DESIGN OF A WEEDING MACHINE FOR AN UPLAND RICE FARM

BY

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DEDICATION

I dedicate this project, firstly to Almighty God, The Alpha, Omega, The beginning and the ending, the one which was, which is and which is to come, the Almighty God, for he is my victory, help, peace, joy, strength, beauty, protection, provision and for His love, grace mercy and favor towards me during the course of my studying in FUOYE.

CERTIFICATION

This is to certify that **SANNI** Olamide Kazeem, an undergraduate student in the Department of Agricultural and Bioresources Engineering, Federal University Oye-Ekiti with Matriculation Number ABE/12/0823, has successfully carried out and completed this project work in partial fulfillment of the requirements for the award of the Degree of Bachelor of Engineering in Agricultural and Bioresources Engineering. The work embodied in this report is original and has not been submitted in part or full for any other Diploma or Degree in this University or any other University.

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ABSTRACT

Weed control is one of the most difficult tasks on an agricultural farm. Three methods of weed control are commonly known in agriculture. These are mechanical, chemical and biological control. Mechanical weed control is easily adopted by farmers once they get convinced of its advantages. Mechanical weed control not only uproots the weed between the crop rows but also keeps the soil surface loose, ensuring better soil aeration and water intake capacity. Weeding by mechanical devices reduces the cost of labour and also saves time. This project work involved the design of a mechanical weeder, after discovering that tools such as cutlass and hoes require high drudgery, time consuming and high labour force. As a solution to these problems, a mechanical weeder was designed. The design component of the machine is from Engineering principles and standard equations. Detailed drawings would be required after the design, using AutoCAD to represent the different views of the machine.

CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF DRAWINGS

LIST OF SYMBOLS

a.i/ha	Active ingredient per hectare
cm	Centimeter
Ha/h	Hectare per hour
Hp	Horsepower
Kg	Kilogram
Kg/ha	Kilogram per hectare
Kg/N	Kilogram per Newton
Kg/h	Kilometer per hour
Kg/m^3	Kilogram per meter cube
KN/m	Kilo newton per meter
kw	Kilowatts
L/ha	Liter per hectare
m^3	Meter cube
M/sec	Meter per second
#	Nigerian Naira
Nm	Newton meter.
Qt/ha	Quintal per hectare
Rs	Indian Rupees
Rpm	Revolution per minute
T/ha	Ton per hectare.

CHAPTER ONE

INTRODUCTION

1.1 General Introduction

Weed control is one of the most difficult tasks in agriculture that accounts for a considerable share of the cost involved in agriculture production. Farmers generally expressed their concern for the effective weed control measures to arrest the growth and propagation of weeds. In Nigerian agriculture, it's a very difficult task to weed out unwanted plants manually as well as using bullock operated equipment's which may further lead to damage of main crops. More than 33 percent of the cost incurred in cultivation is diverted to weeding operations there by reducing the profit share of farmers. A weed is essentially any plant which grows where it is unwanted. A weed can be thought of as any plant growing in the wrong place at the wrong time and doing more harm than good (Parish, 1990). It is a plant that competes with crops for water, nutrients and light. This can reduce crop production. Some weeds have beneficial uses but not usually when they are growing among crops. Weeds decrease the value of land, particularly perennial weeds which tend to accumulate on long fallows; increase cost of cleaning and drying crops. Weeds waste excessive proportions of farmers' time, thereby acting as a brake on development.

Weeding is an important but equally labour intensive agricultural unit operation. Today the agricultural sector requires non-chemical weed control that ensures food safety. Consumers demand high quality food products and pay special attention to food safety. Through the technical development of mechanisms for physical weed control, it might be possible to control weeds in a way that meets consumer and environmental demands.

