GUIDELINES, PROCESSES, OPERATIONAL TECHNIQUES AND FACTORS TO CONSIDER IN MECHANIZED AGRICULTURAL BUSH CLEARING IN NIGERIA

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ABSTRACT

Bush clearing for any purpose causes environmental degradation when improperly done. To reduce this effect, there are guidelines to be followed. This paper presents the guidelines, processes operational techniques and factors to be considered in mechanized agricultural bush clearing in the tropics.

The author relied on literature, interaction with farmers and machinery operators and his experience as field officer in National Agricultural Land Development Authority of Nigeria (NALDA) to develop a system for mechanized agricultural bush clearing in the tropics. Some of the recommendations are that the site should have a slope and stoniness of less than 5% and 20% respectively, depth to compact layer and bedrock should be greater than 40 cm and 75 cm respectively, a band of between 5 m – 10 m of vegetation must be left along both sides of rivers and streams where they exist, and where a bulldozer is used for windrowing, a maximum depth of 80 mm and a maximum lateral movement of 1 m of the soil are allowed. Areas that are poorly drained with sandy gravel and silty clay loam should not be cleared mechanically.

In all cases, mechanized agricultural bush clearing must be properly planned and executed. Also, the operation should be supervised by experts who must include soil scientists and agricultural engineers. This is to ensure that the operators adhere strictly to the guidelines.

KEYWORDS: Bush clearing, agriculture, mechanization, machinery, soil.

1. INTRODUCTION

Bush clearing for crop production such as construction is different from bush clearing for other purposes. This is because, the cardinal objective in clearing for other purposes is not only the removal of all bush, rubbish, debris and other objectionable materials, but the top soil is also removed and may be replaced with sub soil (laterite) and where necessary, compacted or stabilized depending on the type of project. In agricultural bush clearing, the top soil must be preserved. The top soil contains nutrients needed by crops for optimum performance. Agricultural bush clearing is therefore defined as the process of scientific removal and disposal of existing material, vegetation, rubbish and other obstructions from the land by manual, mechanical and chemical means for agricultural food production (Anazodo, 1986; NALDA, 1992; Adama, 2013). Agricultural bush clearing operation is effective only when all the unwanted vegetation including all roots and stumps are removed with minimum disturbance to the top soil (Nwuba, 1984).

The basic objectives of mechanized agricultural bush clearing and land development are to remove unwanted materials from the land and to increase the size of land to be cultivated. Unwanted materials include trees, boulders, stumps and tree trunks. These materials cause obstructions to smooth field operations during subsequent tillage and other operations on the land. Tall trees also prevent rain and sunlight from getting to the soil by shielding. The area to be cultivated could be limited by presence of unwanted vegetation and undulating terrain, and stumps which could be easily removed using mechanical means.

Bush clearing in general increases erosion and sedimentation of waterways and reduces water quality. Also, the operation removes habitats leading to the direct loss of native animals and plants. To reduce the negative effects of mechanized agricultural bush clearing especially in the tropics, the operation requires to be properly supervised and guidelines followed. This is because soils in the tropics are known to be delicate and low in organic matter content both down the depth and in profiling (FAO, 1990; Adama, 2013). In Nigeria for instance, about 63% of the soils are low in productivity and over 90% of them are alfisols and ultisols which are low in organic matter and have low activity clays (Ojeniyi, 1997).

A number of researchers have conducted field studies on agricultural bush clearing in the tropics. For instance, Anazodo, (1986) developed appropriate methods and equipment for agricultural land clearing and development in Nigeria. Oni and Adeoti (1994) conducted field experiment to determine the effects of mechanized land clearing and tractor traffic on agricultural soils and crop growth. Okore, et al. (2006) carried out field studies on impact of land clearing methods and cropping systems on labile Soil C and N pools in the Humid zone Forest of Nigeria. Fagbemi and Gana (1994) attempted to produce guidelines for agricultural bush clearing in Nigeria. Couper, 1996 working under the International Institute for Tropical Agriculture, produced a guide for agricultural land clearing in the tropics. Although these works are useful and relevant, they are limited in scope. They failed to give comprehensive approach to mechanized agricultural bush clearing. Also documents to guide farmers, field officers, machinery operators, etc on operational guidelines and specifications for mechanized agricultural bush clearing existed mostly as technical bulletins and abridged guides in government agencies. Peer reviewed publications in reputable journals in this field are scarcely available.

