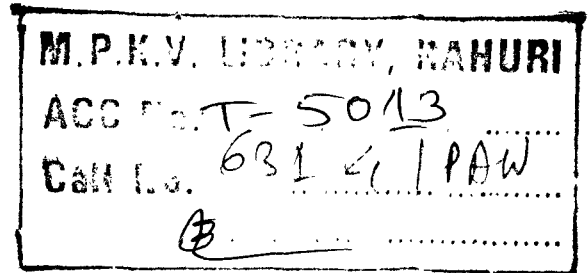


**EVALUATION OF MANURIAL VALUE OF
BIOGAS PLANT SLURRY WITH MAIZE AS A TEST CROP
ON MEDIUM BLACK SOIL**

**A Thesis Submitted to the
MAHATMA PHULE AGRICULTURAL UNIVERSITY
Rahuri, Maharashtra (India)**

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE (Agriculture)

IN
SOIL SCIENCE



BY

SURYAKANT DAULATRAO PAWAR

B. Sc. (Agri.) First Class

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MAHATMA PHULE AGRICULTURAL UNIVERSITY
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PUNE
(Maharashtra)

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CANDIDATE'S DECLARATION

I hereby declare that the thesis entitled, "Evaluation of manurial value of biogas plant slurry with maize as a test crop on medium black soil ", or any part of the thesis has not been previously submitted by me or other person to any other university or Institute for a degree or diploma.

Pune - 411 005

Dated 18, Feb 1989



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CERTIFICATE

This is to certify that the thesis entitled,
"Evaluation of manurial value of biogas plant slurry with
maize as a test crop on medium black soil" submitted to
the Mahatma Phule Agricultural University, Rahuri, Dist.
Ahmednagar (Maharashtra) in partial fulfilment of the
requirements for the degree of MASTER OF SCIENCE (Agriculture) in SOIL SCIENCE embodies the results of bona fide research work of original nature carried out by Shri. Suryakant Daulatrao Pawar under my guidance and supervision. It is of a sufficiently high standard to warrant its submission to the University for the award of said degree. No part of the thesis has been submitted for any other degree, diploma or published in any other form.

The assistances and help received during the course of this investigation and source of literature referred to in the text have been duly acknowledged.

Solapur 413 002
Dated 18 Feb 1989


(B. K. Jagtap)
Research Guide.

Dr.D.S.Ajri
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CERTIFICATE

This is to certify that the thesis entitled, "Evaluation of manurial value of biogas plant slurry with maize as a test crop on medium black soil" submitted to the Faculty of Agriculture, Mahatma Phule Agricultural University, Rahuri, for the award of the degree of MASTER OF SCIENCE (Agriculture) in SOIL SCIENCE embodies the results of bonafide research carried out by Shri. Suryakant Daulatrao Pawar under the guidance and supervision of Dr. B.K.Jagtap, Soil Chemist, Dry Farming Research Station, Solapur and that no part of the thesis has been submitted for any other degree or diploma.

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Dated 18, Feb 1989


(D.S.Ajri)

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Dated 18, Feb 1989



(S.D. PAWAR)

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ABBREVIATIONS USED

| | | |
|------|----|-------------------|
| ha | .. | Hectare |
| g | .. | Gramme (s) |
| Kg | .. | Kilogramme (s) |
| q | .. | Quintal (s) |
| t | .. | Tonnes |
| mm | .. | Milimetre (s) |
| cm | .. | Centimetre (s) |
| m | .. | Metre (s) |
| °C | .. | Degree centigrade |
| N | .. | Nitrogen |
| P | .. | Phosphorus |
| K | .. | Potassium |
| Fig. | .. | Figure |
| % | .. | Percentage |
| viz. | .. | Namely |
| hrs | .. | Hours |

ABSTRACT

EVALUATION OF MANURIAL VALUE OF BIOGAS PLANT SLURRY
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SURYAKANT DAULATRAO PAWAR

A Candidate for the degree
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in

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MAHATMA PHULE AGRICULTURAL UNIVERSITY
RAHURI

Research Guide : Dr. B.K.Jagtap
Department : Soil Science

An investigation entitled, "Evaluation of manurial value of biogas plant slurry with maize as a test crop on medium black soil" was laid out in a factorial randomised block design with three replications at the Agricultural College Farm, Pune during Kharif, 1987. There were four levels of biogas plant slurry viz., 0, 5, 7.5 and 10 tonnes/ha and three levels of nitrogen viz., 0, 50 and 100 kg N/ha under study.

The maize grain yield was significantly increased with increased levels of slurry application. The stover

yield showed significant improvement due to different levels of slurry application as compared to control.

N, P and K content of maize grain and stover, crude protein content of maize grain and N, P and K uptake by maize grain and stover and total uptake of these nutrients was significantly increased with the increased levels of slurry application.

Important physico^{and}chemical and biological properties of the soil showed significant improvement with increased levels of applied slurry.

Grain yield of maize was significantly increased with increased levels of nitrogen application. The application of 50 and 100 kg N/ha were on par but increased the stover yield significantly over control.

The N, P and K content of grain and stover, crude protein content of grain and uptake of N, P and K was significantly more with increased levels of nitrogen application.

Nitrogen application showed the favourable influence on physico-chemical and biological properties of the soil.

The grain and stover yield of maize obtained at 7.5 tonnes/ha of slurry was equivalent to that of 100 kg N/ha application. Therefore, it would be advisable to use 7.5 tonnes/ha of slurry instead of applying 100 kg N/ha through urea.

Chapter Opener Page

1. INTRODUCTION

India faces a critical shortage of fuels in view of its increasing population and limited reserves of a petroleum and coal. The gohar gas plant has to play a significant role in the country's economy as 80 per cent of our population is depending on agriculture. At present, a major portion of cattle dung is used as a fuel and only a limited quantity is available as manure. The introduction of biogas plant, offers a dual scope to utilize the dung both as a source of fuel as well as manure. Biswas et al. (1964) and Ghosh et al. (1968) showed that organic matter level and structural status of soil could be modified to a certain extent and maintained by the application of farm yard manure and digested slurry from biogas plant.

Gerhard and Pol (1973) stated that biogas plant slurry has a higher manurial value than other organic manures. It has a higher fertilizing effect than decomposed dung since it contains greater amount of nitrogen, soluble in water which can be easily available to plants. Similarly, Krishnappa et al. (1977) found that the slurry coming out of gohar gas plant is well decomposed and rich in major nutrients like N, P and K and apart from this, it contains trace nutrients like zinc, sulphur and iron. The slurry is well decomposed and is in a fine state of division and hence, it can be applied

directly to the soil for better crop production.

It is known that the nitrogen in F.Y.M. is lost to a great extent because of faulty handling and storage. Such losses of nitrogen are minimised by processing cow-dung in the biogas plant. In it, weed seeds and insects are almost completely destroyed resulting in less expenditure on weedicides and insecticides. Subramanian (1977) stated that the absence of white ants and weed seeds makes the digested dung a better fertilizer than farm yard manure.

Though popularised recently, hybrid maize has caught the imagination of the farmers because of its high production potential and capacity to effectively utilize moisture and nitrogen. Besides water, nitrogen is another basic important input to realize potential yield from improved maize hybrids and varieties. The majority of farmers are not in a position to supply the prescribed fertilizer recommendations for valid reasons of high input cost and shortage in supply. Naturally, cultivators are constrained to effect reduction in fertilizer usage to a level which may fetch them the adequate economic returns. Therefore, the total nutrient supply to maize through fertilizers is still much below the optimum level.

Subramaniam et al. (1982) recorded linear response to applied nitrogen upto 180 kg/ha. They also reported that the uptake of nitrogen, phosphorus and potassium was increased with increased levels of nitrogen application to maize. Choudhary and Tribedi (1988) obtained highest maize grain yield of 65.1 q/ha due to application of $N_{80}P_{40}K_{40}$ organic matter at 8 t/ha.

Sankaran et al. (1981) stated that organic manures like slurry obtained from biogas plant used in combination with chemical fertilizers gave better yield of ragi.

The present investigation was, therefore, planned to study the effect of biogas plant slurry and nitrogen levels alone and in combination on maize yield and quality and physico^{and}chemical and biological properties of soil with the following objectives

1. To study the effect of biogas plant slurry on maize growth, yield and quality and to observe its feasibility to serve as a partial substitute for nitrogen fertilization;
2. To study the effect of nitrogen levels on growth, yield and quality of maize;
3. To study the nutrient uptake by maize;
4. To study the effect of biogas plant slurry and nitrogen levels on physico-chemical and biological properties of soil;
5. To find out interaction effects between biogas plant slurry and nitrogen levels.

Chapter Opener Page



2. REVIEW OF LITERATURE

The present investigation was undertaken to study the manurial value of biogas plant slurry. The purpose of this section is to review the work done on different aspects of effects of organic manures on yield and soil properties. The review of literature has been grouped into the following categories.

2.1 Effect of slurry and organic manures on maize yield and yield contributing characters.

Krishnappa et al. (1977) observed that the yield of ragi due to application of gobar gas plant slurry ranged from 68 kg to 220 kg/acre and this amounted to an increase in yield of 10.4 to 33.85 per cent over F.Y.M. The application of digested manure resulted in increased paddy yield (Anonymous, 1977).

Pain et al. (1977) stated that due to application of of slurry there was increase in maize fodder yield. They also stated that slurry alone gave satisfactory yield and upto 70 t/ha, improved the response to inorganic N. Slurry^{application} at 105 t/ha tended to delay crop maturity and reduced yield when more than 40 kg inorganic N/ha was applied.

✓ Rogers et al. (1977) found that due to application of organic manure there was increase in maize fodder yield.

Subramanian (1977) observed that due to application of digested slurry, the taste and size of pea was the best.

Dass et al. (1981) reported that the application of inorganic fertilizer along with digested slurry increased the yield of maize in respect of green matter and dry matter.

Sankaran et al. (1981) stated that due to application of dried slurry plus urea, the yield of grain and straw significantly increased than urea or slurry alone. They also found that application of dried slurry as compared to other forms of organic manures gave the highest yield of ragi grain and straw.

Vasil'ev et al. (1981) observed that fermented manure was effective in increasing crop yield. However, the application of digested effluent and slurry gave better yield (Etherbridge et al., 1984).

✓ Prasad et al. (1982) at Pusa (Bihar) observed that when 100 quintals of compost or F.Y.M. was used, the dose of 50 kg P_2O_5 /ha could be reduced to 25 kg P_2O_5 /ha without reducing in yield of sugarcane in calcareous saline-sodic soils.

Jagtap and Pharande (1982) conducted a trial to find out the effect of different levels of N, organic matter and moisture regime on panicle character, grain yield and protein

content of grain sorghum. There was significant increase in the panicle character, grain yield and protein content of each of their higher doses of nitrogen and organic matter.

Kulkarni and Kulkarni (1982) found that 12 t F.Y.M./ha with fertilizers yielded higher than chemical nutrients alone at higher levels of application.

✓ Krishnasamy et al. (1984) observed that organic manures at 15 t/ha had a significant effect in increasing the available P from native and applied sources. They also stated that due to application of F.Y.M. there was increase in grain and straw yield of maize.

Gorltz et al. (1985) stated that a higher slurry rate gave no further yield increments. Slurry manuring should be related to N needs of the crop and should not exceed 600 kg N/ha. They also observed a residual effect of the slurry on succeeding crop.

Koriath et al. (1985) stated that fermented and unfermented slurry both were less effective in increasing yield of maize than ammonium nitrate fertilizer, especially on loamy sand soils.

Dahiya and Vasudevan (1986) observed that the replacement of nitrogenous fertilizer with slurry decreased the yield of major crops but application of slurry to replace

half the nitrogenous fertilizer gave better yield in vegetables while replacement of the total nitrogenous fertilizer gave better yield in fodder crops.

2.2 Effect of organic manures and slurry on physical and chemical and biological properties of soil.

There are ample examples how organic manure influences the physical^{and} chemical and biological properties of soil.

✓ Acharya and Rajagopalan (1956) showed that the application of F.Y.M. considerably increased the 'C' content of soil, such was not the case with the soils receiving green manuring.

✓ Salter and Haworth (1962) stated that there was 33% increase in soil moisture of surface layers of a sandy loam soil with continuous application of F.Y.M.

✓ Kanwar and Prihar (1962) showed that continuous use of F.Y.M. resulted in increasing the nitrogen content in the soil.

Biswas et al. (1964) showed that the amount of organic matter and structural status of soil could be modified to a certain extent, by the application of farm yard manure and digested slurry from the cow dung gas plant.

Chakrabarty and Sen (1967) observed that under high temperature and favourable moisture conditions only a small

portion of the added organic matter remained in the soil. Manuring had narrowed C/N ratio and it may be due to less release of organic carbon which helps in narrowing the C/N ratio.

