Selection and Management of Agricultural Tractor and Implement:

A Case of Finchaa Sugar Factory

Kasahun Lulu Deressa

A Thesis Submitted to the Department of Mechanical Engineering

School of Mechanical Chemical and Materials Engineering

Presented in Partial Fulfillment of the Requirement for the Degree of Master of

Science in Agricultural Machinery Engineering

Office of Graduate Studies

Adama Science and Technology University

November, 2022

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DECLARATION

I hereby declare that this Master Thesis entitled “Selection and Management of Agricultural Tractor and Implement: A Case of Finchaa Sugar Factory” was my original work. That was, it has not been submitted for the award of any academic degree, diploma or certificate in any other university. All sources of materials that were used for this thesis have been duly acknowledged through citation.

Kasahun Lulu Deressa	____________	__________________
Name of student	Signature	Date of Submission

RECOMMENDATION OF ADVISORS

I, the major advisor of this thesis, hereby certify that I have read the revised version of the thesis entitled "Selection and Management of Agricultural Tractor and Implement: A Case of Finchaa Sugar Factory" Prepared under my guidance by Kasahun Lulu Deressa and submitted in partial fulfillment of the requirements for the degree of Master of Science in Agricultural Machinery Engineering.

Therefore, I recommend the submission of revised version of the thesis to the department following the applicable procedures.

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APPROVAL PAGE

I, the advisor of the thesis entitled hereby "Selection and Management of Agricultural Tractor and Implement: A Case of Finchaa Sugar Factory" and developed by Kasahun Lulu Deressa, hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

Dr. Amana Wako Koroso (PhD)	___________	________________
Name of Advisor	Signature	Date

We, the undersigned members of the Board of Examiners of the thesis by Kasahun Lulu Deressa have read and evaluated the thesis entitled "Selection and Management of Agricultural Tractor and Implement: A Case of Finchaa Sugar Factory" and examined the candidate during open defense. Therefore, this is to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in Agricultural Machinery Engineering.

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ACRONYMS AND ABBREVIATIONS

AMSE	Agricultural Mechanization Service Enterprise
ASABE	American Society of Agricultural and Biological Engineers
ECRA	Ethiopian Custom and Revenue Authority
EFC	Effective Field Capacity
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	Food And Agriculture Organization Corporate Statistical Database
FC	Fuel Consumption
FSF	Fincha Sugar Factory
GTP	Growth Transformation Plan
Ha	Hectares
HP	Horsepower
IFPRI	International Food Programme Research Institutions
KW	Kilowatt
METEC	Metals and Engineering Corporation
PTO	Power Take-Off
SFC	Specific Fuel Consumption
SPSS	Statistical Package for the Social Sciences
SSA	Sub-Sahara Africa
UNDP	United Nations Development Project
USDA	United State Department Of Agriculture

ABSTRACT

Sustainable agricultural mechanization refers to agricultural mechanization that is economically viable, environmentally conscious, and socially acceptable . There are still major gaps between current farm yield and the potential yield due to lack of a technological inputs. Estimated data based on soil type, implement working depth, and width is not accessible. There is a lack of information on the draft and power requirements of different agricultural implements operating on different soils in Finchaa Sugar Factory, which could affect the correct selection and matching of tillage implements for different types of soil. The implement drawbar pull and power requirement is important factor to determine tractor and implement selection in machinery management. The objective of this study is to optimize the selection, utilization, and management of tractors, and implements for Finchaa Sugar Factory. Three tractor models were selected for the study. The tractors were Newholland TM135, Belarus MTz1221, and Johndeer 6130J with four-disc plow . The experimental site was 0.9 ha, divided into four sections of 180 x 50m^2. Each unit was 14m apart to avoid plot border interaction and to be equally used as headlands for the start of the experimental procedures. The soil textural class of the field was determined based on the particle size distribution using USDA Soil Textural Triangle method. The soil analysis showed that the experimental field is vertisol, with sand 35.17%, silt 22.91%, and clay 41.92%. The results obtained shows that the relationship between tractor speed and draft of disc plough was linear, particularly at depths of 10 cm, and 30cm. In a case of Belarus MTZ1221, there was linear relationship between depth and draft force and the minimum and maximum draft force obtained was 5.5, and 7.5km/hr was 4.97, and 13.28KN, respectively. However, in a case John Deer 6130J tractor, the minimum and maximum draft force at different depth, width, and speed was 5.42 to 24.26KN, and depth, width, and speed was nonlinear relationship with draft force, and the maximum power utilization of the three tractors at D3, W3,S3 was 66,69,52%. The average fuel consumption both for New holland, Belarus MTZ1221 was 9.07/hr, while for Jondeer6130 was 8.79L/hr. The average fuel consumption for both Newholland TM135 and Belarus MTz1221 was 28.82%. In other way, johndeer 6130J consumed 31.14%. Generally, as Dbpull increases, FC increases, at the same time over/under utilization causes breakage of tractors and unnecessary wastage fuel.

Keywords; *selection of tractor, implement, plow depth, forward speed, fuel consumption, machine management.*

CHAPTER ONE

INTRODUCTION

1.1. Background and Justification

Selecting suitable machines and implements is a challenging problem in machinery management due to the wide range of machine types and sizes, capital investment requirements, trained labor requirements, timeliness, farm size, and the possibility of using the same equipment with different speeds, widths, and tractive efficiencies of machines as well as with different crops. (Omer et al., 2005).

Farm mechanization or modern agriculture machinery is critical and essential for agricultural success in many countries. The primary goal of agricultural machinery is to reduce the work drudgery and expenses of agricultural activities while also increasing output. Due to the rise in global population and the demand for food, agricultural mechanization has received a lot of attention recently. Agricultural field machinery refer to those machines/implements basically used in the farm for field operations such as land clearing machines; tillage or seed bed preparation machines; seed planting machines, fertilizer applicators, mechanical weeding machines; sprayers for weed and pest controls; harvesting machines and transporting machines (Okechukwu et al., 2019).

Farm machinery and the system of operation generally make up the field of farm mechanization. Agricultural mechanization is defined as the "Employment of machinery mechanisms and devices in agricultural production to replace manual labour" (Tewheeda et al., 2016). Agricultural mechanization could be also defined as the economic application of engineering technology to enhance the effectiveness and productivity of human labor (Dagninet et al., 2016).

In Ethiopia, agriculture has a long history. The economy of Ethiopia and the Ethiopian people both rely heavily on it. It provides a huge number of rural people with food security, income support, raw materials for agroprocessing businesses, a market for industrial goods, and a source of foreign exchange (MoA, 2014).

Agricultural mechanization technology, like other inputs, could help boost productivity and production. Proper machinery selection and utilization would increase and optimize agricultural productivity by reducing avoidable breakdown/failure, energy and power losses, and mismatching of implements to prime movers. (Okechukwu et al., 2019). Land clearing machines, tillage or seedbed preparation equipment, seed planting machines, fertilizer applicators, mechanical weeding machines, weed, and pest control sprayers, harvesting machines, and transporting machines are examples of agricultural field machinery (Hunt, 2013).

The proper selection and matching of tractors and implements, as well as their management, plays a significant role in boosting farm production and productivity, which improves a country's overall economic growth. The implication of making the wrong tractor choice might be costly. For instance, a small tractor would need to work long hours in the field when utilized on a large piece of land, which would cause delays and premature replacement, whereas a bigger tractor may result in expensive operating and overhead expenses (Amini & Asoodar, 2016). Because of the wide range of machinery types, varied available sizes, capital investment, qualified technician labor demand, timeliness, varieties of crops, unbalanced crop rotation, and other associated considerations, selecting a tractor is a challenging task in machinery management (Osman, 2011).

Tractor and implement selection and management play an essential part in the growth of a country related to increase farm produce and productivity. Tractor and implement choice for field operation especially, when used for land preparation conventional method which no go with current soil type, and mostly adopted from previous experienced farm machinery management.

Management decisions related to agricultural machinery could affect production profits in many ways. Fuel, interest, labour and timeliness of operation are the pertinent factors that contributed to the tractor's productivity and efficiency. To improve productivity and efficiency, it is necessary to have comprehensive information on all aspects of the tractor and implement performance in the field operation.

Because machinery selection is directly related to management's success in combining land, labor, and capital to return a satisfactory profit, it has become more important in today's farming operations. As a result, selection decisions are more difficult to pin down than most other farming decisions. Most equipment management issues might be managed by precisely determining total working time available for key field operations, determining effective field capacities of machines, matching power units to machine capacities, and accurately forecasting any machine application costs. Users could expect less power loss, increased operating efficiency, lower operating costs, and the most efficient use of capital on fixed costs when farm tractors and implements were properly selected (Mwasandube & Amon, 2015). When it comes to effectively matching agricultural equipment and tractors, draft, energy, and fuel requirements have all been recognized as essential. The necessity for a tillage implement was one of the criteria that determines the size of use, the age of the tractor, and the amount of energy used in an operation (Daum & Birner, 2020). According to the report, proper agricultural machinery selection and matching could lower the amount of energy required for each implement. The machine's performance and the time it takes for the machine to complete the task were other important considerations. As a result, it's critical to pick the right machine or machines to do the task with the least amount of energy and in the shortest amount of time. To determine the rear tire slippage of a tractor when employing one plows at different speeds, as well as the efficiency and fuel consumption for each speed.

1.2. Statement of Problem

The agricultural tractor, which is commonly used for farm activities and provides power for driving and controlling a range of accompanying equipment and machines, is an important part of agricultural mechanization. It is critical to select the right size farm tractors and equipment to ensure profitable agricultural operations. Many factors have been attributed to users' improper selection and use of agricultural tractors and equipment . Some of the factors that have been recognized by (Misandube & Amon, 2015) include; insufficient mechanization extension services, lack of general technical know-how, poor quality of imported farm tractors and implements, lack of awareness and knowledge about the influence of soil characteristics on mechanization in their respective areas, the diversity in the makes, types, and sizes of tractors and implements offered in the market, high prices of spare parts, poorly trained operators and mechanics, lack of well-equipped workshops to carry out repair service.

Estimated data that is updated in parallel with existing soil type, working depth, and width is not accessible. Currently, there is a lack of data on draft and power requirements of agricultural implements operating on different soils for agricultural production in Fincha Sugar Factory, which could affect advancement in tillage implements operation in different types of soil. Commercial farms and farmers in Ethiopia lack knowledge of these parameters and often rely on trial and error to match the tractor with the equipment. As a result, certain types of machinery become inefficient if they do not reach the end of their useful This means that no systematic examination is conducted to see whether the implement is compatible with the tractor, resulting in poor management (Marta, 2019).

The main agricultural mechanization issues are small-scale and fragmented farming, improper tractor and machinery selection, a lack of knowledge about effective and proper usage, tractor and agricultural machinery maintenance, and an old combined tractor park (Akdemir, 2013). The tractor and implement are the most expensive components of an agricultural operation. As a result of mismanaging these resources machinery downtime occurs, causing the organization to suffer significant costs, risk, and eventually close down.

In Finchaa Sugar Factory, lack of spare parts is the major factor keeping tractors off the field, which delays the completion of field work. In addition to the issues already mentioned, poorly trained operators, poorly structured maintenance schedules, inappropriate garages, and poorly arranged tools all contribute to the excessive breaking of tractors and implements.

The research sought to quantitatively and experimentally determine the drawbar pull, drawbar power, wheel slip, field capacity, and power utilization ratio in order to save energy and prevent tractor and implement breakage. It also sought to show how operation costs could be decreased by comparing the power requirement of the tillage implement with the tractor's drawbar power output. The assessment was done on an experimental site at the Finchaa Sugar Factory.

1.3. Objective

1.3.1. General Objective

- The objective of this study is to investigate selection, utilization, and management tractors, and implement of Finchaa Sugar Factory.

1.3.2. Specific Objective

- To Evaluate the availability and selection of farm tractors with implement in the sugar Factory.
- To determine utilization of sugar cane farm tractors and implement in the Sugar Factory.
- To Evaluate Performance and efficiency of tractors and implements in the Sugar Factory.

- To Assess the maintenance cost of farm tractors and implements.

1.4. Significance of the Study

Agriculture is a risky business as it depends heavily on short-duration rainfall in developing countries like Ethiopia. To make the most of the short growing season, careful consideration must be given to the level of mechanization to be developed and the selection of the appropriate machines to be used in order to maximize the utilization of the relatively short growing season. Furthermore, these countries usually have severe difficulties in funding agricultural production activities. This demands making the right selection, particularly when large quantities of money are to be devoted toward purchasing machinery and implements to extend current agricultural areas or to replace aging equipment and machines. On the other hand, selecting the incorrect type of machine or the incorrect size of power unit may result in either over or under utilization of these important and expensive inputs, resulting in a massive pileup of useless machineries and crippling financial debt. Therefore, assessing the existing farm machinery selection and management of the Finicha Sugar Factory, recommending improvements, and identifying the most important machinery selection-related aspects aretimely and relevant topics for researchers interested in farm machinery selection and management. Furthermore, the overview offered in this study will spark fresh ideas that will be useful in future discussions about the significance of agricultural machinery choice. It also acts as a resource for scholars undertaking in-depth research on the subject under consideration.

1.5. Scope of the Study

The goal of this study was to analyze and test the influence of implement drawbar pull and drawbar power requirements on tractor operating conditions for New Holland TM135, Belarus MTZ1221, and john Deer 6130J tractors at three different working depths, widths, and forward speeds. The tractor was then checked to see if it was overloading or underloading conditions, and which tractor implements combination with which working depth and width was better for optimal tractor performance. Increase agricultural product and productivity by selecting the better tractors and implements based on economic feasibility for a specific activity.

Better tractor and implement management systems, as well as determining the field availability of tractors and implements, increase industrial profitability and create a conducive environment for workers via machinery management systems. .Energy-savings strategies must be considered as machinery cost is one of the major costs of any agricultural production system, so improving farm machinery performance efficiency leads to an increase in profitability.

The goals of this study were to see how speed and depth affect the draft and power requirements of three common tractor-tillage implement on different soil type, as well as to establish regression equations for draft and power requirements based on speed and depth.

performance criteria might be utilized to choose the best tractors and implements for a particular agricultural setting (Daum & Birner, 2020). Field machines become more crucial when energy costs rise since they contribute significantly to the overall cost of agricultural production systems.

CHAPTER TWO

LITERATURE REVIEW

2.1. Mechanization

Mechanization was defined by the FAO as the use of tools, implements, and machinery to achieve agricultural production (Diao et al., 2016).

Agricultural mechanization refers to a shift in technology that involves the use of non-human sources of power to perform tasks such as ploughing, harvesting, shelling, and planting (Diao et al., 2016). Power-intensive processes such as land preparation, threshing, pumping, and transport have been largely motorized by tractors and stationary machinery throughout the developing world since the early 1970s (Diao et al., 2014).

To develop a long-term agricultural mechanization strategy at any scale, the first step was to assess the current state of farm mechanization and determine the steps needed to progress from that state to the best possible future state. A thorough understanding of the current situation and the issues confronting agricultural mechanization development was a prerequisite requirement for developing a credible plan to create sustainable agricultural mechanization (Kunihiro, 2013; Misandube & Amon, 2015).

Agricultural mechanization that was economically viable, environmentally conscious, and socially acceptable was referred to as sustainable agricultural mechanization (Sims & Kienzle, 2017).

The Food and Agriculture Organization (FAO) of the United Nations (UN) elaborates on basic ideas of mechanization, which span all levels of farming and processing technology, from simple hand tools to more advanced and motorized equipment (Sims & Kienzle, 2017).

Under the Growth Transformation Plan the agriculture sector was the largest contributor to economic growth, which was harmful to reaching food security targets and a significant increase in export revenues (National Planning Commission, 2016).

Agricultural production in Ethiopia has shown a steady growth over time, however, the advancement largely comes from the expansion of farmlands (IFPRI, 2010; UNDP, 2011).

There were still major gaps between farm yield and exploitable yield due to the limited use of technological packages and inputs (Amha et al., 2013; UNDP, 2011).

Appropriate private farms with all of their assets and place them under the supervision of staff farms. More emphasis was being placed on mechanizing state-owned large farms and providing assistance to nascent smallholder producer cooperatives (Belete et al., 1991).

Ethiopia, Ghana, Nigeria, and Tanzania, all of which have low tractor density, look to be making some of the most significant progress toward mechanization. On a national level, low land availability per worker may mask the presence of locations where land was still available for commercial production but requires labor-saving technologies to cultivate.

Table 2. 1. Countries with very low Tractor Density Figures (Diao et al., 2016).

Country	Burkina Faso	Ethiopia	Ghana	Kenya	Mozambique	Nigeria
	8.9	4	11	26.9	12.7	5.7
	Rwanda	South Africa	Tanzania	Tunisia	Zambia	Zimbabwe
	1.3	43	7.4	143	20.7	35.6

Source: World Bank (2014b); FAOSTAT

Ethiopia's high population density and poor supply of agricultural land per worker, combined with an extraordinarily low tractor density of 4 per 100 square km, render it unsuitable for mechanization. Ethiopia might be neglected in a discussion on mechanization based on national data, yet the country was nevertheless undergoing a dynamic mechanization process in several areas. While these figures were skewed by the densely populated central highlands, where tractor use was low and animal traction was common, mechanized commercial agriculture was thriving in the Western Highlands, where fertile land remains (Berhane, 2014).

2.2. Dealers and Manufacturers Tractors

In the country, there were machinery merchants who specialize in the importation of tractors and agricultural machinery, as well as providing after-sales services. Some of the major companies include Ries Engineering, Moenco, Kaleb, Hagbes, Gedeb, and Case. Messey Ferguson, Landini, Class, SAME, John Deere, and Case were just a few of the well-known tractor brands imported by the firms mentioned. Another notable enterprise was the former Nazareth Tractor Factory, now known as the Adama Agricultural Machinery Industry and operated by EFDRE Metals and Engineering Corporation (METEC), which imports and assembles tractors including Belarus and various Chinese manufacturers, ranging from 8 hp Walking tractors to 300 hp four-wheel tractors.

According to figures from the Ethiopian Customs and Revenue Authority (ECRA), roughly 12 231 tractors were imported into the nation between 2011 and March 2014. About 10,000-11000 tractors may currently be found in Ethiopian farmlands, out of the 3000 tractors imported previously to 2004 that have reached the end of their service life and 60 percent -70 percent of the tractors imported after 2010 that were out in the field.

2.3. Selection of Agricultural Tractors and Implement during the Purchasing Process

The following procedure was suggested by Donel Hunt. (a) Determine the basic machinery requirements, taking into account rotations, machinery practices, and other factors; (b) select a tractor that was approximately the right size. (c) Choose a complement of machinery that the tractor would manage based on the tractor's specific data. (d) Determine the total annual cost of ownership and operation of the apparatus, revising or deleting sizes as necessary. (e) Repeat the process for different sizes of tractors for those machines for which ownership was not warranted. By comparing the costs estimated in step (d), the tractor with the lowest overall cost may be identified; in step (c), the most cost-effective size of machine for usage with that particular tractor could be established by experimenting with various sizes (Mwasandube & Amon, 2015).

2.4. Selection of Farm Tractors and Equipment Use Management

It was critical to choose the right size farm tractors and equipment to allow for profitable agricultural operations. Many constraining factors have been blamed for farmers' poor selection and use of agricultural tractors and equipment across the country. The following were some of the factors discovered insufficient extension services for mechanization (ii) a lack of general technical knowledge, (iii) most small-scale farmers have limited purchasing capacity, and (iv) there was a dearth of mechanization financing. (v) poor quality farm tractors and implements bought from abroad (vi) a lack of awareness and understanding about the impact of soil conditions on mechanization in their respective areas, (vii) a wide range of manufacturers, types, and sizes of tractors and implements available on the market, and (viii) expensive spare part prices. (ix) Inexperienced personnel. Planning and selection of optimum farm tractor-implement was a complex process as it involves a number of factors including field performance parameters and other technical and socio-economic factors such as those stipulated above and illustrated.

The intricacy in the analysis of dynamics and stability behavior of the tractor-implement system, as well as the prediction of soil-tire and tractor-soil-implement interactions, contributes to the complexity.

Small scale farming and fragmented agricultural holdings in uplands, like in Mgeta and Mali villages of Mvomero District, face exacerbated difficulties in the selection and adoption of appropriate farm machinery technologies (Mwasandube & Amon, 2015).

Selection of tractor and implement systems like Socio-economic factors, (Price of machine, Brand of machine, Commonly used machine in the area), Technical factors; Farm power and equipment use, Price relating to mechanization, Fuel consumption, Power delivered by tractor, Implement power requirement, Availability of spare parts, Availability of maintenance service, Availability of maintenance service, and Farming systems ; Type of crops, Method of production, Allotted time, Farm power and equipment use, and Soil physical properties; Soil cone index, Soil Bulk density, Soil texture, Moisture content, and those were factors influencing the selection of farm machinery

2.5. Selection of Tractor

2.5.1. Selection Based on Criterion of Tractor

The tractor should be selected based on the following factors (Power et al., 2012).

Landholding: In a single cropping design, 1 horsepower was usually recommended for every 2 hectares of land. In other words, one tractor with a horsepower of 20-25 was sufficient for a 40-hectare farm. This means that as the size of the land grows, the horsepower required grows by a factor of two.

Cropping pattern: When suitable irrigation facilities were provided and more than one crop was grown, 1.5 hectare/hp was often suggested. So a tractor with 30-35 horsepower was adequate for a 40-hectwere farm. Because the soil was moist enough that the wheel requires more torque to complete field operations, the horsepower to be used here was growing.

Soil conditions: In lighter soil, a tractor with a shorter wheelbase, higher ground clearance, and a lower total weight may be successful, but in black cotton soil, it will not be able to provide sufficient depth.

Climatic conditions: Air-cooled engines were favored over water-cooled engines in extremely hot zones and desert environments. Similarly, air-cooled engines were recommended at higher altitudes because water was more likely to freeze.

Repairing facilities: It should be ensured that the tractor to be purchased has a dealer at a nearby place with all the technical skills for repair and maintenance of the machine.

Running cost: Tractors with less specific fuel consumption should be preferred over others so that running costs may be less.

Initial cost and resale value: While keeping the resale value in mind, the initial cost should not be very high, otherwise a higher amount of interest would have to be paid.

2.5.2. Based on Type of Construction

(a) Riding type tractors: Tractors in which a driver can sit and drive e.g. General purpose four-wheel tractors.

(b) Walking type tractors: Tractors with which the operator Walks along e.g., garden tractors, power tillers.

2.5.3. Based on Type of Drive

(a) Track-type tractors: In this type of tractor, instead of wheels; one track was fitted on either side. This track gets driven from the sprocket run by the rear axle shaft. To steer the tractor, there was no steering gear fitted. The tractor was steered by applying brakes to one side of the track with the other track moving. These were used for bulldozing or land clearing work.

(b) Wheel type of tractors: These were the most commonly used agricultural tractors. They can run fast and wheel tyres absorb a certain amount of field shocks also. These could be further divided as:

1) Two-wheel tractors:- These tractors were used for small farms, hilly areas, and gardening purposes and were called power tillers.

2) Three-wheel tractors:- These tractors were very popular 15 years back but now its place has been taken by four-wheel tractors. These tractors had single or dual wheels fitted at the front end in the Centre and were considered good for negotiable shorter turns.

3) Four-wheel tractors:- These were the most commonly used tractors in the country. These were also known as all-purpose tractors. On the basis of available power, these have been classified as; Small tractors 15 to 25hp, Medium tractors 25 to 45hp and Large tractors more than 45 hp.

Table 2. 2. Average 4-wheel Tractor Horsepower

Estimated Average Tractor HP	Burkina Faso	Ethiopia	Ghana	Kenya	Mozambique	Nigeria	Zambia
Hp-power	40-60	102.3	60-80	101.4	84.9	65-80	65

2.5.4. Based on Purpose

(a) Utility tractors: It was a specific purpose field tractor and was designed for plowing driving any other equipment through its PTO drive. It was not being manufactured at present in the country.

(b) All-purpose tractor: It was designed in such a way that it could meet practically all the demands for agricultural purposes such as plowing, harrowing, leveling, pulling, seed drill, operating threshers, and pumps through its PTO. These are provided with three-point linkages.

(c) Orchard-type tractors: These are special types of tractors used in orchards. These are made very high in height so that driver while sitting on the seat, the operations on the trees could be performed. No part of the tractor was protruded outside so that tractor can go easily in between trees safely.

(d) Garden tractors: These tractors are in the range of 1 to 10 hp and were very small in construction. These are mostly used for kitchen or vegetable gardens.

(e) Rotary Tillers: These were walking tractors that were employed in small fields or on hills where fields were small and at varying levels, making standard tractors ineffective. Tined blades were attached to the tillers to properly pulverize the soil and prepare the seedbeds. These were also used for puddling and other operations in rice fields.

(f) Earth Moving tractors: These tractors are heavy in weight and strongly built available both was tract and tyre types. These are used for earthmoving work on dams, quarries and other constructional works.

2.5.5. Selection Based on Tractor Model

There are many types' tractors models which was available in the world, but for this research thesis, selected tractor models are Newholland TM135, Belarus MTZ1221, and Johndeer 6130J.

2.5.6. Selection Based on Soil Type

In lighter soil, a tractor with a shorter wheelbase, higher ground clearance, and a lower total weight may be successful, but in black cotton soil, it will not be able to provide sufficient depth. The USDA soil textural triangle can be used to determine the soil type after determining the percentage of clay, silt, and sand. The results of the soil sieve examination are obtained from a field experiment.

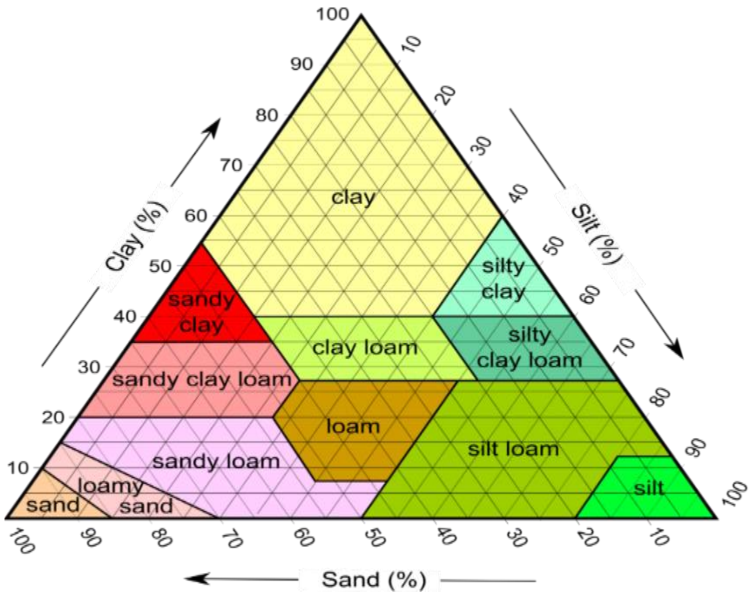


Figure 2.1. USDA soil textural triangle

2.5.7. Selection Based on Capacity

The following categories is to select tractor based on capacities stated by (Johnson, 2016).

Horsepower (15 to 20): Horsepower in the 15 to 20 range (sometimes slightly more) was the amount offered by a basic lawn or garden tractor. This was more than sufficient for typical lawn tasks such as mowing the yard, pulling carts or small trailers full of debris or supplies, and even ploughing light soil (with appropriate tires, tire chains and weights, of course). However, field cultivation tasks are out of reach.

Horsepower (25 to 35): Subcompact tractors and low-end compact utility tractors have 25 to 35 horsepower, which was a step up from lawn and garden tractors. Their increased power allows them to use a front-end loader or a backhoe attachment. Small-scale field farming was also possible with the correct tools. Compact utility tractors, unlike lawn and garden tractors, usually incorporate a power take-off, or PTO, for driving implements. This spinning drive shaft allows devices like a mower, loader, or backhoe to draw energy from the engine in order to operate. Most tractors come with a typical rear-mounted PTO, however some models additionally include midline PTOs.

Horsepower (40 to 50): Between 40 and 50 horsepower, the border between compact utility tractors and conventional utility tractors begins to blur, greatly increasing the variety of farming operations that could be tackled. With this amount of horsepower, tasks such as plowing fields and baling small square hay bales are possible, while it was possible that hard conditions, such as working in clay soil or hauling a wagon behind a hay baler, would push tractors of this strength to their limits. Tractors in this category, on the other hand, could be an ideal choice for a hobby user provided they do these jobs in little amounts and were willing to work at a slow pace; some even contain interchangeable mower decks, making them extremely versatile.

Horsepower (60 to 90): A utility tractor in this horsepower range (especially the high end) would probably handle everything a hobby user could realistically ask it to do. The added strength makes the tractor more stable on challenging jobs such as baling hay even round bales were feasible and let use larger and wider implements at a faster pace.

Horsepower (100 to 150): Talk about serious power tractors offering 100 to 150 horsepower can handle all but the most extreme farming tasks without hesitation and were suitable for farming at a commercial level, although this power and ability come with a big price. The only question was whether it can put a tractor of this level to good use. The typical hobby of agricultural users probably won't have enough large-scale farming tasks to warrant the cost of a tractor in this range (Johnson, 2016).

For mowing the yard and doing some work with a front-end loader, a tractor with 25 to 35 horsepower might be all you need. If you envision doing a little of everything and int a versatile "jack of all trades" tractor, something in the 40 to 50-horsepower range will probably be sufficient while remaining maneuverable and relatively affordable. But if it needs more power for serious field cultivation tasks, a large tractor with 75 horsepower or more can be worth the added expense.

- Lack of airflow prevents optimal engine temperature
- Dirty engine oil
- Contaminated diesel exhaust fluid filter increases emissions
- Residue plugs engine gas recirculation valve

2.6. Field Tractors-implement Performance Evaluation

One of the basic considerations in selecting tillage machinery is its size. The operational speed, width of cut, soil type/condition was usually sufficient information to match the size of implements to the farming enterprise (Oduma et al., 2021).

The performances of farm machinery are conversely influenced by different factors. These factors include the power units, machine/implements condition, operational speed, nature of the field, crop type, weather condition, soil type/condition, and system management. The operational speed, implement effective working width and cutting depth, soil type/conditions, and operator's skill of operation influence fuel (energy) consumption rate. It, therefore, means that size of implement and speed of operation should be matched to machine size to improve the field capacitive performance of the machine (Oduma et al., 2021).