The objective of this study is to develop a comprehensive approach for mechanized agricultural bush clearing in the tropics. The approach includes guidelines, processes, operational techniques and factors to consider before embarking on mechanized agricultural bush clearing in the tropics. The approach is intended to serve large scale farmers, agronomists, agricultural engineers, machinery operators and other stake holders in crop production industry.

2. METHODOLOGY

Part of the information and data used in this study were sourced from relevant literature. Other information and data were gathered from field experience and interview of farmers, machinery operators and field engineers/officers of Agricultural Development Programme, River Basin Development Authority, Federal Department of Rural Development and National Directorate of Employment in South East and South South geopolitical zones of Nigeria. The interview was conducted using questionnaire and the enumerators were the 2013/2014 set of final year students of the Department of Agricultural and Bioresources Engineering, Michael Okpara University of Agriculture Umudike Nigeria. The interviews were conducted in the first semester of 2013/2014 session.

The field experience was acquired during bush clearing operations in the project sites of the National Agricultural Land Development Authority (NALDA) in Nigeria. The literatures were sourced from the National Agricultural Land Development Authority (NALDA) and International Institute for Tropical Agriculture (IITA).

3. RESULTS AND DISCUSSION

3.1 Processes and Unit Operations in Mechanized Agricultural Bush Clearing

The processes and unit operations for mechanized agricultural bush clearing were identified which include the following:

(a) Acquisition of land: In areas where land is donated by the community, the first step is to acquire the land and then follow necessary steps to register it.

(b) Notification of availability of land: The first major step is for the farmer to know where land is available. This can be obtained through agents or land owners, In National Agricultural Land Development Authority, it was required that land owners (donors) should notify the authority of the availability of land and their willingness to give such land for mechanized agricultural bush clearing in writing through the Local Government Chairman.

(c) Site visitation and selection: The farmer then visits the site to observe the location, condition and suitability of the land.

(d) Site evaluation: The site will be evaluated to obtain its suitability for crop production. This will involve surveys such as perimeter, contour and soil to determine the nutrient status; demarcation of the farm and mapping out the roads; indication of permanent features such as rivers, valleys, hills and hanging cliffs; show the topography of the land depth to bedrock, drainage ability, percent slope, percent stoniness, surface stone and rock outcrops.

Table 1 gives soil suitability criteria for mechanized agricultural bush clearing. Soils having components falling within the "Not recommended" category in the Table should not be cleared because such areas are prone to accelerated erosion or surface ponding.

Table 1: Soil suitability selection criteria for mechanized agricultural bush clearing

S/N	Soil factors	Good	Fair	Not recommended
1	Surface Texture	Sandy Loam, Loam, Silt Loam	Loamy Sand, Clay Loam	Sandy Gravel, Silty, Clay Loam
2	Depth to Compact Layer	Greater than 40 cm	20 to 40 cm	Less than 20 cm
3	Depth to Bedrock	Greater than 75 cm	40 to 75 cm	Less than 40 cm
4	Drainage	Well Moderately	Rapid, imperfect	Poor
5	Slope (%)	Less than 5%	5% to 10%	Greater than 10%
6	Stoniness (%)	Less than 20%	20% to 30%	Greater than 30%
7	Surface stone (%)	Less than 0.1%	0.1 to 3%	Greater than 3%
8	Rock Outcrops (%)	0%	Less than 10%	Greater than 10%

Source: (Brunswick, 2008)

(e) Tree count and tree size:
The tree count involves taking a census of the trees in the area. The result will be the density (population per hectare) of trees in the area. The tree size is then determined by measuring circumference ''Cs'' of each tree at a height of 1.37m from the ground using the Rome Job Industries formula (Elesa, 2003). The diameter ''D'' of each tree is then calculated from the formula, $D = Cs/\pi$. After getting the diameter, the basal area ''A'' is calculated from the formula $A = \pi(D^2)/4$. Before undertaking the above exercises, a section of the field should be mapped out in blocks and the blocks divided into plots. The tree count and the tree circumferences are done within the plots in each block. It is also required that the trees in the plots should be grouped in diameter ranges (Adama, 2013)