Ghosh et al. (1968) showed that due to application of the digested slurry improves the soil structure significantly.

Srivastava et al. (1968) stated that due to the application of sewage, there was significant improvement in soil fertility by lowering its pH.

Biswas and Ali (1969) observed that there was a considerable increase in the moisture retention capacity of the soil by addition of organic manure.

✓ Balasubramanian et al. (1972) reported that an addition of organic matter could increase the bacteria, actinomycetes and fungi by improving the nutrient status as well as physical and chemical conditions for the favourable growth of these organisms.

X Bavaskar and Zende (1973) observed that the application of compost to the soil proved to be beneficial in maintaining the soil aggregates to more than 0.25 mm in all top dressing combinations of nitrogen.

X Gaikwad and Khuspe (1976) stated that the application of F.Y.M. at 5-6 t/ha resulted in improving the nitrogen and available K_2O content of the soil as compared to the control.

It is thus clear, that, addition of organic matter seems to have helped in increasing the nitrogen and potash content of soil there by enhancing the fertility of soil.

✓ Indiraraja and Raj (1979) observed that press mud at 10 t/ha improved stability index and aggregate stability of the black and acid soils significantly. He also stated that there was a progressive increase in the available nitrogen, phosphorus and organic carbon contents of all the soil studied. He also observed that there was an increase in the cation exchange capacity of all soils, while it increased the exchangeable calcium in red, acid and black soils. Press mud application resulted in an increase in bacterial population of red soil and fungal population of black (wetland) soil.

✓ Shanmugam^h and Ravikumar (1980) reported that due to incorporation of organic residues, farm yard manure or pig manure at 25 t/ha reduced the bulk density and improved the physical properties like hydraulic conductivity, infiltration rate, porosity, stability index and aggregate stability. The organic matter content of the soil was improved by the addition of the organic residues.

Singh et al. (1980) reported that due to application of farm yard manure to sierozem soil in the semi-arid region

at Haryana resulted in the lowering of pH and increase in organic carbon content, cation exchange capacity and exchangeable cations. They also stated that due to the application of phosphatic fertilizer there was build up of available nitrogen, phosphorus and potassium. Potassium application had no marked effect on the chemical properties of the soil.

Pandia (1980) stated that long term application of compost slightly decreased the soil pH, CEC and exchangeable K, Fe and Mn but was helpful in building up of soil fertility as evidenced by higher organic carbon, total nitrogen and available phosphorus.

Bhatia and Ganguly (1981) stated that there was a decrease in bulk density due to the incorporation of manures as compared to original soil. Bulk density increased again after the harvest of crops under F.Y.M. treatment but remained more or less constant in plots receiving slurry.

Muthuvel et al. (1982) reported that the structural parameters like aggregate stability improved in NPK and cattle manure treatments. This improvement in soil structure might be through improvement in the organic matter build-up.

Grewal et al. (1982) observed that due to application of F.Y.M., there was better use of profile water and

encouraged deep rooting to explore water from lower profile layers during drought periods.

Gupta et al. (1983) conducted field trials from 1975 to 1979 in Western Rajasthan and observed that with increase in the application of F.Y.M. and reduction in urea, there was decrease in bulk density of soil, increase in moisture retention at 0.1 bar tension and decrease in saturated hydraulic conductivity. He also reported that the addition of F.Y.M. and green manure to soils, increased the bacterial population significantly. Application of both the manures showed significant increase in fungi also in all the soils except for Banihal soils, whereas, the number of actinomyces did not show any significant change.

Singh et al. (1983) stated that F.Y.M. application significantly increased organic carbon and availability of P and K status of soil.

✓ Rayar (1984) reported that due to the application of farm yard manure there was significant increase in organic carbon content and cation exchange capacity of soil. He also observed that water holding capacity was also significantly increased in all textural classes except in the sandy loam. In general, addition of organic manures significantly improved the physical ^{and} chemical properties of soil.

Destain et al. (1985) observed that there was improvement in soil structure as a result of slurry dressing.

Koriath et al. (1985) stated that the application of fermented slurry, increased the 'N' content of maize.

Singh et al. (1988) observed that blending SSP with biogas slurry and its application as broadcast exhibited significantly higher fertilizer P uptake and per cent P utilization at flowering over similar application of unblended SSP. Application 30, 60 and 90 kg P_2O_5 /ha through unblended SSP, was equivalent in its effect on total P uptake at maturity at 22, 38 and 46 kg P_2O_5 /ha applied through blended SSP.

2.3 Effect of nitrogen on yield and yield contributing characters and uptake by maize.

Castel et al. (1961) reported that the yield of green matter, dry matter and crude protein of maize was increased with an increase in 'N' application.

Nitrogen applications to the crop had a marked effect on the vegetative growth. Saxena (1962) reported that nitrogen fertilization helped in increasing the height of plant, number of functional leaves per plant and leaf area in hybrid maize.

✓ Bhosale (1968) studied the effect of N and P on yield

and growth of Deccan double hybrid maize at Nagpur. He observed that height, leaf number, dry matter, number of internodes and girth of stem increased more or less progressively as the level of N fertilization was increased.

Sharma and Gautam (1968) reported that three levels of N viz., 67.5, 135 and 225 kg/ha could significantly influence the cob length of hybrid variety.

Chaugule (1968) noted a significant difference in the yield of maize fodder due to different levels of N, viz., 60, 120 and 180 kg/ha. The fodder yield at the highest dose of N was significantly more than that of lower doses.

Karche (1969) in a trial of N and P requirement of Deccan double hybrid at Nagpur observed that application of increased level of N, increased the girth of stem and internodes significantly, over control and the dose of 250 kg/ha was superior to all other levels. Similarly, Garkal (1970) also observed that nitrogen application to maize had pronounced beneficial effect on plant height, leaf number, number of internodes and dry matter per plant. Further, he stated that the application of 148 kg N/ha was found to be the best of all treatments.

Karche and Khuspe (1970) reported that nitrogen at 250 kg/ha had produced the highest grain and stover yield viz., 40.91 and 61.86 g/ha, respectively, over the control.

Kareem and Relwani (1971) reported that the yield of green matter, dry matter and crude protein of maize was increased with an increase in N application.

Reddy and Kaliappa (1974) reported that at higher levels of nitrogen the protein content was also higher.

Bhargava et al. (1978) reported significant increase in yield of fodder maize over control by the application of fertilizers. The highest N, P and K uptake was recorded by the application of 100 per cent NPK (N, 150, P 80, K 40) and 100 per cent NPK + F.Y.M. (15 t/ha), respectively.

Shinde and Khuspe (1978) reported that the yields of grain and stover were significantly affected by nitrogen fertilization. The response was graded and significant in case of grain yield only. Since the response upto 150 kg N/ha was linear it would be advisable to try higher doses of nitrogen beyond 150 kg/ha to obtain economic optimum dose. They also stated that height, leaf number and leaf area were improved with each higher dose of nitrogen.

Singh (1980) observed that the application of $N_{90}P_{45}K_{45}$ gave significantly higher yield of maize than that of other N, P, K levels.

Dass et al. (1981) stated that an increase in the dose of N from 0 to 60 kg N/ha showed sequential increase in green fodder yield of maize from 172.8 to 304.7 g/ha.

They also stated that the yield of 20 and 40 kg N/ha was more or less the same.

Gangwar and Kalara (1981) observed that application of nitrogen was found essential for better growth of maize grown either alone or in association with legumes. However, the amount of nitrogen required for better growth depends upon rainfall distribution.

Sarkar and Sinha (1981) stated that the direct application of N significantly increased the yield of maize grain.

Subramanian et al. (1981) observed that protein content in maize grain was progressively and significantly increased by increasing nitrogen levels. Similar results were reported by Perry and Olsen (1975) and Subramanian (1977).

Rao and Bhardwaj (1981) reported that the application of fertilizer to maize even at the lowest level, caused significant improvement in the number of cobs per plant and 500 grain weight. The grain yield increased significantly with increasing levels of fertilizers while stover yield was favourably affected only by the highest level. They also stated that the uptake of N, P and K in grain and stover increased with the increase in fertility level.

Patel et al. (1982) reported that nitrogen application at 100 and 150 kg/ha recorded significantly higher crude protein than control and 50 kg N/ha. Similar results were reported by Desai (1978) and Desai and Deore (1980).

Subramaniam et al. (1982) reported that the grain and stover yield of maize, and yield attributes like cob length, grain numbers/cob, 1000 grain weight etc. exhibited progressive increase with each additional level of nitrogen starting from 60 kg/ha. The highest grain yield (5528 kg/ha) was obtained from 180 kg N/ha. Similar results were reported by Shah et al. (1971).

✓ Further, Subramaniam et al. (1982) reported that the uptake of nitrogen, phosphorus and potassium increased significantly as the nitrogen application was enhanced. Increasing levels of nitrogen fertilization increased the nutrient uptake in maize (Pathak, et al. 1971). The uptake of N, P and K by grain and straw of maize increased with increased rates of nitrogen application. (Sharma et al., 1975).

✓ Minhas and Metha (1984) stated that the grain yield of wheat and maize increased with higher levels of fertilizer application and the effect was significant as well as consistent. They also stated that the highest uptake of N, P and K and Zn was observed under 100% NPK treatment and the lowest in control.

Muthukrishnan and Subramanian (1984) reported that the protein content of maize grain was significantly influenced by varied nitrogen levels. At 180 kg/ha, applied N registered the maximum protein content of grain. This might be due to

higher absorption of N at higher levels of applied nitrogen. The results of this study were in line with the findings of Shanmugasundram et al. (1974).

Bhatia and Ganguly (1984) observed that the green yield of maize fodder increased upto 60 kg N/ha and there was lodging when nitrogen was applied at 120 kg/ha.

Prasad et al. (1985) reported that the height of plant, thousand grain weight and grain yield increased with increased levels of nitrogen upto 100 kg N/ha.

Subramanian et al. (1987) observed that grain and stover yield of maize increased progressively with each additional level of applied nitrogen and highest yield recorded was at 150 kg N/ha.

Chowdhary and Tribedi (1988) reported that the highest maize grain yield of 65.1 g/ha was recorded with $N_{80}P_{40}K_{40}$ + organic matter at 8 t/ha closely followed by $N_{80}P_{40}K_{40}$ + organic matter at 4 t/ha (60.1 g/ha).

2.4 Effect of fertilizers on soil properties.

Singh et al. (1980) reported that due to application of phosphatic fertilizers there was build up of available nitrogen, phosphorus and potassium. Potassium application had no marked effect on the chemical properties of the soil.

Muthuvel et al. (1982) observed that structural indices were not significantly improved by the long term fertilizer treatments. The aggregate stability improved with NPK and cattle manure treatments.

Sharma et al. (1983) reported that phosphorus and potassium applied in combination with F.Y.M. stimulated the growth of bacteria and actinomycetes. They also stated that the population of bacteria, fungi and actinomycetes in the rhizosphere had been much influenced by continuous application of inorganic fertilizer, F.Y.M. and lime.

Prasad et al. (1982) noticed rise in bulk density from 1.43 to 1.58 g/cc with increasing doses of chemical fertilizers (50% to 100% NPK). Continuous application of high doses of NPK seemed to have some deteriorating influence on water holding capacity.

Rana et al. (1983) reported that the availability of P and K was found to be associated with the amount of fertilizer P and K applied to the rotation.

Singh et al. (1983) observed that phosphorus treatment increased available P only in combination with F.Y.M., whereas, potassium fertilizer did not influence available K level of soil. Contents of organic carbon, available P and K were significantly higher when both the crops were fertilized.

Chahal et al. (1984) reported that cumulative use of 60 kg P_2O_5 /ha dose raised the available P level in soil from 17 to 28 P/ha at the end of 8 years of cropping. Potassium application did not show any significant effect on these attributes.

Minhas and Metha (1984) reported that there was reduction in pH due to NPK fertilizer use. Increased removal of cations due to higher production under fertilizer treatment might have also contributed indirectly to the lowering of the pH.

Grewal et al. (1985) stated that F.Y.M. application to maize ensured about 50% more water retention than inorganic fertilizer treatments at maize harvest in the surface 0-30 cm soil layer and this was highly beneficial for germination and establishment of subsequent wheat crop. The treatment of F.Y.M. and NPK + F.Y.M. retained 3.8 and 4.9 cm of more water in 120 cm deep profile than NPK alone.

Koriath et al. (1985) stated that the effect of fermented slurry and unfermented slurry were less effective in increasing yield of maize than ammonium nitrate fertilizers, especially on loamy sand soils.

