

**USE OF ENRICHED PRESSMUD AS SOURCE OF ORGANIC  
MANURE FOR IRRIGATED MULBERRY CROP**



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# USE OF ENRICHED PRESSMUD AS SOURCE OF ORGANIC MANURE FOR IRRIGATED MULBERRY CROP

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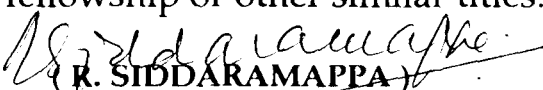
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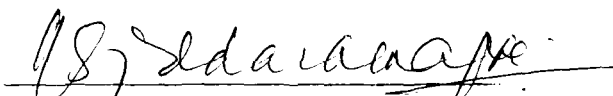
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Bangalore,  
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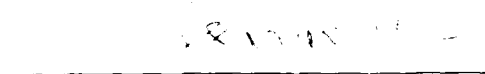
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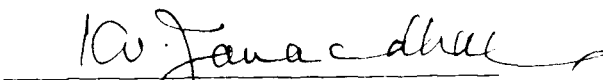
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# **INTRODUCTION**

## I INTRODUCTION

Mulberry crop is grown in India over an area of 3.13 lakh hectares. The Karnataka state accounts for 1.5 lakh hectares of mulberry plantation (Anon., 1992). Mulberry (*Morus indica* L.) leaf forms the sole source of food for silkworms (*Bombyx mori* L.) and constitutes over 70 per cent of material to biosynthesize silk proteins, sericin and fibroin. The quality of mulberry leaves has an intimate relation to the healthy growth of larvae and quality of cocoons. Nutrient management influences the quality of the mulberry leaves.

The importance of organic manuring in Indian agriculture has been known since ancient time as it augments part of total nitrogen, phosphorus and fairly a good amount of micronutrients apart from increasing availability of applied and native soil nutrients. More than the nutrients supply it improves the soil physical, chemical and biological properties thus helps in improving the soil productivity. FYM, compost, green leaf manure, green manure, oil cakes, crop residues, bone/fish meal etc. are the conventional sources of organic manures being used since time-immemorial. However, there are several unconventional sources of organic manures of industrial origin which are found to have manurial value but left untapped. For example, pressmud is an important byproduct of sugar industry found to contain considerable quantity of calcium, organic carbon and phosphorus, nitrogen, potassium and micronutrients in varying quantities. It has generally been used as soil conditioner and soil ameliorant in case of acid and alkali soils.

The pressmud cakes obtained from sulphitation and carbonation processes differ widely in their composition and are expected to influence the soil properties differently. The continuous and imbalanced use of inorganic fertilizers alone may cause a deleterious effect on the soil properties and lower the soil productivity. Moreover, there is a possibility

of essential micronutrients of the soil being depleted under continuous cropping system there by resulting in serious deficiency of these nutrients and reduction in total crop production.

Pressmud being a good source of plant nutrients is reported to have 2.4 per cent of nitrogen, 1.47 per cent of phosphorus and 1.31 per cent of potassium under sulphitation process. These values are found to be very low. However, there is a scope for increasing the nutrient content of the pressmud through enrichment. In India, vast potential of more than 2.8million tonnes of pressmud cake is available (Ramalingaswamy *et al.*, 1996). Therefore, enrichment of such organic manure to improve the nutrient content could help not only to reduce the fertilizer dose but to improve the soil quality. Addition of phosphatic fertilizers to manures during composting is an useful practice to improve the availability of phosphorus to crops. This helps to overcome the transformation of available form of phosphorus to unavailable forms of added phosphorus in acidic and calcareous soils. Addition of indigenous and cost effective rock phosphate to enriched pressmud helps to increase efficiency of added phosphorus in crop production. Further use of P-solubilizing microorganisms is found to have a favourable effect on the release of phosphorus from rock phosphate (Khalafallah *et al.*, 1982). Thus treating the pressmud with rock phosphate and P-solubilizing micro organisms might prove to be not only cost effective but also as an efficient alternative phosphorus source to the water soluble forms of phosphorus.

Since the information on use efficiency of non-conventional source of pressmud is very meager and inadequate the present investigation was undertaken to study the possibility of improving the quality of the pressmud by enriching with Farm Yard Manure, Biogas Spent Slurry and rock phosphate with P-solubilizing microorganisms and its effect on the crop yield of mulberry during kharif season under condition with the following objectives.

- a. To characterize untreated and enriched pressmud.
- b. To study the effect of enriched pressmud on growth and yield of mulberry leaf .
- c. To study the effect of enriched pressmud on the changes in physical and chemical properties of the soil.

# **REVIEW OF LITERATURE**

## II REVIEW OF LITERATURE

In an effort to understand the effect of enriched pressmud on soil properties and mulberry crop yield under Irrigated conditions, an attempt has been made to review the related work being reported on these aspects.

The research information available on the effect of enriched pressmud on properties of soil and yield of mulberry crop is very limited and fragmentary. However, the available literature on the enrichment of organic manures and their effect on crops has been reviewed and presented in this chapter under the following topics

### **2.1 Chemical composition of pressmud**

### **2.2 Effect of fertilizers, organic manures and pressmud on crops**

### **2.3 Effect of enriched manures on crop production**

### **2.4 Effect of pressmud on physical, chemical and biological properties of soil**

### **2.5 Bio-organic influence on phosphorus availability**

### **2.1 Chemical composition of pressmud**

Antil *et al.* (1987) reported that pressmud cake from sulphitation process had pH 5.6, EC 3.2  $\text{dsm}^{-1}$  and 43.2 per cent of organic carbon, 3.08 per cent of nitrogen, 0.62 per cent of phosphorus, 0.31 per cent of potassium, 16.25 per cent of sulphur, 3.00 per cent of calcium and 1.99 per cent of magnesium. Among micronutrients, 880.0 ppm of iron, 111.1 ppm of manganese, 153.1 ppm of zinc and 45.0 ppm of copper.

Narwal *et al.* (1990) reported that the chemical composition of sulphitation pressmud cake had pH 5.6, EC 3.2  $\text{dsm}^{-1}$ , 43.2 per cent of organic carbon 3.08 per cent of nitrogen and 0.62 per cent of phosphorus.

Virendrakumar and Mishra (1991) reported the chemical composition of sulphitation pressmud. It had pH 7.5, 26 per cent of organic carbon, 1.07 per cent of nitrogen, 2.62 per cent of phosphorus 1.75 per cent of potassium and 2500 ppm of iron, 1500 ppm of manganese, 272ppm of zinc and 126ppm of copper.

Narwal *et al.* (1993) reported on the chemical composition of sulphitation cake. It had pH 6.5, EC 2.6  $\text{dsm}^{-1}$ , 41.3 per cent of organic carbon and 2.9 per cent of phosphorus.

Abubacker and Rao (1995) reported on the chemical composition of pressmud. It had 1.8 per cent of nitrogen, 3.2 per cent of phosphorus and 2.1 per cent of potassium. Calcium and magnesium contents were 4.1 per cent and 1.2 per cent respectively. However, the micronutrients were in traces.

Prakash *et al.* (1995) reported that *Zinc, Manganese, and Copper* were abundant in pressmud.

## **2.2 Effect of fertilizers, organic manures and pressmud on crops**

Application of 200 kg nitrogen / ha / year resulted in 40 per cent increase in yield compared to control while application of 100kg phosphorus and 50 kg of potassium/ha/year increased the leaf yield marginally compared to no phosphorus and potassium application (Kasiviswanathan and Iyengar, 1967).

Kasiviswanathan and Sitram Iyengar (1970) indicated that the importance of NPK in increasing the yield of mulberry leaves need no emphasis. the influence nutrient on the leaf yield of mulberry crop in general is influenced by nitrogen than the other nutrients.

Ray *et al.* (1973) reported that highest leaf yield of mulberry crop was recorded with 336kg nitrogen, 180kg phosphorus and 112kg potassium  $\text{ha}^{-1}$  and FYM 2200  $\text{kg ha}^{-1}$ . It is quite apparent that nitrogen plays the most important role in increasing the yield of leaf and the role of phosphorus and potassium does not appear to be so important.

Chauhan *et al.* (1985) reported that a balanced unit of nutrients NPK significantly improved yield of mulberry at 150 gram of potash/tree, 1000(g) nitrogen and 1000(g) phosphorus respectively.

Kasiviswanathan and Sitaram Iyengar (1966) showed that nitrogen fertilization significantly increased leaf and stalk yield of mulberry fresh and dry matter production also increased due to nitrogen application

Basavanna *et al.* (1967) noticed that a higher population of mulberry require a higher level of nitrogen to maintain better vegetative growth of mulberry.

Kasivishwanathan and Sitaram Iyengar (1969) stated that application of 50kg nitrogen $\text{ha}^{-1}$  under rainfed condition significantly increased the yield of mulberry over no nitrogen. Further the authors stated that the increased yield was due to efficient moisture utilization as influenced by the increased availability of nitrogen.

Sengupta *et al.* (1972) working on seasonal and total leaf yield of mulberry under different doses of nitrogen in West Bengal found that application of nitrogen beyond 300kg nitrogen $\text{ha}^{-1}$  indicated a fairly

consistent increase of about 5.6 per cent in mean leaf yield for each 100kg ha<sup>-1</sup> applied

Ray *et al.* (1973) studied the response of mulberry for yield and nutritive value of leaf at three different levels of phosphorus viz., 0, 90 and 180 kg ha<sup>-1</sup>. Results have revealed that phosphorus in its highest level only increased the leaf yield. Phosphorus levels have effect on starch content and total minerals

Radha *et al.* (1988) studied the effect of phosphorus deficiency on mulberry plant under potassium with Kanva-2 mulberry variety. Shoot weight and leaf area of mulberry leaves were reduced in phosphorus deficient nutrient solution. Deficiency of phosphorus resulted in lowering of almost all other mineral content in the leaves.

Aoki and Yamamoto (1968) concluded that increase in potassium application in mulberry leaves lead to constant increase of potassium content in leaf on the contrary Calcium and Magnesium content decreased with increased potassium levels.

Leinmary joseph (1991) studied the role of potassium in mulberry found that increased level of potassium resulted in increased nitrogen and crude protein content of leaf. On the contrary Magnesium total soluble sugar and crude fiber reduced with increasing levels of potassium up to 300kg ha<sup>-1</sup>.

Sen (1949) reported that 80 per cent of the nutrients requirement of the crop could be provided in the form of organic manures of which 47 per cent could be through composted.

Lipke and Frankel (1956) and Dadd (1963) stressed the importance of the soil fertility and nutrition of the host plant in governing the nutrition of

the insects. Organic manuring seems to play a dominant role in the production of the mulberry crop.

Pain (1961) observed that application of FYM or composed at 30t ha<sup>-1</sup> increased the foliage yield by 75 per cent compared to no application. An improvement was observed in crude protein, crude fat, sugar, starch, pH and *Potassium* besides silk content and cocoon filament length .

Ito and Matsuda (1966) observed better growth of mulberry in plots treated with localized placement of FYM on sandy soil. Application of composed increased the larval survival, cocoon quality and silk yield.

Ray *et al.* (1973) opined that a combination of organic and inorganic nutrients enhanced the quality of the leaves in terms of moisture, crude protein and sugar. A good response was observed with FYM 20t ha<sup>-1</sup> which was further benefited by additional dose of 336:180:120 kg of nitrogen, phosphorus and potassium respectively .

Kayakoshibuya and KastuKoisomatsy (1980) reported that the application of Swine and poultry waste resulted in increased leaf yield in mulberry trees. However, the latter had deleterious effect on growth and development of roots.

Jolly (1986) suggested that under irrigated conditions application of 20t of FYM/ha/year as basal dose and 255:255:255kg of nitrogen, phosphorus and potassium/ha/year was better for harvesting higher quality of the leaves required for chawkiworms.

Results of green house and field trials demonstrated that dry matter yield, phosphorus uptake, grain and straw yield of rice were comparable for pressmud and Triple super phosphate (Mesbahul-karim *et al.*, 1974).

Kumaresan *et al.* (1985) reported that the application of pressmud at  $5\text{tha}^{-1}$  with  $37.5\text{kg}$  of  $\text{ZnSO}_4$  and  $100\text{kg}$  of  $\text{FeSO}_4$   $\text{ha}^{-1}$  significantly increased the sugarcane yield ( $109.68\text{tha}^{-1}$ ) over the Nitrogen, Phosphorus and Potassium control ( $102.68\text{tha}^{-1}$ ).

Chowdhury *et al.* (1989) reported that cane and sugar yields increased significantly due to application of pressmud.

\* Dubey (1992) reported that the yield of soybean was increased by 22.6 per cent and 15.8 per cent with application of FYM ( $6\text{MTha}^{-1}$ ) or pressmud ( $6\text{MTha}^{-1}$ ) respectively with Bradyrhizobium inoculation.

Haidar *et al.* (1993) observed the effect of application of castor cake, mustard cake, and pressmud or carbofuran to soil on nematodes population, yield and juice quality of sugarcane. All the treatments reduced the nematode population in the field, augmented the plant growth and crop productivity significantly. Carbofuran and pressmud were reported to be economical.

\* Abubacker and Rao (1995) reported the pressmud application increased the dry weight, chlorophyll, protein, sugar and starch content in the rice crop.

\* Swamy *et al.* (1995) reported the quantity of nitrogen required to produce one tonne cane was highest for the ratoons than for the plant crop. Though the contribution of nitrogen from soil is almost the same for planted and ratoon crops, the contribution from fertilizers, pressmud cake and *Azotobacter* were higher in ratoon crops than the plant crop. Integrated use of  $84\text{kg}$  of nitrogen +  $6\text{t}$  of pressmud  $\text{ha}^{-1}$  provided  $28\text{kg}$  of nitrogen  $\text{ha}^{-1}$  in plant crop, whereas  $168\text{kg}$  of nitrogen +  $4\text{t}$  of pressmud cake +  $5\text{kg}$  of *Azotobacter*  $\text{ha}^{-1}$  gave an economy of  $56\text{kg}$  of nitrogen  $\text{ha}^{-1}$  besides maintaining the yield of cane and sugar from ratoon crops.

### 2.3 Effect of enriched manure on crop production

In a pot culture experiment with sandy loam soil, Shailendranath and Rao (1979) noticed that pre treatment of urea and rock phosphate fertilizers with oil cakes, FYM or brewery or gohar gas plant effluent significantly increased grain and straw yield of *Eleusine coracana*. Pre-treated rock phosphate had a greater influence on grain yield than pre-treated urea but the reverse was true for straw yield. Nitrogen, Phosphorus, Potassium, calcium and magnesium uptake was also improved by fertilizer pre-treatment.

Mathur *et al.* (1980) observed that after 60 days incubation, compost mixed with varying levels of mussoorie rock phosphate with and with out pyrites significantly released citrate soluble and water soluble phosphorus. In the earlier stages the release of phosphorus was greater from compost changed rock phosphate alone.

Phosphate enriched compost containing 3.13 per cent phosphorus was prepared by composting cattle dung and farm waste with mussoorie rockphosphate. The phosphate-rich phospho-compost had low water soluble and bicarbonate soluble phosphorus but had 50 per cent of total phosphorus in citric acid soluble form. The phosphate released from rock phosphate during composting did not exist freely, but was refixed with excess calcium present in this system. The phospho compost was found to be comparable to single super phosphate in field trials with the yield of green gram and wheat (Mishra *et al.*, 1982).

Shinde *et al.* (1985) studied the effect of enriched city compost with rock phosphate and p-solubiliser such as *Azotobacter chroococcum* and *Aspergillus awamorii* on yield of mung. The results revealed that the carbon content of compost was reduced significantly due to enrichment. Total as well as available nitrogen content and olsen phosphorus was also

increased significantly when the composed was enriched with rock phosphate and *Aspergillus awamorii* and *Azotobacter chroococcum*. As regards the grain yields of mung, it was observed that enriched composed could readily supply nutrients to produce higher yield.

