KANSAS STATE UNIVERSITY

USAID FROM THE AMERICAN PEOPLE

Impact of Direct Seeding Mulch-Based Cropping Systems on Soil Health in the Guinea Savanna Zone of Ghana

Edwin K. Akley[1,2], Charles W. Rice[1], Benjamin D.K. Ahiabor [2], Wilson Dogbe[2] and Michael Mawuenya[2]

1.Department of Agronomy, Kansas State University, Manhattan, KS 66506, 2. CSIR-Savanna Agricultural Research Institute,Tamale, Ghana

BHEARD Borlaug Higher Education for Agricultural Research and Development

COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH · CSIR · GHANA

UID: 93051

Introduction

Sustainable agricultural intensification practices such as direct seed mulch–based cropping (DMC) systems affects soil physical, chemical and biological properties. Direct seed mulch-based cropping system is conservation Agriculture (CA) practice where emphasis is on no-till or minimum-till, maintenance of permanent plant cover and relevant crop sequence or crop rotation. Direct seeding mulch-based cropping system improves soil health by: (1) controlling erosion, (2) increasing soil fertility, (3) preserving biodiversity, and (4) sequestrating soil carbon. Agriculture practices that have negative impact on soil health and crop productivity in Northern Ghana are shown below.

A. Bush fires B. Crop residue removal C. Poor soil fertility D. Soil erosion–Gully E. Excessive tillage

Objectives

- To evaluate the effects of DMC on soil health using selected soil biological and chemical indicators.

Materials and Methods

- Location: Nyankpala, Ghana
- Soil Type: Ferric luvisols and Gleyic plinthosols (Nyankpala and Changnayili series), FAO classification
- Experimental Design: Split plot in a Randomized Complete Block Design

Treatments :

- Five direct seed mulch based-cropping systems (Main plot factor):
  - Cover crop (CC1): consisted of each row of *Braccharia ruziziensis*, *Stylosanthese guianensis, Crotalaria juncea and Crotalaria retusa*
  - Check (CK): Maize
  - DMC1: Maize and Stylosanthese planted together.
  - DMC2: Maize and *Black Dolichos lab lab* *
  - DMC3: Maize and cowpea (short duration)*

*Black *Dolichos lab lab* and cowpea were intercropped into maize 25 days after planting.

- Fertilizer rate (Sub plot factor): Three levels of N-P-K (kg ha^{-1})
  - F0 = 0-0-0
  - F1 = 30-30-15
  - F2 = 60-60-30
- Soil sampling depths: 0-5 and 5-15 cm

A. Maize + Crotalaria B. Maize C. Stylosanthese D. Braccharia F. Maize+Stylosanthese

Different Direct Mulch Based Cropping Systems (DMC)

Analyses

- Biomass yield (kg/ha): sampled (1m X 1m).
- Soil pH (H_2O 1:1)
- Soil organic C and Total N (SOC and TN)
- Potentially mineralizable nitrogen (PMN)
- Soil microbial respiration (flush of CO_2)
- Microbial biomass C and N (MBC & MBN)

Statistical Analysis

- Proc mixed in SAS 9.4 and means separated by LSD at a significance level of 0.05