Hazra and Tripathi (1986) reported that nitrogen application improved the organic carbon, available nitrogen

and phosphorus status of soil under agro-forestry system.

Jadhav (1986) reported that the important physical properties like bulk density, water stable aggregates and moisture content at 0.33 and 15 bar, and available soil moisture retention were increased with increased levels of fertilizer application to wheat. Further, he observed that the important chemical properties viz., organic carbon, total N and available P_2O_5 and K_2O content were significantly increased with increased levels of fertilizer application to wheat.

Acharya et al. (1988) observed in a long term fertilizer trial that the treatment receiving F.Y.M. + 100% of the recommended N, P and K improved the structural index, infiltration rate, water retention characteristics, organic carbon content, available N, P and K status of the soil and gave significantly higher crop yield than other treatments in maize-wheat rotation. Continuous N application and control treatments considerably deteriorated the soil physical and chemical properties but N + P improved these properties and significantly increased the crop yield as compared with N alone.

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3. MATERIAL AND METHODS

The present investigation was carried with a view to evaluate the "Manurial value of biogas plant slurry and its effect on soil and yield of maize crop". The details regarding the material used and methods followed are given in this chapter.

MATERIAL

3.1 Experimental site

The field experiment was conducted at the Agricultural College Farm, Pune. The experimental soil was uniform to a depth upto 75 cm.

3.2 Soil

The soil samples were collected from the experimental plot from 10 different locations and composite soil sample was prepared and analysed after air-drying for different constituents. The important physical, chemical and biological properties are given in Table 1.

Table 1. Physical^{and}/chemical and biological properties of soil.

| Sr.No. | Property | Values |
|--------|-------------------|--------------------|
| I | Physical analysis | |
| | 1. Coarse sand | (per cent) 5.95 |
| | 2. Fine sand | (per cent) 22.35 |
| | 3. Silt | (per cent) 21.50 |

contd.

Table 1 contd.

| Sr.No. | Property | Values |
|--------|---|------------|
| 4. | Clay (per cent) | 41.60 |
| 5. | Organic matter (per cent) | 1.34 |
| 6. | CaCO ₃ eq. (per cent) | 6.5 |
| 7. | Textural class | Clay loam |
| 8. | Maximum water holding capacity (per cent) | 61.00 |
| 9. | Soil moisture at 1/3 bar (per cent) | 36.68 |
| 10. | Soil moisture at 15 bar (per cent) | 18.47 |
| 11. | Bulk density (g/cm ³) | 1.32 |
| II | Chemical analysis | |
| 1. | pH | 8.1 |
| 2. | EC (mmhos/cm) | 0.14 |
| 3. | Organic carbon (per cent) | 0.77 |
| 4. | Total nitrogen (per cent) | 0.063 |
| 5. | C/N ratio | 11.32 |
| 6. | Available P ₂ O ₅ (kg/ha) | 30.98 |
| 7. | Available K ₂ O (kg/ha) | 484.00 |
| 8. | Ex. Ca (meq) | 41.9 |
| 9. | Ex. Mg (meq) | 12.0 |
| 10. | Ex. K (meq) | 1.9 |
| 11. | Ex. Na (meq) | 3.6 |
| III | Biological analysis | |
| 1. | Bacteria | 1,75,000/g |
| 2. | Fungi | 1,20,000/g |
| 3. | Actinomycetes | 20,000/g |

3.3 Slurry

The slurry used for experimental work was obtained from a private source and analysed. The chemical composition of slurry is given in Table 2.

Table 2. Chemical composition of slurry.

| Sr.No. | Composition | Per cent |
|--------|-------------|----------|
| 1. | Nitrogen | 1.83 |
| 2. | Phosphorus | 0.76 |
| 3. | Potassium | 0.89 |

3.4 Fertilizers

Urea, single super phosphate and muriate of potash used in the present investigation were analysed and chemical composition is given in Table 3.

Table 3. Chemical composition of fertilizers.

| Sr.No. | Fertilizer | Per cent nutrient content |
|--------|-----------------------------------|---------------------------|
| 1. | Urea : Nitrogen | 46.20 |
| 2. | Single super phosphate : P_2O_5 | 16.00 |
| 3. | Muriate of potash : K_2O | 60.00 |

METHODS

3.5 Soil analysis

The soil samples were analysed by adopting the following standard methods.

3.5.1 Mechanical analysis

It was carried out by using International Pipette method (Piper, 1966).

3.5.2 Maximum water holding capacity

This was determined by the method described by Piper (1966) using brass perforated dishes with screw rings.

3.5.3 Soil moisture^{at} 1/3 bar and 15 bar

The soil moisture content at 1/3 bar (field capacity) and 15 bar (permanent wilting point) was determined by pressure membrane apparatus (Richards, 1965).

3.5.4 Bulk density

The bulk density was determined by taking undisturbed soil cores from surface 0-15 cm layer using the core sampler (Dastane, 1972). These determinations were made at the start of the experimentation and at physiological maturity of maize. The moisture at soil sampling was around field capacity.



3.5.5 pH

This was determined by glass electrode using 1:2.5 soil : water suspension (Piper, 1966).

3.5.6 Electrical conductivity (EC)

A soil:water suspension was prepared (1:2.5 soil: water ratio) as described by Jackson (1967).

3.5.7 Organic carbon

This was determined by Walkley and Black Rapid Titration method as described by Piper (1966).

The organic matter was calculated by multiplying the content of organic carbon by the conventional factor of 1.724(Piper, 1966).

3.5.8 Total nitrogen

Total nitrogen was determined by modified Kjeldhal's Method (A.O.A.C., 1975).

3.5.9 C/N ratio

C/N ratio was calculated by dividing per cent carbon with per cent total nitrogen.

3.5.10 Available P_2O_5

This was determined by extracting the weighed quantity of soil with 0.5 M sodium bi-carbonate solution, pH 8.5 (Olsen, 1954) followed by colour development with Dickman

and Bray's procedure (1940) and the colour intensity was read in spectronic-20 using red filter (640 μ).

3.5.11 Available K_2O

It was determined by Flame Photometer (Hanway and Heidal, 1967).

3.5.12 Exchangeable cations

For determination of exchangeable cations, the triple salt solution (Ammonium oxalate, Ammonium acetate and Ammonium carbonate) described by Puri (1955) was used as leaching agent. The exchangeable calcium oxalate was estimated volumetrically. The exchangeable Mg, Ca, Na and K were estimated in an aliquot of lechate by using Puri's method.

3.5.13 Bacterial count.

Bacterial count was determined by dilution plate method as described by Collins and Lyne (1970), Warkup (1950).

3.6 Slurry

Slurry was analysed for total N, P and K content (A.O.A.C., 1975).

3.7 Fertilizer analysis

Fertilizer samples were analysed for their nutrient contents (A.O.A.C., 1975).

3.8 Experimental details

The experiment was laid out in a factorial randomised block design with three replications. There were 12 treatment combination under study formed due to 4 levels of biogas plant slurry and 3 levels of nitrogen as given below.

1) Biogas plant slurry (t/ha)

- 0 - S₀
- 5 - S₁
- 7.5 - S₂
- 10.0 - S₃

2) Nitrogen levels (kg/ha)

- 0 - N₀
- 50 - N₁
- 100 - N₂

The gross and net plot sizes were 6.7 x 2.5 m² and 6.2 x 1.6 m², respectively. The certified seed of test crop maize Ganga-5 was sown on July 24, 1987 (30th Met. week) by giving presoaking irrigation. The crop was irrigated 15 days after sowing which helped for germinating gap filled seeds. The biogas plant slurry was applied as basal dose as per the treatments. Half the quantity of nitrogen as per treatments was applied at the time of sowing and the remaining half of the quantity of nitrogen as per treatments was top dressed on August, 17, 1987. The crop was harvested on October 18, 1987 (42nd Met. week).

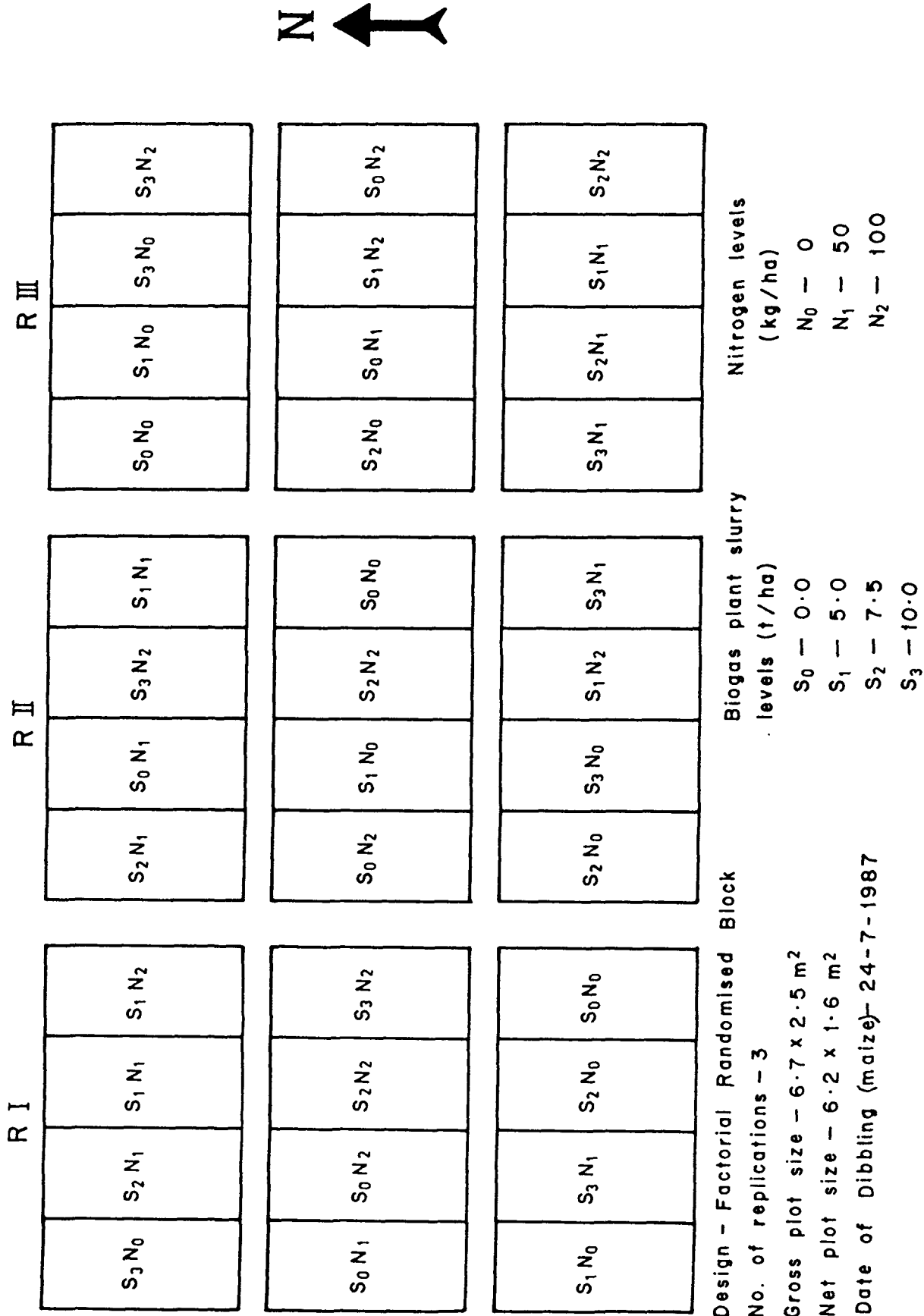


Fig. 1 . Plan of layout .

3.9 Climatic data

A) General

Pune comes under the plain zone (transitional belt) and is situated at an elevation of 557.74 meters above the mean sea level on 18 - 22' North latitude and 73 - 51' East longitude. The average annual rainfall of this place is 675 mm. It receives mostly from the South-West monsoon, commencing from about middle of June. Of the total annual precipitation, about 75 per cent precipitation is received during the period from June to September.

B) Climatic conditions during the Experimental period :

The weekly relevant data of weather parameters during the experimental period obtained from the Agricultural Meteorological Observatory located at the Agricultural College Farm, Pune are presented in Table 4.

It would be seen from Table 4 that, the total rainfall of 539.7 mm in 29 rainy days was received from June to October, out of which 400 mm rainfall in 15 rainy days was received during the crop growth period. A drought period of 3-4 weeks was observed during September. The grain development in maize corresponded to this drought resulting in shrivelling of grains and low yields.

