EFFECT OF TILLAGE METHODS ON SOIL COMPACTION AND PERFORMANCE OF BEANS

BY

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CERTIFICATION

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DEDICATION

This work is dedicated to Almighty Allah who made it possible for me to see the end of this work successfully, to my parents Mallam Yahaya Masin, Abubakar and Malama Aishat and to my uncle Mallam Mohammad Ndanusa.

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ABSTRACT

The effects of different tillage methods on compaction and beans farmland were investigated. The experimental design comprised of two tillage methods: Conventional tillage (disk ploughing, harrowing and ridging) and plough and ridge tillage. Preliminary tests were conducted for bulk density, moisture content and soil strength before tillage operation and also after tillage operations. Result show that bulk density increased with depth and was significantly influenced by tillage methods but there existed no significant difference between the two tillage methods applied. Soil resistance to penetrometer decreased drastically after tillage operation when compared with the value obtained before tillage operation. Moisture content increased after tillage operation. Root length of conventional tillage was greater than that of plough and ridge tillage but show no significant variation when tested at 5% level. The same results were obtained for depth of seed placement and seedling emergence. In conclusion tillage methods significantly changed the structure and affected the physical properties of the soil looked into in this work positively.

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1.0 CHAPTER ONE

1.1 INTRODUCTION

The beginning of agriculture marks the beginning of soil tillage, crude sticks and shaped ruminal bones were probably the first tillage, tools used to establish crop by planting the vegetative parts of plants, including stem section, roots and tubers. Paintings on the walls of ancient Egyptian tombs dating back 5,000 years, depict one yoke together pulling a plough made from a forked tree. By Roman times, tillage tools and techniques had advanced to the point that thorough tillage was a recommended (practice for crop production). Childe (1951) considered the discovery and development of the plough to be one of the nineteenth most important discoveries or application of science in the development of civilization. Now the strange thing is that the use of the plough for primary tillage is being challenged.

Tillage is the mechanical manipulation of soil for any reason. In agriculture and forestry, tillage is usually restricted to the modification of soil condition for plant growth. There are commonly accepted purposes of tillage.

(1) To manage crop residue

(2) To kill weeds and

(3) To alter soils structure especially preparation of soil for planting seed or seeding.

Weeds compete with crop plants for nutrients, water, light etc. Weeds however can be controlled with herbicides, if weeds are eliminated without tillage, can cultivation of row crops be eliminated? Data from many experiments support the conclusion that the major benefit of cultivating corn is weed control.

All tillage operations change the structure of the soil. The lifting, twisting and turning action of a mould board plough leaves soil in a more aggregated condition. Cultivation of a field to kill weeds may also have the immediate effect of loosening the soil in a more aggregated condition. Cultivation of a field to kill weeds may also have the immediate effect of loosening the soil and increasing water infiltration and aeration. The resistance of peds to disintegration or breakdown remains unchanged. Consequently, tillage with cultivator, disks, and packer crushes some of the soil pads and tends to reduce soil porosity. Exposed cultivated land suffers from disruption of peds by raindrop impact in absence of a vegetative cover. In addition, tillage hastens organic matter decomposition. Therefore, the long-term effect of ploughing and cultivation is a more compacted soil as a result of crushing of peds and subsequent settling of soil.

When forest or grassland soils are converted to use for crop production. There is a decline in soil aggregation and soils become more compacted because of long-term effect of tillage. Compaction results in a decrease in the total pore space and increase in the bulk density, pushing particles together as a result of tillage results in a decrease in the average pore size. Some of the macropores are reduced to micropores and thus there is an increase in the volume of micropore space and decrease in the amount of macropores space. The overall decrease in total porosity result from a greater decrease in macropores space than the increases in micropore space.

AIMS AND OBJECTIVES

The objectives of this investigation were to study

(a) The extent to which two tillage methods could relieve differently compacted soil.

(b) The effects of the treatment combinations on the growth and yield of beans.

SCOPE

In other to effectively achieve the set objectives the following experiment was carried out, these include determination of;

(a) Depth of seed placement

(b) Seedling emergence

(c) Soil dry bulk density

(d) Moisture content

(e) Soil resistance to penetrometer

(f) Root length of the crop.

(g) Bean kernel yield.

2.0 CHAPTER TWO

2.1 LITERETURE REVIEW

2.2 Review on tillage methods

Primary Tillage

This is the first and deepest tillage operation and forms the basis of seedbed. The effects on badly or land executed primary tillage operations are extremely difficult to correct with secondary tillage implements and the end result is a less than optimum yield.

Secondary Tillage

This operation is designed to refine and consolidate the seeded to a condition suitable for successful germination and unimpeded growth. The general rule is a "fine seedbed for fine seed" and a seedbed particularly in the tropics, should always be left as coarse textured as the following crop can tolerate. It is also worth remembering that a fine seedbed provides ideal condition for weed seed germination. With wide space crops such as maize and cotton the ideal thing is to cultivate only the strip that is going to be planted and leave the inter row in rough ploughed state to withstand runoff, erosion and the germination of weeds. Far too often a seedbed is over refined purely because it looks better, this is a waste of money and has no agronomic value.

Conservation Tillage

Conservation tillage is any tillage system that reduces the loss of soil or water relative to conventional tillage; it often is a form of non-inversion tillage that retains protective amount of residue much on the soil surface. Conventional tillage on the other hand, is the combined primary and secondary tillage operations performed in preparing a seedbed for a given crop grown in a given area (soil conservation society of America, 1982).

Mannering and Fenster (1983) have discussed a number of conservation tillage system for row crop and small grain agriculture. Their categories for row crop conservation tillage systems are narrow strip tillage, ridge planting, full width no plough tillage and full width plough tillage. Their subdivision for small grain agriculture are stubble much tillage, ecofallow and direct drill.

Narrow strip tillage is divided into no tillage and strip rotary tillage (i) No tillage is a method of planting that requires on seedbed preparation other than opening a soil slit for seed placement at the desired depth. Coulters, narrow chisels or angled disks are used to open the slit. (ii) Strip rotary tillage limits seedbeds preparation to a rototilled strip 50 to 200mm wide and 20 to 100mm deep in the row area. A conventional planter is then used in the strip.

