Fluid Mechanics
2019; 5(1): 1-7
http://www.sciencepublishinggroup.com/j/fm
doi: 10.11648/j.fm.20190501.11
ISSN: 2575-1808 (Print); ISSN: 2575-1816 (Online)

Productivity Challenge of Soils Along the Slopes of Mount Oku in Cameroon

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To cite this article:
Godwill Tobouah Nyanchi. Productivity Challenge of Soils Along the Slopes of Mount Oku in Cameroon. *Fluid Mechanics*. Vol. 5, No. 1, 2019, pp. 1-7. doi: 10.11648/j.fm.20190501.11

Received: September 6, 2018; **Accepted**: October 6, 2018; **Published**: April 2, 2019

Abstract: Soil fertility is the major determinant of output in Oku today. The objective of this study is based on the techniques used by rural farmers to maximize output on an advanced deteriorating soil. This phenomenon has not only impinged on output but limits the quality of food available to this agricultural dependent people. Over the years, soil constituents became exhausted as a result of continuous cultivation. The planting of Leucaena and Tephrosia tree species in farms played a challenging role in ameliorating output. The methodology adopted by this study centered on the administration of questionnaires, observation, interviews and field visits. A total of 38 Leucaena and Tephrosia trees were counted on four nearby farms. In these farms selected maize seeds were planted at regular ring distance around the trees. The results obtained revealed that, quality maize was harvested at closer perimeter to the soil fertilizer trees. This strategy maximized sustainable soil management and promoted agro forestry activities in Oku. The study concluded that soil fertility is improved upon by planting soil fertilizer trees in farms. At least one of these tree species is identified in farms in Oku.

Keywords: Productive, Soils, Cultivation, Output

1. Introduction

Continuous cultivation leads to low soil fertility, enhances nutrient depletion, accelerate degradation thus leading to low crop yields. Subsistent farmers lack major farm inputs consequently promoting a decline in soil fertility. Crop Yields largely depend on soil fertility, water availability, quality of seeds and farming techniques. Soil fertility has drastically fallen with fallows shortening and even disappearing to make place for continuous farming [1]. Sustainable agricultural practice remains the best way of ensuring food production as a result seeking to strike a balance between production and consumption. The selective planting of manure tree species is the back bone of ensuring a sustainable agriculture.

2. Methodology

The methodology adopted was based on farm visits which permitted the spotting of *Leucaena and Tephrosia* tree species. A total of 38 *Leucaena and Tephrosia* trees were counted on four farms. Selected maize seeds were planted at regular ring distance around the trees and yield around this ring was analyzed.

Farmers were interviewed while data obtained was assembled and grouped in terms of similar and varied responses in respect to tree preferences. Attention was centered on farmers' opinions of tree and ways of improving the ageing soils in Oku.

3. Results

Common form of cultivation in Oku is slash, bury and burn, bush fallowing, slash and mud methods. Agricultural production over the past years has experienced negative return. Improved fallows using leguminous trees and shrub species have been widely tested in the western highlands of Cameroon and are increasingly becoming adopted for soil fertility improvement. Sustainable rural development and food security are an important component of the anti-poverty strategies of the community. Training and education of farmers, nurseries, use of fast maturing seedling, mulching, orchards, gardens and new cultivation techniques are steps ensuring food security within the study area [2]. In a nutshell, a blend of different agricultural techniques is geared towards assuring food security in Oku.

4. Discussion

4.1. Heterogeneous Soil Types in Oku

The soil types in Oku Sub Division are heterogeneously distributed due to parent rock differences. These comprise of ancient Precambrian basement complex rocks made up of granitic soils, trachytic soils, volcanic soils and basaltic soils as seen in figure 1.

