurry and more readily available nutrients much increased plant biomass. So while mean root fresh weight that was observed more in compost application than bioslurry treatments. That’s why compost overall showed better results than bioslurry application and control in plant height. The increase in root fresh weight on the application of compost in combination of N inorganic fertilizer was in line with the results reported by Bo *et al.* (2009).



Values sharing same letters do not differ significantly at *P* = 0.05, accordingly to DMR test.
LSD: 10.407

Figure 6: Effect of bio-slurry and compost on root fresh weight per plant in the presence of different levels of inorganic nitrogen under field conditions

T_1 = Control (Recommended NPK @ 180: 90: 40 kg ha^{-1})

T_2 = Biogas slurry @ 600 kg ha^{-1} + Recommended NPK ha^{-1}

T_3 = Biogas slurry @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}

T_4 = Biogas slurry @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}

T_5 = Compost @ 600 kg ha^{-1} + Recommended NPK ha^{-1}

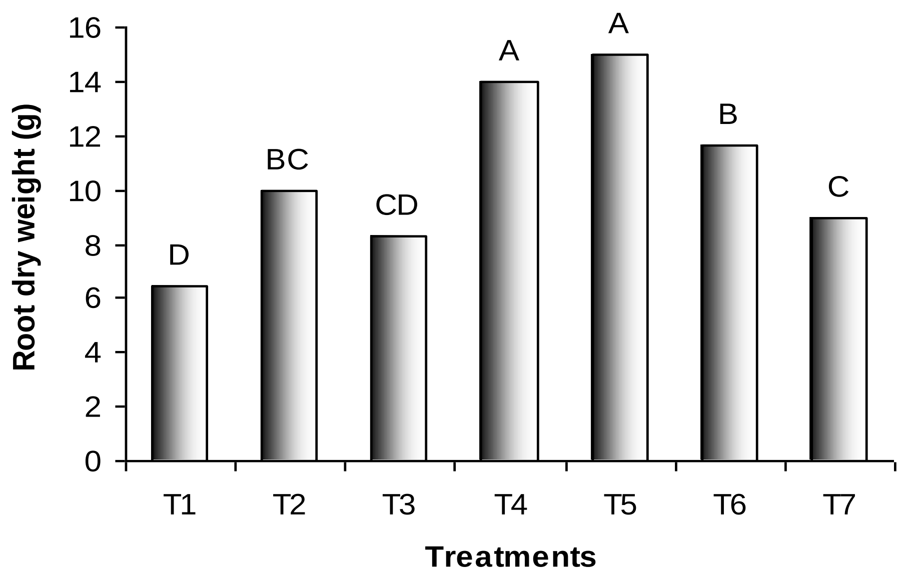
T_6 = Compost @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}

T_7 = Compost @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}

4.7 Root dry weight (g $plant^{-1}$)

Effect of bioslurry and compost in the presence of variable rates of N and full rates of P and K fertilizers on root dry weight graphically is shown by Figure 7. The data clearly depicted that application of bioslurry and compost with different level of inorganic N significantly affected the root dry weight. Minimum root fresh weight 6.0 g was observed in control, where only recommended dose of NPK fertilizers was applied. All treatments containing compost and bioslurry caused an increase in root dry weight ranging from 20-75 % over control. Maximum root dry weight (15 g) was observed in T_5 where compost was applied @ 600 kg ha^{-1} along with recommended dose of N fertilizer which was 75 % more over control. This was followed by 14 g where bioslurry was applied @ 600 kg ha^{-1} along with 50 % less of N of recommended N, and 12 g was observed where compost was applied @ 600 kg ha^{-1} along with 25 % less N of recommended N fertilizers (T_6).

Comparative analysis of compost and bioslurry indicated that the effect of compost along with fertilizer showed better results on root dry weight per plant than control and even than bioslurry treatments. The data also showed that compost containing treatments significantly increased root dry weight ranging from 34-71 % more than control and bioslurry containing treatments significantly increased root fresh weight from 12-51 % than control. It is also cleared from data that compost performs 15 % relatively better on root dry weight than bioslurry at significant level of 0.05 according to DMR test. The reason is that compost had narrower C:N ratio than bioslurry and more readily available nutrients which increased plant biomass. Because of this mean root dry weight that was observed more in compost application than bioslurry treatments, while compost overall showed better results than bioslurry application and control in root dry weight. The increase in root dry weight on the application of compost in combination of N inorganic fertilizer was in line with the results reported by Bo *et al.* (2009).



Values sharing same letters do not differ significantly at $P = 0.05$, accordingly to DMR test.
LSD: 4.001

Figure 7: Effect of bio-slurry and compost on root dry weight per plant in the presence of different levels of inorganic nitrogen under field conditions

T_1 = Control (Recommended NPK @ 180: 90: 40 kg ha^{-1})

T_2 = Biogas slurry @ 600 kg ha^{-1} + Recommended NPK ha^{-1}

T_3 = Biogas slurry @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}

T_4 = Biogas slurry @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}

T_5 = Compost @ 600 kg ha^{-1} + Recommended NPK ha^{-1}

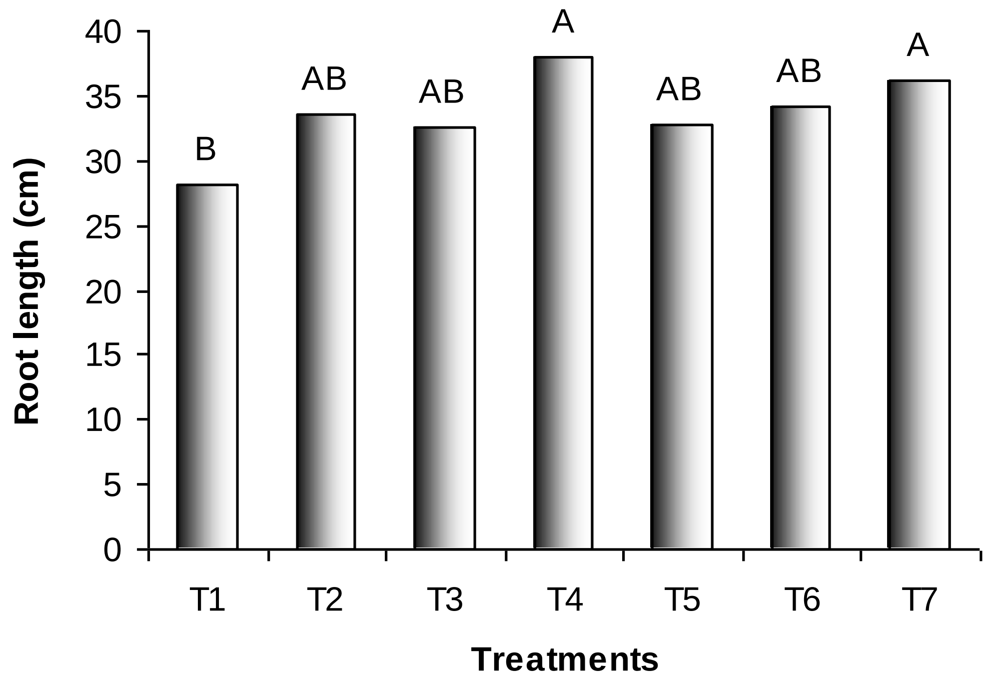
T_6 = Compost @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}

T_7 = Compost @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}

4.8 Root length

Effect of bioslurry and compost in the presence of variable rates of N and full rates of P and K fertilizers on root length is graphically shown in Figure 8. The data clearly depicted that application of bioslurry and compost with different level of N significantly affected the root length. Minimum root length (28 cm) was observed in control, where only recommended dose of NPK fertilizers was applied. All treatments containing compost and bioslurry caused an increase in root length ranging from 19-35 % over control. The maximum root length (38 cm) was observed in T_4 where bioslurry was applied @ 600 kg ha^{-1} along with 50 % less N of recommended N fertilizer which was 35 % more than that of control. This was followed by 28 cm where compost was applied @ 600 kg ha^{-1} along with 50 % less N of recommended N.

Comparative effect of compost and bioslurry indicated that the effect of bioslurry along with fertilizer showed better results on root length per plant than control and even than compost treatments. The data also showed that those treatments contained bioslurry increased root length from 19-35 % more over control. While compost containing treatments increases root length from 16-28 % more than control. It is also clear from the data that bioslurry performed 25 % relatively more better on root length than compost at significant level of 0.05 according to DMR test. The reason is that bioslurry perform better in long terms in soil and affected the root length while staying more consistently in soil and supplied essential nutrients and hormones like auxin in long terms. That’s why mean root length was observed more in bioslurry application treatments than compost. That’s why bioslurry overall showed better and significant results over control and compost containing treatments in root length. The increase in root length with the application of bioslurry was also reported by Yu *et al.* (2010).



Values sharing same letters do not differ significantly at $P = 0.05$, accordingly to DMR test.
LSD: 6.9676

Figure 8: Effect of bio-slurry and compost on okra fruit weight in the presence of different levels of inorganic nitrogen under field conditions

T_1 = Control (Recommended NPK @ 180: 90: 40 kg ha^{-1})

T_2 = Biogas slurry @ 600 kg ha^{-1} + Recommended NPK ha^{-1}

T_3 = Biogas slurry @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}

T_4 = Biogas slurry @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}

T_5 = Compost @ 600 kg ha^{-1} + Recommended NPK ha^{-1}

T_6 = Compost @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}

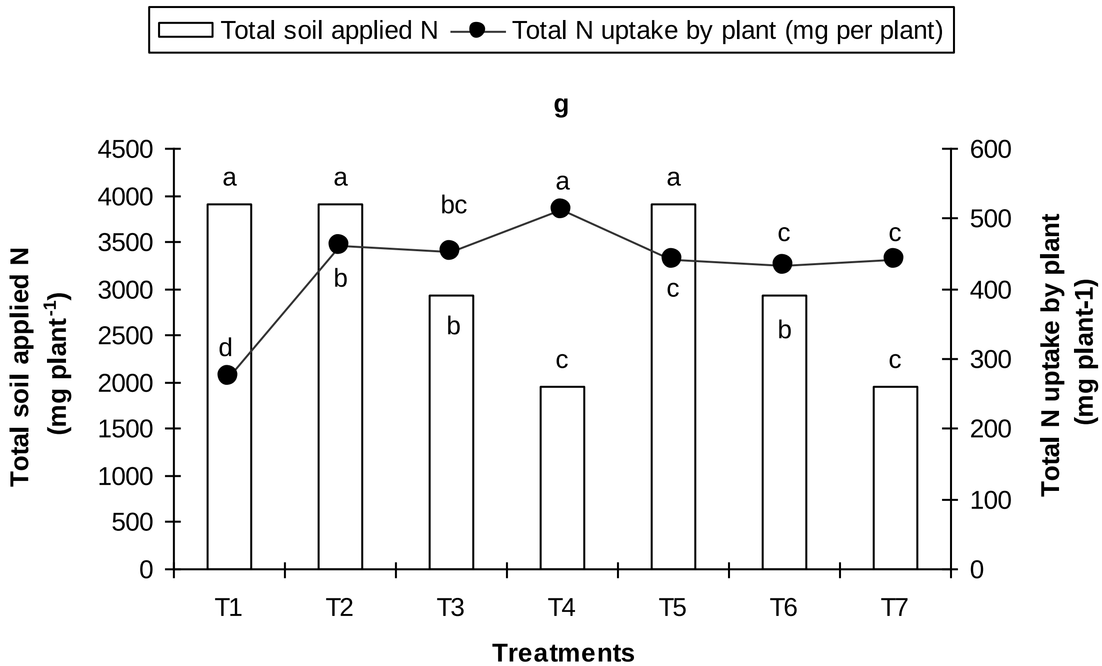
T_7 = Compost @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}

4.9 Effect of bioslurry and compost on nitrogen uptake by plant

The data regarding total soil applied nitrogen and total total nitrogen uptake by plant is graphically elaborated in Figure 9. Results showed that bioslurry and compost significantly affected the uptake of nitrogen from growth media into plant and so improved plant health by providing more nitrogen to plant which ultimately affected plant metabolism, plant chlorophyll contents and plant physical appearance because there was 58-87 % more N uptake by those plants where either compost or bioslurry was applied along with NPK fertilizers. Minimum uptake of nitrogen by plant was observed in control nitrogen uptake by plant was almost similar in both bioslurry and compost treatments, however in T_4, where bioslurry was applied @ 600 kg ha^{-1} along with 50 % less N of recommended N fertilizer showed significantly results as compared to control and other treatments.

The increase in N uptake by plant ranged from 65-87 % higher than control, in treatments where bioslurry was applied @ 600 kg ha^{-1} along with different levels of chemical N and recommended P and K fertilizer. Where as in treatments where compost @ 600 kg ha^{-1} was applied with different levels of inorganic nitrogen and recommended P and K fertilizer increased N uptake ranged from 58-61 % higher than control.