One important food crop that has attained a staple food status in Nigeria and also become a major source of calories for the urban poor is rice. (Akpokodje, et al. 2001). The per capita consumption of this commodity has been increasing at an average of 7.3 percent annually due to increasing population, changing consumers' preferences from traditional staples (yams, garri, cocoyam etc.) and urbanization among others (Akpokodje, et al. 2001). Domestic productions of this commodity have been inadequate and unable to bridge the increasing demand-supply gap.

Government's efforts of making the country self-sufficient in rice production have not yielded the required results and thus the resort to importation of the commodity with so much of the hard earned foreign exchange. (Belbase, et al. 1985).

Rice production occurs in all agro-ecological zones in Nigeria with the middle belt enjoying a comparative advantage in production over the other parts of the country. Production is primarily by small-scale producers, with average farm size of 1-2 hectares. Yield per hectare is low due to production systems, aging farming population and low competitiveness with imported rice. Rice growing environment in Nigeria are usually classified into five rice ecosystems namely: Rain-fed upland, Rain-fed lowland, Irrigated lowland, Deepwater and Mangrove swamp.

Rice is cultivated in upland and swamp ecosystems in the country. Upland rice production accounts for about 30-35 percent of total rice area in the country with yield of between 0.8-2.0 tonnes/kg, while swamp production system accounts for about 25 percent in Nigeria with yields as high as 2 to 8 tonnes/hectare. The latter also accounts for about 43-45 percent of national rice production (Singh, et al. 1997). In Cross River State, swamp rice production is predominant, followed by upland. Swamp rice farmers in particular and small scale farmers in general in Nigeria have been reported to be inefficient in resource use (Nwaru, 2004, Oniah, 2005).

The mangrove swamp ecology is the least important in terms of area, accounting for less than 1% of total rice area. Another 5% of the rice production area is generally estimated to fall in deep water environment, although it is believed that this figure is most likely overestimated given the physical limits to area expansion within this environment and the reports that water control projects have reduced the potential suitable area. Irrigated systems (including large-scale irrigation schemes and small-scale irrigation schemes) account for 16% of total rice area; rain-fed upland systems, 30% and rain-fed lowland systems, the remaining 47%.

In general, of the estimated 3 million metric tons of annual rice production in Nigeria, three major rice production systems in Nigeria namely upland rain-fed, lowland rain-fed and irrigated production account for 97%. Consistently during the period from 2000-2003 Kaduna State is the largest producer of rice, accounting for about 22% of the country's rice annual production followed by Niger State (16%), Benue State (10%) and Taraba State (7%). The annual domestic output of rice still hovers around 3.0 million metric tons, leaving the huge gap of about 2 million metric tons annually, a situation, which has continued to encourage dependence on importation. Some of the reasons for the gap are connected with the improper production methods, scarcity and high cost of inputs, rudimentary post - harvest and processing methods, inefficient milling techniques and poor marketing standards particularly in terms of polishing and packaging. Also poor or low mechanization on rice farms means heavy reliance on manual labor to carry out all farm operations. Labor costs on Nigerian farms are driven by opportunity costs of labor (hired) in alternative jobs in the cities like civil service, informal sector jobs e.g. motorcycle taxis riding, street hawking etc. Labor and financial constraints make it more difficult to expand farm size or increase production base.

With the advent of mechanization and the adoption of high yielding varieties interest in mechanical weeders is seen among the farmers. Mechanical weed control reduces the drudgery involved in uprooting of the weeds. Moreover mechanical weeders besides killing the weeds loosen the soil between rows thus increasing air and water intake capacity. But this method of weed control has received much less scientific attention compared to the other methods. As a result traditional tools, implements and methods are still used by majority of the farmers for weed control.

1.2 Statement of Problem

Weeding with the use of tools like cutlass and hoe requires high labour force in a commercial farming system hence mechanical weeder is necessary to reduce the labour force. Environmental degradation and pollution caused by chemical is reduced by the use of mechanical weeder.

Low effective operation, low work effort and high time requirement for different types of hoe or cutlass, can be overcome with the use of mechanical weeder.