Bhriguvanshi (1988) reported that organic manures were prepared in pits using cattle shed wastes, Kudzu vine, Kharif weeds and pineneed less and enriched with fertilizers. The results showed that total nitrogen per cent was higher in all the manures and C:N ratio of decomposing mixtures narrowed down considerably. Phosphorus enrichment conserved nitrogen in the manures. Total phosphorus from single superphosphate tended to increase whereas, in general total phosphorus decreased with decomposition under field condition there was significant effect on yield and Nitrogen, Phosphorus, Potassium up take by wheat.

The effect of inoculation with *Azotobacter* and phosphate solubilizing microorganism and addition of mussoorie rock phosphate on nitrogen and phosphorus content during composting of rice straw was studied by Tiwari *et al.* (1988). Composting with rock phosphate increased both citrate and water soluble phosphorus and this was further increased by inoculation with *Aspergillus awamorii*. Optimum responses were recorded with the treatment receiving microbial cultures and rock phosphate. Three months rotted enriched compost increased the nodulation and yield of green gram crop.

Kapoor *et al.* (1990) noticed that multiple inoculation, increased the decomposition rate and nitrogen content significantly. There was increase in soluble phosphorus content due to addition of rock phosphate. The enriched compost was significantly better than ordinary compost in trials conducted with wheat as a test crop

The results obtained in millet scheme at Bangalore showed that among the different levels of FYM tried, 750kg enriched FYMha<sup>-1</sup> produced

significantly highest grain yield ( $6398\text{kg ha}^{-1}$ ) compared to  $5000\text{kg}$  not enriched FYM  $\text{ha}^{-1}$  ( $5675\text{kg ha}^{-1}$ ) and control ( $5053\text{kg ha}^{-1}$ ) (Anon., 1991).

The inoculation of phosphorus, solubilising fungi and addition of mussoori rockphosphate to the municipal waste did not bring any change either in available phosphorus or citrate soluble phosphorus. This was due to the most unfavourable alkalinity of the compost for the microbial activity (Balakrishna *et al.*, 1991).

#### **2.4 Effect of pressmud on physical, chemical and biological properties of soil**

Pressmud application resulted in progressive increase in available nitrogen, phosphorus and organic carbon contents of all the soils studied. Pressmud at  $10\text{ t ha}^{-1}$  increased the cation exchange capacity of soils, while it increased the exchangeable calcium in red, acid and black soils. The biological activities of the soil as indicated by the  $\text{CO}_2$  evolution recorded a significant increase with pressmud application in red, alkali and acid soils. Pressmud application resulted in increase in bacterial population of red soil and fungal population of black soil (Indira Raja and Raj, 1979).

Indira Raja and Raj (1981) observed that the uptake of nutrients such as nitrogen, phosphorus and potassium significantly increased with pressmud application and this was more pronounced in the red and lateritic soils than in black and alluvial soils.

Gupta *et al.* (1987) reported that the pressmud produced from carbonation process contained higher amount of calcium carbonate and as such it cannot be used as a organic fertilizer particularly in alkaline soils. However, it can be used for reclamation of acid soils. In Haryana, this type of pressmud is used as a building material only after burning and converting it to  $\text{CaO}$ . The pressmud of sulphitation process is used as a organic manure as it contained 34.65 to 35.20 per cent of organic carbon depending

upon single/double sulphitation process. The pressmud of double sulphitation process contained 16 per cent of sulphur as such is used for reclamation process of alkali soils based on sulphur content and in sulphur deficient soils for sulphur nutrition of the crop.

Kathiresan (1991) reported that pressmud is one of the main byproducts of the cane sugar industry, derived during purification of sugarcane juice by carbonation or sulphitation process. Its main use is as a soil ameliorant, supplying nitrogen, phosphorus, calcium and organic carbon.

Application of pressmud not only increased the available nitrogen status but also improved the retention capacity of the nutrients. The available phosphorus status was improved by the application of pressmud (Parama sivam, 1991).

Virendra Kumar and Mishra (1991) studied that available phosphorus, potassium and organic carbon content of soil increased due to addition of the sulphitation pressmud.

The effect of pressmud application on acid soil from Uttar pradesh, India, was studied. The results indicated that the pH of the soil and availability of phosphorus increased (Bhardwaj *et al.*, 1992).

Bose *et al.* (1992) observed that the effect of pressmud on chemical properties of alkali soil from CSRTI, Mysore were studied. The pH and the ESP of red loamy soil considerably reduced and also more effective in surface soil than the sub surface soil.

Deshmukh *et al.* (1993) observed in a laboratory experiment, a clay soil at 50 per cent water holding capacity was given. Pressmud 0-10t ha<sup>-1</sup> and incubated at 37°C for 75 days. Pressmud applications significantly increased the availability of nitrogen and phosphorus, particularly but

during the first 45 days, while available nitrogen remained constant throughout. Zinc availability generally increased at higher pressmud applications, but the concentrations decreased over time. The available copper increased both with pressmud application and with time.

\* Verma (1993) reported from a pot experiment, applying pressmud to a saline sodic soil reduced the soil pH, EC and ESP to desirable levels after 2 years of growing rice and wheat.

More (1994) observed that the application of pressmud increased the organic carbon content, available nitrogen, phosphorus and potassium in soil than the farm yard manure.

Room-Singh *et al.* (1994) studied that farm yard manure and pressmud enhanced the soil reclamation process.

Jayamani and Devarajan (1995) reported that pressmud application increased the soil phosphorus and exchangeable calcium and decreased exchangeable sodium.

The beneficial effects on physical and chemical properties of soil revealed that pressmud cake increased the efficiency of use of added nitrogen about 4-8 per cent. It was suggested to use sulphitation pressmud cake in saline sodic soils (Yadav *et al.*, 1995)

Pressmud cake is used as soil conditioner to improve the fertility status of soil (Zende *et al.*, 1995).

## **2.5 Bio-Organic influence on phosphorus availability**

Organic compounds are dominantly anionic in character (Caldwell and Black, 1958) and are expected to compete with phosphate ions in polar adsorption by the soil colloids and thus decrease phosphate fixation.

Organic anions can also decrease phosphate fixation by competing with phosphate ions to fit into the clay mineral lattice and block the passage of lattice for phosphate. Acid produced in organic matter transformation could chelate with Fe and Al and prevent them from reacting with phosphate to form insoluble precipitation. Organic anions particularly the hydroxy acids such as citrate, tartarate, oxalate and succinate and inorganic anions such as hydroxyl fluoride, arsenate, ferrocynide, etc., have been found to reduce phosphorus fixation and assist in the release of native soil phosphate.

Ghosh (1963) reported that mixtures of organic substances like FYM, cowdung, wheat straw, plant leaves etc. Fortified by the addition of phosphate could prove to be of immense value in producing more crops and in building soil fertilizers. Organic matter addition resulted in higher percentage of added phosphorus remaining in soluble form during the initial period of incubation (Mandal and Chatterjee, 1972).

Mandal and Mandal (1973) observed that organic matter treatment maintains higher amount of phosphorus in soluble form..

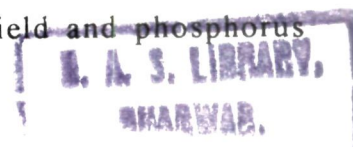
Continuous application of FYM to a Sierozim soil in the semi- arid region of Haryana resulted in increase of total phosphorus content of the soil (Singh *et al.*, 1980).

Chaudhary *et al.* (1981) reported that the application of phosphatic fertilizers with FYM resulted in an increased availability of phosphorus in soil.

The efficiency of utilization of rock phosphate and super phosphate increased when supplied with FYM to bajra and wheat sequence (Chahal *et al.*, 1981).

✶ Mussoorie rock phosphate was comparable to single super phosphate in field trial with *Vigna radiata* and wheat for grain yield and phosphorus

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up take when it was composted with cattle dung and farm waste (Mishra *et al.*, 1982). FYM improved the availability of phosphorus when rock phosphate and super phosphate together, well decomposed FYM contains acidic and hydroxyl functional groups and these groups help to reduce the fixation of applied phosphorus ( Anon., 1983).

^ Krishnamurthy *et al.* (1984) reported that organic manures at 15t ha<sup>-1</sup> had a significant effect in increasing the available phosphorus from the native and applied sources. Build up of organic matter in soil is advantages for efficient utilization of phosphorus by plants. FYM and poultry manure can serve as better source of organic matter when compared with castor cake for enhancing phosphorus availability in soil (Sharma and Saxena, 1985).

More and Ghonsikar (1988) observed that single super phosphate mixed with organic manures increased the availability of phosphorus than single super phosphate alone because the organic anions compete with phosphate ions for the binding sites on the soil particles and the complex organic anions chelate Al<sup>3+</sup>, Fe<sup>3+</sup> and Ca<sup>2+</sup> and thus decrease the phosphate precipitating capacity of these cations. There was increase in yield of wheat with single super phosphate + manure compared to single super phosphate alone.

^ Phosphate up take was highest by finger millet in the recommended NPK + FYM treatment and lowest with soils which had been cropped with out fertilizer application (Subramanian and Kumaraswamy, 1989). The availability of phosphorus significantly increased when rock phosphate was applied with FYM (Chandrappa,1990).

Rose (1957) reported that *Aspergillus niger*, *Aspergillus ferreus* and *Sclerotium rolfssii* had a solubilizing effect on magnesium phosphate and iron phosphate. Among the eighteen fungi isolated from soils of a paddy field, *Aspergillus niger*, *Sclerotium rolfssii* and *penicillium sp.* had the

ability to solubilize in soluble phosphates (Das, 1963). The fungi viz., *Aspergillus sp.*, *Aspergillus nidulans*, *Aspergillus niger*, *Aspergillus feavus*, *Aspergillus terreus* and *Penicillium lilacinum* which were associated with root nodules legume could solubilize tricalciumphosphate (Chhonkar and SubbaRao, 1967).

Ahmed and Jha (1968) isolated fungi *Aspergillus*, *penicillium* and *rhizopus*, bacteria and actinomycetes which had ability to dissolve the precipitated hydroxyl appetite and rockphosphate. Among these groups of organisms, fungi had higher phosphate dissolving capacity. Tricalciumphosphate and calcium pyrate are effectively solubilized by *penicillium*, *Aspergillus*, *cladosporium*, *fusarium* and *paecolimyces* (Sethi and Subba Rao, 1968).

Two years field study by Rana *et al.* (1975) revealed that inoculation of phosphate solubilizing microorganisms like *Bacillus Polymexa*, *Pseudomonas striata* and *Aspergillus awamorii* with or with out application of rock phosphate did not result in increased yield or total phosphorus content of wheat grain or straws.

Arora and Gaur (1979) reported that among several fungi tested for their solubilizing ability of rock phosphate and triplesuperphosphate. *Aspergillus carbenum* and *Aspergillus awamorii* were found to be most efficient species. Isolates of *penicillium*, *Aspergillus* and *Penicillium favesosame* and *Pencillium farolum* solubilized more of aluminum phosphate, iron phosphate and triplesuperphosphate respectively (Raj, 1980).

Phosphate solubilizing fungi, *Aspergillus awamorii* increased the availability of phosphorus from rock phosphate and enhanced the rate of decomposition which affected significantly the growth parameters of the chick pea plants (Rasal *et al.*, 1988).

Tiwari *et al.* (1988) reported that inoculation of rock phosphate with *Azotobacter sp.* and *Aspergillus awamorii* increased both citrate and water soluble phosphorus from mussoorie rock phosphate and also the yield of green gram crop. Inoculation with phosphate solubilizing fungus *Aspergillus awamorii* during composting increased phosphorus content from rock phosphate (Kapoor *et al.*, 1990).

# **MATERIAL AND METHODS**

### III MATERIAL AND METHODS

Preparation of enriched pressmud compost followed by a field experiment was carried out at the Main Research Station (MRS), UAS, Hebbal campus to find out the effect of enriched pressmud application on changes in soil properties and yield of mulberry crop under irrigation during the Kharif season of 1996.

#### 3.1 Location

The Main Research Station, Hebbal is located at 77°78' East longitude and 12°58' North latitude at an altitude of 899 m above mean sea level.

#### 3.2 Soil Characteristics

The initial soil samples collected from the experimental plot, before start of the experiment were analyzed for important physical and chemical properties. The analytical results of the soil sample are presented in Table-1.

#### 3.3 Crop variety

Mulberry, variety S-54, a high yielding mutant strain suitable for irrigated conditions was used. It is obtained from M<sub>3</sub> generation of Ethylmethane sulphonate treatment (Rangaswami *et al.*, 1976).

#### 3.4 Preparation of enriched pressmud

##### Materials used:

1. Pressmud of sulphitation process was obtained from Sri. Chamundeshwari sugars limited, K. M. Doddi, near Maddur in Mandya district.

2. Farm yard manure (FYM) and Biogas spent slurry (BGSS) were obtained from the College of Dairy Sciences, UAS, Hebbal campus.
3. The cultures of *Azotobacter sp.* a free living atmospheric nitrogen fixing bacteria and *Aspergillus awamorii*, a phosphorus solubilizing fungus, were obtained from the Department of Agricultural Microbiology, UAS, GKVK campus.
4. Nitrogen, phosphorus and potassium in the form of urea, triple superphosphate and Muriate of potash were used for enrichment purpose.

#### 3.4.1 Composting and Enrichment

1. 50 kg pressmud and NPK at 5% each
2. 75 kg pressmud and 25 kg FYM (3:1)
3. 50 kg pressmud and 50 kg FYM (1:1)
4. 75 kg pressmud and 25 kg BGSS (3:1)
5. 75 kg pressmud and 25 kg BGSS (3:1) +100 gm *Azotobacter sp.* culture
6. 75 kg pressmud and 25 kg FYM (3:1) +100 gm *Azotobacter sp.* culture
7. 75 kg pressmud and 25 kg FYM (3:1) +5% Mussoorie rock phosphate +50 gm each *Aspergillus awamorii* and *Azotobacter sp.* culture
8. 75 kg pressmud and 25 kg BGSS (3:1) + 5% Mussoorie rock phosphate + 50 gm each *Aspergillus awamorii* and *Azotobacter sp.* culture

Note : N, P, K and rockphosphates were added at 5 per cent of pressmud

The treated pressmud was kept in cement tanks and allowed decomposition for 85 days. During the process of decomposition the moisture content of the materials was maintained at optimum level and also the aerated conditions by periodical mixing. At the end of 85 days the enriched manure was analyzed for pH, EC, Organic Carbon, Nitrogen, Phosphorus, Potassium, Calcium, Magnesium, Sulphur and micronutrients such as Iron, Manganese, Zinc and Copper.

### 3.5 Field study

Field investigations were carried out to study the effect of enriched pressmud on mulberry leaf yield and soil properties by employing the following treatments .

#### Treatments :

T<sub>1</sub> = Untreated pressmud and no fertilizers

T<sub>2</sub> = Enriched pressmud with 5 % NPK each + 100 % Rec. Fert.

T<sub>3</sub> = Enriched pressmud with 5 % NPK each + 75 % Rec. Fert.

T<sub>4</sub> = Enriched pressmud with FYM (3:1) +100 % Rec. Fert.

T<sub>5</sub> = Enriched pressmud with FYM (1:1) +100 % Rec. Fert.

T<sub>6</sub> = Enriched pressmud with BGSS (3:1) +100 % Rec. Fert.

T<sub>7</sub> = Enriched pressmud with BGSS (3:1) + *Azotobacter sp.* + 100 % Rec.

T<sub>8</sub> = Enriched pressmud with FYM (3:1) + *Azotobacter sp.* +100 % Rec.

Fert.

T<sub>9</sub> = Enriched pressmud with FYM (3:1) + 5 % Mussoorie rock phosphate + *Aspergillus awamorii* + *Azotobacter sp.* + 100% Rec. Fert.

T<sub>10</sub> = Enriched pressmud with BGSS (3:1) + 5 % Mussoorie rock phosphate  
*Aspergillus awamorii* + *Azotobacter sp.* + 100% Rec. Fert.

T<sub>11</sub> = Untreated pressmud with FYM 20MT/ha + 100% Rec. Fert.

T<sub>12</sub> = Absolute control.

### 3.6 Levels of fertilizer

(a) The recommended levels of fertilizer for mulberry crop are 300 : 120 : 120 Kg ha<sup>-1</sup> N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O respectively. They were applied as urea, Triple superphosphate and Muriate of potash to supply 300 : 120 N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O Kg ha<sup>-1</sup> respectively.