The field capacity of a machine/implement depends upon the working speed. Thus, there may be a drop in the field efficiency if the machine/implement working speed is increased. An increase in travel speeds would decrease the productive working time needed. However, when the time losses remain effectively the same, there would be a drop in the field efficiency of the machine. Such a result show that as much as there is a speed consideration, it is not good management to attempt to reduce field efficiency; therefore, it is not good operation to use slow speeds to achieve high field efficiency (Hunt, 2013).

Since high field capacity and/or material capacity can possibly be achieved with high working speeds, an experienced operator should assess the soil or crop conditions and thus operate with high speed while maintaining the best quality of operation. In field operation speeds may be influenced by factors such as: machine overloading, poor steering operation, careful operation to avoid loss of functional and structural damage to the machine owing to rough ground surface and being prudent in handling materials.

Values of machine capacities are applied in scheduling field operations, its power units and labour; as well as to determine machine operating costs, and different machines have different field efficiencies, though depending upon the system of operations, soil type/ conditions and the system of management. If crop or soil conditions are inefficient for machine operations, forward speed of operation must be reduced. This condition improves field efficiency but it was not, of course, a desirable operating condition (Oduma et al., 2021).

Machine/implement performance are the rate and quality at which the operations are accomplished (Hunt, 2013). Tillage operations are soil-related operation; soil type and condition are essential indices impacting the field performance of the tractor through their effect on the traction effect of the tractor and implement being powered.

The performance of plough differs extensively based on the soil type, moisture content, weed growth, crop residues and shape or pattern of the field, and the soil type/condition was a major factor that affects the performance of field machineries.

The energy consumption depends mostly among other factors on soil type/condition, speed of operation and quality of tillage; they explained the effects of soil type as they reported that clay soil has a higher break up energy requirement than sandy soils (Oduma et al., 2019).

Data are not available from operations under local conditions to be able to quantify the effect of soil type and operational speed on farm machinery performances in finchaa sugar Factory. It was therefore necessary to examine the effect of soil type and operational speeds on the performances of selected agricultural field machineries under field conditions, and Effective machinery utilization and management demand knowledge of the performance data on the efficiencies of the available machines to be able to meet up with a given work schedule and to establish a balanced system of mechanization which would match the capacities of different equipment.

2.6.1. Equipment Size

Large tractors and implements use more gasoline per hour than smaller tractors driving smaller implements, although the cost of fuel per acre covered is comparable. It was critical to match your current and future needs to the tractor size want to buy. Rental or custom hire are the most cost-effective options for some field operations that require larger tractors on a regular basis. Because a huge tractor may have no other uses for the scale of operation, it may not be required to purchase one when starting up. The operating of a small acreage or a high tunnel, may need only one small tractor and attachments to match. The first step in selecting tractors and equipment is to determine the size needed to complete tasks in a timely fashion.

2.6.2. Improving Field Efficiency

The capacity to increase field efficiency is the next critical stage in honing machinery management abilities. There are several major reasons why a machine's field efficiency may vary. There are several lost-time factors incorporated into the operation. Other sources of lost time could be eliminated with good planning and management.

One loss factor incorporated into every field operation was turning time and field operations, which could be minimized to a minimum by arranging fields with lengthy rows. A standard turn at the end of a field was one that can be completed in a single motion. The rate and quality with which operations are completed used to assess farm equipment performance. This was often described in terms of both capacity and efficiency.

Machine capacity is calculated by measuring the area covered, the weight of the material, and the duration.The capacity of a machine is usually stated in one of three ways:
a) Capacity of the field b) Capacity of the materials c) Capacity of the throughput

A. Field Capacity

Successful farm machinery management does not guarantee a profit, but machinery costs are a major expense and they must be monitored and managed. Therefore, the efficient use of farm machinery starts with determining working capacity in conjunction with the amount of work to be accomplished in a timely manner (Hanna, 2016). It is the rate of field coverage, and also expressed in two ways: a) Theoretical field capacity b) Effective field capacity

B. Theoretical field capacity

The theoretical field capacity of an implement is defined as the rate of field coverage that would be produced if the machine performed its function 100% of the time at rated forward speed and always covered 100% of its rated width by (Kepner et al.,1972). Theoretical field capacity (TFC) is a straightforward calculation using speed and width, with 100% efficiency (Cherinet, 2011). As a result, these values represent the best that a machine can perform if there are no stoppages and the machine is always operating at full width.

C. Effective Field Capacity

The farm equipment seldom covers its rated width and performs its function 100% of the time. Therefore, it never meets the theoretical field capacity. Effective field capacity is the actual rate of field coverage.

The effective field capacity of a machine was a measurement of its ability to perform a task in real-world settings. It is the actual output that a machine produces. It is determined by the proportion of the machine width used, the travel speed, and the time spent in the field during the operation. Blockages, working regions such as headlands many times, adjustments, checks, and small repairs all cost time. This does not cover everyday servicing requirements such as lubrication, but it does include the time it takes to change points (Subrata et al., 2015).

The effective field capacity (EFC) is a more useful measure because it brings in the factor of efficiency. Effective Field capacity can be calculated by dividing the area covered with theoretical field capacity or by multiplying the theoretical field capacity with Field efficiency (Mehta, 2010).

2.6.3. Draft and Power

The draft of a tillage implement is affected by the width, operating depth, and speed of the implement. The impact of speed on implement draft varies depending on the soil type and implement type. The draft forces on implements are frequently documented to grow greatly with speed, with the relationship varying from linear to quadratic (Grisso et al., 1994). Depth has a clear impact on how the draft is implemented. ASABE in (2006) issued the standard (497), for estimating the draft requirements for different implements at the different working conditions as follows:

The interaction between the tractor drive wheel and the soil converts the tractor engine's power into pulling force. By enhancing the tractor's traction capability, the pulling force could be enhanced for operations like tillage. In addition, the amount of gasoline consumed is lowered in order to provide the appropriate pulling force. The bulk of research in this field have found that between 20 and 55 percent of the tractor's power is isted owing to wheel-slip, rolling resistance, and tire and soil deformation due to the contact between tire and soil surface. As a result, it can be stated that the traction performance of the tractor is influenced by vehicle design, attachments, and soil conditions.

When engine power is transmitted through the drive wheels, the PTO shaft, and the hydraulic system, power losses occur. If flywheel power known, multiply it by 0.9 to get an estimate of the PTO power. The power delivered through the drive wheels or tracks to move the tractor and implement is known as drawbar power. By multiplying the PTO power by the relevant value from the table below, you can estimate Drawbar power:

Table 2. 3. Drawbar power by multiplying the PTO power

Tractor Type	Concrete	Firm Soil	Tilled Soil	Soft Soil
2 wheel drive	0.87	0.72	0.67	0.55
Front-wheel assist	0.87	0.77	0.73	0.65
4 wheel drive	0.88	0.78	0.75	0.70
Tracks	0.88	0.79	0.80	0.78

(Source: ASABE, 2000, 2003, 2006) Maximum mechanical power performance expected from agricultural tractors.

By correcting management of some tractor parameters such as tire inflation pressure, wheel load, number of drive wheels, and type of driving system there is a possibility to optimize the tractor’s traction performance reduce fuel consumption, and enhance field productivity.

Increasing the working breadth to achieve the highest pulling force possible is one approach to fully utilize the power of a tractor engine. Excessive pulling force, on the other hand, almost always results in the tractor's wheel slipping beyond the permissible limit. When the driven wheel slips over the allowable limit, significant soil compaction ensues, reducing crop production. To avoid soil compaction, a maximum of 10% to 15% slippage is permitted. The use of extremely heavy tractors allows for a maximum pulling force of less than 10% in slip. However, this strategy has negative consequences, such as increased fuel consumption and soil compaction due to excess weight carrying.

Rest stops: Both for safety and increased performance, short but frequent pauses or rest stops are desirable and necessary. When an operator must focus on a job for long periods of time, taking a short break every hour or so will boost alertness, reduce accidents, and improve work quality.

Machine capacity unrivaled: A system of mismatched machines is one of the most common causes of inefficient operations. It is critical to utilize the correct equipment with the power source at all times. Faster speeds, broader widths, and higher efficiency improve field capacity. In the same length of time, more acres may be treated. Increased field capacity comes at a cost of increased investment and fuel consumption in exchange for less labor. Because not every minute is spent accomplishing the work, time is spent in the field rotating, adjusting, and lubricating;refil fuel, and other duties are all part of the equation. Field efficiency varies based on the type of activity being performed as well as the size and shape of the field; smaller fields are less effective to farm than bigger ones since more time is spent turning at the field's ends relative to the total area covered. Selecting and sizing machinery also depends on labor availability, crop mix, available field days, and timeliness when selecting and sizing machinery (Ry & En, 2016).

2.6.4. Slip

One of the key efficiency variables affecting tractor fuel consumption has always been in tractors. A tractor that is operating at peak efficiency not only saves money on fuel but also makes the best use of time and resources. Agricultural tillage involves soil cutting, turning, and pulverization, all of which require a lot of energy, not only because of the vast amount of soil mass that needs to be moved, but also because of poor energy transfer mechanisms to the soil (Ahaneku et al., 2011).

Traction elements, soil conditions, implement type, and tractor setup all affect tractor performance (Zoz et al., 2003). Tillage energy is influenced by soil moisture content, bulk density, soil texture, and shear strength (Olatunji et al., 2009). Plough resistance and energy requirements are known to be affected by plough body parameters and soil variables such as hardness, density, friction, and stickiness (Aday, 2011; Vilde, 2004).

2.6.5. Soil Moisture Content

Direct and indirect approaches are used to determine the moisture content of the soil (Fan & Su, 2008). Direct approaches entail removing water from the system via evaporation, leaching, or chemical reaction, and then calculating the amount of water lost. Calculate the soil's moisture content as a percentage of its dry weight.

2.6.6. Bulk Density of Soil

The dry weight of soil divided by its volume yields bulk density, which is a measure of soil compaction. The volume of soil particles as well as the volume of pores between soil particles are included in this volume (Ditzler & Tugel, 2002). Soil texture, as well as the densities of soil minerals (sand, silt, and clay) and organic matter particles, as well as their packing arrangement, influence bulk densitydetermined it (Javadi & Hajiahamad, 2006).

2.6.7. Selection Based on Fuel Consumption

Tillage is a type of preliminary land preparation that is necessary for crop production. Tilling the soil to increase food production in agriculture has been practiced for many years prior to the mechanization of agriculture (McKyes, 1985). According to (Rahate et al., 2020), the only source of power is a tractor. Plowing, harrowing, and ridging are all tillage procedures that are particularly significant in agricultural land cultivation.

A predictive model could be used to estimate a tractor's fuel consumption during tillage and anticipate the variance of the process's dependent and independent variables. Fuel consumption is the major diagnostic indicator in determining the state of a vehicle, according to Michalski et al. (2014). Furthermore, since fuel prices continue to climb, energy consumption has become one of the most significant aspects of the agricultural economy. Increased power consumption by raising the operating speed, actual breadth of cut, soil strength, moisture content, and working depth are the parameters that fundamentally affect fuel consumption when utilizing tillage equipment (Cortez et al., 2008; Kichler et al., 2011; Silveira et al., 2013; Moitzi et al., 2014; Leghari et al., 2016; Nasr, 2016).

There are a variety of methods for calculating gasoline use, including filling the fuel tank and then refilling it after the job is finished. After the work is completed, another method is to read from the gauge. A graduated cylindrical container could be used to measure the amount of fuel necessary to refill the tractor's fuel tank immediately after a specific operation, and this measurement could be used to determine the amount of fuel utilized during any operation (Oduma et al., 2019). Due to the increase in fuel prices, the lower fuel using tractor is chosen to make a profit, and any farm organization or private sector participating in farm production should select the better and lower energy consuming tractors, according to these research ideas.

2.7. Selection Based on Spare Part Availability

Most businesses struggle to maintain good spare parts management because they are afraid that stocking spares would compromise their ability to regulate operating costs. As spare part managers, have a lot of pressure to figure out how to manage spare parts more efficiently. Practical spare part inventory management remains the foundation for dependable plant operation for a successful spare part manager. As a plant manager or supply chain manager, you must understand how to determine the replacement components you require to keep your system running.

It is also a good idea to come up with a strategy that would work well with inventory management. Spare parts for equipment that aren't used every day, for example, are frequently overlooked in stocking plans. If wasted production time means a significant financial loss for your company, however, staying a day or going without spare parts for such important assets is virtually unthinkable.

Creating made-to-order parts for items with long lead times and removing expediting possibilities are two things to think about when trying to have a better grasp of lead times for parts inventory (preferably it is best to keep parts with long lead times).
Creating a list of readily available off-brand components (as a viable substitute during a crisis).

2.8. Research Gap

Agricultural mechanization today has a very broad definition that encompasses the manufacture, distribution, and use of a wide range of tools, machinery, and equipment for agricultural land development, planting, harvesting, and primary processing (Akinbamowo et al., 2013).
Agricultural mechanization refers to a shift in technology that involves the use of non-human sources of power to perform tasks such as ploughing, harvesting, shelling, and planting (Diao et al., 2016).

Since the early 1970s, all over the developing world, power-intensive operations of land preparation, threshing, pumping, and transport have been largely motorized via tractors and stationary machines.

The Food and Agriculture Organization (FAO) of the United Nations (UN) elaborates on basic ideas of mechanization, which span all levels of farming and processing technologies, from simple and basic hand tools to more complex and motorized equipment (Sims & Kienzle, 2017).

Ethiopian agricultural production has increased steadily over time, however the progress is mostly due to the development of acreage (IFPRI, 2010). Due to the limited utilization of technical packages and inputs, there are still significant gaps between farm production and exploitable yield (Amha et al., 2013; UNDP, 2011).

According to united Nation and Development Programme, even steady growth of agricultural production, but only motorizing agriculture does not increase product, and productivity (UNDP, 2011). All input used for agricultural production, especially the largest input like tractor and implement, should be selected properly by considering different factors like soil type, moisture content bulk density, etc.

Even though the current government lacks a clear mechanization policy, it has supported the state-owned machinery assembling plant and formulated a regulation to establish an Agricultural Mechanization Service Enterprise, farm machinery import and use is halted before completing their economic life span due to a lack of spare parts and dismounting the component of a stopped tractor for another tractor either of two put into operation, resulting in a decrease in the number of tractors on the road. In 2010, the Metals and Engineering Corporation took over the tractor assembly plant that had been built during the previous administration (METEC). Ethiopia’s high population density and low availability of agricultural land per worker would make it ill-suited to mechanization, and with an extremely low tractor density of 4 per 100 square kilometer.

Weak management systems, poor quality of purchased tractor and implement, availability of spare parts, handling system machinery, deploying to and from the field systems, storing systems, and other factors all contribute to a drop in the number of tractors and implements on the field.

To develop a long-term agricultural mechanization strategy at any scale, the first step was to assess the current state of farm mechanization and determine the steps needed to progress from that state to the best possible future state. For the construction of a trustworthy plan to promote sustainable agricultural mechanization, precise understanding of the current situation and the difficulties that face the growth of agricultural mechanization was a prerequisite necessity. Sustainable agricultural mechanization could be described as mechanization that was economically feasible, comfortable to operators, environmentally sensitive and socially acceptable. The following must be considerd;

- ✓ Selection of agricultural tractors and implement during the purchasing process, Hunt suggested the following procedure;
- ✓ Based on rotations, machinery practices, and other factors, determine the basic machinery requirements.
- ✓ Select a tractor that was approximately the right size.
- ✓ Using the tractor's unique data, select a complement of machinery that the tractor can manage.

- ✓ Calculate the total yearly cost of ownership and operation of the machinery, changing sizes or deleting machines where ownership was not justified, and E. Repeat the process for various tractor sizes. By comparing the costs estimated in step (D), the tractor with the lowest overall cost may be identified; in step (C), the most cost-effective size of machine for use with that particular tractor could be discovered by experimenting with various sizes (Misandube & Amon, 2015).

Farm tractor and equipment utilization management, as well as selecting the appropriate size of farm tractors and equipment to allow for economic production in farms, were critical. Many constraining issues have been ascribed to users' improper selection and use of farm tractors and equipment throughout the country. The following were some of the parameters discovered (Mwasandube & Amon, 2015).

- inadequate mechanization extension services
- a lack of general technical knowledge
- lack of mechanization credit
- poor quality of imported farm tractors and implements
- lack of awareness and knowledge about the influence of soil characteristics on mechanization in their respective area
- the variety of makes, types, and sizes of tractors and implements offered in the market
- high prices of spare parts
- poorly trained operators and mechanics
- lack of well-equipped workshops to repair farm tractors and implements
- some relevant machinery packages for main farm operations were unavailable.

Socio-economic factors; Price of machine, Brand of machine, commonly used machine in the area. Technical factors like; Farm power and equipment use, Price relating to mechanization, Fuel consumption, Power delivered by tractor, Implement power requirement, Availability of spare parts, Availability of maintenance service.

Soil cone index, bulk density, texture, and moisture content were all physical qualities of soil.
Farm machinery management does not ensure a return, but it was a significant expense that must be closely watched and managed. As a result, determining operating capacity in conjunction with the quantity of work to be completed in a timely manner was the first step in making efficient use of agricultural machinery (Hanna, 2016).

Knowing the common soil types of a given location, the moisture content of the soil, the types of tractor and implement to be deployed to the field, and selecting the most efficient and low fuel consumed tractor were all things to consider before deploying tractor, and implement to the field.

To do so, management must have data on hand and arrange the right selection of agricultural tractors, as well as implement sending them to the field for optimum production while saving energy such as fuel and labor.

Farm machinery sits dormant for much of the year due to the seasonal nature of agriculture in the country. As a result, idle machinery results in unnecessarily high expenses unless adequate off-season alternate use was made. Furthermore, equipment was sometimes unsuitable for the operational settings (i.e., the soil, climate, and agro ecological parameters), causing it to degrade more quickly (Amponsah & Kumi, 2012).

Idle tractors and implements, which exposed the deterioration, were not given enough attention. To operate and maintain machinery, skilled labor was required. Many tractor mechanization programs have failed in the past due to a severe lack of qualified workers to maintain and run them efficiently, resulting in tractors and equipment having shorter lives. Farm mechanization was hampered by a lack of repair and replacement facilities.

2.9. Managing Machinery and Equipment

To perform the necessary responsibilities of crop production, most small-scale and part-time farms would required certain equipment (s). Many tasks could be accomplished utilizing custom operators for individuals who were just getting started. However, it need to acquire a few products in order to accomplish chores on time. On a restricted start-up budget, matching the equipment to your operation can be tough. Effective machinery management entails having the proper size and type of equipment on hand to complete the work at the lowest possible cost (William, 2017).

2.9.1. Machinery Cost

Owning and operating machinery was costly. Purchasing equipment was a significant financial commitment that could have a significant influence on your company's solvency and liquidity. To make the best machinery management decisions, you must be knowledgeable of the costs of owning and operating a specific piece of equipment.

2.9.2. Ownership Costs

Because the goal of farmers who practice good machinery management was to provide dependable service for their agricultural enterprises at the lowest possible cost, it's important to think about the different options for doing so, such as owning the equipment, using custom hire services, renting, sharing, or a combination of these. Although most farmers prefer to own and run their own equipment, doing all duties using owned equipment could be highly costly.

Depreciation, interest on investment, taxes, insurance, and housing were all costs of ownership for machinery and equipment. Because ownership expenses exist whether or not an object was used, they were typically referred to as "fixed" costs. Certain implements may only be used once in a while (or even once every couple of years), but having them on hand takes up space, necessitates regular upkeep to keep them usable, and depreciates in value year after year. Rather than trying to keep obsolete equipment in working order, renting or custom hiring such implements or machinery was often a preferable option.

Depreciation was a noncash expenditure that reflects an asset's loss in value over time due to wear and tear, as well as obsolescence. Depreciation was a method of allocating an asset's cost over its useful life on accounting accounts. Although accelerated depreciation methods could be used to depreciate an item for tax purposes, straight-line depreciation (also known as economic depreciation) was a more accurate approximation of a machine's actual annual depreciation and value fall over time. Economic depreciation was determined by taking the initial cost (plus any taxes, registration fees, or license costs) less the salvage value (sale price when the item was sold off the farm) divided by the expected years of use.

Having capital invested; In machinery and equipment means that this money was not available for other purchases. Interest on investment was a fixed cost because, it was tied to the ownership of the asset rather than its actual use. The interest on investment for a single piece of equipment could be calculated by multiplying the average value of the machine by your interest rate for borrowing:

Insurance; Another cost that was related to ownership rather than the quantity of use for a piece of farm equipment was insurance to protect the investment. The cost of insurance could be considered of as the cost of an actual policy to cover liability, weather damage, fire, theft, or collision, or it could be looked on as the cost of self-insurance if you bear all of the risk yourself. The cost of insurance was highly dependent on the location, the amount and kind of coverage, and whether or not the vehicle would be used over the road. An estimate of 0.5 percent of the machine's typical worth could be used, but your insurance agent could offer you with more accurate estimations based on your specific insurance needs.

Business Insurance: Another expenditure that should be considered a fixed cost was housing. It was critical to protect machinery from the weather in order to keep it in working order and reduce maintenance costs. Calculate the annual cost of a square foot of storage space in a machinery shed or barn and multiply it by the number of square feet the piece of equipment occupies to get an estimate of housing costs. Another technique to determine the cost of machinery housing was to double the machine's typical cost by 1%, which was the average cost based on studies of various types of equipment in various storage settings.

Operating Costs: The cost of operating a machine or tool is exactly proportional to the amount of time it is used. They were $0 if the machine or implement was not used, unlike ownership costs. The volume of use, the cost of fuel and labor, the size of the equipment, its efficiency, and the level of maintenance all influence operating expenses. Operating expenses were frequently referred to as "variable" costs since they fluctuate depending on how much a machine or piece of equipment is used.

Annual repair expenses vary depending on the type of machinery and its age, as well as its use and level of maintenance. New machines frequently come with warranties, and repair expenses were typically cheap in the first few years of ownership. As the piece of equipment ages and more parts wear out and need to be replaced, the cost of repairs will rapidly rise. Detailed repair records for each piece of equipment you possess were the finest source of information on repair costs. Based on your current amount of use, crop choices, and maintenance schedule, these data would help to decide when it's time to replace a specific item.

Fuel and lubrication costs primarily relate to a tractor or self-propelled equipment usage and depend on engine size, load, operating speed, and field conditions. Fuel usage depends on tractor size (power take off horsepower, PTOph), and fuel type; a diesel engine was more efficient than a similarly sized gasoline engine.

Diesel tractors use an average of 0.044 gallons of gasoline per hour for each PTO hp, according to data from University of Nebraska tractor tests. For each PTO horsepower, gasoline engines need an average of 0.06 gallons of fuel per hour. The cost of lubrication and filters could be estimated by adding 10% to 15% to the cost of fuel for tractors and self-propelled equipment.

Labor: was a significant cost in equipment operations, and it should be taken into consideration when comparing the costs of operating various quantities of machinery or determining if bespoke hire makes sense. The farmer normally provides labor for machine operation, however, this was not always the case. Another essential factor to consider while managing your machinery investment was the availability and quality of workers.

Equipment Life: Properly maintained equipment will remain usable for many years. Poorly maintained equipment would wear out several years before well-maintained equipment. Preventive maintenance was time and money well spent. Think of a personal vehicle if it was serviced regularly, it will last many years. This includes oil changes, removing road debris, and fixing a problem as soon as it arises. The same principle was true for farm equipment. The operator's manual that comes with a new tractor would have recommendations as to the amount of hours between maintenance intervals.

When buying new equipment, ask the vendor to explain the types of oil to use for the various seasons of the year, or which oil they recommend. Some tractor companies advocate (engine and hydraulic oils, and some require) their own brand of grease, and any warranties would be voided if they were not used. If this was the case with the brand, it was strongly recommended that follows their guidelines. Ask the dealer to show where the fittings were located and at what intervals to grease, and this information was also available in the operator's manual.

CHAPTER THREE

MATERIALS AND METHODS

3.1. Description of Study Area

The study was carried out at Fincha Sugar Factory, Horro Guduru Wallaga zone, west central Ethiopia from March 2014 to September 2015. The project was bounded by escarpments from east, west and south within the general boundaries of latitudes 9º 37''N to 9º 57''N and longitudes 37º 10'' to 37º 30''E at an altitude between 1350 and 1600 m above sea level at about 332km north-west of Addis Ababa. The Factory can be reached via the main highwaiy from Addis Ababa to Gedo (192 Km west of Addis Ababa) and thereafter by means of an all-weather gravel road from Gedo to Finchaa Dam (95 Km to the north-west of Gedo). Then at 47 Km away from Fincha town, following a gravel road running along the top of the escarpment before it descends very steeply end to the factory area (FSF report, 2010 EC).

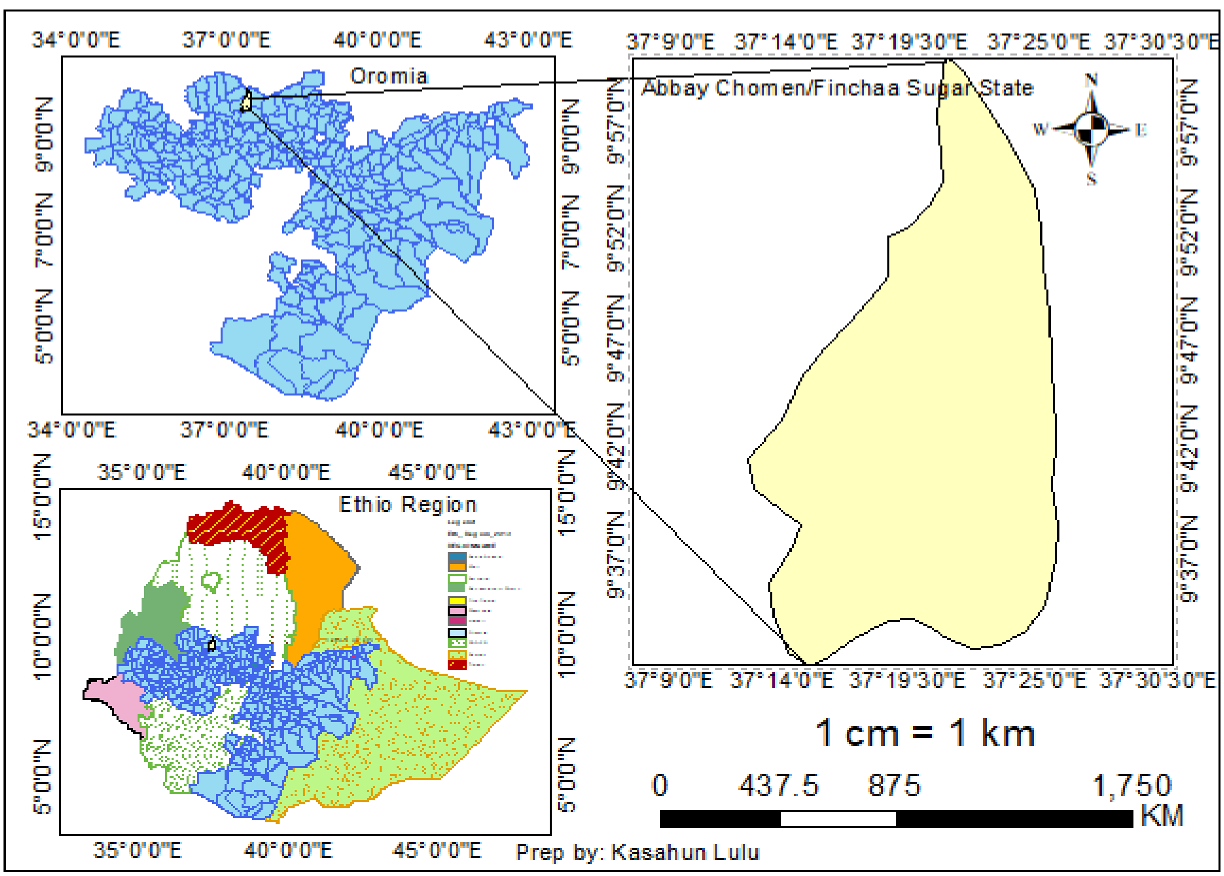


Figure 3. 1. Map of Ethiopia and fincha Sugar Factory

3.2. Materials

During the time that this research is carried out some resources have been used.

Table 3. 1. The Materials used for the study were presented as follows

Balance	For measuring the weight
Oven	For drying the soil sample
Sieve	For particle size distribution
Tractors	New Holland TM135, Belarus MTZ1221, John Deer 6130J
Implements	Notched Or Plain Disc (Optional)
Stop pitch	For counting the running time of the tractor
Tape Metter	To measure the Depth,and Width of soil cut

A. Tractors Specification

Table 3. 2. Technical Specifications of Tractos

Specification	New Holland (T1)	Belarus (T2)	John Deere (T3)
No. Of Cylinder	6	6	6
Power (KW)	100.7	96.9	96.9
Capacity (CC)	25.5L/h	27.0 L/h	27.0L/h
Engine Rated RPM	2200	2100	2100
Cooling	Iter cooled	Iter cooled	Iter cooled
Air Filter	dual dry element	Cab air filter	Distribution filter
Clutch	electro-hydraulic wet disc	electro-hydraulic wet disc	dry, two-disk the option of permanently closed type
Gear Box	Power shuttle	24 forward and reverse	Gear box (GB). Primary shaft (16x8)
Forward Speed	30.2km/h	40 km/h	33.8Km/h
PTO Type	Independent	Independent/Standard	Mechanical independent live
PTO RPM	540@1970	540 rpm PTO/1496 engine rpm	540/1000
Fuel Capacity	219.9L	195 L	160 L

Source: (Rahate et al., 2020)

a. New Holland TM135 b. John Deer 6130J c. Belarus MTZ1221

Figure 3. 2. Tractors used in the field experiment

A. Implement Specification

Table 3. 3. Selection of implement used in the field experiment

Model	Disc Plough Fkmdp – 4
Cutting Width	1100-1800 mm
Disc Diameter	660 x 6 T (26") OR 710 x 7 T (28")
Frame	Seamless Tabular Frame (OD 168, ID 146)
No of Discs	4
Required tractor HP	81-100 , 91-120, 91-135
type of Disc	Notched Or Plain Disc (Optional)
Weight (kg)	510

Source: Manufacturer manual, (2012)

A. Field Test:- The following were the field test to be carried out:

Effect of forwarding velocity and implement type on the draft requirement, fuel consumption, wheel slippage, tractor drawbar power, traction efficiency, and overall energy efficiency.

Each of the experimental sites covers an average of 9000 m^2 (0.9ha). For random observations, the land area was divided into four 180 x 50 m^2 sections. Each unit was 14 m apart to avoid plot border interaction and to be equally used as headlands for the start of the experimental procedures.