Ridge planting is a conservation tillage system where one row of crop is planted on each ridge. In conventional planting on a ridge; ridges are shaped at the last cultivation or after harvest of the previous crop. Little or on spring seedbed preparation is used. Till planting involved scalping the old crop row, leaving crop residue in the unscalped in one operation.

Full width no plough tillage is accomplished using chisels or disk tillage rather than a mould board plough. Full width plough tillage uses strip seedbed preparation on land that has been mould board ploughed. Usually a few hours before planting. The two principal forms are wheel track and plough plant.

Stubble mulch tillage is a system of small grain farming where a cover of vegetative residue is maintained on the soil surface at all times. The two types of tillage machines used in stubble much tillage are those that stir and mix the soil and those that cut the soil beneath the surface without inverting the tilled layer. Stirring and mixing machines are one-way; offsets are tandem disks, field cultivators, chisel ploughs and mulch traders. Subsurface tillers include sweeps rotary rod weeder and rod weeder with short chisels.

Ecofallow, sometimes called chemical fallow, is a form of stubble mulch tillage where persistent herbicides is used to control weeds. Subsurface tillage sometimes is used if the herbicides are not effective in controlling all weeds. The land is left fallow until the next crop which may be 4 to 16 months depending on the rainfall, the following crop is planted into the residue.

Direct drilling – is a system of seeding cereals directly into the residue of the previous crop, which remains on the soil surface. Weed control is a accomplished with herbicides.

2.2 REVIEW ON COMPACTION

Soil compaction is a process of densification in which porosity and permeability are reduced, strength is increased and many changes are included in the soil fabric and in various behaviour characteristics.

Compaction by Animals and Machines

An increase in the bulk density of soil resulting from load applied for short periods is referred to as soil compaction. This contrast with compression under a static loads which, when accompanied by the slow expulsion of water from a saturated soil is referred to as consolidation. Under intensive agriculture and grazing surface horizons are subjected to the compacting effect of machinery and animals which can exert pressures of 100 kPa, surface horizons usually have a relatively small bulk density because of the disturbances such as those due to animals and plant roots and those caused by tillage. Hence pressure of about 100 kPa can be expected to cause compaction and this may adversely affect water and air movement, seedling emergence and root penetration. An example of compaction by machinery is given in the Fig 1 below.

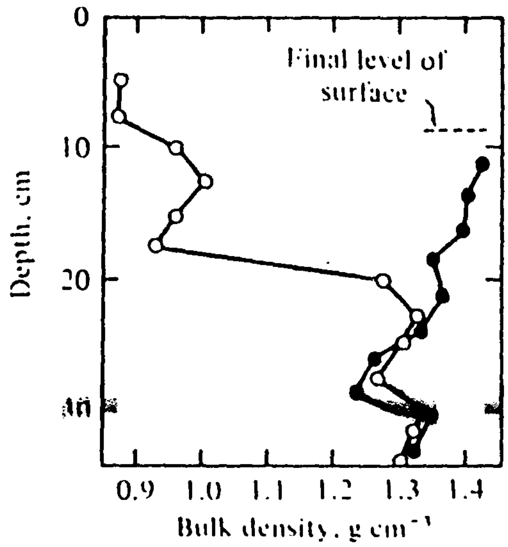

Fig2.1 Bulk density profile before (O) and after (•) the passage of tractor wheel (soane, 1970).

Soil / Plant Interaction

The physical, chemical and biological aspects of the root environment have a profound influence on crop growth and yield characteristics. Compaction imposes considerable changes both within and below the root zone and it is clearly important to be able to understand the complex mechanisms of resulting crop responses.

Early studies of crop response to compaction tend to involve entirely empirical attempts to correlate a single soil property (e.g. penetration resistance) with a single aspect of plant response (usually yield). While in some cases, close correlations could be demonstrated. It soon became apparent that they were often of limited applicability, perhaps only to one season at one location. In certain cases, the variation in the type (positive or negative) and the closeness of fit of observed correlations was found to be so variable as to discredit the relevance of the soil property. Although not yet fully evaluated, there is now conclusive evidence for the concept of an optimum level of soil compactness for crop production. The optimum level will be influenced by soil type, crop type, weather conditions and other factors. This optimum represents the dynamic balance between interacting soil / plant mechanism which tend to restrict plant growth or function as either high or low levels of compactness (Table 2.1).

The root distribution of crop plants can be changed markedly as a result of compaction in both the top soil and the sub soil (Tardieu, 1988; Van Ouwerkerk and Van Noordwijk, 1991; fig 2). Three-dimensional mapping of the root distribution and statistical analysis of the result (Tardieu, 1988) have shown that obstacles to root penetration, such as compacted zones caused by wheel tracks can cause a reduction in root density, not only in the compacted zone itself, but also in underlying or adjacent soil which has not been compacted. ("Shadow" effect). A study of root distribution is therefore a vital component in studies on crop responses to compaction. Different crops and even different varieties show fundamentally different sensitivity to soil compactness.

TABLE2.1 Soil / plant interactions tending to induce adverse crop responses at low and high levels of compactness (Soane, 1985).

Low Compactness	High Compactness
(a) Restricted germination and emergence due to poor seed/soil contact.	- Anaerobiosis of the soil leading to ethylene accumulation, poor O_2 supply and N_2 loss by denetrification.
(b) Unfavourable hydraulic properties reduced water transport and capillary rises	- Restricted root penetration and clustered root distribution leading to reduced uptake of water and nutrients
(c) Restricted uptake of water and nutrient per unit root length due to poor root/soil contact.	- High root/soil contact leading to restricted O_2 uptake
(d) Trace Element deficiencies e.g. manganese in baley.	- Diminished nitrogen fixation nitrification and activity soil fauna.

Cowpea for example, have been shown to be capable of rooting well at a level of compactness, which inhibits more sensitive crops such as maize or soybeans. This variation in sensitivity to soil compactness has already given added importance to the use of crop rotation in the tropic.

Negative effects of soil compaction on crop production due to poor penetration can often be compensated to a large extent by increased supply of water and nutrient (Schulman, 1971, Van Noordwijk and De willigen, 1991). Reduced root development for example due to soil compaction, may affect the efficiency of the use of water and nutrient, may force the farmer to use more fertilizer and irrigation water and may thus enhance negative environment impacts of agriculture (Van Noordwijk and De Willegen, 1991). Nutrient or water uptake efficiency depend on (1) The required uptake rate per unit root (which.is related to shoot/root ratio and actual growth rate of the plant) (2) The degree of synlocation of roots and nutrient (depending on nutrient mobility and soil water content) (3) The degree of synchronization of nutrient demand and supply (De Willigen and Van Noordwijk, 1987). (4) Spatial variability in field, which are managed as if they were homogeneous units (Van Noordwijk and Wadman, 1992).

