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Research Article

EFFECT OF BROKEN IMPERVIOUS IRON LAYER ON WATER AVAILABILITY TO SEMI-ARID NORTHERN GHANAIAN FERRIC LIXISOLS

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Abstract: Rainwater is not readily available to sandy loam Ghanaian ferric lixisols. In an attempt to increase water availability to Nyankpala ferric lixisols, their impervious iron pan was broken. Average yield (number of bags) of maize from ferric lexisol with ironpan broken was compared with that with iron pan unbroken. At an average annual rainfall of 64.125 to 106.775 mm for Nyampkala, ferric lexisol with or without iron pan broken yielded similar quantity (20-25bgs/ha) of maize. Breaking of ironpan alone cannot increase water availability to Nyankpala ferric lixisols. Measures other than the breaking of iron pan are needed to increase water availability to ferreiclesisols and similar soils. Research into sustainable technologies such as permanent amendments for increased soil water availability to ferric lixisol and similar soils is required.
Keywords: Optimize, maize, rain water, soil water.
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INTRODUCTION

Rainwater is not readily available to crops on northern semi-arid sandy loam Ghanaian ferric lixisol because they have low water holding capacity and its top 45-150 cm is sealed off by impervious ironpan(from oxidization of ferrous iron to ferric hydroxide) or plinthite horizon. Available soil water is not adequate to give crops optimum performance (growth and yield). Limited crop performance is a threat to food and water security in northern Ghana and a precursor to urban migration amid growth in population from 1.5 million (in 1990) to 1.85 million (in 2000). Thus, the need to harness rain water for increased water availability to semi-arid sandy loam northern Ghanaian soils. In countries such as Burkina Faso, Mali, Niger and Togo micro catchments (zai pits) have been used to somewhat increase water availability in similar soils, depending on geography. Nonetheless, the effect of simply breaking ironpanon water availability to similar soils has not been established. Hence, the oven-dried grain yield (number of bags) of maize from farms, each four-hectare fromTunayeli, Garishegu, Kpene, Cheshegu and Golinga communities in Nyankpala with ironpan of half of the land broken were recorded for 2003 to 2008.

MATERIALS AND METHODS

Description of Nyankpala: Nyanpkala falls within the interior Guinea Savannah Agro-Ecological Zone lying between latitude 9º 25'14", longitude 0º 58'142" at an altitude of 183 m above sea level with 900-1100mm annual monomodal rainfall which starts April/May and ends September/October (Runge-Metzger, 1993). Grasses with few shrubs dominate its natural vegetation. It has a minimum and maximum average temperate of 25 º C and 35 ºC respectively. Its soil is derived from Voltaian sandstone and classified as Nyankpala series (PlinthicAcrisol; FAO, 1988). Its top 30cm arable soil has 66.7% sand, 27.3% silt, 6% clay, 4.4 pH($CaCl_2$), 0.5% organic C, 0.3% total N, 18.3mg/kg Avail. P, 36.6mg/kg Exch. K, 158mg/kg Ca, 18.4mg/kg Mg, 3.8cmol/kg CEC and 26% base saturation. Ferric lixisols have an ironpan at a shallow depth of about 45 cm which is impervious to rain water and only rendered permeable by breaking through. The surface soils are sandy loam to loamy sand in texture but silty clay loams are common with percentage gravel as high as 20% in some soils. The soils have internal drainage problems and are described as moderate to well-drained. The top arable soil is well aggregated and aerated when rid of impervious ironpan (Fosu *et al*. 2004). Low crop performance is responsible for marked seasonal hunger, low bodyweights and systematic malnutrition of all sections of the population. Shifting cultivation seemed to be dominant in much of the low-density areas but it has been replaced by bush-fallow more recently. The soils are moderately suitable for millet, sorghum, pulses, cowpeas, maize, rice, groundnuts and guinea yam. Cassava, cocoyams and sweet potatoes are usually grown on a small scale in riverine areas (Blench, 1999).

Formation of Iron pan in Nyankpala: Hardpan is the general term used to classify dense layers of soil, normally found below the uppermost topsoil. Hardpan comes in types based on soil structure, soil pH and soil particle size, all of which are characteristically hard and highly impervious to water. Some hardpans are formed from the fusing and binding together of soil deposits ranging from dissolved silica to matrices formed from iron oxides and calcium carbonate. It is called iron pan when it is formed from iron oxides. Others are formed through man-made compaction from repeated ploughing. The soils of Nyankpala like that of the interiorsavannah and the transitional zones develop over shale composed mainly composed of iron, which is responsible for iron pan formation in the sub-soils (Auburn University, 2007 and Hogan, 2011).