1.3 Justification

Presently in Nigeria, weeding with simple tools such as cutlass, hoe etc. is labour intensive and intensive and time consuming. Thus, there is a need for the design of self-propelled weeder for intensive and commercial farming system in Nigeria. One of the problems in crops and vegetables production is poor weed control; hence there is need of mechanical weeder to increase the production of these products. The cost for employing a labour force when using simple tools is very high in commercial farming system. This can be reduced using mechanical weeder.

1.4 Objectives of the Project

1.4.1 Broad objectives

To design a reciprocating weeding machine for an upland Rice farm.

1.4.2 Specific objectives

1. To design a double row reciprocating weeder for rice farms, using locally available materials.

CHAPTER TWO

REVIEW OF LITERATURE

This chapter deals with the previous research work carried out by different researchers. The review of research information related to the present study has been arranged under the following headings.

2.0 General:

2.1 Weeds:

Weeds are nothing but those unwanted plants which are grown with the crop and they compete with the growing crop for light, nutrients and water. For the controlling of weed it is essential to know about the weeds for the experimental study to fulfil the purpose of design and development of friendly weeder.

Smith(1964) stated that inter cultivation is an operation that required some kind of tool that stir the surface of the soil to a shallow depth in such a manner that young weeds could be destroyed and crop growth promoted. The primary objectives sought in cultivation of crop are:

1. Retain moisture by
    a. killing weeds
    b. loose mulching on surface
    c. Retaining rainfall
2. Develop plant food
3. Aerate the soil to allow oxygen to penetrate soil.
4. Promote activity of microorganism.

Agrawal and Singh (1968) listed the common weeds of agricultural land with their scientific and common names.

Biswas (1984) reviewed and reported about weeds in Bhopal region. Weeds classified in different ways as per their place of occurrence or habitat, duration of life cycle, plant family etc. As per the occurrence weeds may be classified in two broad groups:

1. Upland weeds

2. Aquatic weed

Upland weeds may further be classified as:

a) Weeds of agricultural land

b) Weeds of Pasteur land

c) Forests weeds

d) Weeds of wasteland etc.

The aquatic weeds may be classified as:

a) Fresh water weeds

b) Marine water weeds

As per the life cycle, weeds may be classified as:

a) Annual weeds

b) Biennial weeds

c) Perennial weeds

Devnani (1988) and Singh et al. (1996) reported that the aim of inter cultivation is to provide best opportunity for the crop to established and grow vigorously, up to the time of harvest. The purpose of inter cultivation is to control the weed growth, improve the soil conditions by reducing evaporation from the soil surface, improve infiltration of rain or surface water, and to maintain ridges or beds on which the crop is grown. The control of weed, its major objective as they compete with the crop for light, nutrient and water. Most of the work on weeding therefore emphasizes the need for timeliness of weeding operation. This underlines the need for farmers to have operation control over power and machinery. Since timeliness in weeding is virtually impossible to achieve if one is to rely on the traditional manually operated hand tools such as hand hoe, cutlass and family labors.

2.1.1 Weed flora distribution

Vega, et al. (1985) recorded that Echinochloa crusgalli, Echinochloa colonum cyperus iria, commelina Benghalensis and Digtaria sauguinalis are the predominant weeds in rice fields.

Shelk et al. (1986) observed the weed flora in upland comprised of Acalypha indica, Binebra retroflexa, Corchonus aestuans, Digera arvensis, Condon dactylon, Alysicarpus regesus, Abutilon indicum and Cyperus rotundus.

Fischer, et al. (1993) revealed that Eleusine indica, Echinochloa crus-galli, Echinochloa colonum, cyperus difformis, cyperus esculenthus, Cyperus iria and Eclipta alba were the main weed species present in direct seeded rice. Echinocloa crus galli and Eclipta alba were the major weeds which were widely distributed.