Discplow: There were four share disc on the Disc plough. The Disc coverage width was set to 1800 mm, and the maximum work depth is 300 mm.

During field test the following parameters keep constant; engine speed, gear ratio, and ballast and tyre inflection.

B. Field Specification:- For this research so many materials have been used. The main material specifications were shown in the table below.

The field has a dimension of (180x50) m^2. The assumed run given for the tractor was 50 and 14 m was given for calibration of the tractors.

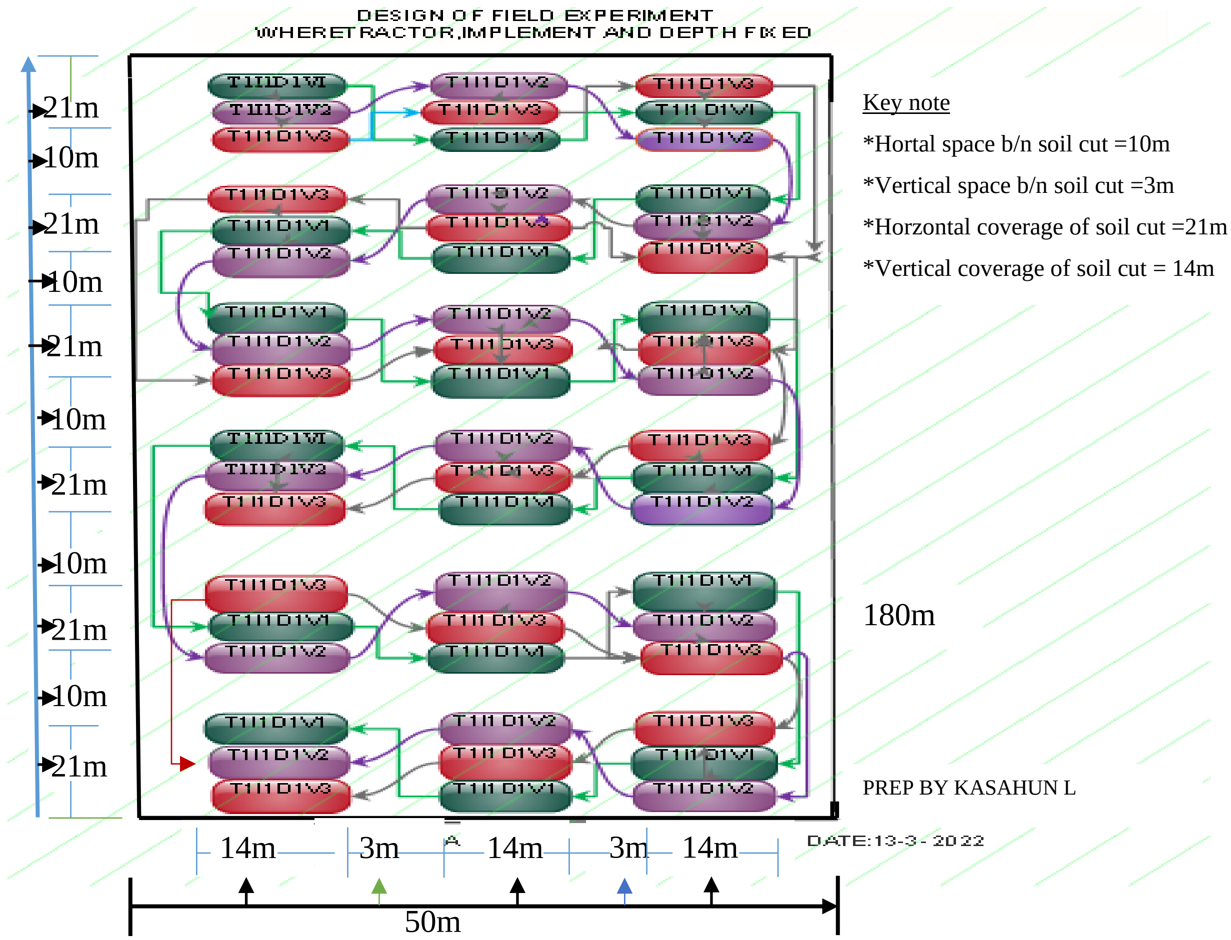


Figure 3. 3. Figure design of field experiment

T1 = New holland TM135 T2=Belarus MTZ1221 T3 =John Deer 6130J D = Depth W =Width S = Speed

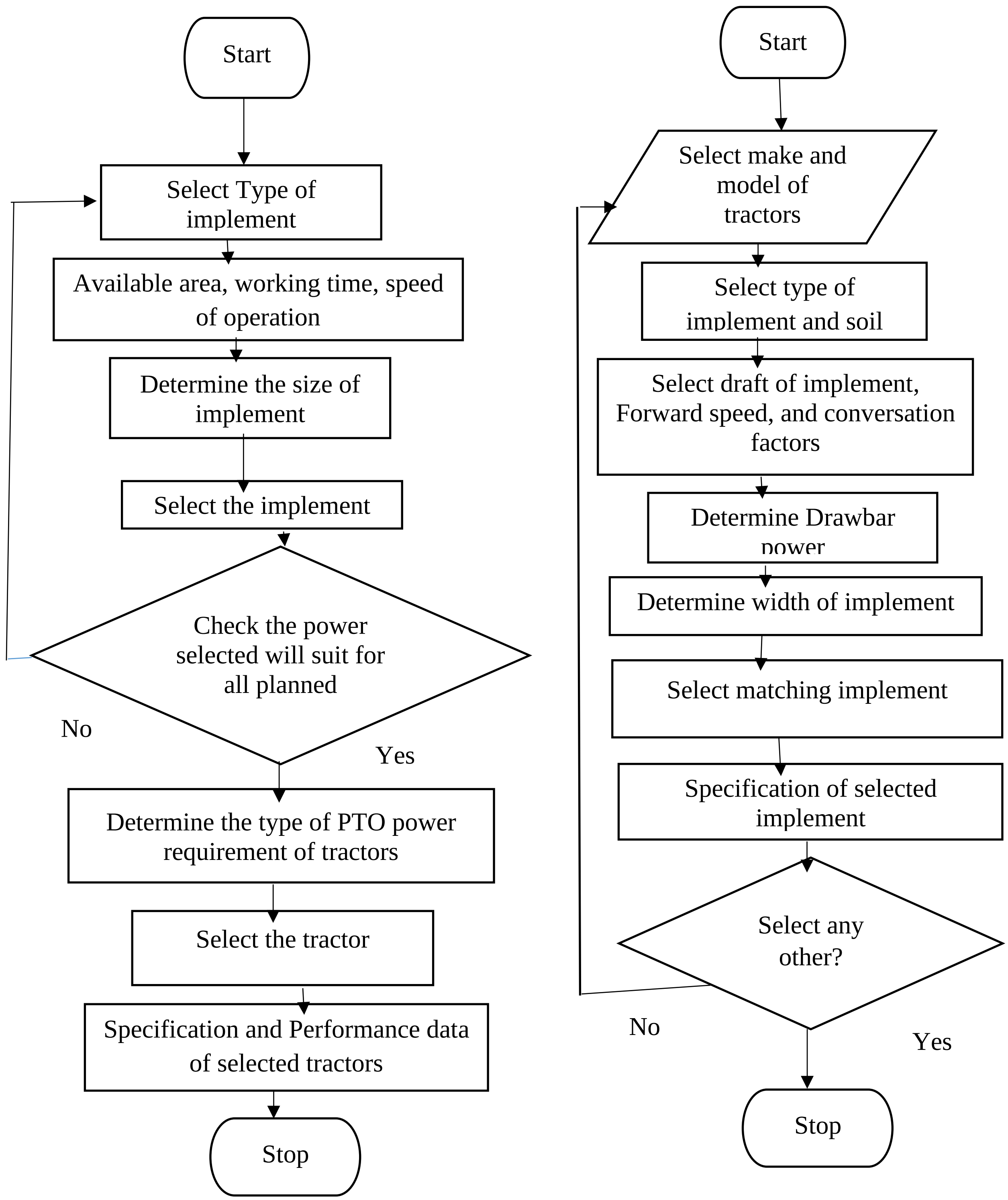


Figure 3. 4. Flowchart of the overall operation process in the research

3.3. Data Requirement

Data for the study used both primary and secondary data obtained from plantation office, product office, harvesting office and planning and project office. The primary data was collected through a developed questioner to collect detailed information on various aspects of sugarcane productivity using the target group farm units.

3.3.1. Source of Data

Secondary data was obtained from documents of the firm from each section (cross-sectional data will be used 2013/2014). The primary was collected from the target Farm units based on prepared questionnaires targeting the data of machinery management and outputs of sugarcane production and actual data was collected from field operation.

3.3.2. Method of Data Collection

The data was collected using diploma level and degree enumerators first trained and who know the local language.

3.3.3. Method of Data Analysis

To fit the objectives of the research and to analyze the data, the study was used two types of data analyses, namely; qualitative data analysis and quantitative data analysis. These methods were used for analyzing the primary data collected from the study area. After the data collection was completed, information was compiled for data processing. Then the compiled and coded data was analyzed using a computer softwwere program called SPSS,Origin and excel.

3.3.4. Soil Analysis Tests on Research Farm

Random sampling method was used to identify and select research farm based on the following variables; The farm is engaged in commercial crop production, and it must have its major field operation mechanized with adequate availability of farm tractors and equipment, farm size must be large that was, 180x50 m of land used in order to sufficiently accommodate the field studies.

Table 3. 4. Variations of selected soil physical properties with soil (Tesfaye et al., 2020)

Variables	From selected farm site
PH- value	6.9-7.13
% sand	35.17
% silt	22.91
% clay	41.92
Soil type	Clay-loam
Moisture content(db)	1.30g/cm3

3.4. Improving Field Efficiency

The capacity to increase field efficiency was the next critical stage in honing machinery management abilities. There were several major reasons why a machine's field efficiency may vary. There were several lost-time factors incorporated into the operation. Other sources of lost time could be eliminated with good planning and management.

Field operations and turning time; one loss factor incorporated into every field operation was turning time, which could be reduced by arranging fields with lengthy rows. A standard turn at the end of a field was one that could be completed in a single motion.
The rate and quality with which operations were completed were used to assess farm equipment performance. This was commonly described in terms of both capacity and efficiency.

3.5. Capacity

Farm tractor implementation planning and selection is a complicated process that involves a number of criteria, including field performance characteristics and other technical and socioeconomic aspects.
Calculations of machine capacity involve measuring the area covered, the weight of material and time.
The machine capacity was normally expressed in three ways:
a) Field capacity b) Material capacity c) Throughput capacity

3.5.1. Field Capacity

It is the rate of field coverage. It was also expressed in two ways:
A) Theoretical field capacity B) Effective field capacity
It is measured by considering 100 percent of time at the rated speed and covering 100 percent of its speed and covering 100 percent of its rated width (Rahate et al., 2020; Cherinet, 2011).
Theoretical field capacity (Ct) was expressed as;

$$TFC = \frac{SW}{8.25} \text{ ,acre/h} \quad \text{.........} \quad (3.1)$$

Where: S = average speed of machine, mph
w = rated width of the machine, ft.

$$TFC = \frac{SW}{10} \text{ ,ha/h} \quad \text{.........} \quad (3.2)$$

Where:
S = average speed of the machine, km/h
w = rated width of the machine, m

Thus, these values represent the best that a machine can do if there were no stoppages and the machine was taking its full width all the time.

A. Determination of Effective Field Capacity

The effective field capacity (EFC) of a machine in the field could be easily calculated by dividing the acres completed by the hours of actual field time. Recording acres and hours for several fields over the whole season could be used to find an average field capacity in differing terrain and weather conditions (Hanna, 2016).

The machine speed can be selected or determined by noting the working or operation distance of the machine and time taken to cover such distance and evaluated using (Oduma et al., 2021) The farm equipment seldom covers its rated width and performs its function 100% of the time. Therefore, it never meets the theoretical field capacity. Effective field capacity was the actual rate of field coverage. It was expressed as;

$$EFC = \frac{SWEf}{10}\text{, ha/h} \quad \ldots\ldots\ldots (3.3)$$

Field capacity (acres/hour = (speed (mph) x width (feet) x field efficiency (%))/8.25 or

$$EFC = \frac{SWEf}{8.25}\text{, acre/h} \quad \ldots\ldots\ldots (3.4)$$

Where: EFC = effective field capacity, ha/h

Ef = field efficiency, fraction

Unclogging machine: One-time factor that can be nearly eliminated by good management is unclogging machines. It was also the main reason for an unusually high percentage of lost field time.

There were three main reasons for clogging a machine.

1) Overloading the machine

2) Faulty working of the machine

3) Operating the machine when conditions were not right

By checking out machines ahead of the season there would be less clogging and field efficiency would improve substantially.

Making adjustments: With most machines, it was necessary to make adjustments before going to the field. Some machines, like combines or balers, have to be adjusted occasionally in the field as crop conditions vary throughout the day.

Reducing breakdowns: It was impossible to predict when some parts of a machine would fail, but many machine breakdowns in the field could be avoided by making thorough inspections before and during operation.

To help eliminate or reduce breakdowns the following points need to be considered:

- Inspect and repair the machines well ahead of the use season.
- Carry out preventive maintenance.
- Avoid rocks, holes, and obstructions.
- Drive cautiously in rough fields.
- Avoid overloading the equipment.
- Check out strange sounds, vibrations or smells.
- Make small repairs when needed.
- Use periodic checking to locate potential trouble.
- Keep all power transmitting members adjusted, aligned and lubricated.

B. Determination Field Efficiency

The field efficiency was calculated using the formula presented by (Kepner, et al., 1982). The ratio of a machine's productivity in the field to its theoretical maximum productivity was known as field efficiency.

Actual effective field capacity was less than this due to turns and other delays. The ratio of actual or effective field capacity (EFC) to TFC was called the machine's field efficiency (Hanna, 2016).

$$FE(\%) = \frac{EFC}{TFC} X100 \quad \text{.......} \quad (3.5)$$

Failure to utilise the machine's theoretical operating width, time lost due to operator capability, habits, and operating policy, and field characteristics were all factors in field efficiency. Field time and field efficiency do not include travel to and from a field, major repairs, preventative maintenance, and daily service tasks.

Field efficiency was influenced by the size and shape of the field, the pattern of field activity, crop yield, moisture, and crop conditions. It was wating for other machines, turning an idle travel, materials handling, seed, fertilizer, chemicals, water, harvested material, cleaning clogged equipment, machine adjustment, lubrication, and refueling (aside from daily servicing) account for the majority of time lost in the field. Effective field capacity was influenced by field speed, machine operating width, field efficiency, and field unit yield. An area's capacity was expressed as:

$$\mathrm{Ca} = \frac{\mathrm{SWEf}}{10} \quad (3.6)$$

Where: Ca = area capacity, ha/h;

s = field speed, km/h;

w = implement working width, m;

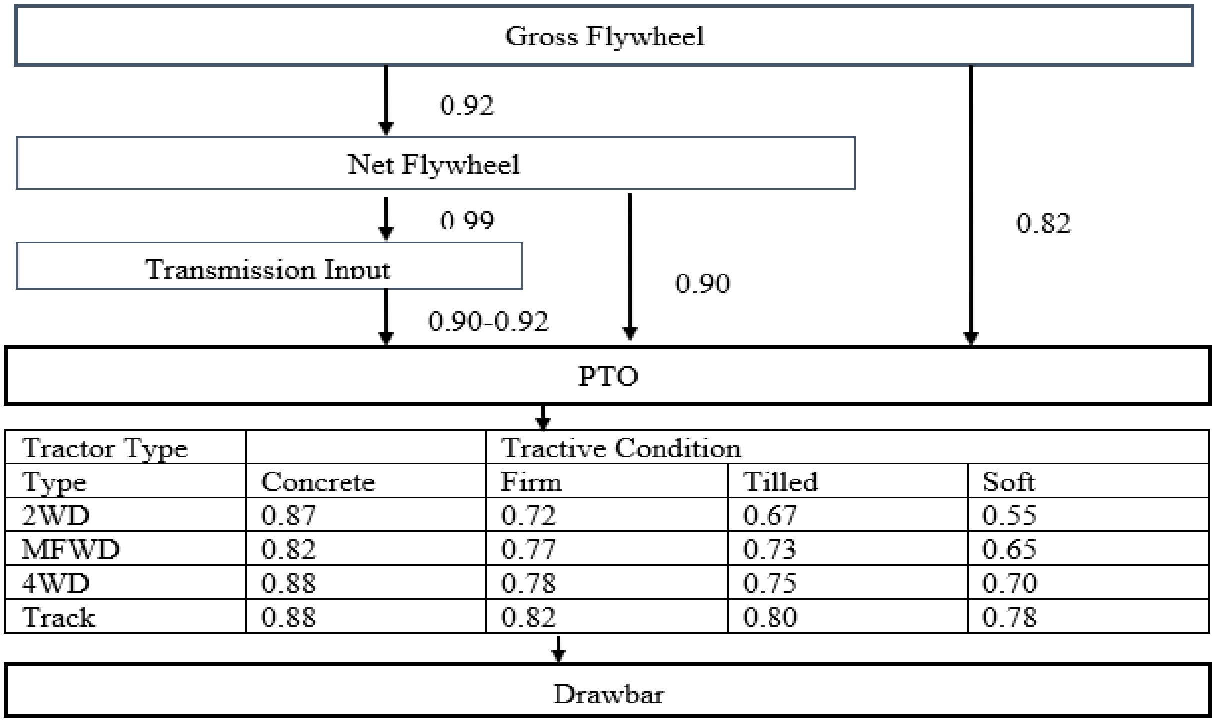
Ef = field efficiency, decimal;

Tractors were the main consumers of energy in agricultural operations. The increasing price of fuel and the environmental impacts of fuel pollutants compel optimizing fuel consumption of the tractors. Tillage operations such as plowing were the most common use of tractors on the farm. Since the performance of a tractor has a significant effect on the tractor's fuel consumption, optimizing the performance can play a substantial role in reducing fuel consumption.

3.6. Tractor Available Power

Engine power was not utilized totally due to some power losses. Engine gross power output represents a particular engine's maximum output under ideal conditions. Net flywheel power was the engine power measured at the flywheel, not counting drive train losses. Drive train loss occurs when the power was transmitted from the fly wheel to the wheel. Then there was power loss due to slip, and rolling resistance.

Then by reducing the total power loss from the total power of the tractor was obtained the drawbar power of the tractor. According to ASABE, (2000) throughout the drive train, power at a given location could be used to estimate power at another location. For example, PTO power was estimated from net flywheel power by multiplying the net flywheel power by 0.90. If drawbar power was desired, choose the tractor type and tractive condition to determine the ratio from Figure below.



Tractor Type		Tractive Condition		
Type	Concrete	Firm	Tilled	Soft
2WD	0.87	0.72	0.67	0.55
MFWD	0.82	0.77	0.73	0.65
4WD	0.88	0.78	0.75	0.70
Track	0.88	0.82	0.80	0.78

Fgure 3. 1. Max P_m performance expected from agricultural tractors (Source: ASABE, 2000, 2003, 2006).

After comparing the calculated drawbar requirement of implement with the available usable tractor power the status of the current working condition of tractor ould be known. If the tractor available power was much greater than the power requirement of the implement it means the tractor was working under its performance it was consuming time to finish a specific task and also consuming more fuel. If the drawbar requirement of the implement was greater than the available usable power of the tractor it means the tractor was working over its performance due to overloading and this results in high operational cost and maintenance cost because the tractor was subjected for frequent breakage.

3.7. Power Utilization Ratio

Power utilization ratio designated by x and it was the ratio between the equivalent power required by the implement and the maximum available power from the tractor. (ASABE, 2000).

$$x = \frac{\text{implement by the requirement PTOpower equivalet}}{\text{tractor from PTOpower available}} \quad \text{...} \quad (3.7)$$

Where; X= Power Utilization Ratio

3.8. Development of Empirical Regression Equation

The study's data was subjected to regression analysis, and empirical regression equations for forecasting implement performance at various operation speeds were created. By comparing the experiment findings with the regression results using percentage error, the appropriateness of the equations developed from the study was determined. After that, the root mean squwere (RMS) of the error was calculated to see how accurate the anticipated results were. If the RMS errors of the prediction were less than 5%, the prediction is considered accurate. Furthermore, if the coefficient of determination, R2, was between 0 and 1, it will demonstrate the model's adequacy (Hunt. 2013).

3.9. Determination of Draft and Power

The American Society of Agricultural & Biological Engineers (ASABE) in (Feb, 2006) issued the standard (497), for estimating the draft requirements for different implements at different working conditions as follows:

$$D = Fi[A+BV+CV]wd \quad (3.8)$$

Where: D = implement draft (N)

F = dimension less soil texture adjustment parameter

i = 1 for fine, 2 for medium and 3 for coarse texture

A, B & C = machine specific parameters from table

V = field speed (km/hr)

W = machine working width, (m)

D = tillage depth (cm), (in).

Measurement of draft: Draft was the power, in relation to pull-type or mounted implements, actually required to pull or move the implement at uniform speed. Draft is calculated due to drawbar power using equation (Oduma et al., 2019).

$$D = \frac{CxDBp}{V} \quad (3.9)$$

Where: D = draft, kN;

C = constant = 3.6;

DBP = drawbar power, kW;

V= travel speed,km/h-1.

Drawbar power

$$Pdb = \frac{DxV}{C} \quad (3.10)$$

Where: Pdb = drawbar power, kW

D = implement a draft, KN

C = constant = 3.6

V= travel speed, Km/hr

3.10. Slip

Tractor wheel slippage has traditionally been one of the most important efficiency variables impacting fuel usage. A tractor that was operating at peak efficiency not only saves money on fuel but also makes the best use of time and resources. Agricultural tillage involves soil cutting, turning, and pulverization, all of which require a lot of energy, not only because of the vast amount of soil mass that needs to be moved, but also because of poor energy transfer mechanisms to the soil (Ahaneku et al., 2011).

Traction elements, soil conditions, implement type, and tractor setup all affect tractor performance (Zoz et al., 2003). Tillage energy was influenced by soil moisture content, bulk density, soil texture, and shear strength (Olatunji et al., 2009). Plough resistance and energy requirements were known to be affected by plough body parameters and soil variables such as hardness, density, friction, and stickiness (Aday, 2011; Vilde, 2004).

The rear wheel slippage was determined as follows: (i) The rear wheel of the tractor was marked with a piece of chalk at a position tangent to the ground surface, (ii) A distance covered by seven revolutions of the wheel when the tractor was unloaded was measured, (iii) Another distance covered by the same number of revolutions was measured when the tractor was loaded with the implement, and these measurements were repeated (percent).

$$S\% = \frac{D_u - D_l}{D_u} x100 \quad (3.11)$$

Where: D_U= Distance travelled with unloaded tractor.

D_L= Distance travelled with loaded tractor.

$$Sw = \frac{Dw}{T} \quad (3.12)$$

Where: Sw = Working speed, kmh-1;

Dw = Working distance, km;

T = time, (h)

3.11. Soil Moisture Content

Direct and indirect approaches were used to determine the moisture content of the soil (Fan & Su, 2008). The direct methods entail removing water through evaporation, leaching, or chemical reaction, and then calculating the amount of water lost. Calculate the soil's moisture content as a percentage of the dry soil weight;

$$W = \frac{W_s - W_d}{W_d} x100 \quad \text{.......... (3.13)}$$

Where: W = moisture content, % db

Ws = wet mass of soil, g

Wd dry mass of soil, g

3.12. Bulk Density of Soil

The dry weight of soil divided by its volume yields bulk density, which was a measure of soil compaction. The volume of soil particles as well as the volume of pores between soil particles were included in this volume (Ditzler & Tugel, 2002).

Soil texture, as well as the densities of soil minerals (sand, silt, and clay) and organic matter particles, as well as their packing arrangement, influence bulk density. It was determined as follows (Javadi & Hajiahamad, 2006).

$$\rho = \frac{M}{V} \quad \text{.......... (3.14)}$$

Where: ρ = bulk density, g/cm^3

M = mass of the soil, g

V = volume of soil, cm^3

3.13. Fuel Consumption

Tillage was a type of preliminary land preparation that was necessary for crop production. Prior to the mechanization of agriculture, tilling the soil to increase food output in agriculture had been practiced for many years (McKyes, 1985). According to (Ahaneku et al., 2011), the only source of power was a tractor. Plowing, harrowing, and ridging were all tillage procedures that were particularly significant in agricultural land cultivation.

A predictive model can be used to estimate a tractor's fuel consumption during tillage and anticipate the variance of the process's dependent and independent variables.

Fuel consumption was the major diagnostic indicator in determining the state of a vehicle, according to (Michalski et al., 2014). Furthermore, since fuel prices continue to climb, energy consumption has become one of the most significant aspects of the agricultural economy. Increased power consumption by raising the operating speed, actual breadth of cut, soil strength, moisture content, and working depth were the parameters that fundamentally affect fuel consumption when utilizing tillage equipment (Cortez et al., 2008; Kichler et al., 2011; Silveira et al., 2013; Moitzi et al., 2014; Leghari et al., 2016; Nasr, 2016).

There were a variety of methods for calculating gasoline use, including filling the fuel tank and then refilling it after the job was finished. After the work was completed, another method was to read from the gauge. A graduated cylindrical container can be used to measure the amount of fuel necessary to refill the tractor's fuel tank immediately after a specific operation, and this measurement could be used to determine the amount of fuel utilized during any operation (Udo et al., 2000). Following the readings, the fuel consumption was calculated quantitatively using Equation.

$$FC = \frac{Vfc}{T} \quad (3.15)$$

Where, FC = fuel consumption

V_{fc} = volume of fuel consumption

T= time of operation

If the fuel consumption was measured in the form of mass, it must convert to volume using the density of the fuel at a given temperature.

$$Q_{ave} = (0.22X+0.096)xPtop\ available \quad (3.16)$$

Where: Q_{ave} = average fuel consumption, L/hr

X= Power utilization Ratio

It also evaluated specific fuel consumption using the following equation if diesel was used;

$$SFC = 2.64X+3.91-0.203\sqrt{738X+173} \quad (3.17)$$

Where: SFC = Specific fuel consumption, L/kwh

X= Power utilization Ratio

According to ASABE EP 496.2, (2003) the average gasoline fuel consumption could be calculated;

Q_{ave} = 0.305XPTO .... (3.18)

Where: Q_{avg} = average gasoline consumption, L/h;

P_{pto} = maximum PTO power required by the implement, kW;

3.14. Management of Machine Costs

The variety of tractor types and sizes, capital investment, trained labor requirements, timeliness, farm size, and the possibility of using the same equipment with different depth of cut, width of cut, and speed of travel with different crops make selecting the appropriate tractor and implement a difficult problem in machinery management (Marta., 2019).

To perform the necessary responsibilities of crop production, most small-scale and part-time farms would require certain equipment (s). Many tasks could be accomplished utilizing custom operators for individuals who were just getting started. However, you may need to acquire a few products in order to accomplish chores on time. On a restricted start-up budget, matching the equipment operation can be tough. Effective machinery management entails having the proper size and type of equipment on hand to complete the work at the lowest possible cost.

3.14.1. Machinery Cost

Owning and operating machinery was costly. Purchasing equipment is a significant financial commitment that can have a significant influence on company's solvency and liquidity. To make the best machinery management decisions, must be knowledgeable of the costs of owning and operating a specific piece of equipment.

3.14.2. Ownership Costs

Because the goal of farmers who practice good machinery management was to provide dependable service for their agricultural enterprises at the lowest possible cost, it's important to think about the different options for doing so, such as owning the equipment, using custom hire services, renting, sharing, or a combination of these. Although most farmers prefer to own and run their own equipment, doing all duties using owned equipment could be highly costly.

Depreciation, interest on investment, taxes, insurance, and housing were all part of the machinery and equipment ownership costs. Because ownership expenses exist whether or not an object was used, they were typically referred to as "fixed" costs. Certain implements may only be used occasionally (or even only once every couple years); however, having them on hand means they take up space, require periodic maintenance to stay usable, and decrease in value every year. Renting or custom hiring such implements or machines was often a better choice than trying to keep old equipment in operating condition.

Depreciation; Depreciation was a noncash expenditure that indicates an asset's depreciation over time due to wear and tear and obsolescence. Depreciation was a method of allocating an asset's cost over its useful life on accounting accounts. Although accelerated depreciation methods could be used to depreciate an item for tax purposes, straight-line depreciation (also known as economic depreciation) was a more accurate approximation of a machine's actual annual depreciation and value fall over time. The salvage value (selling price when the item was sold off the farm) is subtracted from the initial cost (plus any taxes, registration fees, or license expenses) and divided by the estimated years of use:

Economic Depreciation = (Cost − Salvage Value)/ Expected Years of Life

$$D = \frac{P_p - S_V}{L} \quad \text{...(3.19)}$$

Where: D = Depreciation

P_P = purchase price

S_V = salvage value

L = economic life

Having capital invested in machinery and equipment means that this money was not available for other purchases. Interest on investment was a fixed cost because it was tied to the ownership of the asset rather than its actual use. The interest on investment for a single piece of equipment can be calculated by multiplying the average value of the machine by your interest rate for borrowing: Average value of investment = (cost + salvage value) /2

$$AVI = \frac{P_p - S_V}{2} \quad \text{... (3.20)}$$

Where: AVI = Average value of investment

P_p = Purchase price (cost)

S_v = salvage value

Interest on investment = interest rate × average/ value of investment

$$I = R x \frac{P_p + S_V}{2} \qquad (3.21)$$

Where: I = interest

R = Rate of interest, %

P_p = purchase price

S_V = salvage value

Insurance; another cost that was related to ownership rather than the amount of time a piece of farm equipment was used insurance to protect the investment. The cost of insurance could be considered of as the cost of an actual policy to cover liability, weather damage, fire, theft, or collision, or it can be thought of as the cost of self-insurance if you bear all the risk yourself. The cost of insurance was highly dependent on local conditions, the amount and type of coverage, and whether or not the vehicle would be used off-road. As an estimate, a charge of 0.5 percent of the machine's average value could be utilized, but your insurance agent could give more accurate estimates that reflect your specific insurance needs.

