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CONSCIENTIOUS MANAGEMENT OF SOIL HUMUS AND WATER: A MAJOR CONDITION FOR PURPOSEFUL MECHANISATION OF FIELD CROP HUSBANDRY IN TROPICAL RAIN FOREST OF NIGERIA

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Abstract

Machinery and implements used in agricultural product/on work in media of lives - the soil, livestock and crops. Certain features of these media determine the possibility and extent of mechanization of works relating to them. In the tropical rain forest areas, mechanization remains the greatest obstacle to the expansion of production and therefore constitute great problem to food and primary raw materials supply. This paper highlights the problems, discusses the problems as well as the correlating factors and the possibilities of improving on the level of mechanization in view of the present technological and socio- economic development of the peoples of tropical rain forest areas of Nigeria. The work is an original scholarly research based on review of relevant publications and visit to several locations within the Tropical Rain forest belt. The results reveal inadequacies managerial skills and in appropriate deployment of technical staff as well as poor education as major factors for the insufficient understanding of the soil-machine-crop-climate relationship which is the bedrock for conscientious planning and execution of mechanization. The paper is aimed at drawing the attentions of the relevant authorities charged with ensuring adequate availability and supply of food and raw materials for the populace and the industries to the need to purposeful mechanization. The paper ends by making some practicable recommendations and warning of the dangers of not mechanizing farm production as well as the implications of failure of mechanized farm projects in the tropical rain forest zones.

Key words**:** *husbandry, mechanization, soil, tropical rain forest, water*

INTRODUCTION

It has been observed that ‘‘without soil there can be no agriculture and without agriculture in our present state of knowledge, the world cannot be fed” [7]. The food must be satisfactory both in quantity and quality. It has been evaluated on the basis of studies by FAQ [11] specialists that a great part of the world population is under-nourished considering the fact that the food does not correspond qualitatively, being poor in Protein, especially the protein of animal origin [28].

In view of the above, it became apparently necessary to take series of measures to address the problems. Principally among the measures are:

(i)To increase production per unit surface area (hectare) or per head of animal; and

(ii)To increase the total surface area cultivated.

However, the ever-increasing population of the world and the limit in the size of the land that can be made available for agriculture led to the present basic tendency in agriculture which includes maximum utilization of the production capabilities of both land and the biological materials [26].

The single most important factor that can simultaneously facilitate the expansion of the surface area cultivated as well as the number of animals and the intensification of production per unit surface area (hectare) and per head of reproductive animal, respectively, is high degree of mechanization. However, there are other measures such as genetic improvement, expansion of use of chemicals, improved training or education of agricultural workers, expansion of irrigation and drainage, boosting of soil humus content, etc., which

mostly influence the intensification of production. Irrigation and drainage of large surface area must be sufficiently mechanized for maximum labour and economic efficiency [1]. In the tropical rain forest zone which include part of Nigeria the impression has always been created that it is not feasible to introduce mechanization especially of arable field crops because of the thick forest and excessive rainfall which makes the soil too soft for mechanical aggregates to ply upon. Consequently agricultural production has continually been taught in schools and practiced under peasant subsistence system. As a result food production has been low, raw materials supply to industrial has been inadequate and the whole agricultural production has been of low yield, poor quality and of low returns to farmings. Since mechanization has remained a single most important factor in intensification and expansion of agricultural production, the tropical rain forest area of Nigeria can not afford not mechanizing is agricultural production in view of the increasing draught, desert expansion and religious disturbances in the northern part of the country. The fast expansion of the desert inwards is not unconnected with the global climate change.

Literature review

Too much stress has often been laid on the barriers presented by "Virgin" forest to human activity**.** The tropical forest**s** that cover such vast expanses remain not so much because of their own resistance as because of the feebleness of human attack on them [23]. This means that the existence of the forest is simply a proof of the absence of a population interested in its destruction and thus the forest cannot resist if groups if cultivator wish to take its place. This has been proven to be so because a vast portion of the rain forest has been cut down, howbeit recklessly due to excessive ill-organized logging for timber for wood furnishing materials. With much of the forest gone (over 75 %), the common features of the exposed landmass are heavy sheet and deep, long and large gully erosion posing great threat on continuous trend (Fig.1.)