Statistical analysis showed that T4 where 50 % less recommended n was applied along with bioslurry, utilized more efficiently soil applied nitrogen, i.e. it utilized 26 % of total soil applied nitrogen while control utilized only 12 % of total soil applied nitrogen. Overall effect of bioslurry along with fertilizer showed better results on soil applied nitrogen than control and compost treatments. The data also showed that bioslurry gave 42 % more N uptake of soil applied N by plant than compost containing treatments at significant level of 0.05 according to DMR test.



Values sharing same letters do not differ significantly at P = 0.05, accordingly to DMR test.
LSD N uptake by plant: 10.298

Figure 9: Effect of bio-slurry and compost on total soil applied N and total N uptakes by plant in the presence of different levels of inorganic nitrogen under field conditions

T_1 = Control (Recommended NPK @ 180: 90: 40 kg ha^{-1})

T_2 = Biogas slurry @ 600 kg ha^{-1} + Recommended NPK ha^{-1}

T_3 = Biogas slurry @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}

T_4 = Biogas slurry @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}

T_5 = Compost @ 600 kg ha^{-1} + Recommended NPK ha^{-1}

T_6 = Compost @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}

T_7 = Compost @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}

4.9.1 Nitrogen uptake by fruit, shoot and root.

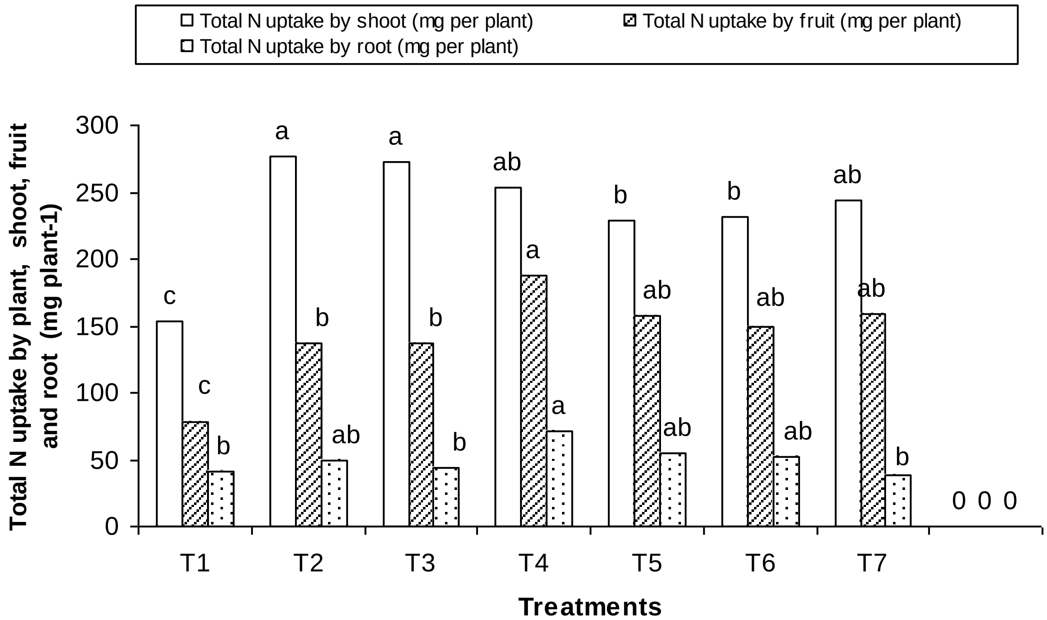
The data regarding Nitrogen uptake by shoot, fruit and root in response to the application of bioslurry and compost along with different levels of inorganic N and recommended dose of P and K fertilizer is shown in Figure 10. Statistical analysis showed that bioslurry and compost along with different levels of inorganic nitrogen and recommended doses of P and K fertilizers significantly increased nitrogen uptake by shoot, fruit and root as compared to control.

N- Uptake by Shoot

Maximum nitrogen uptake by shoot was observed in T_2 where bioslurry @ 600 kg ha^{-1} was applied along with recommended dose of NPK fertilizers that showed significantly 80 % more uptake than control and similar trend was also observed in T_3. Minimum nitrogen uptake was observed in control where only recommended dose of NPK fertilizer was applied. The treatments where bioslurry was applied with different levels of chemical N and recommended P and K fertilizer increased nitrogen uptake by shoot from 65 to 80 % over control and treatments where compost @ 600 kg ha^{-1} was applied along with different levels of inorganic nitrogen and recommended P and K fertilizers increased nitrogen uptake up to 49-51 %. Statistical analysis also showed that bioslurry treatments performed 23 % better in N uptake than compost while shoot uptake of nitrogen was 55 % of total plant uptake at significant level of 0.05 according to DMR test.

N- Uptake by Fruit

Maximum nitrogen uptake by fruit was observed in T_4 where bioslurry was applied @ 600 kg ha^{-1} along with 50 % less N of recommended N fertilizers, that showed 140 % more uptake over control. Minimum nitrogen uptake was observed in T_1 where only recommended doses of NPK fertilizers were applied. The treatment where bioslurry was applied with different levels of chemical N and recommended P and K fertilizers increased nitrogen uptake by shoot ranging from 75 to 140 % higher than control while treatments where compost @ 600 kg ha^{-1} was applied with different levels of inorganic nitrogen and recommended P and K fertilizers increased nitrogen uptake up to 92-104 %. Statistical analysis also showed that bioslurry containing treatments performed 34 % better in N uptake



Values sharing same letters do not differ significantly at $P = 0.05$, accordingly to DMR test.
LSD shoot: 15.432, LSD fruit: 17.41, LSD root: 4.431

Figure 10: Effect of bio-slurry and compost on nitrogen uptake by plant shoot, fruit and root in the presence of different levels of inorganic nitrogen under field conditions.

T_1 = Control (Recommended NPK @ 180: 90: 40 kg ha^{-1})

T_2 = Biogas slurry @ 600 kg ha^{-1} + Recommended NPK ha^{-1}

T_3 = Biogas slurry @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}

T_4 = Biogas slurry @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}

T_5 = Compost @ 600 kg ha^{-1} + Recommended NPK ha^{-1}

T_6 = Compost @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}

T_7 = Compost @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}

by fruit over compost containing treatments and fruit uptake of nitrogen was 33 % of total plant uptake at significant level of 0.05 according to DMR test.

N- Uptake by Root.

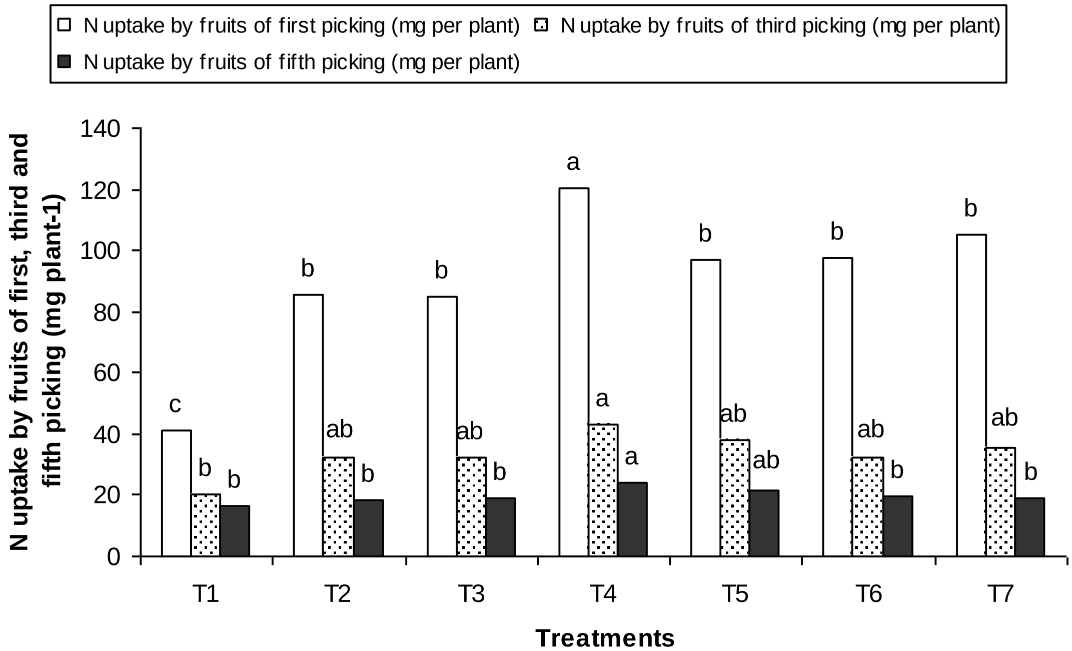
Maximum nitrogen uptake by root was also observed in T_4 where bioslurry @ 600 kg ha^{-1} was applied along with 50 % less N of recommended N fertilizers, that gave 86 % more uptake over T_7. Minimum nitrogen uptake was observed in T_7 where compost was applied @ 600 kg ha^{-1} along with 50 % less N of recommended fertilizer. The treatment where bioslurry was applied with different levels of chemical N and recommended P and K fertilizers increases in nitrogen uptake by root ranged from 10 to 86 % higher than control and treatments where compost @ 600 kg ha^{-1} was applied with different levels of inorganic nitrogen and recommended P and K fertilizers increased nitrogen uptake ranging from 38-45 %. Statistical analysis also showed that bioslurry containing treatments performed 91 % more in N uptake over compost containing treatments while root uptake of nitrogen remained 12 % of total plant N uptake at significant level of 0.05 according to DMR test.

4.9.2 Effect of compost and bioslurry on nitrogen uptake at different fruit pickings.

The data regarding nitrogen uptake by fruit in three pickings in response to application of bioslurry and compost with different levels of inorganic nitrogen and recommended doses of P and K fertilizers is shown in Figure 11. Statistically it was observed that bioslurry and compost along with different level of inorganic nitrogen and recommended doses of P and K fertilizers significantly increased nitrogen uptake by fruit in different pickings as compared to control.

Nitrogen uptake at 40 days fruit (1^{St} picking)

The data showed that on an average 1^{st} fruit picking, uptake was 62 % N of the all three fruit pickings nitrogen uptake, Maximum nitrogen uptake was observed in T_4 where bioslurry @ 600 kg ha^{-1} was applied along with 50 % recommended dose of N and full dose of P and K fertilizers that showed 194 % more uptake over control. Minimum N uptake was observed in T_1 where only recommended doses of NPK fertilizers were applied. The treatment where bioslurry was applied with different levels of chemical N and recommended



Values sharing same letters do not differ significantly at $P = 0.05$, accordingly to DMR test.
1st picking, LSD: 20.5251, 3rd picking LSD: 9.871, 5th picking LSD: 3.4210

Figure 11: Effect of bio-slurry and compost on nitrogen uptake by 1st, 3rd and 5th picking of fruit in the presence of different levels of inorganic nitrogen under field conditions.

T_1 = Control (Recommended NPK @ 180: 90: 40 kg ha^{-1})

T_2 = Biogas slurry @ 600 kg ha^{-1} + Recommended NPK ha^{-1}

T_3 = Biogas slurry @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}

T_4 = Biogas slurry @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}

T_5 = Compost @ 600 kg ha^{-1} + Recommended NPK ha^{-1}

T_6 = Compost @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}

T_7 = Compost @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}

P and K fertilizers increased nitrogen uptake by 1st fruit picking from 108-194 % higher than control while compost treatments gave 137-156 % more uptake over control.

Statistical analysis also showed that overall effect of bioslurry along with fertilizer remained 24% more in N uptake by bioslurry containing treatments than compost containing treatments at significant level of 0.05 according to DMR test.

Nitrogen uptake at 50 days fruit (3rd Picking)

The data showed that on an average 3rd fruit picking uptake was 24 % N of the all three fruit pickings, Maximum N uptake was observed in T_4 where bioslurry @ 600 kg ha^{-1} was applied along with 50 % recommended dose of N and full dose of P and K fertilizers that showed 110 % more better results than control. Minimum N uptake was observed in control, where only recommended doses of NPK fertilizers were applied. The treatment where bioslurry was applied with different levels of chemical N and recommended P and K fertilizers increased N uptake by 3rd fruit picking from 58 – 110 % higher than control while compost treatments showed 57-86 % better results over control.

Statistical analysis also showed that overall effect of bioslurry along with fertilizer was remained 92 % more in N uptake by 3rd fruit picking than compost containing treatments at significant level of 0.05 according to DMR test.

Nitrogen uptake at 70 days fruit (5th Picking).