It is now recognized that successful crop production is dependent on the presence and vigorous functioning of a wide range of soil borne micro and macro- flora and fauna. The habitat of these organisms will be strongly influenced by level of compactness and in particular by the pore size distribution.

Tillage And Traffic Interaction

In practical crop production, there is a very close interactive relationship between tillage and traffic system which, however, has often been overlooked in field experimentation, attempt to reduce the depth or intensity of tillage have in some areas been found to result in crop failure due to unrelieved compaction from vehicle Westmas Research group, (1984). However, there are many soil processes such as the stabilization of plant root channels, growth of soil fauna populations and accumulation of organic matter, which are encouraged under no till cropping and under certain condition. These effects reduced or even reverse the compaction effects induced by machinery.

The adoption of zero traffic regime within a conventional tillage system of mould board ploughing may result in soil conditions, which are below the optimum level of compactness for crop growth (Lamers et al, 1986, chamen et al.; 1992) and in this case the full potential will not be achieved without a suitable modification to the tillage systems.

The Penetrometer

Penetrometer includes any device that can be forced into the soil and from which resistance to penetration can be measured. A wide variety of such instruments has been developed to measure either static penetration resistance (when the rate of penetration is constant) or dynamic penetration (when the instrument is driven by a series of blows).
The penetration resistance so measured has been used as index of a wide range of soil physical and mechanical properties in empirical soil studies in civil and agricultural engineering, (Keith and Chris, 1979). For agricultural experimentation a cone type penetrometer with base area of $1 cm^2$ and angle at the top $2\alpha = 22^0 30^1$ for hard soils and the 2^{nd} one with base area of $2 cm^2$ and $2\alpha = 30^0$ are common.

Penetration resistance will not very only with the size and shape of the probe that penetrates into the soil but also with a range of soil properties including soil metal friction, particle size distribution, water content, resistance to compression and shear strength (Ohu, 1987).

Dexter and Tanner (1973) found the average resistance to pushing spheres through soil increased with decreasing diameter in the (40-10) mm range. However, Barley et al. (1965), found no difference in resistance between 30^0 Semiangle conical probes of 1, 2, and 3 mm diameters penetrating remolded sandy loam similarly, Bradford (1980), found no significant difference between the average resistance experienced by probes of 3.8 and 5.1mm diameter.

In contrast, in a study of the effect of diameter on penetrometer resistance in remolded soil cores with textures ranging from heavy clay to sand, resistance to a 1mm probe was typically 45 - 55% greater than to a 2mm probe. Whitelay and Dexter (1981), Gooderham (1973), cited in reference Whitelay et al, (1981) also found that resistance to a 1mm diameter probe was 35 - 74% greater than to a 2mm probe. As a further

Bulk density

Bulk density measurements are made in the course of many routine soil surveys as a guide to soil compaction and porosity. The results are used as indicators of problems of root penetration and soil aeration in different soil horizon. Bulk density values very considerably with moisture content, particularly those of fine-textured soil; sample should therefore be taken at or near to field capacity. Bulk density refers to the overall density of a soil (i.e. the mass of mineral soil divided by the overall volume occupied by soil, water and air), and it should be distinguished from the density of the solid soil constituents, usually called the particle density, which are conventionally taken as $2.65gcm^{-3}$. The weight of soil solids in bulk density measurements is taken as the ovum-dry constant weight at 105^0C (BSI, 1975).

Interpretation of bulk density result

The bulk densities of clay, clay loam and silt loam topsoils may range between 1.00 and $1.60gcm^{-3}$ depending on their condition. Sands and sandy loams usually show variations between about 1.20 and 1.80 gcm^{-3}. There is very often a tendency for Bulk density values to rise with depth, as effects of cultivation and organic matter content decrease. Very compact subsoils, of whatever texture, may have bulk densities exceeding $2gcm^{-3}$.

Bulk densities above $1.75gcm^{-3}$ for sands, or 1.46 to $1.63gcm^{-3}$ for silts and clays, are quoted by De Geus (1978) as causing hindrance to root penetration these value correspond broadly with those shown below.

Table2.1 Typical bulk density ranges

Material	Bulk density (gcm^{-3})
Recently cultivated soils	0.9 - 1.2
Surface mineral soils, not recently	
Cultivated, but not compacted	1.1 – 1.4
Soils showing root restriction	
Sands and loams	< 1.6 – 1.8
Silts	< 1.4 – 1.6
Clays	extremely variable.

Note deleterious or harmful effects of reduced air filled pore space when bulk density $\geq$ about 1.3 gcm^{-3} for clay soils.

Even in horizon of similar texture lying at similar depths, there are usually great differences in bulk density values depending on organic matter levels, root penetration and soil structure. Increases in soil density impose the following stresses on a plant root system.

(a) The mechanical resistance to root penetration increases, so reducing the plant's ability to exploit its environment.

(b) The air-filled porosity of the soil decreases, thus restricting the air supply to plant roots and facilitating the build-up of toxic product such as carbon dioxide and ethylene. As well as decreasing total porosity, compaction of soil decreases the volume of coarse pores relative to the volume of fine ones, and have also increases the proportion of total porosity occupied by water at any given suction (Russell, 1973).

(c) In general, permeability decreases with increasing density, making field crops more susceptible to the adverse effects of water logging. Note that under certain circumstances, such as where crops are direct drilled, permeability may be largely governed by the size and abundance of fissures (a long deep crack in rock or in the earth) and macropores (cannel and Finney, 1973).

Using cotton seedlings, Taylor and Gardner (1963) found that under laboratory conditions in which they considered aeration to be non-limiting, root penetration was related linearly to soil strength as estimated with a penetrometer. The range of soil strength studies was achieved by a number of combinations of bulk density and soil water tension values, but only poor correlation was reported between root growth and these two parameters individually. Mirreh and Ketcheson (1972) showed that soil strength increases with both density and tension.