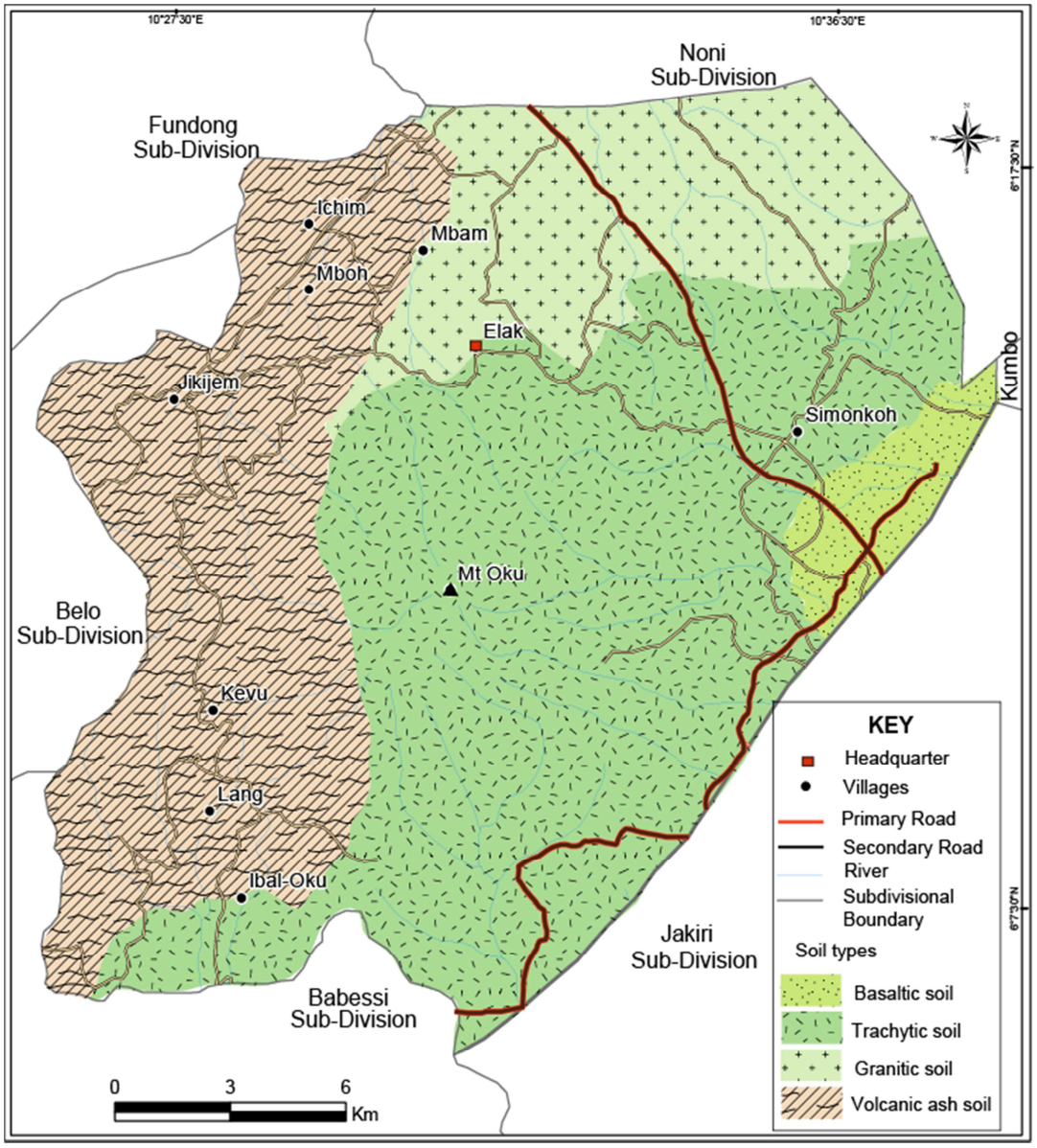

Figure 1. *Soil distribution map of Oku.*

High lava plateau soils are mainly found at altitudes of 1800-2520m. The low altitudes are covered with low lava plateau soils at altitudes of about 1400m and below. Agro forestry practices largely depend on these soils for food supply. The growth *Leucaena* and *Tephrosia* trees is largely dependent on the age of the soils. These trees deepen the soil and provide an anchorage where the roots can tap sufficient nutrients.