The data showed that on an average in 5th fruit picking uptake was 14 % N of the all three fruit picking, Maximum nitrogen uptake was observed in T_4 where bioslurry @ 600 kg ha^{-1} was applied along with 50 % of recommended dose of N and full dose of P and K fertilizers, that showed 46 % more uptake than control. Minimum N uptake was observed in Control, where only recommended dose of NPK fertilizer was applied. The treatment where bioslurry was applied with different levels of chemical N and recommended P and K fertilizers increased nitrogen uptake by 5th fruit picking ranging from 13-46 % higher than control while compost containing treatments gave 14-33 % better uptake than control.

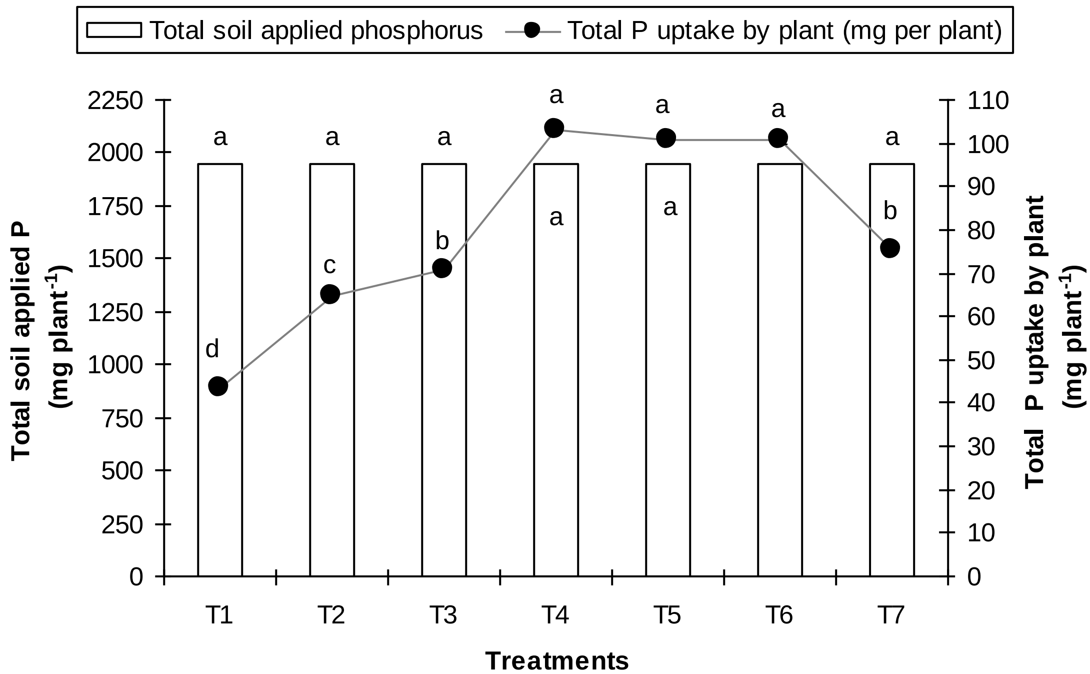
Statistical analysis also showed that overall effect of bioslurry along with inorganic fertilizer remained 39 % more in uptake of N by fruit than compost containing treatments at significant level of 0.05 according to DMR test.

4.10 Effect of bioslurry and compost on phosphorus uptake by plant.

The data regarding total soil applied phosphorus and total phosphorus uptake by plant is graphically shown and elaborated in Figure 12. Results showed that bioslurry and compost significantly affected the uptake of phosphorus from growth media into plant and improved plant health by providing more phosphorus to plant which ultimately affected plant metabolism, root growth, fruit quality and plant health because there was 49-134 % more phosphorus up take by those plants who received compost or bioslurry along with fertilizers. Minimum uptake of soil applied phosphorus was observed in control where only recommended dose of NPK. Phosphorous up take by plant was almost similar in both bioslurry and compost treatments, while T_4, where bioslurry was applied @ 600 kg ha^{-1} with 50 % less N of recommended N fertilizer gave comparatively best results as compare to control and other treatments.

Of total soil applied phosphorus only 2-5 % was taken up by plants while in treatments T_4,T_5 and T_6 uptake was similar (5 %) and behaved non significantly among each other, and similarly T_3 and T_7 also uptake same phosphorus (4 %) and behaved non significantly with each other, while in control the uptake was minimum i.e. 2 % of soil applied phosphorous. The treatment where bioslurry was applied with different levels of chemical N and recommended P and K fertilizers increased P uptake by plant from 3-5 % higher than control and treatments where compost was applied @ 600 kg ha^{-1} with different levels of inorganic nitrogen and recommended P and K fertilizer increased in phosphorus uptake from 4-5 %.

Statistical analysis showed that T_4 treatment utilized more efficiently soil applied nitrogen (138 %) of soil applied nitrogen over control. Overall effect of bioslurry applied along with mineral fertilizers showed better results on soil applied nitrogen than control and compost treatments. Data also showed that bioslurry depicted 4.5 % better results in soil applied P uptake by plant than bioslurry treatments at significant level of 0.05 according to DMR test.



Values sharing same letters do not differ significantly at $P = 0.05$, accordingly to DMR test.
LSD P uptake: 15.7510

Figure 12: Effect of bio-slurry and compost on total soil applied P and P uptake by plant in the presence of different levels of inorganic nitrogen under field conditions

T_1 = Control (Recommended NPK @ 180: 90: 40 kg ha^{-1})

T_2 = Biogas slurry @ 600 kg ha^{-1} + Recommended NPK ha^{-1}

T_3 = Biogas slurry @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}

T_4 = Biogas slurry @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}

T_5 = Compost @ 600 kg ha^{-1} + Recommended NPK ha^{-1}

T_6 = Compost @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}

T_7 = Compost @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}

4.10.1 Phosphorous uptake by shoot, fruit and root.

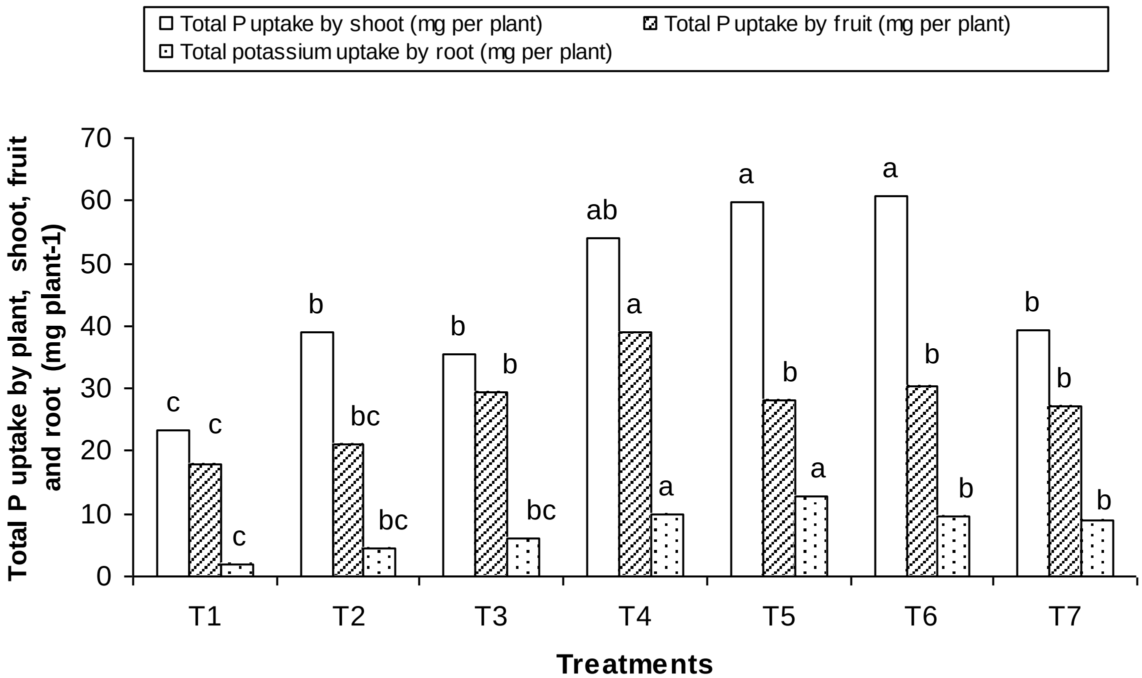
The data regarding phosphorus uptake by shoot, fruit and root in response to application of bioslurry and compost with different levels of inorganic nitrogen and recommended dose of P and K fertilizers shown in Figure 13. The Figure elaborated that bioslurry and compost along with different level of inorganic nitrogen and recommended doses of P and K fertilizers significantly increased phosphorus uptake by shoot and fruit and non significantly by root as compared to control.

P- uptake by Shoot

Maximum phosphorus uptake by shoot was observed in T_6 where compost @ 600 kg ha^{-1} was applied along with 25 % less N of recommended N fertilizer, while showed 164 % more better results over control. Minimum phosphorus uptake was observed in T_1 where only recommended dose of NPK fertilizer was applied. The treatment where bioslurry was applied with different levels of chemical N and recommended P and K fertilizer increased P uptake by shoot from 70-135 % higher than control and treatments where compost @ 600 kg ha^{-1} was applied with different levels of inorganic nitrogen and recommended P and K fertilizers increased P uptake up to 71-164 %. Statistical analysis also showed that compost treatments performed 21 % better than bioslurry in P uptake while shoot contributed 56 % of total plant phosphorous that was uptaken from soil at significant level of 0.05 according to DMR test.

P- Uptake by Fruit

Maximum phosphorus uptake by fruit was observed in T_4 where bioslurry was applied @ 600 kg ha^{-1} along with 50 % less N of recommended N fertilizers, that showed 116 % better results over control. Minimum phosphorus uptake was observed in T_1 where only recommended dose of NPK fertilizer was applied. The treatment where bioslurry was applied with different levels of chemical N and recommended P and K fertilizers increased P uptake by fruit from 17-116 % higher than control and treatments where compost was applied @ 600 kg ha^{-1} along with different levels of inorganic nitrogen and recommended P and K fertilizers increased nitrogen uptake up to 51-69 %. Statistical analysis also showed that bioslurry treatments perform 68 % more uptake of P from soil in fruit than compost and fruit uptake contributed 35 % of total plant uptake of P from soil at significant level of 0.05 according to DMR test.



Values sharing same letters do not differ significantly at $P = 0.05$, accordingly to DMR test.
Shoot LSD: 10.701, Fruit LSD: 7.4321, Root LSD: 2.890

Figure 13: Effect of bio-slurry and compost on P uptake by root, shoot and fruit of okra in the presence of different levels of inorganic nitrogen under field conditions.

T_1 = Control (Recommended NPK @ 180: 90: 40 kg ha^{-1})

T_2 = Biogas slurry @ 600 kg ha^{-1} + Recommended NPK ha^{-1}

T_3 = Biogas slurry @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}

T_4 = Biogas slurry @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}

T_5 = Compost @ 600 kg ha^{-1} + Recommended NPK ha^{-1}

T_6 = Compost @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}

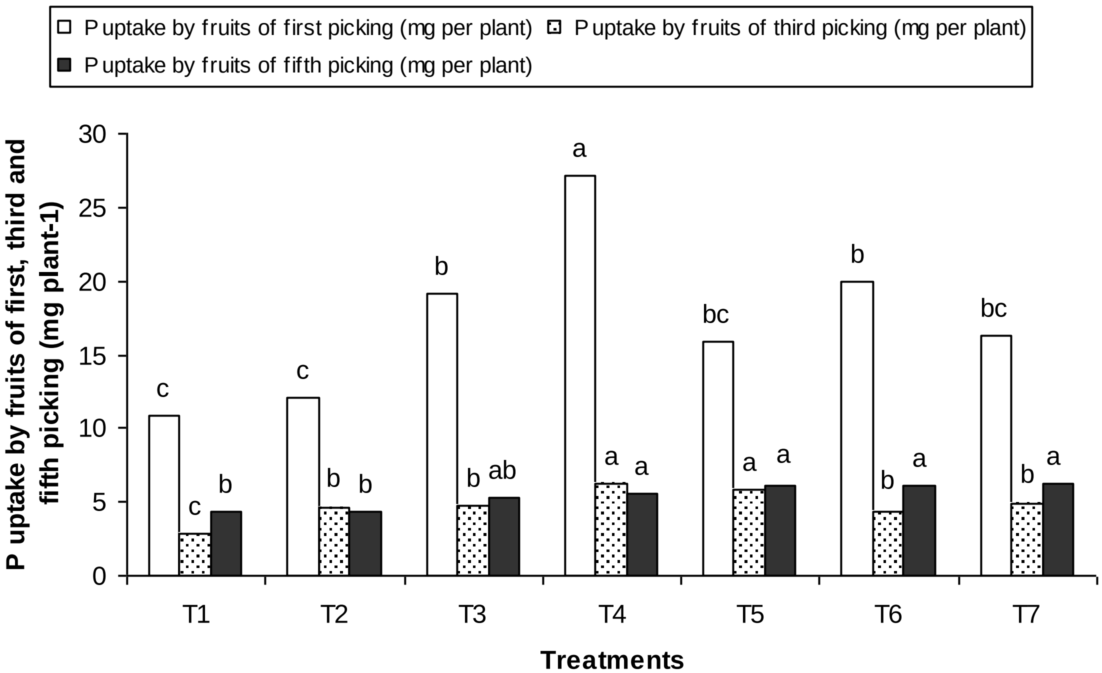
T_7 = Compost @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}

P- Uptake by Root.