(f) Machinery sourcing and mobilization to the site:
After the above operations, the next operation is to source for suitable machinery. Crawler tractor which should not be more than model D7 or its equivalent should be sourced to reduce soil compaction problem. Crawler tractors can be sourced from road construction firms and adopted for the operation in absence of specialized agricultural bush clearing companies to provide such specialized agricultural bush clearing machinery like brush rake, tree pusher, anchor chains etc.

The next step is machinery mobilization to site for the clearing.

(g) Bush clearing, monitoring and inspection.
In the field, as bush clearing is going on, the operation is closely monitored by experts to ensure that proposed guidelines are adhered to (Figure 1).

Figure 1: Crawler tractor bulldozer in agricultural bush clearing operation under supervision (Adama, 2013)

3.2 Guidelines and Specifications for Mechanized Agricultural Bush Clearing

The following guidelines are to be observed in bush clearing for crop production (NALDA, 1994a and b; Brunswick, 2008; Miscellaneous, 2009). They are applicable for all mechanized agricultural bush clearing project irrespective of the clearing machinery.

(a) The vegetation should be cleared in such a way that minimum disturbance is caused to the top soil to a depth of not more than 80 mm. In fact, the clearing should limit the movement of top soil from the area being cleared. This is to ensure that the top soil which contains the nutrients is retained as much as possible.

(b) All standing dry trees must be knocked down and all shrubs, stumps, large stones and other obstacles to the normal subsequent field operations like ploughing, harrowing and ridging must be completely removed. It is dangerous to leave dry trees in the farms as they could fall anytime damaging crops and/or causing injury if they fall on workers.

(c) Economic trees must as much as possible be left in place, but they should be at least 20 m apart. Where there are clusters of such trees, the older ones that are spent should be cleared leaving only the ones that shall be identified by the field engineer or supervisor. The older ones are removed so that they will give way to young ones.

(d) When a bulldozer (where clearing rake, chains or tree pusher is not available) is used for windrowing, a maximum depth of 80 mm and a maximum lateral movement of 1 m of the soil are allowed. The depth limit should be strictly observed to avoid digging out the subsoil which has little nutrient. The 1 m lateral movement should also be observed in order to reduce compaction during piling and /or windrowing.

(e) Windrows should be 120 m apart and the width of each should not be more than 4 m. When windrows are spaced as recommended, it will give way for proper parcellation and tractor maneuverability.

(f) Land should not be cleared on slopes above 10%. This is because clearing on lands with such slope will accelerate erosion which could jeopardize the venture.

(g) A band of between 5 m – 10 m of vegetation must be left along both sides of rivers and streams. This is necessary to preserve the stream and the habitats and prevent erosion from encroaching into the farm.

(h) Under no circumstances should felled trees or shrubs be piled across or along water way. This is to allow free flow of water thereby reducing ponding and water flow into the field.

(i) When uprooting trees using crawler tractor equipped with dozer blade, take care to control the fall of the tree to avoid breaking trees marked as economic or wind breakers.

(j) Ensure minimum top soil removal along the debris on the windrow. Wind breakers help to reduce wing erosion.

(k) Protective tractor mounted cabs, complete jungle bush clearing protection package or forest canopy should be used when extensive clearing operations are anticipated. This will protect both the perator and the machinery and thus permit greater flexibility and increase operator efficiency.

3.3 Processes and Operational Techniques for Tree Felling (Knockdown) Using Crawler Tractor Bulldozer

In Nigeria and in a number of countries in the tropics, crawler tractor bulldozer is the commonest equipment for mechanized agricultural bush clearing. In absence of specialized agricultural bush clearing machinery like anchor chains, tree pusher, brush rake, good clearing can be achieved using crawler tractors. Farmers in these adopt this category of machinery. The machinery are sourced from road construction firms in absence of specialized agricultural equipment hiring firms. Research has shown that under proper supervision, crawler tractor bulldozer can serve as agricultural bush clearing (Adama, 2013). The greatest challenge when crawler tractor bulldozer is used is experienced when the equipment is uprooting a tree and during windrowing (Adama, 2014). With specialized machinery like anchor chains, tree pusher, brush rake as listed earlier, good clearing is achieved with minimum disturbance to the soil system. But where tractor bulldozer is used, the following processes and techniques are recommended to be followed (Miscellaneous, 2009; Adama, 2013). This will ensure good clearing and thus achieve the objective of minimum disturbance to the top soil.

