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Comparative effects of organic based fertilizer and mineral fertilizer on the dry matter yield of maize

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ABSTRACT: A greenhouse experiment was conducted to evaluate comparative effectiveness of organic based fertilizer (OBF), Compost and mineral fertilizer (MF) on maize performance. The OBF was a product of Compost and MF containing major ingredients which are locally sourced and regarded as wastes. The fertilizers were applied to pot filled with 3 kg soil at rates having equivalent weight of between 0 and 400 mgN/kg.

The results of organic fertilizers analysis showed that the N concentration in Compost was twice that in farm waste and 40% higher than that in the poultry manure. The phosphorus level was 25% higher than in farm waste and 30% lower in poultry manure. The Ca and Mg contents were higher in Compost almost by 400% and 200% respectively as compared with the levels in farm waste. Higher levels of some micronutrients were also detected in the Compost than in the original materials. The OBF, on the other hand, was richer in plant nutrients than the Compost.

Application of the organic and mineral fertilizers increased the dry matter yield of maize. In the first cropping, the MF and OBF were more superior to Compost at application rates less than 400 mgN/kg. The MF was less effective than the organic fertilizers in subsequent croppings showing that the latter gave better residual effect than the former which is a conventional fertilizer. Application of OBF improved uptake of both macro and micronutrients by maize. On the whole, influence of the fertilizers on nutrient uptake followed in the ascending order of Compost, MF and OBF except that there were some slight variations in cumulative uptake of some of the lements. The use of OBF as fertilizer source in crop production provides an alternative to lack of organic input in inorganic fertilizer application.

Key Words:

Introduction

The practices of involving multicropping system and reduced fallowing are commonly engaged by farmers in the developing countries. These practices often cause nutrient depletion and low organic matter in most soils due to lack of proper soil management (Abdullah and Lombin, 1978; Agboola and Sobulo, 1981). The use of mineral fertilizers as soil ammendment has been widely accepted by farmers and is regarded to be a quick solution to soil fertility problems in the area. However, wide adoption of most fertilizer recommendations has been limited due to scarcity and/or high cost of product.

The use of organic materials as alternative source of fertilizer for maintenance of soil organic matter is now receiving attention in the developing countries (Agboola and Unamma, 1994). It is envisaged that

locally available materials of plant and animal origin, by-products of agricultural activities be used or, where such materials are available in abundance, *in situ* recycling of organic wastes be done. Proper use of organic material as fertilizer improves both physical and chemical properties and as well as microbial activities of the soil (Titiloye et al., 1985).

There are a number of free-living bacteria that have been implicated in making significant contributions to plant productivity in tropical cropping systems. Members of the genus *Azotobacter* are free-living bacteria with the remarkable ability to fix N_2 aerobically. The two best-known species, *A. chroococcum* and *A. vinelandi* are very susceptible to pH variation and normally found in a few near-neutral soils in the humid tropics (Dobereiner and Podrosa, 1987).

Organic materials such as farmyard manure, crop residues, etc, are bulky and supply low quantities of major plant nutrients. Nutrients release from the materials are also slow. Their eficiency, therefore, require to be improved through addition or supplementary application of some essential plant nutrients in the form of mineral fertilizer and/or agrominerals (Lombin et al., 1994). Recycling of these organic wastes is therefore important for a sustainable agriculture (Parr et al., 1986).

Also, Composting of organic materials reduces bulk, transportation and application costs, increases rate of nutrients release and enhances crop yield. Parr (1975) indicated significant yield increase when Compost was used on Korean soils low in organic matter.

Short- and long-term effects of organic manures have been demonstrated widely in India and China where cowdung is abundantly available for use as an organic source of plant nutrients (Tandon, 1992). In Nigeria, the importance of organic manuring in farming system has been highly emphasised and its effect as a source of lime and micronutrients under intensive agriculture has been demonstrated (Amon and Adetunji, 1957, 1960). Micronutrients problems are well shown in some major soils in tropical Africa (Kang and Osiname, 1985). The micronutrients are rarely supplied with the conventional mineral fertilizers except recently, in the late 90s, but they are very expensive.

Supplementation of organic manure with mineral fertilizer is highly necessary in meeting crop requirement of plant nutrients. This, however, involves extra costs of application, especially at top dressing. Production of mixed fertilizer materials (organic and mineral fertilizers) may be a complication at the farmers' level. The present study was, therefore, aimed at evaluating, in the greenhouse, the effecttiveness of organic based fertilizer (Compost fortified with mineral fertilizer) on maize performance.