Measurement of root growth

In many cases root growth measurements may be used to asses whether a particular physical factor or group of factors has influenced the root system. The major soil physical factors that influenced roots are temperature, aeration, water potential and mechanical impedance. Bohm gives a more complete description of methods that can be used in all circumstances.

Purpose

(1) To asses the significance of a given change in soil physical conditions on plant functions.

(2) To help to interpret the reasons for a given plant response to a particular soil treatment through an understanding of effects on water and nutrient supply.

(3) To improve the use of input (e.g. irrigation water and fertilizers or to study and optimize the effects of tillage and other management practices.

(4) To allow the development of better plant root system by conventional breeding or genetic engineering.

TABLE23 The functional significance of some commonly measured root system parameters

Root parameter		Significance
Mass		Total root system size, standing crop
Length		Total root system size. Ability to absorb water and mineral nutrients.
Number		Hormone production.
Density		Water inflow rate.
Distribution	Vertical	Soil volume exploits stability.
	Horizontal	Interaction with other species, stability
Specific root length		Carbon allocation within the system.
Diameter		Water stress regulation, soil penetration, response to soil impedance.
Longevity		Soil carbon supply, length change.
Periodicity		Available length at particular time in season.
Growth rate		Ability to exploit within the soil volume.
Ratio of root to shoot		Relative carbon partitioning
Branching		Nutrient uptake potential within a given Volume
Root hair density		Effective root surface area
Mycorrhizal infection		Carbon allocation, effective surface area for Nutrient uptake.

Method of measuring root length

Field method

(1) Root system removal – Either complete excavation or part of the root system (soil monolith soil cores and needle boards) is removed from the soil or measured or assessed insitu (profile wall).(Langdon, parker and Renan 1987).

Root length as suggested by Newman

Is given as

$$L = \frac{\pi NA}{2H} \quad (cm)$$

l= Root length (cm)

Where N = intersection of roots number

H = randomly placed straight line (length) (cm)

A = Area of field of view. (cm^2)

3.0 CHAPTER THREE

3.1 MATERIALS AND METHODS

(a) Materials for hardness test

(i) The penetrometer

(ii) Recording book.

(b) Materials for moisture content and bulk density.

(i) Auger

(ii) Weighing balance

(iii) Cutlass

(iv) Ovum drier

(v) Stop watch

(vi) Polythene bags

(vii) Shovel.

(c) Materials for root length

(i) Square glass with 2 x 2 cm squares on it.

(ii) Cutlass.

Determination of bulk density

Auger hole method for bulk density measurement described by Zwarich and Shaykewich. (1969). Using a 9.5cm diameter auger a hole of 15cm deep was bored. The extracted soil was weighed and ovum dried as well as ovum-dried weight of the extracted soil determined. The volume of the hole is calculated from the measurements of the depth and cross sectional area as described below.

Let W_c = weight of container (g)

V_a = volume of the hole (cm)

W_w = weight of wet soil

W_d = weight of dried soil

W_{wc} = weight of wet soil + weight of container

W_{dc} = weight of dry soil and container

Then weight of wet soil = $W_{wc} - W_c$.

Weight of dry soil = $W_{dc} - W_c$.

$$\text{Wet bulk density} = \frac{W_w}{V_a}$$

$$= \frac{\text{Weight of wet soil}}{\text{Volume of the hole.}}$$

$$\text{Dry bulk density} = \frac{\text{Weight of dry soil}}{\text{Volume of the hole}}$$

$$= \frac{W_d}{V_a} \qquad \text{eqn 3.1}$$

Determination of moisture content

Thermogravimetric method was used where soil sample was placed in heat- proof polythene bag of known weight, weighed, dried in an ovum set at temperature of 105^0C for 24 hours and reweighed at interval of 6 hours until the sample attains a constant weight. The water content W of the sample is the mass of water per unit mass of dry soil, thus.

$$W = \frac{(\text{mass of wet soil} - \text{mass of dry soil}) \times 100}{\text{Mass of dry soil.}} \qquad \text{eqn 3.2}$$

The procedure remained the same as that of bulk density.

Determination of soil hardness.

A penetrometer (S05 : 718.00117) was used to measure the soil strength. A penetrometer needle of 0.87 cm^2 area was selected and screwed to the bottom of the spring dynanometer casing. Three circular bases of areas 2.01 cm^2, 3.46 cm^2 and 4.71 cm^2 were used one after the other on the chosen spot. The penetrometer was erected and constant load of 30kg (300N) was applied and then the depth of penetration was read off from the calibrated shank and recorded. The pressure exerted on the chosen spot was calculated using the relationship.

$$P = \frac{hqs}{Sa} \quad \text{———— eqn } 3.3$$

Where p = Standard soil hardness. Nh cm

h= Average ordinate of gauge (cm)

qs=spring resistance calibration volume

Sa= Area of base (circular) cm

Determination of root length.

Bohm's procedure as reported by Yisa (2001) was used which involves complete excavation of root system and placing on a squares of 2 x 2 cm, lines were drawn in such a way that the point of intersection of x and y Ares serve as the datum. Number of root intersection was determined for each root and at the end the total root length was determined or calculated from the relationship

$$L = \frac{11}{14} iK \quad \text{— eqn } 3.4$$

Where i = Number of intersections

k = constant value

= 1.57 for 2 x 2cm squares. (Bohm 1979).

Field operation.

The investigation was conducted on a sandy loam soil in the Agricultural Engineering Departmental Demonstration Farm 15 km on Minna-Bida road.

The land of size 12 x 30m was first cleared (i.e. land clearing). Two tillage methods comprising of three tillage combinations were carried out on the farm. These are

(a) Conventional tillage (CT), which comprises of ploughing (disk plough), disk harrowing and ridging.

(b) Plough and ridge tillage, which was carried out using disk plough and a ridger.

The land was initially ploughed to the depth of between 25 - 40cm and left for five days for the buried grasses to decay, then half of the whole plot was disk harrowed and lastly the in tire land was ridged using a ridger.

Beans seeds were planted manually at a between the row spacing of 50cm and within the row spacing of 45 - 50cm. Seedling emergence count was conducted about this period.

The bulk density, root length density, the soil resistance to penetrometer penetration and moisture content were conducted between 28 and 32 days after planting when the field was at or near field capacity condition of the sandy loam soil, this was when the soil pore spaces were fully saturated.