Table 4. Meteorological data recorded during cropping period from June to October, 1987.

| Month | Meteo- rolog- ical week (No.) | Rainfall (mm) | No. of rainy days | Temperatures °C | | Relative humidity (%) | | Evapo- ration U.S.A. Std. (mm) |
|----------------|---|----------------------|-------------------------|--------------------|------|-------------------------------|--------------------------------|--|
| | | | | Max. | Min. | Mor- ning (7.30 hrs) | Eve- ning (14.30 hrs) | |
| June | 23 | 5.2 | 1 | 34.2 | 23.1 | 77 | 52 | 7.9 |
| | 24 | 18.9 | 2 | 30.9 | 22.6 | 85 | 63 | 5.6 |
| | 25 | - | - | 33.6 | 22.8 | 77 | 50 | 9.3 |
| | 26 | 43.0 | 3 | 33.9 | 23.2 | 86 | 65 | 5.6 |
| July | 27 | 40.6 | 3 | 29.0 | 22.2 | 85 | 71 | 4.5 |
| | 28 | 8.6 | 1 | 30.5 | 23.1 | 81 | 63 | 6.0 |
| | 29 | 10.9 | 2 | 29.8 | 22.0 | 88 | 70 | 5.5 |
| | 30 | 0.7 | - | 30.4 | 22.2 | 83 | 69 | 5.7 |
| | 31 | 0.1 | - | 32.0 | 22.5 | 84 | 56 | 6.9 |
| August | 32 | 0.3 | - | 31.1 | 22.6 | 82 | 62 | 6.1 |
| | 33 | 150.4 | 2 | 30.3 | 22.4 | 88 | 74 | 5.1 |
| | 34 | 70.5 | 5 | 27.2 | 21.7 | 93 | 77 | 3.0 |
| | 35 | 5.5 | 1 | 28.2 | 22.5 | 84 | 75 | 4.0 |
| Sept- ember | 36 | 0.8 | - | 29.6 | 21.1 | 85 | 64 | 5.3 |
| | 37 | 1.7 | - | 30.4 | 17.6 | 85 | 63 | 4.8 |
| | 38 | 0.0 | - | 33.5 | 22.6 | 89 | 50 | 5.3 |
| | 39 | 16.1 | 2 | 32.3 | 27.2 | 91 | 56 | 3.6 |
| Octo- ber | 40 | 138.8 | 4 | 29.7 | 20.9 | 94 | 72 | 3.8 |
| | 41 | 0.0 | - | 33.0 | 17.7 | 93 | 38 | 4.0 |
| | 42 | 15.2 | 1 | 31.9 | 19.1 | 90 | 63 | 4.0 |
| | 43 | 12.4 | 2 | 31.7 | 14.0 | 90 | 54 | 4.2 |
| | 44 | 0.0 | - | 32.7 | 13.3 | 87 | 35 | 4.7 |

The mean maximum and minimum temperature recorded during the crop growth period was 33.5° and 17.6° C, respectively. The mean relative humidity during the crop growth period ranged between 82 and 94 and 38 and 77 per cent, during morning and evening hours, respectively.

3.10 Yield components and yield

The important yield components viz., number of plants/net plot, plant height, number of leaves/plant, number of cobs/plant, weight of cob (g) and grain weight/cob (g) were recorded at harvest. The grain and fodder yield were also recorded. The harvest index was calculated. The composite sample of the grain was drawn from the net plot produce and 1000 grains were counted and their weight was recorded.

3.11 Water stable aggregates

The soil samples collected for determination of bulk density were used for analysis of water stable aggregates. Hundred gram soil sample (oven dry basis) passed through 8 mm sieve and retained on 5mm sieve was used for water stable aggregates studies by wet sieving (Yoder's method, 1936). The total percentage of aggregate was expressed as a sum of fraction > 0.25 mm in diameter. It was reckoned by summing up the aggregates retained on each sieve.

3.12 Plant analysis

A fine powder of plant material was digested as described by Parkinson and Allen (1975) in a mixture of sulphuric acid and hydrogen peroxide. After digestion of plant material, the volume was made with distilled water to 100 ml and filtered. A suitable quantity of aliquot was taken for the determination of mineral constituent viz., Nitrogen, Phosphorus and Potash.

3.12.1 Nitrogen

It was estimated by modified micro-kjeldhal's method (Parkinson and Allen, 1975).

3.12.2 Phosphorus

The phosphorus was determined in an aliquot of the acid extract by measuring the intensity of the Vanadophosphomolybdate yellow colour with spectronic 20 (640 μ) (Olsen, 1954).

3.12.3 Potassium

This was estimated with the help of flame photometer (Prasad, 1971).

3.12.4 Grain analysis

It was carried as per the plant analysis described by Parkinson and Allen (1975).

3.12.4.1 Protein content in grain

Protein content of the maize grain was calculated by multiplying per cent nitrogen in grain with conventional factor 6.25 (A.O.A.C., 1975).

3.13 Statistical analysis and interpretation of data

The data recorded was statistically analysed by technique of "Analysis of Variance" (Fisher, 1958) and test of significance was carried out as given by Cochran and Cox (1967) and Panse and Sukhatme (1967). In tabular data in text, C.D. values have been given for comparison only in cases where 'F' test was significant. Where it was not significant, figures for S.E._t only are given.

3.14 Correlation studies

Correlation between grain yield (q/ha) and yield components of maize and grain yield (q/ha) and physical, chemical and biological properties of soil was worked out by 'Karl Pearson' method by using following formula.

$$r = \frac{\sum_{i=1}^n X Y - \frac{\sum X \sum Y}{n}}{\sqrt{\left(\sum X^2 - \frac{(\sum X)^2}{n} \right) \left(\sum Y^2 - \frac{(\sum Y)^2}{n} \right)}}$$

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4. RESULTS AND DISCUSSION

The field experiment was conducted to study the influence of four levels of biogas plant slurry and three levels of nitrogen on the growth, yield and quality of maize (Ganga-5) and physico-chemical and biological properties of soil. The results of this investigation are presented and discussed in this chapter.

4.1 Yield components

The different yield components of maize were recorded at harvest and the data are presented in Table 5.

The data presented in Table 5 show that the mean values of yield components were 45.41, 206.52, 13.22, 0.96, 152.93, 67.33 and 213.53 for number of plants per net plot, plant height (cm) number of leaves per plant, number of cobs per plant, weight of cob (g), grain weight (g) per cob and 1000 seed weight (g), respectively.

Biogas plant slurry levels :

All the important yield components recorded were influenced significantly due to different levels of slurry. The number of plants per net plot at harvest and number of cobs per plant were not affected significantly. The plant height was significantly increased due to application of different levels of slurry

Table 5. Growth and yield components of maize as influenced by different treatments.

| Treatments | Number of plants/Net plot | Plant height (cm) | No. of leaves/plant | No. of cobs/plant | Wt. of cob (g) | Grain Wt./cob (g) | 1000 seed Wt. (g) |
|-------------------|---------------------------|-------------------|---------------------|-------------------|----------------|-------------------|-------------------|
| Slurry (t/ha) | | | | | | | |
| 0 | 45.33 | 187.77 | 12.44 | 0.92 | 130.09 | 58.67 | 209.14 |
| 5 | 45.55 | 208.33 | 12.88 | 0.96 | 150.65 | 66.18 | 212.00 |
| 7.5 | 45.00 | 212.22 | 13.66 | 0.99 | 158.86 | 68.35 | 214.92 |
| 10 | 45.77 | 217.77 | 13.88 | 1.00 | 172.94 | 76.12 | 218.07 |
| S.E. _± | 2.19 | 2.51 | 0.29 | 0.92 | 2.69 | 0.84 | 0.15 |
| C.D. at 5% | - | 7.36 | 0.84 | - | 7.89 | 2.46 | 0.43 |
| Nitrogen (kg/ha) | | | | | | | |
| 0 | 45.08 | 197.08 | 12.83 | 0.95 | 141.64 | 61.47 | 209.58 |
| 50 | 45.42 | 206.66 | 13.33 | 0.96 | 152.41 | 67.79 | 213.80 |
| 100 | 45.75 | 215.53 | 13.50 | 0.98 | 164.75 | 72.23 | 217.22 |
| S.E. _± | 1.90 | 2.17 | 0.25 | 0.02 | 2.33 | 0.72 | 0.13 |
| C.D. at 5% | - | 6.36 | - | - | 6.83 | 2.11 | 0.38 |
| Interaction | | | | | | | |
| S.E. _± | 3.79 | 4.34 | 0.49 | 0.04 | 4.65 | 1.45 | 0.26 |
| C.D. at 5% | - | - | - | - | - | - | 0.76 |
| Mean | 45.41 | 206.52 | 13.22 | 0.96 | 152.93 | 67.33 | 213.53 |

as compared to control. The increase in plant height might be due to the availability of additional nitrogen from slurry for plant growth. Further, it was observed that the application of slurry at 10 tonnes/ha also increased plant height significantly over slurry application at 5 tonnes/ha. The application of slurry at 7.5 and 10 tonnes/ha significantly increased the number of leaves per plant as compared to control. The slurry application at 10 tonnes/ha also increased number of leaves per plant over slurry application at 5 tonnes/ha.

The important yield components viz., weight of cob, grain weight per cob and 1000 seed weight were significantly increased with increased levels of slurry application. Thus, response was graded and significant. This was attributed to the release of more nitrogen with increased levels of slurry for plant use. Jagtap and Pharande (1982) reported increase in panicle character of sorghum due to higher doses of organic matter application.

Nitrogen levels :

The number of plants per net plot, number of leaves per plant and number of cobs per plant were not influenced significantly due to different levels of nitrogen application. However, plant height, weight of cobs, grain weight

per cob and 1000 seed weight were significantly increased with increased levels of nitrogen application. Thus, response was graded and significant. Garkal (1970), Subramaniam (1977), Shinde and Khuspe (1978) and Subramaniam et al. (1982) also reported increase in yield attributing characters with increased levels of nitrogen application.

Interaction :

Interaction effects between different levels of slurry and nitrogen application in respect of different yield components were found to be non-significant except 1000 seed weight.

Table 6. Mean 1000 seed weight (g) as influenced by interaction of slurry and nitrogen levels.

| Slurry (t/ha) | Nitrogen | | |
|-------------------------------------|----------|--------|--------|
| | : 0 | : 50 | : 100 |
| 0 | 206.23 | 209.23 | 211.97 |
| 5 | 208.03 | 212.50 | 215.47 |
| 7.5 | 210.93 | 214.87 | 218.97 |
| 10 | 213.13 | 218.60 | 222.50 |
| S.E.* = 0.26 C.D. at 5% = 0.76 | | | |

It was observed from the data presented in Table 6, that 1000 seed weight was significantly increased with increased levels of slurry application at all the levels of nitrogen. Similarly, 1000 seed weight was significantly increased with increased levels of nitrogen application at all the levels of slurry.

4.2 Yield

The data pertaining to the grain and stover yield and harvest index are presented in Table 7 and graphically shown in Fig. 2.

Table 7. Mean yield and harvest index of maize as influenced by different treatments.

| Treatments | Yield (q/ha) | | Harvest index |
|------------------|--------------|--------|---------------|
| | Grain | Stover | |
| Slurry (t/ha) | | | |
| 0 | 14.78 | 39.07 | 27.79 |
| 5 | 19.26 | 46.50 | 29.95 |
| 7.5 | 21.78 | 47.23 | 31.48 |
| 10 | 23.42 | 51.05 | 31.33 |
| S.E.* | 0.36 | 0.88 | 0.72 |
| C.D. at 5% | 1.02 | 2.58 | 2.12 |
| Nitrogen (kg/ha) | | | |
| 0 | 17.81 | 42.80 | 29.35 |
| 50 | 19.57 | 46.64 | 29.54 |
| 100 | 22.04 | 48.46 | 31.51 |
| S.E.* | 0.31 | 0.76 | 0.63 |
| C.D. at 5% | 0.91 | 2.22 | 1.84 |
| Interaction | | | |
| S.E.* | 0.62 | 1.52 | 1.25 |
| C.D. at 5% | 1.81 | 4.46 | - |
| Mean | 19.80 | 45.96 | 30.13 |