Materials and Methods

Composting of some farm wastes (maize straw, cobs and sheaths) with poultry manure was carried out using the passively aerated composting technique, i.e. passive supply of air into the Compost heap. The Compost after maturity was fortified with a solution of mineral fertilizer, raising the nitrogen content to about 5%. This forms the organic based fertilizer (OBF).

The agronomic efficiency of the Compost and OBF were evaluated in the greenhouse using the mineral fertilizer (MF) as a check. The fertilizers were applied at the rates of 0, 50, 100, 200 and 400 mg N/pot respectively; OBF as 0, 1.56, 3.12, 6.24, 12.48 g/pot respectively and urea (MF) as 55.56, 111.12, 223.24 and 444.48 respectively. Basal P and K each at 100 mg/kg of soil were supplied to the treatment with MF. The soil used for the experiment was Iwo series classified as paleustalf (USDA). It was passed through 2mm sieve and each experimental pot was filled with 3 kg of soil. Furthermore, the organic fertilizers were thoroughly mixed with soil and incubated for one week before planting.

Maize (DMRESR) was grown as test crop for five weeks. Four seeds were planted and later thinned to two plants per pot. Cropping was carried out for three cycles. The design of the experiment was randomised complete block replicated four times. Shoot dry matter yield was determined, plant and soil samples were analysed for nutrients in the laboratory.

The organic fertilizers and plant samples were digested with 2:1 mixture of HNO_3 and $HClO_4$. The plant materials were also ashed in the muffle furnace at 450^oC. Cations, including heavy metals, were detected in the Atomic Absorption Spectrophotometer. Nitrogen was determined on the Technicon II Auto Analyzer and phosphorus on the Spectronic 20 (IITA, 1979).

Estimates of the biomass of heterotrophic N_2 fixing *Azotobacter* was made after growth on the Sesan medium (Alexander, 1977). The medium consisted of the following nutrients: 0.01g K_2HPO_4; 0.01g

$MgSO_4$; 0.01g NaCl; 0.05g $FeSO_4$; 0.05g $CaSO_4$; 0.005g $MnSO_4$; 0.05g $NaMoO_4$ and 0.75g $CaCO_3$ in 1000 ml of distilled water (Jensen and Petersen, 1955).

Results

Fertilizer Analysis

Table 1 shows the results of the chemical analysis of Compost and the materials used for composting. The nutrients values in farm waste were lower than those in poultry manure. The concentration of nitrogen in the Compost was twice thta in the farm waste and higher by 40% than that in the poultry manure. Potassium in the Compost was almost thrice that in the farm waste and 18% higher than that in the manure. This could be as a result of mineralization of the organic waste during composting which might enhance availability of fixed nutrients in the organic material.

On the other hand, phosphorus concentration in Compost was about 30% lower than in the manure and maintained a 25% increase over the farm waste. Micronutrients such as Zn was highest while Fe was lowest in the Compost. Cd and Pb were either very low or not detected in the fertilizer materials. However, Cu was much more concentrated in the poultry manure than in other materials. The physico-chemical properties of the pre-crop soil are shown in Table 2. The soil was low in most of the essential plant nutrients with the exception of K which was moderately adequate.

Dry Matter Yield

Fig. 1 illustrates the effect of the organic fertilizers on dry matter yield (DMY) of maize. The least effect was from aplying Compost and was well shown both in the first and third croppings. The organic based fertilizer (OBF) and mineral fertilizer (MF) were almost similar in effectiveness from 0 to 200 mgN/kg in the first cropping. At 400 mgN/kg MF the DMY decreased. The OBF on the other hand showed gradual yield increase as fertilizer rates increased. The advantage of OBF over other fertilizers was well shown inthe third cropping. Application of 200 mgN/kg gave optimum DMY. This indicates that the OBF showed higher residual effect and this would be of high benefit on long-term use.

The effect of the fertilizers on cumulative DMY is presented in Fig. 2a. there was linear yield increase at increased organic fertilizer rate. Depression was observed due to MF application at 400 mgN/kg. This might be as a result of luxurious consumption of the element at this rate. The overall trend of DMY accumulation was similar to that observed in the first cropping.