(b) Farm yard manure (FYM) @ 20 t ha<sup>-1</sup>

(c) Biogas spent slurry (BGSS) @ 20 t ha<sup>-1</sup>

(d) Enriched pressmud (EPM) @ 20 t ha<sup>-1</sup>

### 3.7 Experimental Design

The experiment was laid out following a randomized complete block design (RCBD) with twelve treatments and three replications on a gross plot size of 17.64 m<sup>2</sup> (4.2 m x 4.2 m) with plant spacing at 60 cm x 60 cm. The layout plan of the experiment is given in Fig. 1.

### 3.8 Application of manures and fertilizers

The experiment was laid out on an established mulberry plantation of six years old. The cultural practices were carried out as per the package of practices recommended for irrigated mulberry crop (Krishnaswamy, 1986). Bottom pruning was carried out during the first week of August 1996. After the bottom pruning, the treatments were imposed and incorporated into the soil and provided irrigation once in 10 days based on crop requirement and climatic conditions. Nitrogen, Phosphorus and Potassium fertilizers were applied as per the treatments.

<-N-

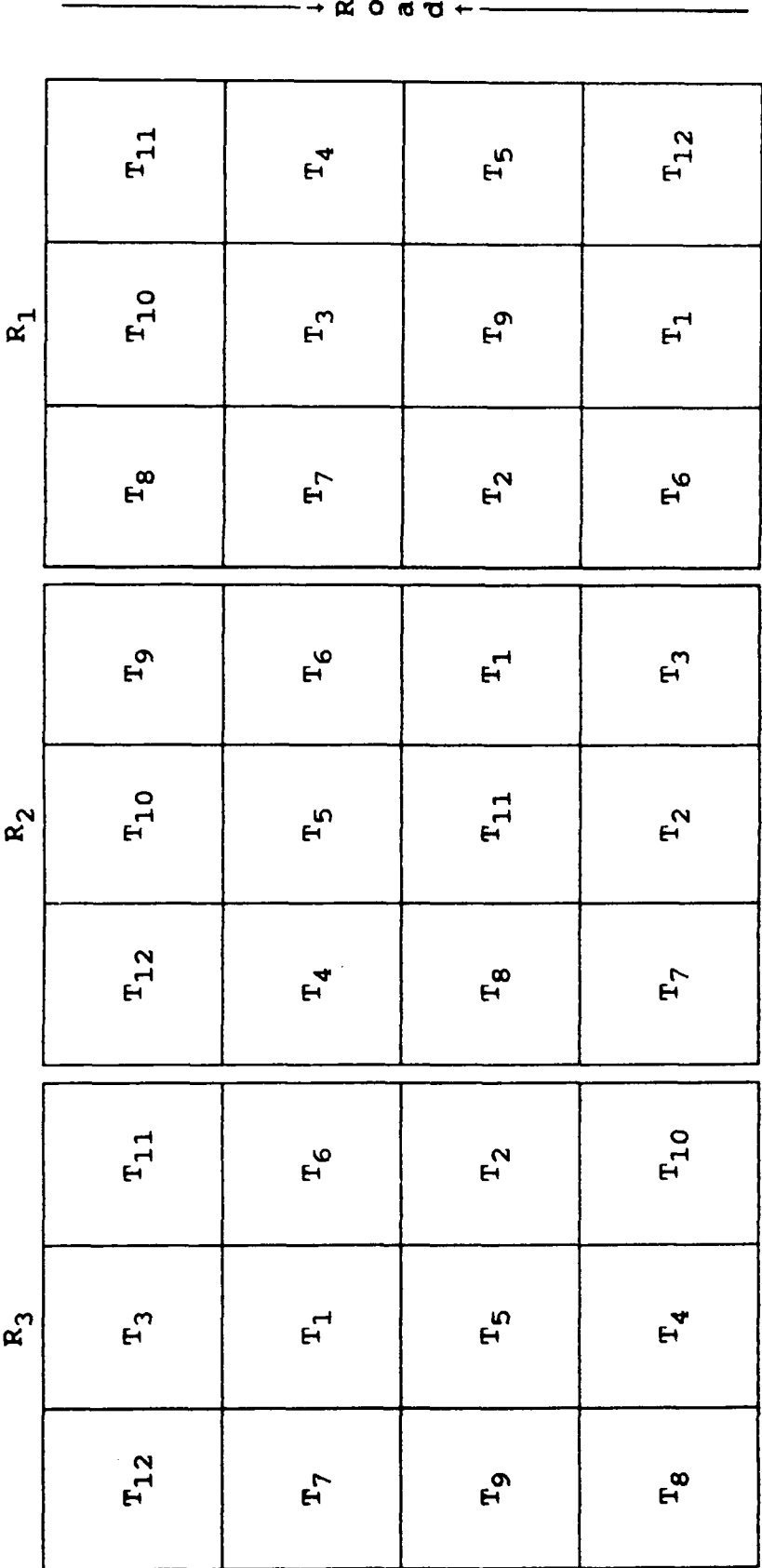


FIG 1 : LAYOUT OF PLAN OF THE EXPERIMENT

### **3.9 Harvesting**

During 75 days of crop growth period, necessary cultural operations were carried out for weed control and irrigation. A net plot size of 3.6 x 3.6 m (12.96 m<sup>2</sup>) was used for sampling and yield assessment. The mulberry leaves were harvested at 75 days after imposing treatments and the yield of fresh leaves were recorded and expressed in Kg ha<sup>-1</sup>. The leaves from five randomly selected plants from each treatment were collected and dried. The dried leaves were powdered in laboratory and stored for further analysis.

### **4.00 Method of soil Analysis**

#### **4.1 Collection and preparation of soil samples**

Surface soil samples at a depth of 0 - 30 cm were collected from each plot, at harvesting of the crop. The samples were dried under the shade powdered with wooden mallet, passed through a metal free 2mm sieve and preserved in clean polythene bags for analytical work.

##### **4.1.1 Mechanical Analysis**

Mechanical analysis of soil samples collected at the start of the experiment only was carried out by adopting International pipette method using sodium hexameta phosphate as the dispersing agent (Piper, 1966).

##### **4.1.2 Keen Raczkowski measurement**

Bulk density and water holding capacity were determined by keen Raczkowski method as outlined by Piper (1966).

#### **4.1.3 Soil pH**

Soil pH was determined in 1: 2.5 soil water suspension by glass electrode using digital pH meter (Jackson 1973).

#### **4.1.4 Electrical Conductivity**

Electrical conductivity was measured in the soil water 1 : 2.5 extract using conductivity bridge (Jackson, 1973).

#### **4.1.5 Organic carbon and Organic matter**

Organic carbon was determined by Walkley and Black's wet oxidation method as described by Jackson (1973). The per cent of organic carbon multiplied with the factor 1.724 gave the per cent of organic matter.

#### **4.1.6 Available Nitrogen**

Available nitrogen was determined by alkaline permanganate method as described by Subbaiah and Asija (1956).

#### **4.1.7 Available Phosphorus**

The available phosphorus was determined by using Olsen's extractants for soil having pH > 7 and above and Bray's No.I extractant for soil having pH < 7 (Jackson, 1973).

#### **4.1.8 Available potassium**

The method suggested by Black (1965b) was adopted on a suitable aliquot of neutral normal ammonium acetate extract. Potassium was

determined flame photometrically fitted with appropriate filter as described by Jackson (1973).

#### **4.1.9 Exchangeable calcium and magnesium**

Exchangeable calcium and magnesium were determined by titration with EDTA using suitable indicators from the extract using neutral normal ammonium acetate (Jackson, 1973).

#### **4.1.10 Available Sulphur**

Sulphur was determined turbidometrically as described by Black (1965b). 20g soil was extracted with 50 ml of sodium acetate-acetic acid buffer adjusted to pH 4.8. A suitable aliquot was mixed with acid seed solution containing 20ppm Sulphur, stabilizing agent (glycerol + ethanol in 1: 4 ratio) and 0.5g barium chloride and the intensity of turbidity was measured on a spectronic-20 Spectrophotometer at 420nm wavelength.

#### **4.1.11 DTPA Extractable Micronutrients**

Micronutrients such as Iron, Manganese, Zinc, and Copper were extracted with DTPA as described by Lindsay and Norvell (1978) and determined by using atomic absorption spectrophotometer fitted with appropriate hollow cathode lamp under standard condition.

### **5 Methods of Plant Analysis**

Plant samples collected from each of the representative plot at the time of harvesting were dried in a oven at 60°C and the dried samples were powdered in a clean grinder fitted with stainless steel blades and preserved in polythene bags for further analysis.

## 5.1 Total Nitrogen

A sample of 0.5g was digested in concentrated  $H_2SO_4$  with  $K_2SO_4$  +  $CuSO_4$  + selenium mixture as a catalyst in Kjeldhal flask and distilled in alkaline medium. The liberated ammonia was collected in 4 per cent boric acid containing bromo cresol green methyl red mixed indicator and titrated against standard  $H_2SO_4$ . From the data the per cent of nitrogen was calculated (Jackson, 1973).

### 5.1.1 Crude Protein

Crude protein content of leaves was calculated by multiplying the per cent nitrogen by factor 6.25.

## 5.2 Digestion of leaf samples and extraction

### 5.2.1 Wet ashing

One gram of dried samples were pre-digested with 5ml of concentrated nitric acid and further digested with diacid mixture consisting of nitric acid and perchloric acid at 10:4 ratio. The digested material was diluted to 50ml with distilled water and filter through whatman No.1 filter paper to remove silica. This solution was used for estimating phosphorus, potassium, calcium, magnesium, sulphur and micronutrients.

### 5.2.2 Phosphorus

Phosphorus was determined in an aliquot of the plant extract by the Vanadomolybdate yellow colour method in  $HNO_3$  medium. The colour intensity was measured in the spectrophotometer at 420 nm as described by Jackson (1973).

### **5.2.3 Potassium**

The potassium content in the digested extract was determined using flame photometer (Jackson, 1973).

### **5.2.4 Calcium and Magnesium**

The calcium and magnesium was determined by Versenate titration method by taking a suitable aliquot (Jackson, 1973).

### **5.2.5 Sulphur**

The sulphur in the digested sample was determined turbidimetrically as described by Black (1965b).

### **5.2.6 Micronutrients**

Micronutrients such as Iron, Manganese, Zinc, and Copper in the digested extract were determined by using atomic absorption spectrophotometer fitted with appropriate hollow cathode lamps under standard conditions.

# **EXPERIMENTAL RESULTS**

## IV EXPERIMENTAL RESULTS

The experimental results on the irrigated mulberry crop yield and changes in physical and chemical properties of soil are presented in this chapter.

### 4.1 Characteristics of the soil

The physical and chemical properties of the soil of the experimental site are presented in Table-1. The texture of the soil is sandy clay loam. Bulk density and water holding capacity of the soil were  $1.44\text{gcm}^{-3}$  and 29.23 per cent respectively. The soil is neutral in reaction (pH 7.75) with electrical conductivity  $0.16\text{ dsm}^{-1}$ . The soil was medium in available nitrogen ( $311\text{kg ha}^{-1}$ ),  $\text{P}_2\text{O}_5$  ( $18.75\text{kg ha}^{-1}$ ) and  $\text{K}_2\text{O}$  ( $146\text{kg ha}^{-1}$ ). The available sulphur was  $18.75\text{kg ha}^{-1}$ . The exchangeable calcium and magnesium contents were  $3.10\text{cmol (p}^+)\text{ Kg}^{-1}$  and  $0.87\text{cmol (p}^+)\text{ Kg}^{-1}$  of soil respectively. The available iron (60.8ppm), manganese (31.9ppm), Zinc (5.9ppm) and copper (3.1ppm) were in appreciable amounts in the soil.

### 4.2 Characteristics of Farm Yard manure (FYM) and Bio-gas spent slurry (BGSS)

The chemical compositions of FYM and BGSS used in the experiment are presented in Table-2. The nutrient content in BGSS was higher as compared to FYM.

### 4.3 Chemical composition of untreated pressmud

The pressmud employed in the experiment is slightly acidic in nature with higher soluble salts content. The details are furnished in Table-3.

**Table 1. Physical and chemical properties of soil of the experimental site**

Property/constituents	composition
<u>Mechanical composition (%)</u>	
Coarse sand	50.22
Fine sand	19.30
Silt	03.74
Clay	25.35
Loss in solution	01.39
Textural class	Sandy clay loam
Bulk density(g cm <sup>-3</sup> )	1.44
Maximum Water holding Capacity (%)	29.23
pH (1:2.5)	7.75
Electrical conductivity (1:2.5)(dsm <sup>-1</sup> )	0.16
Organic carbon (%)	0.63
Available nitrogen (kg ha <sup>-1</sup> )	311.00 M
"    P <sub>2</sub> O <sub>5</sub> ( " )	018.75 L
"    K <sub>2</sub> O ( " )	146.98 M
Exchangeable Ca <sup>2+</sup> [c mol(p <sup>+</sup> ) Kg <sup>-1</sup> ]	3.10
"    Mg <sup>2+</sup> [ " ]	0.87
Available Sulphur(kg ha <sup>-1</sup> )	18.75
DTPA extractable Fe (ppm)	60.80
" extractable Mn ( " )	31.94
" extractable Zn ( " )	5.90
" extractable Cu ( " )	3.08

Note :

H - High

M - Medium

L - Low

**Table 2. NPK content (%) in Farm Yard Manure (FYM) and Biogas Spent Slurry (BGSS) [ air dry basis ]**

Sl. No.	Particulars	Nitrogen	Phosphorus	Potassium
1.	FYM	0.69	0.21	0.72
2.	BGSS	0.93	0.38	1.03

**Table 3. Chemical composition of untreated pressmud (air dry basis )**

Constituent	Composition
pH (1:10)	6.40
Electrical Conductivity (1:10) ( $\text{dsm}^{-1}$ )	4.10
Organic carbon (%)	41.37
Total Nitrogen ( " )	2.40
" Phosphorus ( " )	1.47
" Potassium ( " )	1.31
" Calcium ( " )	2.10
" Magnesium ( " )	1.23
" Sulphur ( " )	2.50
" Iron (ppm)	2542.0
" Manganese ( " )	246.0
" Zinc ( " )	43.5
" Copper ( " )	25.0

The organic carbon content is high. It is also high in sulphur, nitrogen, calcium, phosphorus, potassium and magnesium contents. Among the micronutrients Iron is highest as compared to other micronutrients analysed.

#### **4.4 Chemical composition of enriched pressmud**

The pressmud enriched with different organic materials and fertilizers was analysed after 85 days of composting. The data on the chemical composition of the enriched pressmud are presented in Table-4 and 5.

#### **4.5 Effect of applied enriched pressmud and fertilizers on yield of mulberry leaves**

The data on mulberry leaves yield as influenced by the application of enriched pressmud and fertilizers are presented in Table-6.

Application of enriched pressmud and fertilizers significantly increased the yield of mulberry leaves over absolute control ( $T_{12}$ ). The highest yield was recorded in treatment  $T_2$ , while the lowest yield of crop was recorded in treatment  $T_{12}$ . The treatments  $T_4$  to  $T_{10}$  were comparable. The important to notice was treatment  $T_1$  and  $T_{11}$  were almost identical.

#### **4.6 Changes in soil properties as influenced by application of enriched pressmud and fertilizers**

The data on the effect of enriched pressmud along with fertilizers on pH, EC, organic carbon, available nitrogen, phosphorus ( $P_2O_5$ ) and potassium ( $K_2O$ ) content of soil are presented in Table-7.