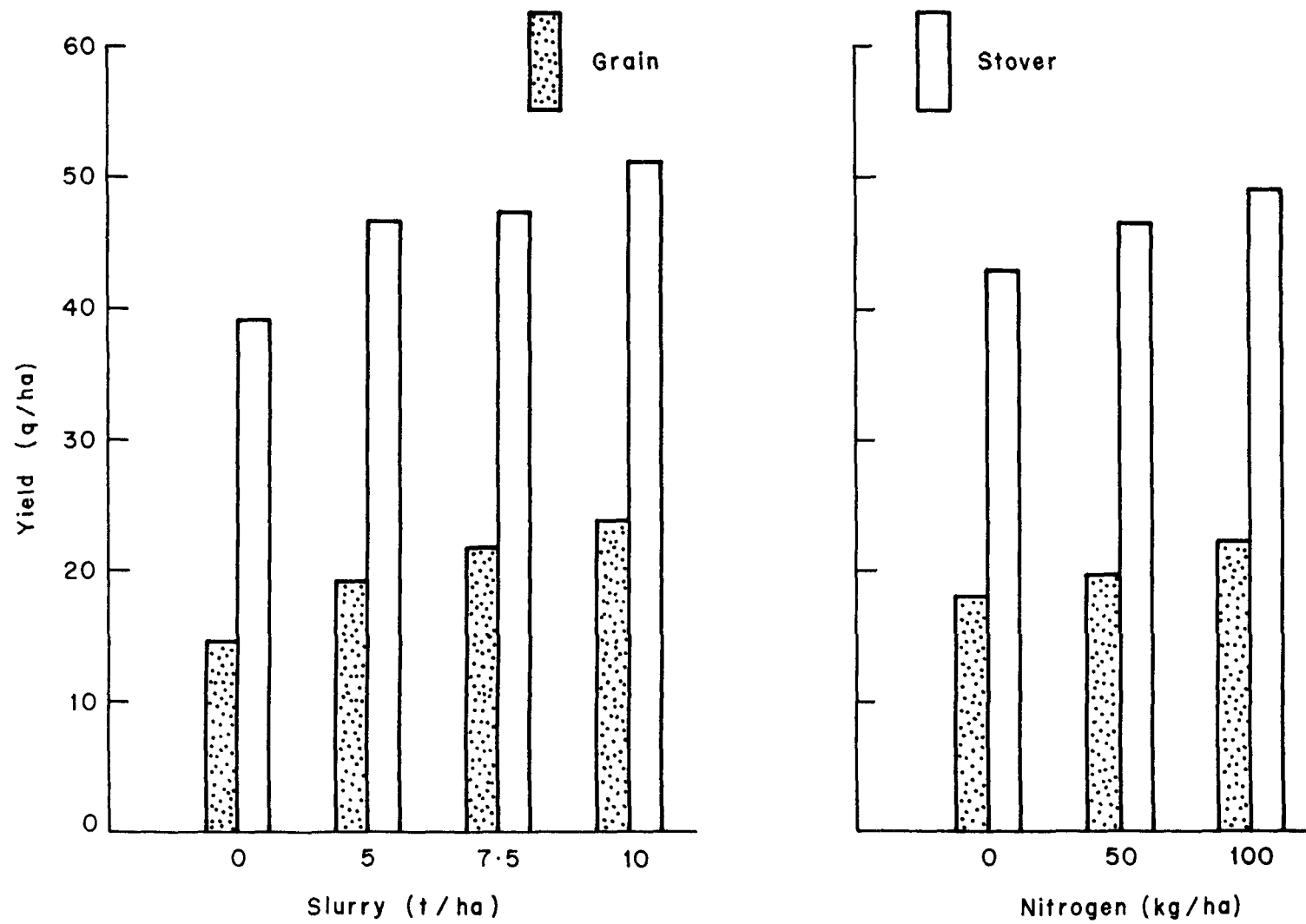


Fig . 2 . Mean grain and stover yield of maize as influenced by different treatments.

It was observed from the data presented in Table 7 that the mean grain and stover yields were 19.80 and 45.96 q/ha, respectively. The mean harvest index was 30.13.

Biogas plant slurry levels

The maize grain yield was significantly increased with increased levels of slurry applications. The grain yield was increased by 35.06, 47.36 and 58.46 per cent, due to application of 5, 7.5 and 10 tonnes/ha slurry, respectively, over control. The increase in grain yield with increased levels of slurry was due to increase in important yield components viz., weight of cobs, grain weight per cob and 1000 seed weight. The application of increased levels of slurry might have released more nutrients, particularly nitrogen, which perhaps creates a favourable effect on the nature of the roots and uptake system of plants resulting in increased grain yield. Increase in grain yield with increased levels of slurry was partly attributed to the improved physical^{and} chemical and biological properties of the soil. Dass et al. (1981), Vasil'ev et al. (1981), Etherbridge et al. (1984), Krishnasamy et al. (1984) also reported increaseⁱⁿ maize grain yield due to application of increased levels of slurry or organic manures.

The stover yield of maize was significantly increased due to application of different levels of slurry as compared

to control. Further, it was noticed that the application of 10 tonnes/ha of slurry also gave significantly more stover yield than slurry applied at 5 tonnes/ha. The stover yield was increased by 19.02, 20.89 and 30.67 per cent due to application of 5, 7.5 and 10 tonnes/ha of slurry, respectively, over control. The increase in stover yield due to slurry application was attributed to increase in plant height and number of leaves per plant. The application of increased levels of slurry might have also released more nutrients for plant use and resulted in increased stover yield. The results corroborate the findings of Pain et al. (1971), Roger et al. (1977), Dass et al. (1981), Krishnasamy et al. (1984).

The application of different levels of slurry were found to be on par with each other, however, significantly increased harvest index as compared to control. This indicated that conversion efficiency from vegetative to reproductive phase was increased due to slurry application.

Nitrogen levels

The maize grain yield was significantly increased with increased levels of nitrogen application. The grain yield was increased by 9.88 and 23.75 per cent due to application of 50 and 100 kg N/ha, respectively, over control. The increase in grain yield was due to increase in important

yield attributing characters. viz., weight of cob, grain weight per cob and 1000 grain weight. Results are inconformity with the findings of Shinde and Khuspe (1978), Singh (1980), Sarkar and Sinha (1981), Subramaniam et al.(1982), Prasad et al. (1985), Subramanian et al. (1987) and Chowdhary and Tribedi (1988).

The application of 50 and 100 kg N/ha were found to be on par with each other but significantly increased stover yield as compared to control. The stover yield of maize was increased by 8.97 and 13.22 per cent with the application of 50 and 100 kg N/ha, respectively, over control. The increase in stover yield was due to increase in plant height due to nitrogen application. Similar findings were reported by Kareem and Relwani (1971), Bhargava et al. (1978), Dass et al. (1981), Rao and Bhardwaj (1981), Subramaniam et al. (1982) and Subramanian et al. (1987).

The application of 100 kg N/ha significantly increased harvest index as compared to application of 50 kg N/ha and control which were found to be on par with each other.

Interaction

The grain and stover yields of maize were significantly influenced due to interaction between different levels of slurry and nitrogen application.

Table 8. Mean grain and stover yield as affected by interaction between slurry and nitrogen levels.

| Slurry (t/ha) | Nitrogen (kg/ha) | | | | | | |
|------------------|-------------------|-------|-------|---|--------------------|-------|-------|
| | Grain yield(q/ha) | | | : | Stover yield(q/ha) | | |
| | 0 | 50 | 100 | : | 0 | 50 | 100 |
| 0 | 13.44 | 14.95 | 15.95 | | 32.70 | 38.40 | 46.13 |
| 5 | 18.30 | 18.65 | 20.83 | | 45.61 | 47.46 | 46.45 |
| 7.5 | 19.32 | 21.67 | 24.26 | | 44.77 | 48.30 | 43.64 |
| 10 | 20.21 | 23.01 | 27.05 | | 48.12 | 52.40 | 52.65 |
| S.E.+ | 0.61 | | | | 1.52 | | |
| C.D.at 5% | 1.81 | | | | 4.46 | | |

The application of different levels of slurry significantly increased grain yield over control at different levels of nitrogen. Further, it was observed that application of 10 tonnes/ha of slurry significantly increased grain yield over 5 tonnes/ha of slurry at different nitrogen levels. The grain yield at 0 and 5 tonnes/ha of slurry was significantly more due to application of 100kg N/ha over control. However, the increased levels of nitrogen application increased grain yield at higher levels of slurry (7.5 and 10 t/ha).

The application of different levels of slurry significantly increased stover yield over control at no nitrogen and 50 kg N/ha application. The application of slurry at 10 tonnes/ha significantly increased stover yield over control and 5 tonnes/ha of slurry when 100 kg N/ha was applied. The stover yield was significantly increased with increased levels of nitrogen application when slurry was not applied. The application of 100 kg N/ha gave significantly more stover yield over control when 10 tonnes/ha of slurry was applied.

The data presented in Table 7 show that the grain and stover yield of maize obtained at 5 and 7.5 tonnes/ha of slurry were equivalent to that of 50 and 100 kg N/ha application, respectively. With the introduction of biogas plant, it offers a dual scope to utilize the dung both as a source of fuel as well as manure. The slurry coming out of gober gas plant is rich in major and trace elements. It improves physical^{and} chemical and biological properties of soil than chemical fertilizers. Therefore, it would be advisable to use 7.5 tonnes/ha of slurry instead of applying 100 kg N/ha through urea or any other fertilizer source.

4.3 Nutrient content and its uptake

Data regarding mean N, P and K content in grain and stover and crude protein content of maize grain are presented in Table 9 and nutrient uptake in Table 10 and graphically depicted in Fig. 3.

The mean N, P and K content of maize grain was 1.706, 0.225 and 0.290 and that of maize stover was 0.770, 0.113 and 0.804 per cent, respectively. The mean crude protein content of maize grain was 10.66 per cent (Table 9).

The data presented in Table 10 show that the N, P and K uptake by grain was 34.57, 4.53 and 5.79 and that of stover was 35.52, 5.22 and 37.02 kg/ha, respectively. The mean total N, P and K uptake was 70.20, 9.76 and 42.82 kg/ha, respectively.

Biogas plant slurry levels

The N, P and K content of maize grain and stover was significantly increased with increased levels of slurry application. The mineralization of biomass of biogas plant slurry might have provided additional N, P and K which might be absorbed by maize in higher quantities resulting in higher contents of these nutrients with increased levels of slurry application. Similar results were reported by Koriath et al. (1985).

Table 9. Mean percentage of nitrogen, phosphorus and potash in maize grain and stover and crude protein content in grain as affected by different treatments.

| Treatments | Grain | | | : | Stover | | | Crude protein |
|------------------|-------|--------|--------|---------|--------|--------|-------|---------------|
| | N | P | K | | N | P | K | |
| | P e r | | | C e n t | | | | |
| Slurry (t/ha) | | | | | | | | |
| 0 | 1.488 | 0.196 | 0.279 | 0.738 | 0.107 | 0.788 | 9.30 | |
| 5 | 1.538 | 0.216 | 0.288 | 0.762 | 0.109 | 0.799 | 9.61 | |
| 7.5 | 1.702 | 0.240 | 0.294 | 0.774 | 0.114 | 0.810 | 10.63 | |
| 10 | 2.097 | 0.247 | 0.300 | 0.805 | 0.121 | 0.819 | 13.10 | |
| S.E.* | 0.008 | 0.0006 | 0.0003 | 0.004 | - | 0.0006 | 0.05 | |
| C.D. at 5% | 0.023 | 0.0018 | 0.0009 | 0.012 | ** | 0.0018 | 0.13 | |
| Nitrogen (kg/ha) | | | | | | | | |
| 0 | 1.636 | 0.221 | 0.288 | 0.764 | 0.112 | 0.801 | 10.22 | |
| 50 | 1.708 | 0.224 | 0.290 | 0.768 | 0.112 | 0.804 | 10.67 | |
| 100 | 1.775 | 0.229 | 0.292 | 0.777 | 0.115 | 0.807 | 11.09 | |
| S.E.* | 0.007 | 0.0005 | 0.0003 | 0.003 | - | 0.0005 | 0.04 | |
| C.D. at 5% | 0.020 | 0.0015 | 0.0009 | 0.009 | ** | 0.0015 | 0.11 | |
| Interaction | | | | | | | | |
| S.E.* | 0.014 | 0.0011 | 0.0006 | 0.006 | - | 0.0011 | 0.08 | |
| C.D. at 5% | 0.040 | - | 0.0018 | - | ** | - | - | |
| Mean | 1.706 | 0.225 | 0.290 | 0.770 | 0.113 | 0.804 | 10.66 | |

** Highly significant.

The crude protein content of maize grain was significantly increased with increased levels of slurry application. The absorption of extra nitrogen by maize grain with increased levels of slurry might have resulted in more nitrogen content in grain and consequently more crude protein. Jagtap and Pharande (1982) also reported increased crude protein content of sorghum grain due to increased levels of organic matter application.

The N, P and K uptake by maize grain and stover and total uptake of these nutrients was significantly increased with increased levels of slurry application except N and K uptake by stover and total K uptake where the application of 5 and 7.5 tonnes/ha of slurry levels were found to be on par with each other. This was attributed to the increased grain and stover yield and N, P and K content of grain and stover with increased levels of slurry application. The results are in agreement with the findings of Rogers et al. (1976).

