Improved soil, fertilizer and crop residue management for corn-based rotation system

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Introduction

Corn has recently become an important crop due to demand for sweetcorn as snacks and graincorn for poultry feed. Up till now, corn cultivation in Malaysia has depended mainly on chemical fertilizers. For sustainable crop production, the fertility of the soil need to be sustained and the environment need to be protected from pollutants and contaminants. Thus, chemical fertilizer application should be minimized. The few work done on organic fertilization of maize has concentrated on yield responses and alleviation of aluminium toxicity. Understanding the effect of organic residue/fertilizer applications on dynamics of soil organic matter and availability of nutrients, particularly, nitrogen is greatly lacking. Some micro-organisms, called effective micro-organisms (EM), are claimed to enhance organic matter decomposition and nutrient availability. Thus a long-termed study was established to investigate the extent of the benefits of organic fertilizer or soil amendments (crop residues) in corn cultivation. The study was conducted in 2 phases. Phases I was conducted form 1996 – 1998 and continued with phases II (1999 – 2000) under this project (improved soil, fertilizer and crop residue management for corn – based rotation system)

Materials and Methods

Field experiment established in the UPM Puchong experimental farm to study the effects of crop residue and organic fertilizer (chicken dung) applications on corn in a rotation crop system with groundnut. Three treatments were laid out with 4 replications, i.e. recommended chemical fertilizer rates with crop residues (T1), recommended fertilizer rates without crop residues (T2) and combination of chicken dung and chemical fertilizers with crop residue (T3). For corn in T1 and T2, the fertilizer rates were 150 kg N/ha, 90 kg P/ha and 90 kg K/ha, and for T3, 10 tonnes/ha chicken dung combined with chemical fertilizers :75 kg N/ha, 90 kg P/ha and 90 kg K/ha. Fertilization for groundnut was 30 kg N/ha, 90 kg P/ha and 90 kg K/ha for T1, T2 and T3. Crop residues were returned to the respective plots after each harvest. Besides yield recording, soil and plant samples were taken for analysis of soil organic matter and nutrient (N,P,K) uptake. Decompoosition of the crop residues was also investigated using litter bags and mineralization tubes. Another experiment was also set-up in concrete minilysimeters using the same soil (Bungor series) to study the effect of EM on nutrient availability from sewage sludge and chicken dung application to corn (monocrop). This was compared to chemical fertilizer treatment in field mineralization potential rate experiment studies was also conducted in the laboratory.

Results and Discussion

The main field experiment was set up in April 1997 and to-date, 10 crops had been grown (corn and groundnut crops). The effect of treatments were investigated after the first crop, i.e. after the application of the crop residue. Up to the third crop, although the mean crop yield values show higher yield of maize cobs in T3 than T2, and T1 higher than T2 (control), i.e. 4.25, 3.54 and 2.65 kg/ha, respectively. However, statistically there was no significant difference between the treatments, i.e. no significant effects of the crop residue and chicken dung application. This is because the variability in yield between the replicates were still high. This indicate that the results of the treatments should be studied in the long-term, i.e. after several crop residue and organic fertilizer applications. Although there was no significant difference in yield, the total N uptake by the third crop, maize in the T3 plots (chicken dung + chemical fertilizer + residue) was significantly ($P<0.05$) higher than N uptake in T2 plots. The potassium uptake by the third crop was also higher in the plots with crop residue application (T1 and T3) than the T2 plots (without crop residue), i.e. 120, 82 and 48 kg K/ha in the T3, T1 and T2, respectively. The soil analysis also indicate highest input of P, K, Ca and Mg from T3 treatment. The decomposition study in the field show that 50% dry matter weight loss of the maize

residue was attained after 5.4 weeks after application (WAP) compared to 3.5 WAP of groundnut residue, under the Malaysian tropical climate. Thus, implicating that fallow periods in between cropping season should be short (4-6 weeks) in order to utilize the nutrient released by decomposing crop residues. This experiment will continue for another 21/2 year. The long – termed results show that even after 10 crops cycles the treatment with chemical fertilization and residue incorporation after each harvest, did not produce higher yield than treatment without crop residue incorporation., This may be due to fallow periods (in between crop) which were to long (> 6 weeks) and this lead to surface erosion of organic matter and leaching of mineralized nutrients. However the treatment (T3) with combined application (chemical fertilizer and crop residue) consistently gave higher yields than the chemical fertilization treatments. Soil and plant of the 10^{th} crop are still in progress. Results of the minilysimeter experiment show that no effect of the EM was observed until the third crop of maize. There was highest uptake of nitrogen in the sewage sludge with EM. No EM effect was observed with chicken dung treatment. This means that EM is more effective in making nutrients in higher C/N ratio organic fertilizer more available than the low C/N ratio organic fertilizer.Do not include figures.