Business Insurance: Housing was another cost that should be considered as a fixed cost. Protecting machinery from the elements was important to keep the machine or implement in working order and minimizing maintenance costs. Housing costs can be estimated by calculating the annual cost of a square foot of storage space in a machinery shed or barn and multiplying it by the number of square feet the piece of equipment occupies. Another way to roughly estimate machinery housing cost was to multiply the average cost of the machine by 1 percent, which was the average cost based on surveys of many types of equipment in various storage situations

Operating Costs: The use of the machine or implement determines the operating costs. They were zero if the machine or implement was not used, unlike ownership costs. The volume of use, the cost of fuel and labor, the size of the equipment, its efficiency, and the level of maintenance all influence operating expenses. Operating expenses were frequently referred to as "variable" costs since they fluctuate depending on how much a machine or piece of equipment was used. Annual repair expenses vary depending on the type of machinery and its age, as well as its use and level of maintenance. New machines frequently come with irranties, and repair expenses were typically cheap in the first few years of ownership. As the piece of equipment ages and more parts wear out and need to be replaced, the cost of repairs will rapidly rise.

Repair Cost: Detailed repair records for each piece of equipment you possess were the finest source of information on repair costs. Based on your current amount of use, crop choices, and maintenance schedule, these data would help you decide when it's time to replace a specific item.

Fuel and lubrication costs: The primarily relate to tractor or self-propelled equipment usage and depend on engine size, load, operating speed, and field conditions. Fuel usage depends on tractor size (power takeoff horsepower, PTOph and fuel type; a diesel engine is more efficient than a similarly sized gasoline engine.

Data from tractor tests conducted by the University of Nebraska show that diesel tractors use an average of 0.044 gallons of fuel per hour for each PTO hp. Gasoline engines use an average of 0.06gallonsn of fuel per hour for each PTO hp. Adding 10 to 15 per cent to the cost of fuel for tractors and self-propelled equipment provides a rough estimate of the cost for lubrication and filters.

Labour was a major cost in machinery operations and should be accounted for in order to compare the cost of operating different sizes of machinery or determine whether custom hire might make sense. Labour for machinery operation was usually provided by the farmer, but this was not always the case. The availability and quality of labour was another important consideration in managing your machinery investment.

Equipment Life: Equipment that was properly maintained would last for many years. Poorly maintained equipment would outlast well-kept equipment by several years. Preventive maintenance was a wise investment of both time and money. Consider personal vehicle: if it was serviced on a regular basis, it would last a long time. This includes oil changes, road debris removal, and problem-solving as quickly as possible. The same logic applies to farm machinery.

The operator's manual that comes with a new tractor will provide suggestions for how long between maintenance intervals should be. When buying new equipment, ask the vendor to explain the types of oil to use for the various seasons of the year, or which oil they recommend. Some tractor companies advocate (engine and hydraulic oils, and some require) their own brand of grease, and any warranties would be voided if they were not used. If this was the case with the brand, it should strictly adhere to their standards. Inquire with the dealer about where the fittings were and how often they should be greased; this information was also accessible in the operator's manual.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

Selection depends on resources owned by owners, and therefore; selection of farm machinery depends on machine owned by farm organization. For this study, three different models of tractors were used. The inventory of tractors (Table 4.1.) showed that the total available number of tractors for field operation owned by Finchaa Sugar Factory was thirty five tractors, of which three models of tractors were selected. These tractors were; New Holland TM135, Belarus MTZ1221 and John Deer 6130J.The other tractors, such as John Deer 9410, John Deer 9320, and Versatile 2375, were not considered for the study since they were huge in horsepower.. The percentage availability those tractors was; 40, 34.27, 8.57, 2.86, 8.57, and 5.71%.

A study was conducted to evaluate the effect of operating depth and working width on the drawbar pull and drawbar power of the implement. A number of performance measurements have been made including computation of drawbar pull, drawbar power, slip, power utilization ratio, effective field capacity, and annual cost incurred by tractors and implement . The summarized results obtained are presented in tables and graphs, discussed and the relevant interpretations given in the following sub sections.

Table 4. 1. The availability of Tractors in Finchaa Sugar Factory

S/n	Machine type	Model	Number	Percentage (%)	Condition	Under spare	Total
1	John Deer	6130J	12	40	Good	2	14
2	New Holland	TM135	9	34.29	Good	3	12
3	Belarus	MTZ1221	3	8.57	Good	1	3
4	John Deer	9410	1	2.86	Good	-	1
5	John Deer	9320	3	8.57	Good	-	3
6	Versatile	2375	2	5.71	Good	-	2
Total				100		6	35

(* Source Finchaa Sugar Factory).

4.1. Soil Physical Properties

For the soil type test the soil samples were taken from 0-10cm and 10-20, and 20-30cm depth. The soil textural class of the field was determined based on the particle size distribution through using USDA Soil Textural Triangle method. Accordingly it was vertisol which mean reach in clay, and sand 35.17%, silt 22.91%,and clay 41.92%. The bulk density of the soil at the field was found to be 1.30g/cm3 the moisture content was 30%.

4.2. Drawbar Pull and Drawbar Power Requirement

4.2.1. Drawbar Pull of Implement

From the (Table 4.2) show that how draft forces was determined using ASABE Standard and collecting draft requirement using tractors and implement by considering different parameters.

Results obtained shows that the relation between Depth of cut and Width of cut of disc plough was linear particularly Newholland TM135 and Belarus MTz1221 at depths 10 and 30cm. In a case of Belarus MTZ1221 with Depth of cut and Width of cut was linear relationship and the minimum and maximum draft force obtained was 5.5km/hr, and 7.5km/hr was 4.78, and 22.49KN (figure 4.3).

Both New Holland TM135 and Belarus MTZ1221 tractors was non linear relationship in a case of depth, width, and draft force. The minimum and maximum draft force obtained at W1=1.1m, D1=0.1m, V1=5.5km/hr was 4.78KN, and maximum draft output was W3= 1.6m, D3=0.3m, S3=7.5km/hr, and W3=1.78m, D3=0.3m, V3=7.5km/hr was 22.49KN (Table 4.2 and 4.3). But in a case John Deer 6130J tractor was minimum and maximum draft force at different depth, width, and speed was 5.22KN to 25.16KN, and depth, width, and speed was nonlinear relationship with draft force (figure 4.5, and 4.6).

Table 4. 2. Draft force analysis Tractors with Disk Plow

DRAFT FORCES FOR (T1)	W(cm)	D(cm)	V(Km/hr	DRAFT FORCES FOR (T2)	DRAFT FORCES FOR (T3)
FixK1xW1D1	180	10	5.5	FixK1xW1D1	FixK1xW1D1
FixK1xW1D1	180	10	6.5	FixK1xW1D1	FixK1xW1D1
FixK1xW1D1	180	10	7.5	FixK1xW1D1	FixK1xW1D1
FixK1xW1D2	180	20	5.5	FixK1xW1D2	FixK1xW1D2
FixK1xW1D2	180	20	6.5	FixK1xW1D2	FixK1xW1D2
FixK1xW1D2	180	20	7.5	FixK1xW1D2	FixK1xW1D2
FixK1xW1D3	180	30	5.5	FixK1xW1D3	FixK1xW1D3
FixK1xW1D3	180	30	6.5	FixK1xW1D3	FixK1xW1D3

FixK1xW1D3	180	30	7.5	FixK1xW1D3	FixK1xW1D3
FixK2xW1D1	180	10	5.5	FixK2xW1D1	FixK2xW1D1
FixK2xW1D1	180	10	6.5	FixK2xW1D1	FixK2xW1D1
FixK2xW1D1	180	10	7.5	FixK2xW1D1	FixK2xW1D1
FixK2xW1D2	180	20	5.5	FixK2xW1D2	FixK2xW1D2
FixK2xW1D2	180	20	6.5	FixK2xW1D2	FixK2xW1D2
FixK2xW1D2	180	20	7.5	FixK2xW1D2	FixK2xW1D2
FixK2xW1D3	180	30	5.5	FixK2xW1D3	FixK2xW1D3
FixK2xW1D3	180	30	6.5	FixK2xW1D3	FixK2xW1D3
FixK2xW1D3	180	30	7.5	FixK2xW1D3	FixK2xW1D3
FixK3xW1D1	180	10	5.5	FixK3xW1D1	FixK3xW1D1
FixK3xW1D1	180	10	6.5	FixK3xW1D1	FixK3xW1D1
FixK3xW1D1	180	10	7.5	FixK3xW1D1	FixK3xW1D1
FixK3xW1D2	180	20	7.5	FixK3xW1D2	FixK3xW1D2
FixK3xW1D3	180	30	5.5	FixK3xW1D3	FixK3xW1D3
FixK3xW1D3	180	30	6.5	FixK3xW1D3	FixK3xW1D3
FixK3xW1D3	180	30	7.5	FixK3xW1D3	FixK3xW1D3

W= width of implement, D =depth of Cut, Fi = soil machine parameters, V = speed of travel, T1= New Holland, T2= Belarus, and T3= John Deer

From the (Table 4.3) show that the average minimum Draft Force obtained at D1W1 V1, D1W1V2 and D1W1V3 was 4.97 KN and the average maximum Draft Force obtained at D3W3V1,D3W3V2 and D3W3V3 was 21.69 KN.

Table 4. 3. Draft forces Evaluation for each plot of land using New Holland TM135 Tractor

value of (K)	constant	constant	Fi	W (m)	D(m)	V(Km/hr)	draft (KN) T1
435.16	390	19	0.88	1.1	0.1	5.5	4.78676
451.88	390	19	0.88	1.1	0.1	6.5	4.97068
468.6	390	19	0.88	1.1	0.1	7.5	5.1546
Average							**4.97068**
435.16	390	19	0.88	1.3	0.2	5.5	11.31416
451.88	390	19	0.88	1.3	0.2	6.5	11.74888
468.6	390	19	0.88	1.3	0.2	7.5	12.1836
Average							**11.74888**
435.16	390	19	0.88	1.6	0.3	5.5	20.88768

451.88	390	19	0.88	1.6	0.3	6.5	21.69024
468.6	390	19	0.88	1.6	0.3	7.5	22.4928
Average							**21.69024**

The following (figure 4.1, 4.2) show that minimum and maximum draft force obtained from D1W1 and D3W3 respectively. As depth, width and speed increase draft force also increase and depth width and speed decrease draft force also decrease.

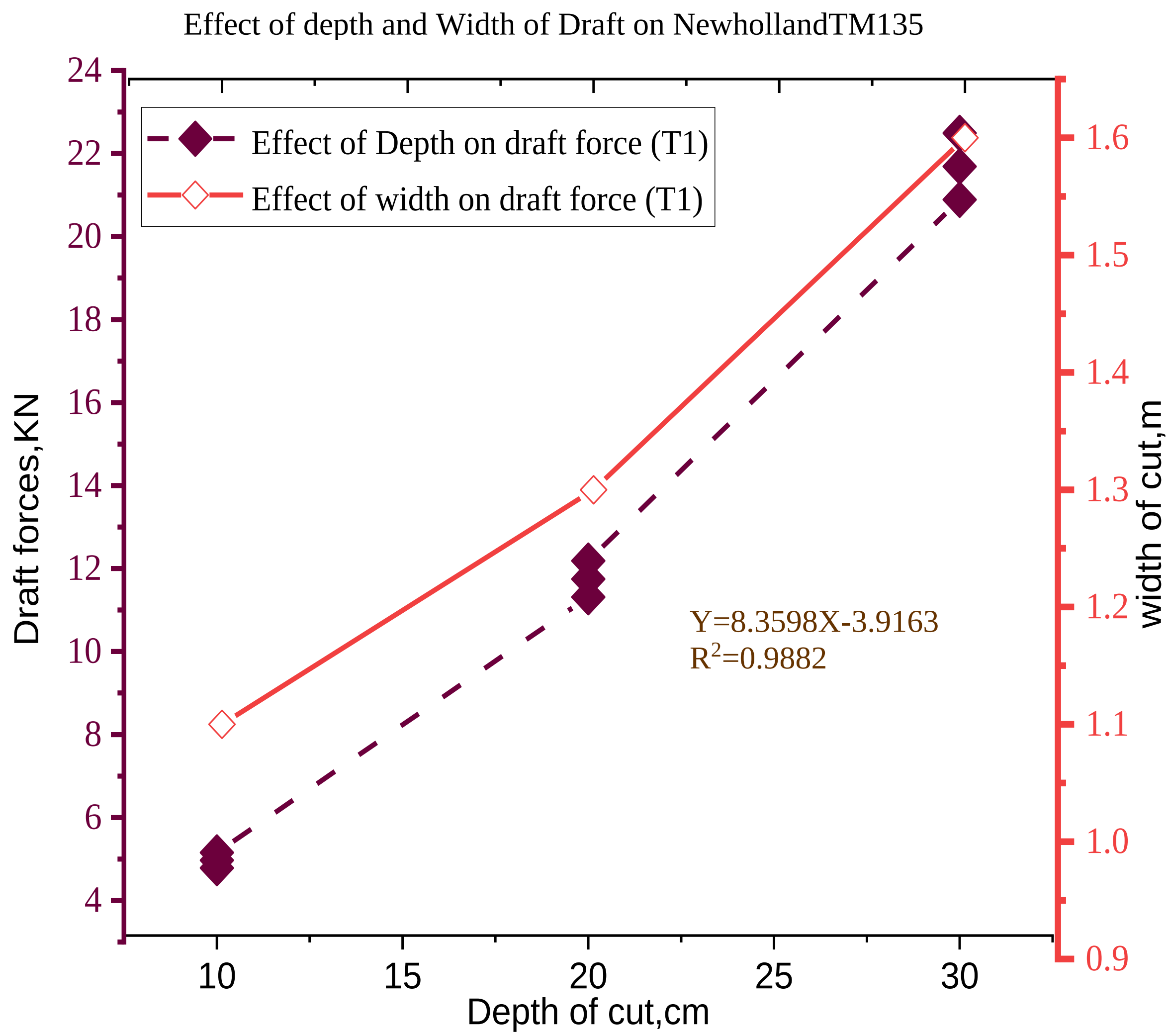


Figure 4. 1. Effect of depth, and Width on Draft Force (T1) of in Clay loamy Soil.

Effect of depth and Speed of Draft on NewhollandTM135

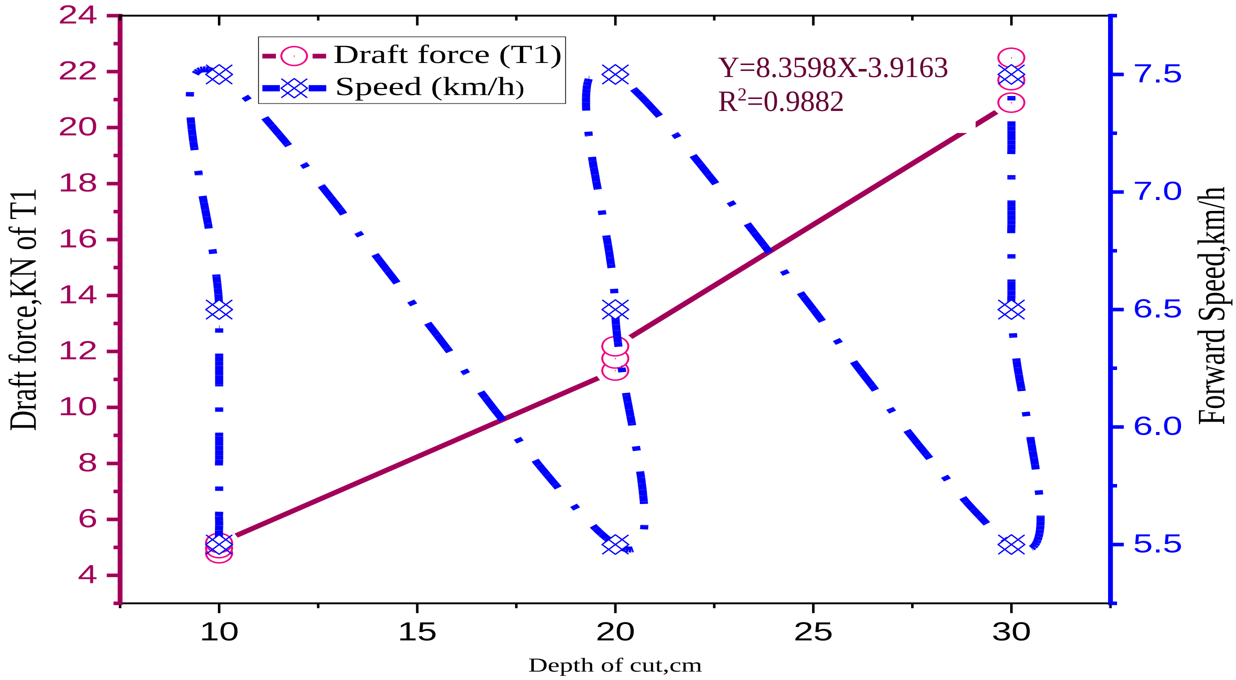


Figure 4. 2. Effect of Speed, on Draft Force (T1) of in Clay loamy Soil.

From the (Table 4.4) show that the average minimum Draft Force obtained at D1W1 V1, D1W1V2 and D1W1V3 was 4.97 KN and the average maximum Draft Force obtained at D3W3V1,D3W3V2 and D3W3V3 was 21.69 KN.

Table 4. 4. Draft forces Evaluation for each plot of land using Belarus MTZ1221 Tractor

value of K	Constant	Constant	Fi	W2 (m)	D (m)	V (Km/h)	Draft(T2) (KN)
435.16	390	19	0.88	1.3	0.1	5.5	4.78676
451.88	390	19	0.88	1.3	0.1	6.5	4.97068
468.6	390	19	0.88	1.3	0.1	7.5	5.1546
Average							**4.97068**
435.16	390	19	0.88	1.5	0.2	5.5	11.31416
451.88	390	19	0.88	1.5	0.2	6.5	11.74888
468.6	390	19	0.88	1.5	0.2	7.5	12.1836
Average							**11.74888**
435.16	390	19	0.88	1.78	0.3	5.5	20.88768
451.88	390	19	0.88	1.78	0.3	6.5	21.69024
468.6	390	19	0.88	1.78	0.3	7.5	22.4928
Average							**21.69024**

The following (figure 4.2, 4.3) show that minimum and maximum draft force obtained from D1W1 and D3W3 respectively. As depth, width and speed increase draft force also increase and depth width and speed decrease draft force also decrease.

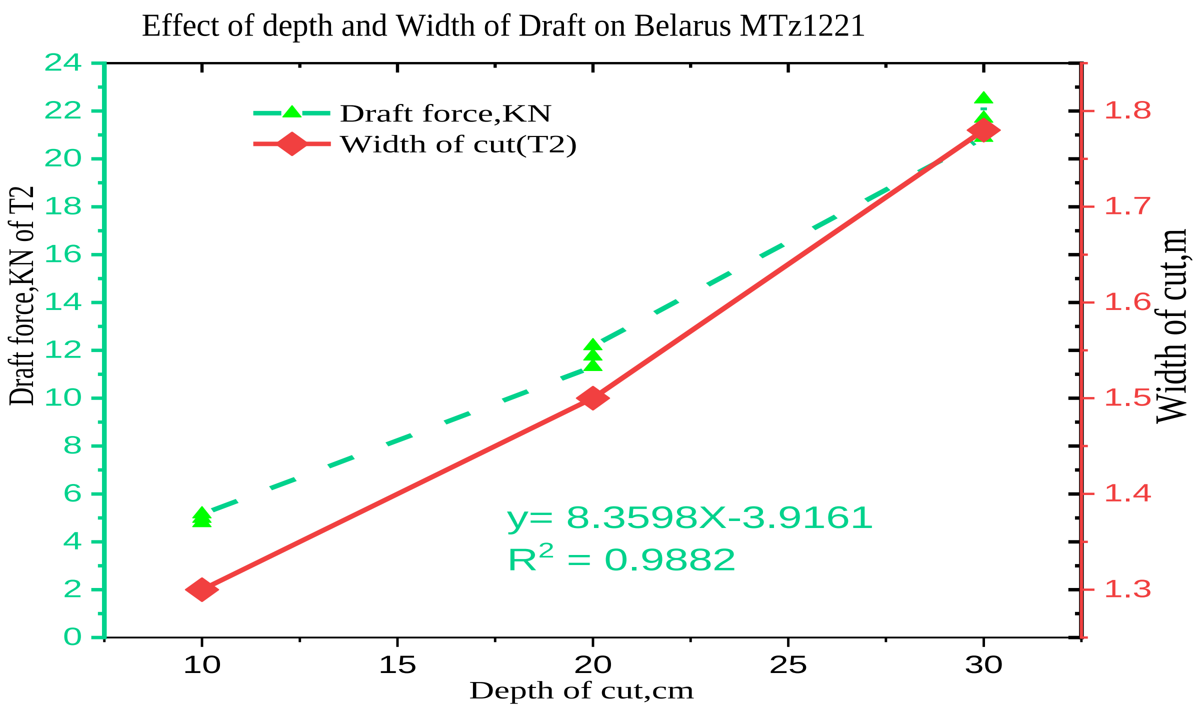


Figure 4. 3. Effect of Depth, and Width of cut on Draft Force (T2) in Clay loamy Soil.

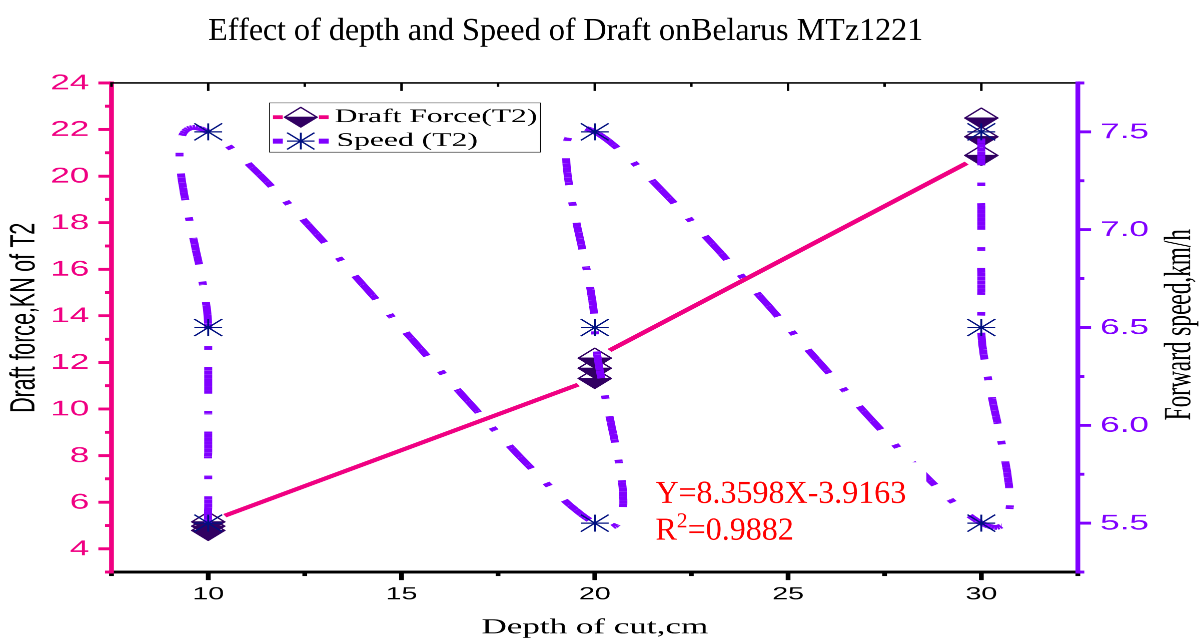


Figure 4. 4. Effect of Speed,and Depth on Draft Force (T2) in Clay loamy Soil.

From the (Table 4.5) show that the average minimum Draft Force obtained at D1W1 V1, D1W1V2 and D1W1V3 was 5.42 KN and the average maximum Draft Force obtained at D3W3V1, D3W3V2 and D3W3V3 was 24.26 KN.

Table 4. 5. Draft forces Evaluation for each plot of land using John Deer 6130J Tractor

Value of (K)	Constant	Constant	Fi	W3 (m)	D (m)	V (Km/hr)	Draft (T3) (KN)
435.16	390	19	0.88	1.2	0.1	5.5	5.22192
451.88	390	19	0.88	1.2	0.1	6.5	5.42256
468.6	390	19	0.88	1.2	0.1	7.5	5.6232
Average							**5.42256**
435.16	390	19	0.88	1.6	0.2	5.5	13.92512
451.88	390	19	0.88	1.6	0.2	6.5	14.46016
468.6	390	19	0.88	1.6	0.2	7.5	14.9952
Average							**14.46016**
435.16	390	19	0.88	1.79	0.3	5.5	23.368092
451.88	390	19	0.88	1.79	0.3	6.5	24.265956
468.6	390	19	0.88	1.79	0.3	7.5	25.16382
Average							**24.265956**

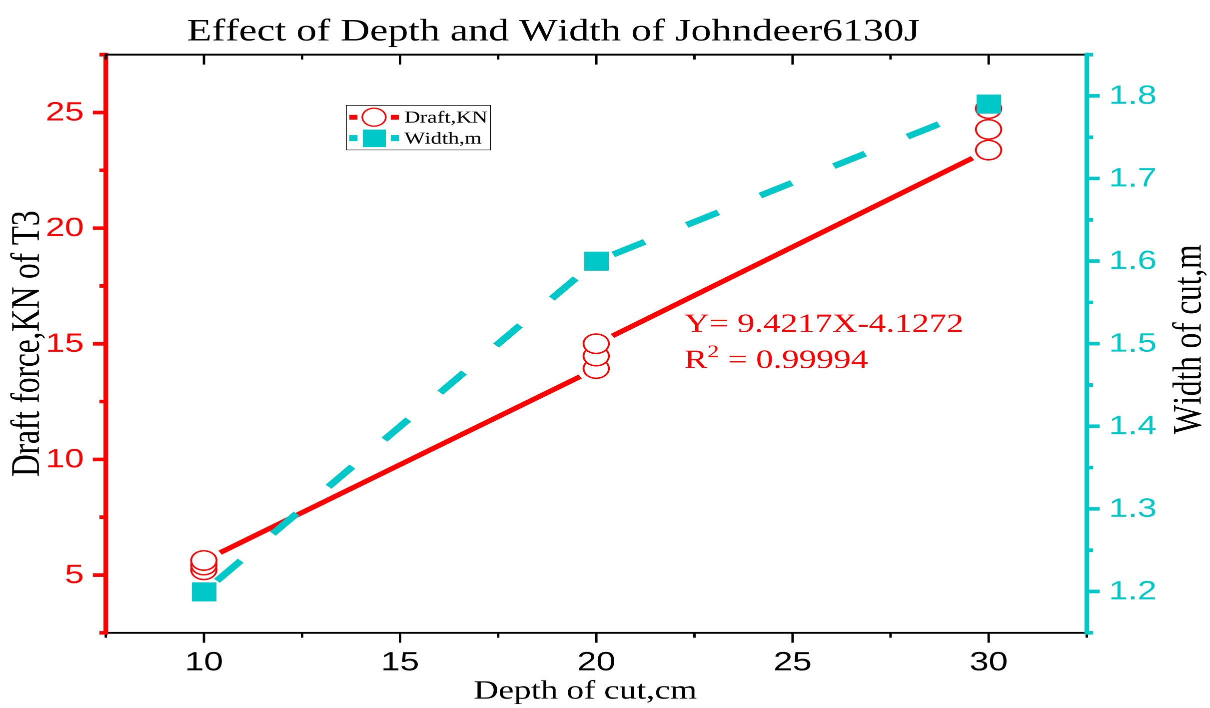


Figure 4. 5. Effect of Depth,and Width on Draft Force (T3) of in Clay loamy Soil.

The following (figure 4.5, 4.6) show that minimum and maximum draft force obtained from D1W1 and D3W3 respectively. As depth, width and speed increase draft force also increase and depth width and speed decrease draft force also decrease.

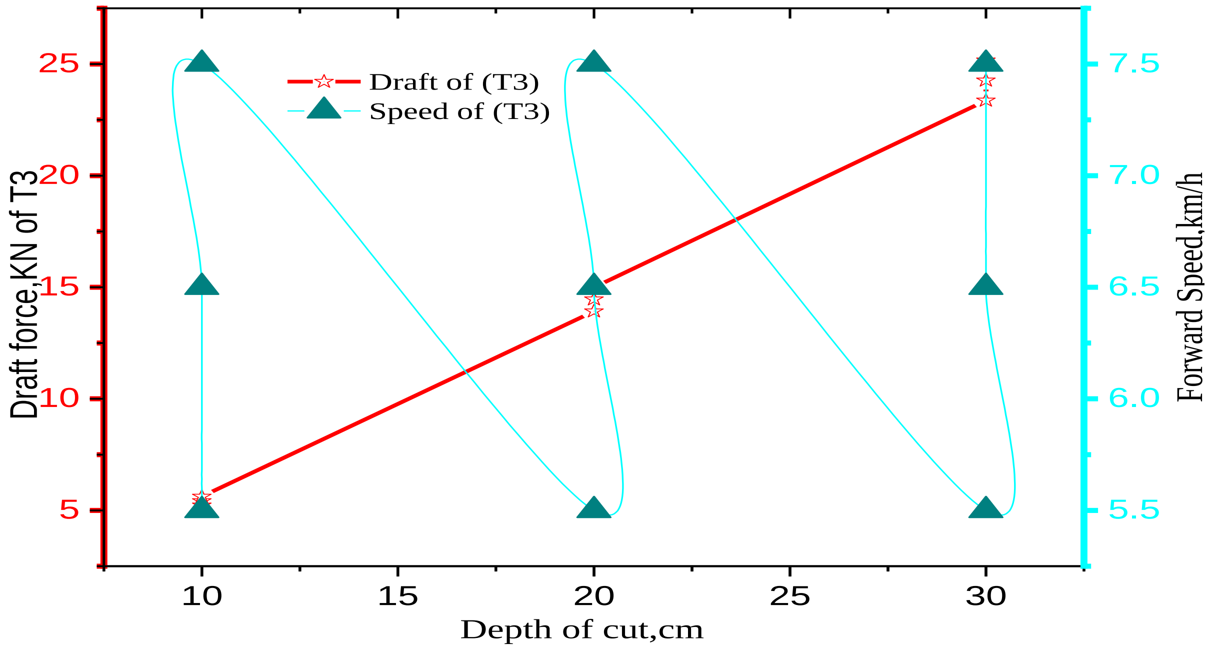


Figure 4. 6. Effect of Depth,and Speed on Draft Force (T3) of in Clay loamy Soil.