The cleanings of forests have revealed that sand is rather found instead of deep humus and that the forest may have great difficulty in growing up again once man's exploitation has exposed the underlying sand.

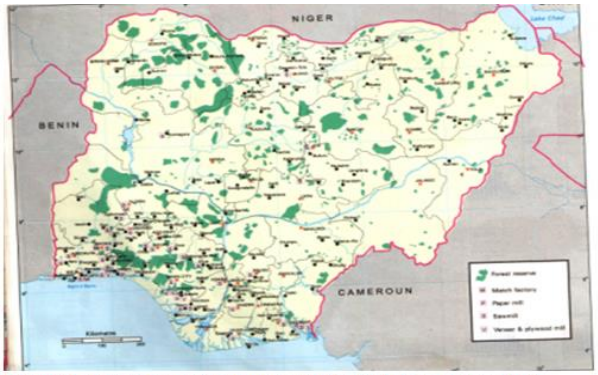

Figure 1: Map of Nigeria showing the Forest Resoureces, 2005
Source: Longman Atlas, Second Edition

Thus Tropical soils are very poor in assimilable bases and phosphorous and ill supplied with humus. The deficiencies are such that soils of similar composition would have been barren in a temperate climate [23]. So great is the poverty of tropical soils in bases that they are acid, a condition unfavourable to good use of humus. However cultivated tropical plants are adapted to acid conditions. These conditions can be found in south west, Benin and south east areas of Nigeria, which falls within the rain forest area.

The tropical rain forest soil is easily leached. The ease of leaching of the soil is due in part to the feeble capacity for adsorption by tropical soils. They can not retain fertilizers because they are poor in humus due to the fact that their clays have unfavourable structure because they have a tendency to accumulate inert lateritie elements [23]. These inert materials contribute nothing to the fertility of the soil and does not help to prevent leaching of the elements that determine the fertility of the soil.

Intensive method can transform poor soils into heavy yielders, as the Flemish peasants have done in the fields of Flanders and the Chinese in Malaya. Even though at the cost of immense labour and the application of abundant manure [23]; [1]. In present day agricultural practice, intensification and reduction in labour can only be guaranteed by **efficient** mechanization.

The single most important factor for the intensification of agricultural production is mechanization backed by irrigation, drainage and good soil study/management. People have seen the heavy and very frequent rain fall as problems to the use of heavy machinery for crops cultivation, thereby shying away from mechanizing agriculture [21].

The non-mechanization of agricultural production means that the needed food and raw materials supply is in the hand or subsistence peasants and thus the food needs has heavily depended on importation [3].

However, the current economic reality and the market behaviours of the sole product heavily relied upon by Nigeria, crude oil, for foreign exchange earning, has shown that the livelihood of the people is seriously threatened and urgent actions need to be taken to savage the population [4].

Unfortunately, mechanization of field agricultural work in the tropical rain forest zones of Nigeria has been in shamble [5]. It has been observed that the fundamental problems of mechanization of the process of crop production in the tropical rain forest zones, are the excessive humidity, high temperatures and the delicate nature of the soil [2]. These make the behaviour of an exposed soil very complex and delicate to manage. The problem of management of excess and shortage of water is not as complex and delicate as the management of the physical properties of tropical rain forest soils, especially in regards to humus content, and the structure of the soils. Enough researches abound in the areas of irrigation and drainage (water use) as means of improving the soil for increased productivity [18].

"Agricultural mechanization is a broad subject requiring very meticulous planning and execution"[2]. It goes beyond merely buying few tractors and implements, machines etc.

The problems of conservation of the soil increases with mechanization. Removal of roots reduces soil stability, and heavy cultivation may breakdown the soil structure due to accelerated fall in humus levels [9]; [2]. In most of the forest zones, the relief is typically steep and dissected and most of the ground sloping. The gradient together with the normal heavy and intense rainfall associated with land line squalls common at the beginning of the rains, could be expected to result in heavy erosion, both sheet and gully [9].