Results and Discussion

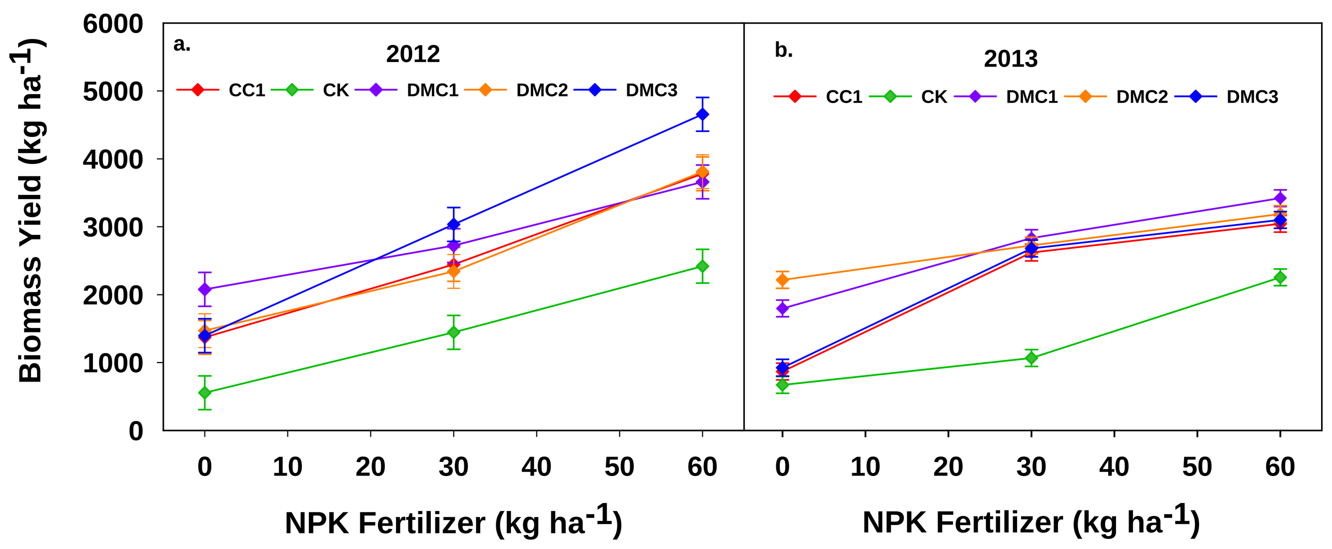

Figure 1. Biomass yield affected by interaction of cropping systems and mineral fertilizer (a) 2012 and (b) 2013.

- Biomass yield was significantly affected ($P < 0.001$) by the interaction of cropping systems and mineral fertilizer in 2012 (Fig.1a).
- Greater biomass yield due to the interaction effect was observed at 60-60-30 NPK (kg ha^{-1}) (Fig.1a). Similar trend was observed in 2013 (Fig.1b).

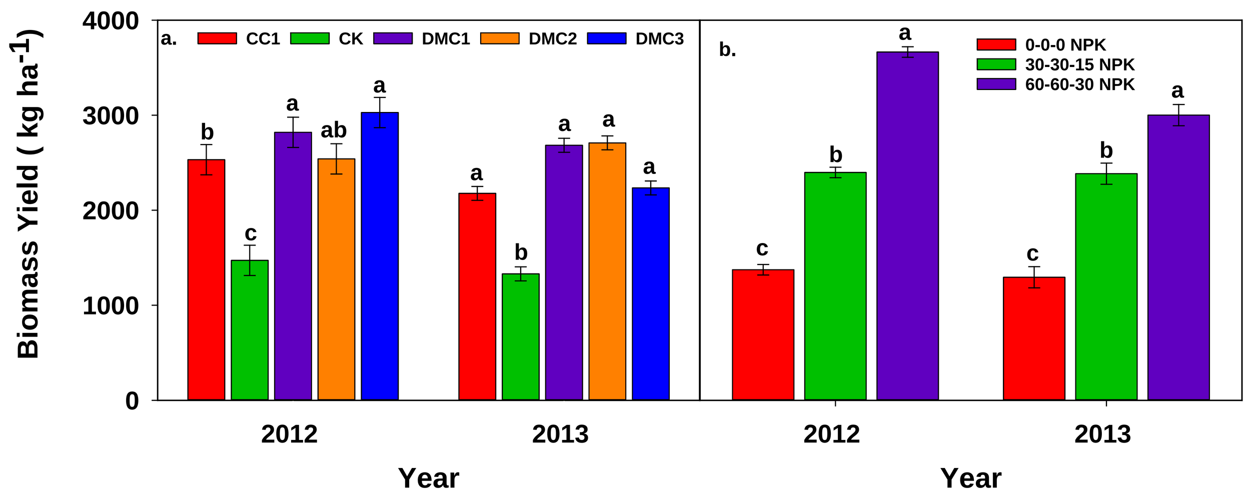

Figure 2. Biomass yield affected by (a) cropping systems and (b) mineral fertilizer in different years.