Contrary to the pattern of cumulative DMY obtained in three cropping cycles, the nitrogen recovery fraction in DMY decreased as fertilizer rates increased. More nitrogen was recovered from MF application, followed by OBF and then Compost. The highest recovery was obtained from applying 50 mgN/kg. However, the difference between the fertilizers narrowed down as the fertilizer rates increased. Application of additional amount might have the tendency to cause nutritional imbalance in the plant and therefore could not give yield increase in accordance with increased fertilizer rates.

Cumulative Nutrient Uptake

Application of organic fertilizers improved the uptake of some macronutrients by maize (Fig. 3). The nitrogen uptake increased with increased fertilizer rates and the differences ($P = 0.05$) between the fertilizer rates was significant (Fig. 3a). However, there was no significant difference between the fertilizers at the same application rates. The highest value of nitrogen uptake from MF application was realised in the first cropping. In subsequent croppings the Compost and OBF showed higher uptake. A similar observation was as regards other major nutrients (data not shown). Maximum phosphorus uptake from MF was found to

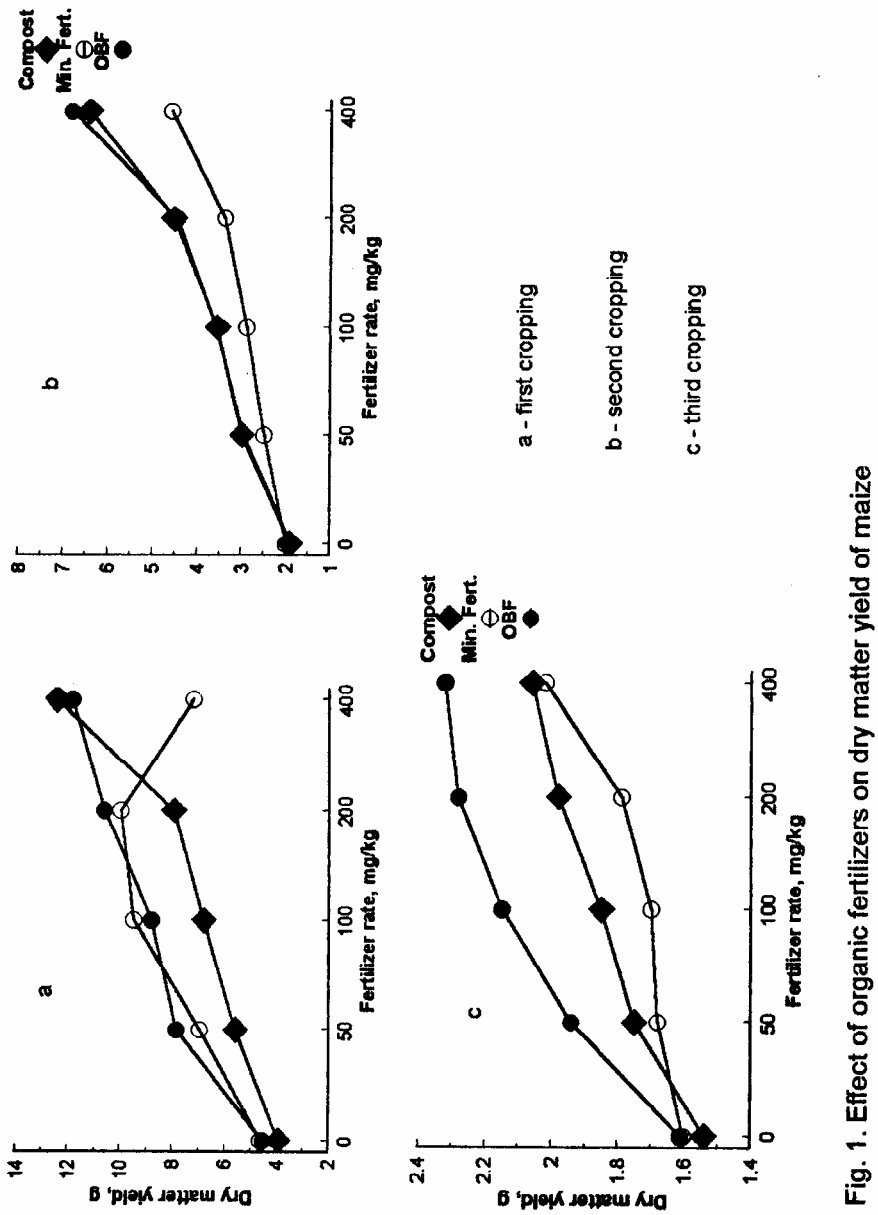

Fig. 1. Effect of organic fertilizers on dry matter yield of maize

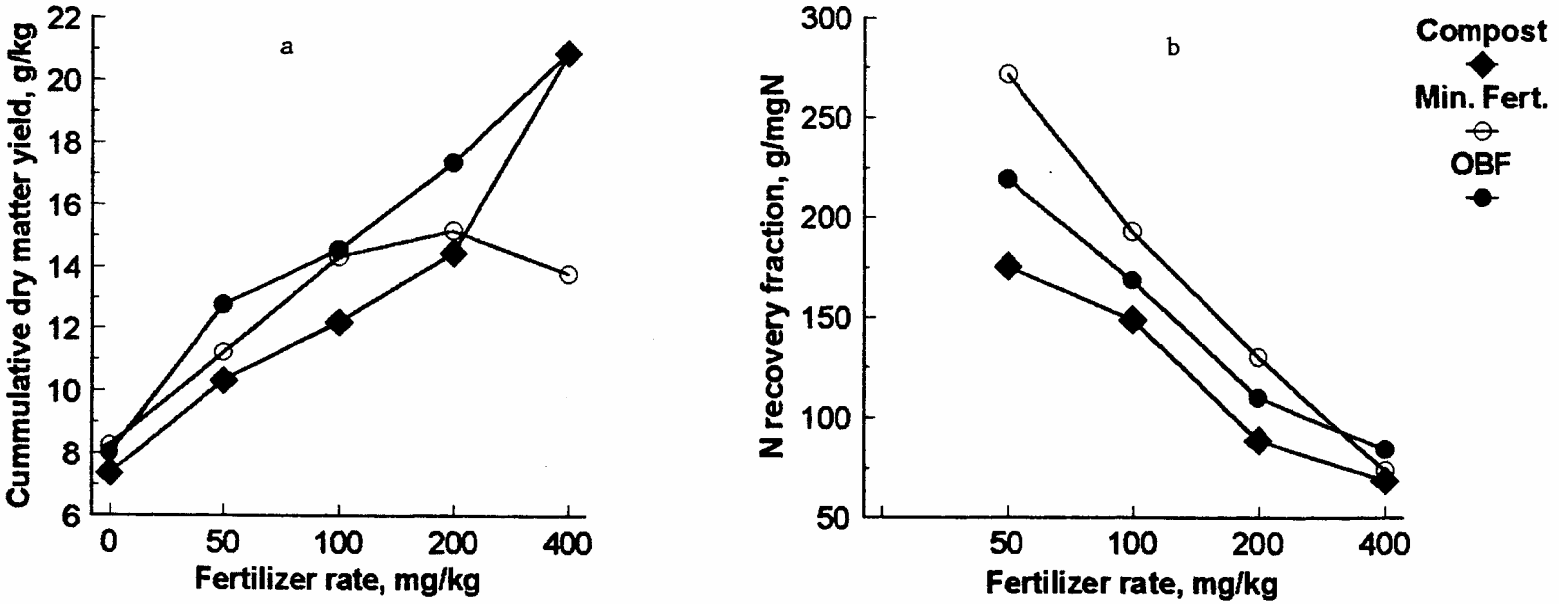

Fig. 2. Effect of organic based fertilizers on cummlative dry matter yield (a) of maize and N-recovery fraction (b) in dry matter yield .