At the end of the growing season, the bean pods were harvested by hand and shelled. The kernel yield weight was determined for each tillage method.

3.1. Experimental design selection

A completely randomized design comprising of two methods as treatments each replicated three times on a plot of size 6 x 10 m or 6000 x 1000mm each, the two tillage methods were randomly assigned.

This method was chosen because of the fact that number of treatment was small; also, each plot contains one complete treatment.

3.2 Data collection

Depth of seed placement and seedling emergence count were conducted at the time of planting and recorded. The bulk density, moisture content test were conducted twenty ninth day after planting while penetrometer pressure and root length density were measured thirty one (31) days after planting, lastly the beans kernel yield was weighed after the harvesting by the end of growing season.

However before the above procedures were undertaken penetrometer reading, bulk density and moisture content of the experimental block were conducted as preliminary values to serve as my bases of comparison.

3.3 Data analysis (completely randomised design)

There were two treatments each replicated three times and hence there were six plots each 6 x 10m in size as shown on the layout below.

The analysis was carried based on the method of completely randomized design as shown below

Number of treatment = T
Replication number = R
Experimental plot number = RT.

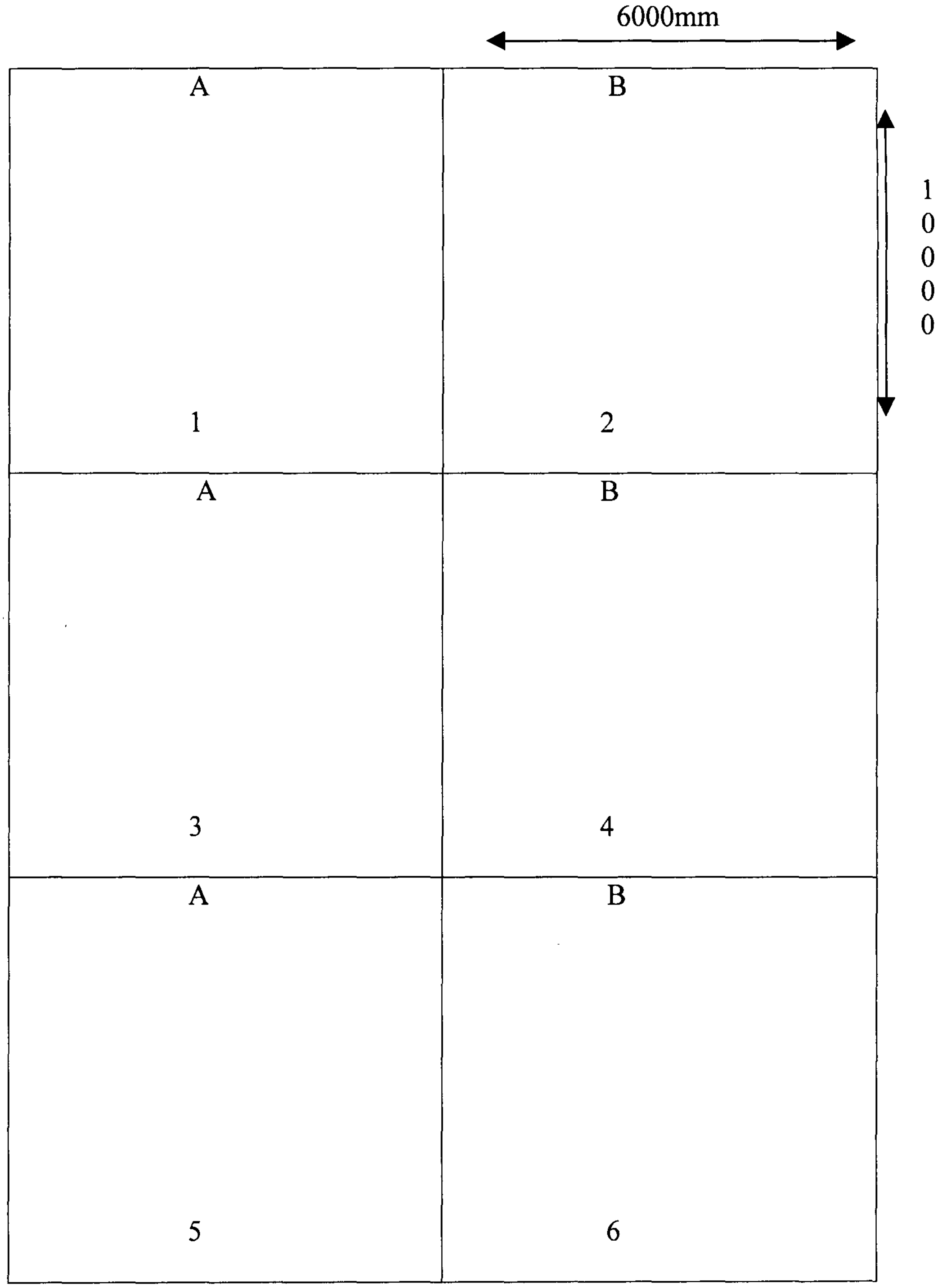

Fig. 3 Experimental plot layout

A = Conventional tillage

B = Plough and Ridge tillage

Total degree of freedom = DF = RT - 1. ______ 3.5

Treatment degree of freedom = TDF = T - 1. ____ 3.51

Error degree of freedom = EDF = T (R-1) ____ 3.52

Correction factor $= CF = \dfrac{GM^2}{N}$ ——— 3.53

Where Gm^2 = Grand mean

$N = RT$

Total sum of squares $= SS = \sum_{i=1}^{n} Xi^2 - CF$ ——— 3.54

Where Xi = measurements of I plots

Treatment sum of squares $= TSS = \dfrac{\sum Ti^2 - CF}{R}$ ——— 3.56

Where Ti = total in treatment

Error sum of squares = SS – TSS = ESS

Mean Squares = MS

Treatment mean squares (TMS) $= \dfrac{TSS}{TDF}$ ——— 3.56

Error mean squares (ERS) $= \dfrac{ESS}{EDF}$ ——— 3.57

Calculation of F value for testing the significance of the treatment difference as

$$F = \frac{\text{treatment mean square}}{\text{Error mean square}} = \frac{TMS}{EMS}$$ ——— 3.58

Coefficient of variation $= Cv = \dfrac{\sqrt{ESS}}{GM} \times 100$ ——— 3.59

4.0 CHAPTER FOUR

4.1 RESULTS AND DISCUSSION

The results gotten from the experiments include bulk density, moisture content and resistance to circular base Penetrometer before and after the tillage operation, other parameters were depth of sowing, seedling emergence, root length of the beans and kernel yield of the crop. The results are presented below.