Challenges and way-rounds with hardpans: Hardpan impedes drainage of water, restricting the growth of plant roots. Hardpan is mechanically broken up bydigging or ploughing or by soil amendments, especially at the onset of formation to allow water drain. Soil amendments are employed to alter the soil structure in order to prevent formation or promote dissolution of the hard pan. Amendments with manure, compost or peat have been observed to increase the amount of soil organic matter, local drainage and the number of earthworms that can, over time, break up hardpan. Lime and gypsum can be used to adjust pH of soils with difficult hardpans. This can help loosen clay particles from one another in a hardpan by the actions of hard salts of iron, calcium carbonate and sodium that promote mobility through a higher pH while proving a suitable source of material exchange (the gypsum). Gypsum salts, though not "soft", are still permeable to water with larger and more open structure. Breaking up a hardpan by soil amendment takes place over a longer period of time with very few means of assurance of success. Success depends very much on the extensiveness and/or intractability of hardpan (Malinda, 2002).

Experimentation: Ten four-hectare farms each were selected from Tunayeli, Garishegu, Kpene, Cheshegu and Golinga communities in Nyankpala. With the aid of a chisel plough, the ironpan of half of the farmland was broken and that of the other half left unbroken in staggered-patterned catchments (30cm Ø) 60 by 60cm apart. Four seeds each of certified obaatampa maize variety were planted in each catchment just when the rain had started in April/May. A week after germination three seedlings were thinned out to one. After approximately 4 months, maize was harvested and grains oven-dried to constant weight. Average yields of maize (number of bags) for 2003 to 2008 were recoreded for each community. Average rainfal (mm) for 2003 to 2008 was also recorded in Nyankpala.

Statistical Analysis: With the aid of Excel 2008, average yields of maize (number of bags) from the half of farmland with ironpan broken were compared with the other with ironpan unbroken for significant differences for 2003 to 2008 for each community in relation to average annual rainfall.

Dissemination: Focused group discussions involving the 50 farmers and academia were held to find the way forward.

RESULTS AND DISCUSSION

From Figures 1-4, there was no significant difference between the average yields (number of bags) of maize grown on ferric lixisols with iron pan broken and that with iron pan unbroken. Thought average yields of maize appeared to not change from 2003 to 2008, they decreased slightly in 2005 and 2006 with less average rainfall. Similarities in the outline of Figures 1-4 shows that ferric lexisols of Tunayeli, Garishegu, Kpene, Cheshegu and Golinga are quite similar and may vary only very narrowly in physical and chemical properties. Focus group discussions ended with academia resolving to research into sustainable technologies for increasing water availability to ferric lixisols and similar soils. Ferric lexisols with or without iron pan broken yielded similar quantity of maize because breaking of iron pan alone cannot increase water availability to ferric lixisols. Yield of maize on ferric lexisols with or without iron pan broken decreased only slightly in 2005 and 2006 with less average rainfall because excesses of rainfall is not that critical as insufficiencies far below the optimum. Where ferric lexisols of Tunayeli, Garishegu, Kpene, Cheshegu and Golinga vary very narrowly in physical and chemical properties, they must be under different land cover and use. Permanently cultivated soils show significantly lower physical and chemical properties than transiently cultivated and uncultivated ones (Braimoh and Vlek, 2004).