4.1.1. Soils in Upland Areas in Oku

Forest soils in upland Oku are mostly dominated by trachytic soils. Characterised by deep profiles with high clay content, these soils are suitable for the practice of agro forestry. Deforested areas at Ngashie, Keyon, Mboh, Jikijem, Lang, Kevu and Kesotin have trachytic soils on the fringes of the forest. These soils are suitable for the cultivation of specific food crops such as beans, maize, potatoes, yams and cassava. In these areas the planting of *Leucaena* and *Tephrosia* trees is gaining grounds thus reducing fertilizer application. This takes ring distances around *Leucaena* and *Tephrosia* trees. Soils here are deeply weathered, fine texture and structure. Trachytic soils are humid with high carbon and organic matter content found in upland Oku at an altitude of 2000m and 2600m. With a slope gradient ranging from 15^0 to 40^0 the fertility of these areas attracted the population to open farms for the cultivation of basic food crops [3].

Table 1. *Soil type, altitude and characteristics in Oku.*

Average altitude	Soil types	Soil characteristics
Less than 1600m	Granites	Deep, well drained, highly permeable, less humiferous and sandy
2000-2400m	Basalts	Well drained, reddish in colour, granular in shape, moderately deep profiles, high silt content
	Volcanic ash soil	Humiferous, brown, cemented ash pyroclast, stony
	Forest soil	Deep, humiferous, high clay content
Above 2400m	Trachytes	Deep profiles, high clay content, fine texture, fine structure, Humid, high carbon and organic matter content, heavily leached, friable

Source: Nkwambi 1996, Field work 2016.

4.1.2. Soils in Lowland Areas

Granitic soils are found in northern lowland Oku precisely in Mbam. Rich in quartz and / or mica, these soils are derived principally from granitic parent material dominated by coarse. The soils are well drained, highly permeable and have a high retention capacity. Granitic soils are less humiferous and sandy. They have a deep and fine texture which can easily be eroded. Found in lowland Oku relatively on a flat land area, the rate of erosion is insignificant. Agro forestry practice is well developed in Mbam with a variety of food crops such as cassava, plantains, ground nuts, pine apples mangoes, raffia palm and sugar cane. Drawing inspiration from the correlation between relief and agricultural systems, farmers in these lowland areas highly benefit from deep well drained soils. At Ibal and Ngemsiba with altitude below 2000m, with pockets of magmatic gneisses, agro forestry practices occupy a predominant place.

4.2. Suitable Climatic Conditions in Oku

Oku experiences the tropical climate type common in high altitudes in Cameroon. This climate type is however not uniform as it has two distinctive seasons: the wet season from March to October (8 months) and the dry season from November to February (4 months). The climate has generally been described as cool, mild and misty [4]. Furthermore, in relation to soil distribution, climate follows a similar pattern marked by two types; the lowland climate type and the upland climate type.

In lowland areas in Oku temperatures are generally higher with least minimum monthly temperatures being 11.2°C in February and the highest minimum at 17.6°C in April. The lowest maximum temperature is 24.8°C in September while it's corresponding highest is 31.8°C in February. Mean monthly temperatures range between 20.4°C in October and 21.9°C in April giving an annual monthly range of 0.8°C. Maximum monthly precipitation in August averages about 421.3m of rain. The climatic background favors the growth of *Leucaena* and *Tephrosia* trees.

4.2.1. Farmer Sensitivity About Climate Change Alteration and Mitigation

Climate change is a serious environmental threat. Agriculture is sensitive to changes in climate. The time of planting and crop growth duration need to be closely fitted in respect of the agricultural calendar. One of the most difficult issues which farmers must contend with is climate change in Oku. Although farmers always have some traditional rough and ready knowledge of rainfall patterns in this area, they have often been taken by surprise by changes in the 'normal' rainfall patterns. These variations have enormous effects on farming systems particularly in the lowland areas. The reasons for these variations do not seem to be understood by the farmers. The seasonality of rainfall varies greatly and has a profound effect on crop diversity.