In thick vegetation with trees that have diameters between 0.15 m and 0.3 m the machinery should be operated with the blade raised as high as possible to gain added leverage (Figure 2) As the tree falls, the implement is backed up quickly to clear the roots. As the implement is lowered, the machine travels forward again to dig the roots (Figure 3).

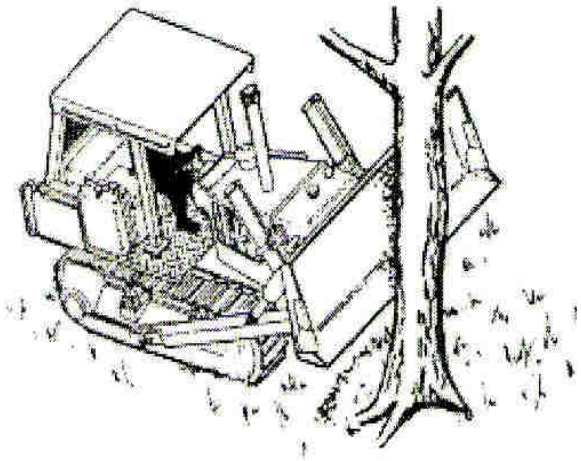

Fig 2: Crawler tractor with the bulldozer in a raised position to fell a tree
Source: (Miscellaneous, 2009).

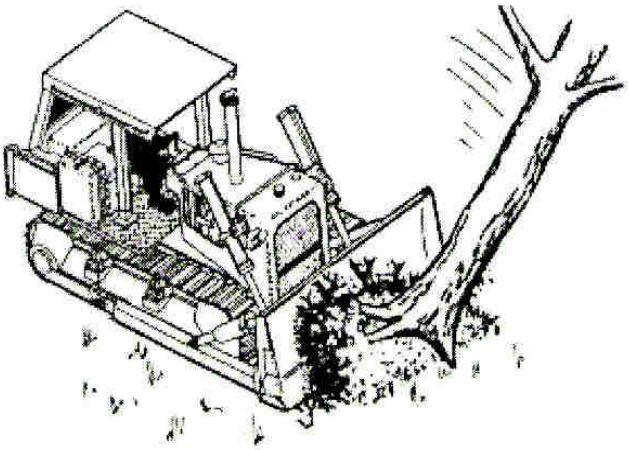

Fig 3: Crawler tractor traveling forward with the bulldozer to dig out tree roots
Source: (Miscellaneous, 2009).

The process and techniques for removing large trees 1.00 m diameter and above is slower and more difficult (Miscellaneous, 2009). First, gently and cautiously probe the tree for dead limbs that could fall and injure the operator or other workers or damage the machine and/or the components. Then, position the implement for maximum leverage. Determine the direction of fall before pushing. The direction of lean is usually the direction of fall. When this is determined, the following steps are followed:

Step 1: Opposite the direction of fall, make a cut deep enough to cut some of the large roots as shown in Figure 4(a)

Step 2: Cut side two as shown in Figure 4(b)

Step 3: Cut side three as shown in Figure 4(c)

Step 4: To obtain greater pushing leverage, build an earth ramp on the same side as the original cut. The tree is pushed over as shown in Figure 4(d)

As the tree starts to fall, reverse the tractor quickly to get away from rising roots mass. After fall, fill the hole created so that water will not collect in it. As the tree starts to fall, the operator should watch to ensure that the tree does not fall on him and the machine. As these processes are going on, experienced professionals namely, agricultural engineer, soil scientist and technical assistants should be on the watch to ensure that clearing including the tree felling operations are done in accordance with lay-down procedure.