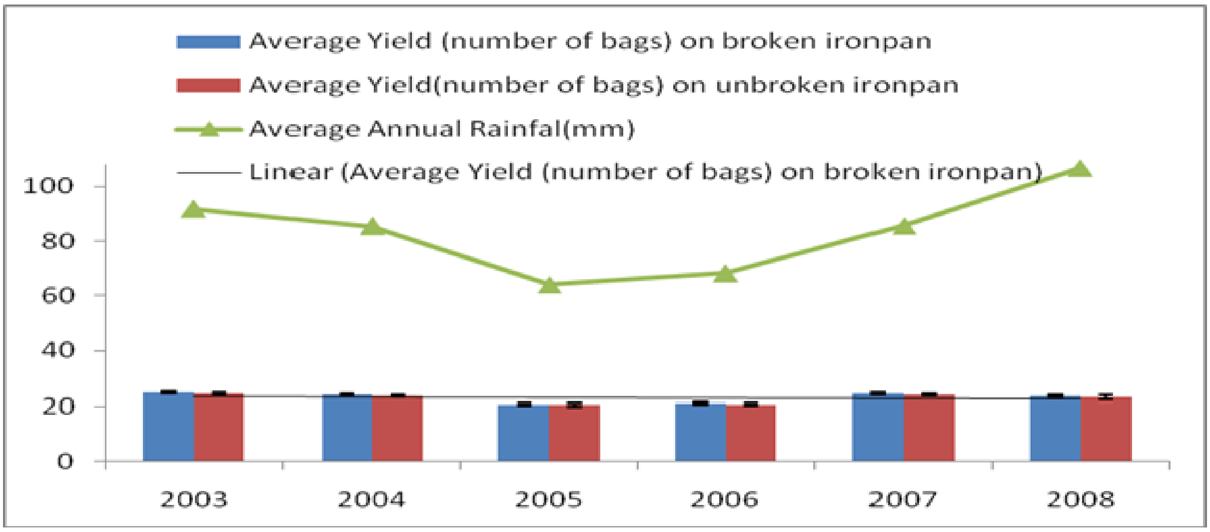

Figure 1: Average yields of maize on Tunayeli ferric lexisols, N=10

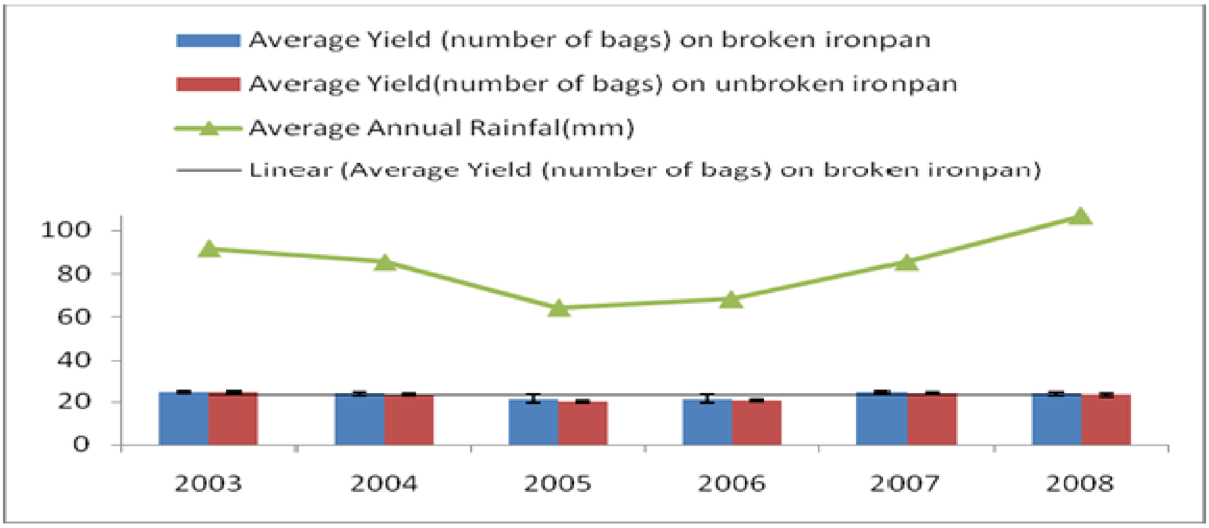

Figure 2: Average yields of maize on Garishegu ferric lexisols, N=10

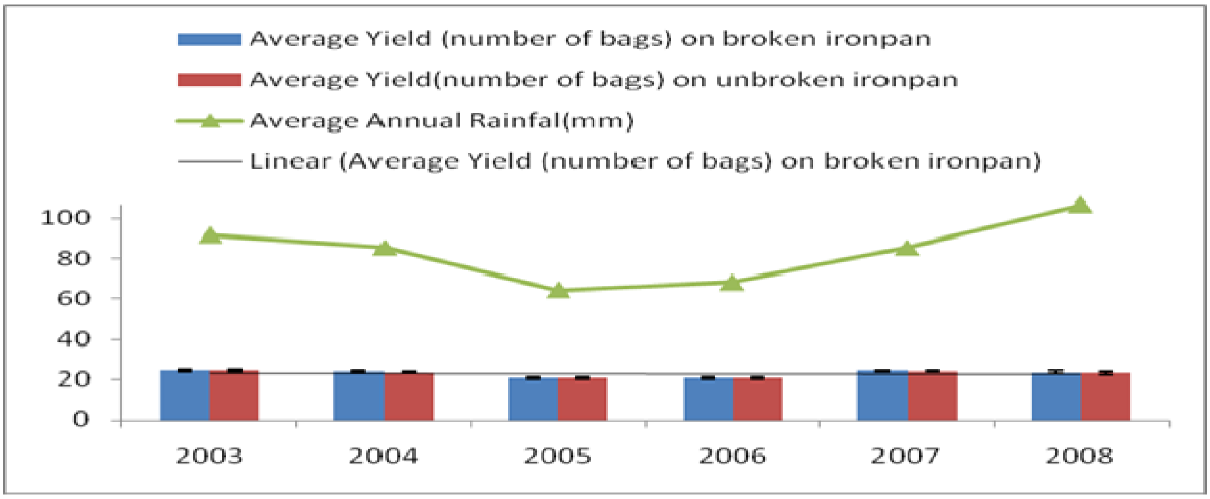

Figure 3: Average yields of maize on Kpene ferric lexisols, N=10

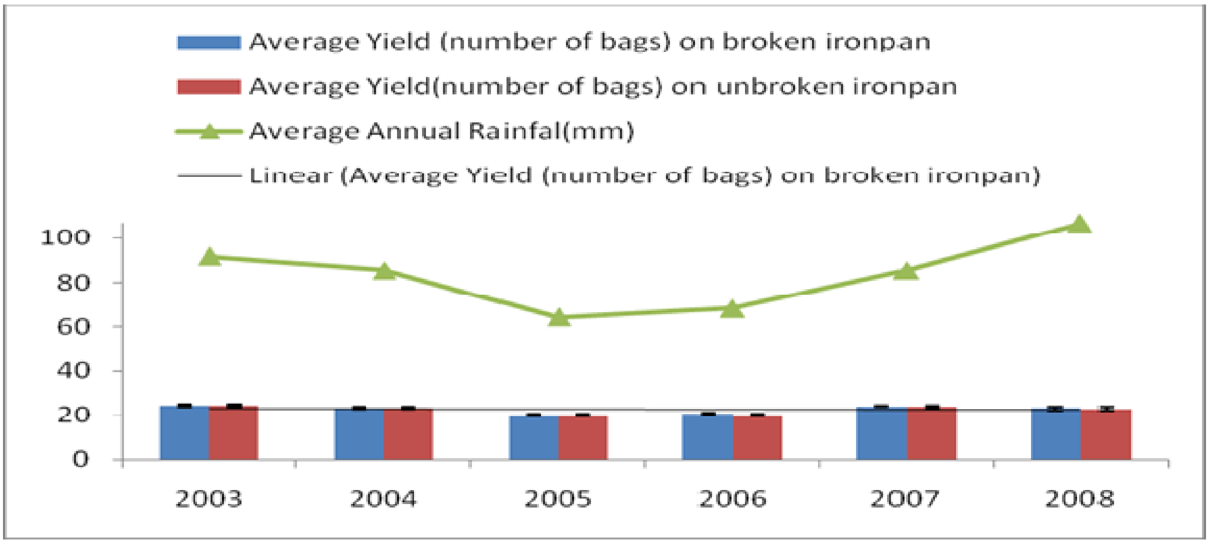

Figure 4: Average yields of maize on Cheshegu ferric lexisols, N=10