4.2.2. Adaptation of Land-Use to Climate Change in Oku

Farmer perceptions about climate change directly influence their farming activities on the agro calendar. These variations are marked with time changes in farming activities such as tilling, planting, weeding, and harvesting. Findings in the field presented a slightly new farming calendar from the previous one respected some years back. These changes occur in the upland as well as in the lowlands of Oku. The planting of different crop species such as maize, beans, potatoes and others respects these changes.

Farm activities are practiced in different months of the year. Tilling and ridge forming on farms is done in the early months of January and February. Planting and weeding is done during the months of March and April. This is later on followed by second weeding and harvesting of beans. Harvesting continue in July. In August, there is clearing of the farms in preparation for the dry season beans to be planted. During the months of September, harvesting and tilling continues.

4.3. TraditionaL Farming Systems and Soil Fertility

Deforestation of the Kilum Mountain Forest for agricultural practice dates as far back as the 1930's. Initially, the forest covered what is today neighbouring quarters to the forest. Villages such as Keyon, Jiyane, Lui, Jikijem, Simonkoh, Ngashie were in the heart of the forest during this era. The passage of time gradually accompanied the deforestation of the thick forest to open up new farmlands. Trends in this search for fertile lands for cultivation progressively lead to intrusion into forested areas. Between 1958 and 1988, more than 50% of the montane forest was cut down to open up new farmlands. In an effort to curb the cutting down of this forest for farmlands, in 1988 regeneration of the forest was initiated by conservation project.

4.3.1. Shorter Fallow Periods

Fallowing is defined as leaving land that is normally cultivated temporarily uncultivated. An improved fallow is defined as enrichment of a natural fallow with trees, shrubs

or herbaceous legumes planted at high density to improve soil fertility for this practice is carried out successfully; it requires that land be available. Our findings gathered that fallowing was practiced in Oku during the 1980's and early 1990 period. During this time, farmlands were abundant and larger in size. Though advantageous, fallowing periods allow the land bare and uncultivated for a good number of years. Famers within the study area testified that some 25 to 30 years back when farmland was abundant, on fallowed farms was planted trees such as *Leucanea, Tephrosia vogelli* were planted on fallowed farms to soften them. Such farms were cultivated for 4 to 5 years before being left to fallow for the next 3 years. Immediately yields started dropping, the farmer immediately started mobilizing his resources to acquire a new farm. Rotational bush fallowing is a method of farming where farmers tend to rotate their farms as yields decrease with years. Here cultivation rotates only on farmlands while settlement is permanent. This type of farming system is not really practised in Oku Considering the growing population and compatible increase in farmlands, it is practically impossible to allow plots to fallow. The farmer needs to feed herself and carry surpluses to the market. To promote agro forestry practices within the study area, more suitable practices are being encouraged to strengthen old time farming activities. Shorter fallow periods reduce nutrients and thus further deplete soil fertility [5]. In an exclusive interview with some of these farmers, they attributed this to the fact that family sizes have greatly increased in number unlike in the past. The proportion of farmers not respecting fallow periods is considerably high in Oku. In a locality where more than 80% of the population is involved in agriculture, more than 90% of these farmers do not respect fallow periods as a way of regaining soil fertility. As a matter of fact then, agricultural practices carried out yearly on farms, require improved techniques to hold the soil in a good and productive state.