Conclusions

It could be concluded that:

Decomposition of crop residues is rapid under the tropical conditions i.e. in 4 – 6 weeks particularly for leguminous crop.

If subsequent crops are not established with 4 – 6 weeks after crop residue application, i.e. in the absence of crop uptake the mineralized nutrient would be lost through surface – run – off and leaching. Thus, crop residues (e.g. maize and groundnut recycling would not translate into increase in yield.

Combined chemical fertilizer with organic fertilizer (e.g. chicken manure) can produce higher corn yield than chemical fertilizers alone. However, high rate of animal manure (low C/N ratio organic fertilizer) may still contribute to environmental pollution. Further study need to done.

The experiment with effective micro-organism show beneficial effect for use with application of sewage sludge but not with chicken manure.

Benefits from the study

The study will provide a cropping system for corn production that is more sustainable in terms of soil fertility and environment. Currently, the cropping system depends mainly on chemical fertilizers and crop residues are burnt. This is not a good system as it depletes soil organic matter and does not recycle nutrients effectively also contributing air pollution,

Patent(s), if applicable:

Nil

Stage of Commercialization, if applicable:

Nil

Project Publications in Refereed Journals:

1. M.I. Khalil., **A.B. Rosenani,** O. Van Cleemput., C.I. Fauziah., J. Shamshuddin. 2002. Nitrogen management in a maize-groundnut crop rotation of humid tropics: Effect on N_2O emission. The Scientific World (2002) 1(S2), 320 –327.

2. Mubarak A.R., **A.B. Rosenani,** S.D. Zauyah. And A.R. Anuar. 2002. Decomposition and nutrient release of maize stover and under the humid tropical field conditions. Comm. In Soil Science Plant Anal. Volume 33 issue 3&4.

3. Mubarak A.R., **A.B. Rosenani,** S.D. Zauyah. And A.R. Anuar. 2001. Nitrogen mineralization from crop residues in different tropical soils. Tropical Agriculture (Trinidad)

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5. **Rosenani A.B.,** A.R. Mubarak and S.D. Zauyah. 2001. Recycling of crop residues for sustainable crop production in maize-groundnut rotation system. The Use of Nuclear Techniques on the Management of Organic Crop Yoelds (IAEA Technical Document)

Project Publications in Conference Proceedings

1. A.R. Mubarak, **A.B. Rosenani**, S. Zauyah and A.R. Anuar 200. The role of crop residue in sustainable yields of maize (*Zea mays L.*) and groundnut (*Arachis hypogaea L.*) in the humic tropics of Malaysia. In Proceeding 15th Conference of the International Soil Tillage Research Organization (ISTRO 2000). 2 – 7 July 2000, Fort Worth, Texas, USA.

2. A.R. Mubarak, **A.B. Rosenani**, S. Zauyah and A.R. Anuar 1999. Decomposition and Nutrient Release of Crop Residues under Malaysian Field Conditions. In Proceedings Soil Science Conference of Malaysia, 20-21 April, 1999, Seremban

3. Mubarak A. R., **A.B. Rosenani**, S. Zauyah, A.R. Anuar and A. Norhayati. Decomposition and nutrient release from maize residue and N-uptake by groundnut in tropical acid soil. In Proceedings Soil Science Conference of Malaysia, April, 1998, Kuala Lumpur. p. 180 – 198

Graduate Research

Name of Graduate	Research Topic	Field of Expertise	Degree Awarded	Graduation Year
Mubarak Abdel Rahman Abdallah	The contribution of crop residues for sustaining production of groundnut (*Arachis hypogea L*) and Maize (*Zea mays L*) in a rotation	Soil chemistry and plant nutrition	PhD	2001
Mohamad Ibrahim Khalil	Nitrous oxide fluxes in a maize-groundnut rotation system under tropical conditions	Soil chemistry and plant nutrition	PhD	2001
Ngoi Lee Chin, B.S	Growth response and nutrient uptake from organic fertilizer application to maize	Soil chemistry and plant nutrition	B.sc. Bioindustry	2000
Tai Kin Leon	Mineralization rate potential of maize and groundnut residues	Soil chemistry and plant nutrition	B.sc. Bioindustry	1999

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