Table 4. Chemical composition of enriched pressmud

Sl. No.	Particulars	pH (1:10)	Electrical Conductivity (dsm <sup>-1</sup> )	Organic Carbon (%)	Total		
					Nitrogen (%)	Phosphorus (%)	Potassium (%)
1.	Pressmud enriched with 5% N,P, K each.	6.28	5.148	34.48	2.54	1.94	1.89
2.	Pressmud enriched with FYM (3:1 Ratio)	7.68	1.638	38.30	2.41	1.24	1.36
3.	Pressmud enriched with FYM (1:1 Ratio)	7.58	1.716	40.51	2.40	1.20	1.30
4.	Pressmud enriched with BGSS (3:1 Ratio)	7.49	1.872	35.10	2.45	1.61	1.38
5.	Pressmud enriched with BGSS (3:1 Ratio) + <i>Azotobacter</i> sp.	7.47	1.868	34.90	2.49	1.68	1.39
6.	Pressmud enriched with FYM (3:1 Ratio) + <i>Azotobacter</i> sp.	7.70	1.248	37.70	2.44	1.28	1.36
7.	Pressmud enriched with FYM (3:1 Ratio) + 5% Mussoorie Rock phosphate + <i>Aspergillus awamorii</i> + <i>Azotobacter</i> sp.	7.64	1.640	36.90	2.46	1.92	1.37
8.	Pressmud enriched with BGSS (3:1 Ratio) + 5% Mussoorie Rock Phosphate + <i>Aspergillus awamorii</i> + <i>Azotobacter</i> sp.	7.72	1.246	34.12	2.49	1.97	1.39

Table 5. Chemical composition of enriched pressmud -continued

Sl.No.	Total						
	Calcium	Magnesium (%)	Sulphur	Iron	Manganese	Zinc	Copper
	←		→		ppm		
1	2.40	1.32	2.55	5125.0	574.0	143.5	60.00
2	2.23	1.27	2.51	4265.0	405.9	101.9	49.95
3	2.15	1.24	2.49	4169.5	397.7	86.2	43.7
4	2.27	1.28	2.52	4511.6	512.5	121.7	54.1
5	2.29	1.29	2.54	4530.5	522.7	123.7	55.2
6	2.26	1.28	2.52	4365.5	410.0	102.5	50.5
7	2.28	1.29	2.53	4418.5	486.5	123.5	55.9
8	2.30	1.30	2.54	4735.0	530.1	142.9	59.9

Table 6. Effect of applied enriched pressmud and fertilizers on crop yield

Treatments		Fresh leaf (Kg ha <sup>-1</sup> ) Harvest at 75 days
T <sub>1</sub>	Untreated pressmud	6065.4
T <sub>2</sub>	Pressmud enriched with 5% NPK each + 100% Rec. Fert.	6826.2
T <sub>3</sub>	Pressmud enriched with 5% NPK each + 75% Rec. Fert.	6656.2
T <sub>4</sub>	Pressmud enriched with FYM (3:1) + 100 % Rec. Fert.	6154.2
T <sub>5</sub>	Pressmud enriched with FYM (1:1) + 100% Rec. Fert.	6110.9
T <sub>6</sub>	Pressmud enriched with BGSS (3:1) + 100% Rec. Fert.	6194.6
T <sub>7</sub>	Pressmud enriched with BGSS (3:1) + <i>Azotobacter sp.</i> + 100% Rec. Fert.	6196.8
T <sub>8</sub>	Pressmud enriched with FYM (3:1) + <i>Azotobacter sp.</i> + 100% Rec. Fert.	6166.1
T <sub>9</sub>	Pressmud enriched with FYM (3:1) + 5% Mussoorie Rock Phosphate + <i>Aspergillus awamorii</i> + <i>Azotobacter sp.</i> + 100% Rec. Fert.	6208.1
T <sub>10</sub>	Pressmud enriched with BGSS (3:1) + 5% Mussoorie Rock Phosphate + <i>Aspergillus awamorii</i> + <i>Azotobacter sp.</i> + 100% Rec. Fert.	6229.9
T <sub>11</sub>	Untreated pressmud with FYM 20 MT / ha + Rec. Fert.	5990.1
T <sub>12</sub>	Absolute Control	5696.1
F-test		*
S Em ±		45.45
CD at 5%		133.30

\* Significant at 5% level

NS Non Significant

The pH the soil did not change significantly due to application of enriched pressmud along with fertilizers, except in treatment T<sub>2</sub> which was enriched with 5 per cent NPK each .

**4.6.2 Electrical conductivity of soil**

Application of enriched pressmud along with the fertilizers had significantly increased electrical conductivity of the soil extract. The highest electrical conductivity of the soil was recorded in treatment T<sub>2</sub>, while it was lowest in the treatment T<sub>8</sub> and T<sub>9</sub>. However, the other treatments were on par with each other.

**4.6.3 Organic carbon content of the soil**

Application of enriched pressmud along with fertilizers significantly increased the organic carbon content of the soil. The highest organic carbon content of the soil was recorded in treatment T<sub>1</sub> and T<sub>9</sub>, while the lowest organic carbon content in treatment T<sub>12</sub>. However the treatment T<sub>1</sub> and T<sub>9</sub> were on par with other.

**4.6.4 Available Nitrogen**

The available nitrogen content in soil did not differ significantly due to application of enriched pressmud along with fertilizers. It was 320kg $\text{ha}^{-1}$  in treatment T<sub>12</sub>, but it increased to 370kg $\text{ha}^{-1}$  in treatment T<sub>2</sub> no much change in available nitrogen content of the soil was noticed in all the other treatments.

Application of enriched pressmud along with fertilizers significantly influenced the available phosphorus content of soil. It was  $20.16\text{kg ha}^{-1}$  in treatment  $T_{12}$ , which increased to  $45.78\text{kg ha}^{-1}$  in treatment  $T_{10}$ . However, the treatment  $T_{10}$  was on par with the other treatments.

**4.6.6 Available potassium**

Application of enriched pressmud along with fertilizers did not change the available potassium content of soil. However, the highest potassium availability was noticed in treatment  $T_2$  ( $190.40\text{kg ha}^{-1}$ ) whereas the lowest in treatment  $T_{12}$  ( $151.19\text{kg ha}^{-1}$ ).

**4.7 Chemical properties of soil - continued**

The data on the effect of enriched pressmud along with fertilizers on exchangeable calcium, magnesium, available sulphur, iron, manganese, zinc and copper content of the soil are presented in Table-8.

**4.7.1 Exchangeable calcium**

The exchangeable calcium in soil did not differ appreciably due to application of enriched pressmud along with fertilizers. It was  $3.61\text{ c mol (p}^+) \text{ kg}^{-1}$  soil in treatment  $T_{12}$  but it was further increased to  $4.86\text{ c mol (p}^+) \text{ kg}^{-1}$  soil due to application of treatment  $T_2$ .

#### **4.7.2. Exchangeable magnesium**

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Application of enriched pressmud along with fertilizers had significant effect on the exchangeable magnesium content of soil. It was  $0.98\text{cmol(p')} \text{kg}^{-1}$  soil in treatment  $T_{12}$ , which increased significantly to  $1.76\text{cmol(p')} \text{kg}^{-1}$  soil due to application of treatment  $T_2$ . However, the treatment  $T_2$  was on par with other treatments.

#### **4.7.3. Available sulphur**

There was significant change in sulphur content of soil due to application of enriched pressmud along with fertilizers. It was  $24.19\text{kg ha}^{-1}$  in treatment  $T_{12}$ , which increased significantly in treatment  $T_2$ . However, treatment  $T_2$  was on par with other treatments.

#### **4.7.4 Available Iron**

There was significant change in iron content of soil due to application of enriched pressmud along with fertilizers. It was 47.9ppm in treatment  $T_{12}$ , which increased significantly in treatment  $T_2$  (68.6ppm). However treatment  $T_2$  and  $T_3$  were comparable.

#### **4.7.5 Available Manganese**

Manganese content of soil differed significantly due to application of enriched pressmud along with fertilizers. It was 30.6ppm in treatment  $T_{12}$ , which increased significantly to 38.9ppm in treatment  $T_2$ .

Table 7. Changes in chemical properties of soil as influenced by application of enriched pressmud and fertilizers

Treatments	Soil reaction pH (1:2.5)	Electrical Conductivity ( $\text{dsm}^{-1}$ )	Organic carbon (%)	Available		
				Nitrogen ←	Phosphorus ( $\text{P}_2\text{O}_5$ ) →	Potassium ( $\text{K}_2\text{O}$ ) →
T <sub>1</sub>	7.10	0.22	0.97	352.00	36.90	174.97
T <sub>2</sub>	6.79	0.30	0.82	370.00	45.68	190.40
T <sub>3</sub>	6.86	0.29	0.84	368.00	43.25	184.80
T <sub>4</sub>	6.90	0.24	0.84	350.00	35.50	173.60
T <sub>5</sub>	6.98	0.26	0.85	348.00	32.50	170.12
T <sub>6</sub>	6.98	0.25	0.84	362.00	39.10	177.58
T <sub>7</sub>	7.11	0.22	0.96	364.00	39.50	178.58
T <sub>8</sub>	7.12	0.21	0.96	362.00	37.68	176.12
T <sub>9</sub>	7.11	0.21	0.97	366.00	42.98	179.86
T <sub>10</sub>	7.08	0.23	0.96	367.00	45.78	180.96
T <sub>11</sub>	6.87	0.28	0.71	340.00	29.68	164.16
T <sub>12</sub>	6.85	0.29	0.67	320.00	20.16	151.19
F-test	NS	*	*	NS	*	*
S.E.m ±	0.53	0.02	0.06	15.81	4.35	8.07
CD at 5%	-----	0.061	0.177	-----	12.77	23.66

\* Significant at 5% level  
NS Non Significant

**Table 8. Changes in chemical properties of soil as influenced by application of enriched pressmud and fertilizers- continued**

Treatments	Exchangeable				Available			
	Calcium [ c mol (p+) kg ha <sup>-1</sup> ]	Magnesium kg ha <sup>-1</sup> ]	Sulphur Kg ha <sup>-1</sup> ]	Iron	Manganese ppm	Zinc	Copper	
T <sub>1</sub>	4.60	1.21	31.18	57.8	36.1	6.2	3.4	
T <sub>2</sub>	4.86	1.76	35.72	68.6	38.9	8.0	4.2	
T <sub>3</sub>	4.82	1.72	35.13	65.8	38.9	7.8	3.8	
T <sub>4</sub>	4.51	1.19	30.19	53.5	35.2	5.9	3.7	
T <sub>5</sub>	4.41	1.16	29.11	51.1	34.1	5.8	3.4	
T <sub>6</sub>	4.63	1.53	33.25	52.9	36.2	6.2	3.4	
T <sub>7</sub>	4.68	1.58	33.75	66.0	36.9	6.8	3.5	
T <sub>8</sub>	4.59	1.21	32.21	55.7	34.9	6.0	3.4	
T <sub>9</sub>	4.65	1.68	34.21	56.0	36.9	6.9	3.5	
T <sub>10</sub>	4.69	1.70	34.89	58.3	37.9	7.1	3.7	
T <sub>11</sub>	4.10	1.10	28.16	49.5	32.9	5.0	3.1	
T <sub>12</sub>	3.61	0.98	24.19	47.9	30.7	4.8	2.9	
F-test	NS	*	*	*	*	*	*	
S Em ±	0.43	0.09	2.13	1.91	1.64	0.34	0.11	
CD at 5%	-----	0.28	6.25	5.62	4.80	0.99	0.33	

\* Significant at 5% level  
NS Non Significant

#### **4.7.6 Available Zinc**

40

Application of enriched pressmud along with fertilizers had significant effect on the zinc content of soil. It was 4.8ppm in treatment T<sub>12</sub>, which increased significantly to 8.0ppm in treatment T<sub>2</sub>. However treatment T<sub>2</sub> was on par with T<sub>3</sub> and T<sub>10</sub>.

#### **4.7.7 Available Copper**

The application of enriched pressmud along with fertilizers significantly increased copper content of soil. It was 2.9ppm in treatment T<sub>12</sub>, which increased significantly to 4.1ppm in treatment T<sub>2</sub>. However, treatment T<sub>2</sub> was on par with treatment T<sub>3</sub>.

### **4.8 Physical properties**

The data on the effect of enriched pressmud along with fertilizers on water holding capacity and bulk density of soil are presented in Table-9.

#### **4.8.1 Water holding capacity of soil**

The water holding capacity of soil increased significantly due to application of enriched pressmud along with fertilizers. The highest water holding capacity of the soil was recorded in treatment T<sub>1</sub> (32.03%) where as lowest in treatment T<sub>12</sub> (29.89%). The treatment T<sub>1</sub> was on par with treatment T<sub>12</sub>.

**Table 9. Changes in physical properties of soil as influenced by application of enriched pressmud and fertilizers**

Treatments	Maximum water holding capacity (MWHC) (%)
T <sub>1</sub>	32.03
T <sub>2</sub>	30.29
T <sub>3</sub>	30.36
T <sub>4</sub>	30.35
T <sub>5</sub>	30.39
T <sub>6</sub>	30.30
T <sub>7</sub>	30.45
T <sub>8</sub>	30.46
T <sub>9</sub>	30.48
T <sub>10</sub>	30.40
T <sub>11</sub>	30.10
T <sub>12</sub>	29.89
F-test	*
S. Em $\pm$	0.37
CD at 5%	1.07

\* Significant at 5% level

NS Non Significant

Bulk density of soil decreased significantly due to application of enriched pressmud along with fertilizers. The bulk density of soil in treatment T<sub>12</sub> 1.44 gcm<sup>-3</sup> which decreased to a minimum of 1.09 and 1.09 gcm<sup>-3</sup> in T<sub>1</sub> and T<sub>9</sub> treatment respectively. The treatment T<sub>12</sub> was on par with treatment T<sub>11</sub>.

## **5.0 Nutrients content and their uptake by mulberry crop as influenced by the application of enriched pressmud and fertilizers**

### **5.1 Nutrient content and their uptake**

The data on nitrogen (crude protein), phosphorus, potassium, iron, manganese, zinc and copper content of mulberry leaves and uptake (N, P, K Ca, Mg and S) as influenced by application of enriched pressmud along with fertilizers are presented in Table-10 and 11.

#### **5.1.1 Nitrogen content and its uptake**

Owing to application of enriched pressmud along with fertilizers, the nitrogen content of mulberry leaves as well as uptake was significantly increased.

The highest uptake of nitrogen by the mulberry crop was recorded in treatment T<sub>2</sub> (57.10kg ha<sup>-1</sup>) but it was lowest in treatment T<sub>12</sub> (30.45 kg ha<sup>-1</sup>) However, the treatment T<sub>2</sub> was on par with the other treatments.

The enriched pressmud with the fertilizers significantly increased the crude protein content of mulberry leaves. 17.81 per cent of crude protein was recorded in treatment T<sub>2</sub> whereas it was 15.69 per cent in treatment T<sub>12</sub>. However, the treatment T<sub>2</sub> was on par with other treatments.

**5.1.2 Phosphorus content and its uptake**

Phosphorus content of mulberry leaves and uptake were significantly increased due to application of enriched pressmud along with fertilizers. The highest phosphorus uptake by the mulberry crop was recorded in treatment T<sub>2</sub> (11.22kg ha<sup>-1</sup>) but it was lowest in treatment T<sub>12</sub> (3.82 kg ha<sup>-1</sup>) however, treatment T<sub>2</sub> was on par with other treatments.

**5.1.3 Potassium content and its uptake**

Potassium content of mulberry leaves and uptake were significantly increased due to application of enriched pressmud along with fertilizers. In treatment T<sub>12</sub>, uptake of potassium by the crop was 14.47kg ha<sup>-1</sup> which was significantly increased to 29.25kg ha<sup>-1</sup> in treatment T<sub>2</sub>. However the treatment T<sub>2</sub> was on par with other treatments.

**5.1.4 Calcium content and its uptake**

Calcium content of mulberry leaves and uptake were significantly increased due to application of enriched pressmud along with fertilizers. The highest calcium uptake by the mulberry crop recorded in treatment T<sub>2</sub> (33.05kg ha<sup>-1</sup>) but it was lowest in treatment T<sub>12</sub> (13.13kg ha<sup>-1</sup>). However, the treatment T<sub>2</sub> was on par with other treatments.

### **5.1.5 Magnesium content and its uptake**

There was significant change in magnesium content of mulberry leaves and uptake due to application of enriched pressmud along with fertilizers. The highest uptake of magnesium by the crop was recorded in treatment T<sub>2</sub> (15.02kg $ha^{-1}$ ) but it was lowest in treatment T<sub>12</sub> (6.08kg $ha^{-1}$ ). However the treatment T<sub>2</sub> was on far with other treatments.