4.3.2. Slash and Mulch Methods

This is a method whereby the grass is cleared, arranged in ridges and covered with soil. The difference here is that there is no uses of fire like in the slash bury and burn method. The buried grass decomposes to fertilize the soil. The practice of agro forestry is favoured by this way of cultivation. This system helps to maintain soil fertility in the farms and it is that which is widely recommended by NGO's, the defunct KMFP and CIG for the cultivation of agro forestry crops. Farmers in Oku are sensitise to use more of slash and mulch methods on their farms. A total of 80% of farmers within the study area are involved in the slash and mulch methods. This is an environmentally friendly way of cultivation. It possesses very little threat to the environment. Output from such farms is not all that bad as compared to other cultivation methods. The farms are cultivated for a longer period of time while the rate of soil depletion is less. Slash and mulch practice is mostly done during farm tilling periods from December to March. The advantages attached to this method both in Oku and elsewhere are many. Mulches decrease the energy of raindrops and therefore protect the soil from erosion, limit evaporation, retain soil moisture, reduce the rate of organic matter decomposition, prevent excessively high soil temperatures, which can impede seedling emergence and increase soil water storage within the study area. Agro forestry crop yields are substantially increased by mulching. Consequently, the farmers are striving hard to realise higher outputs from their farms by using this method.

4.3.3. Slash Bury and Burn Methods

This is one of the old methods of cultivation in the study area. It is the practice where the bush is cleared using rudimentary tools such as cutlasses, hoes and fire. The grass is gathered into mounts and ridges covered with soil and then burnt. The soil becomes reddish in colour. Such a reddish colour is not a reflection of fertile soil. The soil structure becomes less suitable since crop roots can no longer anchor well in it. Once the soil is burned, organic matter breaks down rapidly. This cultivation method remains a threat to soil nutrients. This method is not an environmentally friendly way of cultivation. This particular farming activity usually takes place during the months of December, January February and March. Also known as "Ankara" this farming technique is practised by more than 60% of the farmers. On the slopes of the Kilum Mountain, the first harvest from these farms is often very high and tends to decrease as years go by as testified by farmer. Repeated practice leads to a reduction in soil fertility in farms where burning is carried out. On such farms, the application of chemical fertilizers yields less compared to farms in which other techniques are used. Soils from such farms are vulnerable to wind and water erosion on the slopes of Mount Oku. Crop production is further affected by diminishing returns in the farms, giving way for sustainable agro forestry practices to salvage the situation.

4.4. Techniques OF Soil Fertility Improvement in Oku

Different local techniques are used by farmers in Oku to improve on soil fertility. The farmers in their quest for better output from their farms develop new strategies. Besides the use of chemical fertilisers, peasant farmers use local resources to improve or maintain soil fertility. Animal droppings from cattle, goats and sheep are carried and spread on the farms. This helps in fertilizing the soil and improves on harvest.

4.4.1. Carrying Decomposed Manure from the Forest to the Farms

Considering the enormous practice of agricultural activities on soils in Oku, there is need for a much greater and more sustained effort to manage and conserve the soils. Processes that influence nutrient availability under trees are those acting via redistribution, those nutrient losses and that increasing soil fertility. Substantial increase in crop yield will result from correcting soil deficiencies in Oku. Increased productivity is often largely the result of improved management including inputs such as fertilizers. Decomposed manures from leaves are carried from the

Kilum Mountain Forest and placed on the furrows of farms and solanum potato is later on cultivated on these farms. As an innovative practice in Oku, about 15% of farmers carry decomposed manures from the forest to their farms. In terms of payment, Mrs, Ngala Vivian spends close to 15.000 FCFA to get 8 bags of decomposed manure from the forest to her farm in Ngvuinkei 11. A glaring example of this practice is found on farms closer to the forest in Upland Oku. These farms witness an increase potato yield as explained by Mr; Kelese Paul. Studies carried out in the field shows that more than 78% of farmers in Oku prefer applying chemical fertilizers on their farms. This is justified by the fact that huge quantities of these products are stored in different cooperatives around Oku. Indeed, only about 16.5% of the farming population is involved in gathering house hold waste and depositing it on the furrows of their farms. Longer fallow periods are not more respected in Oku. As a result of limited lands destined for agriculture an population increase nowadays, farmers do not allow their farms to fallow. It is indeed regrettable that only 4.9% of the farming population is still engage in longer fallow periods as seen in figure 2 below.