Contrary to the popular view of the peoples of the tropical rain forest zones, the main difficulties and danger of mechanization are fundamentally related to the nature of the soil and the associated climate; because if land is completely cleared for the first time, it can then be regularly ploughed, cultivated (primary and secondary), modelled, seeded, planted, fertilized, weeded and crops harvested mechanically. Hence, the dense vegetation of the rain forest do not really constitute a problem to mechanization, although the removal of the forest cover leaves the soil more exposed to the effect of sun and rain, particularly before the planted crop establishes itself and after it had been harvested [2].

Another salient problem of mechanization, and which requires very serious attention, has been observed to be its encouragement of quick farming of too large areas at the expense of careful farming, hence mechanization does not necessarily increase yield per hectare even if it increases productivity per day's work [2]. In fact large scale mechanization is generally associated with lower yields than are obtained by more intensive methods but the benefits of mechanization results from the economy of large scale associated with mechanization [2].

It has been observed that the behavior of the soil once it has lost its humus depends on its texture and structural stability. Soils which are high in clay and iron are firmly aggregated into silt-size particles, and this gives them considerable stability, they may remain permeable and porous even when low in humus, and percolating water may remove little if any clay from them [13]. This structural stability is said to be one of the favorable properties of some highly weathered latosols. Some soils are known to completely lose their structure under intense cultivation. If finer particles are washed downwards,

cultivation may result in a relatively sandy sterile top soil overlying lower horizons in which soil pores are clogged by silt and clay, or which may even contain a clay pan below normal plough depth [2]; [26].

The high temperatures favour very high rate of evapo-transpiration and of chemical reactions/processes leading to rapid breakdown of soil organic matters and other components.

This high rate of mineralization promotes easy leaching of the resulting simpler products as well as too quick absorption by plants. This explains why tropical rain forest soils have very little and unstable humus content, hence low fertility while at the same time supporting luxuriously growing vegetation [6].

Humus is the store house of soil nutritive substances in complex organic compounds, and it represents part of the soil colloidal system. It is known to form an active part of the soil, and has great influence on the soil's physical properties, therefore playing a great role in structuring of the soil particles. The structure of the soil affects retention capability, stability, mechanical strength, rate of erosion and the aeration of the soil, (all these properties are factors of the porosity of the soil) [19]. The application of lime helps to improve the structuring of the soil particles besides the effect of correcting soil solution reaction. It is known that:

(i)The worse the structure of the soil, the higher the number of tiny spaces, hence the greater the process of capillarity which influences the humidity of the soil [25].

(ii)The bigger the structured aggregate, the greater the mechanical resistance of the soil [20].

(iii)Fine unstructured soil easily gets saturated after rainfall due to lack of deep infiltration, thus causing water to stagnate at the surface unlike well-structured soil [2]; [27].

(iv) Structured soils have greater resistance to the process of erosion than the unstructured and the structured soils are easier worked [27] and

(v)Generally, structured soils have greater fertility than the unstructured soils [2]; [25]; [26];[27].

MATERIALS AND METHODS

Firstly, this work is an original research and a review work based on scholarly inquiry to find out the reasons for the peasant nature of agriculture in the tropical rain forest world, the level of food and raw materials supply for the populace as the result of this peasantry, the challenges to expansive agriculture granted only by efficient mechanization of production and to find out the prospect of mechanized agricultural production (especially arable field crops) that can enhance the livelihood and socio-economic development of the people, the agriculture and their rural community.

The country Nigeria lies between Longitude 3^0 and 15^0 East of the Greenwich Meridian and Latitude 4^0 and 14^0 North of the Equator. The Tropical Rain Forest area is found between Latitude $5\frac{1}{2}^0$ and 7^0 North of the Equator; stretching from Ogun State in the South-West through Benin in the Mid-West to South Eastern State of Cross River (Northern Part). Figures 2, 3, and 4 show the physical features, Soil distribution and Vegetation respectively.