### **5.1.6 Sulphur content and its uptake**

There was significant change in sulphur content of mulberry leaves and uptake due to application of enriched pressmud along with fertilizers. In T<sub>12</sub>, uptake of sulphur by the crop was 2.50kg $ha^{-1}$  which was significantly increased to 8.41kg $ha^{-1}$  due to application of T<sub>2</sub>. However, T<sub>2</sub> was on par with other treatments.

### **5.1.7 Iron content**

Application of enriched pressmud and fertilizers significantly increased iron content of mulberry leaves. 266.2ppm of iron content of mulberry leaves was recorded in T<sub>2</sub>, while it was 246.1ppm in T<sub>12</sub>. However treatment T<sub>2</sub> was on par with other treatments.

### **5.1.8 Manganese content**

Manganese content of mulberry leaves was increased significantly due to application of enriched pressmud and fertilizers. Manganese content of mulberry leaves was recorded in T<sub>2</sub> (80.5ppm ) whereas in T<sub>12</sub> (64.9ppm). However, treatment T<sub>2</sub> was on par with other treatments.

### **5.1.9 Zinc content**

Owing to application of enriched pressmud and fertilizers the zinc content of mulberry leaves increased non-significantly. In treatment T<sub>2</sub>, the highest zinc content of mulberry leaves was recorded (61.5ppm) whereas the lowest (48.9ppm) was in treatment T<sub>12</sub>.

### **5.1.10 Copper content**

Copper content of mulberry leaves did not change appreciable due to application of enriched pressmud and fertilizers. The highest copper content of mulberry leaves was recorded in T<sub>2</sub> (8.9ppm) whereas the lowest copper content of mulberry leaves in T<sub>12</sub> (6.1ppm).

Table 10. Nutrient content of mulberry leaves as influenced by application of enriched pressmud and fertilizers

Treatments	Total										
	Nitrogen	Crude Protein	Phosphorus	Potassium	Calcium	Magnesium	Sulphur	Iron	Manganese	Zinc	Copper
	ppm										
	(%)										
T <sub>1</sub>	2.69	16.81	0.41	1.30	1.33	0.61	0.30	261.1	71.8	57.0	7.8
T <sub>2</sub>	2.85	17.81	0.56	1.46	1.65	0.75	0.42	266.2	80.5	61.5	8.9
T <sub>3</sub>	2.83	17.69	0.53	1.42	1.58	0.73	0.39	265.8	80.2	61.0	7.9
T <sub>4</sub>	2.72	17.00	0.51	1.40	1.42	0.65	0.33	259.7	70.8	51.9	7.5
T <sub>5</sub>	2.70	16.88	0.50	1.38	1.46	0.63	0.32	257.8	68.9	54.9	7.1
T <sub>6</sub>	2.75	17.19	0.52	1.42	1.48	0.68	0.34	262.8	74.6	58.1	7.8
T <sub>7</sub>	2.77	17.31	0.53	1.43	1.49	0.69	0.35	263.1	76.1	59.9	7.9
T <sub>8</sub>	2.74	17.13	0.52	1.41	1.45	0.66	0.34	261.8	73.9	56.9	7.6
T <sub>9</sub>	2.80	17.50	0.54	1.43	1.56	0.70	0.37	264.8	77.9	60.10	8.1
T <sub>10</sub>	2.82	17.63	0.52	1.44	1.57	0.72	0.37	265.9	78.1	60.8	8.4
T <sub>11</sub>	2.59	16.19	0.36	1.28	1.26	0.58	0.24	251.8	67.9	52.9	6.8
T <sub>12</sub>	2.51	15.69	0.32	1.21	1.10	0.51	0.21	243.1	64.9	48.9	6.1
F-test	*	*	*	*	*	*	*	*	*	NS	NS
S.Em ±	0.05	1.28	0.03	0.04	2.05	0.04	0.04	3.62	2.94	3.00	0.65
CD at 5%	0.13	0.83	0.09	0.12	0.14	0.12	0.10	10.62	8.62	-----	-----

\* Significance at 5% level

Table 11. Nutrient uptake by mulberry crop

Treatments	Total					
	Nitrogen	Phosphorus	Potassium	Calcium	Magnesium	Sulphur
	(Kg ha <sup>-1</sup> )					
T <sub>1</sub>	38.01	5.80	18.37	18.79	8.62	4.24
T <sub>2</sub>	57.10	11.22	29.35	33.05	15.02	8.41
T <sub>3</sub>	51.41	9.63	25.80	28.70	13.26	7.08
T <sub>4</sub>	41.31	7.75	21.26	21.56	9.87	5.01
T <sub>5</sub>	39.52	7.32	20.18	21.36	9.22	4.68
T <sub>6</sub>	43.75	8.27	22.59	23.54	10.81	5.40
T <sub>7</sub>	46.28	8.85	23.90	24.89	11.52	5.84
T <sub>8</sub>	42.24	8.02	21.73	22.35	10.17	5.24
T <sub>9</sub>	46.93	9.05	23.97	26.14	11.73	6.20
T <sub>10</sub>	47.43	8.25	24.23	26.40	12.11	6.22
T <sub>11</sub>	34.29	4.76	16.95	16.68	7.67	3.18
T <sub>12</sub>	30.45	3.82	14.47	13.13	6.08	2.50
F-test	*	*	*	*	*	*
S Em ±	0.44	0.59	0.58	0.64	0.73	0.54
CD at 5%	1.30	1.72	1.71	1.88	2.14	1.57

\* Significant at 5% level

NS Non Significant

## **DISCUSSION**

## V DISCUSSION

Pressmud is a byproduct of sugar industry and a sizable quantity is available in India. In the absence of systematic study on its effective utilization, the accumulating pressmud becomes a economical waste apart from causing environmental hazard. Alternatively, it would be effectively utilized in agriculture for higher crop yields and to maintain soil fertility. In India, limited attempts have been made to asses the agricultural utility of pressmud. Hence, the present investigation was aimed to explore the possibility of utilizing pressmud in agriculture. Looking at the chemical properties of pressmud it was felt that pressmud can be used as an amendment like gypsum in problematic soils and used as organic fertilizer if it can be enriched with nutrients through organic and inorganic sources.

Mulberry crop since, requires adequate quantity of organic manure the inexpensive and locally available pressmud could serve as useful organic manure with suitable treatment. The pressmud used in the present study is a product of sulphitation process obtained from sri chamundeswari sugars limited, K .M. Doddi, Mandya district.

The enriched pressmud prepared by composting it with different organic matters and fertilizers and the effect of this enriched pressmud was assessed on soil properties and yield of mulberry leaves.

The results obtained in the above investigations are discussed in this chapter under the following headings.

1. Characterization of the pressmud generated from the sugar factory and preparation of enriched pressmud.
2. Study of the effect of enriched pressmud on growth and yield of mulberry crop.
3. Study of the effect of applied enriched pressmud on changes in physical and chemical properties of soil.

### **5.1 Chemical composition of untreated pressmud**

The analytical results indicate that the pressmud is acidic in reaction and rich in organic carbon contents. It has appreciable quantity of macro and micro-nutrient such as Nitrogen, Phosphorus, Potassium, Calcium, Magnesium, Sulphur and Iron, Manganese, Zinc and Copper (Fig.2). Antil *et al.* (1987) reported that the chemical composition of pressmud of sulphitation process obtained from Karnal sugar factory had pH 5.6, EC  $0.3\text{dsm}^{-1}$  and 43.20 per cent of organic carbon. The content of micronutrients were Iron (880.0ppm), Manganese (111.1ppm), Zinc (153.1ppm) and Copper (45.0ppm). Narwal *et al.* (1990) reported that the chemical composition of pressmud of sulphitation process had pH 5.6, EC  $3.2\text{dsm}^{-1}$ , 43.2, 3.0 and 0.6 per cent of organic carbon, nitrogen and phosphorus respectively. Prakash *et al.* (1995) reported that Zinc, Manganese and Copper were abundant in the pressmud. These results supported the findings on chemical composition.

### **5.2 Chemical composition of enriched pressmud**

The chemical composition of enriched pressmud indicates that the enriched pressmud had appreciable quantity of macro and micro nutrients (Table 4&5, Fig.3). Higher contents of sulphur, nitrogen and iron are present

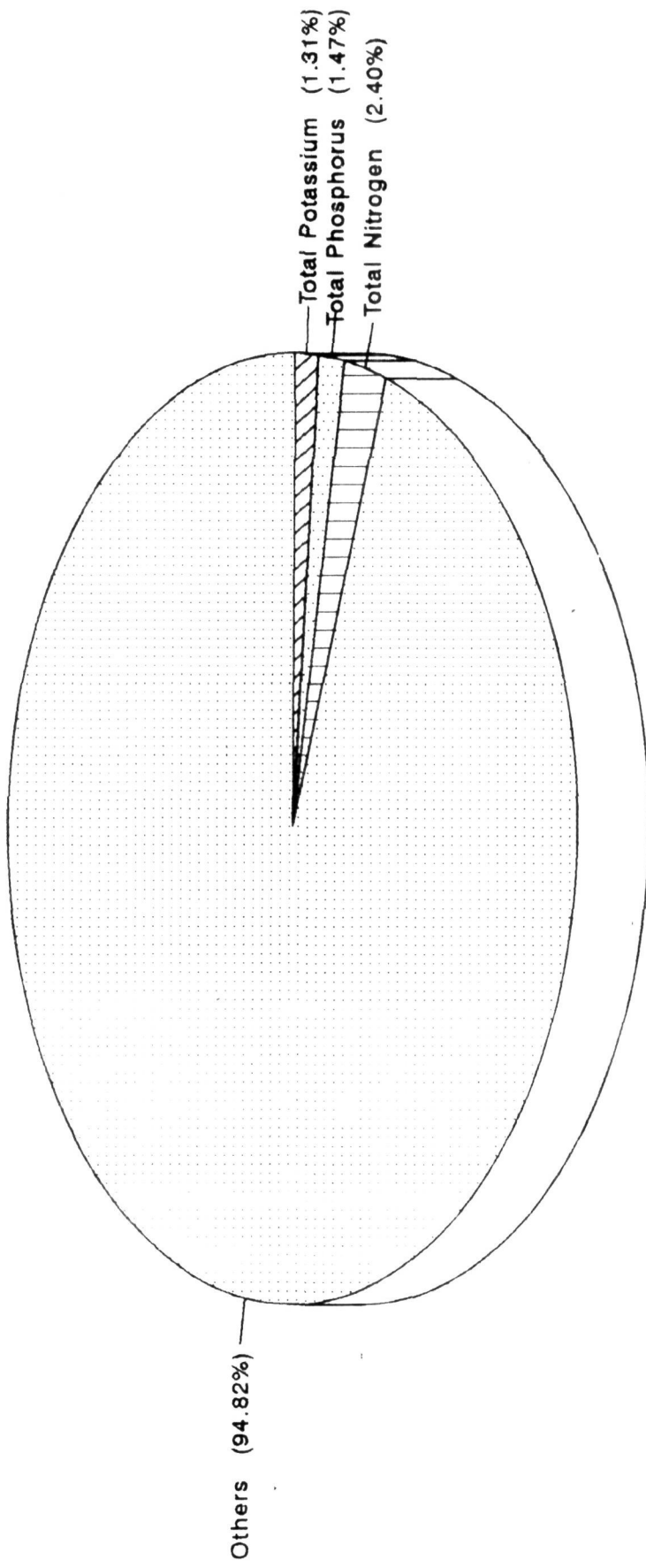


Fig.2: Chemical composition of untreated pressmud

Sl. No

1. Pressmud enriched with 5% NPK each
2. Pressmud enriched with FYM (3:1)
3. Pressmud enriched with FYM (1:1)
4. Pressmud enriched with BGSS (3:1)
5. Pressmud enriched with BGSS (3:1) + *Azotobacter* sp.
6. Pressmud enriched with FYM (3:1) + *Azotobacter* sp.
7. Pressmud enriched with FYM (3:1) + 5% Mussoori rock phosphate + *Aspergillus awamorii* + *Azotobacter* sp.
8. Pressmud enriched with BGSS (3:1) + 5% Mussoori rock phosphate + *Aspergillus awamorii* + *Azotobacter* sp.

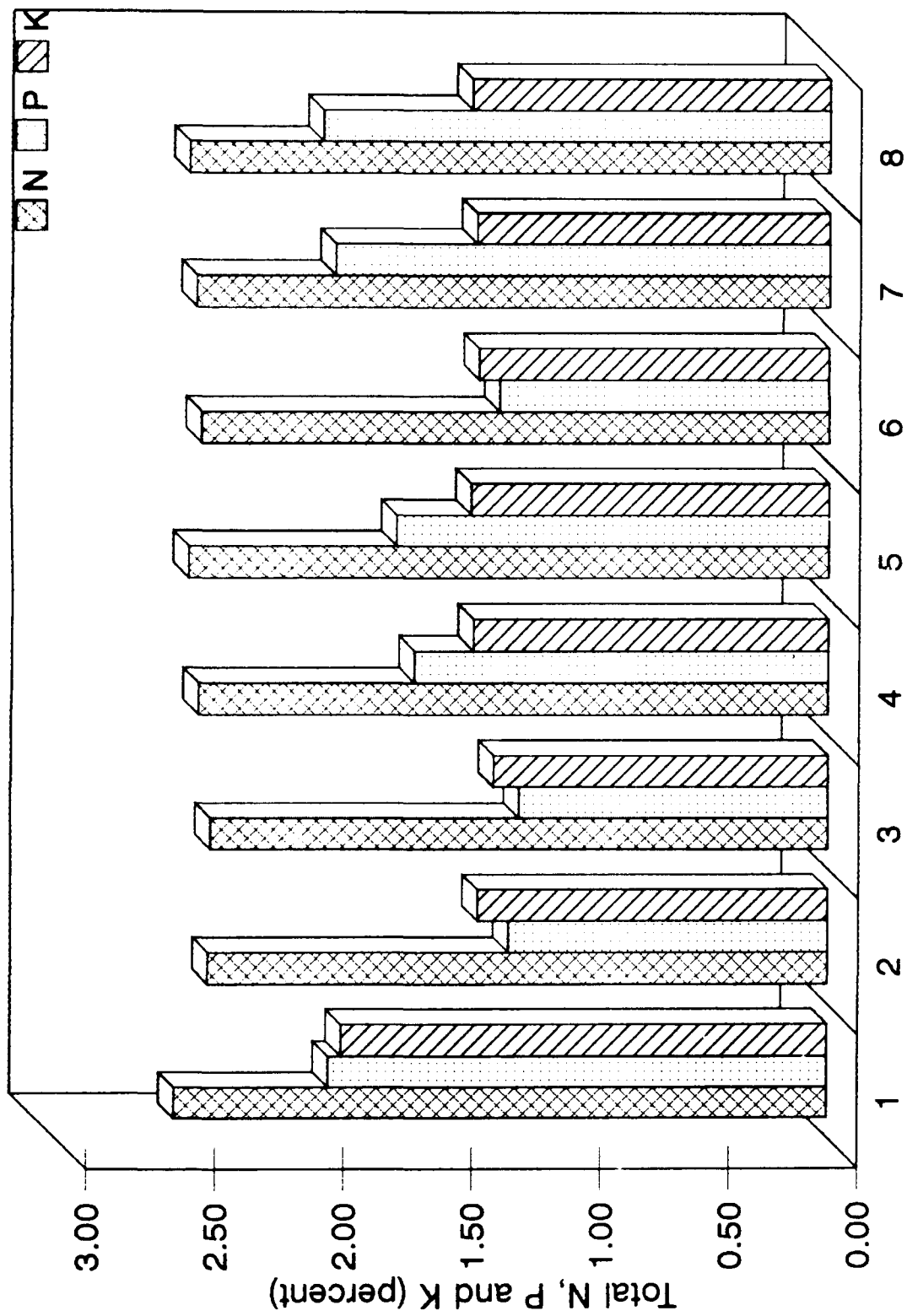


Fig.3.: Total Nitrogen, Phosphorus and Potassium content of Enriched pressmud

in enriched pressmud when compared to the untreated pressmud. Sikora and Azad (1993) reported that, composts made from pressmud and Bagasses were mixed with nitrogen and Phosphorus-fertilizers in a loamy soil to supply 0, 25, 50, 75 or 100 per cent nitrogen by the compost

### **5.3 Effect of applied enriched pressmud and fertilizers on mulberry leaf yield**

Application of enriched pressmud and fertilizers significantly increased the yield of mulberry leaves. The data in (Table-6, Fig.4) suggested that the fresh leaf yield obtained in the treatment receiving the enriched pressmud was significantly higher over control indicating promising trend crop yield. The highest yield of  $6826.27\text{kg ha}^{-1}$  ( at 75 days harvest ) was obtained from the treatment  $T_2$  compared to  $5696.18\text{kg ha}^{-1}$  (at 75 days harvest) in treatment  $T_{12}$ . Accounting an additional yield of 19 per cent. The yield obtained from treatment  $T_1$  (only pressmud) and  $T_{11}$  (untreated pressmud with fertilizers and 20 MT FYMha<sup>-1</sup>) are comparable indicating the possibility of reducing the fertilizer quantity to be added to the crop especially when pressmud is added as a manure to the mulberry crop. The leaf yield in various treatments followed the order  $T_2 > T_3 > T_{10} > T_9 > T_7 > T_6 > T_8 > T_1 > T_{11} > T_{12}$ . Narwal *et al.* (1990) reported that the increase in leaf yield by the application of pressmud may be attributed to the fact that pressmud being the byproduct of sugar industry is a good source of plant nutrients which contains 43.20 per cent organic carbon, 3.08 per cent total nitrogen and 0.62 per cent phosphorus. In addition to supply nutrients to mulberry crop, pressmud being organic in nature and acidic pH 5.6 had brought about marked changes in the soil properties which is similar to the results reported by Kapur and Kanwar (1989). Paramasivam (1991) reported that application of 20t pressmud, 75 kg Nitrogen and  $37.5\text{kg P}_2\text{O}_5\text{ha}^{-1}$  and 10t pressmud, 100 kg Nitrogen and  $37.5\text{kg P}_2\text{O}_5\text{ha}^{-1}$ , to rice were comparable in yield.