The operational techniques have been demonstrated in a field trial at Ako Nike and Agu Ukehe Enugu state Nigeria (Adama, 2013).

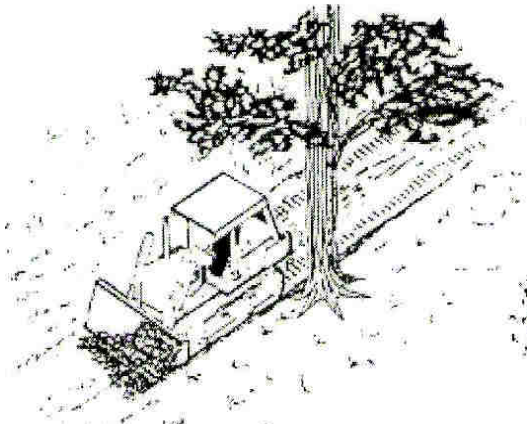

Fig 4a: The Technique of Felling a Tree (Step 1)

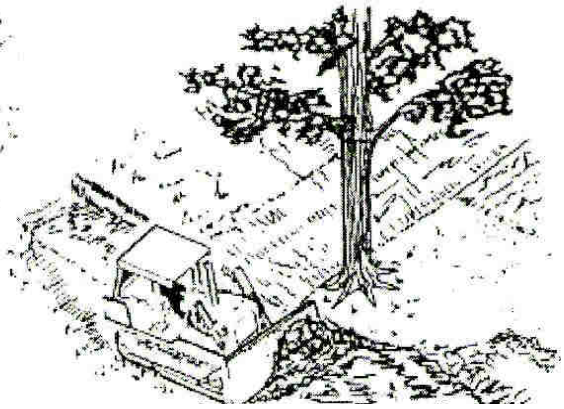

Fig 4b: The Technique of Felling a Tree (Step 2)

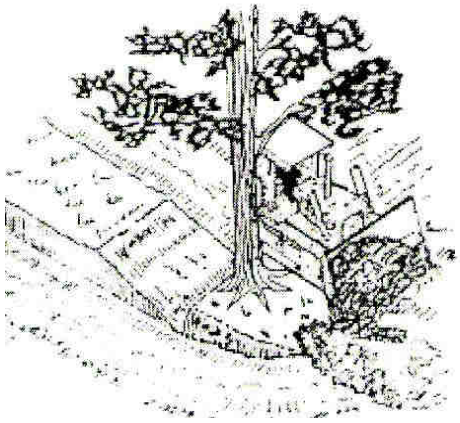

Fig 4c: The Technique of Felling a Tree (Step 3): The Bulldozer Cutting Roots at Side Three

Source: (Miscellaneous, 2009)

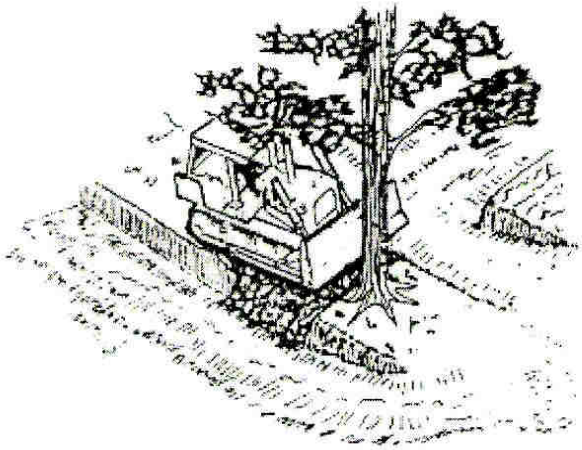

Fig 4d: The Technique of Felling a Tree (Step IV)

3.5 Factors to Consider in Planning and Undertaking Integrated Agricultural Land Development Project

Agricultural bush clearing can be carried out as a single operation but the planning is integrated with other operations involved in large scale crop production. These other operations include surveys, mapping, bush clearing, tillage, erosion control, irrigation design and management. All these operation including bush clearing are referred to as integrated agricultural land development project.