4.2.2. Drawbar Power of Implement

Drawbar power is a function of draft and speed. The results of the performance tests on the three tractors were shown in Table 4.6. Since a large pull and high speed results in a large drawbar power,and Newholland and Belarus produce high drawbar power which was 46.86KW, and minimum power was 7.31 kW at speed 5.5km/hr, 6.5km/hr and 7.5km/hr. Both New Holland and Belarus was show the same drawbar power output. The minimum and maximum Drawbar power obtained by Johndeer 6130J was 7.97 and 38.44 kW. Since minimum and maximum Drawbar power obtained by Newholland and Belarus was same output(Table 4.6).

Table 4. 6. Effect of Depth, and speed on DBpower of Disc Plough in clay loamy Soil.

D(cm)	V(Km/hr)	Draft (kN) T1	Dbp T1	draft KN T2	Dbp T2	Draft, T3	dbp T3
10	5.5	4.78676	7.3131	4.78676	7.31310	5.22192	7.97793333
10	6.5	4.97068	8.97483	4.97068	8.97483	5.42256	8.28446666
10	7.5	5.1546	10.7387	5.1546	10.7387	5.6232	8.591

20	5.5	11.3141	17.2855	11.3141	17.2855	13.9251	21.2744888
20	6.5	11.7488	21.2132	11.7488	21.2132	14.4601	22.0919111
20	7.5	12.1836	25.3825	12.1836	25.3825	14.9952	22.9093333
30	5.5	20.8876	31.9117	20.8876	31.9117	23.3680	35.7012516
30	6.5	21.6902	39.1629	21.6902	39.1629	24.26596	37.07298833
30	7.5	22.4928	46.86	22.4928	46.86	25.16382	38.444725

T1= New hollandTM135,T2=BelarusMTz1221,T3=Johndeer6130J, KN=Kilonewton

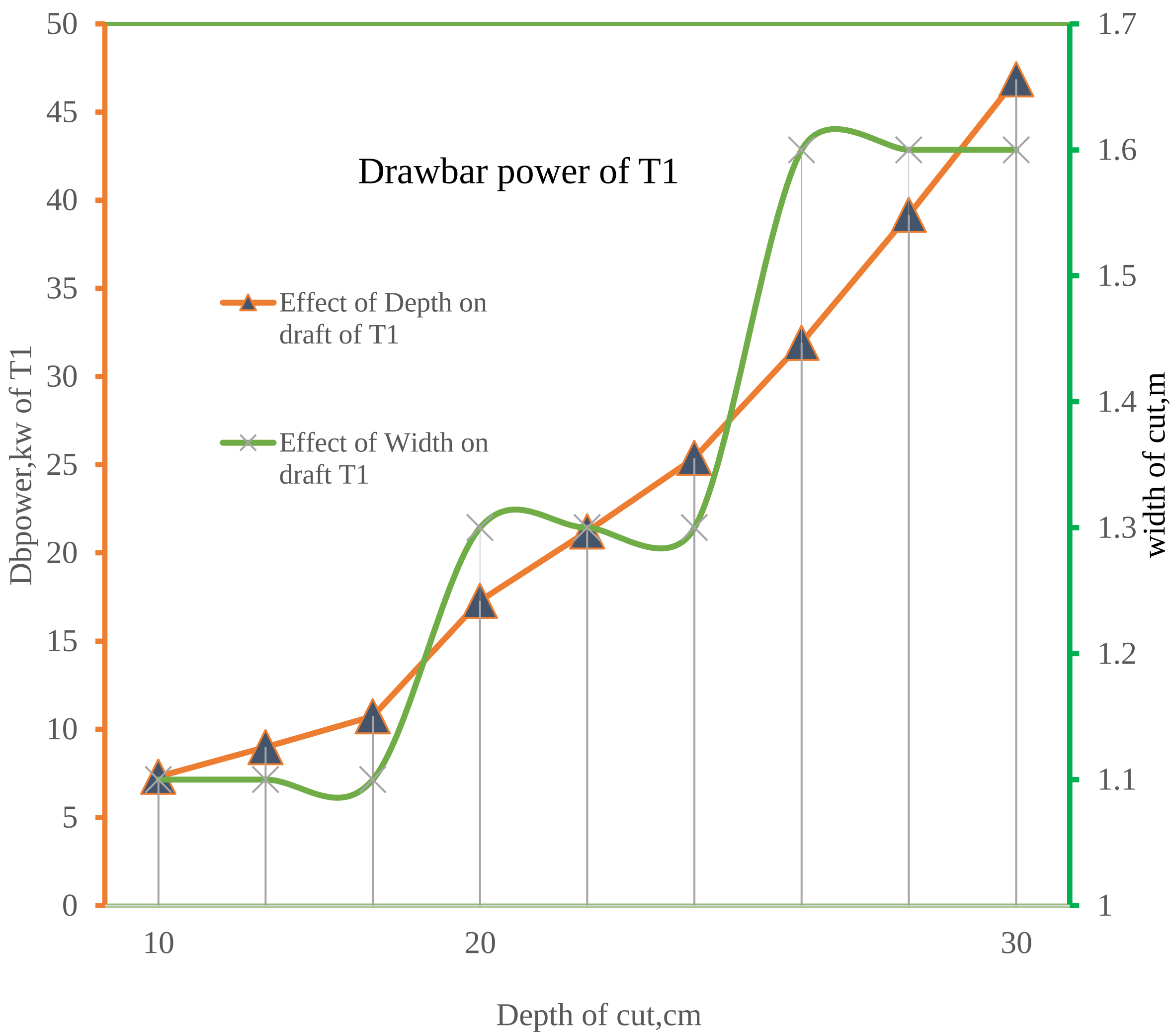


Figure 4. 7. Effect of depth, and Width on Dbpower (T1) of in Clay loamy Soil.

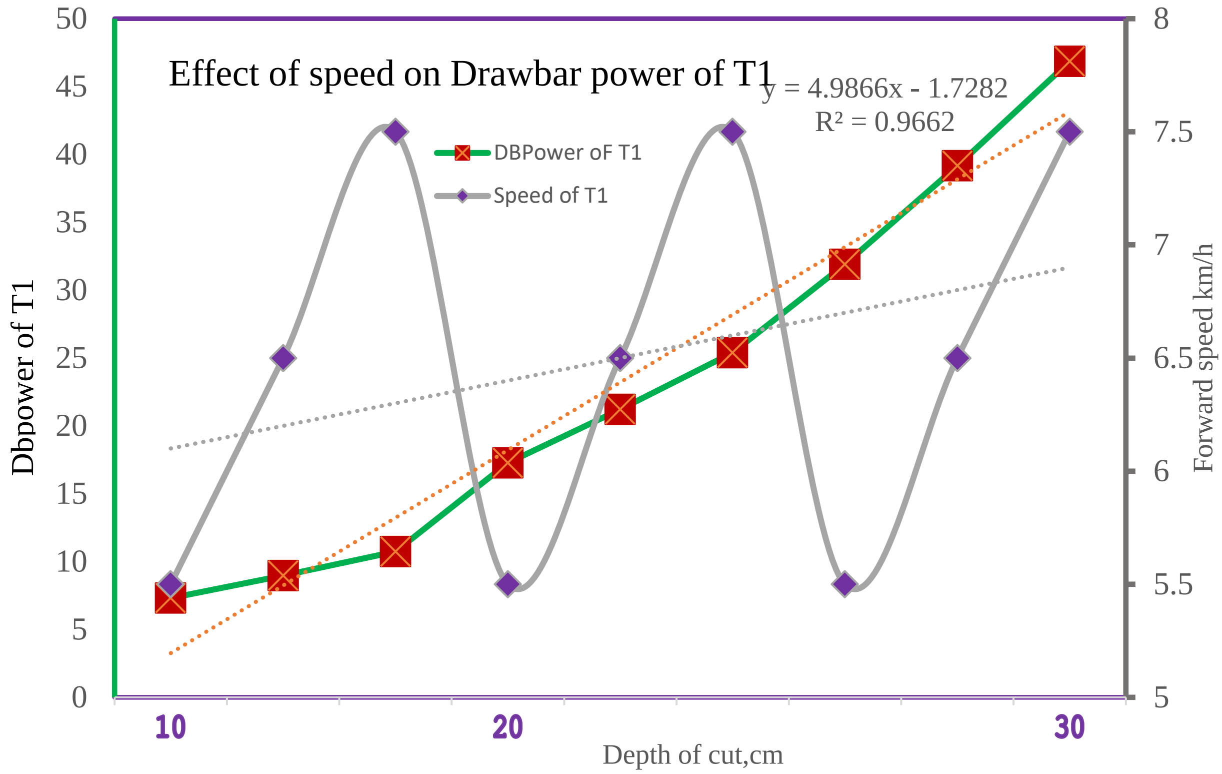


Figure 4. 8. Effect of depth, and Speed on Dbpower (T1) of in Clay loamy Soil.

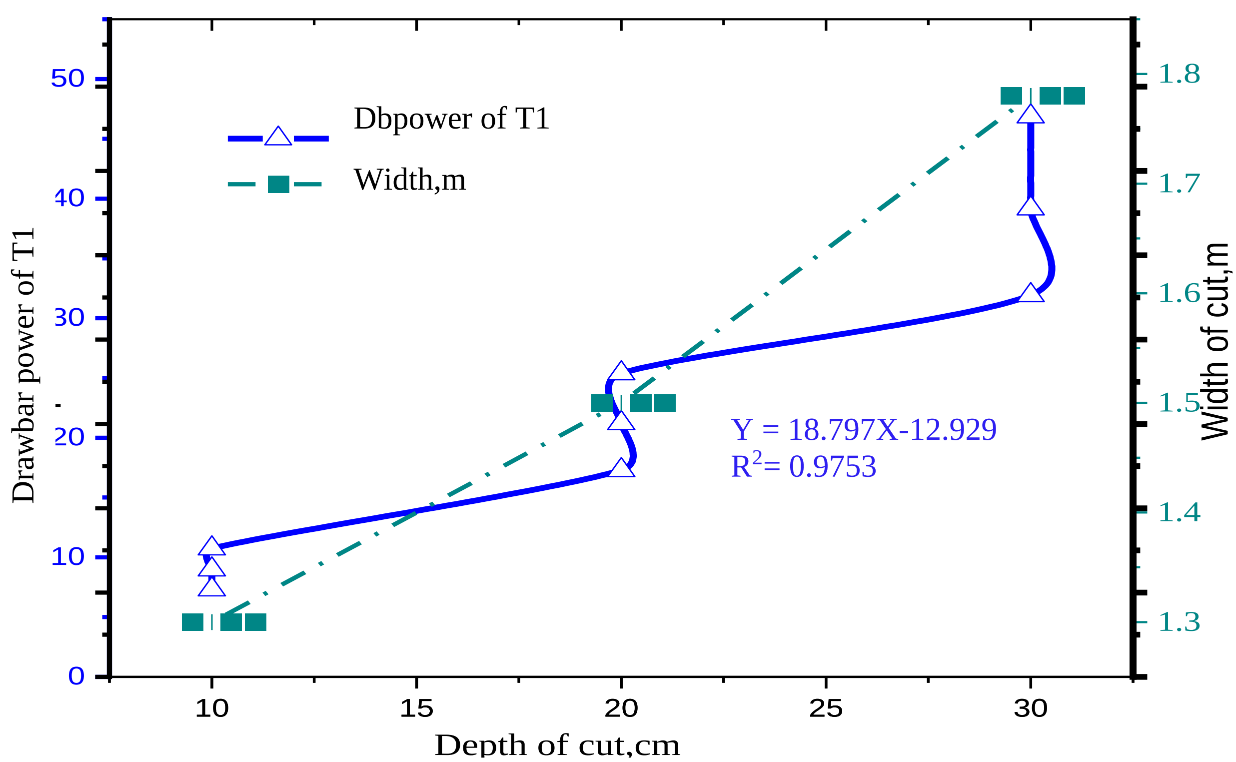


Figure 4. 9. Effect of depth, and Width on DBpower(T1) of in Clay loamy Soil.

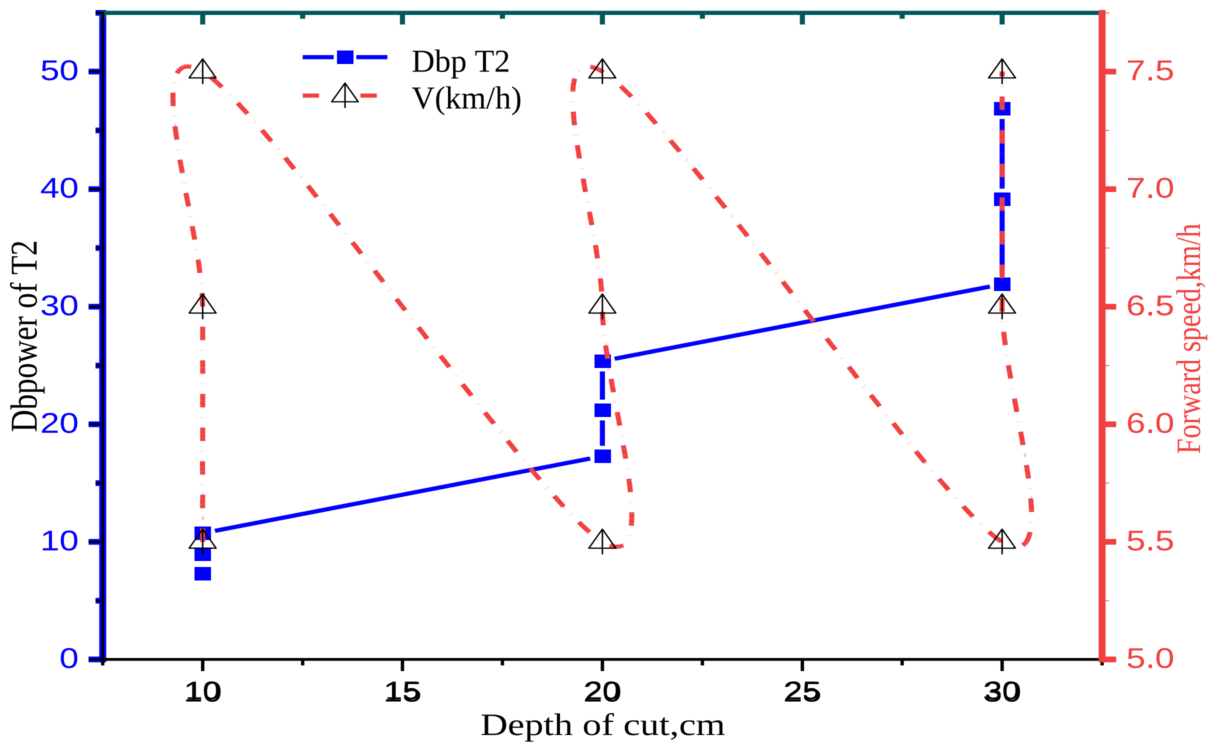


Figure 4. 10. Effect of depth, and Speed on DBpower(T2) of in Clay loamy Soil.

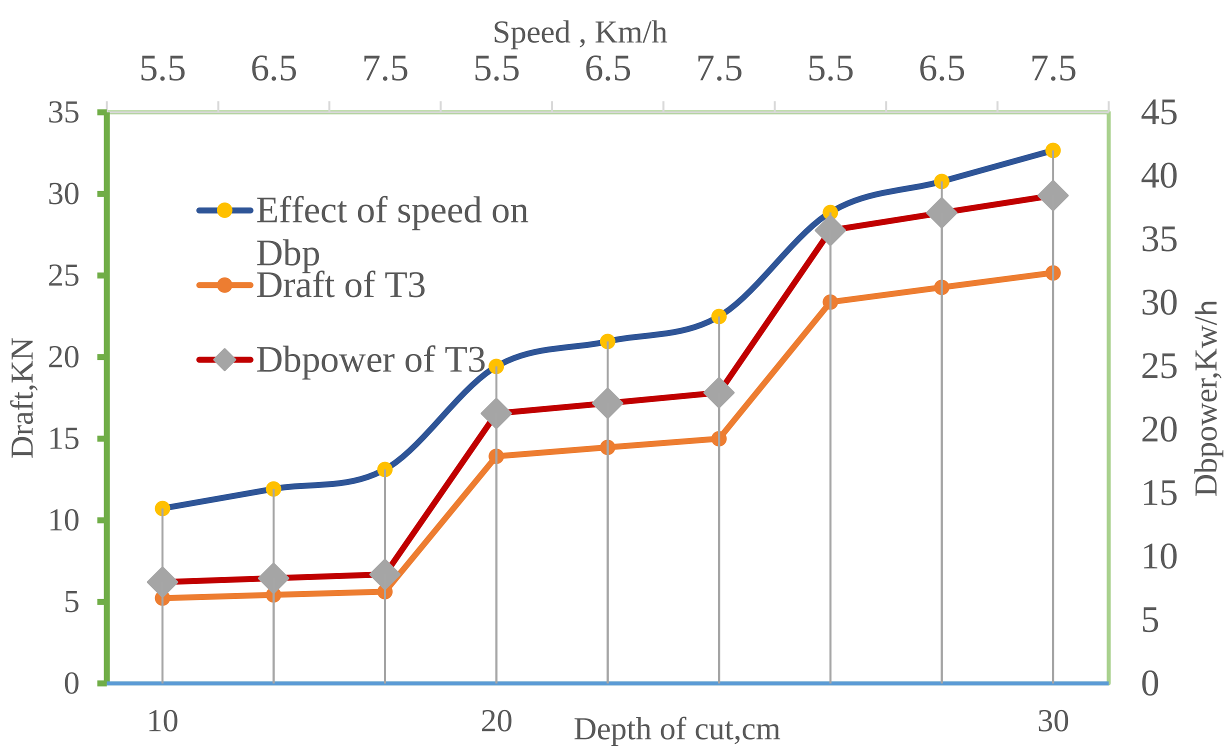


Figure 4. 11. Effect of Depth,m on DBpower(T3) of in Clay loamy Soil

4.3. PTO Power

4.3.1. Tractor Available Power

Based on the figure provided in the figure 3.5, PTO power is estimated from net flywheel power by multiplying the net flywheel power by 0.90 based on the ASABE 2006. Then New Holland have a PTO power 121.5 hp or 90.64 kW, Belarus tractor have a PTO power is 117 hp or 87.28 kW, and John deer 126.9 hp or 94.7 kw.

4.3.2. Implement PTOPower Requirement

Based on the figure provided in the figure 3.5, PTO power is estimated from Drawbar power by dividing the drawbar power by 0.78 based on the ASABE 2006. Then the result presented in the table below.

Table 4. 7. PTO Power required by implement

D(cm)	V (Km/h)	Draft kN T1	Dbp KT1	Ptop, T1	draft KN T2	Dbp T2	Ptop, T2	Draft KN T3	dbp T3	Ptop T3
10	5.5	4.78	7.31	9.37	4.786	7.31	9.37	5.22	7.97	10.22
10	6.5	4.97	8.97	11.50	4.970	8.97	11.50	5.42	8.28	10.62
10	7.5	5.15	10.73	13.76	5.154	10.73	13.76	5.62	8.591	11.01
20	5.5	11.31	17.28	22.16	11.34	17.28	22.16	13.92	21.27	27.27
20	6.5	11.74	21.21	27.19	11.74	21.21	27.19	14.46	22.09	28.32
20	7.5	12.18	25.38	32.54	12.18	25.38	32.54	14.99	22.90	29.37
30	5.5	20.88	31.91	40.91	20.88	31.91	40.91	23.36	35.70	45.77
30	6.5	21.69	39.16	50.20	21.69	39.16	50.20	24.26	37.07	47.52
30	7.5	22.49	46.86	60.07	22.49	46.86	60.07	25.16	38.44	49.28

T1= New hollandTM135,T2=BelarusMTz1221,T3=Johndeer6130J,KN=Kilonewton

4.4. Power Utilization Ratio

Since the power utilization ratio means the ratio between the PTO power requirement of the implement and the power available in the tractor drawbar the results were presented on the table 4.8. The minimum power utilization ratio obtained at D1= 0.1m,W1=1.3m, V1=5.5km/hr by New holland TM135, Belarus MTz1221 and John deer 6130 was 10%, and maximum power utilization ratio was obtained at D3,W3m,V3=7.5km/hr by New holland TM135, Belarus MTz1221 and John Deer 6130 was 66, 69, and 52%. The maximum power utilization of the three tractors at D3, W3, V3 was 66, 69, 52% (figure 4.8). If the Power Utilization Ratio less than100% it indicate tractor and implement were operating at less than full capacity. The ratio above 100% indicate the operation were over capacity.

Table 4. 8. Power utilization ratio of the three Tractors and Disc Plow

The Computation of power utilization ratio of NewhollandTM135					
Depth(cm)	V(Km/hr	Draft,kN T1	Dbp T1	Ptop,T1	PUR,T1
10	5.5	4.78676	7.313106	9.375776	0.103439721
10	6.5	4.97068	8.974839	11.5062	0.126943995
10	7.5	5.1546	10.73875	13.76763	0.151893515
20	5.5	11.31416	17.28552	22.16093	0.244493887
20	6.5	11.74888	21.21326	27.19648	0.300049443
20	7.5	12.1836	25.3825	32.54167	0.359021036
30	5.5	20.88768	31.91173	40.91248	0.45137333
30	6.5	21.69024	39.16293	50.20889	0.553937433
30	7.5	22.4928	46.86	60.07692	0.662808066
The Computation of power utilization ratio of Belarus MTz1221					
Depth(cm)	V(Km/hr	draft KN T2	Dbp T2	Ptop, T2	PUR,T2
10	5.5	4.78676	7.313106	9.375776	0.107421819
10	6.5	4.97068	8.974839	11.5062	0.131830932
10	7.5	5.1546	10.73875	13.76763	0.157740928
20	5.5	11.31416	17.28552	22.16093	0.253906117
20	6.5	11.74888	21.21326	27.19648	0.311600384
20	7.5	12.1836	25.3825	32.54167	0.372842194
30	5.5	20.88768	31.91173	40.91248	0.468749755
30	6.5	21.69024	39.16293	50.20889	0.575262247
30	7.5	22.4928	46.86	60.07692	0.68832405
The Computation of power utilization ratio of Johndeer 6130J					
Depth(cm)	V(Km/hr	Draft, T3	dbp T3	Ptop	PUR T3
10	5.5	5.22192	7.977933	10.22812	0.108005487
10	6.5	5.42256	8.284467	10.62111	0.112155344
10	7.5	5.6232	8.591	11.0141	0.116305201

20	5.5	13.92512	21.27449	27.27499	0.288014633
20	6.5	14.46016	22.09191	28.32296	0.299080918
20	7.5	14.9952	22.90933	29.37094	0.310147203
30	5.5	23.36809	35.70125	45.77084	0.483324556
30	6.5	24.26596	37.07299	47.52947	0.501895166
30	7.5	25.16382	38.44473	49.28811	0.520465776

T1= New hollandTM135,T2=BelarusMTz1221,T3=Johndeer6130J, KN= Kilonewton

The following (Figure 4.12, 4.13, 4.13) show that as PTOPower required by implement to available power increase power utilization ratio increased.

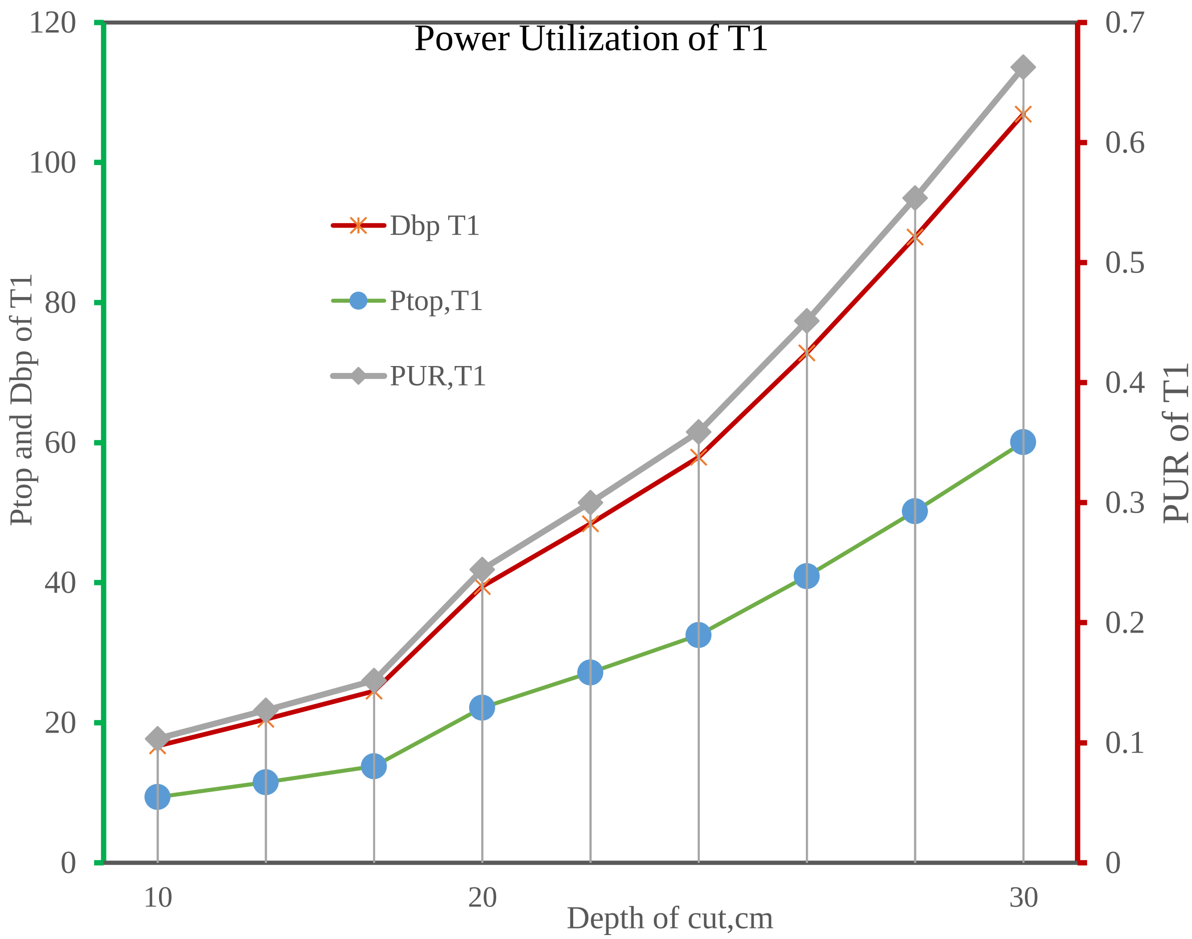


Figure 4. 12. Effect of Depth,m on PUR in Case New holland TM135

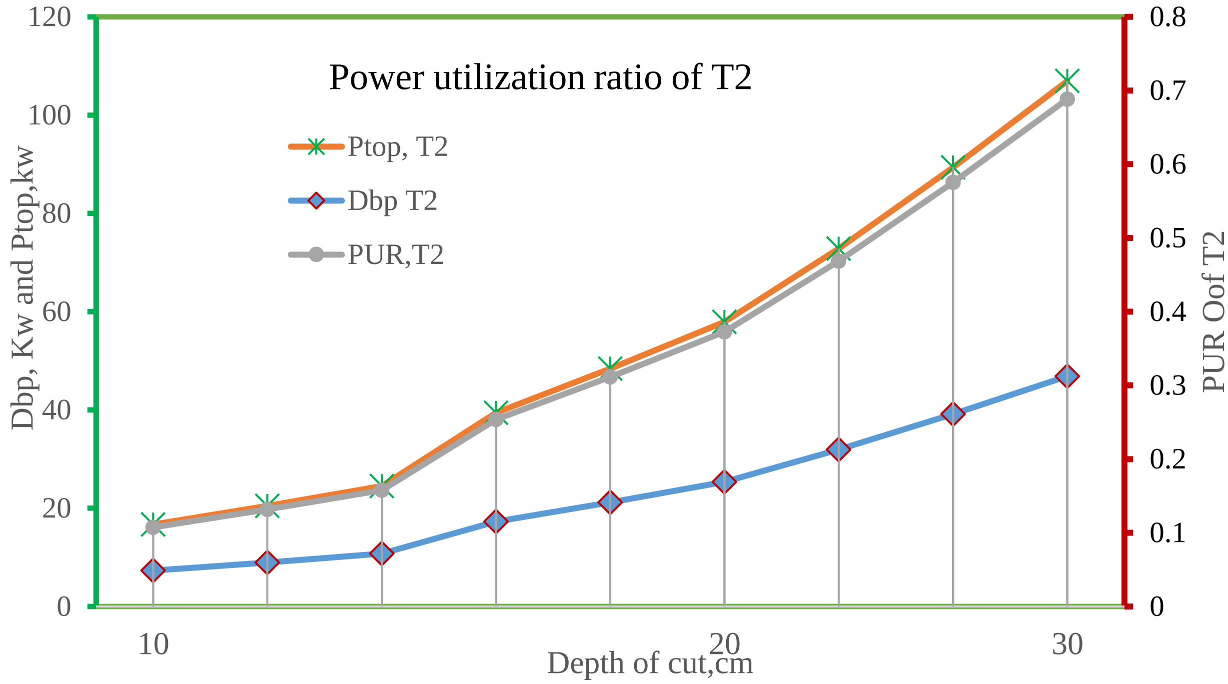


Figure 4. 13. Effect of Depth on PUR in case of Belarus MTz1221

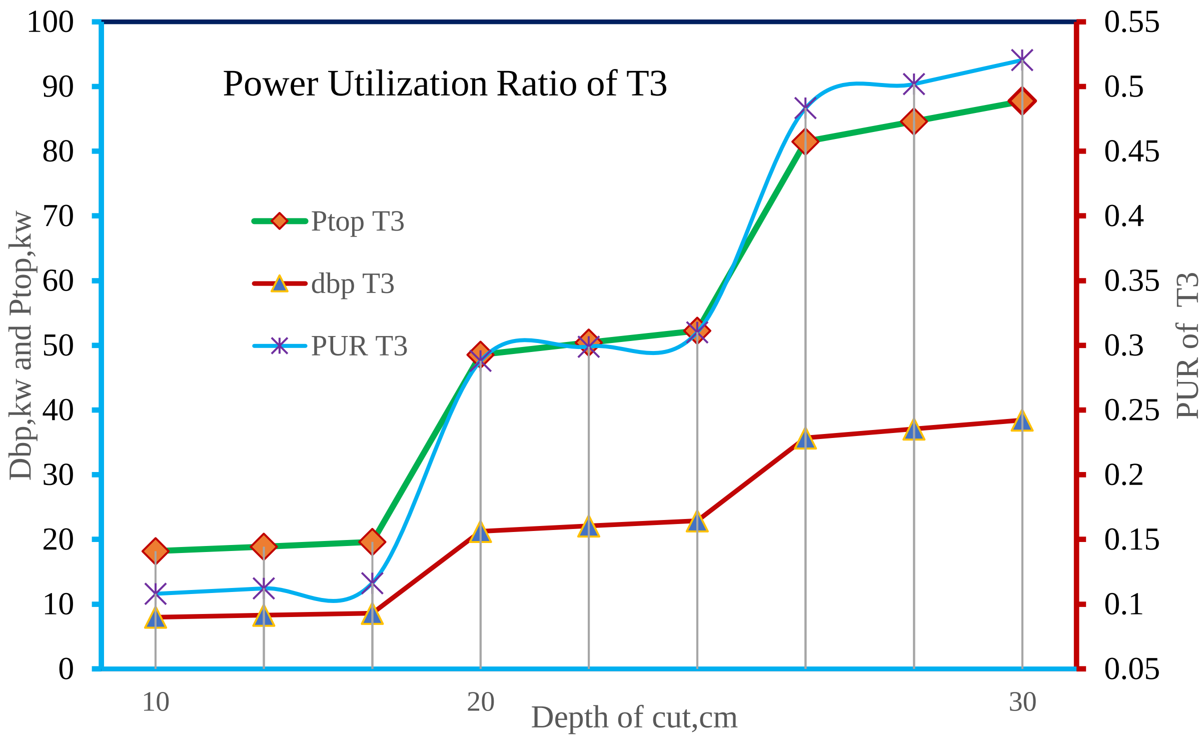


Figure 4. 14. Effect of Depth on PUR in Case of John Deer 6130J

4.5. Feul Comsuption

Fuel consumption is the major diagnostic indicator in determining the state of a vehicle, according to Michalski et al. (2014). Furthermore, since fuel prices continue to climb, energy consumption has become one of the most significant aspects of the agricultural economy. Increased power consumption by raising the operating speed, actual width of cut, soil strength, moisture content, and working depth were the parameters that fundamentally affect fuel consumption when utilizing tillage equipment (Cortez et al., 2008; Kichler et al., 2011; Silveira et al., 2013; Moitzi et al., 2014; Leghari et al., 2016; Nasr, 2016). The minimun fuel consumption was consumed by New holland, Belarus MTZ1221,and Jondeer 6130 at D1=0.1, W1=1.1, V1=5.5km/hr, Belarus D1=0.1m,W1=1.2,V1=5.5km/hr was 2.85, 3.11L/hr and maximum fuel was 15.37, 18.15l/hr. Since high fuel consumed by Johndeer at D3=0.3m, W3=1.79m, V3=7.5km/hr was 15.03L/hr, and but the same fuel was consumed by both Newholland and Belarus that was 18.32L/hr. The average fuel consumption both New holland,Belarus MTZ1221 was 9.0736L/hr, and Jondeer 6130 was 8.791L/hr. the average fuel consumption for both Newholland TM135 and Belarus MTz1221 was 28.82%. In other way johndeer 6130J consumed 31.14%. The fuel efficience can be obtained by average fuel consumption of implement divide by average fuel consumption of tractors, and therefore, three tractors fuel efficience was 28.67, 27, and 31.15%.