- Biomass yield was significantly ($P < 0.05$) greater in DMC systems compared to the check (maize) in 2012 and 2013 (Fig. 2a).
- Biomass yield was also significantly affected by mineral fertilizer application. 60-60-30 NPK (kg ha^{-1}) gave the most increased biomass yield($P < 0.05$) in both years (Fig. 2b).

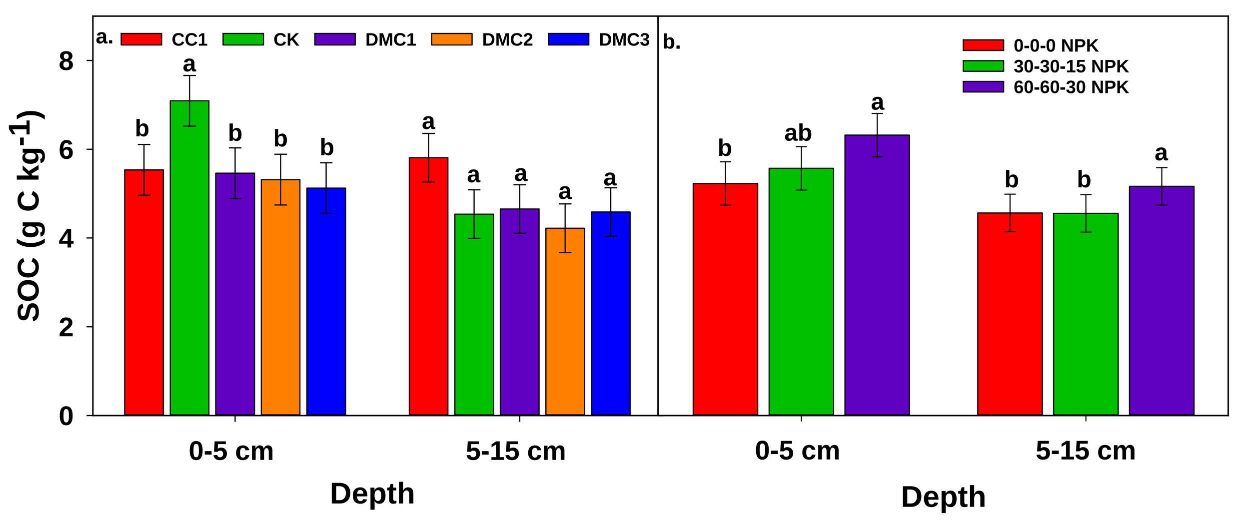

Figure 3. Soil organic carbon (SOC) affected by (a) cropping systems and (b) mineral fertilizer at different depths.

- The check (maize) cropping system had the highest ($P < 0.05$) SOC compared to the other DMC systems at the 0-5 cm depth (Fig. 3a).
- Mineral fertilizer had a positive effect ($P < 0.05$) on SOC at both 0-5 cm and 5-15 cm depths (Fig. 3b).