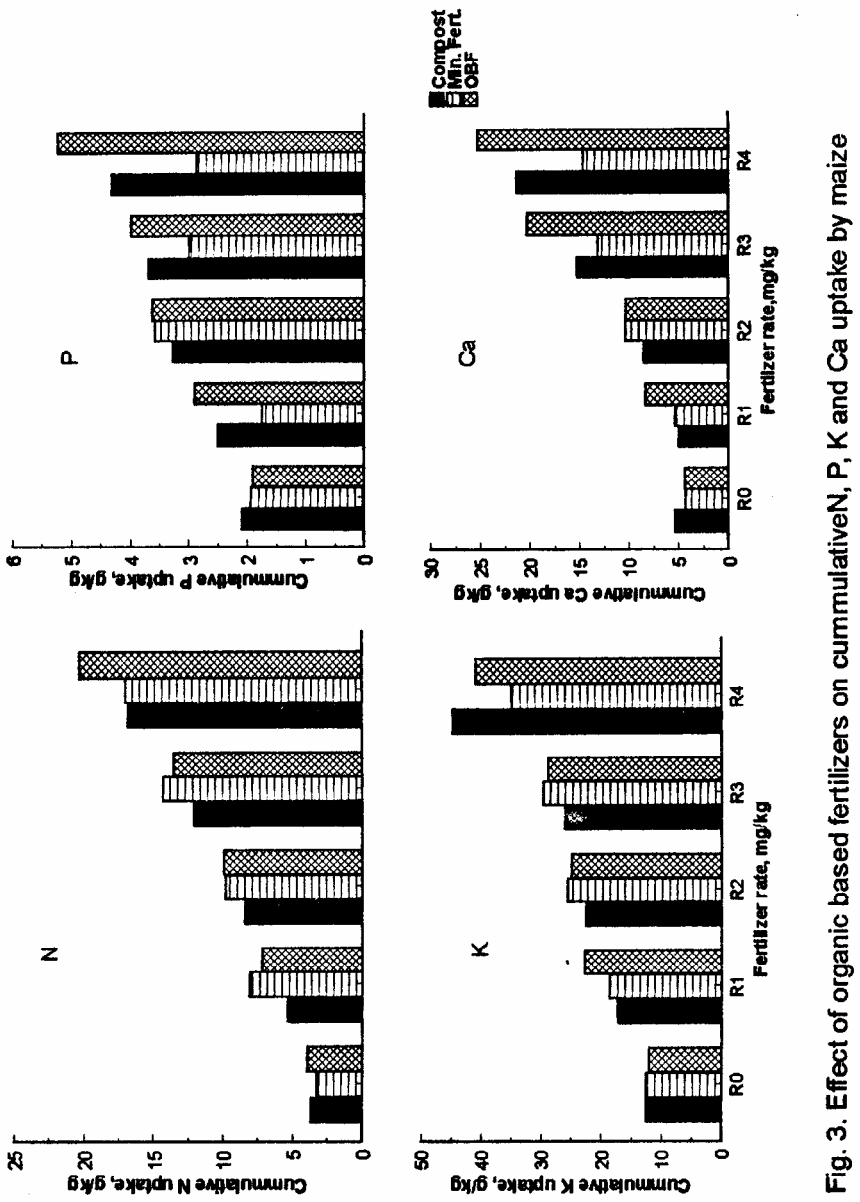

Fig. 3. Effect of organic based fertilizers on cummulativeN, P, K and Ca uptake by maize

occur at 100 mgN/kg. At this rate, the uptake was almost similar to that from Compost and OBF. At higher rates, however, Compost and OBF showed higher uptake than the MF (Fig. 3b). The Compost, on the other hand, gave higher potassium uptake than other fertilizers at 100 mgN/kg and above (Fig. 3c). Both OBF and Compost gave significantly higher uptake than the MF at 400 mgN/kg., whereas at lower rates Compost gave the least values (Fig. 3d).

The pattern of uptake of some micronutrients by maize is illustrated in Figs. 4a, b and c. The organic fertilizers showed better Zn uptake than the MF, except at 100 mgN/kg. The effect of OBF on Zn uptake was highest at 200 mgN/kg while that of Compost was at 400 mgN/kg. This shows that twice the quantity of Compost would be required in order to obtain an effect similar to that of OBF. Zn uptake due to MF application decreased at rates above 100 mgN/kg. This is an indication that MF application at 200 mgN/kg commonly used as optimum in greenhouse studies may require addition of Zn.

Application of Compost and MF increased Cu uptake by maize. High significant increase in Cu uptake was obtained from applying Compost and MF at 100 mgN/kg (Fig. 4b). Application of the tested fertilizers also had positive effect on Fe. The organic fertilizers, however, were more superior to the MF in improving Fe nutrition of maize (Fig. 4c). The evidence of higher effect of OBF on Fe uptake than other fertilizers was clearly shown as from application of 50 mgN/kg onward. Application of the fertilizer sources gave positive effect on Mg uptake by maize. The advantage of using OBF over other fertilizers at high rates was observed (Fig. 4d).