Nitrogen levels

The N, P and K content of maize grain and stover was significantly more with the increased levels of nitrogen application except N content in maize stover, where there was no significant difference between different nitrogen levels. The higher absorption of N at higher levels of

Table 10. Mean uptake of nutrients as influenced by different treatments.

| Treatments | U p t a k e | | | | | | | | | | |
|------------------|-------------|------|------|--------|------|-------|-------|-------|---|---|-------|
| | Grain | | | Stover | | | Total | | | | |
| | N | P | K | N | P | K | N | P | N | P | K |
| | kg/ha | | | | | | | | | | |
| Slurry (t/ha) | | | | | | | | | | | |
| 0 | 22.01 | 2.90 | 4.16 | 28.90 | 4.19 | 30.80 | 50.92 | 7.10 | | | 34.96 |
| 5 | 29.64 | 4.16 | 5.55 | 35.46 | 5.08 | 37.19 | 65.11 | 9.25 | | | 42.74 |
| 7.5 | 37.17 | 5.24 | 6.42 | 36.60 | 5.41 | 38.29 | 73.77 | 10.69 | | | 44.72 |
| 10 | 49.47 | 5.79 | 7.02 | 41.12 | 6.21 | 41.80 | 90.59 | 12.00 | | | 48.83 |
| S.E.† | 0.53 | 0.08 | 0.10 | 0.76 | 0.10 | 0.78 | 0.89 | 0.14 | | | 0.81 |
| C.D. at 5% | 1.55 | 0.23 | 0.29 | 2.22 | 0.29 | 2.28 | 2.61 | 0.41 | | | 2.37 |
| Nitrogen (kg/ha) | | | | | | | | | | | |
| 0 | 29.47 | 3.99 | 5.15 | 32.82 | 4.81 | 34.32 | 62.30 | 8.83 | | | 39.47 |
| 50 | 34.06 | 4.46 | 5.73 | 35.98 | 5.27 | 37.59 | 70.05 | 9.74 | | | 43.33 |
| 100 | 40.17 | 5.12 | 6.48 | 37.76 | 5.59 | 39.15 | 77.04 | 10.72 | | | 45.64 |
| S.E.† | 0.46 | 0.07 | 0.08 | 0.65 | 0.09 | 0.68 | 0.77 | 0.12 | | | 0.70 |
| C.D. at 5% | 1.34 | 0.20 | 0.23 | 1.90 | 0.26 | 1.99 | 2.26 | 0.35 | | | 2.05 |
| Interaction | | | | | | | | | | | |
| S.E.† | 0.92 | 0.14 | 0.17 | 1.31 | 0.18 | 1.36 | 1.53 | 0.25 | | | 1.41 |
| C.D. at 5% | 2.69 | - | 0.49 | - | - | - | 4.49 | - | | | - |
| Mean | 34.57 | 4.53 | 5.79 | 35.52 | 5.22 | 37.02 | 70.09 | 9.76 | | | 42.82 |

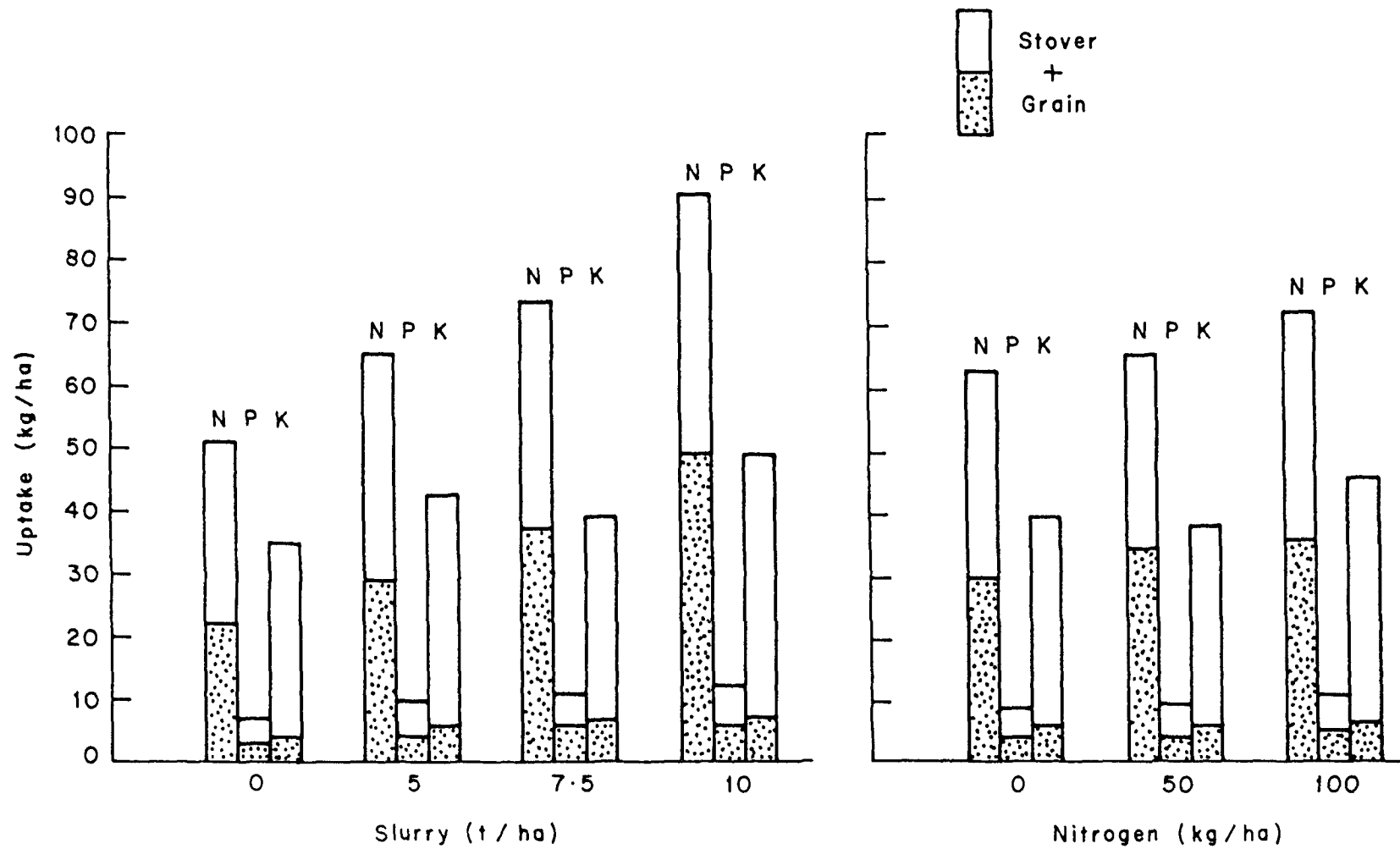


Fig. 3. Mean N, P and K uptake by maize grain and stover as influenced by different treatments.

applied nitrogen might have resulted in more nutrient content in maize grain and stover. Similar results were reported by Subramaniam et al. (1982).

The crude protein content of maize grain was significantly improved with the increased levels of nitrogen application (Table 9). The increased N absorption with increased nitrogen levels resulted in a greater accumulation of nitrogen in grain and consequently increased the crude protein content. The increase in crude protein content of maize grain with increased levels of nitrogen was also reported by Kareem and Relwani (1971), Reddy and Kaliappa (1974), Perry and Olsen (1975), Subramaniam et al. (1981) and Muthukrishnan and Subramanian (1984).

The uptake of N, P and K by maize grain and stover and total uptake of these nutrients was significantly increased with increased levels of nitrogen application except K uptake by maize stover where the application of 50 and 100 kg N/ha were found to be on par with each other (Table 10). This was attributed to the increased grain and stover yields and N, P and K content of grain and stover with increased levels of nitrogen application. The results corroborate the findings of Pathak et al. (1971), Sharma et al. (1975), Bhargava et al. (1978), Rao and Bhardwaj (1981), Subramanian et al. (1982) and Minhas and Metha (1984).

Interaction

The interaction effects between slurry and nitrogen levels were found to be non significant except N and K content of grain, P content of stover and N and K uptake by grain and total N uptake (Tables 9 and 10).

Table 11. Mean total nitrogen uptake (kg/ha) as influenced by interaction between slurry and nitrogen levels.

| Slurry (t/ha) | Nitrogen (kg/ha) | | |
|--------------------------|------------------|-------------------|--------|
| | 0 | 50 | 100 |
| 0 | 43.89 | 50.38 | 58.51 |
| 5 | 62.06 | 64.81 | 68.46 |
| 7.5 | 65.90 | 74.18 | 81.24 |
| 10 | 77.38 | 90.85 | 103.54 |
| S.E. _t = 1.53 | | C.D. at 5% = 4.49 | |

The total nitrogen uptake by maize was significantly increased with increased levels of slurry at all the nitrogen levels except 5 and 7.5 tonnes/ha of slurry were found to be on par where nitrogen was not applied. Similarly, total nitrogen uptake was also significantly increased with increased levels of nitrogen except 0 and 50 kg N/ha were on par with each other at 5 tonnes/ha of slurry application.

4.4 Soil properties

The physico-chemical and biological properties of soil as influenced by slurry and nitrogen application alone and in combination are discussed herewith.

4.4.1 Physical properties

Data pertaining to the physical properties of soil are presented in Table 12.

The mean maximum water holding capacity (per cent), bulk density (g/cm^3) and water stable aggregates (> 0.25 mm) were 62.61, 1.31 and 39.71, respectively (Table 12.).

Biogas plant slurry levels

The maximum waterholding capacity was significantly influenced by the application of different slurry levels. The application of different levels of slurry significantly increased maximum water holding capacity as compared to control. The increase in water retention at saturation due to the application of slurry is expected from the more organic matter content and improved aggregation, resulting in favourable pore geometry of the soil. Similar results were reported by Salter and Haworth (1962), Biswas and Ali (1969), Biswas et al. (1971), Gattani et al. (1976), Gupta et al. (1983) and Rayar (1984). Further, it was noticed that

slurry applied at 7.5 and 10 tonnes/ha also significantly increased maximum water holding capacity as compared to 5 tonnes/ha of slurry application.

Table 12. Physical properties of soil as affected by different treatments.

| Treatments | Maximum water holding capacity (per cent) | Bulk density (g/cm ³) | Water stable aggregates (>0.25 mm) |
|-------------------|---|------------------------------------|-------------------------------------|
| Slurry (t/ha) | | | |
| 0 | 60.44 | 1.39 | 33.67 |
| 5 | 61.77 | 1.31 | 37.49 |
| 7.5 | 63.55 | 1.30 | 41.90 |
| 10 | 64.66 | 1.27 | 45.80 |
| S.E. _± | 0.40 | 0.04 | 0.37 |
| C.D. at 5% | 1.16 | - | - |
| Nitrogen (kg/ha) | | | |
| 0 | 62.00 | 1.31 | 37.72 |
| 50 | 62.83 | 1.31 | 40.22 |
| 100 | 63.00 | 1.32 | 41.21 |
| S.E. _± | 0.34 | 0.03 | 0.32 |
| C.D. at 5% | - | - | 0.94 |
| Interaction | | | |
| S.E. _± | 0.68 | 0.06 | 0.64 |
| C.D. at 5% | - | - | - |
| Mean | 62.61 | 1.31 | 39.71 |

It was also observed that the bulk density of the soil was not significantly affected due to application of different levels of slurry. However, with increased levels of slurry application, the bulk density was slightly decreased. Incorporation of slurry resulted in decrease in bulk density as compared to original soil (1.32 g/cm³). The decrease in bulk density with an addition of slurry or organic matter was also reported by Shanmugam and Ravi Kumar (1980), Singh et al. (1980), Bhatia and Ganguly (1981) and Gupta et al. (1983).

The water stable aggregates (> 0.25 mm) were significantly increased with the increased levels of slurry application. The stability of aggregates depends upon the kind of clay, the chemical compounds around the clay, nature and amount of root growth and nature of decomposition and its products with microbial population. Therefore, improved aggregation with increased levels of slurry in the present investigation are attributable to roots and root residues left in slurry plots and the decomposition pattern and microflora of rhizosphere and organic carbon status of the soil. Increased availability of phosphorus in slurry plots would have also helped in better aggregation. The results are in agreement with the findings of Biswas et al. (1964),

Ghosh et al. (1968), Bavaskar and Zende (1973), Indiraraja and Raj (1979), Shanmugam and Ravi Kumar (1980) and Muthuvel et al. (1982).

Organic matter makes an important contribution to good soil structure through its stabilizing influence on soil aggregates (Parson, 1984). Subbiah (1984) stated that bulky organic manures were held to be important contributors to the soil productivity.

