Ethno-management of plinthic and ironpan soils in the savanna regions of West Africa

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ABSTRACT

The savanna regions of West Africa, consisting of Guinea, Sudan and Sahel savannas, form the bulk of lands for producing cereals, vegetables, legumes, root crops, tree crops, and livestock. As a result of land degradation from natural and anthropogenic factors (such as deforestation, overgrazing, annual bush burning and soil erosion), food insecurity and rural poverty are prevalent. The most serious threat to land use for agricultural production is the insidious formation of plinthite and ironpan (petroplinthite) in the agricultural soils of the regions. Plinthite is an iron-rich, humus-poor, clayey material which hardens irreversibly into ironpan on repeated wetting and drying over the seasons. They occur extensively in the savanna soils of West Africa, especially within the groundwater laterites. It was found that the materials also occur in the soils of the uplands, which are extensively used for cultivation. Their presence and effect on agricultural performance have been observed throughout the region. Farmers have developed and adopted management practices to mitigate the problems associated with these materials. Discussions have been held with farmers, scientists, extension officers, and NGOs on the importance of the material on agricultural productivity. Indigenous farmers' management practices that circumvent the problems posed by the materials and boost yields within the region include stone bunds, vertiver bunds, other anti-erosion measures, fertilization, mulching, cover cropping, agroforestry practices and incorporation of legumes in their farming systems. For serious situations in which the ironpan is too close to the surface or even exposed over large tracts of land, the Zaï method of chiselling into the pan and growing crops in the pits is adopted These indigenous farmers' practices need scientific improvement to make them more effective.

RÉSUMÉ

ASIAMA, R. D. & DWOMO, O. : *Ethno-gestion des sols de la plinthe et d'alios ferrugineux dans les régions de savane de l'Afrique occidentale*. Les régions de savane de l'Afrique occidentale qui comprennent les savanes guinéenne, soudanaise et sahelienne constituent la plus grande partie de terres pour la production de céréals, de végétaux, de légumes, de racines comestibles, de cultures d'arbre, et de bestiaux. A la suite de la dégradation de terre, des facteurs naturels et anthropogéniques (tels que le déboisement, le surpâturage, le brûlage des terres annuel et l'érosion du sol), l'insécurité alimentaire et la pauvreté rurale sont courantes. La plus sérieuse menace à l'emploi de la terre pour la production agricole, est la formation insidieuse de la plinthe et de l'alios ferrugineux (Pétroplinthe) dans les sols d'agriculture des régions. La Plinthe est une substance minérale argileuse riche en fer, maigre en humus, qui s'endurcie irréversiblement en alios ferrugineux en raison de conditions de mouillement et de séchage répétés au cours de saisons. Ils existent extensivement dans les sols de savane de l'Afrique de l'Ouest surtout au fond de la latérite de la nappe phréatique. Il était noté que la substance minérale existe dans les sols des hautes terres qui sont extensivement labourées pour la culture. Leur présence et leur effets sur la performance agricole ont été observés à travers la région. Les agriculteurs de la région ont développé et adopté les pratiques de gestion pour atténuer les problèmes associés avec la présence de cette substance. Des discussions ont été organisées avec les agriculteurs, les scientifiques, les vulgarisateurs et les ONGs sur l'importance de la substance sur la productivité agricole. Les pratiques de gestion d'agriculteurs indigènes qui font échouer les problèmes posés par les substances et pour accroître les rendements dans les régions comprennent les levées à la Pierre, les levées vertivères, et autres mesures d'anti-érosion, la fertilisation, le mulch la culture de plante de couverture, l'agroforestérie, et l'incorporation de légumineuse dans leur système d'agriculture. Dans les situations très sérieuses où l' alios ferrugineux est trop proche de la surface ou bien exposés sur des vastes étendues de terre, la méthodologie Zaï de crevasser l'alios ferrugineux et semer les cultures

Ghana Jnl agric. Sci. **42**, 25-29

Original scientific paper. Received 02 Aug 05; revised 20 Aug 08.

dans les trous est adoptée. Ces pratiques par les agriculteurs indigènes exigent une amélioration scientifique pour qu'elle soit plus efficace.