Figure 2 : Map of Nigeria showing Physical Features
Source: Longman Atlas, Second Edition

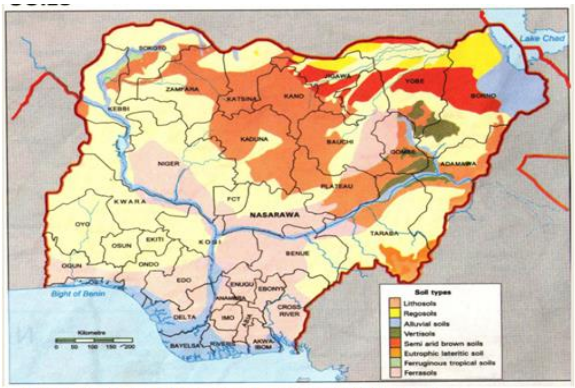

Figure 3 : Map of Nigeria showing Soil Distribution
Source: Longman Atlas, Second Edition

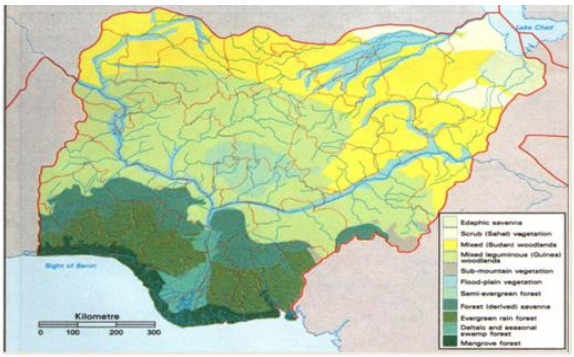

Figure 4 : Map of Nigeria showing the Vegetation
Source: Longman Atlas, Second Edition

Secondly, informal visitations were made to some selected locations for first hand observations, namely:

(i)Benin-Owina River Basin Development Authority (one of the federal government established and managed attempted mechanized agricultural projects scattered all over the country) expanse of farmlands in Edo and Ondo States (for Benin and Owina project respectively). The ambient/environments were carefully observed and willing staff interacted with in each location.

(ii)Two (2) rural farming settlements were visited in each of Ogun, Ondo, Edo, Anambra, Imo, Abia States and central part of Cross River State. The tillage practices of the farmers were observed.

(iii)Teaching and Research Farm of College of Engineering and Engineering Technology Micheal Okpara University of Agriculture, Umudike and National Root Crops Research Institute, Umudike.

RESULTS AND DISCUSSIONS

Observations revealed that there has been attempted mechanization of arable field crop production in the Nigerian Tropical Rain forest belt and that the failure of the attempts left negative ecological and socio-economic impacts in the environments attributable largely to insufficient work on the soil for sustained productivity.

Hence the rapid degeneration of the soil and the uneconomic outputs leading to the ceasation of production activities.

(1)The skill workforce in the River Basin: was in appropriately distributed for reasons of:

(a)Agricultural engineers specializing in mechanization was Nil while agricultural engineers, Technologists and Technicians in Civil work, design and repairs was 100 %

(b)Crop agronomist, irrigation agronomist and competent soil specialist was in proportion of 90 %, 5 % and 5 % respectively.

(c)Application of mulch and organic manure was Nil while application of inorganic fertilizers was 100 %, despite the repeated tillage of the land with ploughs and harrows in the Tropical Rain Forest Climatic conditions.

(d)State of the farm is failure with ill exploited and ill managed machinery littering the storing unit (a huge loss of passive energy).

(2)Visited farm settlements reveal high level of poverty and lack of educational expertise among the rural farmers using manual labour and implements.

Farmers are not aware of the need to incorporate grass mulch and/or organic manure to strengthen the soil physically and chemically. And the effects of gully erosion in exposed deforested areas were visible. Dry season cultivation is absent. These are contrary to literature presentation and some of the observations are shown in the plates below.

Plate 1: Exposed Land in Edo State.

Plate 2: Exposed Land in Ondo State

Plate 3: Gully Erosion in Imo State

Plate 4: Gully in abandoned farmland in Anambra State

Plate 5: sheet erosion in central Cross River State

(3)Some few machines have been invented and produced for seeding/planting arable crops like yam, cocoyam and cassava but the commercialisation of these as well as successfull year-in year-out production on the field is still a mirage.