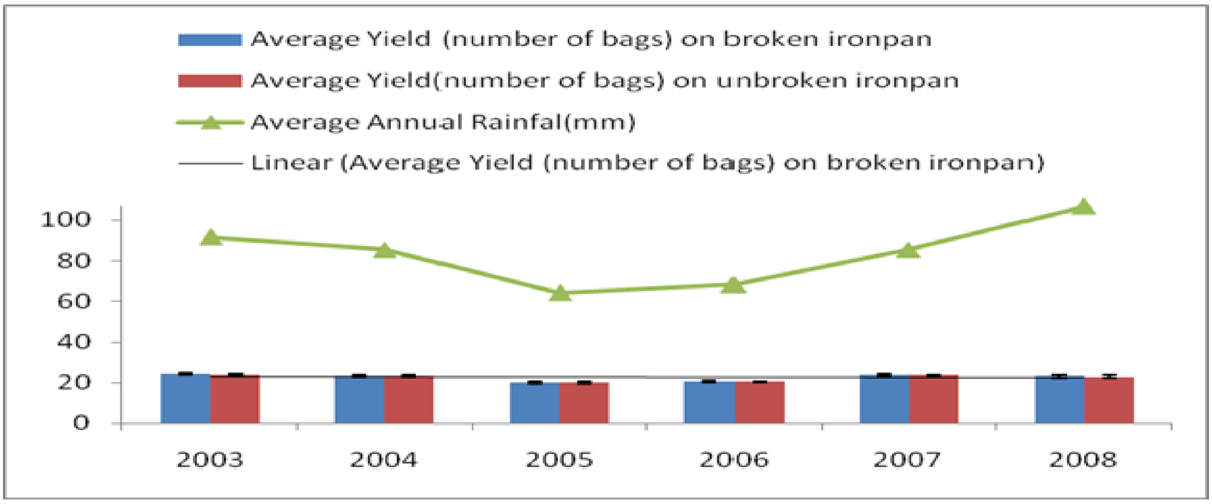

Figure 5: Average yields of maize on Golinga ferric lexisols, N=10

CONCLUSIONS

Measures other than the breaking of iron pan are needed to increase water availability to ferreiclesisolsand their like. Research into sustainable technologies such as permanent amendments for increased soil water availability to ferric lixisols and their like is required.

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