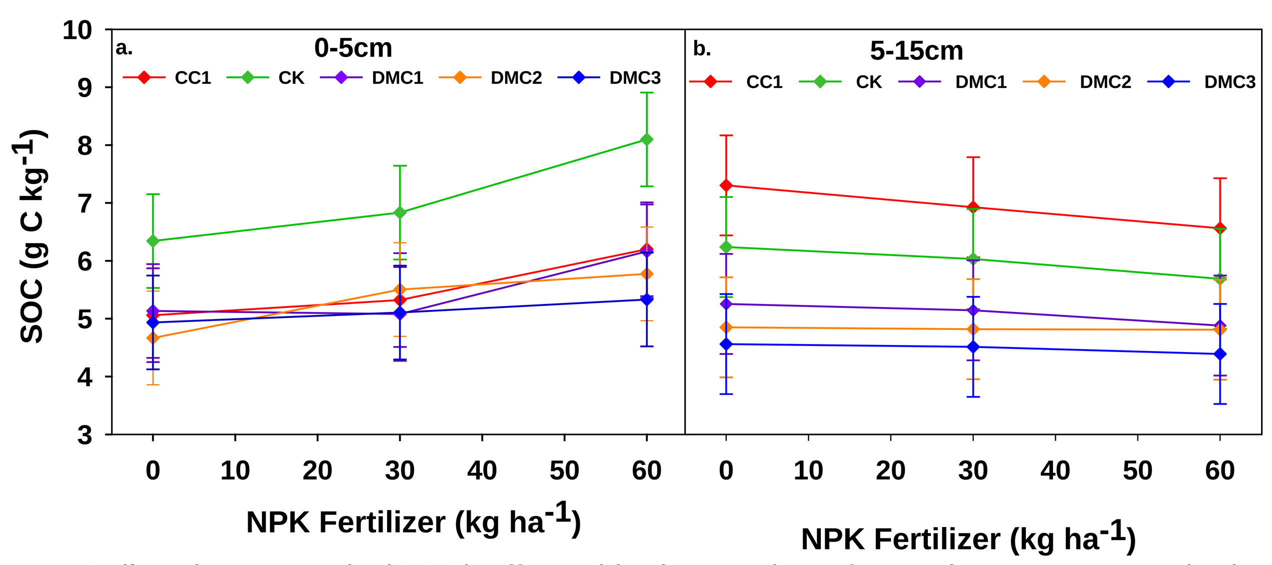

Figure 4. Soil carbon organic (SOC) affected by interaction of cropping systems and mineral fertilizer at (a) 0-5 cm and (b) 5-15 cm depths.

- Interaction effect of cropping systems and mineral fertilizer on SOC showed an increasing trend at the 0-5 cm depth but a decreasing trend at the 5-15 cm depth (Fig. 4a&b).

Results and Discussion (cont.)

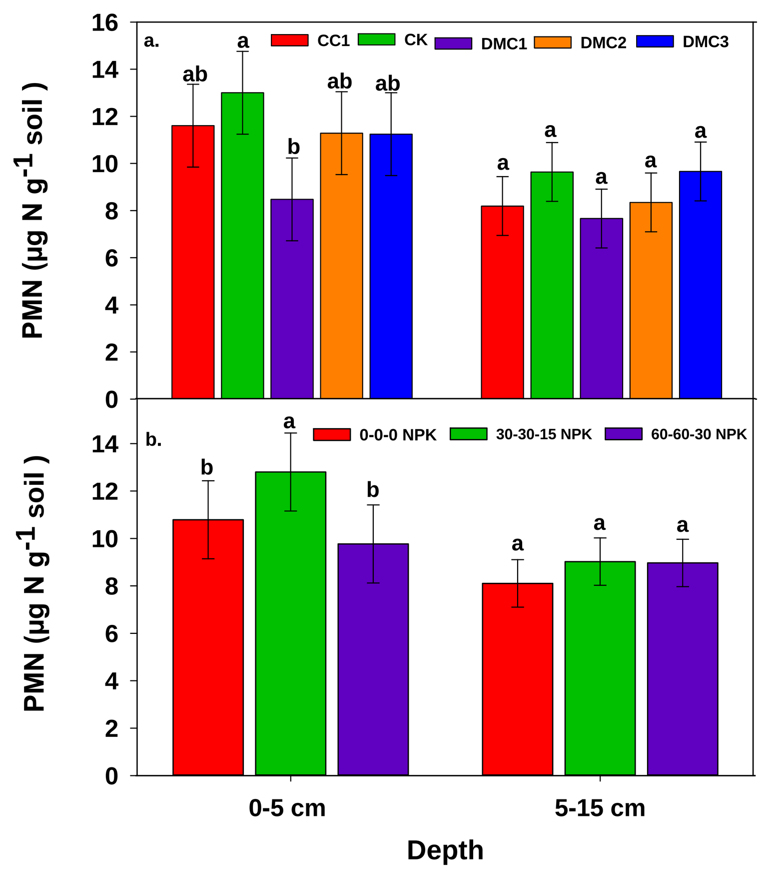

Figure 5. Potentially mineralizable nitrogen (PMN) affected by (a) cropping systems and (b) mineral fertilizer at different depths.