Table 4. 9. Fuel Consumption of different model of the three Tractors

Fuel consumption by T1

D(cm)	V(Km/h)	Draft,kNT1	Dbp T1	Ptop,T1	PUR,T1	FC,L/hr
10	5.5	4.78676	7.313106	9.375776	0.10344	2.859612
10	6.5	4.97068	8.974839	11.5062	0.126944	3.509392
10	7.5	5.1546	10.73875	13.76763	0.151894	4.199127
20	5.5	11.31416	17.28552	22.16093	0.244494	6.759082
20	6.5	11.74888	21.21326	27.19648	0.300049	8.294927
20	7.5	12.1836	25.3825	32.54167	0.359021	9.925208
30	5.5	20.88768	31.91173	40.91248	0.451373	12.47831
30	6.5	21.69024	39.16293	50.20889	0.553937	15.31371
30	7.5	22.4928	46.86	60.07692	0.662808	18.32346

Fuel consumption by T2

D(cm)	V(Km/h)	Draft,kNT1	Dbp T2	Ptop,T2	PUR,T2	FC,L/hr
10	5.5	4.78676	7.313106	9.375776	0.107422	2.859612
10	6.5	4.97068	8.974839	11.5062	0.131831	3.509392
10	7.5	5.1546	10.73875	13.76763	0.157741	4.199127
20	5.5	11.31416	17.28552	22.16093	0.253906	6.759082
20	6.5	11.74888	21.21326	27.19648	0.3116	8.294927
20	7.5	12.1836	25.3825	32.54167	0.372842	9.925208
30	5.5	20.88768	31.91173	40.91248	0.46875	12.47831
30	6.5	21.69024	39.16293	50.20889	0.575262	15.31371
30	7.5	22.4928	46.86	60.07692	0.688324	18.32346

Fuel consumption by T3

D(cm)	V(Km/h)	Draft, T3	Dbp,T3	Ptop ,T3	PUR, T3	FC,L/hr
10	5.5	5.22192	7.977933	10.22812	0.108005	3.119576
10	6.5	5.42256	8.284467	10.62111	0.112155	3.239439
10	7.5	5.6232	8.591	11.0141	0.116305	3.359301
20	5.5	13.92512	21.27449	27.27499	0.28801	8.318871
20	6.5	14.46016	22.09191	28.32296	0.299081	8.638504
20	7.5	14.9952	22.90933	29.37094	0.310147	8.958137
30	5.5	23.36809	35.70125	45.77084	0.48332	13.9601
30	6.5	24.26596	37.07299	47.52947	0.501895	14.49649
30	7.5	25.16382	38.44473	49.28811	0.520466	15.03287

FC=fuel consumption, kw= kilowatt, T1= New holland,T2=Belarus,and T3=John deer

Table 4. 10. Fuel Consumption and SFC predicted by ASABE D497.4.

Depth,cm	PUR of T1	FC, L/HR	SFC,L/KWh	PUR of T2	FC,L/hr	SFC,L/KW/hr		PUR of T3	FC,L/hr of T3	SFC,L/KWh
10	0.12	11.09	0.95	0.13	14.14	0.92	10.87	0.11	11.37	0.96
20	0.3	14.68	0.67	0.31	14.33	0.66	14.33	0.29	15.12	0.69
30	0.55	19.66	0.48	0.57	19.34	0.46	19.32	0.5	19.49	0.5

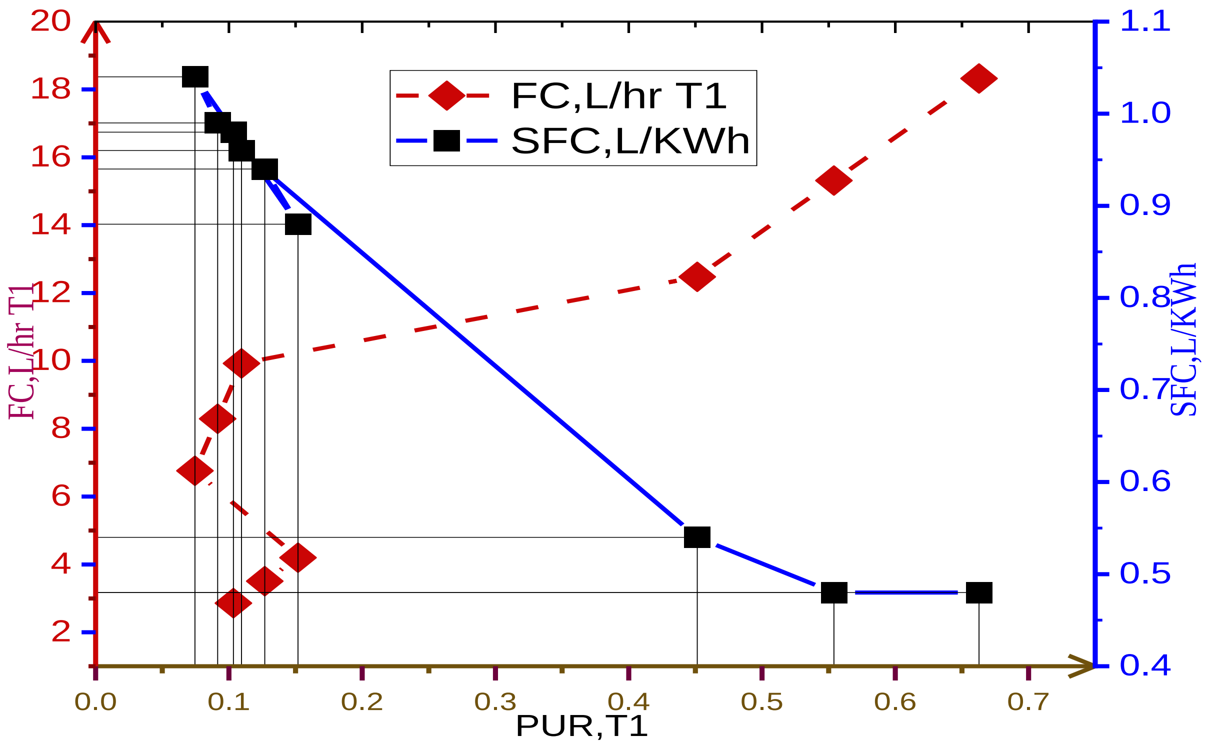


Figure 4. 15. Figure of FC and SFC Consumption of New Hollnd TM135

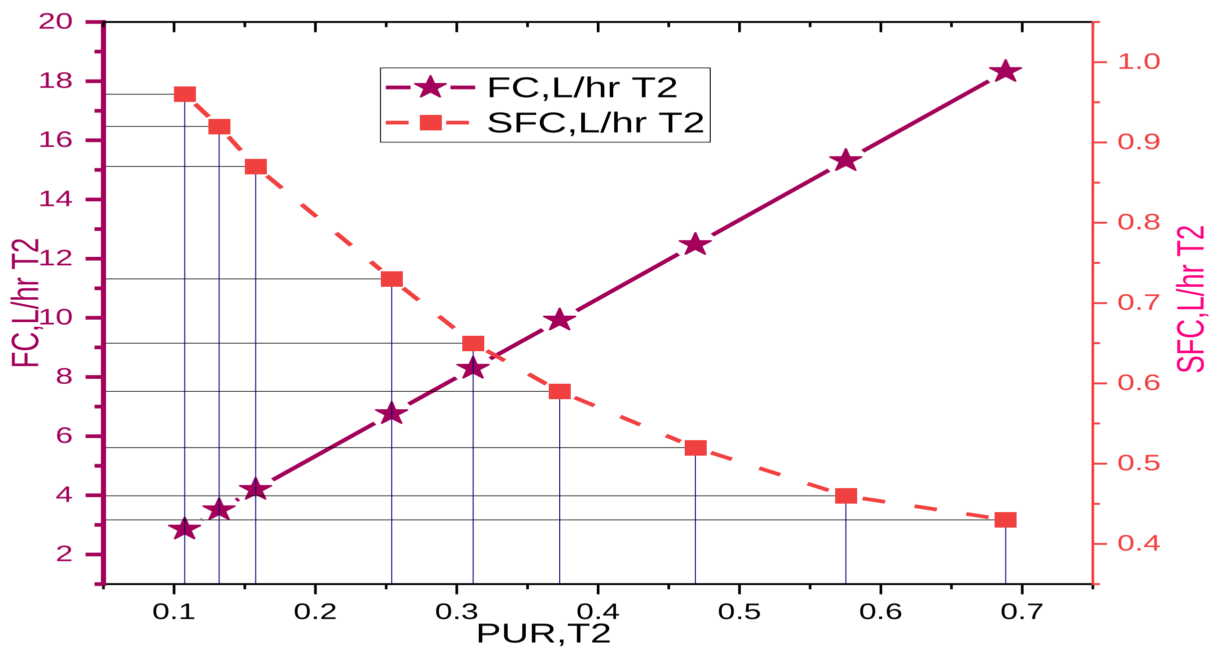


Figure 4. 16. Figure of FC and SFC of Belarusmtz1221

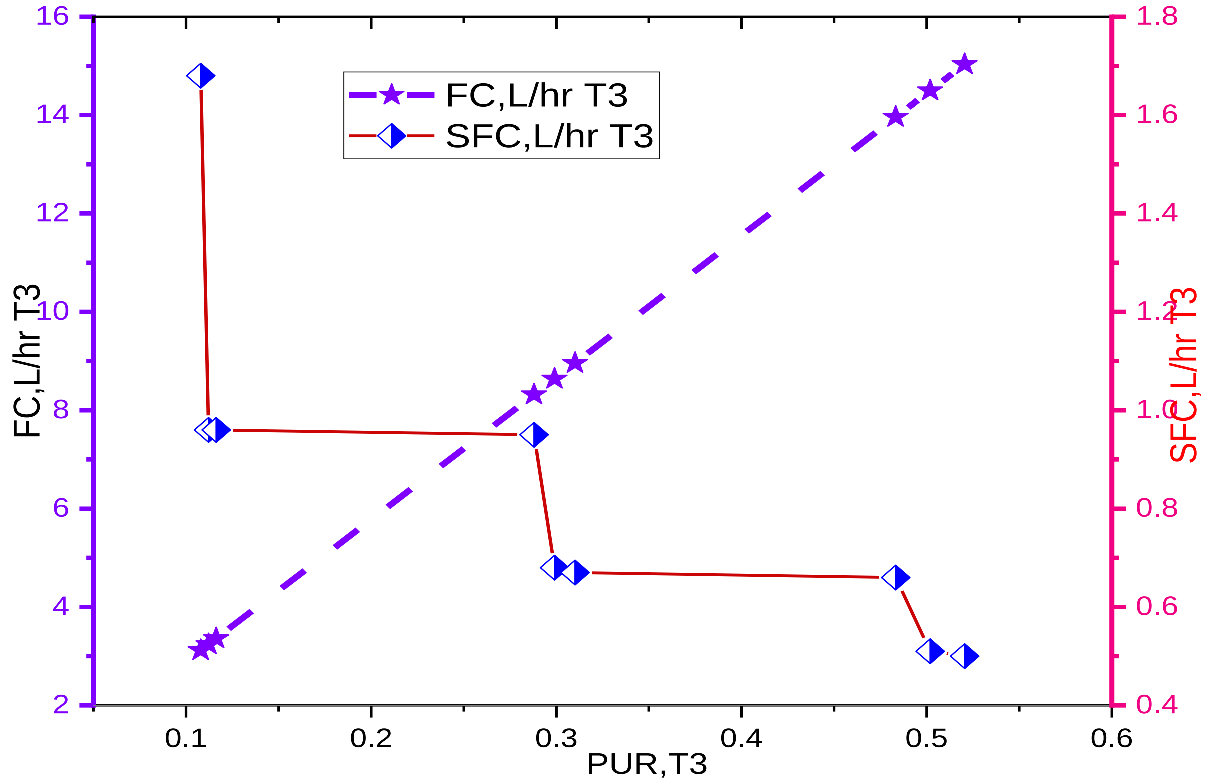


Figure 4. 17. Figure of FC and SFC of John Deer6130J

4.6. Slip

Travel reduction affects the traction efficiency of any tractive device. Table 4.11 presents the results of the travel reduction emanating from the field test of the three tractor models. The minimum slippage obtained both New Holland TM135, Belarus MTZ1221, and John deer 6130J at D1=0.1m, V1=5.5, and V3=7.5km/hr was 9.9, 8.6, and 8.4%.

The maximum slippage obtained from both New HollandTH135 and Belarus MTZ1221 at D3=0.3m, V3=7.5km/hr, and D2=0.2m, V2=6.5km/hr was 20% and also the three tractors Slippage almost similar at D3=0.3m, V1=5.5, V3=7.5km/hr was 18%.

Table 4. 11. Tractors slip of New Holland TM135,Belarus MTZ1221, and John Deer6130J

Depth	UD, m	DL, m	slippae T1%	UD,m	DL.m	Slippae T2%	UD, m	DL.m	Slippage, T3%
D1	162.9	146.8	9.88	163.2	149.1	8.63	165.1	151.2	8.41
D1	162.9	146	10.37	163.2	148.9	8.76	165.1	149.7	9.32
D1	162.9	145.7	10.55	163.2	147.9	9.37	165.1	148.7	9.93

D2	162.9	138.5	14.97	163.2	139.9	14.27	165.1	145.3	11.99
D2	162.9	137.9	15.34	163.2	141.8	13.11	165.1	142.4	13.74
D2	162.9	138.8	14.79	163.2	143.6	12.00	165.1	140.6	14.83
D3	162.9	132.4	18.72	163.2	131.9	19.17	165.1	135.2	18.11
D3	162.9	128.9	20.87	163.2	130.5	**20.03**	165.1	134.9	18.29
D3	162.9	129.5	**20.50**	163.2	133.4	18.25	165.1	132.5	19.74

Du=distance traceled with unloaded tractor,DL= distance traceled with loaded tractor,T1=new holland, T2=belarus, and T3=john deer

4.7. Field Capacity

The field capacity of a machine was a function of its width, speed and efficiency of operation. The data regarding these parameters was presented in (Table 4.12.,4.13, and 4.14) shows that effective field capacity of New holland TM135, Belarus MTz1221, and John deer 6130J with W2= 1.3m, and V3=7.5km/hr, and W2=1.78m, and V2= 6.5km/hr, and W3=1.79m, V1=5.5km/hr was 82%.

Table 4. 12. The Field Capacity of a New Holland TM135

W1 (m)	V(Km/hr	Constant	Theo.W	EFC	TFC	FE%	Area covered,ha	T.time to cover field	EFC	FE,%
1.1	5.5	10	1.8	0.50	0.99	51.44	0.9	1.069	0.84	85.04
	6.5	10	1.8	0.60	1.17	51.44	0.9	1.069	0.84	71.95
	7.5	10	1.8	0.69	1.35	51.44	0.9	1.069	0.84	62.36
1.3	5.5	10	1.8	0.60	0.99	60.80	0.9	1.069	0.84	85.04
	6.5	10	1.8	0.71	1.17	60.80	0.9	1.069	0.84	71.95
	7.5	10	1.8	0.82	1.35	60.80	0.9	1.069	0.84	62.36
	5.5	10	1.8	0.74	0.99	74.83	0.9	1.069	0.84	85.04
	6.5	10	1.8	0.87	1.17	74.83	0.9	1.069	0.84	71.95
1.6	7.5	10	1.8	1.01	1.35	74.83	0.9	1.069	0.84	62.36

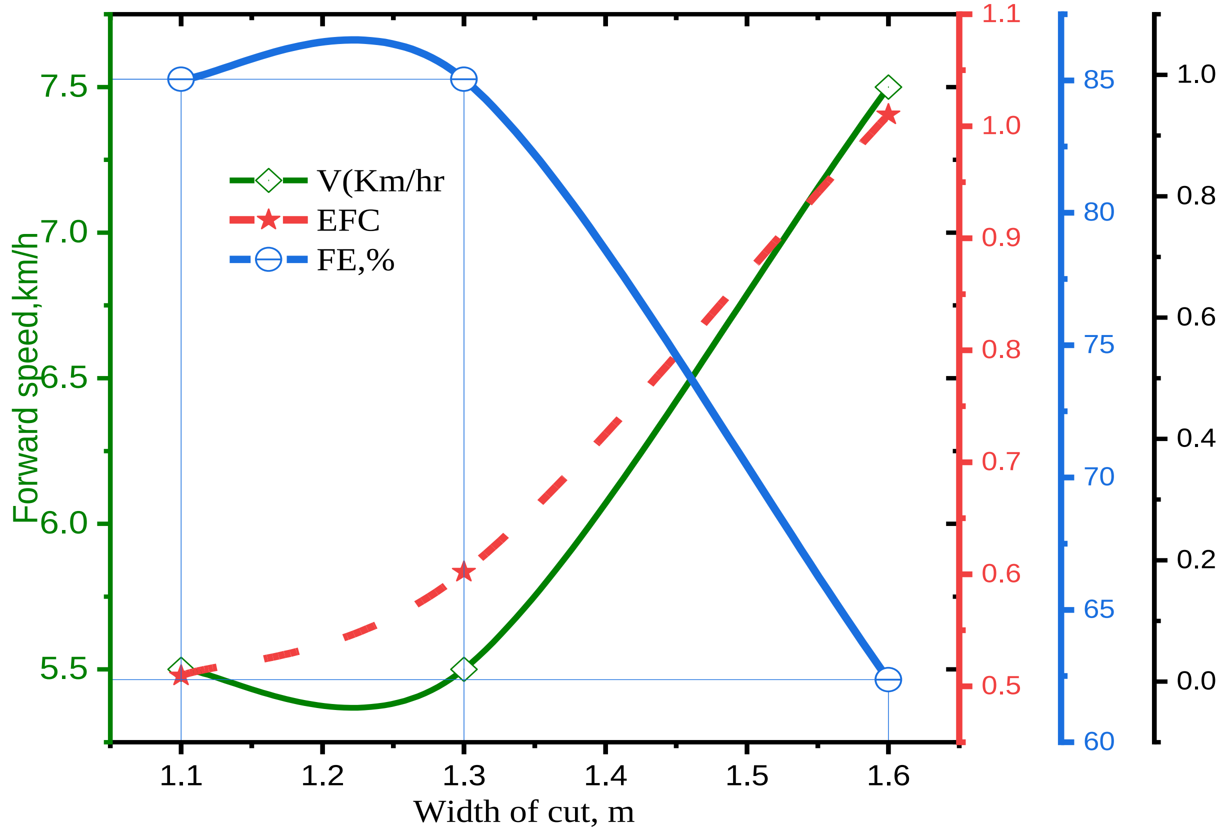


Figure 4. 18. Effect of width, and Speed on EFC of Disc Plough in Clay loamy Soil

Table 4. 13. The Field Capacity of a Belarus MTZ1221

W2m	V(Km/hr	constant	Theo.W	EFC	TFC	FE%	Area covered,ha	T.time to cover field	Ave.FC	FE,%
1.3	5.5	10	1.8	0.60	0.99	60.80	0.9	1.069	0.841908	85.041245
1.3	6.5	10	1.8	0.71	1.17	60.80	0.9	1.069	0.841908	71.957977
1.3	7.5	10	1.8	0.82	1.35	60.80	0.9	1.069	0.841908	62.36358
1.5	5.5	10	1.8	0.69	0.99	70.15	0.9	1.069	0.841908	85.041245
1.5	6.5	10	1.8	0.82	1.17	70.15	0.9	1.069	0.841908	71.957977
1.5	7.5	10	1.8	0.94	1.35	70.15	0.9	1.069	0.841908	62.36358
1.78	5.5	10	1.8	0.82	0.99	83.25	0.9	1.069	0.841908	85.041245
1.78	6.5	10	1.8	0.97	1.17	83.25	0.9	1.069	0.841908	71.957977
1.78	7.5	10	1.8	1.12	1.35	83.25	0.9	1.069	0.841908	62.36358

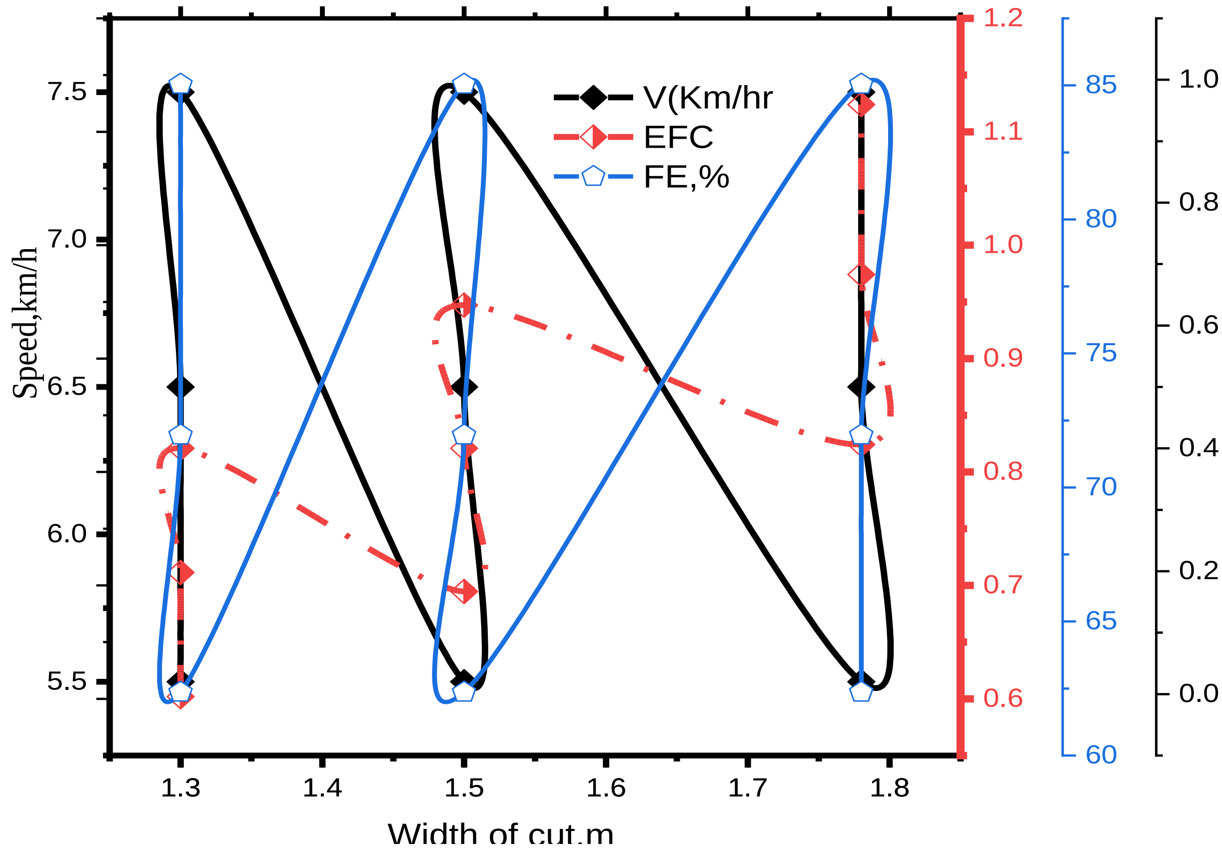


Figure 4. 19. Effect of width on EFC of Disc Plough in Clay loamy Soil

Table 4. 14. The Field Capacity of a John Deer6130J

W3(m)	V(Km/hr)	Constant	Theo.W	EFC	TFC	FE%	Area covered ha	T.time to cover field	EFC	FE
1.2	5.5	10	1.8	0.55	0.99	56.12	0.9	1.069	0.84	85.04124
1.2	6.5	10	1.8	0.65	1.17	56.12	0.9	1.069	0.84	71.95797
1.2	7.5	10	1.8	0.75	1.35	56.12	0.9	1.069	0.84	62.36358
1.6	5.5	10	1.8	0.74	0.99	74.83	0.9	1.069	0.84	85.04124
1.6	6.5	10	1.8	0.87	1.17	74.83	0.9	1.069	0.84	71.95797
1.6	7.5	10	1.8	1.01	1.35	74.83	0.9	1.069	0.84	62.36358
1.79	5.5	10	1.8	0.82	0.99	83.72	0.9	1.069	0.84	85.04124
1.79	6.5	10	1.8	0.97	1.17	83.72	0.9	1.069	0.84	71.95797
1.79	7.5	10	1.8	1.13	1.35	83.72	0.9	1.069	0.84	62.36358

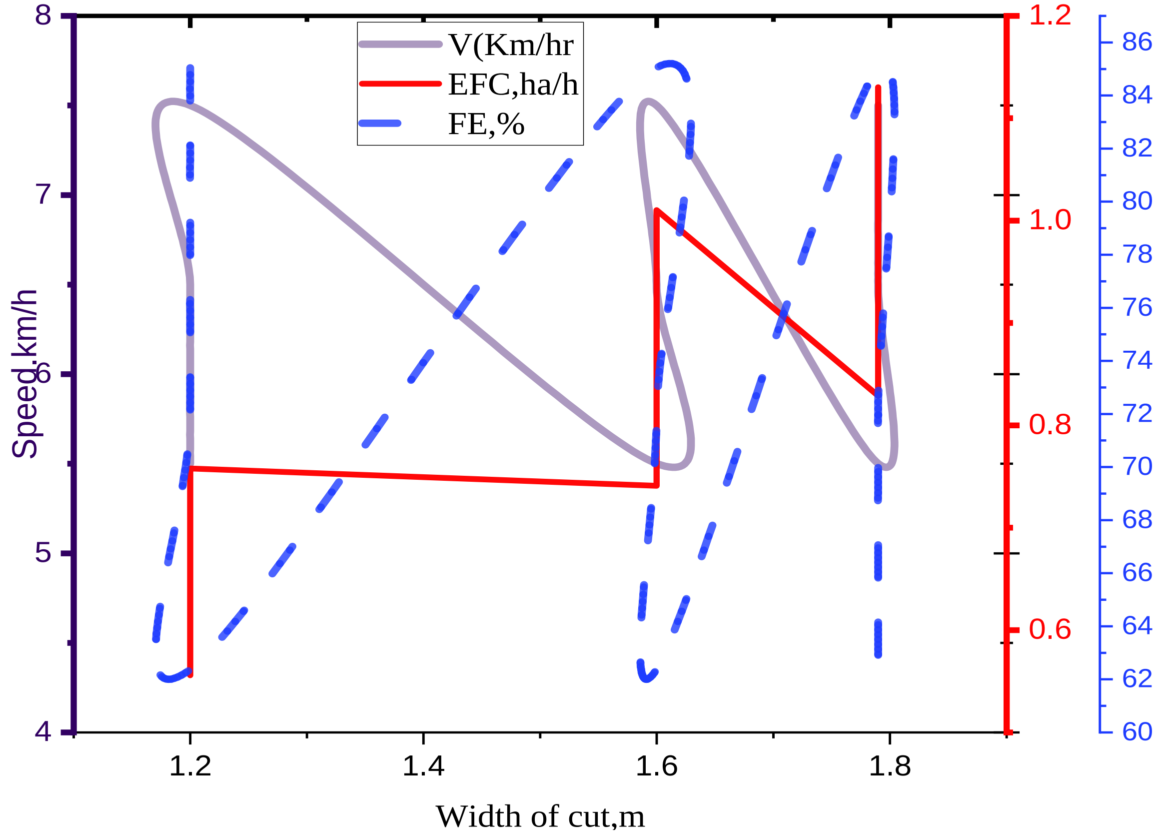


Figure 4. 20. Effect of width on EFC of Disc Plough in Clay loamy Soil

4.8. Annual Cost analysis of the three Tractors

The cost incurring these industrial organization numerus like production cost, transportation cost, raw material cost, lobour cost and machinery cost. Among those costs it was necessary to focus on machery cost like tractors and implement cost per year.