## Treatments

- T<sub>1</sub> Untreated pressmud
- T<sub>2</sub> Pressmud enriched with 5% NPK each + 100% Rec. Fert
- T<sub>3</sub> Pressmud enriched with 5% NPK each + 75% Rec. Fert.
- T<sub>4</sub> Pressmud enriched with FYM (3:1) + 100% Rec. Fert.
- T<sub>5</sub> Pressmud enriched with FYM (1:1) + 100% Rec. Fert.
- T<sub>6</sub> Pressmud enriched with BGSS (3:1) + 100% Rec. Fert.
- T<sub>7</sub> Pressmud enriched with BGSS (3:1) + *Azotobacter* sp. + 100% Rec. Fert.
- T<sub>8</sub> Pressmud enriched with FYM (3:1) + *Azotobacter* sp. + 100% Rec. Fert.
- T<sub>9</sub> Pressmud enriched with FYM (3:1) + 5% Mussoori rock phosphate + *Aspergillus awamorii* + *Azotobacter* sp. + 100% Rec. Fert.
- T<sub>10</sub> Pressmud enriched with BGSS (3:1) + 5% Mussoori rock phosphate + *Aspergillus awamorii* + *Azotobacter* sp. + 100% Rec. Fert.
- T<sub>11</sub> Untreated pressmud with FYM 20 MT/ha + 100% Rec. Fert.
- T<sub>12</sub> Absolute control

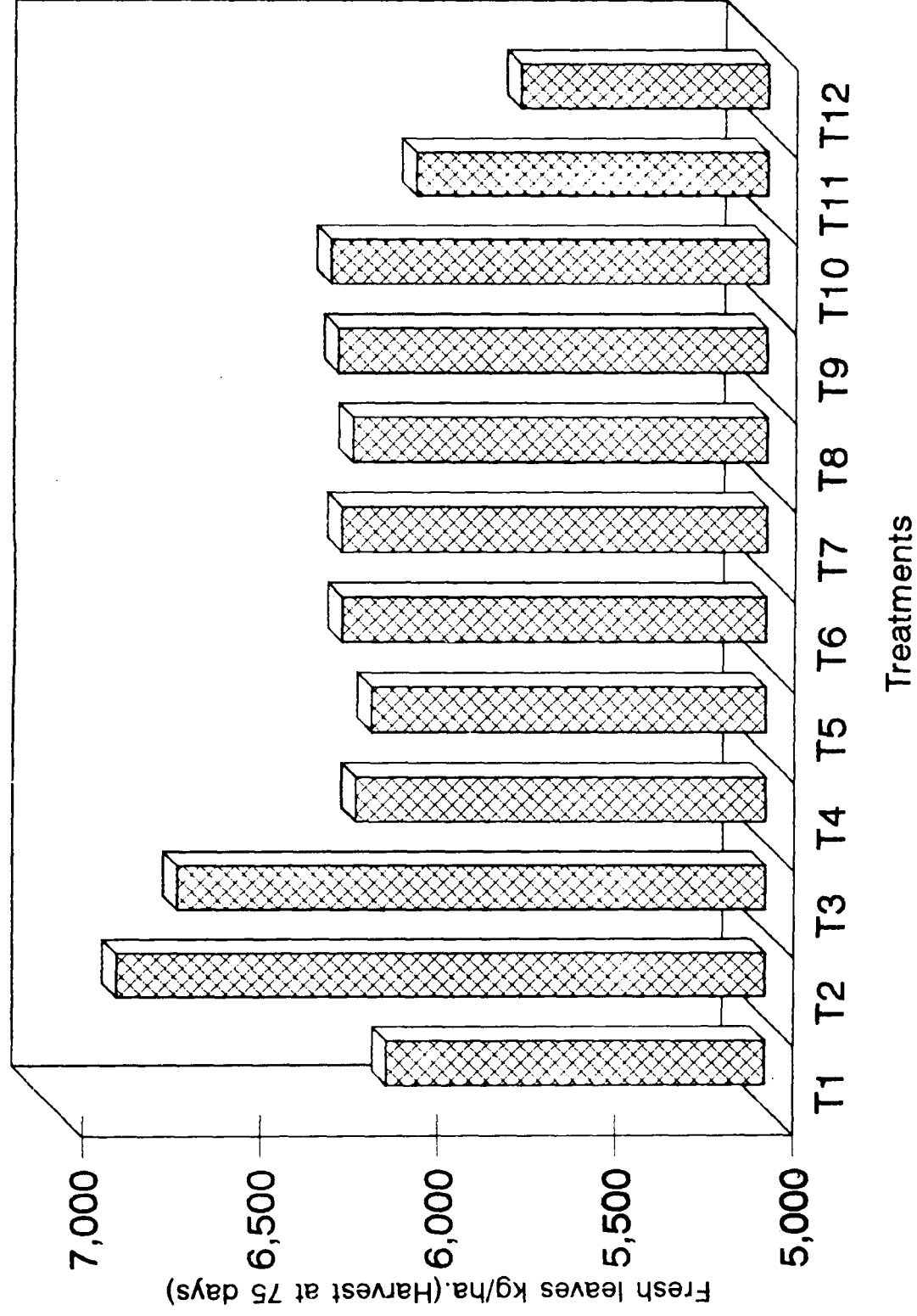


Fig.4.: Effect of Enriched pressmud and fertilizers on yield of mulberry leaves

## **1. A View of the field experiment**



2. **Growth of mulberry crop in treatment receiving untreated pressmud (A) and untreated pressmud with FYM 20 MT / ha + 100% Rec. Fert. (B).**



A



B

3. **Growth of mulberry crop in treatment receiving pressmud enriched with NPK each at 5% + 75% Rec. Fert. (A) and 100% Rec. Fert. (B).**



A



B

4. **Growth of mulberry crop in treatment receiving pressmud enriched with BGSS + 100% Rec. Fert. (A) and in absolute control (B).**



A



B

#### **5.4 Changes in soil properties as influenced by application of enriched Pressmud and fertilizers**

The soil samples collected after 75 days of application of enriched pressmud which coincided with the harvest of mulberry leaves were analysed for various physical and chemical properties and the results obtained discussed.

##### **5.4.1 Soil pH**

A reduction in soil pH was noticed due to application of enriched pressmud and fertilizers. The soil pH initial was 7.75 which was slightly reduced to 6.79 due to application of enriched pressmud in treatment T<sub>2</sub>. The reduction in soil pH was attributed to the release of organic acids. The pH values showed a significant reduction in case of alkali soil due to application of 10 tha<sup>-1</sup> of pressmud as reported by Indira Raj and Raj (1979) and Rajanna *et al.* (1997).

##### **5.4.2 Electrical conductivity of soil**

Use of enriched pressmud and fertilizers slightly increased the electrical conductivity of soil over control. The initial electrical conductivity of soil was 0.29dsm<sup>-1</sup> which was increased to 0.30dsm<sup>-1</sup> due to application of enriched pressmud and fertilizers in treatment T<sub>2</sub>. The increase in EC due to application of enriched pressmud and fertilizers was due to higher electrolyte concentration and also the release of electrolytes by degradation of enriched pressmud. In contrast however, Indira Raj and Raj (1979) reported that the electrical conductivity of soil was not significantly influenced by pressmud treatment. Gupta *et al.* (1987) reported that the increase in electrical conductivity under pressmud alone can be ascribed to initial high EC of pressmud obtained from sulphitation process.

### 5.4.3 Organic carbon content

The increase in organic carbon content of soil was attributed to application of the pressmud (Fig.5). The initial organic carbon content of the soil was 0.63 per cent which was increased significantly to 0.97 per cent in treatment T<sub>1</sub> and T<sub>9</sub> and 0.96 in T<sub>7</sub>, T<sub>8</sub> and T<sub>10</sub>. The enriched pressmud contains decomposable organic matter which has increased the organic carbon content of soil. Gupta *et al.* (1986) reported that application of either type of pressmud cake i.e. sulphitation and carbonation process brought an increase in organic carbon content of soil after the maize crop sequence but, the increase was more in case of pressmud of sulphitation than with pressmud of carbonation process. At higher doses, this difference was more pronounced. More (1994) reported that application of pressmud increased the organic carbon content of soil. A similar trend was observed in the present investigation also.

### 5.4.4 Available nitrogen

Available nitrogen status of soil was generally increased due to addition of pressmud (Fig.6). This may be due to mineralisation of added pressmud which helped in increasing the available nitrogen status of soil. The initial available nitrogen was 311kg/ha<sup>-1</sup> which increased to 370kg/ha<sup>-1</sup> due to application of enriched pressmud and fertilizers in treatment T<sub>2</sub>. A slight decrease in available nitrogen status in T<sub>4</sub>, T<sub>5</sub> and T<sub>11</sub> could be due to immobilization of nitrogen added through fertilizer. However, T<sub>3</sub>, T<sub>7</sub>, T<sub>8</sub>, T<sub>9</sub> and T<sub>10</sub> were comparable. However, the enriched pressmud had direct effect in increasing the available nitrogen content of soil by providing a congenial environment for soil microorganisms involved in nitrogen transformation and also application of nitrogen in the form of urea which helped in increasing

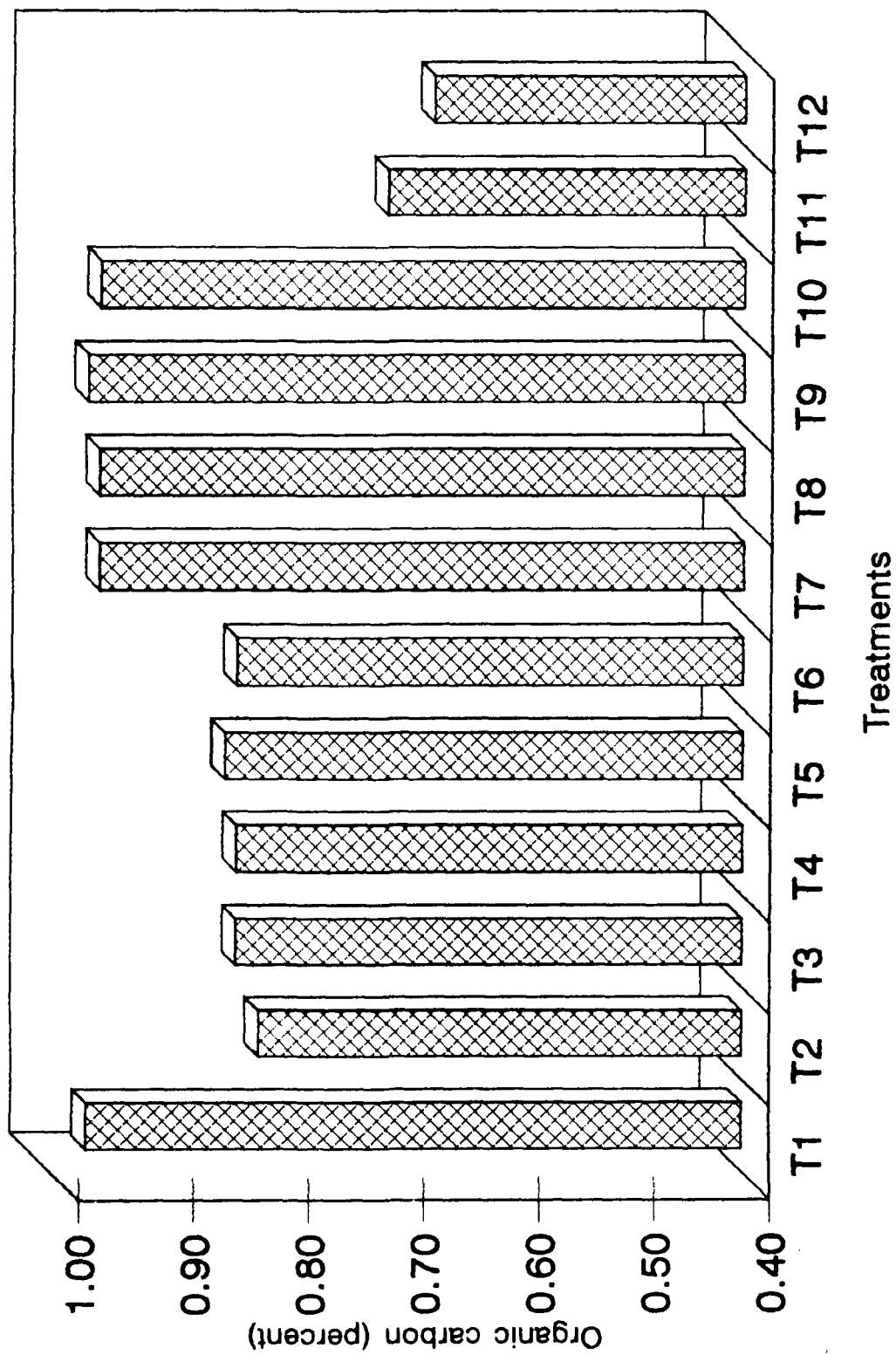


Fig.5.: Changes in organic carbon content of soil as influenced by application of Enriched pressmud and fertilizers

available nitrogen of soil. Application of pressmud not only increased the available nitrogen status but also improved the retention capacity of nutrient as reported by Paramasivam (1991).