- Maize and Stylosanthese cropping system (DMC1) had significantly ($P<0.05$) lower PMN compared to the other DMC systems in the 0-5 cm depth (Fig. 5a).
- Mineral fertilizer had a significant effect ($P< 0.05$) on the PMN. Greater PMN was found in 30-30-15 NPK kg ha^{-1} compared to the other treatments in the 0-5 cm depth (Fig. 5b).

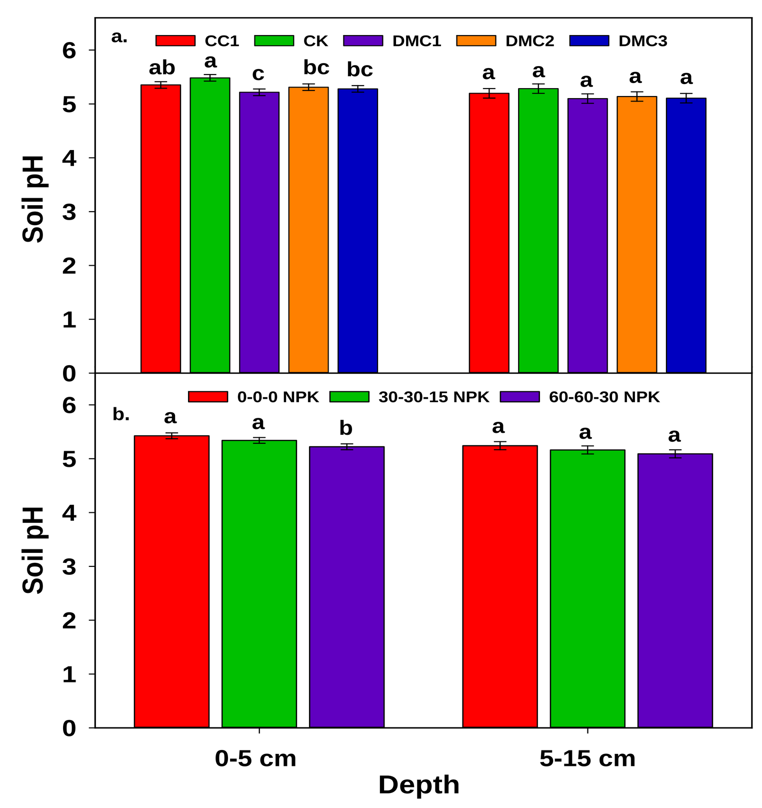

Figure 6. Soil pH affected by (a) cropping systems and (b) mineral fertilizer at different depths.

- Check (maize) cropping system had the least ($P<0.05$) pH decline than the other cropping systems in the 0-5 cm depth (Fig. 6a).
- Mineral fertilizer application significantly ($P<0.05$) decreased soil pH in the 0-5 cm and 5-15 cm depths (Fig. 6b).

Conclusion

- All DMC systems yielded greater biomass in both years. Biomass responded to mineral fertilizer application.
- Check (maize) cropping system had the least decline in soil pH and the greatest increase in SOC and PMN.
- Fertilizer application increased SOC and PMN but decreased soil pH.

Generally, organic and fertilizer inputs along with lime would improve soil biological and chemical properties in the Guinea Savanna Zone of Ghana.

Acknowledgements

- This material is based upon work supported by the United States Agency for International Development, as part of the Feed the Future initiative, under the CGIAR Fund, award number BFS-G-11-00002, and the predecessor fund the Food Security and Crisis Mitigation II grant, award number EEM-G-00-04-00013.