RESULTS

TABLE 4.1 : **Bulk densities before tillage operation depth**

range 0 – 15 cm. (g/cm^3)

			AVERAGE
1.32 B	1.03 B	0.99 B	1.110
0.85 A	1.08 A	0.99 A	0.97

TABLE 4.1.2 **Bulk density before tillage operation (g/cm^3)**

depth 15 – 30cm

			AVERAGE
1.46 B	1.27 B	1.08 B	1.27
1.13 A	1.18 A	1.32 A	1.21

TABLE 4.2 **Moisture content before tillage operation (%)**

depth 0 – 15 cm.

			AVERAGE
12.5 B	11.5 B	12.5 B	12.17
21.7 A	15.4 A	12.5 A	16.53

TABLE 4.2.1 **Moisture Content Before Tillage Operation (%)**

depth 15 – 30cm

			AVERAGE
8.82 B	10.00 B	14.81 B	11.21
14.29 A	15 A	12.5 A	13.93

TABLE 4.3 **Penetrometer Reading Before Tillage Operation (N/cm^2) Load = 30 kg**

Base area = $4.19cm^2$

			AVERAGE
12.2 B	91.6 B	91.6 B	101.7
91.6 A	91.6 A	12.2 A	101.7

TABLE 4.3.1 **Penetrometer reading before tillage operation (N/cm^2) Load = 30kg,**

Base area = 3.14 cm^2

			AVERAGE
764.3 B	382.2 B	392.2 B	512.9
382.2 A	477.7 A	350.2 A	403.4

TABLE 4.3.2 **Penetrometer reading before tillage operation (N/cm^2)**

Load = 20kg, Base area = 2.01cm^2

			AVERAGE
497.51 B	597.01 B	746.27 B	613.60
398.00 A	696.52 A	746.27 A	613.60

TABLE 4.10 **Bulk density after tillage operation (g/cm^3)**

Depth 0 – 15cm.

			AVERAGE
0.74 B	0.72 B	0.71 B	0.72
0.60 A	0.74 A	0.71 A	0.68

TABLE 4.4.1 **Bulk density after tillage operation (g/cm^3)**

depth = 15 – 30cm.

			AVERAGE
0.87 B	0.87 B	0.89 B	0.88
0.74 A	0.86 A	0.95 A	0.85

TABLE 4.5.0 **Moisture content after tillage operation (%)**

depth = 0 – 15cm

			AVERAGE
12.99 B	13.72 B	11.98 B	12.90
15.18 A	14.59 A	20.63 A	16.80

TABLE 4.5.1 **Moisture content after tillage operation (%)**

depth = 15 – 30cm.

			AVERAGE
8.48 B	6.65 B	5.84 B	6.99
9.94 A	8.25 A	8.88 A	9.02

TABLE 4.60 **Penetrometer pressure after tillage operation (N/cm^2)**

Load = 30kg .Base area = 4.91cm^2

			AVERAGE
1 733 B	3 470 B	5 489 B	564
2 611 A	4 733 A	6 532 A	625.33

TABLE 4.61 **Penetrometer pressure after tillage operation (N/cm^2)**

Load = 30kg, Base area = 3.14cm^2)

			AVERAGE
987 B	637 B	478 B	700.67
828 A	540 A	669 A	679

TABLE 4.62 **Penetrometer pressure (N/cm^2) after tillage operation**

Load =20kg, Base area = 2.01 cm^2

			AVERAGE
896 B	726 B	431 B	684.33
1094.5 A	597 A	895.5 A	862.7

TABLE **4.70 Difference in bulk densities kg/cm^3**

depth = 0 – 15cm.

Treatment	Before tillage operation	After tillage operation	Differences
Conventional tillage (A)	1.11	0.72	0.39
Plough and ridge tillage (B)	0.97	0.68	0.29

TABLE **4.71 Difference in bulk densities kg/cm^3**

depth 15 – 30cm.

Treatment	Before tillage operation	After tillage operation	Differences
Conventional tillage	1.27	0.88	0.39
Plough and ridge tillage	1.21	0.85	0.36

TABLE 4.7.2 : **Average difference in moisture content (%)**

Depth = 0 – 15cm.

Treatment	Before tillage operation	After tillage operation	Differences
Conventional tillage (A)	16.53	16.80	- 0.27
Plough and ridge tillage (B)	12.17	12.90	- 0.73

TABLE 4.7. 3 : **Average difference in moisture content (%)**

depth = 15 – 30cm.

Treatment	Before tillage operation	After tillage operation	Differences
Conventional tillage (A)	13.93	9.02	4.91
Plough and ridge tillage (B)	11.93	6.99	4.94

TABLE **4.7.4 Difference in Penetrometer reading (N/cm²).**

Load = 30kg Base area 4.19 cm².

Treatment	Before tillage operation	After tillage operation	Differences
Conventional tillage (A)	101.7	625.33	- 523.63
Plough and ridge tillage (B)	101.7	564	- 462.3

TABLE **4.7.5 Difference in Penetrometer reading (N/cm²)**

Load = 30kg. Base area = 3.14cm²

Treatment	Before tillage operation	After tillage operation	Difference
Conventional tillage (A)	403.4	679.0	- 275.60
Plough and ridge tillage (B)	512.9	700.67	- 187.77

TABLE 4.7.6: **Difference in Penetrometer reading (N/cm²)**

Load = 20kg Base area = 2.01cm²

Treatment	Before tillage operation	After tillage operation	Difference
Conventional tillage (A)	613.60	862.70	- 249.10
Plough and ridge tillage	613.0	684.33	- 71.33

Analysis was also carried out on each of the parameters measured after the tillage operation to determine the significance of variance between the two tillage methods used. This is shown below

TABLE 4.8.0 **Bulk density after tillage operation (g/cm²)**

Depth = 0-15cm

Treatment	Bulk density			treatment total	treatment mean
Conventional tillage	0.60	0.74	0.71	2.05	0.68
Plough and ridge tillage (B)	0.74	0.72	0.71	2.17	0.72
Grand total (G)				4.22	
Grand mean Gm					1.40

ANOVA TABLE: **for bulk density after tillage operation g/cm^3**

depth = 0- 15cm

Source of variation	Degree freedom	Sum of square	Mean square	F value	Tabular F	
					1%	5%
Treatment	1	0.002	0.002	1.000^{ns}	21.20	7.71
Experimental error	4	0.008	0.002			
Total	5	0.01				

C.v = 6.39%

TABLE 4.8.1 **Bulk density after tillage operation (g/cm^3)**

depth = 0 – 15cm.