#### 5.4.5 Available phosphorus

Available phosphorus content in treatment T<sub>12</sub> was 20.16kgha<sup>-1</sup> which was significantly increased to 45.78kgha<sup>-1</sup> in the treatment T<sub>10</sub>. A similar increase in available phosphorus status of soil was noticed in T<sub>2</sub>, T<sub>3</sub> and T<sub>9</sub>(Fig.6). While in other treatments the values ranged between 32.5 and 39.5kgha<sup>-1</sup> with exception to T<sub>11</sub> (29.68kgha<sup>-1</sup>). The data suggest that pressmud application either untreated or enriched could increase the phosphorus status of soil. This may apparently be due to release of phosphorus by the process of mineralisation of enriched pressmud and also applied phosphorus in the form of triple superphosphate which helped in increasing the available phosphorus status of soil. Further, most of the microbial cultures found to be very useful as they play a vital role in release of phosphorus both from native and applied phosphorus sources due to production of phosphate solubilising enzymes. Rose (1957) reported that *Aspergillus niger*, *Aspergillus ferreus* and *Sclerotium rolfsii* had a solubilizing effect on magnesium and iron phosphate. Among the eighteen fungi isolated from soils of paddy fields, *Aspergillus niger*, *Sclerotium rolfsii* and *penicillium sp.* had the ability to solubilize insoluble phosphate (Das, 1963). The fungi viz, *Aspergillus spp.*, *Aspergillus nidulans*, *Aspergillus niger*, *Aspergillus feavus*, *Aspergillus terreus* and *penicillium lilacinum* which were associated with root nodules legumes could solubilize tricalcium phosphate (Chhonkar and Subba Rao, 1967). Organic compounds are dominantly anionic in character (Caldwell and Black, 1958) and are expected to compete with phosphate ions in polar adsorption by the soil colloids and thus decrease the phosphate fixation. Organic anions can also decrease phosphate fixation by competing with

phosphate ions to fit into the clay mineral lattice and block the passage of lattice for phosphate. Acid produced in organic matter transformation could chelate with Iron and aluminum and prevent them from reacting with phosphate to form insoluble precipitation. Organic anions particularly, the hydroxy acids such as citrate, tartarate, oxalate and succinate and inorganic anions such as hydroxyl fluoride, arsenate, ferrocyanide etc ; have been found to reduce phosphorus fixation and assist in the release of native soil phosphate. Tiwari *et al.* (1988) reported that inoculation of rock phosphate with *Azotobacter sp.* and *Aspergillus awamorii* increased both citrate and water soluble phosphorus from mussoorie rock phosphate and also the yield of green gram crop. Inoculation with phosphate solubilizing fungus *Aspergillus awamorii* during composting, increased the phosphorus content from rock phosphate (Kapoor *et al.*, 1990). Virendra Kumar and Mishra (1991) reported that the available phosphorus content in soil determined after a maize crop increased due to application of pressmud cake of sulphitation process but it decreased in case of pressmud cake of carbonation process. So, the difference between the two types of pressmud widened with level of application. This effect of pressmud of carbonation process might be the result of excessive  $\text{CaCO}_3$  added through it and high pH thus developed. On the other hand, presence of organic matter, sulphides and phosphates coupled with absence of free lime in pressmud of sulphitation process would favour build up of available Phosphorus- in the soil.

#### **5.4.6 Available potassium**

Available potassium in soil was increased slightly due to application of enriched pressmud and fertilizers (Fig.6). In the treatment  $T_2$  the available potassium was  $151.19\text{kg ha}^{-1}$  and the same was increased to  $190.40\text{kg ha}^{-1}$  due to application of enriched pressmud and fertilizers in treatment  $T_2$ . In the rest of the treatments the values ranged between  $164.16$  to  $180.96\text{kg ha}^{-1}$ . This is

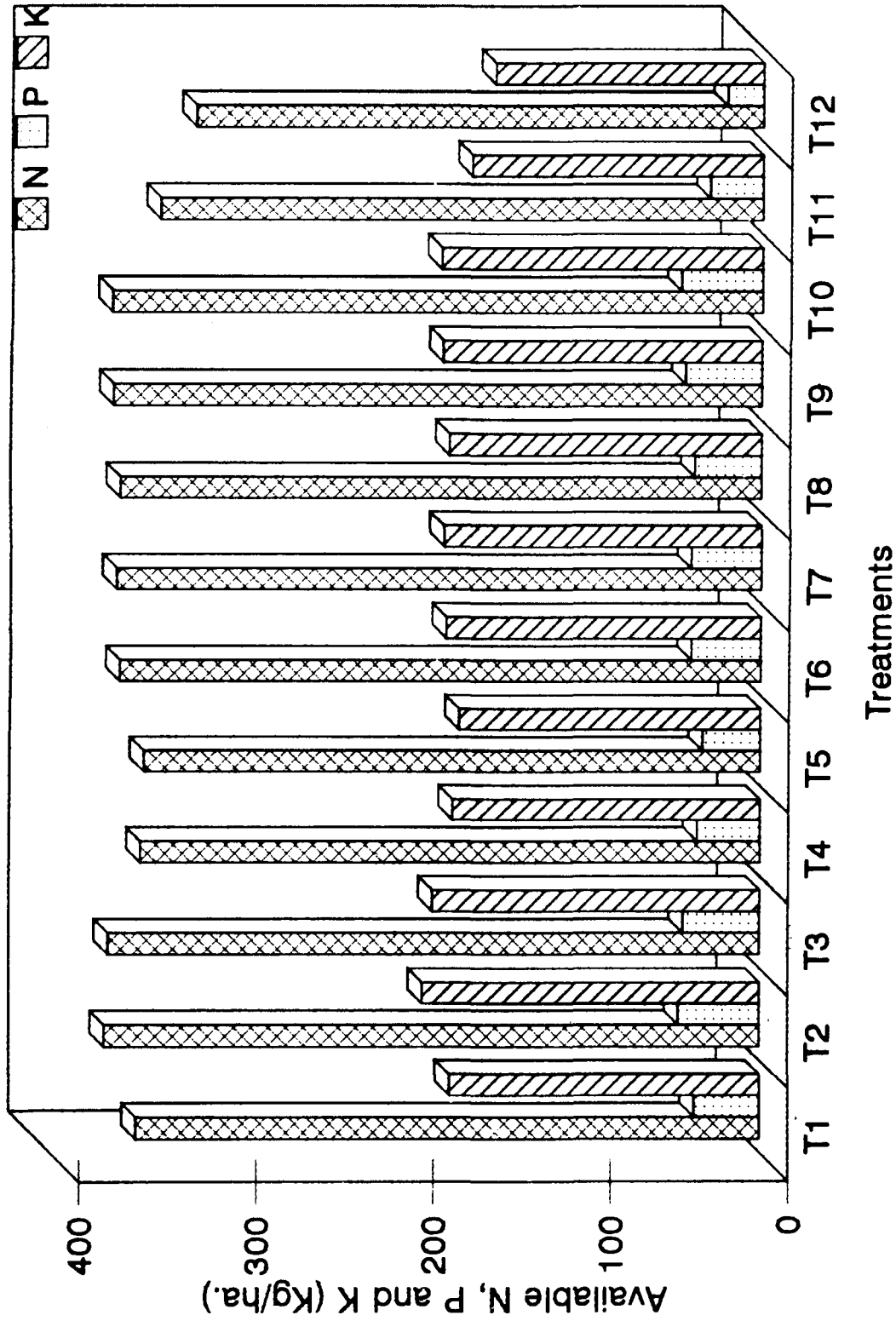


Fig.6.: Changes in available Nitrogen, Phosphorus and Potassium in soil as influenced by application of enriched pressmud and fertilizers

mainly due to release of potassium by the process of mineralisation of enriched pressmud and also application of potassium in the form of muriate of potash, which helped in increasing the available potassium of soil. Virendra kumar and Mishra (1991) reported that available Potassium in soil after maize was increased with an increase in doses of pressmud cake because the material contained appreciable quantity of Potassium which is not found in any organic combination. Here, again pressmud of sulphitation process showed better effects on available Potassium in the soil.

#### **5.4.7 Exchangeable calcium**

The addition of enriched pressmud and fertilizers to soil increased the exchangeable calcium content of soil. The initial content of exchangeable calcium in soil was  $3.61 \text{ cmol (p}^+) \text{ Kgha}^{-1}$  which was increased to  $4.86 \text{ cmol (p}^+) \text{ Kgha}^{-1}$  soil due to imposition of the treatment  $T_2$ , suggesting that considerable amount of calcium from enriched pressmud and fertilizers have gone to exchange complex of soil. Since, enriched pressmud contain about 2.15 to 2.4 per cent calcium, the addition of it to soil might have contributed to the pool of calcium in the soil. It was mainly because of the fact that the initially the solubility of calcium in enriched pressmud was slow but increased progressively with time. Hence, the calcium content in soil increased with time. Increase in availability of calcium in soil due to pressmud application has been reported by Golden (1975) and Prasad (1976). These authors noted an increase in solubility of calcium in the enriched pressmud with time.

#### **5.4.8 Exchangeable magnesium**

Next to calcium, magnesium is the dominant cation on the soil exchange complex. Addition of enriched pressmud and fertilizers increased the exchangeable magnesium content of the soil significantly over control. The

initial content of exchangeable magnesium in soil was  $0.98 \text{ cmol (p')} \text{ kg ha}^{-1}$  which was increased to  $1.76 \text{ cmol (p')} \text{ kg ha}^{-1}$  soil due to application of enriched pressmud and fertilizers in the treatment  $T_2$ . The increase was possibly through its dissolution from solid phase by the acidulation effect of decomposing enriched pressmud. Since, enriched pressmud contained about 1.24 to 1.32 per cent magnesium, the addition of it to soil might have contributed to the pool of magnesium in the soil. The magnesium content in soil increased due to application of pressmud in all the treatments apparently due to increased solubility of magnesium as reported for calcium by Golden (1975) and Prasad (1976).

#### 5.4.9 Available sulphur

The available sulphur in soil was significantly increased due to application of enriched pressmud and fertilizers. The highest available sulphur in treatment  $T_2$  was  $35.72 \text{ kg ha}^{-1}$  whereas the was observed in treatment  $T_{12}$   $24.19 \text{ kg ha}^{-1}$ . The available sulphur content in different treatments varied between  $28.16$  to  $35.13 \text{ kg ha}^{-1}$  as against  $24.19 \text{ kg ha}^{-1}$  in control. Addition of enriched pressmud applied to the soil is oxidized by the *Thiobacillus thiooxidans* species bacteria and made available to the crop. The pressmud being a potential source of sulphur because it is produced from sulphitation process. Application of pressmud at  $10 \text{ t ha}^{-1}$  increased the available sulphur in soil as reported by Sinha and Sakal (1993).

#### 5.4.10 DTPA extractable micro nutrients

The data on the DTPA extractable micronutrients in soil showed that the amount of available iron in soils increased considerably due to application of enriched pressmud. The increase in the amount of available manganese, zinc and copper was only marginal or low. Such variations might be attributed to

the variable amount of micronutrients present in enriched pressmud. Application of enriched pressmud and fertilizers in T<sub>2</sub> had significant influence on micronutrients status of soil as the contents 68.6, 38.9, 8.0 and 4.2ppm of Iron, Manganese, Zinc and Copper was increased from 47.9, 30.7, 4.8 and 2.9ppm in T<sub>12</sub> respectively. In all the treatments receiving the enriched pressmud the values for the micronutrients were on par with each other. The increase might be due to application of enriched pressmud might be attributed to various reasons, such as reduction in soil pH, dissolution of micronutrients from the solid phase into solution phase and chelation of micronutrients by organic acids. Deshmukh *et al.* (1993) reported a slight increase in both Zinc and copper content in soil with pressmud application. Shrishail S. Pujar (1994) reported that application of pressmud had significantly increased the available Iron, Manganese, Zinc and Copper content of soil over control. Soil pH decreased whereas availability of micronutrients in soils increased with an increased addition of pressmud as reported by Yaduvan Shi and Yadav (1992).

## **5.5 Physical properties of soil**

### **5.5.1 Water holding capacity of soil**

The water holding capacity of soil, in general, increased significantly in all the treatments over control. The values increased from 29.89 per cent (control) to 32.03 per cent (T<sub>1</sub>). In the rest of the treatments (T<sub>2</sub> to T<sub>11</sub>) the values ranged between 30.10 to 30.48 per cent. The effect of pressmud in increasing water retention capacity of soil is well documented. It was observed that the addition of enriched pressmud to soil reduced the bulk density of soil considerably. This factor was responsible for increasing water retention capacity of soil. Yelayutham and Raj (1971) reported a high correlation between water holding capacity and organic carbon in soil.

### **5.5.2 Bulk density of soil**

Bulk density of soil was significantly reduced due to application of enriched pressmud and fertilizers. Bulk density of soil in treatment  $T_{12}$  was  $1.44\text{gcm}^{-3}$  which was reduced to  $1.09\text{gcm}^{-3}$  due to application of treatment  $T_9$  and  $T_1$ . In the rest of treatments the bulk density values varied between 1.10 to  $1.39\text{gcm}^{-3}$ . The role of pressmud in increasing aggregate stability and volume of the porespace and consequent reduction in bulk density is well understood. The higher organic matter and calcium and magnesium contents of pressmud might have favoured flocculation and aggregation of soil particles and thus reduced the bulk density of soil to a greater extent.

The beneficial effects of pressmud is to improvement in soil physical conditions (Puttaswamy Gowda and Pratt, 1973).

## **6 Nutrient content and their uptake by the mulberry crop as influenced by application of enriched pressmud and fertilizers**

### **6.1 Nitrogen content and its uptake**

There was significant increase in nitrogen content of mulberry leaves as well as the uptake due to application of enriched pressmud and fertilizers (Fig.8). The uptake of nitrogen in the treatment  $T_{12}$  was  $30.45\text{kg ha}^{-1}$  which was significantly increased to  $57.10\text{kg ha}^{-1}$  due to application of the treatment  $T_2$ , the higher uptake of nitrogen may be due to higher percentage of nitrogen in the pressmud along with the fertilizers in the form of urea which contributed to higher nitrogen values. The data revealed that higher nitrogen content and its uptake by mulberry crop in the enriched pressmud as compared to untreated suggest the need for treating pressmud before its use. Virendra Kumar and Mishra (1991) reported that total nitrogen uptake by rice plant increased with

increasing dose of pressmud cake up to  $10\text{tha}^{-1}$  but above this dose a marked decrease occurred.

## 6.2 Crude protein

There was significant increase in the crude protein content of mulberry leaves due to application of enriched pressmud and fertilizers (Fig.7). Crude protein content of mulberry leaves in the treatment  $T_{12}$  was 15.69 per cent which was significantly increased to 17.81 per cent due to application of the treatment  $T_2$ , which is attributable relatively higher nitrogen content of pressmud enriched with nitrogen at 5 per cent level in the form of urea, thus the readily available nitrogen has contributed to increased uptake and the crude protein content. This was evident by having higher values of crude protein in treatments receiving fertilizers during composting as compared to without fertilizers.