Nitrogen levels

The maximum water holding capacity and bulk density were not influenced due to application of different levels of nitrogen. However, these values were slightly increased with increased levels of nitrogen application. Biswas et al. (1971), Prasad et al. (1983) and Grewal et al. (1985) reported an increase in bulk density with inorganic fertilizer application because of deterioration of soil structure by nitrogenous fertilizers.

The water stable aggregates (> 0.25 mm) were significantly increased with increased levels of nitrogen application. The increase in organic carbon status of the soil with increased levels of nitrogen application might have been favourably influenced the soil aggregation. Results are in conformity with the findings of Muthuvel et al.(1982), Jadhav (1986) and Acharya et al. (1988).

Interaction

The interaction effect between slurry and nitrogen levels were found to be non-significant in respect of physical properties of soil.

4.4.2 Chemical properties

Data regarding chemical properties of the soil as influenced by different treatments are presented in Table 13.

The data presented in Table 13 show the mean values of pH (8.2), Ec (0.14 mmhos/cm), organic carbon (0.76 per cent), total nitrogen (0.069 per cent), C/N ratio (11.48), available P_2O_5 (32.02 kg/ha), available K_2O (487.19 kg/ha), calcium carbonate (6.96 per cent), exchangeable cations, Ca (42.91 per cent), Mg (14.16 per cent), Na (3.4 per cent) and K (2.1 per cent).

Biogas plant slurry levels

The soil pH, electrical conductivity, organic carbon, calcium carbonate and exchangeable Na content were not influenced significantly due to application of different slurry levels. There was no definite trend for electrical conductivity. There was a decreasing trend in soil pH with increased levels of slurry, decline being more pronounced under 10 tonnes/ha of slurry treatment. Similar results were reported by Acharya et al. (1988).

Table 13. Chemical properties of soil as affected by different treatments.

| Treatments | pH | EC (mmhos/cm) | Organic carbon (per cent) | Total nitrogen (per cent) | C/N ratio | Available | | CaCO ₃ (per cent) | Exchangeable cations (Per cent) | | | |
|-----------------|------|------------------|------------------------------|------------------------------|-----------|--|-----------------------------|---------------------------------|------------------------------------|-------|------|------|
| | | | | | | P ₂ O ₅ (kg/ha) | K ₂ O (kg/ha) | | Ca | Mg | Na | K |
| Slurry (t/ha) | | | | | | | | | | | | |
| 0 | 8.24 | 0.13 | 0.76 | 0.062 | 12.31 | 28.12 | 479.55 | 7.05 | 41.11 | 11.22 | 3.37 | 1.88 |
| 5 | 8.21 | 0.14 | 0.78 | 0.066 | 12.01 | 31.52 | 485.55 | 7.00 | 41.33 | 13.44 | 3.41 | 2.11 |
| 7.5 | 8.20 | 0.15 | 0.79 | 0.071 | 11.19 | 33.61 | 490.33 | 6.94 | 43.22 | 15.55 | 3.46 | 2.13 |
| 10 | 8.18 | 0.14 | 0.80 | 0.078 | 10.40 | 34.85 | 493.33 | 6.83 | 46.00 | 16.44 | 3.56 | 2.51 |
| S.E.# | 0.02 | 0.02 | 0.01 | 0.002 | 0.37 | 0.49 | 0.86 | 0.27 | 0.41 | 0.52 | 0.06 | 0.04 |
| C.D. at 5% | - | - | - | 0.006 | 1.08 | 1.44 | 2.52 | - | 1.19 | 1.53 | - | 0.10 |
| Nitrogen(kg/ha) | | | | | | | | | | | | |
| 0 | 8.22 | 0.14 | 0.77 | 0.067 | 11.65 | 30.61 | 486.00 | 7.08 | 42.33 | 13.00 | 3.51 | 2.05 |
| 50 | 8.20 | 0.14 | 0.78 | 0.069 | 11.53 | 32.17 | 487.17 | 7.00 | 43.00 | 14.00 | 3.43 | 2.08 |
| 100 | 8.20 | 0.15 | 0.80 | 0.072 | 11.25 | 33.29 | 488.42 | 6.79 | 43.41 | 15.50 | 3.40 | 2.33 |
| S.E.# | 0.01 | 0.01 | 0.01 | 0.002 | 0.32 | 0.43 | 0.74 | 0.23 | 0.35 | 0.45 | 0.05 | 0.03 |
| C.D. at 5% | - | - | - | - | - | 1.25 | - | - | - | 1.33 | - | 0.09 |
| Interaction | | | | | | | | | | | | |
| S.E.# | 0.03 | 0.03 | 0.02 | 0.003 | 0.64 | 0.85 | 1.49 | 0.46 | 0.71 | 0.90 | 0.11 | 0.06 |
| C.D. at 5% | - | - | - | - | - | - | - | - | - | 2.65 | - | 0.18 |
| Mean | 8.20 | 0.14 | 0.78 | 0.069 | 11.48 | 32.02 | 487.19 | 6.96 | 42.91 | 14.16 | 3.45 | 2.16 |

Organic carbon content of the soil registered increase with increased levels of slurry application. The organic carbon content of the soil slightly declined under control treatment where as increased slightly under plots where slurry was applied as compared to original organic carbon content (0.77 per cent). An increase in organic carbon content with the continuous application of organic matter was reported by Acharya and Rajgopalan (1956), Gattani et al. (1976), Indiraraja and Raj (1979), Singh et al. (1980), Pandia (1980), Singh et al. (1983) and Rayar (1984).

The application of slurry at 7.5 and 10 tonnes/ha significantly increased the total nitrogen content as compared to control and 5 tonnes/ha of slurry which were on par with each other. The beneficial increase in organic carbon content of the soil and significant increase in number of bacteria and fungi with increased levels of slurry application increased total nitrogen content of the soil. Similar results were reported by Gaikwad and Khuspe (1976), Indiraraja and Raj (1979), Pandia (1980) and Koriath et al. (1985).

The application of 7.5 and 10 tonnes/ha of slurry had significantly narrowed C/N ratio as compared to control. It may be due to less release of organic carbon which helped in narrowing C/N ratio. Chakrabarty and Sen (1967) also reported narrowed C/N ratio due to manuring.

The application of higher levels of slurry viz., 7.5 and 10 tonnes/ha significantly recorded more available P_2O_5 content than control and 5 tonnes/ha of slurry. Further, it was noticed that the application 5 tonnes/ha of slurry also registered significant improvement in available P_2O_5 content than control. This may be attributed to the mineralization of organic P, contributing its accumulation in soil (Vig and Bhumbra, 1970). The increase in soil P content due to organic matter application was also reported by Indira Raja and Raj (1979), Pandia (1980) and Singh et al. (1983).

The available K_2O content of the soil was significantly increased with increased levels of slurry application . This was attributed to the progressive incorporation of K through biogas plant slurry and improved retention of bases in the soil. Results are in agreement with the findings of Kanwar and Prihar (1962), Gaikwad and Khuspe (1976) and Singh et al. (1983). A significant depletion of available K_2O from the initial level (484.0 kg/ha) under control treatment was visible, because maize wholly depended for their K needs on soil K reserve.

The application of 10 tonnes/ha of slurry significantly increased exchangeable Ca, Mg and K over control and lower

levels of slurry application. The application of 7.5 tonnes/ha of slurry also significantly improved exchangeable Ca and Mg than 5 tonnes/ha of slurry application and control. Singh et al. (1980) reported that application of F.Y.M. increased the cation exchange capacity and exchangeable cations in the soil. A significant reduction in exchangeable K content under control treatment as compared to slurry treatments was observed owing to crop wholly depended for their K need on soil K-reserve. Rayar (1984) reported that due to application of farm yard manure there was significant improvement in cation exchange capacity of soil.

Nitrogen levels

All the chemical properties were not influenced significantly due to application of different nitrogen levels except available P_2O_5 and exchangeable Mg and K content.

There was a slight reduction in soil pH due to nitrogen fertilization than control. The increased removal of cations due to higher production under nitrogen treatments might have contributed indirectly to the lowering of pH. Similar results were reported by Minhas and Metha (1984).

There was a slight improvement in organic carbon and total nitrogen content of the soil with increased levels

of nitrogen application. Subbiah (1984), Jadhav (1986) and Acharya et al. (1988) noticed higher nitrogen and organic carbon content due to continuous use of nitrogenous fertilizers in rotation. The C/N ratio was slightly narrowed with increased application of nitrogen.

The application of 50 and 100 kg N/ha showed significant improvement in available P_2O_5 content of the soil over control. The increased root mass due to nitrogen application might have mineralized fixed P and increased its content in the soil. The increase in available P_2O_5 content of soil due to increased levels of fertilization was also reported by Singh et al. (1980), Singh et al. (1983), Jadhav (1986) and Acharya et al. (1988).

The slight improvement in available K_2O content and exchangeable Ca content was observed due to increased levels of nitrogen application, however, $CaCO_3$ and exchangeable Na were slightly declined with increased levels of nitrogen application.

The application of 100 kg N/ha significantly improved exchangeable Mg and K content of the soil as compared to the control and 50 kg N/ha.

The interaction effects between slurry and nitrogen levels in respect of chemical properties were found to be non-significant except exchangeable Mg and K.

Table 14. Exchangeable Mg and K (per cent) as influenced by interaction between slurry and nitrogen levels.

| Slurry (t/ha) | Nitrogen (kg/ha) | | | | | |
|---------------|------------------|-------|-------|----------------|------|------|
| | Exchangeable Mg | | | Exchangeable K | | |
| | 0 | 50 | 100 : | 0 | 50 | 100 |
| 0 | 10.67 | 11.33 | 11.67 | 1.67 | 1.70 | 2.27 |
| 5 | 12.00 | 12.00 | 16.33 | 2.03 | 2.03 | 2.27 |
| 7.5 | 12.00 | 18.33 | 16.33 | 2.03 | 2.17 | 2.20 |
| 10 | 13.00 | 16.00 | 20.33 | 2.27 | 2.43 | 2.83 |
| S.E.± | 0.90 | | | 0.06 | | |
| C.D. at 5% | 2.65 | | | 0.18 | | |

The application of 10 tonnes/ha of slurry significantly increased exchangeable Mg and K as compared to control at all the nitrogen levels (Table 14). The application of 7.5 tonnes/ha of slurry significantly increased exchangeable Mg and K over control at 50 and 100 kg N/ha and 0 and 50 kg N/ha, respectively. The application of 100 kg N/ha resulted in significant improvement of exchangeable Mg and K content as compared to control at all the levels of slurry application except exchangeable K content at 7.5 tonnes/ha of slurry application.

4.4.3 Biological properties

Data regarding biological properties of soil are presented in Table 15.

The data presented in Table 15 indicate that the mean number of bacteria, fungi and actinomycetes are 17.08, 11.00 and 1.91 ($10^4/g$) of soil, respectively.

Biogas plant slurry levels

The application of different levels of the slurry did not influence the number of actinomycetes significantly. However, the application of different levels of slurry significantly improved bacteria and fungi count as compared to control. This may be attributed to the addition of slurry could increase the nutrient status as well as physico-chemical conditions for the favourable growth of these organisms. Similar results were reported by Balsubramanian et al. (1972) and Indiraraja and Raj (1979). The addition of farm yard manure and green manure to soils increased bacterial and fungi population significantly where as the number of actinomycetes did not show any significant change (Gupta et al. 1983). Further, it was noticed that the application of 7.5 and 10 tonnes/ha of slurry significantly increased the bacterial count over 5 tonnes/ha of slurry application, where as, slurry applied at 10 tonnes/ha significantly improved the fungi count than slurry applied at 5 and 7.5 tonnes/ha.

Table 15. Biological properties of soil as influenced by different treatments.

| Treatments | Bacteria | Fungi | Actino- mycetes |
|------------------|--------------|-------|--------------------|
| | ($10^4/g$) | | |
| Slurry (t/ha) | | | |
| 0 | 16.44 | 10.44 | 1.77 |
| 5 | 16.89 | 10.88 | 1.88 |
| 7.5 | 17.33 | 10.88 | 2.00 |
| 10 | 17.67 | 11.77 | 2.00 |
| S.E.* | 0.13 | 0.15 | 0.29 |
| C.D. at 5% | 0.38 | 0.43 | - |
| Nitrogen (kg/ha) | | | |
| 0 | 16.67 | 10.33 | 1.83 |
| 50 | 17.00 | 11.08 | 1.91 |
| 100 | 17.58 | 11.58 | 2.00 |
| S.E. † | 0.11 | 0.13 | 0.25 |
| C.D. at 5% | 0.32 | 0.38 | - |
| Interaction | | | |
| S.E.* | 0.22 | 0.25 | 0.51 |
| C.D. at 5% | - | - | - |
| Mean | 17.08 | 11.00 | 1.91 |

Nitrogen levels

The actinomycetes count was not significantly affected due to different levels of nitrogen application. However, the bacterial and fungi population was significantly increased with the increased levels of nitrogen application. This may be attributed to addition of nitrogen could beneficially increased the nutrient status and physico-chemical conditions for the favourable growth of these organisms. Similar results were reported by Sharma et al. (1983).