Maximum phosphorus uptake by root was observed in T_5 where compost was applied @ 600 kg ha^{-1} along with recommended NPK fertilizers. Minimum nitrogen uptake was observed in T_1 where only of recommended NPK fertilizers were applied. Treatment where compost was applied with different levels of chemical N and recommended P and K fertilizers performed better than control but there was significantly no difference among other treatments. Statistical analysis also showed that plant roots contributed only 9 % of total plant phosphorous uptake from soil at significant level of 0.05 according to DMR test.

4.10.2 P- Uptake by different fruit pickings.

The data regarding phosphorus uptake by shoot in response to application of bioslurry and compost with different levels of inorganic nitrogen and recommended dose of P and K fertilizer is showed in Figure 14. Statistical analysis of data also showed that bioslurry and compost along with different level of inorganic nitrogen and recommended doses of P and K fertilizers significantly increased P uptake by fruit as compared to control. Maximum P uptake by 1^{st} fruit picking was observed in T_4 that was significantly differ from all other treatments, where bioslurry was applied @ 600 kg ha^{-1} along with 50 % recommended dose of N and full dose of P and K fertilizers and maximum uptake in 3^{rd} picking was observed in T_4 but all behave non significantly among each other while 5^{th} picking also behave non significantly among each other mean all treatments uptake almost similar amount of P except control.



Values sharing same letters do not differ significantly at *P* = 0.05, accordingly to DMR test.
1st picking LSD: 8.432, 3rd picking LSD: 1.2651, 5th picking LSD: 0.598

Figure 14: Effect of bio-slurry and compost on P uptake by 1st, 3rd and 5th fruit picking of okra in the presence of different levels of inorganic nitrogen under field conditions

T_1 = Control (Recommended NPK @ 180: 90: 40 kg ha^{-1})

T_2 = Biogas slurry @ 600 kg ha^{-1} + Recommended NPK ha^{-1}

T_3 = Biogas slurry @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}

T_4 = Biogas slurry @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}

T_5 = Compost @ 600 kg ha^{-1} + Recommended NPK ha^{-1}

T_6 = Compost @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}

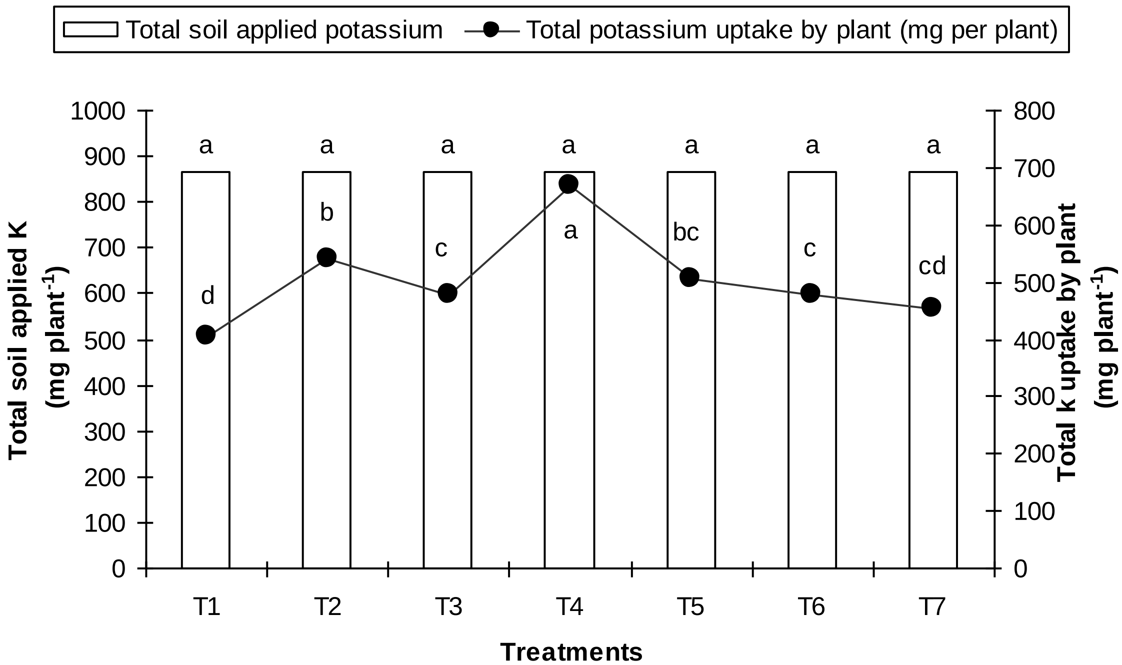
T_7 = Compost @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}

4.11 Effect of bioslurry and compost on potassium uptake by plant

Data regarding total soil applied potassium and total potassium uptake by plant is graphically elaborated in Figure 15. Results showed that bioslurry and compost significantly facilitated the movement of potassium from growth media into plant and so plant health by providing more potassium to plant which ultimately affected plant metabolism as K is evolved about sixty (60) enzymatic processes and transportation of metabolites among the different parts of the plant because there was 12-65 % more K uptake by those plants where either compost or bioslurry was applied along with different rates of inorganic N and full doses of P and K fertilizers.

Statistical analysis clearly showed that bioslurry and compost along with different level of inorganic nitrogen and recommended doses of P and K fertilizers significantly increased potassium uptake by plant as compared to control. Potassium uptake was more significantly increased by applying bioslurry with different level of inorganic nitrogen as compare to control and compost application. Maximum potassium uptake was observed in T_4 where bioslurry was applied @ 600 kg of ha^{-1} with 50 % less dose of inorganic N of NPK fertilizers. Similarly minimum nitrogen uptake was observed in control, where no bioslurry and compost was applied with recommended fertilizer. Treatment where bioslurry was applied with different levels of chemical N and recommended P and K fertilizer increased K uptake by root from 56 to 115 % than control after and treatments where compost @ 600 kg ha^{-1} was applied with different levels of inorganic nitrogen and recommended P and K fertilizer increase K uptake from 72 to 102 %. While the compost containing treatments does not significantly differ from each other and T4 significantly differ from all other treatments.

Statistical analysis showed that overall effect of bioslurry along with fertilizer showed best results on potassium uptake by plant over control and compost containing treatments. The data also showed that bioslurry gave 13 % more better results in K uptake by plant than compost containing treatments at significant level of 0.05 according to DMR test. The reason is that bioslurry application slowly releases nutrients than compost, while due to more staying nature of bioslurry in soil along with more holding and supplying of nutrients more efficiently, bioslurry performed better in K uptake by plant than compost, beside this bioslurry itself provide K to the soil and also affect the chemical properties of soil that



Values sharing same letters do not differ significantly at *P* = 0.05, accordingly to DMR test.
Total K uptake LSD: 10.524

Figure 15: Effect of bio-slurry and compost on total soil applied potassium and uptake by plant in the presence of different levels of inorganic nitrogen under field conditions

T_1 = Control (Recommended NPK @ 180: 90: 40 kg ha^{-1})

T_2 = Biogas slurry @ 600 kg ha^{-1} + Recommended NPK ha^{-1}

T_3 = Biogas slurry @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}

T_4 = Biogas slurry @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}

T_5 = Compost @ 600 kg ha^{-1} + Recommended NPK ha^{-1}

T_6 = Compost @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}

T_7 = Compost @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}

Increased K uptake by plant. That's why bioslurry overall showed better results than compost application on K uptake by plant.

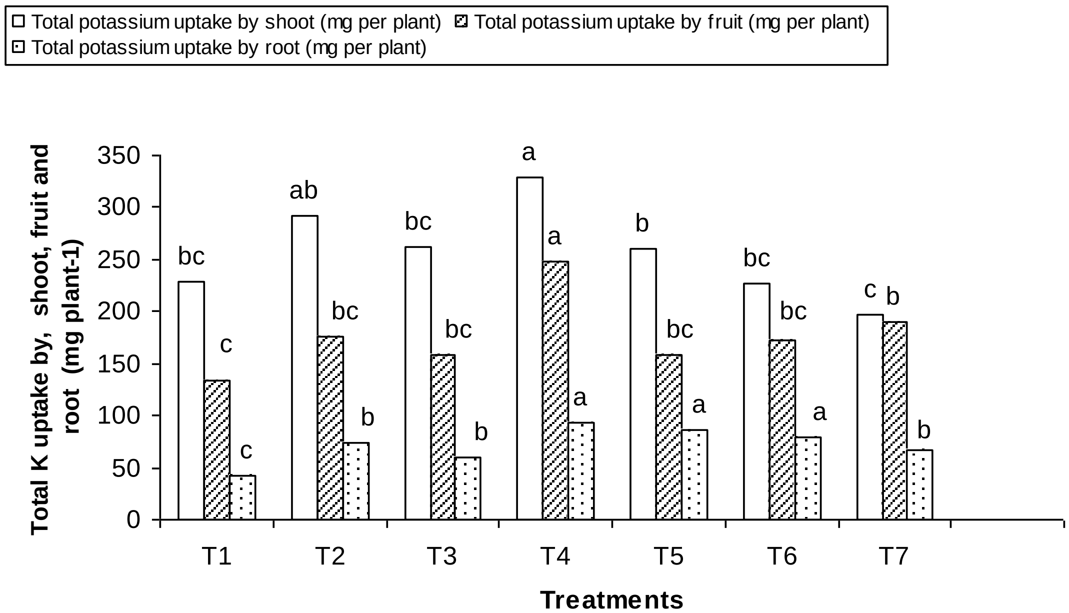
4.11.1 Effect of bioslurry and compost on potassium uptake by shoot, fruit and root.

K-Uptake by shoot

The data regarding potassium uptake by shoot in response to application of bioslurry and compost with different levels of inorganic nitrogen and recommended dose of P and K fertilizer is shown in Figure 16. Statistical analysis of data clearly showed that bioslurry and compost along with different level of inorganic nitrogen and recommended doses of P and K fertilizers significantly increased potassium uptake by shoot as compared to control. Maximum potassium uptake by shoot was observed in $T_{4,}$ where bioslurry @ 600 kg ha^{-1} was applied along with 50 % less N of recommended N that was 44 % more uptake than control. Minimum potassium uptake was observed in T_7 where compost was applied @ 600 kg ha^{-1} along with 50 % less N of recommended N fertilizer. The data also showed the on an average 51 % of total plant potassium was up taken by shoot. Treatment where bioslurry was applied @ 600 kg ha^{-1} along with different levels of chemical N and recommended P and K fertilizer increased K uptake by shoot from 28 to 44 % over control and treatments where compost was applied @ 600 kg ha^{-1} along with different levels of inorganic nitrogen and recommended P and K fertilizer increased K uptake up to 14 %. Statistical analysis showed that overall effect of bioslurry along with fertilizer showed best results on K uptake by shoot than control and compost treatments. The data also showed that bioslurry showed 26 % more better results in K uptake by shoot than compost treatments at significant level of 0.05 according to DMR test.

K- Uptake by fruit

The data regarding potassium uptake by fruit in response to application of bioslurry and compost with different levels of inorganic nitrogen and recommended dose of P and K fertilizer is shown in Figure 16. The figure clearly showed that bioslurry and compost along with different levels of inorganic nitrogen and recommended doses of P and K fertilizers significantly increased potassium uptake by root as compared to control. Maximum potassium uptake by root was observed in T_4 shows 85 % more better results than control, where bioslurry @ 600 kg ha^{-1} was applied along with 50 % less N of recommended NPK.