Fertilizer application caused reduction in microbial biomass and therefore could possibly inhibit N_2 fixation from the atmosphere. When Compost was added to soil, the microbial biomass of free-living *Azotobacter* species was reduced significantly, compared with the control (soil without fertilizer). As Compost rate increased the biomass remained reduced. Similar results were obtained when MF and OBF were applied (Fig. 5). However, application of MF gave the highest reduction in the biomass of *Azotobacter*. These results indicate that inorganic fertilizer had more negative impact than the organic fertilizer on the heterotrophic *Azotobacter* which are free-living microorganisms.

Discussion

On the whole, the influence of Compost and OBF on nutrient uptake enhancement was positive. In this experiment, the MF contained no micronutrient. Its effect on the micronutients uptake was indirect. Application of the organic fertilizers might have performed the same way. In addition, it contributed further by making available to plants the existing nutrients in them. the slow nutrients release ability of the organic fertilizers was an indication of their capability to give higher residual effects than the MF. This is in agreement with various results obtained by Olsen et al. (1970) and Lombin et al. (1994).

Unlike MF, the OBF and Compost are regarded as well balanced fertilizers due to the presence of both macro- and micronutrients. Although the Compost performed relatively lowest in comparison with OBF and MF, its residual effect was higher than that of MF. However, the organic fertilizer contains lower nutrients concentration than the MF and it is normally required in larger quantity. Complementary application of compost with MF is normally advocated in order to meet crop demand for nutrients. Most recommendations suggest the idea of organic manure application before or at planting, followed by top dressing.

The OBF formulations, on the other hand, provide already blended fertilizer materials consisting of Compost and MF at a specific ratio. Its outstanding performance in this study emphasizes advantage of its use over tested fertilizers. In practice, the opportunities attached to application of OBF are in many ways. these include reduction in the bulk of organic manure and provision of booster nutrients from the blended MF which can rapidly supply the required nutrients in the early growth of crop plant.

Conclusion

Organic based fertilizer is a complete nutrients source that contains both macro and micronutrients and the major ingredients are locally sourced. The fertilizer improved soil fertility, enhanced nutrients uptake