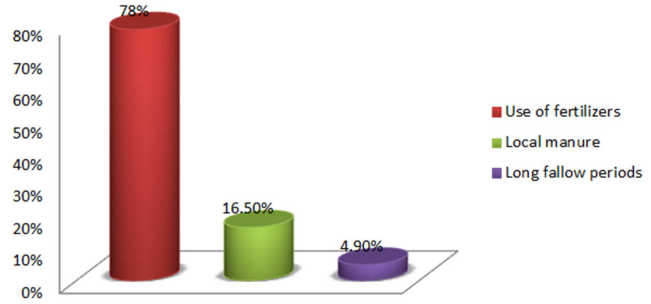

Figure 2. *Farmers approach on ways of improving soil fertility.*

4.4.2. Predominance of Soil Erosion

Within the study area, it is generally agreed that one of the greatest threats to sustained rain fed agricultural production is uncontrolled erosion, due to the sloping nature of the terrain. Soil erosion therefore remains a constant problem to the local farmer. As population pressure increases on the available limited, uncontrolled erosion is depleting valuable topsoil in Oku. We equally found the recurrent situation of erosion in poorly cultivated areas. Under natural vegetation undisturbed by human or domestic animals, the soil surface is normally protected by leaf litter and a canopy of leaves and as such negligible erosion takes place. Soil nutrient loss is significant after burning the farms. The extent of erosion is inversely proportional to the vegetative cover over the soil during the rainy season be it in the form of natural vegetation, perennial crops, one or more annual crops or leaf litter or mulch on the soil surface. Here most important farming practices for the prevention of erosion are those that maintain an effective vegetative cover over the soil. Soil erosion on agricultural lands in Oku is higher than for natural vegetation. The stability of the latter is only achieved by the combined effects of the tree and the herbaceous ground cover, and their effects on soil characteristics such as organic matter content. However, any agro forestry system with inadequate protection of the soil cover (due to burning, removal of crop residue or intensive grazing) will therefore not offer a good protection against erosion within the locality. Relatively, deep rooting shrubs and trees may recapture leached nutrients in the soil. Leaching is a common process under sub humid and humid conditions. A perennial root system may also decrease losses by leaching in the non growing season.

4.5. Protective Role of Agro Forestry on Sloping Lands

Considering the sloping nature of Oku's landscape, agro forestry techniques stand out as the best way of ensuring a topo stability of the region. The combination of both crops and fruit trees on a piece of farm land, plays a major protective role on the area. This technique contributes in reducing the frequent landslides common within the study area. After heavy down pours, steep sloping areas in Oku suffer from landslides. Sloping areas covered with trees and crops to a greater extent, experience less or no landslides. This is greatly accounted for by the vegetative cover of the area.

4.5.1. Using Agro Forestry Alternatives to Reverse Land Degradation

Farmers in Oku have shown great ingenuity in developing traditional farming practices to meet local needs and minimize risk of further depleting the soils. In their continuous effort and struggles to practice farming, they consciously or unconsciously reverse land degradation. Both the planting of trees and crops on farmlands significantly contributes in land management. Land degradation involves the different ways of rendering lands unsuitable for both agriculture and other uses. Agro forestry techniques are tailored towards ensuring proper land management. Respondents acknowledged that the defunct KMFP intervention to practice soil conservation and erosion control techniques by planting hedges of agro forestry tree species like *Calliandra*, *Acacia*, *Leucaena*, *Tephrosia* in their farms for soil improvement was a welcome gesture appreciated by most farmers. Project benefits to the farmers equally saw a great improvement in the manner in which their ridges and furrows were aligned on their farms as a way preventing erosion. Considerable debate concerning the links between conservation and poverty has taken place and it intensified since the 1992 Earth Summit held in Rio de Janeiro [5]. Chapter 14 of Agenda 214, on Sustainable Agriculture and Rural Development (SARD), notes that, by the year 2025, 83 per cent of the expected global population of 8.5 billion will be living in developing countries. These are countries which by virtue of their level of development have exhibited the highest levels of poverty and heavy reliance on primary goods. It further notes that without changes in the modus operandi, the capacity of available resources and technologies to satisfy the demands of this growing population for food and other agricultural commodities remains uncertain. Considering our study area at a local level, the ideas of agro forestry needs to be inculcated in the