Treatment	Bulk density			Treatment total	Treatment mean
Conventional tillage (A)	0.74	0.86	0.95	2.55	0.85
Plough and ridge tillage (B)	0.87	0.87	0.89	2.63	0.88
Grand total				5.18	
Grand mean					1.73

TABLE 4.8.2 **ANOVA TABLE for Bulk density after tillage operation**

depth 15 - 30

Source of variation	Degree freedom	Sum of square	Mean square	F value	Tabular F 1%	5%
Treatment	1	0.001	0.001	0.133^{ns}	21.20	7.71
Experimental error	4	0.038	0.008			
Total	5	0.031				

TABLE 4.8.3 **Moisture content after tillage operation**

Depth = 0 – 15cm.

Treatment	Moisture Content (%)			Treatment total	Treatment mean
Conventional tillage ct (A)	15.18	14.59	20.63	50.4	16.8
Plough and ridge tillage (B)	12.99	13.72	11.98	38.69	12.90
Grand total (G)				89.09	
Grand mean (Gm)					29.70

TABLE 4.8.4 : **ANOVA TABLE For moisture content**

Source of variation	Degree freedom	Sum of square	Mean square	F value	Tabular F 1%	5%
Treatment	1	22.85	22.85	3.86^{NS}	21.21	7.71
Experimental	4	23.71	5.93			
error		0.031				
	5	46.56				
Total						

CV = 8.20%

TABLE 4.8.5 **Moisture content after tillage operation (%)**

depth = 15 – 30cm

Treatment	Moisture Contents			T.eatment Total	Treatment Mean
Conventional tillage ct (A)	9.94	8.25	8.88	27.07	9.02
Plough and ridge tillage (B)	8.48	6.65	5.84	20.97	6.99
Grand Total (G)				48.04	
Grand Mean (GM)					16.01

TABLE 4.8.5 : **ANOVA TABLE For moisture content after tillage operation**

Source of variation	Degree freedom	Sum of square	Mean square	F value	Tabular F 1%	5%
Treatment	1	6.20	6.20	4.85^{NS}	21.20	7.71
Experimental error	4	5.12	1.28			
Total	5	11.32				

TABLE 4.8.6 **ANOVA TABLE for Penetrometer reading after tillage operation (N/cm^2)**

Load = 30kg Base area = 4. 91cm^2

Treatment	penetrometer reading			treatment total	treatment mean
Conventional tillage ct (A)	611.0	733	532	1876	625.33
Plough and ridge tillage (B)	733	470	489	1692	564
Grand total				3568	
Grand mean					1189.33

TABLE 4.8.7: **ANOVA TABLE For penetrometer after tillage operation (N/cm^2)**

Source of variation	Degree freedom	Sum of square	Mean square	F value	Tabular F 1%	5%
Treatment	1	5642.67	5642.67	0.36^{NS}	21.20^{ns}	7.71
Experimental error	4	63530.66	15882.67			
Total	5	69173.33				

CV = 7.07%

TABLE 4.8.8 ANOVA TABLE for penetrometer reading (N/cm^2)

Load = 30kg, Base area = 3.14 cm^2

Treatment	pressure N/cm^2			treatment total	treatment mean
Conventional tillage ct (A)	828	540	669	2037	679.00
Plough and ridge tillage (B)	987	637	478	2102	700.67
Grand total				4139	
Grand mean					1379.67

Source of variation	Degree freedom	Sum of square	Mean square	F value	Tabular F 1%	5%
Treatment	1	704.7	704.7	0.016^{ns}	21.20	7.71
Experimental error	4	177242.66	44310.67			
Total	5	177946.33				

CV = 30.5%

TABLE 4.8.9: **ANOVA TABLE for Penetrometer reading N/cm^2**
Load = 20kg. Base area = 2.01cm^2

Treatment	pressure N/cm^2			treatment total	treatment mean
Conventional tillage ct (A)	1094.5	597.0	985.5	2587	862.33
Plough and ridge tillage (B)	895.5	726.4	431.2	2053.1	684.37
Grand total (G)				4640.1	
Grand mean (Gm)					1546.70

Source of variation	Degree freedom	Sum of square	Mean square	F value	Tabular F 1%	5%
Treatment	1	47508.2	47508.2	0.835^{ns}	21.20^{ns}	7.71
Experimental error	4	227531.62	56882.91			
Total	5	275039.82				

TABLE 4 .9 ANOVA TABLES FOR depth of sowing (cm).

Treatment	depth of sowing (cm)			treatment total	treatment mean
Conventional tillage ct (A)	3	4	5	12	4
Plough and ridge tillage (B)	4	5	3	12	4
Grand total					
Grand mean					8

Source of variation	Degree freedom	Sum of square	Mean square	F value	Tabular F 1%	5%
Treatment	1	0	0	0	21.20^{ns}	7.71
Experimental error	4	4	1			
Total	5	4				

TABLE **4.9.1 ANOVA table for seedling emergence (days)**

Treatment	seedling emergence (days)			treatment total	treatment mean
Conventional tillage ct (A)	3	3.5	4	10.5	3.5
Plough and ridge tillage (B)	4	3	3	10	3.3
Grand total				20.5	
Grand mean					6.8

Source of variation	Degree freedom	Sum of square	Mean square	F value	Tabular F 1%	5%
Treatment	1	0.04	0.04	0.132^{ns}	21.20	7.71
Experimental error	4	1.21	0.30			
Total	5	1.25				

CV = 16.18%

TABLE 4.92 **ANOVA tables for root length of beans (cm)**

Treatment	Root length (cm)			Treatment total	Treatment mean
Conventional tillage ct (A)	44.4	28.4	55.5	1283	42.8
Plough and ridge tillage (B)	30.8	49.3	24.7	104.8	34.9
Grand total G				233.1	

Source of variation	Degree freedom	Sum of square	Mean square	F value	Tabular F 1%	5%
Treatment	1	92.04	92.04	0.53^{ns}	21.20	7.71
Experimental error	4	699.41	174.85			
Total	5	791				

Cv = 17.02%

Discussion of results

4.2 Depth of seed placement: - There was no significant effect of the two tillage methods on depth of seed placement as shown on table 15.0 .The average depth of seed placement was 4.0cm which is a clear indication that since planting was done manually care was taken to drill the hole to the desired depth so that you have the same value all over.