Introduction

The savanna regions of West Africa form the bulk of suitable agricultural lands for cereals, vegetables, legumes, root crops, tree crops, and livestock production. The regions are also heavily populated. Unfortunately, these lands are being degraded at alarming rates. Land degradation, in its several forms, is evident throughout the savanna zones of West Africa. The degradation is a result of the interaction of natural and anthropogenic factors, especially climatic and human. Man, in search of food, energy and shelter for himself and his animals, has contributed immensely to the causes of land degradation. Among the major forms of land degradation in the zones, soil fertility decline, soil erosion and acidification have been recognized as the major biophysical constraints to agricultural production (Quansah, 1999). However, the other major form of land degradation, often marginalized but poses the most serious threat to agricultural productivity, is the insidious formation of ironpan (petroplinthite) within the root zone. Ironpan hardens irreversibly from soft plinthite, which forms within the subsoils. Its hardening is facilitated by repeated wetting and drying.

Plinthite is an iron-rich, humus-poor, clayey material that hardens irreversibly to ironpan or irregular aggregates on exposure to repeated wetting and drying (NRCS, 1998; F AO, 1998). It forms from weathering products of iron-rich parent rocks and accumulates to form a plinthic horizon within the subsoil. The accumulated materials build up by enrichment from surrounding soil materials over the seasons.

Plinthite and petroplinthite are widely distributed in the tropical and subtropical regions of the world (FAO, 1991). They develop in areas of hot and humid climate with distinct wet and dry seasons as found in Western India, West Africa, and some parts of South America (Driessen & Dudal, 1991).

The aerial coverage of plinthite and petroplinthite is extensive. Matheis (1982) recorded that about one-quarter of the earth's land have the materials, and FAO (1991) estimates about 60 million hectares as the global extent of soils with the materials. In West Africa, the materials have been observed in all the agro-ecological zones including the savannas (Asiamah, 2000). They occur in 54 per cent of the land area of Ghana (Asiamah, 2000), and 50 per cent of Nigeria (Tiez, 1982). Discussions with colleagues indicated over 70 per cent of lands in Togo and 20 per cent of non-desert lands in Mali have the materials. Other countries in the subregion have similar large acreages of their lands with the materials. They have developed in the soils of the Guinea, Sudan and Sahel savannas, and have reduced the productivity potential of these soils.

The plinthite and its hardened form in the soil has been found to be a major impediment to agricultural production (McNeil, 1964; Goodland & Irwin, 1975). The materials are impenetrable by water and air, restricting development of roots and contributing to frequent waterlogging (Driessen & Dudal, 1991). They cause perching of water, which leads to erosion of overlying soil materials. Brammer (1962) indicated that as soils containing plinthite are strongly leached and are, therefore, poor in bases and most essential elements, they are low in fertility. Phosphorus is fixed by high iron content, making it unavailable to crops. The near absence of organic matter in plinthite also contributes to its being poor for crop growth and performance.

The study was undertaken to create awareness of the problems created by the development of plinthite and its irreversible, hardened form in

agricultural soils of the subregion; to give information on how local farmers are circumventing the problems caused by the materials for high agricultural yields, and to prevent environmental degradation caused by these materials in the soils.

Ethno-management practices

Plinthic and ironpan soils are poor for crop performance; so indigenous farmers in the region have developed management practices to circumvent the limitations they pose in their agricultural lands.

Soil erosion control

Accelerated erosion of topsoil materials causes the subsoils, which normally contain the plinthite and ironpan, to be closer to the soil surface and to the atmosphere to be heated and harden irreversibly. Farmers have adopted management practices to check erosion of the topsoil materials and increase the exploitable soil volume. Throughout the subregions, stone and vertiver grass bunds are in practice over the ironpan soils. The use of agroforestry practices, cover cropping and mulching, and land preparation and planting across slopes and strip cropping are also being adopted with assistance from the FAO, extension officers, and NGOs.