minds of the peasant farmers to be able to catch up with this challenging task ahead.

4.5.2. Soil Enrichment and Use of Chemical Fertilizers in Farms

In recent times there has been an increase in organic farming in Oku. Farmers using this method aim to maintain or even increase content of the soil by applying manures, crop residues and mulches. The landscape is classified as good; the ground is covered by 60-75% of plant and litter [6]. In this way the local farmer strives to reduce the need for inorganic fertilizers. The soil nutrient balance sheet must be maintained in their farms. The tendency to increase production by extending the area of cultivated lands remains stronger than to intensify production. Increased soil fertility generally decreased significantly with radial distance from the centre of the canopy or tree within the agro-system. Besides natural methods of soil fertilisation, chemical fertiliser, pesticides, herbicides and fungicides are highly used in farms in Oku. Fertilisers commonly used include: NPK 20-10-10 and Urea 46%N. Table 2 below shows the total number of bags of fertilizers used within a farming season in Oku.

Table 2. *Fertilizer distributor and quantities from 2010 – 2012.*

Distributor	TYPE	Quantity used in 2010	Quantity used in 2011	Quantity used in 2012
OACU LTD	NPK 20-10-10	866 Bags	1000 Bags	1200 Bags
	Urea 46%N	806 Bags	906 Bags	1106 Bags
Manchok Cooperative Credit Union LTD	NPK 20-10-10	20 Bags	700 Bags	700 Bags
	Urea 46%N	345 bags	400 Bags	400 Bags
Mih Alfred (Elak)	NPK 20-10-10	25 Bags	35 Bags	40 Bags
	Urea 46%N	50 Bags	63 Bags	70 Bags
Njini Johnson (Elak)	NPK 20-10-10	250 Bags	265 Bags	280 Bags
	Urea 46%N	50 Bags	60 Bags	73 Bags

Source: Sub-Divisional Delegation of Agriculture for Oku

From table 2 above, we can observe an increase in the total supply of fertilizers in OSD. Fertilizers within the study area are bought by farmers largely from Oku area Cooperative Union LTD (OACU LTD) and the Manchok Cooperative Credit Union LTD. More than 2000 bags of Nitrogen Phosphorus Potassium (NPK) 20-10-10 was available in 2012 to the farmers in Oku compared to about one thousand bags in 2008. Maize, Solanum potatoe, tomato and cabbage growth is improved upon with the application of NPK 20-10-10 and Urea 46%N. Farmers also receive training on the proper use of chemical fertilizers from Zonal Extension Workers (ZEW) and union staff.

5. Conclusion

In conclusion, farmers realize the best maize harvest at a closer perimeter to the soil fertilizer trees. This strategy maximizes healthy maize production, sustainable soil management and promoting agro forestry activities. Both Leucaena and Tephrosia trees are the dominant species planted in Oku. One of these tree species are identified in farms in Oku. The practice of modern agro forestry within the Oku Mountain Area is growing in leaps and bounds. Agro forestry practices are thus important in organic reconstitution of the soil. The farming systems practised within Oku are an adjustment of farmers to the yester years declining soil fertility caused by ignorant ways of cultivation. Rotational bush fallowing as a result of excess lands is gradually being halted giving way to maximisation of available lands put under cultivation. The influences of soil types and climatic factors are most favourable governing agricultural production in Oku. Another finding realised in the course of this study is the innovative practices in agricultural techniques in Oku.

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