Interaction

The interaction between slurry and nitrogen levels was found to be non-significant in respect of bacteria, fungi and actinomycetes count.

4.5 Correlation studies

Data in respect of association between grain yield and physico-chemical and biological properties of soil as affected by different treatments are presented in Table 16.

It is observed from the data presented in Table 16, that the important physico-chemical and biological soil properties were positively and highly significantly correlated with grain yield/ha except EC and actinomycetes count. Further, it was observed that the bulk density of soil was

Table 16. Correlation coefficient between grain yield and physical, chemical and biological properties of the soil after harvest of maize.

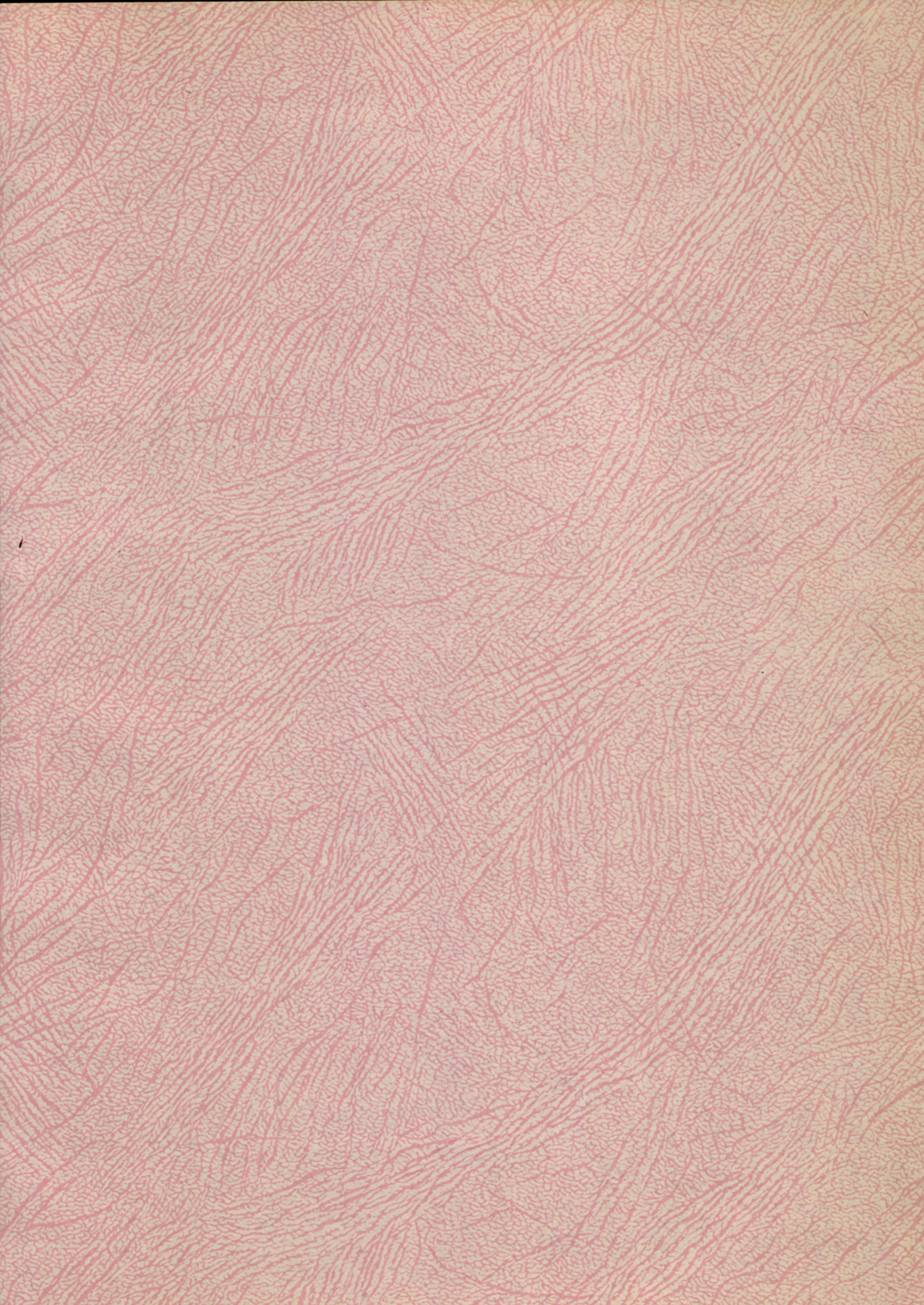
| Characters | Grain yield (g/ha) | Max. water holding capacity (%) | Bulk density (g/cc) | Water stable aggregates (0.25 mm) | pH | EC (mmhos/cm) | Organic carbon (%) | Total N (%) | Available P ₂ O ₅ (kg/ha) | Available K ₂ O (kg/ha) | Bacteria (10 ⁴ /g) | Fungi (10 ⁴ /g) | Actinomycetes (10 ⁴ /g) |
|---|--------------------|---------------------------------|---------------------|-----------------------------------|-------|---------------|--------------------|-------------|---|------------------------------------|-------------------------------|----------------------------|------------------------------------|
| Grain yield (g/ha) | 1.00 | ** | ** | ** | -0.33 | 0.35 | ** | ** | ** | ** | ** | ** | 0.14 |
| Maximum water holding capacity (%) | | 1.00 | ** | ** | -0.33 | 0.24 | ** | ** | ** | ** | ** | ** | 0.15 |
| Bulk density (g/cc) | | | 1.00 | ** | 0.47 | -0.25 | -0.47 | -0.78 | -0.67 | -0.81 | -0.61 | -0.51 | -0.23 |
| Water stable aggregates (70.25 mm) | | | | 1.00 | -0.22 | 0.18 | ** | ** | ** | ** | ** | ** | 0.23 |
| pH | | | | | 1.00 | * -0.58 | -0.01 | -0.29 | -0.38 | -0.35 | -0.37 | -0.34 | 0.02 |
| EC (mmhos/cm) | | | | | | 1.00 | 0.17 | 0.21 | 0.35 | 0.22 | 0.46 | 0.29 | -0.10 |
| Organic carbon (%) | | | | | | | 1.00 | 0.67 | 0.70 | 0.68 | 0.70 | 0.65 | 0.48 |
| Total N (%) | | | | | | | | 1.00 | ** 0.88 | ** 0.94 | ** 0.88 | ** 0.81 | 0.18 |
| Available P ₂ O ₅ (kg/ha) | | | | | | | | | 1.00 | ** 0.95 | ** 0.92 | ** 0.78 | 0.32 |
| Available K ₂ O (kg/ha) | | | | | | | | | | 1.00 | ** 0.85 | * 0.70 | 0.31 |
| Bacteria (10 ⁴ /g) | | | | | | | | | | | 1.00 | ** 0.89 | 0.13 |
| Fungi (10 ⁴ /g) | | | | | | | | | | | | 1.00 | 0.06 |
| Actinomycetes (10 ⁴ /g) | | | | | | | | | | | | | 1.00 |

* Significant.

** Highly significant.

negatively and highly significantly correlated with grain yield/ha, whereas a non significant -ve correlation between soil pH and grain yield was also noticed. Most of the chemical and biological properties were either significantly or highly significantly correlated among themselves except soil bulk density and pH which have negative correlation with all the physical^{and} chemical and biological soil properties. Negative correlations were also observed between bulk density and moisture at 1/3 and 15 bar by Reeve et al. (1973) and Mungare et al. (1983). The significant positive correlations between organic matter and soil moisture at 1/3 bar was reported by Biswas and Khosala (1971), Biswas et al. (1971) and Mungare et al. (1983). The significant +ve correlation between water stable aggregates (> 0.25 mm) and available soil moisture was also observed by Sandhu and Bhumbla (1969) and Mungare et al. (1983). Jadhav (1986) reported that organic carbon and water stable aggregates (> 0.25 mm) were +ve and highly significantly correlated whereas, bulk density was -vely and highly significantly correlated with wheat grain yield q/ha.

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5. SUMMARY AND CONCLUSIONS

The investigation was planned to evaluate the manurial value of biogas plant slurry with maize as a test crop on medium black soil. The experiment was laid out in a factorial randomised block design with three replications. There were four levels of biogas plant slurry viz., 0, 5, 7.5 and 10 tonnes/ha and three levels of nitrogen viz., 0, 50 and 100 kg/ha. The experiment on test crop maize was conducted during Kharif, 1987.

Besides yield data, yield contributing characters were recorded in maize. The N, P and K content in maize grain and stover was determined and uptake of these nutrients was also worked out. The protein content of grain was calculated. The important physico^{and}chemical and biological properties of the soil were determined.

It was observed that the important yield contributing characters were favourably influenced due to application of different levels of biogas plant slurry. The maize grain yield was significantly increased with the increased levels of slurry application. The stover yield was significantly increased with different levels of slurry as compared to control. The application 10 tonnes/ha of slurry also gave

significantly more stover yield than slurry applied at 5 tonnes/ha. The harvest index was significantly more with application of 10 tonnes/ha of slurry than control.

The N, P and K content of maize grain and stover were significantly improved due to increased levels of slurry application. The protein content of grain, N, P and K uptake by maize grain and stover and total uptake of these nutrients was increased with increased levels of slurry application.

The important physical properties viz., maximum water holding capacity and water soluble aggregates were favourably improved. The bulk density of the soil was beneficially decreased due to increased levels of slurry application.

Most of the chemical properties of the soil were favourably influenced due to increased levels of slurry application. The application of 7.5 and 10 tonnes/ha of slurry had significantly narrowed C/N ratio and increased total nitrogen and available P_2O_5 content than control. The available K_2O content of the soil was significantly improved with increased levels of slurry application. The application of 10 tonnes/ha of slurry significantly increased the exchangeable Ca and K over control and lower levels of slurry application.

The application of different levels of slurry significantly increased bacteria and fungi counts as compared to control. The slurry applied at 10 tonnes/ha also significantly improved bacterial and fungi count than slurry applied at 5 tonnes/ha.

The important yield components of maize were favourably influenced with the increased levels of nitrogen application. The grain yield of maize was significantly increased with increased levels of nitrogen application. The application of 50 and 100 kg N/ha were on par but significantly increased stover yield over control. The application of 100 kg N/ha significantly improved harvest index as compared to control and 50 kg N/ha.

The grain and stover yield of maize obtained at 5 and 7.5 tonnes/ha of slurry were equivalent to that of 50 and 100 kg N/ha application, respectively. Therefore, it would be advisable to use 7.5 tonnes/ha of slurry instead of applying 100 kg N/ha through urea.

The N, P and K content of maize grain and stover and crude protein content of maize grain was significantly improved with increased levels of nitrogen application. The uptake of N, P and K by maize grain and stover and total uptake of these nutrients was also significantly increased with increased levels of nitrogen application.

Among the physical properties, the water stable aggregates were significantly increased with increased levels of nitrogen application.

Also, most of the chemical properties did not show significant differences due to nitrogen application. However, all the chemical properties were favourably influenced with the increased levels of nitrogen application. The application of 50 and 100 kg N/ha showed significant improvement in available P_2O_5 content of the soil over control. The application of 100 kg N/ha significantly increased exchangeable Mg and K content of the soil as compared to control.

The bacterial and fungi population was significantly increased with the increased levels of nitrogen application.

CONCLUSIONS

1. The maize grain yield was significantly increased with increased levels of slurry application ;
2. The N, P and K content of maize grain and stover, crude protein content of maize grain and uptake of N, P and K showed significant improvement with increased levels of slurry application;

3. The physical^{and} chemical and biological properties of soil were significantly improved due to slurry application;
4. The maize grain yield, N, P and K content of grain and stover, crude protein content of maize grain and N, P and K uptake by maize significantly increased with the increased levels of nitrogen application.
5. The nitrogen application showed a favourable influence on physical^{and} and chemical and biological properties of the soil;
6. The grain and stover yields of maize obtained at 7.5 tonnes/ha of slurry were equivalent to that of 100 kg N/ha application. Therefore, it would be advisable to use 7.5 tonnes/ha of slurry instead of applying 100 kg N/ha through urea.

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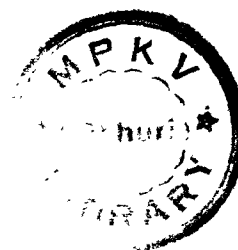
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* Original not seen.



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MASTER OF SCIENCE

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