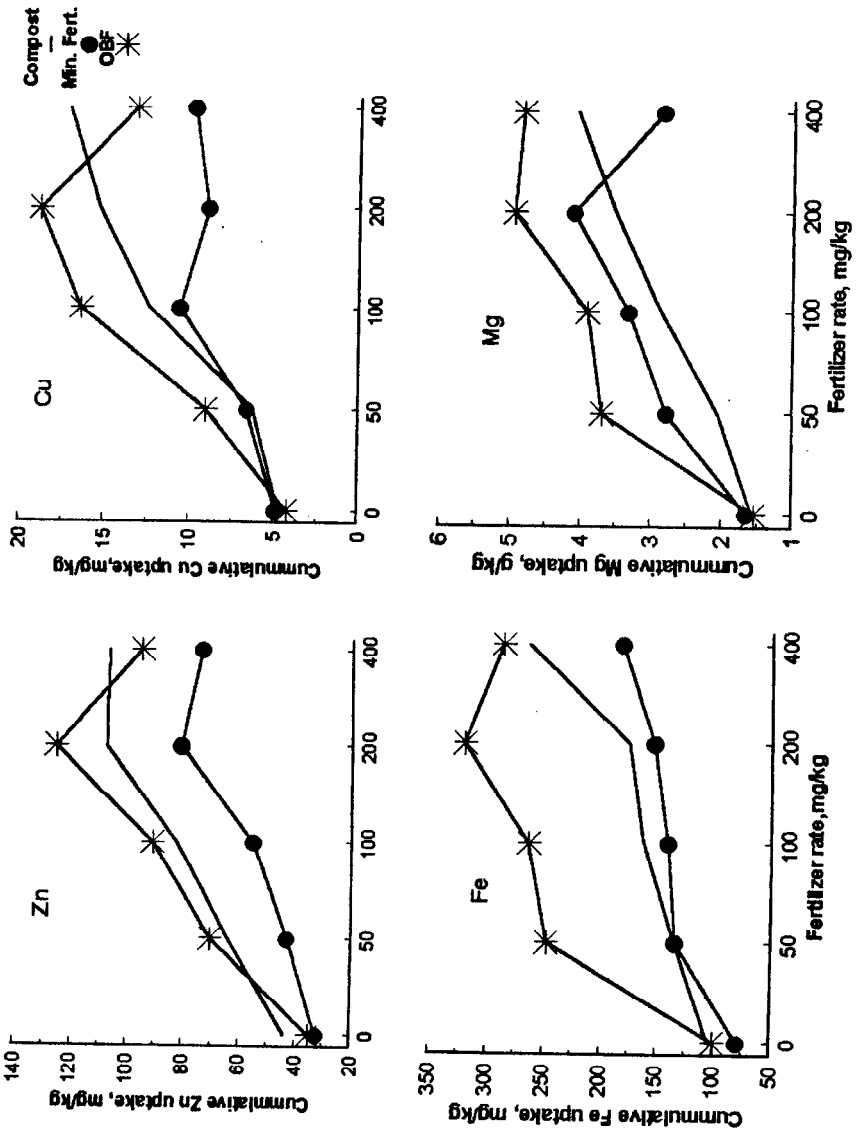

Fig. 4. Effect of organic based fertilizers on Zn, Cu, Fe and Mg uptake by maize

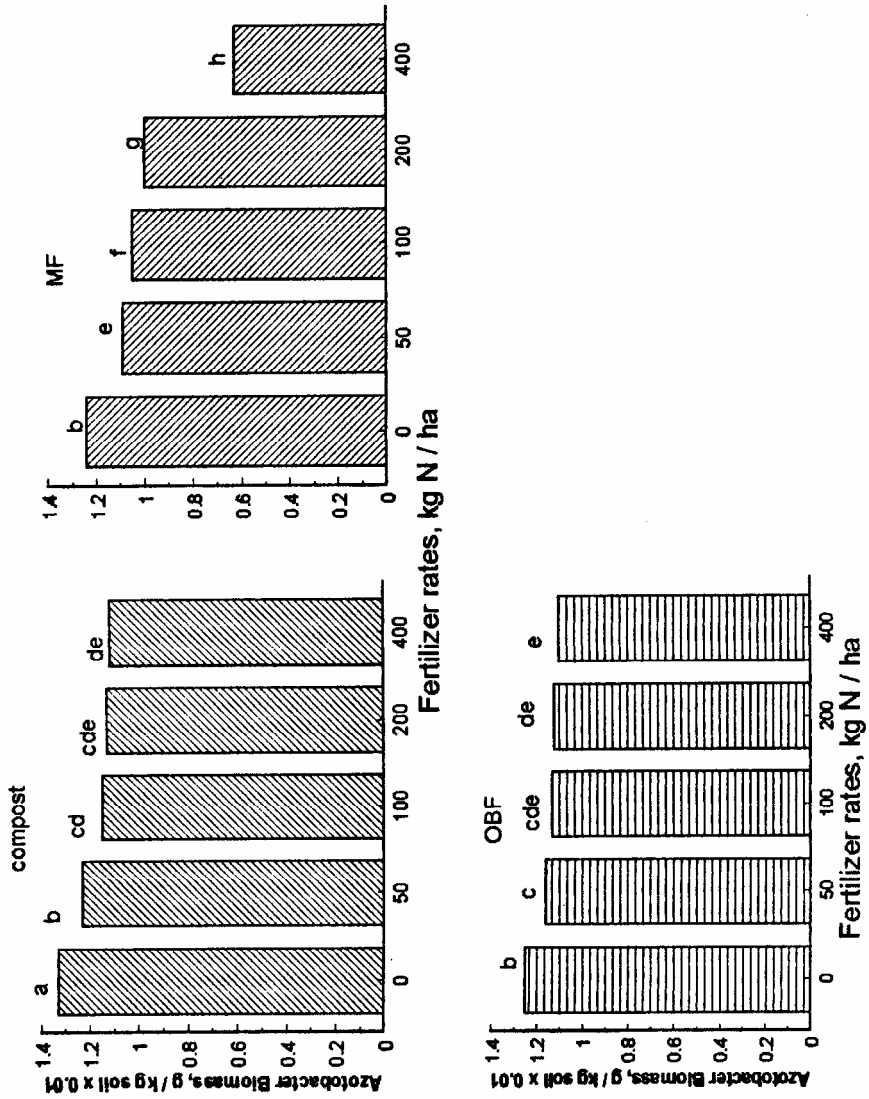

Fig. 5. Effect of organic fertilizer application on Azotobacter biomass (g / kg soil x 0.01)

and dry matter yield of maize. the performance of the tested fertilizers followed in the ascending order of Compost, MF and OBF. Both Compost and OBF showed better residual effect than the MF.

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