The importance of cost prepation was to identify the real profit of the organization after deduction of all costs incurring. Mostly cost was prepared for report purpose for any organization and even it was necessary to compare cost incurring the previous year with the present and then decision could be made if increament or decreament of cost available. In reality in a case finchaa sugar factory cost was prepared mostly for purchasing new machinery and implements or spare parts. For cost computation the following three tractors were selected for this research purpose and those tractors were New holland TM135, Belarus MTZ1221, and John deer 6130J. Total fixed cost of Newholland TM135, Belarus MTZ1221, and John deer 6130J was 76579.56, 240126.33, 309137.58USD and The total variable cost were Newholland

TM135, BelarusMTZ1221, and John deer 6130J was 1901.89, 1359.68, and 1838.48USD. Total cost incurring was 352719.52USD per year (Table 4.15,4.16).

Table 4. 15. Annual Fixed Cost of the three Tractors

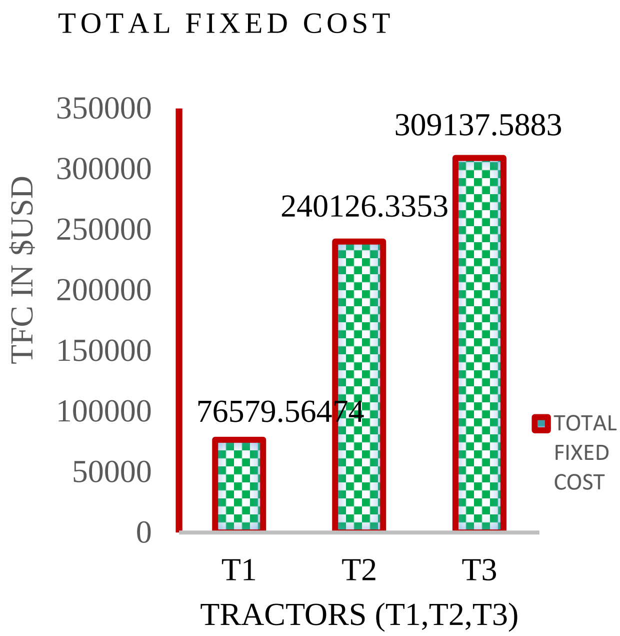
FIXED COST OF THE THREE TRACTORS								
purchase price, T1,T2,	%of SV	Salvage Value	E.Life	Depreciation	Int.	Ins&Tx	TFC	TFC/HR
520949.42	26%	135446	10	38550	32819	5209	76579	17
1633512	26%	424713	10	120879	102911	16335	240126	55
2102976	26%	546773	10	155620.2	132487	21029	309137	71

E.Life=Economic life,SV=salvage salue,Int=Interest,Ins&Tx=Insurance and Tax, TVC= Total vaiable cost TFC=Total fixed cost.

Table 4. 16. Annual Operating Cost of the three Tractors

OPERATING COST OF THE THREE TRACTORS													
Purchaseprice(USD)	M&R,cost	cost of 1lit(USD)	fuel consumed	FUEL,L/hr cost	working hr	work hr/ month	total operator	Total work hr/month	pay per month	Pay/ hr	Lobour,cost	operator per pay	Total Variable cost(USD)
T1	1663	0.69	9.6	6.65	8	240	3	720	102	0.32	231	77	1902
T2	1121	0.69	9.6	6.64	8	240	3	720	102	0.32	231	77	1360
T3	1599	0.69	11	7.64	8	240	3	720	102	0.32	231	77	1838

*M&R=Maitenance and Repair



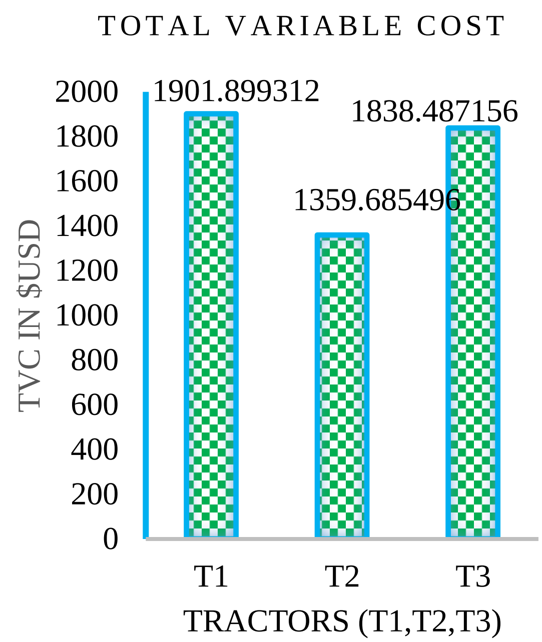


Figure 4. 21. Fixed and Annual Variable cost incurring the three tractors

4.9. Statistical Analysis of Parameters

4.9.1. Disc Plough

The analysis of variance of the following (Table 4.18, 4.19, 4.20, 4.21, 4.22, 4.23, 4.24, 4.25, 4.26, 4.27, 4.28, 4.29, 4.30, 4.31, 4.32, 4,33, 4.34) showed that there were significant interactions between Depth and width, on the drawbar pull, drawbar power, power utilization ratio and fuel consumption of tractors, and slippage.

The analysis of variance the following (Table 4.17, 4.18, 4.19, 4.20, 4.21, 4.22, 4.23, 4.24, 4.25, 4.26, 4.27, 4.28, 4.29, 4.30, 4.31, 4.32, 4,33, 4.34) showed that there were no significant interactions with forward speed, on the drawbar pull, drawbar power, power utilization ratio and fuel consumption of tractors, and slippage.

The analysis of variance of the following (Tables of 4.35, 4.36, 4.37) show that Effective Field Capacity with Forward speed, width, was significant effect ($p<0.005$) with tractors of New Holland TM135, Belarus MTZ1221 and John deer 6130J. But New holland TM135 tractor insignificant effect ($P>0.05$) which was Draft force with width, Depth, and speed.

Table 4. 17. ANOVA Table of Draft forces for New Holland TM135

	SS	df	MS	F	Sig.
Draft force of (T1) X Depth(m)	.000	2	.000	.000	1.000

		SS	df	MS	F	Sig.
		5032.051	24	209.669		
	Total	5032.051	26			
Draft force of (T1) X Width(m)		.000	2	.000	.000	1.000
		5032.051	24	209.669		
	Total		26			
Draft foce,kN(T1) X V(Km/h)		4.609	2	2.304	.043	.958
		1285.553	24	53.565		
	Total	1290.162	26			

Dbp=Drawbarpower SS=sum square,df= degree of freedom,MS=mean square
Newholland TM135, Not Significant effect (P>0.05) on draft force generated due to depth, width,and forward speed.

Table 4. 18. ANOVA Table of Draft forces for Belarus MTZ1221

		SS	df	MS	F	Sig.
Draft foce,kN(T2) X Depth,(m)		1272.939	2	636.469	2933.376	.000
		5.207	24	.217		
	Total	1278.146	26			
Draft foce,kN(T2) X Width,(m)		1272.939	2	636.469	2933.376	.000
		5.207	24	.217		
	Total	1278.146	26			
Draft foce,kN(T2) X V(km/hr)		4.046	2	2.023	.038	.963
		1274.100	24	53.088		
	Total	1278.146	26			

Dbp=Drawbarpower SS=sum square,df= degree of freedom,MS=mean square
Belarus MTZ1221, Not Significant effect (P>0.05) on draft force generated due to forward speed.significant effect(P<0.05) on draft force generated due to depth, and width.

Table 4. 19. ANOVA Table of Draft forces for John Deer 6130J

		SS	df	MS	F	Sig.
Draft foce, kN(T3) X Width,m		1603.903	2	801.952	2779.075	.000
		6.926	24	.289		
	Total	1610.829	26			
Draft foce, kN(T3) X Depth,m		1603.903	2	801.952	2779.075	.000
		6.926	24	.289		

Total	1610.829	26			
Draft foce, kN(T3) XV(km/hr)	5.647	2	2.823	.042	.959
	1605.182	24	66.883		
Total	1610.829	26			

Dbp=Drawbarpower,SS=sum square,df= degree of freedom,MS=mean square
John Deer 6130J, Not Significant effect (P>0.05) on draft force generated due to forward speed.significant effect(P<0.05) on draft force generated due to depth, and width.

Table 4. 20. ANOVA Table of drawbar power of New Holland TM135

	SS	df	MS	F	Sig.
Dbp(T1) X Width (m)	2863.190	2	1431.595	29.942	.000
	1147.490	24	47.812		
Total	4010.680	26			
Dbp(T1) X Depth(m)	3172.907	3	1057.636	29.036	.000
	837.773	23	36.425		
Total	4010.680	26			
Dbp(T1) X V(Km/hr	413.538	2	206.769	1.380	.271
	3597.143	24	149.881		
Total	4010.680	26			

Dbp=Drawbarpower SS=sum square,df= degree of freedom,MS=mean square
New Holland TM135, Not Significant effect (P>0.05) on drawbar power generated due to forward speed.significant effect(P<0.05) on drawbar power generated due to depth, and width.

Table 4. 21. ANOVA Table of drawbar power of Belarus MTZ1221

	SS	df	MS	F	Sig.
Dbp (T2) X Depth(m)	4181.430	2	2090.715	111.195	.000
	451.254	24	18.802		
Total	4632.683	26			
Dbp(T2) X Width(m)	4632.683	2	2090.715	111.195	.000
	451.254	24	18.802		
Total	4632.683	26			
Dbp(T2) X V(Km/hr	350.458	2	175.229	.982	.389
	4282.226	24	178.426		
Total	4632.683	26			

Dbp=Drawbarpower,SS=sum square,df= degree of freedom,MS=mean square
Belarus MTZ1221, Not Significant effect (P>0.05) on drawbar power generated due to forward speed.significant effect(P<0.05) on drawbar power generated due to depth, and width.

Table 4. 22. ANOVA Table of drawbar power of John Deer 6130J

		SS	df	MS	F	Sig.
Dbp(T3) X Width (m)		3731.572	2	1865.786	2822.88	.000
		15.863	24	.661		
	Total	3747.434	26			
Dbp(T3) X Depth(m)		3731.572	2	1865.786	2822.88	.000
		15.863	24	.661		
	Total	3747.434	26			
Dbp(T3) X V(Km/hr)		12.457	2	6.228	.040	.961
		3734.977	24	155.624		
	Total	3747.434	26			

Dbp=Drawbarpower SS=sum square,df= degree of freedom,MS=mean square
John Deer 6130J, Not Significant effect (P>0.05) on drawbar power generated due to forward speed.significant effect(P<0.05) on drawbar power generated due to depth, and width.

Table 4. 23. ANOVA Table of PTOpower of New Holland TM135

		SS	df	MS	F	Sig.
Ptop,(T1) X Width (m)		6872.830	2	3436.415	111.195	.000
		741.706	24	30.904		
	Total	7614.536	26			
Ptop(T1) X Depth(m)		6872.830	2	3436.415	111.195	.000
		741.706	24	30.904		
	Total	7614.536	26			
Ptop(T1) X V(Km/hr)		576.032	2	288.016	.982	.389
		7038.504	24	293.271		
		7614.536	26			

Ptop=ptopower, SS=sum square,df= degree of freedom,MS=mean square
New Holland TM135, Not Significant effect (P>0.05) on PTOpower generated due to forward speed.significant effect(P<0.05) on PTOpower generated due to depth, and width.

Table 4. 24. ANOVA Table of PTOpower of Belarus MTZ1221

		SS	df	MS	F	Sig.
Ptop(T2) X Width(m)		6872.830	2	3436.415	111.195	.000
		741.706	24	30.904		
	Total	7614.536	26	3436.415		
Ptop(T2)X Depth(m)		6872.830	2	3436.415	111.195	.000
		741.706	24	30.904		
	Total	7614.536	26			
Ptop,(T2) X V(Km/hr)		576.032	2	288.016	.982	.389
		7038.504	24	293.271		
		7614.536	26			

Ptop=ptopower, SS=sum square,df= degree of freedom,MS=mean square.
Belarus MTZ1221, Not Significant effect ($P>0.05$) on PTOpower generated due to forward speed.significant effect($P<0.05$) on PTOpower generated due to depth, and width.

Table 4. 25. ANOVA Table of PTOpower of John Deer 6130J

		SS	df	MS	F	Sig.
Ptop(T3) X Width (m)		6133.418	2	3066.709	2822.881	.000
		26.073	24	1.086		
	Total	6159.491	26			
Ptop(T3) X Depth(m)		6133.418	2	3066.709	2822.881	.000
		26.073	24	1.086		
	Total	6159.491	26			
Ptop(T3) X V(Km/hr		20.475	2	10.237	.040	.961
		6139.016	24	255.792		
	Total	6159.491	27			

Ptop=ptopower, SS=sum square,df= degree of freedom,MS=mean square
John Deer 6130J, Not Significant effect ($P>0.05$) on PTOpower generated due to forward speed.significant effect($P<0.05$) on PTOpower generated due to depth, and width.

Table 4. 26. ANOVA Table of power Utilization of New Holland MT135

	SS	df	MS	F	Sig.
PUR(T1)X Width (m)	.837	2	.418	111.195	.000
	.090	24	.004		

	SS	df	MS	F	Sig.
Total	.927	26			
PUR(T1) X Depth(m)	.837	2	.418	111.195	.000
	.090	24	.004		
Total	.927	26			
PUR(T1) X V(Km/hr)	.070	2	.035	.982	.389
	.857	24	.036		
	.927	26			

PUR=power utilization ration, SS=sum square,df= degree of freedom,MS=mean square
New Holland MT135, Not Significant effect (P>0.05) on power Utilization generated due to forward speed.significant effect(P<0.05) on power Utilization generated due to depth, and width.

Table 4. 27. ANOVA Table of Power Utilization of Belarus MTZ1221

	SS	df	MS	F	Sig.
PUR(T2) X Width(m)	.902	2	.451	111.195	.000
	.097	24	.004		
Total	1.000	26			
PUR(T2) X Depth(m)	.902	2	.451	111.195	.000
	.097	24	.004		
Total	1.000	26			
PUR(T2) X V(Km/hr)	.076	2	.038	.982	.389
	.924	24	.038		
Total	1.000	26			

PUR=power utilization ration, SS=sum square,df= degree of freedom,MS=mean square
Belarus MTZ1221, Not Significant effect (P>0.05) on power Utilization generated due to forward speed.significant effect(P<0.05) on power Utilization generated due to depth, and width.

Table 4. 28. ANOVA Table of power Utilization of John Deer6130J

	SS	df	MS	F	Sig.
PUR(T3) X Width (m)	.684	2	.342	2822.881	.000
	.003	24	.000		
Total	.687	26			
PUR(T3) X Depth(m)	.684	2	.342	2822.881	.000
	.003	24	.000		
Total	.687	26			

PUR(T3) XV(Km/hr)	.002	2	.001	.040	.961
	.685	24	.029		
Total	.687	26			

PUR=power utilization ration, SS=sum square,df= degree of freedom,MS=mean square
Deer6130J, Not Significant effect (P>0.05) on power Utilization generated due to forward speed.significant effect(P<0.05) on power Utilization generated due to depth, and width.

Table 4. 29. ANOVA Table of Fuel Consumption of New Holland TM135

	SS	df	MS	F	Sig.
FC,L/hr X Width (m)	639.345	2	319.672	111.195	.000
	68.997	24	2.875		
Total	708.342	26			
FC,L/hr X Depth(m)	639.345	2	319.672	111.195	.000
	68.997	24	2.875		
Total	708.342	26			
FC,L/hr X V(Km/hr)	53.585	2	26.793	.982	.389
	654.757	24	27.282		
Total	708.342	26			

FC=fuel consumption,SS=sum square,df= degree of freedom,MS=mean square
New Holland TM135, Not Significant effect (P>0.05) on Fuel Consumption generated due to forward speed.significant effect(P<0.05) on Fuel Consumption generated due to depth, and width.

Table 4. 30. ANOVA Table of Fuel Consumption of Belarus MTZ1221

	SS	df	MS	F	Sig.
FC,L/hrX Width(m)	639.345	2	319.672	111.195	.000
	68.997	24	2.875		
Total	708.342	26			
FC,L/hrXDepth(m)	639.345	2	319.672	111.195	.000
	68.997	24	2.875		
Total	708.342	26			
FC,L/hr X V(Km/hr)	53.585	2	26.793	.982	.389
	654.757	24	27.282		
Total	708.342	26			

FC=fuel consumption,SS=sum square,df= degree of freedom,MS=mean square
Belarus MTZ1221, Not Significant effect (P>0.05) on Fuel Consumption generated due to forward speed.significant effect(P<0.05) on Fuel Consumption generated due to depth, and width.

Table 4. 31. ANOVA Table of Fuel Consumption of John Deer 6130J

		SS	df	MS	F	Sig.
FC,L/hrXWidth(m)		570.561	2	285.281	2822.881	.000
		2.425	24	.101		
	Total	572.987	26			
FC,L/hrX Depth(m)		570.561	2	285.281	2822.881	.000
		2.425	24	.101		
	Total	572.987	26			
FC,L/hrXV(Km/hr)		1.905	2	.952	.040	.961
		571.082	24	23.795		
	Total	572.987	26			

FC=fuel consumption,SS=sum square,df= degree of freedom,MS=mean square
John Deer 6130J, Not Significant effect (P>0.05) on Fuel Consumption generated due to forward speed.significant effect(P<0.05) on Fuel Consumption generated due to depth, and width.

Table 4. 32. ANOVA Table of Slippage of New Holland TM135

		SS	df	MS	F	Sig.
Slippage, % X Depth,cm		428.787	2	214.393	563.756	.000
		9.127	24	.380		
	Total	437.914	26			
Slippage, (%) XV(Km/hr)		4.917	2	2.458	.136	.873
		432.998	24	18.042		
	Total	437.914	26			

SS=sum square,df= degree of freedom,MS=mean square
New Holland TM135, Not Significant effect (P>0.05) on Slippage generated due to forward speed.significant effect(P<0.05) on Slippage generated due to depth.

Table 4. 33. ANOVA Table of Slippage of Belarus MTZ1221

	SS	df	MS	F	Sig.
Slippage, (%) XDepth,(m)	476.157	2	238.078	427.006	.000

	SS	df	MS	F	Sig.
	13.381	24	.558		
Total	489.538	26			
Slippage, (%)XV(Km/hr)	3.727	2	1.864	.092	.912
	485.811	24	20.242		
Total	489.538	26			

SS=sum square,df= degree of freedom,MS=mean square

Belarus MTZ1221, Not Significant effect (P>0.05) on Slippage generated due to forward speed.significant effect(P<0.05) on Slippage generated due to depth.

Table 4. 34. ANOVA Table of Slippage of John Deer 6130J

	SS	df	MS	F	Sig.
Slippage, (%) XDepth(m)	406.386	2	203.193	235.770	.000
	20.684	24	.862		
Total	427.070	26			
Slippage, (%) XV(Km/hr)	17.993	2	8.997	.528	.597
	409.076	24	17.045		
Total	427.070	26			

SS=sum square,df= degree of freedom,MS=mean square

John Deer 6130J, Not Significant effect (P>0.05) on Slippage generated due to forward speed.significant effect(P<0.05) on Slippage generated due to depth.

Table 4. 35. ANOVA Table of Effective Field Capacity of New Holland TM135

	SS	df	MS	F	Sig.
EFC(T1)XWidth (m)	.341	2	.171	17.643	.000
	.232	24	.010		
Total	.574	26			
EFC(T1)XV(Km/hr)	.227	2	.113	7.849	.002
	.347	24	.014		
Total	.574	26			

EFC=Effective field capacity,SS=sum square,df= degree of freedom,MS=mean square

New Holland TM135, Significant effect (P<0.05) on Effective Field Capacity generated due to forward speed.significant effect(P<0.05) on Effective Field Capacity generated due to width.

Table 4. 36. ANOVA Table of Effective Field Capacity of Belarus MTZ1221

	SS	df	MS	F	Sig.

		SS	df	MS	F	Sig.
EFC(T2) X Width(m)		0.313	2	0.157	12.439	.000
		0.302	24	0.013		
	Total	0.616	26			
EFC(T2) X V(Km/hr)		0.297	2	0.149	11.210	.000
		0.318	24	0.013		
	Total	.0616	26			

EFC=Effective field capacity,SS=sum square,df= degree of freedom,MS=mean square

Belarus MTZ1221, Significant effect ($P<0.05$) on Effective Field Capacity generated due to forward speed. significant effect($P<0.05$) on Effective Field Capacity generated due to width.

Table 4. 37. ANOVA Table of Effective Field Capacity of John Deer6130J

		SS	df	MS	F	Sig.
EFC(T3) X Width (m)		.489	2	.244	19.149	.000
		.306	24	.013		
	Total	.795	26			
EFC(T3) X V(Km/hr)		.299	2	.149	7.217	.004
		.497	24	.021		
	Total	.795	26			

EFC=Effective field capacity,SS=sum square,df= degree of freedom,MS=mean square

John Deer6130J, Significant effect ($P<0.05$) on Effective Field Capacity generated due to forward speed. significant effect($P<0.05$) on Effective Field Capacity generated due to width.

CHAPTER FIVE

CONCLUSIONS AND RECCOMENDATIONS

5.1. Conclusions

Study was conducted at fincha sugar Factory, and the computed values showed that the highest drawbar pull, drawbar power, field capacity, PTO power, Power Utilization ratio observed by New Holland TM135, Belarus MTz1221, and John deer 6130J at W_3, D_3, and V_3 respectively. The lowest drawbar pull, drawbar power, field capacity, PTO power, Power Utilization ratio, observed by above tractors at W1, D_1, and V_1 respectively.

The three tractors with four-share disc plough attached to New Holland TM135 operating at depths of D_1, D_2 , D_3 in cm, and speed of V_1, V_2, and V_3 in km/hr was consumes fuel 3.52, 8.32 and 15.37L h^{-1}, respectively. Increasing plough depth from D_1 to D_2 and D_2 to D_3 in centimeter increases fuel consumption by 12.84, 30.35 and 56.80%, respectively. The average fuel consumption was 9.07L h-1 in the common plough depth of 10 to 30 cm. In the second field test carried out using Belarus MTz1221 with the same operating depth and speed above consume fuel 3.52, 8.32, and 15.21L/hr, respectively. Increasing plough depth from D_1 to D_2 and D_2 to D_3 in centimeter increases fuel consumption by 12.93, 30.58 and 56.49%, respectively. The average fuel consumption was 9.07h-1 in the common plough depth of D_1 to D_3 cm, and the third field test was carried out using John deer 6130J at common operating depth and speed above was consume fuel 3.25, 8.64 and 14.50L/hr, respectively. Increasing plough depth from D_1 to D_2 and D_2 to D_3 in centimeter increases fuel consumption by 12.23, 32.62, and 54.74%, respectively. The average fuel consumption was 8.79Lh-1 in the common plough depth of D_1 to D_3 in centimeter.

The analysis of the data also showed that both operating depth and working width a significant effect on drawbar pull, drawbar power, PTO power, Power utilization ratio for Belarus MTz1221, and John deer 6130J ($P<0.05$). The Drawbar force result also shows that operating depth,working width, and speed has a insignificant effect on New holland TM135 tractor model ($P>0.05$).

5.2. Recommendations

Based on the above conclusion, the following recommendations were made for Finchaa Sugar Factory which requires further studies:

- ✓ Differences exist in soil/field conditions among different agro-ecological areas of Finchaa Sugar state; it is therefore recommended that studies should be conducted in every soil types available in Finchaa sugar state to obtain data on machine/implement performances based on soil/field conditions which will guide Users in selecting proper machines that would suit their areas for increased production.
- ✓ Studies should be conducted with all the agricultural field machinery and on all the dominant soils used in farm operation, if comprehensive performance data for machine selection is to be obtained in fincha sugar Factory, and farm managers and users of farm machinery should strictly use the performance data of machines in selecting proper machines for their farm operations to avoid mismatching of implements, failure/breakdown and energy loss during operation.
- ✓ In Finchaa Sugar Factory, there is no availability of machine based research institution, and its difficult to carried out research for better utilization of agricultural machinery,and also there was no conducive environment to carry out research based on availability machine and impliment for particular agricultural production, so that attention should be given to fulfil agricultural machinery for better agricultural production. For the success of agriculture lead industry, establishing research based agricultural machinery necessary.
- ✓ Continuously using a machine that is underpowered for the tasks it undertakes will damage it and decrease its lifespan. When taking advice or considering power requirements, it's important to remember that most engines are at their most fuel-efficient when working at 80 percent of their rated 'max' power output. Operation at or around 80 percent of full power will provide both optimal fuel efficiency and the promotion of a long, productive service life. Likewise, running an engine at light loads (30–50% of rated capacity) may not be the most fuel-efficient method for completing the task, and Consider using a lower-powered tractor where possible.
- ✓ Since this research cover only one area, that means it carried out at Finchaa sugar state, so that its not cover all sugar state in Ethiopia. Then similar research can be carried out at all sugar state.

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APPENDIXES

Appendix-A: ASABE table for Draft parameters.

ASABE table for Draft parameters and an expected range in drafts estimated by the model parameters for tillage and seeding implements

				SI Units				English Units				
implement	Width units			Machine Parameters	Width units	Machine Parameters			Soil parameters			Range
MAJOR TILLAGE TOOLS(Subsoiler/Manure Injector												
		A	B	C		A	B	C	F1	F2	F3	
narrow point	Tools	226	0	1.8	tools	129	0	2.7	1	0.7	0.45	50
30 cm winged point	Tools	294	0	2.4	tools	167	0	3.5	1	0.7	0.45	50
Moldboard Plough	m	652	0	5.1	ft	113	0	2.3	1	0.7	0.45	40
Chisel Plough												
5 cm straight point	tools	91	5.4	0	tools	52	4.9	0	1	0.85	0.65	50
7.5 cm shovel/35 cm sweep	tools	107	6.3	0	tools	61	5.8	0	1	0.85	0.65	50
10 cm twisted shovel	tools	123	7.3	0	tools	70	6.7	0	1	0.85	0.65	50
Sweep Plough												
primary tillage	m	390	19	0	ft	68	5.2	0	1	0.88	0.78	50
secondary tillage	m	216	13	0	ft	48	3.7	0	1	0.88	0.78	30
Disk Harrow, Offset												
primary tillage	m	364	19	0	ft	62	5.4	0	1	0.88	0.78	50
secondary tillage	m	254	13	0	ft	44	3.8	0	1	0.88	0.78	30
Disk Gang, Single												
primary tillage	m	124	6.4	0	ft	21	1.8	0	1	0.88	0.78	25
secondary tillage	m	86	4.5	0	ft	15	1.3	0	1	0.88	0.78	20
Coulters												
smooth or ripple	Tools	55	2.7	0	tools	31	2.5	0	1	0.88	0.78	25

bubble or flute	Tools	66	3.3	0	tools	37	3	0		0.88	0.78	25
Field Cultivator												
primary tillage	Tools	46	2.8	0	tools	26	2.5	0	1	0.85	0.65	30
secondary tillage	Tools	32	1.9	0	tools	19	1.8	0	1	0.85	0.65	25
Row Crop Cultivator												
S-tine	raws	140	7	0	raws	80	6.4	0	1	0.85	0.65	15
C-shank	raws	260	13	0	raws	148	12	0	1	0.85	0.65	15
No-till	raws	435	22	0	raws	248	20	0	1	0.85	0.65	20
Rod Weeder	m	210	11	0	ft	37	3	0	1	0.85	0.65	25
Disk-Bedder	raws	185	9.5	0	raws	106	8.7	0	1	0.88	0.78	40
MINOR TILLAGE TOOLS												
Rotary Hoe	m	600	0	0	ft	41	0	0	1	1	1	30
Coil Tine Harrow	m	250	0	0	ft	17	0	0	1	1	1	20
Spike Tooth Harrow	m	600	0	0	ft	135	0	0	1	1	1	30
Spring Tooth Harrow	m	2000	0	0	ft	40	0	0	1	1	1	35
Roller Packer	m	600	0	0	ft	180	0	0	1	1	1	50
Roller Harrow	m	2600	0	0	ft	550	0	0	1	1	1	50
Land Plane	m	8000	0	0	ft		0	0	1	1	1	45
SEEDING IMPLEMENTS												
Row Crop Planter, prepwered seedbed												
mounted												
seeding only	raws	500	0	0	raws	110	0	0	1	1	1	25
drawn												
seeding only	raws	900	0	0	raws	200	0	0	1	1	1	25
seed, fertilizer, herbicides	raws	1550	0	0	raws	350	0	0	1	1	1	25
Row Crop Planter, no-till												
seed, fertilizer, herbicides												
1 fluted coulter/row	raws	1820	0	0	raws	410	0	0	1	0.96	0.92	25
Row Crop Planter, zone-till												

seed, fertilizer, herbicides												
3 fluted coulters/row	raws	3400	0	0	raws	765	0	0	1	0.94	0.82	35
Grain Drill w/press wheels									1	1	1	25
<2.4 m drill width	Rows	400	0	0	raws	90	0	0	1	1	1	25
2.4 to 3.7 m drill width	Rows	300	0	0	raws	67	0	0	1	1	1	25
>3.7 m drill width	Rows	200	0	0	raws	25	0	1	1	1	1	25
Grain Drill, no-till												
1 fluted coulter/row	raws	720	0	0	raws	160	0	0	1	0.92	0.79	35
Hoe Drill												
primary tillage	m	6100	0	0	ft	420	0	0	1	1	1	50
secondary tillage	m	2900	0	0	ft	200	0	0	1	1	1	50
Pneumatic Drill	m	3700	0	0	ft	250	0	0	1	1	1	50