Values sharing same letters do not differ significantly at $P = 0.05$, accordingly to DMR test.
K by shoot LSD: 20.3210, K by fruit LSD: 12.2365, K by root LSD: 8.1254

Figure 16: Effect of bio-slurry and compost on K uptake by shoot, fruit and root in the presence of different levels of inorganic nitrogen under field conditions

T_1 = Control (Recommended NPK @ 180: 90: 40 kg ha^{-1})

T_2 = Biogas slurry @ 600 kg ha^{-1} + Recommended NPK ha^{-1}

T_3 = Biogas slurry @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}

T_4 = Biogas slurry @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}

T_5 = Compost @ 600 kg ha^{-1} + Recommended NPK ha^{-1}

T_6 = Compost @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}

T_7 = Compost @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}

Minimum potassium uptake was observed in T_1 where only recommended dose of NPK fertilizer was applied. The results showed that on an average 35 % of total plant potassium was up taken by fruit. Treatments where bioslurry was applied with different levels of chemical N and recommended P and K fertilizer increased K uptake by total fruit from 18 to 85 % than control and treatments where compost @ 600 kg ha^{-1} was applied with different levels of inorganic nitrogen and recommended P and K fertilizer increased uptake up to 18 to 42 %. Statistical analysis also showed that overall effect of bioslurry along with fertilizer showed better results on K uptake by fruit than control and compost treatments. The data also showed that bioslurry gave 102 % more better results in K uptake by fruit than compost treatments at significant level of 0.05 according to DMR test.

K-Uptake by root

The data regarding potassium uptake by root in response to application of bioslurry and compost with different levels of inorganic nitrogen and recommended dose of P and K fertilizer is shown in Figure 16. It is clearly depicted that bioslurry and compost along with different levels of inorganic nitrogen and recommended doses of P and K fertilizers significantly increased potassium uptake by root as compared to control. Maximum potassium uptake by root was observed in T_4 where bioslurry @ 600 kg ha^{-1} was applied along with 50 % less N of recommended N that showed 115 % more uptake by root than control. Minimum potassium uptake was observed in T_1 where only recommended dose of NPK fertilizer was applied. The data also showed the on an average 14 % of total plant potassium was up taken by root. Treatment where bioslurry was applied with different levels of chemical N and recommended P and K fertilizer increased K uptake by root from 38 to 115% than control after and treatments where compost was applied @ 600 kg ha^{-1} along with different levels of inorganic nitrogen and recommended P and K fertilizer increased K uptake up to 56 to 102 % by root. Bioslurry along with fertilizer showed better results on K uptake by root than control and compost treatments. Data also showed that bioslurry showed 12.7 % more better results in K uptake by shoot than compost treatments at significant level of 0.05 according to DMR test.

4.11.2 Effect of compost and bioslurry on the Potassium uptake on different stages of fruit formation uptake by fruit.

The data regarding potassium uptake by fruit in three pickings in response to application of bioslurry and compost with different levels of inorganic nitrogen and recommended dose of P and K fertilizer is shown in Figure 17. The figure depicted that bioslurry and compost application along with different level of inorganic nitrogen and recommended doses of P and K fertilizers significantly increased potassium uptake by fruit at different stages of pickings as compared to control.

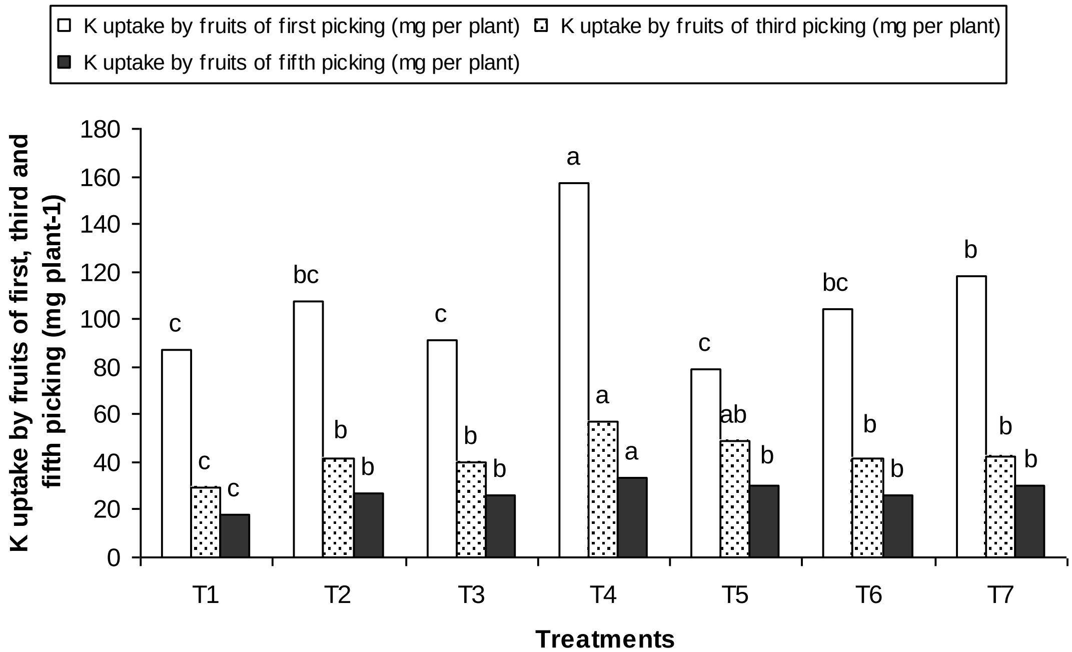
K uptake by fruits of 40 days (1^{St} picking).

The data showed that 60 % K of total three fruit pickings was uptaken by 1^{st} fruit picking. Maximum potassium uptake was observed in T_4 where bioslurry was applied @ 600 kg ha^{-1} along with 50 % recommended dose of N and full dose of P and K fertilizers that showed 99 % more uptake than control. Minimum potassium uptake was observed in T_5 where compost was applied @ 600 kg ha^{-1} along with recommended dose of NPK fertilizer. Treatment where bioslurry was applied with different levels of chemical N and recommended P and K fertilizer increased K uptake by fruit 1^{st} picking from 16 to 99 % than control, while treatments where compost was applied @ 600 kg ha^{-1} along with fertilizer gave 50 % more K uptake than control.

Statistical analysis also showed that overall effect of bioslurry along with fertilizer on K uptake was 98 % more than K uptake by fruit containing compost treatments at significant level of 0.05 according to DMR test.

K uptake by fruits of 50 days (3^{rd} Picking).

The data showed that on an average 3^{rd} fruit picking uptake was 24% of total potassium of the all three fruit picking. Maximum potassium uptake was observed in T_4 where bioslurry @ 600 kg ha^{-1} along with 50% less N of recommended N fertilizer. That showed 95 % more K uptake than control. So T_4 treatment showed 95 % more K uptake than control. Minimum potassium uptake was observed in control (T1) where only recommended dose of NPK fertilizer was applied. Treatment where bioslurry was applied with different levels of chemical N and recommended P and K fertilizer increased K uptake at fruit 3^{rd} picking ranging from 39 to 95 % more than control while compost treatments showed 43 to



Values sharing same letters do not differ significantly at $P = 0.05$, accordingly to DMR test.

1st picking LSD: 15.6520, 3rd picking LSD: 10.5435, 5th picking LSD: 2.8560

Figure 17: Effect of bio-slurry and compost on K uptake by okra fruit in 1st, 3rd and 5th picking of fruit in the presence of different levels of inorganic nitrogen under field conditions

T_1 = Control (Recommended NPK @ 180: 90: 40 kg ha^{-1})

T_2 = Biogas slurry @ 600 kg ha^{-1} + Recommended NPK ha^{-1}

T_3 = Biogas slurry @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}

T_4 = Biogas slurry @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}

T_5 = Compost @ 600 kg ha^{-1} + Recommended NPK ha^{-1}

T_6 = Compost @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}

T_7 = Compost @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}

68 % better results than control. Statistical analysis also showed that overall effect of bioslurry along with fertilizer showed best results on K uptake by increasing 70 % more K uptake by fruit than compost containing treatments at significant level of 0.05 according to DMR test.

K uptake by fruits of 70 days (5^{th} Picking).

The data showed that on an average 5^{th} fruit picking uptake was 15 % potassium of the all three fruit picking. Maximum potassium uptake was observed in T_4 where bioslurry @ 600 kg ha^{-1} was applied along with 50 % recommended dose of N and full dose of P and K fertilizers that showed 84 % more K uptake than control. Minimum potassium uptake was observed in T_1 (Control) where only recommended dose of NPK fertilizer was applied. Treatments where bioslurry was applied with different levels of chemical N and recommended P and K fertilizer increased K uptake by 5^{th} fruit picking from 43 to 84 % more than control while compost treatments showed 45 to 66 % more K uptake than control. Statistical analysis also showed that overall effect of bioslurry along with fertilizer was best on K uptake, i.e. 27 % more in K uptake by fruit than compost containing treatments at significant level of 0.05 according to DMR test.

4.12 General discussion about NPK uptake.

The application of bioslurry and compost 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. Because physical conditions of soil has been improved that's why nutrient uptake was more in plant that effect crop yield similar study was also found by Pinamonti (1997). The reason high uptake of nutrients by soil applied bioslurry and compost along with chemical fertilizers was 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 compost application and bioslurry due to supplying of more readily available nutrients while bioslurry has wider C:N ratio (39) than compost that has almost 11 C: N ratio. That's why compost overall shows better results on early stages of its application in soil on nutrients availability while 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 due to this compost and bioslurry performed in elegant manner over control, Sarwar et al. (2009) also found similar results.

Bioslurry application slowly releases nutrients than compost, while compost provides readily available nutrients to the growth media and plant height flourish more rapidly and chlorophyll contents also increased, while due to more staying nature of bioslurry in soil and holding and supplying more efficiently nutrients, bioslurry perform better in fruit yield than compost, beside this bioslurry and compost itself provide N, P and K to the soil and also affect the chemical properties of soil that increased N, P and K uptake to plant. That's why bioslurry overall showed better results than compost application on N, P and K uptake by plant similar results was also in reported by Yu *et al.* (2010).

Digested slurry and compost contains organic nitrogen (mainly amino acids), abundant mineral elements, and low-molecular-mass bioactive substances (e.g hormones, humic acids, vitamins, etc.) and could be used as organic manure in the sowing that may increase nutrient concentration and uptake in plant (Liu *et al.,* 2008). In addition to this soil applied organic matter not only serves as a reservoir of all the required plant nutrients, but it also gives give structure to the soil, provide energy for the microbial activity which is essential for recycling of nutrients, affected the nutrient availability like N, P, K and S improve soil and water conservation, buffering and exchange capacity of soil and increase with organic and other chemicals and fertilizer (Stevenson, 1986).

Under certain circumstances, these organic based ferilizers can stimulate plant growth. The main explanation for this effect is the presence of growth promoting substances like auxin in bioslurry and compost (O'Donnell, 1973). It also been suggested that these can increase permeability of cell membrane, which result in increased uptake of water and other nutrient element. In a study by Malik and Azam (1985), addition of these organic substance like slurry and compost to the medium in which wheat seedling were grown resulted in 500 % increase in root length. Water uptake and N contents also increased significantly. Similarly, in the N free medium, addition of organic based substances caused a significant increase in growth of roots and shoots as well as water uptake.

4.13 Residual Effect of bioslurry and compost along with fertilizer after harvest of okra.

Usually, vegetables are cultivated on fertile land. Moreover, farmers apply heavy manure and fertilizer to the vegetable crops. It was complained that our recommended dose of fertilizer was not sufficient for the good crop of okra. Compost and bioslurry were applied at the time of seed bed preparation, which reduces the loss of plant nutrients. The residue of the applied compost and bioslurry is presented in Table.

Table 3.

Treatment	Treatment detail	pH	O.M %	%N	P_2O_5 ppm	K_2O ppm
A	Before experiment	7.7	0.72	0.06	6.01	302
B	After experiment					
T_1	Control	7.67	0.64	0.05	6.51	312
T_2	Biogas slurry @ 600 kg ha^{-1} + Recommended NPK ha^{-1}	7.60	1.01	0.12	7.08	340
T_3	Biogas slurry @ 600 kg ha^{-1} + 75% Recommended N ha^{-1}	7.68	1.05	0.09	6.95	335
T_4	Biogas slurry @ 600 kg ha^{-1} + 50% Recommended N ha^{-1}	7.65	1.04	0.08	6.92	335
T_5	Compost @ 600 kg ha^{-1} + Recommended NPK ha^{-1}	7.68	1.02	0.09	7.01	390
T_6	Compost @ 600 kg ha^{-1} + 75 % Recommended N ha^{-1}	7.62	1.01	0.11	6.85	345
T_7	Compost @ 600 kg ha^{-1} + 50 % Recommended N ha^{-1}	7.58	0.98	0.09	6.94	366

There was a little difference on the pH of the soil before and after the experiment. The inherent soil pH (before the experiment) alkaline. This is mainly because the farmers apply mostly urea fertilizer to most of the cereals (Karki and Joshi, 1993). Soil pH went down slightly on the control and other treatments. Even on the soil from the plot treated with different dose of manure, slight improvement on the soil reaction was observed. Despite the fact that well decomposed compost and bioslurry act as the buffering agent no significant improvement was found in this experiment. This may be due to the slow rate of mineralization. Mineralization of organic matter depends upon soil pH (Jenkinson and Rayner, 1977). In tropical condition, it is less than 15 percent per year whereas in temperate condition it is even less than that. Furthermore, okra being highly calcium demanding crop has mined the soil calcium accordingly. Consequently, the pH has slightly gone down. The change in soil pH is very effective to plants as most of the essential elements, for instance, phosphorus are depends upon soil pH. In this pH most of the metallic elements like iron, manganese, aluminium, copper, zinc etc and other nonessential heavy metals become less available and also affect the availability of phosphorus to plants. In the same way calcium, magnesium and molybdenum also affected by pH and affect the plant growth (Sankaran, 1988).