Exploitable soil volume

Practices that keep the exploitable soil volume thick and keep roots out of reach to plinthite and ironpan layers are also important and common practices adopted by farmers throughout the savanna regions. These include planting on mounds and ridges at various spacings for various crops.

Soil fertility enhancement

As plinthic soils are poor in soil fertility, farmers adopt fertility enhancement practices to boost yields. The use of organic matter, vegetative mulching, and leguminous crops in their farming systems is a common practice throughout the region. The unavailability, poor and unreliable distribution, and high prices of inorganic fertilizers make their uses limited. Compost preparation and usage are on the increase as farmers throughout the subregion are being educated on the technology. The use of household refuse on compound farming systems has been in practice for a long time. Animal droppings are important in the system. Cowdung, though important, is not used much because it is also needed for other uses as household fuel, wall plastering, and trapping of termites and ants for chicken feed.

High and constant atmospheric temperatures within the subregion accelerate the formation and hardening of plinthite. Farmers, therefore, adopt practices that prevent the removal of the vegetative covers, to cool the soil surface. These include prevention of deforestation, overgrazing, annual bush burning, charcoal production, mechanical topsoil removal, soil erosion, and improper tillage practices that are prevalent within the savanna regions.

Zaï technology

In mostly the Sudan and Sahel savanna zones in Mali, Senegal, Niger and Burkina Faso, the formation of ironpan is advanced and expanse. The materials occur close to the soil surface, or even exposed, over large areas of once good agricultural land for millet, sorghum and cotton that can no longer be used for production. Farmers have no alternative but use the Zaï method to grow crops. The method consists of chiselling pits of 10 to 15 cm deep and 20 to 40 cm wide at regular spacings into the thick ironpan material that are filled with soil and organic matter before being seeded and watered (Baro *et al*., 2002). It looks like growing the crop in a cup. Crop yields are, therefore, low.

Materials and methods

The authors, during their travels through the subregion, made observations and questioned many male and female farmers, scientists and extension officers on the occurrence of the

plinthite and ironpan materials, and their effect on crop performance and yields. Observations were also recorded on the management practices being adopted to mitigate the problems posed by the development of plinthite and ironpan in their agricultural lands. Reports on the agricultural activities within the zones were consulted. Countries visited included Benin, Burkina Faso, Ghana, Mali, Nigeria, Senegal and Togo through their Guinea, Sudan and Sahel savanna regions. It was observed that formation of plinthite and its hardened form, ironpan (petroplinthite), was prevalent and caused serious problem of land degradation, resulting in poor crop yields. Some areas were found to have been rendered barren by the ironpan, which was close to the soil surface or even exposed. Farmers had been trying to adopt management practices to stop or reduce the rate of formation and hardening of plinthite.

Results and conclusion

The study showed that formation and irreversible hardening of plinthite occur extensively within the savanna regions of West Africa. With the exception of some valleys and depressional bottoms, most uplands have the materials formed in their soils. It was observed that the materials adversely affect the performance and yields of crops, causing widespread rural poverty. Accelerated soil erosion induced by the materials degrade the environment, resulting in severe gully erosion making mechanization and other field operations and field trafficability difficult and costly. The low levels of plant nutrients in such soils require applying large quantities of organic and inorganic fertilizers. The availability and cost of such amounts of the fertilizers are out of the reach of most local farmers who only practice subsistence farming. Ethno-management practices, such as mound and ridge making, cover cropping and mulching, were in common use in all the communities visited. Stone bunding was a common practice in Burkina Faso and Ghana, while the Zaï method was found to be practised only in Mali and Senegal.

Although local farmers have developed and adopted management practices to solve the problems posed by the materials on their farmlands, their crop yields are still not as high as expected. Therefore, the need is for scientists of the subregion to perfect these locally developed practices to help solve the problems holistically. Field extension staff must be trained well to help in improving these practices so that farmers get high and economic crop yields.

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