## 6.3 Phosphorus content and its uptake

There was significant increase in the phosphorus content of mulberry leaves as well as uptake with application of the enriched pressmud and fertilizers (Fig.8). Uptake of phosphorus in treatment  $T_{12}$  was  $3.82\text{kg}\text{ha}^{-1}$  which was significantly increased to  $11.22\text{kg}\text{ha}^{-1}$  due to the application of treatment  $T_2$  and because of higher phosphate content in the pressmud due to application of phosphorus in the form of triple superphosphate which contributed higher phosphorus values. Next to  $T_2$ , the treatment  $T_9$  which received pressmud enriched with rockphosphate and phosphorus solubilizing microorganisms recorded higher phosphorus content and uptake. This was evidently due to solubilization of phosphorus from rockphosphate by *Aspergillus awamorii* released from FYM during compost making process. Indira Raj and Raj (1981) reported that the phosphorus uptake by grain

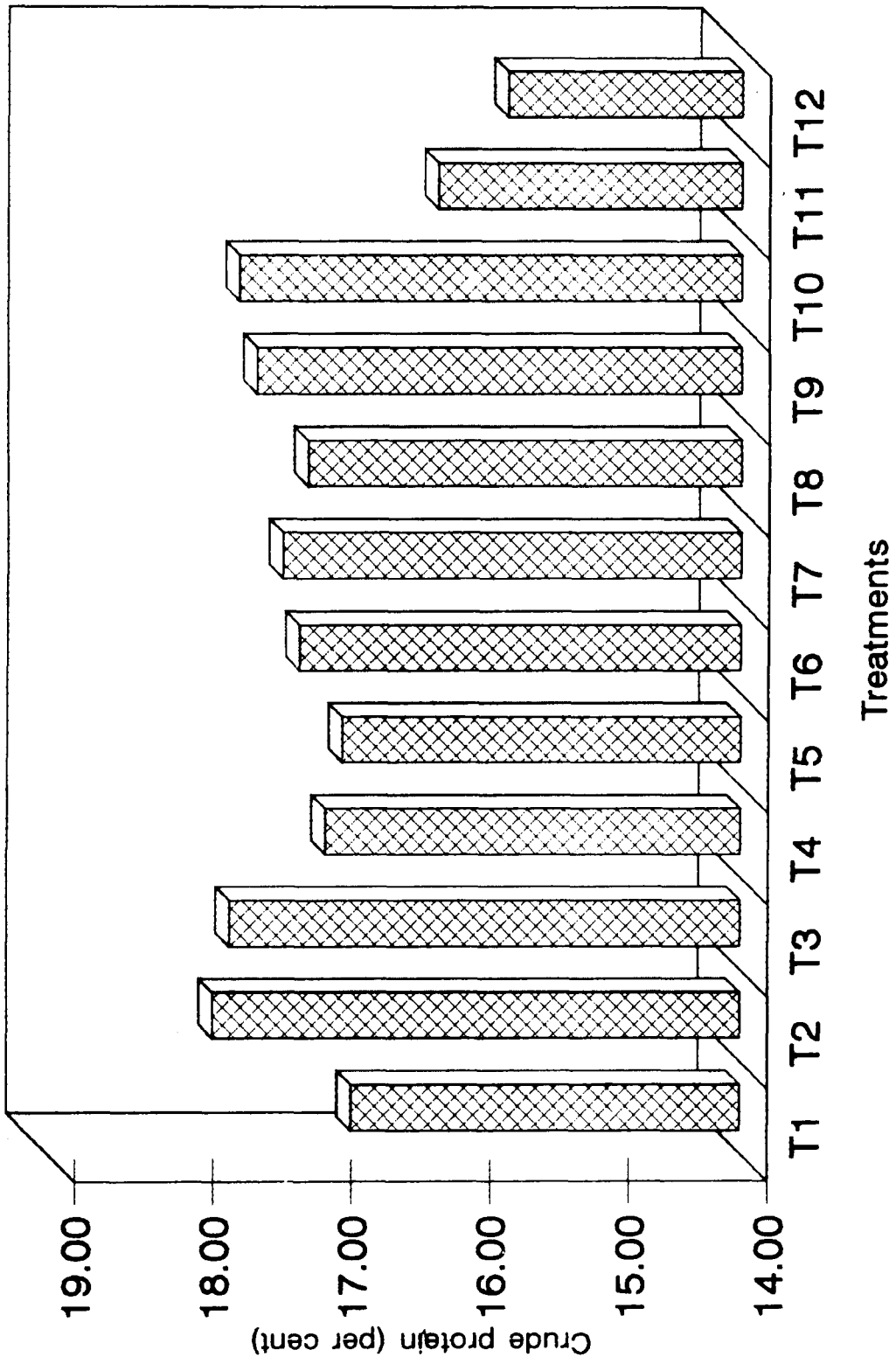


Fig.7.: Crude protein content of mulberry leaves as influenced by application of Enriched pressmud and fertilizers

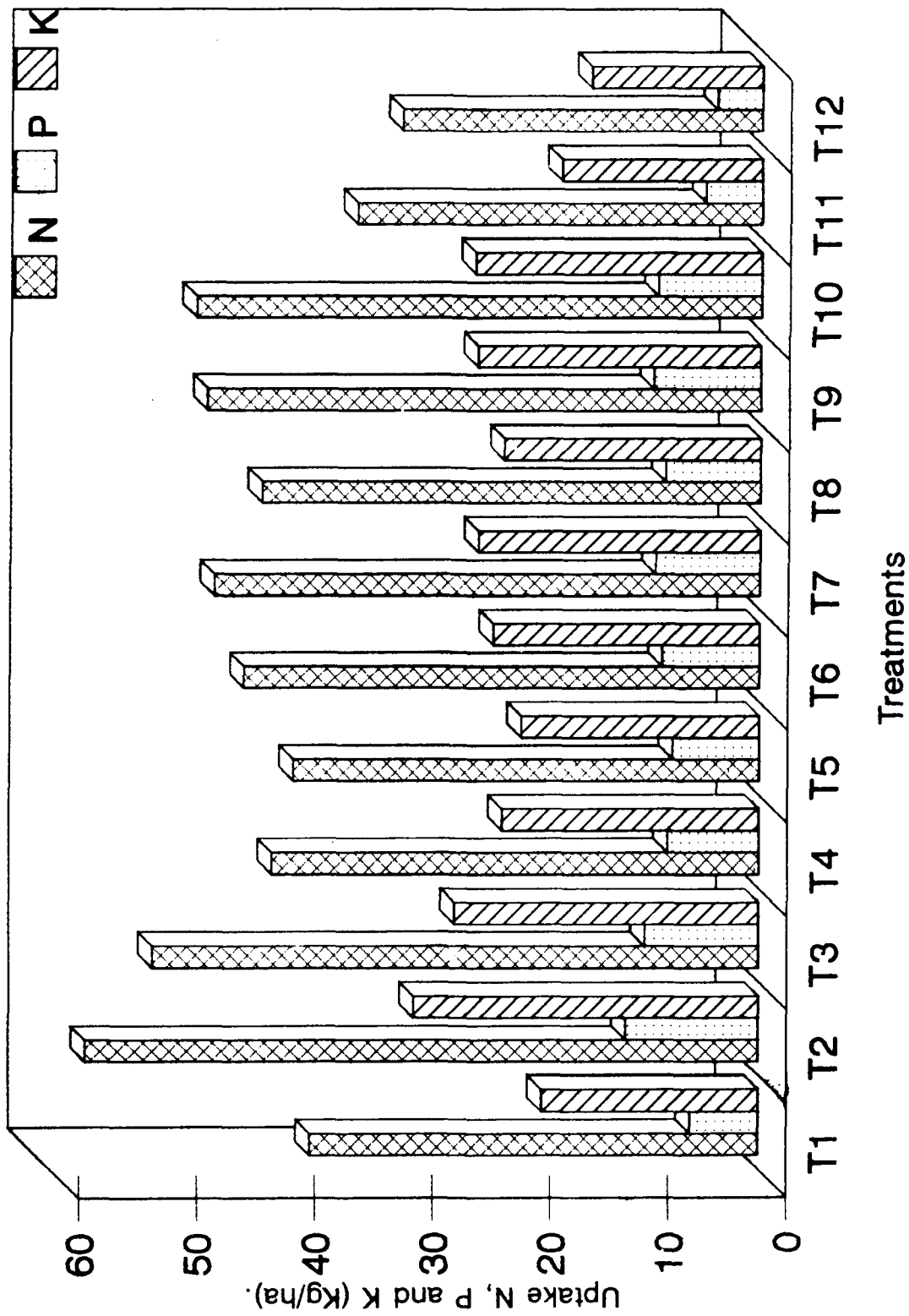


Fig.8: Uptake of Nitrogen, Phosphorus and Potassium by mulberry crop

increased progressively with increasing level of pressmud tried irrespective of soils, probably due to higher availability of phosphorus in these treatments as compared to the control.

#### **6.4 Potassium content and its uptake**

Potassium content of mulberry leaves and uptake were significantly increased due to application of the enriched pressmud and fertilizers (Fig.8). In the treatment  $T_{12}$ , the potassium uptake by crop was  $14.47\text{kg ha}^{-1}$  and the same was significantly increased to  $29.25\text{kg ha}^{-1}$  due to application of treatment  $T_2$ . This higher potassium uptake in treatment  $T_2$  is attributed to release of potassium from pressmud due to its decomposition, as well as contribution from muriate of potash. Indira Raja and Raj (1981) reported that the potassium uptake in grain increased progressively with pressmud application in red and lateritic soils.

#### **6.5 Calcium content and its uptake**

The addition of enriched pressmud and fertilizers to soil significantly increased the calcium content of mulberry leaves and uptake. Uptake of calcium in the treatment  $T_{12}$  was  $13.13\text{kg ha}^{-1}$  which was significantly increased to  $33.05\text{kg ha}^{-1}$  due to application of treatment  $T_2$ . The higher calcium uptake in the treatment  $T_2$  is attributed to release of calcium from the pressmud during its decomposition. Calcium content of sugarcane leaves was increased from deficient to adequate range as a result of filter pressmud application as reported by Prasad (1976).

## 6.6 Magnesium content and its uptake

Significant increase in magnesium content of mulberry leaves as well as uptake was observed with application of enriched pressmud and fertilizers. Uptake of magnesium in treatment T<sub>12</sub> was 6.08kg ha<sup>-1</sup> which was significantly increased to 15.02kg ha<sup>-1</sup> due to application of treatment T<sub>2</sub>. Application of pressmud significantly improved the uptake of magnesium by mulberry crop which might be due to higher amount of magnesium present in pressmud. Prasad (1976) reported that filter pressmud application increased the magnesium content of sugarcane leaves. In general, the calcium and magnesium contents and their uptake increased in treatments receiving pressmud enriched with organics or fertilizers as compared untreated pressmud. Pressmud enrichment process apparently increased the availability of these nutrients.

## 6.7 Sulphur content and its uptake

A significant increase in the sulphur content of mulberry leaves and uptake were observed with application of enriched pressmud and fertilizers. In the treatment T<sub>12</sub>, the sulphur uptake by the crop was 2.5kg ha<sup>-1</sup> which was significantly increased to 8.41kg ha<sup>-1</sup> due to application of the treatment T<sub>2</sub>. This may be due release of more sulphur during decomposition besides higher sulphur content of pressmud from the sulphitation process and a resulting increase in its uptake by the mulberry crop.

## 6.8 Micro-nutrients content of mulberry leaves

### 6.8.1 Iron content

There was significant increase in the iron content of mulberry leaves with application of enriched pressmud and fertilizers. Iron content of mulberry

leave in treatment  $T_{12}$  was 246.1ppm which was significantly increased to 266.2ppm due to application of treatment  $T_2$ . This was due to supply of iron from its pool as well as the result of reduction in soil pH. Both the reactions might have contributed to increase in the availability of iron in soil and up take by the mulberry crop.

#### **6.8.2 Manganese content**

There was` significant increase in the manganese content of mulberry leaves due to application of enriched pressmud and fertilizers. In the treatment  $T_{12}$ , the manganese content of mulberry leaves was 64.9ppm which was significantly increased to 80.5ppm due to application of treatment  $T_2$ . This was mainly due to supply of manganese from the decomposed enriched pressmud and reduction in soil pH. Both the reactions might have contributed to increase in the availability of manganese in soil and uptake by the mulberry crop.

#### **6.8.3 Zinc content**

Zinc content of mulberry leaves was increased due to application of enriched pressmud and fertilizers. The zinc content of the mulberry leaves in treatment  $T_{12}$  was 48.9ppm which was increased to 61.5ppm due to application of treatment  $T_2$  but the difference was in significant. This might be due to decomposition of enriched pressmud and reduction in soil pH.

#### **6.8.4 Copper content**

Application of enriched pressmud and fertilizers slightly increased the copper content of mulberry leaves. The copper content of mulberry leaves in treatment  $T_{12}$  was 6.1ppm and the same was increased to 8.9ppm due to

application of treatment T<sub>2</sub>. This was mainly due to supply of copper from its pool as well as reduction in soil pH. Both the reactions might have contributed to the slight increase in the availability of copper in soil and uptake by the mulberry crop.

It is generally established fact that organic matter interacts with polyvalent cations and forms the stable metal organic complexes in the soil. As a result the availability of micronutrients increased in soil and consequently their uptake by the mulberry crop.

Shinde et al. (1993b) reported an increased uptake of Iron, Manganese, Zinc and Copper in pressmud amended plots. Similar results were also reported by Shrishail S. Pujar (1994) in Maize crop.

# **SUMMARY**

## VI SUMMARY

A field experiment was carried out at Main Research Station, Hebbal, Bangalore, during Kharif 1996 to investigate the effect of applied enriched pressmud and fertilizers on yield of mulberry leaves and the properties of the soil under irrigated conditions. The experiment was laid out in RCBD design with twelve treatments and three replications. Soil and plant samples collected after the harvest of mulberry leaves were analyzed for various parameters. The important findings of this investigation are summarized in this chapter.

The pressmud of sulphitation process obtained from Sri Chamundeswari Sugars limited, K.M. Doddi, near Maddur in Mandya, district was used in the study.

The pressmud is slightly acidic in reaction with high content of soluble salts. The sulphitation process pressmud contains higher level of organic carbon, sulphur, nitrogen, calcium, phosphorus, potassium and magnesium. Among the micronutrients iron is the highest as compared to others.

Composted pressmud enriched either with NPK fertilizers or FYM, Biogas spent slurry (BGSS) and microorganisms such as *Azotobacter sp.* and *Aspergillus awamorii* indicated a slight improvement with higher nutrient status compared to untreated pressmud.

Application of enriched pressmud along with recommended fertilizers found to increase the yield of mulberry leaves over absolute control. The highest yield was recorded in treatment T<sub>2</sub> (Pressmud enriched with N, P, K at 5% each + Recom. Fert.) while the lowest yield was in absolute control (T<sub>12</sub>). However, no yield difference was observed between T<sub>1</sub> and T<sub>11</sub> treatments. The mulberry leaves yield was higher in all the treatments

(T<sub>2</sub> to T<sub>10</sub>) receiving composted and enriched pressmud along with fertilizers as compared to using untreated pressmud with FYM + fertilizers (T<sub>11</sub>) or only untreated pressmud (T<sub>1</sub>).

A reduction in soil pH, an increase in electrical conductivity (E.C), O.C, available N,P,K,S, exchangeable Ca and Mg and micronutrients status of soil was observed with the addition of enriched pressmud and fertilizers.

Pressmud enriched with Mussoori rock phosphate and P-solubilizing microorganisms (T<sub>9</sub> and T<sub>10</sub>) recorded a higher P status in soil as well as uptake by mulberry crop indicating mobilization of phosphorus from Mussoori rock phosphate by P-solubilizing microorganisms.

A slight increase in water holding capacity of soil from 29.89 to 30.48 per cent (T<sub>12</sub> to T<sub>8</sub>) and a significant reduction in bulkdensity was noticed in soil receiving the enriched pressmud.

Significantly increased uptake of N, P, K and crude protein content and Ca, Mg and S including Fe and Mn with reduction in Zn and Cu content in leaves was recorded due to application of enriched pressmud and fertilizers.

In conclusion it is inferred that pressmud with suitable enrichment found to be viable alternative organic source for higher mulberry crop yield and to maintain higher soil fertility status.

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\* Original not seen.

## APPENDIX

Cost and return from mulberry crop (one crop harvest only at 75 days) as influenced by application of enriched pressmud.

Treatment	Total cost of enriched pressmud/crop (A) Rs.	Fertilizer cost (B) Rs.	Cost of Cultivation (C) Rs.	Total Cost (A+B+C) Rs.	Total return Rs.	Net return Rs.
T <sub>1</sub> = 280	-	-	5465	5745	9007.50	3262.50
T <sub>2</sub> = 504	504	938	5465	6907	10389.00	3482.00
T <sub>3</sub> = 504	504	704	5465	6673	9984.30	3311.30
T <sub>4</sub> = 380	380	938	5465	6783	9213.30	2448.30
T <sub>5</sub> = 380	380	938	5465	6783	9166.35	2383.35
T <sub>6</sub> = 380	380	938	5465	6783	9291.90	2508.20
T <sub>7</sub> = 460	460	938	5465	6863	9295.20	2432.20
T <sub>8</sub> = 460	460	938	5465	6863	9249.15	2386.15
T <sub>9</sub> = 500	500	938	5465	6903	9312.15	2409.15
T <sub>10</sub> = 500	500	938	5465	6903	9344.85	2441.85
T <sub>11</sub> = 580	580	938	5465	6983	8985.15	2002.15
T <sub>12</sub> = -	-	-	5465	5465	8409.00	2944.00

Value of leaf : Rs. 1.5/kg    '-' : NO cost

Details :

- |                                    |  |
|------------------------------------|--|
| 1. Cost of urea : Rs. 3400/tonne   | 2. Cost of TSP : Rs. 5900/tonne                    |
| 3. Cost of MOP : Rs. 3900/tonne    | 4. Cost of FYM : Rs. 150/tonne                     |
| 5. Cost of BGSS : Rs. 150/tonne    | 6. Cost of pressmud : Rs. 20/tonne                 |
| 7. Cost of Azotobactor : Rs. 20/Kg | 8. Cost of <i>Aspergillus awamorii</i> : Rs. 20/Kg |