There is a definite trend on the content of organic matter in the soil after the crop. For the noticeable change long-term observation is required. It is too short a period to notice the changes on the soil properties brought about by the application of bioslurry and compost along with different doses of inorganic N fertilizer. Although the content of total N in the soil was low, the contribution made by the application of such a compost and slurry along fertilizer leave the notable amount of residue, Application of mineral fertilizer along with compost and bioslurry has showed positive contribution on the availability of N and K content in soil, whereas the P_2O_5 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 ample amount (Lindsay and Taylor, 1959).

CHAPTER-5

SUMMARY

A field experiment was conducted to evaluate the potential of bioslurry and compost at different levels of inorganic nitrogen to increase the growth and yield of okra (*Hibiscus esculentus* L.). Okra was used as a test crop. In field experiment bioslurry and compost was applied @ 600 kg ha^{-1} along with 100, 75 and 50 % levels of recommended nitrogen and full recommended dose of potassium and phosphorus fertilizer to evaluate potential of bioslurry and compost on okra growth and yield. A field experiment was conducted at Field Experimental Area, Institute of Horticultural Sciences, University of Agriculture, Faisalabad to evaluate the potential of bioslurry and compost with different level of recommended N and full doses of P and K fertilizers on growth and yield of okra (*Hibiscus esculentus* L.). The experiment was laid down according to Randomized Complete Block Design (RCBD) with three replicates having bed to bed distance 75 cm with row to row distance 45 cm and plant to plant distance 75 cm. At the time of seed bed preparation NPK were added @ 180-90-40 kg ha^{-1} as Urea, DAP and SOP into the soil under field conditions. Water required was maintained with the help of drip irrigation system. Bioslurry and compost @ 600 kg ha^{-1} was applied to there respective treatments at the time of seed bed preparation while full recommended doses of P and K fertilizer were also applied at the time of seed sowing and nitrogen according to treatment plan was applied in the form of three split doses, followed by immediate irrigation through canal water. Data on plant height (after 30 days of sowing and at maturity), number of branches, number of fruits, fresh fruit weight, fruit yield per plant, 1000 seed weight, shoot weight, root weight, root length, nitrogen in fruit, nitrogen in shoot, nitrogen in root, potassium in fruit, potassium in shoot, potassium in root, phosphorus in fruit, shoot and in root was recorded. The results of the experiments are summarized as follows:

1. Application of bioslurry and compost affects the plant height at maturity and 30 days of germination by increasing the internodal distance. Treatments where compost was applied along with fertilizers shows best results than control even than bioslurry treatments.

2. Maximum numbers of branches were increased with application of bioslurry and compost along with fertilizer while bioslurry treatments performed relatively better than compost in T_3.
3. Number of branches were maximum where bioslurry @ 600 kg ha^{-1} along with 25 % less N of recommended NPK was applied. Increased number of branches was 73 % more than control.
4. Bioslurry and compost also influenced the number of fruit. Maximum numbers of fruit, i.e. 89 % more than control were observed in T_4 where bioslurry along with 50 % less of recommended NPK was applied.
5. Fruit yield per plot was also significantly affected by application of bioslurry and a compost treatment, while T4 shows the best results than other treatments.
6. Application of bioslurry and compost significantly increased 1000 seed weight, 30 % more than control where bioslurry was applied along with 25 % less N of recommended NPK fertilizer.
7. Bioslurry and compost application also significantly affected the biological yield and harvest index.
8. Root fresh and dry weight was also significantly affected by application of bioslurry and compost. Root fresh weight was 85 % more than control in T_5 and root dry weight was maximum in T_3.
9. Soil applied potassium (K) uptake by plant was increased from 44-77 % by the application of bioslurry and compost along with different level of N and recommended P and K fertilizer.
10. Application of bioslurry @ 600 kg ha^{-1} with 50 % less N of recommended NPK increased potassium uptake by 44 % in total fruit, 85 % in shoot and 115 % in root.
11. Percentage of fruit uptake of K by three different pickings also increases and uptake of K increased up to 99 % in $T_{4.}$

12. Soil applied nitrogen (N) uptake increased by plant from 58-75 % along with application of bioslurry and compost in combination with different level of N and recommended P and K fertilizer.
13. Total plant nitrogen uptakes by shoot were 55 %, 33 % by total fruit and 12 % by root along with application of bioslurry and compost plus inorganic fertilizer. In fruit pickings N uptake was increased from 14-24 % while in case of 1st fruit picking shows maximum N uptake than other pickings.
14. Total soil applied phosphorus uptake was increased from 2-5 % by the application of bioslurry and compost, while plant uptake was increased from 89-135 % than control.
15. In shoot maximum phosphorus uptake was observed in T_6 , in fruit T_4 and in root T_5

Conclusion

Above study indicated that okra responded positively to bioslurry and compost treatments along with different rates of inorganic N and full dose of P and K fertilizer. The treatment of bioslurry @ 600 kg ha^{-1} along with 50 % less of recommended NPK fertilizer (T_4) shows the best results on overall basis. In addition to this the application of bioslurry and compost along with chemical fertilizers had positive residual effect on soil.

Literature Cited

Abd El-Kader, A.A., S.M. Shaaban and M.S. Abd El-Fattah. 2010. Effect of irrigation levels and organic compost on okra plants (*Abelmoschus esculentus* l.) grown in sandy calcareous soil. Agric. Biol. J. N. Am. 1(3): 225-231.

Abedi, T., A. Alemzadeh and S.A. Kazemein. 2010. Effect of organic and inorganic fertilizers on grain yield and protein banding pattern of wheat. A.J.C.S. 4(6): 384-389.

Abraham, E.R., S. Ramachandran and V. Ramalingam. 2007. Biogas: Can it be an important source of energy? Envi. Sci. Poll. Res. Intl. 14: 67-71.

Acharya, C.N. 1983. Preparation of Fuel Gas and Manure by Anaerobic Fermentation of Organic Materials. Indian Agriculture Research Institute, New Delhi.

Adediran, J.A., L.B. Taiwo and R.A. Sobulo. 2003. Effect of organic waste and method of composting on compost maturity, nutrient composition of compost and yield of two vegetable crops. J. Sustain. Agri. 22: 95-109.

Adhikari, K.R and Z.S. Chen. 2011. Combining compost with urea: Nitrogen and phosphorus recovery by cabbage and leaching under imposed high rainfall condition in the greenhouse. SRE 6(4): 819-829

Anonymous. 2006. Horticultural Information Services, Monthly Bulletin. p. 60-62.

Ariyo, O.J. 1990. Variation and heritability of fifteen characters on okra (*Abelmoschus esculentus* (L.) Moench). Trop. Agric. 67: 213-216.

Arroyo, D.M.D., M.Á.P. Cots, R.M.D.I. Hornedo, E.M.B. Rodríguez, L.B. Beringola and J. V. M. Sánchez. 2005. Sewage sludge compost fertilizer effect on maize yield and soil heavy metal concentration. I.N.I.A. Apdo. 8 (2): 272-280.

Aykroud, W.R. 1963. I.C.M.R. Special Report Series No. 42.

Baloch, M.A. 1994. Factors influencing the growth of okra. Pakistan J. Sci. Res. 82: 363–367.

Banik, S. and R. Nandi. 2004. Effect of supplementation of rice straw with biogas residual slurry manure on the yield, protein and mineral contents of oyster mushroom. Industrial Crops and Products 20: 311–319.

Bernat C., D. Casado, C. Ferrando, S. Paulet, M. Pujol and M. Soliva. 2006. Compost, manure and sewage sludge applied to a crop rotation. Escola Superior d'Agricultura de Barcelona Comte d'Urgell 187 – 190.

Bevacqua, R. F. and V. J. Mellano. 1994. Cumulative effects of sludge compost on crop yields and soil properties. Communi. in Soil Sci. and Plant Analysis 25: 395 – 406.

Bo, Y. D., H. X. Jun, S. H. Chuan, Z. W. Di, X. C. Feng, L. S. Qing, G. H. Lin, Y. Fang, P. Y. Xian and L. H. Guo. 2006. Effect of biogas slurry on sweet corn seedling growth, production and quality. Renewable Energy 2: 02-14.

Branson, J., A.S.L. Yates, N. Mooneyham, R. Dotson and K. Stearman. 2009. Compost and cover crop effect on root yield and earthworm population. International Annual Meetings, Pittsburgh, PA, USA.

Camciuc, M., M. Deplagne, G. Vilarem and A. Gaset. 1998. Okra- *Abelmoschus esculentus* L. (Moench.), a crop with economic potential for set aside acreage in France. Industrial Crops Products 7: 257-264.

Chapman, H.D. and P.F. Pratt. 1961. Soil water and plant analysis. Univ. California, Riverside, Agri. Div. Publication, CA, USA.

Chauhan, D.V.S. 1972. Vegetable production in India. 3rd Ed., Pub. Ram Prasad and Sons, Agra, India.

Cott. A.M. 1984. Anaerobically Digested Pig Slurry as Resource for Crop Production. Anaerobic Digestion mircfn. 1: 85-86.

Crossley, A. and T.P. Hilditch. 1951. The fatty acids and glycerides of okra seed oil. J. Sci. Food Agric. 2: 251–255.

Dhussa, A. K. 1985. Biogas plant effluent handling and utilization. Changing Villages 7: 5-6.

Ding, G.F., W.S. Qing, Q.W. Neng, Z.G. Yu, L.J. Huai and J.H. Bo. 2011. Effect of biogas Slurry on Table Bean Quality and Soil Fertility. China Biogas 01.

Dong, H.D. 2010. Effect of application of biogas slurry on the chinese cabbage yield and quality under Soil-less cultivation. J. Anhui Agri. Sci. 4: 22-26.

Douds, D.D., L. Galvez, M. F. Snyder, C. Reider and L.E. Drinkwater. 1997. Effect of compost addition and crop rotation point upon VAM fungi. Agriculture, Ecosystems and Environment 65: 257-266.

Dudal, R and J. Deckers. 1993. Soil organic matter in relation to soil productivity. In: K. Mulongoy and R Merck (ed.). Soil Organic Matter Dynamics and Sustainability of Tropical Agriculture 1: 377-380.

Dudal, R. and J. Deckers. 1993. Soil organic matter in relation to soil productivity. In:

Duggan, J.C. and C.C. Wieles. 1976. Effects of municipal compost and nitrogen fertilizer on selected soils and plants. Compost Science 17: 24-31.

Desuki, M.E., A.M.R. Abdel-Mawgoud, S.R. Salman and S.D. Abou-Hussein, 2010. Performance of some snap bean varieties as affected by different levels of mineral fertilizers. J. of Agron. 4(3): 242-247.

Eghball, B., D. Ginting and J.E. Gilley. 2004. Residual effects of manure and compost applications on corn production and soil properties. Agron. J. 96: 442–447.

Emuh, I.F.N., A.E. Ofuoku and E. Oyefia. 2006. Effect of intercropping Okra (*Hibiscus esclentus*) with Pumpkin (*Curcubita maxima* L.) on some growth parameters and Economic yield of maize (*Zea mays*) and maximization of land use in a Fadama soil. Research J. Biol. Sci. 1(4): 50-54.

Erkossa, T., K. Stahr and G. Tabor. 2008. Integration of organic and inorganic fertilizers: effect on vegetable productivity. University of Hohenheim, Soil Science and Land Evaluation, Germany and Ethiopian Agricultural research organization, Debre Zeit Agricultural Research Centre, Ethiopia.

Garg, R.N., H. Pathak, D.K. Das and R.K. Tomar. 2005. Use of fly ash and biogas slurry for improving wheat yield and physical properties of soil. Environ. Monitoring and Assessment 107: 1-9.

Ghaly, A.E. and F.N. Alkoaik. 2010. Effect of municipal solid waste compost on the growth and production of vegetable crops. American J. Agricultural and Biological Sciences 5 (3): 274-281.