Appendix-B: Current Avaible Field Equipment Status Under Finchaa Sugar Factory

FINCHAA SUGAR FACTORY								
Current Available Field Equipment Status Under tractor and trailer section								
S.n	Machine type	Plate no.	Section	M/model	Machine s/no.	Engine no.	HP	condition FU
1	Johndeere tractor	06/.07	harvesting	8130	6586	RG6090L009526	180	
2	Johndeere tractor	08/.09	harvesting	8130	RW8130P006585	RG6090L009458	180	op
3	Johndeere tractor	10/.11	harvesting	8130	RW8130P006583	RG6090A009589	180	
4	Johndeere tractor	12/.13	harvesting	8130	RW8130P006584	RG6090L009587	180	
5	Johndeere tractor	23/24	harvesting	8130	6523	RG6090L009090	180	
6	Johndeere tractor	127/128	harvesting	8130	RW8130P043040	RG6090B004066	180	
7	Johndeere tractor	129/130	harvesting	8130	RW8130043469	RG6090B004118	180	
8	Johndeere tractor	131/132	harvesting	8130	RW8130P043485	RG6090B004106	180	
9	Johndeere tractor	133/134	harvesting	8130	RW8130P043497	RG6090B004119	180	op
10	Johndeere tractor	135/136	harvesting	8130	RW8130P04523	RG6090B004112	180	0p
11	Johndeere tractor	137/138	harvesting	8130	RW8130P043577	RG6090B004114	180	op
12	Johndeere tractor	139/140	harvesting	8130	1RW8130P043644	RG6090B004108	180	
13	Johndeere tractor	141/142	harvesting	8130	RW8130P043714	RG6090B004124	180	op
14	Johndeere tractor	143/144	harvesting	8130	RW8130P043721	RG6090B004122	180	op
15	Johndeere tractor	145/146	harvesting	8130	RW8130P043749	RG6090B004123	180	

16	Johndeere tractor	147/148	harvesting	8130	RW8130P043767	RG6090B004126	180	op
17	Johndeere tractor	149/150	harvesting	8130	RW8130P043877	RG6090B004144	180	
18	Johndeere tractor	151/152	harvesting	8225R	AAP013058	RG6090G002182	225	op
19	Johndeere tractor	153/154	harvesting	8225R	TAP013018	RG6090G002186	225	op
20	Johndeere tractor	155/156	harvesting	8225R	TAP013309	RG6090G002184	225	op
21	Johndeere tractor	157/158	harvesting	8225R	VAP013124	RG6090G002189	225	
22	Johndeere tractor	159/160	harvesting	8225R	VAP012989	RG6090G002179	225	op
23	Johndeere tractor	161/162	harvesting	8225R	AAP013125	RG6090G002198	225	op
24	Johndeere tractor	163/164	harvesting	8225R	LAP013014	RG6090G002190	225	op
25	Johndeere tractor	165/166	harvesting	8225R	VAP013317	RG6090G002174	225	op
26	Johndeere tractor	167/168	harvesting	8225R	VAP013267	RG6090G002211	225	op
27	Johndeere tractor	169/170	harvesting	8225R	CAP013431	RG6090G002294	225	
28	Johndeere tractor	171/172	harvesting	8225R	1RW8225RKAP013457	RG6090G002280	225	
29	Johndeere tractor	173/174	harvesting	8225R	RTA013438	RG6090G002248	225	op
30	Johndeere tractor	175/176	harvesting	8225R	CAP013520	RG6090G002297	225	
1	Johndeere tractor	177/178	harvesting	8225R	1RW8225RPAP013473	RG6090G002296	225	op
2	Johndeere tractor	179/180	harvesting	8225R	VAP013480	RG6090G002546	225	
3	Johndeere tractor	181/182	harvesting	8225R	1RW8225RABP017886	RG6090G004342	225	op
4	Johndeere tractor	183/184	harvesting	8225R	1RW8225RVBP017871	RG6090G004307	225	
5	Johndeere tractor	185/186	harvesting	8225R	1RW8225RCBP017859	RG6090G004287	225	op
6	Johndeere tractor	187/188	harvesting	8225R	1RW8225RCBP017870	RG6090G004305	225	op

7	Johndeere tractor	189/190	harvesting	8225R	1RW8225RPBP017881	RG6090G004325	225	
8	Johndeere tractor	191/192	harvesting	8225R	1RW8225RCBP017898	RG6090G004348	225	
9	Johndeere tractor	193/194	harvesting	8225R	1RW8225RKBP017879	RG6090G004352	225	OP
10	Johndeere tractor	195/196	harvesting	8225R	1RW8225RLBP017856	RG6090G004292	225	
12	Johndeere tractor	197/198	harvesting	8225R	1RW8225RKBP017901	RG6090G004338	225	op
13	Johndeere tractor	199/200	harvesting	8225R	1RW8225REBP017875	RG6090G004304	225	op
14	Johndeere tractor	201/202	harvesting	8225R	1RW8225RKBP017851	RG6090G004294	225	op
15	Johndeere tractor	203/204	harvesting	8225R	1RW8225RCBP017862	RG6090G004306	225	op
45	Johndeere tractor	205/206	harvesting	8225R	1RW8225RLBP017906	RG6090G004398	225	op
16	Johndeere tractor	207/208	harvesting	8225R	1RW8225RHBP017891	RG6090G004340	225	op
17	Johndeere tractor	209/210	harvesting	8225R	1RW8225RHBP017860	RG6090G004303	225	op
18	Johndeere tractor	211/212	harvesting	8225R	1RW8225REBP017892	RG6090G004340	225	
9	Johndeere tractor	213/214	harvesting	8225R	1RW8225RHBP017907	RG6090G004319	225	op
20	Johndeere tractor	215/216	harvesting	8225R	1RW8225RLBP017887	RG6090G004368	225	op
21	Johndeere tractor	217/218	harvesting	8225R	1RW8225RCBP017867	RG6090G004283	225	op
22	Johndeere tractor	219/220	harvesting	8225R	1RW8225RTBP017880	RG6090G004326	225	op
23	Johndeere tractor		harvesting	8130	RW8130P006582	RG6090L009607	180	
1	Johndeere tractor		LPCD	6130J	1BM6130JCC0000213	J06068T678659	130	
2	Johndeere tractor		LPCD	6130J	1BM6130JCC0000253	J06068T679301	130	
3	Johndeere tractor		LPCD	6130J	1BM61300000214	J06068T678834	130	
4	Johndeere tractor		LPCD	6130J	1BM6130JCC000248	J06068T679026	130	

5	Johndeere tractor		LPCD	6130J	1BM6130JJC0000252	J06068T679293	130	
6	Johndeere tractor		LPCD	6130J	1BM6130JCC000239	J06068T679030	130	
7	Johndeere tractor		LPCD	6130J	1BM6130JCC000240	J06068T679028	130	
8	Johndeere tractor		LPCD	6130J	1BM613000238	JO6068T678891	130	
9	Johndeere tractor		LPCD	6130J	1BM6130JCC00256	J06068T679298	130	
10	Johndeere tractor		LPCD	6130J	1BM6130JCCD000326	J06068T670226	130	
11	Johndeere tractor		LPCD	6130J	1BM61300000254	J06068T67	130	
12	Johndeere tractor		LPCD	6130J	1BM6130JCC00227			
13	Johndeere tractor		LPCD	6130J	1BM6130JCC00255			
14	Johndeere tractor		LPCD	6130J	1BM6130JCC00258			
1	Bell tractor	07/.08	Harvesting	1716F	BHT3897	8875863	171	
2	Bell tractor	29/30	Harvesting	1716F	BHT3845	8877794	171	
3	Bell tractor	41/42	Harvesting	1716F	BHT4070	8876312	171	
4	Bell tractor	31/32	Harvesting	1716F	BHT4052	8877582	171	
5	Bell tractor	15/16	Harvesting	1716F	BHT4093	8871464	171	
6	Bell tractor	27/28	Harvesting	1716F	BHT4057	8876317	171	
7	Bell tractor	39/40	Harvesting	1716F	BHT3889	8877807	171	
8	Bell tractor	21/22	Harvesting	1716F	BHT3834	8873196	171	
9	Bell tractor	05/O6	Harvesting	1716F	BHT4051	8873197	171	
10	Bell tractor	01/O2	Harvesting	1716F	BHT4140	8871453	171	

11	Bell tractor	37/38	Harvesting	1716F	BHT3888	8877801	171	
12	Bell tractor	17/18	Harvesting	1716F	BHT3808	8871457	171	
13	Bell tractor	11/.12	Harvesting	1716F	BHT3879	8870318	171	
14	Bell tractor	09/.10	Harvesting	1716F	BHT4013	8870261	171	
15	Bell tractor	23/24	Harvesting	1716F	BHT3918	8875862	171	
16	Bell tractor	19/20	Harvesting	1716F	BHT3880	8871459	171	
17	Bell tractor	35/36	Harvesting	1716F	BHT4112	8876319	171	
18	Bell tractor	03/.04	Harvesting	1716F	BHT3915	8873204	171	
19	Bell tractor	33/34	Harvesting	1716F	BHT3873	8877804	171	
20	Bell tractor	13/14	Harvesting	1716F	BHT3834	8870320	171	
21	Bell tractor	25/26	Harvesting	1716F	BHT4094	8870262	171	
1	KAT tractor	59/60	Harvesting		103348			
2	KAT tractor	55/56	Harvesting		103339	DG151000351		
3	KAT tractor	51/52	Harvesting		103295			
4	KAT tractor	53/54	Harvesting		103290			
5	KAT tractor	57/58	Harvesting		103353			
1	YTO tractor	43/44	Harvesting	1804				
2	YTO tractor	45/46	Harvesting	1804				
3	YTO tractor	47/48	Harvesting	1804		31390499		
4	YTO tractor		Harvesting	1804		31390541		

1	New Holland tractor	92	LPCD	MT135	ACM283095	HB190133	135	
2	New Holland tractor	94	LPCD	MT135	ACM283252	HB190180	135	op
3	New Holland tractor	86	LPCD	MT135	ACM283288	HB190135	135	
4	New Holland tractor	93	LPCD	MT135	ACM283483	HB190139	135	
5	New Holland tractor	96	LPCD	MT135	ACM283195	HB190456	135	op
6	New Holland tractor	88	LPCD	MT135	ACM283290	HB190159	135	op
7	New Holland tractor	91	LPCD	MT135	ACM283081	HB190202	135	
8	New Holland tractor	90	LPCD	MT135	ACM283375	HB190397	135	op
9	New Holland tractor	89	LPCD	MT135	ACM283099	HB190220	135	op
10	New Holland tractor	97	LPCD	MT135	ACM283170	HB190465	135	
11	New Holland tractor	95	LPCD	MT135	ACM283197	HB190410	135	op
12	New Holland tractor	87	LPCD	MT135	ACM283372	HB190388	135	
1	Belaruse tractor		LPCD	MTZ1221	67626	96544	130	
2	Belaruse tractor		LPCD	MTZ1221	67586	96360	130	
3	Belaruse tractor		LPCD	MTZ1221	67583	96599	130	
1	Ursus tractor		Harvesting	BF6M1013EC	UUH2004601150006	11842050	199	op
2	Ursus tractor		Harvesting	BF6M1013EC	UUH2004601150012	11842049	199	op
3	Ursus tractor		Harvesting	BF6M1013EC	UUH2004601150013	11842057	199	op
4	Ursus tractor		Harvesting	BF6M1013EC	UUH2004601150010	11842053	199	op

5	Ursus tractor		Harvesting	BF6M1013EC	UUH2004601150027	11842037	199	op
1	Ford tractor		L.P.C.D	6610		379	95	op
2	Ford tractor		L.P.C.D	6610		380	95	op
3	Ford tractor		L.P.C.D	6610		78013	95	op
4	Ford tractor		L.P.C.D	6610		78007	95	op
5	Ford tractor		L.P.C.D	6610		94990	95	
1	Johndeere tractor	159/160	harvesting	8225R	VAP012989	RG6090G002179	225	op
2	Johndeere tractor	205/206	harvesting	8225R	1RW8225RLBP017906	RG6090G004398	225	op
3	Johndeere tractor	203/204	harvesting	8225R	1RW8225RCBP017862	RG6090G004306	225	op
4	Johndeere tractor	193/194	harvesting	8225R	1RW8225RKBP017879	RG6090G004352	225	OP
5	Johndeere tractor	183/184	harvesting	8225R	1RW8225RVBP017871	RG6090G004307	225	
6	Johndeere tractor	197/198	harvesting	8225R	1RW8225RKBP017901	RG6090G004338	225	op
7	Johndeere tractor	171/172	harvesting	8225R	1RW8225RKAP013457	RG6090G002280	225	
8	Johndeere tractor	167/168	harvesting	8225R	VAP013267	RG6090G002211	225	op
9	Johndeere tractor	217/218	harvesting	8225R	1RW8225RCBP017867	RG6090G004283	225	op
10	Johndeere tractor	163/164	harvesting	8225R	LAP013014	RG6090G002190	225	op
11	Johndeere tractor	215/216	harvesting	8225R	1RW8225RLBP017887	RG6090G004368	225	op
12	Johndeere tractor	191/192	harvesting	8225R	1RW8225RCBP017898	RG6090G004348	225	
13	Johndeere tractor	151/152	harvesting	8225R	AAP013058	RG6090G002182	225	op
14	Johndeere tractor	165/166	harvesting	8225R	VAP013317	RG6090G002174	225	op

15	Johndeere tractor	155/156	harvesting	8225R	TAP013309	RG6090G002184	225	op
16	Johndeere tractor	181/182	harvesting	8225R	1RW8225RABP017886	RG6090G004342	225	op
17	Johndeere tractor	209/210	harvesting	8225R	1RW8225RHBP017860	RG6090G004303	225	op
18	Johndeere tractor	185/186	harvesting	8225R	1RW8225RCBP017859	RG6090G004287	225	op
19	Johndeere tractor	157/158	harvesting	8225R	VAP013124	RG6090G002189	225	
20	Johndeere tractor	219/220	harvesting	8225R	1RW8225RTBP017880	RG6090G004326	225	op
21	Johndeere tractor	175/176	harvesting	8225R	CAP013520	RG6090G002297	225	
22	Johndeere tractor	187/188	harvesting	8225R	1RW8225RCBP017870	RG6090G004305	225	op
23	Johndeere tractor	161/162	harvesting	8225R	AAP013125	RG6090G002198	225	op
24	Johndeere tractor	201/202	harvesting	8225R	1RW8225RKBP017851	RG6090G004294	225	op
25	Johndeere tractor	199/200	harvesting	8225R	1RW8225REBP017875	RG6090G004304	225	op
26	Johndeere tractor	207/208	harvesting	8225R	1RW8225RHBP017891	RG6090G004340	225	op
27	Johndeere tractor	153/154	harvesting	8225R	TAP013018	RG6090G002186	225	op
28	Johndeere tractor	211/212	harvesting	8225R	1RW8225REBP017892	RG6090G004340	225	
29	Johndeere tractor	177/178	harvesting	8225R	1RW8225RPAP013473	RG6090G002296	225	op
30	Johndeere tractor	213/214	harvesting	8225R	1RW8225RHBP017907	RG6090G004319	225	op
31	Johndeere tractor	189/190	harvesting	8225R	1RW8225RPBP017881	RG6090G004325	225	
32	Johndeere tractor	169/170	harvesting	8225R	CAP013431	RG6090G002294	225	
33	Johndeere tractor	179/180	harvesting	8225R	VAP013480	RG6090G002546	225	
34	Johndeere tractor	195/196	harvesting	8225R	1RW8225RLBP017856	RG6090G004292	225	
35	Johndeere tractor	173/174	harvesting	8225R	RTA013438	RG6090G002248	225	op

36	Johndeere tractor	133/134	harvesting	8130	RW8130P043497	RG6090B004119	180	op
37	Johndeere tractor	137/138	harvesting	8130	RW8130P043577	RG6090B004114	180	op
38	Johndeere tractor	135/136	harvesting	8130	RW8130P04523	RG6090B004112	180	0p
39	Johndeere tractor	12/.13	harvesting	8130	RW8130P006584	RG6090L009587	180	
40	Johndeere tractor	08/.09	harvesting	8130	RW8130P006585	RG6090L009458	180	op
41	Johndeere tractor	141/142	harvesting	8130	RW8130P043714	RG6090B004124	180	op
42	Johndeere tractor	145/146	harvesting	8130	RW8130P043749	RG6090B004123	180	
43	Johndeere tractor	143/144	harvesting	8130	RW8130P043721	RG6090B004122	180	op
44	Johndeere tractor	23/24	harvesting	8130	6523	RG6090L009090	180	
45	Johndeere tractor	147/148	harvesting	8130	RW8130P043767	RG6090B004126	180	op
46	Johndeere tractor	10/.11	harvesting	8130	RW8130P006583	RG6090A009589	180	
47	Johndeere tractor	06/.07	harvesting	8130	6586	RG6090L009526	180	
48	Johndeere tractor	131/132	harvesting	8130	RW8130P043485	RG6090B004106	180	
49	Johndeere tractor	139/140	harvesting	8130	1RW8130P043644	RG6090B004108	180	
50	Johndeere tractor		harvesting	8130	RW8130P006582	RG6090L009607	180	
51	Johndeere tractor	149/150	harvesting	8130	RW8130P043877	RG6090B004144	180	
52	Johndeere tractor	129/130	harvesting	8130	RW8130043469	RG6090B004118	180	
53	Johndeere tractor	127/128	harvesting	8130	RW8130P043040	RG6090B004066	180	
1	Johndeere tractor		LPCD	6130J	1BM6130JCC0000213	J06068T678659	130	
2	Johndeere tractor		LPCD	6130J	1BM6130JCC0000253	J06068T679301	130	

3	Johndeere tractor		LPCD	6130J	1BM61300000214	J06068T678834	130	
4	Johndeere tractor		LPCD	6130J	1BM6130JCC000248	J06068T679026	130	
5	Johndeere tractor		LPCD	6130J	1BM6130JJC0000252	J06068T679293	130	
6	Johndeere tractor		LPCD	6130J	1BM6130JCC000239	J06068T679030	130	
7	Johndeere tractor		LPCD	6130J	1BM6130JCC000240	J06068T679028	130	
8	Johndeere tractor		LPCD	6130J	1BM613000238	JO6068T678891	130	
9	Johndeere tractor		LPCD	6130J	1BM6130JCC00256	J06068T679298	130	
10	Johndeere tractor		LPCD	6130J	1BM6130JCCD000326	J06068T670226	130	
11	Johndeere tractor		LPCD	6130J	1BM61300000254	J06068T67	130	
12	Johndeere tractor		LPCD	6130J	1BM6130JCC00227			
13	Johndeere tractor		LPCD	6130J	1BM6130JCC00255			
14	Johndeere tractor		LPCD	6130J	1BM6130JCC00258			
1	Bell tractor	07/.08	Harvesting	1716F	BHT3897	8875863	171	
2	Bell tractor	29/30	Harvesting	1716F	BHT3845	8877794	171	
3	Bell tractor	41/42	Harvesting	1716F	BHT4070	8876312	171	
4	Bell tractor	31/32	Harvesting	1716F	BHT4052	8877582	171	
5	Bell tractor	15/16	Harvesting	1716F	BHT4093	8871464	171	
6	Bell tractor	27/28	Harvesting	1716F	BHT4057	8876317	171	
7	Bell tractor	39/40	Harvesting	1716F	BHT3889	8877807	171	
8	Bell tractor	21/22	Harvesting	1716F	BHT3834	8873196	171	

9	Bell tractor	05/O6	Harvesting	1716F	BHT4051	8873197	171	
10	Bell tractor	01/O2	Harvesting	1716F	BHT4140	8871453	171	
11	Bell tractor	37/38	Harvesting	1716F	BHT3888	8877801	171	
12	Bell tractor	17/18	Harvesting	1716F	BHT3808	8871457	171	
13	Bell tractor	11/.12	Harvesting	1716F	BHT3879	8870318	171	
14	Bell tractor	09/.10	Harvesting	1716F	BHT4013	8870261	171	
15	Bell tractor	23/24	Harvesting	1716F	BHT3918	8875862	171	
16	Bell tractor	19/20	Harvesting	1716F	BHT3880	8871459	171	
17	Bell tractor	35/36	Harvesting	1716F	BHT4112	8876319	171	
18	Bell tractor	03/.04	Harvesting	1716F	BHT3915	8873204	171	
19	Bell tractor	33/34	Harvesting	1716F	BHT3873	8877804	171	
20	Bell tractor	13/14	Harvesting	1716F	BHT3834	8870320	171	
21	Bell tractor	25/26	Harvesting	1716F	BHT4094	8870262	171	
1	KAT tractor	59/60	Harvesting		103348			
2	KAT tractor	55/56	Harvesting		103339	DG151000351		
3	KAT tractor	51/52	Harvesting		103295			
4	KAT tractor	53/54	Harvesting		103290			
5	KAT tractor	57/58	Harvesting		103353			
1	YTO tractor	43/44	Harvesting	1804				
2	YTO tractor	45/46	Harvesting	1804				
3	YTO tractor	47/48	Harvesting	1804		31390499		

4	YTO tractor		Harvesting	1804		31390541		
1	New Holland tractor	92	LPCD	MT135	ACM283095	HB190133	135	
2	New Holland tractor	94	LPCD	MT135	ACM283252	HB190180	135	op
3	New Holland tractor	86	LPCD	MT135	ACM283288	HB190135	135	
4	New Holland tractor	93	LPCD	MT135	ACM283483	HB190139	135	
5	New Holland tractor	96	LPCD	MT135	ACM283195	HB190456	135	op
6	New Holland tractor	88	LPCD	MT135	ACM283290	HB190159	135	op
7	New Holland tractor	91	LPCD	MT135	ACM283081	HB190202	135	
8	New Holland tractor	90	LPCD	MT135	ACM283375	HB190397	135	op
9	New Holland tractor	89	LPCD	MT135	ACM283099	HB190220	135	op
10	New Holland tractor	97	LPCD	MT135	ACM283170	HB190465	135	
11	New Holland tractor	95	LPCD	MT135	ACM283197	HB190410	135	op
12	New Holland tractor	87	LPCD	MT135	ACM283372	HB190388	135	
1	Belaruse tractor		LPCD	MTZ1221	67626	96544	130	
2	Belaruse tractor		LPCD	MTZ1221	67586	96360	130	
3	Belaruse tractor		LPCD	MTZ1221	67583	96599	130	
1	Ursus tractor		Harvesting	BF6M1013EC	UUH2004601150006	11842050	199	op
2	Ursus tractor		Harvesting	BF6M1013EC	UUH2004601150012	11842049	199	op
3	Ursus tractor		Harvesting	BF6M1013EC	UUH2004601150013	11842057	199	op
4	Ursus tractor		Harvesting	BF6M1013EC	UUH2004601150010	11842053	199	op
5	Ursus tractor		Harvesting	BF6M1013EC	UUH2004601150027	11842037	199	op

Appendix-C: Current Availabilty of Field Tractors status under Finchaa Sugar Factory

Current Avaible Field Equipment Status Under tractor and trailer section							
S.n	Machine type	Section	M/model	Machine s/no.	Engine no.	HP	condition
1	Johndeere tractor	LPCD	6130J	1BM6130JCC0000213	J06068T678659	130	Good
2	Johndeere tractor	LPCD	6130J	1BM6130JCC0000253	J06068T679301	130	
3	Johndeere tractor	LPCD	6130J	1BM61300000214	J06068T678834	130	
4	Johndeere tractor	LPCD	6130J	1BM6130JCC000248	J06068T679026	130	
5	Johndeere tractor	LPCD	6130J	1BM6130JJC0000252	J06068T679293	130	
6	Johndeere tractor	LPCD	6130J	1BM6130JCC000239	J06068T679030	130	
7	Johndeere tractor	LPCD	6130J	1BM6130JCC000240	J06068T679028	130	
8	Johndeere tractor	LPCD	6130J	1BM613000238	JO6068T678891	130	
9	Johndeere tractor	LPCD	6130J	1BM6130JCC00256	J06068T679298	130	
10	Johndeere tractor	LPCD	6130J	1BM6130JCCD000326	J06068T670226	130	
11	Johndeere tractor	LPCD	6130J	1BM61300000254	J06068T67	130	
12	Johndeere tractor	LPCD	6130J	1BM6130JCC00227		130	
13	Johndeere tractor	LPCD	6130J	1BM6130JCC00255		130	
14	Johndeere tractor	LPCD	6130J	1BM6130JCC00258		130	

1	New Holland tractor	92	LPCD	MT135	ACM283095	HB190133	135	

2	New Holland tractor	94	LPCD	MT135	ACM283252	HB190180	135	op
3	New Holland tractor	86	LPCD	MT135	ACM283288	HB190135	135	
4	New Holland tractor	93	LPCD	MT135	ACM283483	HB190139	135	
5	New Holland tractor	96	LPCD	MT135	ACM283195	HB190456	135	op
6	New Holland tractor	88	LPCD	MT135	ACM283290	HB190159	135	op
7	New Holland tractor	91	LPCD	MT135	ACM283081	HB190202	135	
8	New Holland tractor	90	LPCD	MT135	ACM283375	HB190397	135	op
9	New Holland tractor	89	LPCD	MT135	ACM283099	HB190220	135	op
10	New Holland tractor	97	LPCD	MT135	ACM283170	HB190465	135	
11	New Holland tractor	95	LPCD	MT135	ACM283197	HB190410	135	op
12	New Holland tractor	87	LPCD	MT135	ACM283372	HB190388	135	
1	Belaruse tractor		LPCD	MTZ1221	67626	96544	130	op
2	Belaruse tractor		LPCD	MTZ1221	67586	96360	130	op
3	Belaruse tractor		LPCD	MTZ1221	67583	96599	130	op

Annex1 Team of mechanics connecting and adjusting implement to tractor

Annex 2. marking of tractor wheel for percentage evaluation of slippage.

Annex 3. Depth and width of cut were measured by using tape metter.

Questionnaire for tractor-owners

Questionnaire number___________________________________

Date___________________________________

Name of interviewer___________________________________

Name of respondent

Name of the village___________________________________

Name of ward___________________________________

Name of Division___________________________________

1. How big is your farm land? .... (Ha/acres)
2. How big is your cultivated farm land in the current season (2013/2014E.C)? ....(Ha/acres)

Describe the soil in your area

……………………………………………………………..

………………………………………………………………………………………

………………………………………………………………………………………

3. When is the appropriate period for ploughing operation in your area?

(a) From............................ .to...

(b) Give the reasons. …..

……………………………………………………………………………

4. What is the soil condition during the period of land tillage in the area?

………………………………………………………………………………….

5. Which make(s) of tractor(s) do you own? (Fill all that apply in the table below)

sn	Make	Model	Power (Hp)	Age	Condition
1					
2					
3					
4					
5					
6					
7					

6. What kinds of tractor-operated implement(s) do you own? (Fill all that apply in the table below

s/n	make	made	Max.capacity	condition
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				

7. What is the work output of your tractor in a day (10 hrs) in ploughing operations?
   ……………………………………………………………………….. (Acres/day)
8. Which do you think is the most suitable make of tractor in your area?
   ....
9. Which do you consider is the most suitable size in terms of hp of tractor in your area?
   ....

10. Which do your think is the most suitable type of plough in your area?
    ....
11. **Soil Analysis Tests on Research Farm**

Random sampling method was used to identify and select research farm based on the following variables; The farm must be engaged in commercial crop production, It must have its major field operation mechanized with adequate availability of farm tractors and equipment, farm size must be large that is, 180x50m of land used in order to sufficiently accommodate the field studies.

Variables	From selected farm site
PH- value	
% sand	
% silt	
% clay	
Soil type	
Moisture contenta(db)	

Source: Field experiments, 2014E.C

12. Which factor did you consider as the priority in choosing your tractor(s)? (Tick one).

(a) Low price ( )

(b) Availability of spare parts ( )

(c) Low fuel consumption ( )

(d) Durability ( )

(e) Power efficiency ( )

(f) Prior experience ( )

13. For which operations do you often utilize tractor (s)? (Tick all that apply)

(a) Ploughing ( )

(b) Harrowing ( )

(c) Sowing and planting ( )

(d) Weeding and chemical spraying ( )

(e) Fertilizer spreading/distributing ( )

(f) Harvesting ( )

(g) Post Harvest operations ( )

14. What is the average fuel consumption of your tractor in ploughing operations?

....Litres/ha

What are the average costs for running a tractor per season (Fuel, oils, repair and maintenance/season)?

………………………………………………………………………………..

15. Where is the tractor serviced and why?

……………………………………………………………..

....

16. Are there any local dealers/service providers/local mechanics?

……

17. Where do you obtain spare parts for your machines?

……

18. Rank the seriousness of the following constraints with respect to the ownership and use of farm tractors

(5- most serious, 4- very serious, 3- serious, 2- somewhat serious, 1- least serious, 0- not serious)

S/N		5	4	3	2	1	0
	Problem						
1	Difficulties in obtaining spare parts and after sale services						
2	Expensive spare parts						
3	High cost of fuel and lubricants						
4	Lack of well-equipped repair and maintenance service workshops						
5	Scarcity of well-trained tractor mechanics						
6	Scarcity of well-trained tractor operators						
7	Supply of sub- standard tractors						

19. In your opinion, what should be done to improve the level of mechanization in your area?

……

……

………………………………………………………………………………

THANK YOU FOR YOUR PARTICIPATION

Questionnaire for tractor operators

Questionnaire number .... Date ....

Name of interviewer ....

Name of respondent ....

Name of the village .... Ward ....

1. Gender Male ( ) Female ( )(Tick only one)

2. For how long have you been working as an operator?

………………………………………………………………

3. Do you have any formal training in machine operation?

Yes ( ) No ( ) (Tick only one)

4.If the answer to Q.3 is yes, where did you get/receive your training?

………………………………………………………………………………

4. What was the duration of your training?

………………………………………………………………………………………

5. How do you describe the soil in this area?

………………………………………………………………………………………

6. Does it influence the timing of the ploughing operation?

Yes ( ) No ( ) (Tick only one)

7. If the answer to Q.6 is yes, how it

influence?..

…………………………………………………………………………………

8. When is the ploughing season? (Date) From ………………………To ………

9. How much do farmers pay per acre in the ploughing

operation?...

10. What kind of a tractor are you currently operating? (Make and size)

……………………………………………………………………………………

11. What is the work out put on ploughing operation (acres/day)

…………………………………………………………………

12. What is the average fuel consumption of the tractor in ploughing (Litres/acre)

………………………...

13. What do you consider as the most suited type and size of tractor in your area?

……………… ………………………………………..................................

14. Where do you get repairs and maintenance services for the farm tractor? (Tick all that apply)

(a) Home garage [ ]

(b) Formal garages within the district [ ]

(c) Formal garages available in the Morogoro Municipality [ ]

(d) Beyond Morogoro region [ ]

15. What problems do your face in daily operations?

………………………………………………………………………………………

……………………………………………………………………………………

16. In your opinion what should be the solutions to these problems?

………………………………………………………………………………………

THANK YOU FOR YOUR PARTICIPATION

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