The rapid degeneration of the soil can be said to be the negative effect of the state of the soil humus/organic, matter and water (both in the soil and frequent heavy rainfalls) which define so many physical and chemical features of the soil that needed conscientious attention and which unfortunately never got anything let alone a conscientious one. Looking at the distribution of the type of specialist and the competency level of the so-to-say specialist deployed in service in these attempted mechanized projects, the result of failure could not have been otherwise except there had been miracles.

With the level of mechanisation infrastructures provided in the government owned and managed projects, it is obvious that management skill was a huge problem creating inadequate understanding of soil machine – crop – climate relationship and the related dynamics.

Generally it takes an agricultural engineer to mechanise agricultural production but only such engineers with added specialisation in mechanisation (expolitation and management of engineering facilities) can have the adequate competency to manage field production works.

The activities of mechanisation go beyond inventing machines and repairs of broken down machines. It attracts high quality soil specialists, irrigation and drainage experts and facilities, genetical engineering of the crop species, application of chemicals, organic matter (in form of animal manure, grass mulch and dead plants and animals) etc. which must all be efficiently syncronised in optima level in one complex system of production activities.

The result statistics reveal clearly the inadequacies of the managerial skill that contributed immensely to the failures of the attempted mechanization of arable farming in Nigerias Tropical Rain Forest Belt.

In view of the Prevailing Technological and Socio- Economic Development of Nigeria, Crop production can be successfully mechanized to a high degree in the tropical rain forest zone, though it will require reasonable investment and good knowledge of soil-machine-plants relationship. Possibilities exist for this investment to be amortised and profit made if high yielding varieties of crops, high water consuming crops (e.g Yam, Cassava, etc) and all year round cropping (2 - 3 harvests) are implored. The question that readily comes to mind is, how? The answer is

founded on good water management through irrigation and drainage and on meticulous study and management of the soil, which will include slope adjustment, high level of administration of fertilizers, vegetal remains and grasses on regular basis (2 - 3 yearly) via deep mould board plough tillage (sub soiling). Although these are temperate region measures, it is practicable to adapt these measures in the tropical rain forest zone to economically mechanize production, [17]; [2]; [25].

However, the above' measures must be backed up with the use of biological materials with high productive capability and high degree of consumption and utilization of nutritive elements, that is, they should be able to withstand high degree of use of chemicals [16]. Also, the loose tropical soil ploughed to bury vegetal materials, must be mechanically compressed to guide against erosion and excessive leaching. All these measures represent improvement on the soil.

The use of heavy grass mulch, chemical fertilizers and animal manures can form the basis of development of new systems adapted to the rain forest zones. Grass mulches moderate the effect of the high temperatures; chemical fertilizers substitute the leached substances while the structuring of the soil is greatly improved by the application of lime and organic materials [15]. They have shown to be effective in holding stable aggregates together. Consequently the maintenance of the soil in good physical conditions is enhanced by periodic additions of organic materials [26] while the presence of binding agents or aggregating forces such as oxides of iron and manganese, soil compression under the weight of machines and some types of tillage help to improve the structure of the soil. The good structuring of the soil favourably influences the soil factors that determine its mechanized management.

Installation of overhead (Sprinkler and drip/trickle) Irrigation facilities in combination with sub-surface (tile drain) drainage facilities. This should be backed up by sub-soiling to incorporate vegetal materials once in 2-3 years using heavy mould board plough to a depth up to 60 cm [26]; [2]. The use of tile drains will ensure that percolating water is absorbed, collected, transported and emptied into designated basin or course. The irrigation and drainage will facilitate all year round cultivation thus providing for full exploitation of the machineries and quick recovery of the huge investments [8]. Studies have shown that the optimum soil humidity level for quality work of cultivation and safety of the mechanical implements or working organs is about 18- 21 % for loam soil but with a possibility range of 14 – 26 %. This is lower for sandy soils (10 – 20 % of the total capacity of the soil) [10].

Breeding and introduction of high yielding crops of shorter maturity period, of moderate height (possibly below 1.5 m) and possessing high water and nutrients consumption capacity [3].

Full mechanization of land preparation in the tropical rain forest zone with presently available temperate zone equipment. However, landscaping that will give the land the minimum gradient is very necessary and fundamental. A slope of 1 % and below would drastically minimize the velocity of run-off, thus facilitating adequate percolation, sub-surface draining and reduction in the erosive ability of the water [27]; [24]; [2].