Ghorbani, R., A. Koocheki, M. Jahan and G.A. Asadi. 2006. Effects of organic fertilizers and compost extracts on organic tomato production. Aspects of Applied Biology 79: 228-235.

Gupta, D.R. 1991. Biofertilizer from biogas plants. Changing Villages 10: 10-12.

Gutser, R., T. Ebertseder, A. Weber, M. Schraml and U. Schmidhalter. 2005. Short-term and residual availability of nitrogen after long-term application of organic fertilizers on arable land, J. Plant Nutr. Soil Sci. 168: 439–446.

Hafez, M.M., A.R. Mahmoud and F.S. Abid. 2010. Effect of organic and bio fertilizers on the plant growth, green pod yield, and quality of pea. Intl. J. Acd. Res. 2 (1): 87-92.

Hamon, S and P. Hamon. 1991. Future prospect of the genetic integrity of two okra (*Abelmoschus esculentus* and *A. caillei*) cultivated in West Africa. Euphytica 58: 101-111.

Hampton, M.O. and T.A. Obreza. 2002. Residual effect of municipal solid waste and biosolid compost on snap beans production. I. Contam. Ambient. 18: 147-150

Hassan, M., F. Ahmad, M. Sagheer, M.F. Iqbal and M. Tariq. 2005. Residual persistence of chlorpyrifos, imidacloprid and acephate in brinjal fruit. Pak. Entomol. 27(1): 53-55.

Hernandez, A., H. Castillo, D. Ojeda, A. Arras, J. Lopez and E. Sanchez. 2010. Effect of vermicompost and compost on lettuce production. Chil. J. Agr. Res. 70 (4): 583-589.

Herrmann, A., M.A. Bleken, L.E. Haugen, L. Bakken and F. Taube. 2007. Model-based estimate of long-term slurry application effect on n residual effects in silage maize production. Plant and Environmental Sciences, Aas, Norway. 37-43.

Hussain, N., G. Hassan, M. Arshadullah and F. Mujeeb. 2007. Evaluation of amendments for the improvement of physical properties of sodic soil. Int. J. Agric. Biol. 3: 319-322.

Islam, R., S.M.E. Rahman, M.M. Rahman, D.H. Oh and C.S. Ra. 2010. The effects of biogas slurry on the production and quality of maize fodder. Turk J. Agric. 34: 91-99.

Jackson, M.L. 1962. Chemical composition of soil. In F.E. Bean (ed.) Chemistry of soil. van Nostrand Reinheld Co., New York, p: 71-144.

Jagadeeswari, P.V. and K. Kumaraswamy. 2000. Long-term effects of manure fertilizer schedules on the yield and nutrient uptake by rice crop in a permanent manurial experiment. J. Ind. Soc. Soil Sci. 48: 833-836.

Jenkinson, D.S. and J.H. Rayner. 1977. The turnover of soil organic matter in some of the Rothamsted classical experiments. Soil Sci. 123: 298-305.

Kader, A.A., S. M Shaaban and A.M.S. El-Fattah. 2010. Effect of irrigation levels and organic compost on okra plants (*Abelmoschus esculentus* L.) grown in sandy calcareous soil. Agri. Biol. J. N. Am. 8(4): 2151-2157.

Kanthaswamy, V. 1993. Effect of Bio-Digested Slurry in Rice.' In Biogas Slurry- Utilisation New Delhi: CORT.

Karanatsidis, G. and M. Berova. 2007. Effect of organic-N fertilizer on growth and some physiological parameters in pepper plants (*capsicum annum* l.). Biotechnol. & Biotechnol. 23: 254-257

Karki, K.B. 1997. Estimation of plant nutrient loss from biogas slurry. Biogas Support Programme. International Congress Series 1291: 42-52.

Karki. K.B. and B. Gurung. 1996. Evaluation of slurry extension pilot programme. SNV/BSP.

Karki, K.B and D. Joshi. 1997. Soil fertility and fertilizers use in Nepal. In: H.L.S. Tandon (ed.) Soil Fertility and Fertilizer use in South Asia. Fertilizer Development and Consultation Organization. New Delhi, India.

Kashif, S.R., M. Yaseen, M. Arshad and M. Ayub. 2008. Response of okra (*Hibiscus esculentus* L.) to soil given encapsulated calcium carbide. Pak. J. Bot. 40: 175-181.

Kasim, S., O.H. Ahmed, N.M.A. Majid, M.K. Yusop and M.B. Jalloh. 2009. Effect of organic based N fertilizer on dry matter (Zea mays L.), ammonium and nitrate recovery in an acid soil of Sarawak, Malaysia. American J. Applied Sciences 6 (7): 1282-1287.

Kostov, O., G. Petkova, Y. Tzvetkov and J. M. Lynch. 2007. Aerobic composting of plant wastes and their effect on the yield of ryegrass and tomatoes. Biology and Fertility of Soils 23: 20-25.

Kogblevi, A. 1987. Biodigester effluent boosts up vegetable production in benin. Biogas Newsletter No. 25, [Excerpted from Directeur du Centre National d'Agropedologie, B.P. 988, Cotonou, BENIN, July 1985).

Krishna. P.G. 2001. Response to bio-slurry application on maize and cabbage in Lalitpur District. Final Report his Majesty's Government of Nepal, Ministry of Science and Technology. Alternative Energy Promotion Centre, Nepal.

Laura. R.D and L. Idnani. 1992. Effect on wheat yield and nitrogen uptake from manures made from manures made from spent slurry. Plant Soil 32: 283-295.

Lindsay, W.L. and A.W. Taylor. 1960. Phosphate reaction products in soil and their availability to plants. 7th Intern. Congr. Soil Sci. 11 (4): 580-589.

Liu, W.K., L.F. Du and Q.C. Yang. 2008. Biogas slurry added amino acids decreased nitrate concentrations of lettuce in sand culture. Acta Agriculture Scandinavica, Section B- Soil and Plant Science 58: 1-5.

Malik, K.A. and F. Azam. 1985. Effect of humic acid on wheat (*Triticum aestivum*) seedling growth. Experimental and Environmental Botany 25:245-252.

Maramba, F.D. 1978. Biogas and Waste Recycling: The Philippine Experience. Manila: Maya Flour Division. Liberty Flower Mills.

Marchesini, A., L. Allievi, E. Comotti and A. Ferrari. 1988. Long-term effects of compost treatment on soil. Plant and Soil 106: 253-261.

Martens, D. A. 2000. Management and crop residue influence soil aggregate stability. J. Environ. Qual. 29: 723–727.

Maskey, S.L. 1978. Manurial value of biogas slum, Some observations. (International Workshop on Microbiologial Aspects of Biogas Production. May 31-June 3, 1978, Kathmandu. Nepal.

Masarirambi M. T., V. Mavuso, V.D. Songwe, T.P. Nkambule and N. Mhazo. 2010. Indigenous post-harvest handling and processing of traditional vegetables in Swaziland: A review. Afr. J. Agric. Res. 5(24): 3333-3341.

Masood. K., M.A. Jagadishwar, D. Reddy and R.S. Venkateshwar. 2001. Bio efficacy of selected insecticides against pest complex in okra. Pestology 26 (6): 18-23.

Matsunaka, T., T. Sawamoto, H. Ishimura, K. Takakura and A. Takekawa. 2006. Efficient use of digested cattle slurry from biogas plant with respect to nitrogen recycling in grassland. International Congress Series 1293: 242–252.

Mcsorles, R. and R.N. Gallaher. 1995. Effect of yard waste compost on plant-parasitic nematode densities in vegetable crops. Supplement to the J. Nematology 27(4): 545-549.

Michael, T.M., M.M. Hlawe, O.T. Oseni and T.E. Sibiya. 2010. Effects of organic fertilizers on growth, yield, quality and sensory evaluation of red lettuce (*Lactuca sativa* L.). Agric. Biol. J. N. Am. 1(6):1319-1324.

Moler, K. and W. Stinner. 2009. Effects of different manuring systems with and without biogas digestion on soil mineral nitrogen content and on gaseous nitrogen losses (ammonia, nitrous oxides). Europ. J. Agronomy 30: 1–16.

Moodie, C., D.H.W. Smith and R.A. McCreery. 1959. Laboratory Manual of Soil Fertility. Dept. Agron. State College Washington Pullman, Washington. USA. p. 1-175.

Morgan, P. 2007. Toilets that make compost. Stockholm Environment Institute, Stockholm, Sweden. p. 81–90.

Nadunguru, J. and A.C. Rajabu. 2004. Effect of okra mosaic virus diseases on the above-ground morphological yield components of okra in Tanzania. Sci. Horti. 99: 225-235.

Ned, B. 2009. Importance of compost and waste prevention. Connecting Climate Change and Waste Management 2: 202-204.

O'Donnell, R. W. 1973. The auxin-like effects of humic prepration from leonartide. Soil Sci. 116: 106-112.

Okoroigwe, E.C. 2007. Application of biomass techonology in sustainable agriculture. Trends in Applied Sciences Research 2(6): 549-553.

Oldare, M., V. Arthurson, M. Pell, K. Svensson, E. Nehrenheim and J. Abubakar. 2011. Land application of organic waste – Effects on the soil ecosystem. Applied Energy 88(6): 2210-2218.

Oluwatoyinbo, F.I., M.O. Akande, E.A. Makinde, and J.A. Adediran. 2009. Growth and yield response of okra to lime and compost on an acid soil in the humid tropics. Res. J. Agri. and Biol. Sci. 5: 858-863.

Oyelade, O.J., B.I.O. Ade-Omowaye and V.F. Adeomi. 2003. Influence of variety on protein, fat contents and some physical characteristics of okra seeds. J. Food Eng. 57: 111-114.

Ozores-Hampton, M. 2002. Organic materials in horticulture: An industry perspective. Intro. Hor. Tech. 12(3): 8-9.

Pinamonti, F. 1997. Compost mulch effects on soil fertility, nutritional status and performance of grapevine. Nutrient Cycling in Agro. Ecosystems 51: 239–248.

Rahman, S.M.E., M.A. Islam, M.M. Rahman, and O.D. Hwan. 2008. Effect of cattle slurry on growth, biomass yield and chemical composition of maize fodder. Asian-Australasian J. Animal Sciences. 22: 220-225.

Randhawa, J. S. 1986, Genetics of jassid resistance in Okra (*A. esculentus* (L.) Moench). Indian. J. Ent. 48: 369-371.

Rindle, S. 1997. Compost for disease control. www.ipm.iastate.edu/ipm/hortnews/1995/6-9-1995/comp.htm (Jan. 2010).

Salim, M. 1999. Diversity: Role in integrated pest management. Sci. Tech. Dev. 18(4): 26 31.

Sanford, R. G., J. L. Posner, R. T. Schuler and J. O. Baldock. 2007. Effect of dairy slurry application on soil compaction and corn (*Zea mays* L.) yield in Southern Wisconsin. International Annual Meeting November 4-8, 2007 New Orleans, Louisiana, USA.

Sankaran, K., G.V. Kothandaraman and T.S. Manickam. 1981. Comparative study of biodigested slurry as source of organic plant nutrient'. Coimbtore, Tamil Nadu Agricultural University, Seminar on Microbiology of biogas fermentation, India.

Sankaran. K and K.R. Swaminatiian 1988. Residual impact of biodigested slurry as source of organic manure'. In Management and Utilisation of Slurry. Himansulu Publications.

Sarwar, G., H. Schmeisky, M.A. Tahir, Y. Iftikhar and N. U. Sabah. 2010. Application of green compost for improvement in soil chemical properties and fertility status. The J. Animal & Plant Sciences 20(4): 258-260.

Sarwar, G., N. Hussain, H. Schmeisky and S. Muhammad. 2007. Use of compost and environment friendly technology for enhancing rice-wheat production in Pakistan. Pak. J. Bot. 39: 1553-1558.

Savello, P.A., F. Martins and W. Hull. 1980. Nutrition composition of okra seed meals. J. Agri. Food Chem. 28: 1163-1166.

Schulz, R., H. Al-Najar, J. Breuer and V. Römheld. 2002. The effect of bio-compost application on crop yield and nitrogen dynamic in the soil. Plant Nutrition Developments in Plant and Soil Sciences 92: 986-987

Sharma, K.L., J.C. Bajaj, S.K. Das, U.M.B. Rao and K. Ramalingaswami. 2007. Nutrient transformation in soil due to addition of organic manure and growing crops. Nutrient Cycling in Agroeco systems 32: 303-311.

Shiralipour, A. and E. Epstein. 2005. Compost effect on cotton growth and yield and environmental consultants, Inc., Canton, MA, USA.

Siemonsma, J.S. 1982. West African okra – morphological and cytogenetical indicators for the existence of a natural amphidiploid of Abelmoschus esculentus (L.) and A. manihot (L.) Mediks. Euphytica 31: 241-252.