4.3 Seeding emergence: - The tillage method and interaction of these treatment did not show any significant effect on seeding emergence when tested at 5%

4.2 Seeding emergence conted: -

As shown in table 16.0 with the conventional tillage having a average depth of 3.5 days which plough and ridge tillage is having 3.3days this could be accounted for by the fact that seeding emergence is largely control by temperature and depth of sowing and since all these factors are the same there wasn't any significant effect from the treatments.

4.4 Soil dry bulk density: -For all the two tillage treatments, there was increase in the value of bulk densities with soil depth, (i.e. 0 – 15cm and 15 – 30cm). There was also decrease in the bulk density after tillage operation which made the differences between the two values (before and after tillage operations respectively) to be positive with conventional tillage sowing the higher value of 0.39 as against 0.29 of plough and ridge tillage at the depth of between 0 – 15 cm like wise with depth of between 15 – 30cm the differences are 0.39 and 0.36cm for conventional tillage and to have reduced soil dry bulk density more than the other method and this implies that mechanical resistance to root penetration was less and increased the plants ability to exploit their environment.

This also show that air filled porosity of the soil was increased, thus increasing the air supply to plant roots and reducing the build – up of toxic product such as carbon –dioxide and ethylene.

In general, since permeability decreases with increasing density and vise versa, this seemed to gave elicited the problem of water logging (cannel and Finney, 1973).

Also from tables 12.0 and 12.1 it was shown that the interaction between the tillage methods was not significance at 5% level of significance.

4.4 **Moisture content**: - For all the two tillage combination, there was a reduction in the value of bulk moisture content with depth (i.e. for conventional tillage at between 0 – 15cm, moisture content = 16.53% and between 0 – 15cm 13 .93% respectively before tillage operation). There was slight increase in moisture content after the tillage operation as the differences between 0 – 15cm for conventional tillage the difference was – 0.27 while that of plough and ridge tillage was – 0.73) tables 10.0 and 10.1 showed these values. This means that there was more water available at the root zone of the plant food as a solution, however, when the values were tested for the significance of variation between the treatment combinations. There wasn't any significance of variation at5% level of significance and this was shown on tables 13.0 and 13.1 respectively.

4.6 **Soil resistance to penetrometer:** -There was an increase in penetration as the base area of Penetrometer was decreasing in the other of 4.91cm^2; 3.14cm^2 and 2.01cm^2 with conventional method recording the highest value. The difference between the values recorded before and after the tillage operations were negative which indicate that there was an increase in Penetrometer pressure after the tillage operations (tables 11.0, 11.1 and 11.2). This was a clear indication also that root exploration will be improved as well as more moisture content is available at the root zone, However, there wasn't any significant effect of soil resistance to Penetrometer at 5% level of significance.

4.7 **Root length**: - conventional tillage seems to favour root length more than plough and ridge tillage with average length of 42.8cm as against 34.9cm and this is a clear indication that conventional tillage method will have the ability to absorb water and mineral nutrient and also have ability to exploit within the soil volume which had also lead to improvement the use of input. However when tested for the significance of variability, there wasn't any at 5% level of significance for the two tillage methods (table 17.0)

4.9 **Beans kernel yield**: - It is unfortunate that this parameter cannot be measured due to the fact that cattle did enter my farm and the almost all of my crops. However conclusions will be made in respect of other parameters gotten of other parameter gotten during the period experimentation.

CHAPTER FIVE

5.0 CONCLUSION

The effect of tillage methods on soil compaction and performance of beans (Cowpea) was investigated interms of its depth of seed placement (ii) Seeding emergence(iii) Soil dry bulk density (iv) Soil strength (v) Root length (vi) Moisture content and (vii) Kernel yield of beans.

Depth of seed placement and seedling emergence were not significantly influenced by combination of tillage method this is due to the fact, that seed was planted using manual method at average depth of 4cm and seedling emergence was largely dependent of temperature which was the same throughout. These are shown on tables.

Root length should no significant difference when tested at 5% level of significance; This was evident in that both treatments involved tilling which made soil condition favourable for plant root growth. These is in accordance with the findings of Tardieu (1988), Van Ouwerkersk and van Noordwij K (1991) that the root distribution of crop plant can be changed markedly as a result of compaction in both the topsoil and the subsoil table.

Bulk density, which measured level of compactness, was found to have reduced to considerable amount with conventional having the lowest value after tillage operation for the treatment combination. i.e. Tables 9.0 and 9.1. However there exist no significant variation between the treatment combinations.

Penetrometer pressure was found to be increased this was a clear indication that penetrometer needle exploited soil particle deeper than it did before tillage operation on comparison, see tables 11.0, 11.1, and 11.2.

Moisture content which is the amount of water present in the soil which seemed to be increased though slightly after the tillage operations see tables 10.0 and 10.1.

5.1 RECOMMENDATION

The following recommendations were made as regard to the way of improving the accuracy of results obtainable in this research work.

(1) there is need to have more different tillage implement such as subsoilers (para plough), polydisk cultivators, chisel plough, e.t.c.

(2) Some of the tillage implements were not in good condition which in one way or the other affected the accuracy of the work. Hence all implements must be in good working condition.

(3) The penetrometer used has a circular base instead of cone base, hence cone penetrometer should be provided to the department.

(4) Anger method of measuring bulk density was used of anger, there is tendency of having discrepancies in the value obtained. Other methods could be used e.g. corering, sand filling e.t.c.

(5) Electronic weighing balance should be provided to the department as this measures even an infinitesimal weight as against the one in the department which has the accuracy of 0.1kg.

(6) For any experimental design the total degree of freedom should not be less than six (6).

(7) Tillage operation should not be done when the soil is very dry or very wet as this could lead to the formation of plough pan.

(8) Crops should be protected against animals to have expected yield.

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