The factors to consider before planning and embarking on mechanized agricultural land development project can be grouped into four areas, namely: environmental, social or institutional, cost- price and end users (Anazodo, 1986; Onwualu et al; 2006). These operations which are necessary in large scale crop production include:

3.4.1 Environmental Factors

The environmental factors can be divided as follows:
(i) Land: soils, topography, size and shape of land.

(ii) Temperature: annual extremes and length of growing seasons.

(iii) Water: control, rainfall amount and distribution, availability of irrigation water, disruption of natural watersheds.

(iv) Location: access roads, farm stead, market, electricity load centre and service areas.

(v) Vegetative: cover, type and density and possibility of re-growth after initial clearing.

The type of trees, vegetation, soil, and terrain of the site must be determined as accurately as possible. This could be done through climatic geological maps, intelligent reports, aerial and ground reconnaissance. The density of the trees as earlier described is determined by conducting a tree count and recording the tree diameters at breast height which is taken at 1.37 m (4.5 ft) above the ground. Record also the species and number of trees.

3.4.2 Social or Institutional

The social or institutional factors to consider are:

(i) The place accorded land in the overall scope of national development.

(ii) Willingness and /or ability of the government to support agriculture through fiscal tax policy: adequate transportation facilities: favorable policies on land tenure, land reform and settlement project development.

(iii) Willingness and /or ability of the government to support research interpret research findings and disseminate information on various aspects of land development.

(iv) Availability and willingness of the government to provide training at all levels to foster extension programme and to use mass media such as radio, television and print in helping to attain the objectives of agricultural land development.

3.4.3 Cost - price Factors

The cost-price factors referred to as economic considerations to be borne in mind in integrated agricultural land development operations are as follow;

(i) Return on investment. That is the price received by the farmer on the crops he produces.
(ii) Cost of input required. These include; land development, tools, hired labour, agro chemicals, seeds and seedlings and taxes on land, availability and cost of credit which may either be long term credit to finance land, construction of major buildings, machinery or intermediate credit to finance establishment of tree crops, major land development operations such as surveys, bush clearing and tillage and erosion control.
(iii) Availability and cost of transport, storage, processing and market facilities.
(iv) Benefits available from the state such as subsidies, price support and assured markets.

3.4.4 The End User

Another important factor to consider is the ability of the end user (owner or manager of the project) to make proper use of the developed land. Closely related to the end user's ability is the level of his specialized training in the area, of his venture, (crop production, reforestation program, highway construction, etc). Moreover, success of a project whether large or small, depends on favorable cost/ price relationships, favorable environment, and owner or managers skills. Since a range of factors must be

considered, those involved in any land development projects must have sufficient amount of information which must be gathered before undertaking a project.

4. CONCLUSIONS AND RECOMMENDATIONS

An approach to mechanized agricultural bush clearing in the tropics has been developed. The approach includes guidelines, processes, operational techniques, specifications and factors to consider in mechanized agricultural bush clearing.

The approach if followed will ensure the preservation of the soil for sustainable crop production; protect both the operator and the machinery and thus permit greater flexibility and increase in operator efficiency.

The operational techniques as demonstrated in the study are limited to crawler tractor bulldozer. Other bush clearing machinery such as chains, tree pusher, the rake, etc are designed to cause minimum disturbance to the soil if the machine is handled by experienced machinery operator and under the supervision of professionals.

It is recommended that:
Mechanized agricultural bush clearing as an integral part of agricultural land development must be properly planned and executed jointly with such other operations as surveys, erosion control, tillage and irrigation.

Mechanized agricultural bush clearing machinery should be carefully selected. The selection should be based on a number of factors which include type of soil, availability of the equipments, cost of available machinery, size of land available, type and density of the vegetation, tree rooting system, terrain and income level of the farmer.

Although field experimental results (Adama, 2013) showed that crawler tractor bulldozers model D6, D7 and D8 when used for agricultural bush clearing did not significantly affect the yield and growth performance of maize when compared with manual clearing, models D6 and D7 are the most suitable for agricultural bush clearing and therefore, selection should be within D6 and D7 ranges.

Also agricultural bush clearing operation should be supervised by experts who must include soil scientists and agricultural engineers as this will ensure that the operators adhere strictly to the guidelines and specifications.

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