Singh, J.B. 1990. Biogas Slurry Maure. Changing Villages 9 (3): 22-25.

Singh, J.B. 1995a. Effect of biogas digested slurry on pea, rice, okra, soybean and maize. Biogas Forums 4: 63-67.

Singh, J.B. 1995b. Effect of biogas slurry manure and mineral fertilizer on pea, okra, soybean and maize. Agri. Wastes 9: 73-79.

Somasundaram, E., M.M. Amanullah, K. Vaiyapuri, K. Thirukkumaran and K. Sathyamoorthi. 2007. Influence of organic sources of nutrients on the yield and economics of crops under maize based cropping system. J. Applied Sciences Res. 3: 1774-1777.

Srikanth, K. and G. Organics. 2006. Effect of enriched compost on crop growth and soil properties. This presentation is part of 162: 4.1A Organic Farming – Advantages and Disadvantages for Soils, Water Quality and Sustainability, Poster. 162-168.

Steel, R.G.D., and J.H. Torrie. 1980. Principles and Procedures of Statistics, McGraw-Hill Book Co., New York, USA.

Steel, R.G.D., J.H. Torrie and D.A. Dickey. 1997. Principles and procedures of statistics. A biometerical approach, 3rd ed. McGraw Hill Book Co. Inc, New York., USA.

Stevenson, F.J. 1986. Cycles of soil: Carbon, nitrogen, phosphorous, sulfur and micronutrients. 2nd ed. John Wiley and Sons, Inc, New York, USA.

Swift, M.J. and P.L. Woolmer. 1993. Organic matter and the sustainability of agricultural system: Definition and measurement In: K. Mulongoy and R. Merckx (ed.) Soil Organic Matter Dynamics and Sustainability of Tropical Agriculture 3-18.

Tafaghodinia, B. and M. Kamalpour. 2008. Compost tea. Sepehr (ed.) Persian,Tehran, Iran. 75 p.

Tentsher. W. 1985. Digested effluent as fertilizer. Anaerobic digestion, Mircen. 3 (2): 136.

Tani, M., N. Sakamoto, T. Kishimoto and K. Umetsu. 2006. Utilization of anaerobically digested dairy slurry combined with other wastes following application to agricultural land. International Congress Series 1293: 331– 334.

Tripathi, A.K. 1993. Biogas slurry: A boom for agricultural crops. Biogas Slurry Utilization, New Delhi, India.

U.S. Salinity Laboratory Staff. 1954. Diagnosis and improvement of saline and alkali soils. USDA. Hand book No. 60. Washington, DC, USA.

Urselmans, T.T., E. Scheller, M. Raubuch, B. Ludwig and R.G. Jorgensen. 2009. CO_2 evolution and N mineralization after biogas slurry application in the field and its yield effects on spring barley. Applied Soil Ecology 42: 297–302.

Vaccaro, S., A. Muscolo, D. Pizzeghello, R. Spaccini, A. Piccolo and S. Nardi. 2009. Effect of a compost and its water-soluble fractions on key enzymes of nitrogen metabolism in maize seedlings. J. of Agricultural Food Chemistry 57: 11267–11276.

van Barkel, J. 1980. The Lgnis Fatuus of Biogas. Small Scale Anaerobic digesters ("Biogas Plants") A Critical Review of the Pre-1970 Literature Delft, Delft University Press. The Netherlands.

Vogtmann, H. and J.M. Besson. 1993. European Composting Methods: Treatment and Use of Farm Yard Manure and Slurry/ Compost Sci./Land Uttil. 19(1): 15-19.

Warman, P.R. 2002. Soil fertility comparisons between fertilizer and compost-amended soils. Department of Environmental Sciences, Nova Scotia Agricultural College, Truro, N. S., Canada.

Wei, Y. and Y. Liu. 2005. Effects of sewage sludge compost application on crops and cropland in a 3-year field study. Chemosphere 59: 1257–1265

Weiping, W., Z. Fengxiang, C. Xiaoyang, X. Zhiyong, H. Chunlai, W. Chuanzhen and L. Jian. 2010. Influence of biogas slurry irrigating on the soil environment and radish quality. Chinese Agricultural Science Bulletin 24.

Weltzein, H.C. 1990. The use of composted materials for leaf disease suppression in field crops. Crop protection in organic and low-input agriculture. BCPC Monographs 45: 115-120.

Weltzein, H.C. 1989. Some effects of composted organic materials on plant health. Agriculture, Ecosystems and Environment 27: 439-446.

Wenke, L., Y. Q. Chang and W. S. Qing. 2009. A review on effect of biogas slurry on vegetables and soil. Chinese Agricultural Science Bulletin, 24.

Wolf, M. 1982. Characterization of sister chromatid exchange induction by hydrogen peroxide. Environ. Mutag. 4: 135–142.

Yu, F.B., X.P. Luo, C.F. Song, M.X. Zhang and S.D. Shan. 2010. Concentrated biogas slurry enhanced soil fertility and tomato quality. Plant Soil Sci. 60 (3): 262-268.

Zaller, J.G. and U. Köpke. 2007. Effects of traditional and biodynamic farmyard manure amendment on yields, soil chemical, biochemical and biological properties in a long-term field experiment. Biology and Fertility of Soils 40: 222-229

Zhang, M., S. S. Malhi, R. Panasuik and B. Henriquez. 2011. Response of turfgrass growth in a black chernozemic soil amended with municipal solid/biosolid waste compost. J. Plant Nutrition 34: 183 – 205.

Zhou, Q. 2009. Effect of biogas slurry application on yield, nutrition quality of purple cabbage and soil quality. Acta Agriculture Jiangxi 2: 07-27.

ANNEX.

Analysis of Variance

I. Plant height after 30 days of germination of seeds

SOV	D.F	SS	MS	F	P
Replication	2	123.52	61.762		
Treatment	6	1873.14	312.190	6.49**	0.0030
Error	12	577.14	48.095		
Total	20	2573.81			

CV = 9.74

II. Plant height at the time of harvesting plant

SOV	D.F	SS	MS	F	P
Replication	2	137.52	68.762		
Treatment	6	3267.62	544.603	12.92**	0.0001
Error	12	505.81	42.151		
Total	20	3910.95			

CV = 9.01

III. Analysis of Variance Table on number of branches.

SOV	D.F	SS	MS	F	P
Replication	2	8.6667	4.33333		
Treatment	6	40.5714	6.76190	4.06*	0.0187
Error	12	20.0000	1.66667		
Total	20	69.2381			

CV = 18.96

IV. Analysis of Variance Table number of fruits per plant.

SOV	D.F	SS	MS	F	P
Replication	2	2868.7	1434.33		
Treatment	6	38183.8	6363.97	11.97**	0.0002
Error	12	6377.3	531.44		
Total	20	47429.8			

CV = 9.01

IV. Analysis of Variance Table for 1000 seed weight.

SOV	D.F	SS	MS	F	P
Replication	2	23.238	11.6190		
Treatment	6	238.000	39.6667	8.01**	0.0012
Error	12	59.429	4.9524		
Total	20	320.667			

CV = 6.07

V. Analysis of Variance Table on fruit yield per plot.

SOV	D.F	SS	MS	F	P
Replication	2	2147725	1073863		
Treatment	6	3979213	663202	3.65*	0.0269
Error	12	2180789	181732		
Total	20	8307727			

CV = 13.87

VI. Analysis of Variance Table on root fresh weight.

SOV	D.F	SS	MS	F	P
Replication	2	114.00	57.000		
Treatment	6	645.90	107.651	3.15*	0.0432
Error	12	410.67	34.222		
Total	20	1170.57			

CV = 21.00

VII. Analysis of Variance Table of root dry weight.

SOV	D.F	SS	MS	F	P
Replication	2	9.238	4.6190		
Treatment	6	132.667	22.1111	4.37*	0.0144
Error	12	60.762	5.0635		
Total	20	202.667			

CV = 21.78

VIII. Analysis of Variance Table on root length.

SOV	D.F	SS	MS	F	P
Replication	2	1.238	0.6190		
Treatment	6	168.476	28.0794	1.83*	0.0175
Error	12	184.095	15.3413		
Total	20	353.810			

CV = 11.60

IX. Analysis of Variance Table K uptake by plant.

SOV	D.F	SS	MS	F	P
Replication	2	577.46	288.729		
Treatment	6	5230.65	871.774	2.91*	0.0545
Error	12	3595.07	299.590		
Total	20	9403.18			

CV = 24.08

X. Analysis of Variance of K uptake by shoot.

SOV	D.F	SS	MS	F	P
Replication	2	9753.5	4876.76		
Treatment	6	34930.7	5821.78	6.37**	0.0033
Error	12	10970.5	914.21		
Total	20	55654.7			

CV = 11.78

XI. Analysis of Variance of K uptake by root.

SOV	D.F	SS	MS	F	P
Replication	2	1351.4	675.5		
Treatment	6	1493.7	248.95	3.11*	0.015
Error	12	970.5	80.875		
Total	20	3815.6			

CV= 9.5

XII. Analysis of Variance of K uptake by 1st fruit picking.

SOV	D.F	SS	MS	F	P
Replication	2	1141.8	570.90		
Treatment	6	33939.2	5656.54	15.73 **	0.0000
Error	12	4316.2	359.68		
Total	20	39397.2			

CV = 10.69

XIII. Analysis of Variance of K uptake by 3rd fruit picking.

SOV	D.F	SS	MS	F	P
Replication	2	790.4	395.19		
Treatment	6	20433.0	3405.49	9.77**	0.0005
Error	12	4181.6	348.47		
Total	20	25405.0			

CV = 10.88

XIV. Analysis of Variance of K uptake by 5th fruit picking.

SOV	D.F	SS	MS	F	P
Replication	2	1330.3	665.14		
Treatment	6	18653.0	3108.83	11.26**	0.0003
Error	12	3313.0	276.09		
Total	20	23296.3			

CV = 9.19

XV. Analysis of Variance of N uptake by root

SOV	D.F	SS	MS	F	P
Replication	2	569.81	284.905		
Treatment	6	2195.81	365.968	2.77*	0.0632
Error	12	1588.19	132.349		
Total	20	4353.81			

CV = 22.46

XVI. Analysis of Variance of N uptake by shoot

SOV	D.F	SS	MS	F	P
Replication	2	2773.2	1386.62		
Treatment	6	30823.8	5137.30	6.05**	0.0041
Error	12	10182.8	848.56		
Total	20	43779.8			

CV = 11.60

XVII. Analysis of Variance of 1st fruit N uptake

SOV	D.F	SS	MS	F	P
Replication	2	1134.9	567.43		
Treatment	6	30707.0	5117.83	15.24**	0.0001
Error	12	4028.5	335.71		
Total	20	35870.3			

CV = 12.16

XVIII. Analysis of Variance of N uptake by 3rd fruit picking

SOV	D.F	SS	MS	F	P
Replication	2	2275.5	1137.76		
Treatment	6	13804.3	2300.71	5.22**	0.0074
Error	12	5289.1	440.76		
Total	20	21369.0			

CV = 15.71

XIX. Analysis of Variance of N uptake by 5th fruit picking

SOV	D.F	SS	MS	F	P
Replication	2	3017.81	1508.90		
Treatment	6	4643.81	773.97	4.38 *	0.0142
Error	12	2120.19	176.68		
Total	20	9781.81			

CV = 10.09

XX. Analysis of Variance P uptake by plant

SOV	D.F	SS	MS	F	P
Replication	2	638.95	319.476		
Treatment	6	3511.90	585.317	9.86 **	0.0005
Error	12	712.38	59.365		
Total	20	4863.24			

CV = 17.32

XXI. Analysis of Variance P uptake by 1st fruit picking

SOV	D.F	SS	MS	F	P
Replication	2	157.24	78.619		
Treatment	6	1501.14	250.190	18.83 **	0.0000
Error	12	159.43	13.286		
Total	20	1817.81			

CV = 12.61

XXII. Analysis of Variance of P uptake by 3rd fruit picking

SOV	D.F	SS	MS	F	P
Replication	2	31.714	15.8571		
Treatment	6	338.952	56.4921	13.66**	0.0001
Error	12	49.619	4.1349		
Total	20	420.286			

CV = 10.54

XXIII. Analysis of Variance P uptake by 5th fruit picking

SOV	D.F	SS	MS	F	P
Replication	2	268.29	134.143		
Treatment	6	559.90	93.317	6.28 *	0.0035
Error	12	178.38	14.865		
Total	20	1006.57			

CV = 11.60

* = Significant at 0.01 at *P* = 0.01, accordingly to DMR test

** = Highly significant at 0.01 at *P* = 0.01, accordingly to DMR test