Division of the farms into plots of optima dimensions that ensure economic efficiency for the movement of the machinery while preventing prolonged run-off. This will disfavour the erosion of the topsoil [26]. The light compression of the soil by the movement of the heavy farm machinery (being aggregating force) would also be advantageous to the structuring of the loose tropical rain forest soil.

The present engines, machines and implements available for farm works in advanced countries can be successfully adapted and implored to mechanize the planting/seeding of cassava stems (e.g. MPR-5(8), yam seeds (e.g. 4SaBp-62.5), all grains, legumes and fibrous crops on modelled (ridges or beds) and on flat soil surface, the application of manure and chemicals, the transplanting of seedlings and the processing of farm produce [14]. The harvesting of many of these crops can be semi-mechanized e.g.

the digging out of cocoyam tubers can be done with the use machine such as MRS-34, BM-6 and KS-6 while the picking can be done manually [22].

The loading and off- loading of transport vehicles with farm produce can be fully mechanized in the tropical rain forest zone.

The authors of this write up do not see the poor (so to say) economy of most tropical rain forest countries as fundamental issue that can hinder the introduction of mechanization at a greater level. In the present state of the world, manpower can be acquired through exchange programmes [20]. What is lacking is determination and will. Therefore, skilled manpower is not a fundamental problem that can hinder the development of mechanization in tropical rain forest countries. However, the state of technological advancement of the society exercises great influence on the expansion of mechanization of farm/field operations because mechanization must be strongly supported by high level of use of chemicals and genetic engineering amongst others.

The development of varieties of yam that can produce many yam tubers of reduced sizes just like cocoyam and similitude of mini-set yam) will guarantee the mechanization of the harvesting of yam, and of course, available machines for the harvesting of sugar beets, e.g. MRS-3T, KS-6, BM-6, CRS-2, E-684 can be adapted to harvest cocoyam and similar tropical crops. The production of cocoyam can be fully mechanized with minimum difficulties (seeding to harvesting and transporting) at the level of the economic and technical development in the tropical rain forest zones including parts of Nigeria.

The government should put the specialist together (no matter how few the numbers) and fund research into the mechanization of tropical rain forest soil and crops by establishing functional Agricultural Mechanization Research Centers.

The agricultural mechanization research center should be funded through an agricultural mechanization development bank. The bank should be legislated to operate on strict economic profit oriented basis with the capability of amortizing the initial fixed and working capitals and sustaining itself fully.

The lateritic or podsolic soil usually associated with rain forest is characterized (in its natural state) by very low base, an organic layer of raw humus and a loose structure in the mineral A-horizon. The application of lime and chalk will correct the lime deficiency, enhance decomposition of raw humus and promote the development of crumb/structure [12].

A good rotation between arable and grass crops will facilitate a fairly high level of productivity of rain forest soil under permanent cultivation otherwise there would be a rapid degeneration of the soil [7].

CONCLUSIONS

Agricultural mechanization is a very broad and complex subject which goes far beyond just buying tractors with few implements and machines. It requires strict economic and technical planning with due respect to ecological potentials because losses associated with failure of attempted mechanized farm projects are often enormous and of long time effects, financially and ecologically.

With conscientious planning/management based on more meticulous study and management of the soil (including its humidity) field agricultural works can be economically mechanized.

Application of irrigation for dry season cultivation and drainage for wet season cultivation will generate all year round use of the machinery and implement as well as result in multiple harvest. This will facilitate increased surface area cultivated and greater intensification of production. In consequence, more hands would be employed, there would be a higher level of agro-industrialization and there would be more, better and cheaper food items for the populace. Finally, there would emerge a better society.

It is our view, therefore, that only efficient mechanization can guarantee expansive and intensive crop production needed to cope with the demands of the ever-increasing world population. It represent the cheapest way the tropical rain forest people can hope to

improve their standards of living compared to the alternatives which are the importation of food items and the use of traditional subsistence method.

With all practical intents, good will and determination field work can be successfully mechanized to a higher degree at the present level of education and economic development of the Nigeria in its tropical rain forest areas.

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