Huh, et al. (1995) revealed that dominant weed species in dry seeded rice, in descending order of importance were linderia procumbens, cyperus difformis, cardemine, flexuosa, and cyperus serotinus. The most dominant weeds present until the late stage of growth were cyperus difformis, Bidens frondosa and Digetaria ciliaris.

Moorthy (2004) Reported about the problem of weeds in upland rice and gives the weeds and their groups are:

1. Grasses.
2. Sedges.
3. Broad leaf weeds.

Further it gives the common species in above groups are:

Grasses: In grasses, Jungle rice or owned barnyard grass Echinochlora colona (L.) link; Common barnyard grass or small barnyard grass E.crus-galli (L.) Beauv; Goose grass Eleusine indica (L.) Gareth; Bermuda grass cynodon dactylon (L.)Pers; Large crab grass Digitaria sang wina (L.); Crow foot grass Dactyloctenium aegyptium (L.) Wild; Yellow foxtail Setaria glauca Intermedia Roem and schult.

Sedges: Purple nut sedge Cyperus rotundus L; Rice sedge cyperus iria L.

Broad leaf weeds: Bristly starbur Acanthopermum hispidum DC; Spiny pig weed Amaranthus spinosus L; Goat weed Ageratum conyzoides L; Dog weed cleome viscos L; white cock's comb Celosia argentea L; Euphorbia hirta L; Gripe weed phyllanthus niruri L; Day flower Commenlina benghalensis L; Wet land amaranth Alteranthera sessilis (L).

2.2 Timeliness in weeding

Duff and Oricno (1971) reported that the timing rather than the frequency of weeding was a major determinant of effective weed control for rice. Recommendations have been made for the first weeding to be done 2-3 weeks after sowing , followed by a second weeding three weeks later and if necessary a third one.

Igbeka (1984) indicated that the timing rather than the frequency of weeding was a major determinant of effective weed control for rice.

2.3 Loses due to weeds

Smith (1961) reported that the weed competition is a serious problem in almost all rainy seasons' crops causing the losses in yield ranging from 9 to 60 percent or more.

Grist (1976) has reported that the weeds affect the microclimate around the plants harbor diseases and pests, increases the cost of production, plug irrigation and drainage canals and lower the quantity and quality of crop and showed that the competition of one grass plant (Echinocloa crusgalli) per square foot reduced yield of rice by 25 percent.

Moorthy and Manna (1989) Weeds compete severely with upland rice for light, nutrients, moisture and space. The yield losses are colossal ranging from 50- 97 per cent.

Tiwary and Singh (1989) recorded an increase in rice yield of 26.5 and 33.9 percent with the removal of grassy and broad leaf weeds.

Chandrakar and Chandrakar (1992) reported that the weeds compete severely for nutrients and depending upon the intensity of weed growth, deletion of nutrients may be up to 86.5kg N, 12.4kg P and 134.5 kg K per ha.

Moorthy (1996) reported that the percent yield losses due to weed competition for the first one month, two month and entire crop season were 23.7, 35.4 and 40.8 respectively.

Chauhan, et al. (2014) has reported that, in Asian countries, weedy rice, the unwanted plants of Oryza sativa competing with cultivated rice and these plants produce stained grains reduce rice yield from 16% to 74%.

2.4 Methods of weed control

Weed control is the process of limiting weed infestation so that crops could be grown profitably and other activities of man conducted efficiently. Researchers with varied degree of success have tried many methods of weed control. Knowing several of weed control and applying some of them systematically, based on the requirements and the situations, the problem of weeds in the agricultural farm may be kept under control.

2.4.1 Chemical control of weed

Chemical control of weeds is becoming popular day by day in the developing countries.

Singh and Reddy (1981) reported that the pre emergence of butaclor produced the grain yield equal to that of two hand weddings, which was maximum among all the other weed control treatments tested.

Fagade (1980) reported that the cost of herbicide application for weed control was half than that of hand weeding.

Singh, et al. (1982) found that the highest net return was obtained with two weeding at 15 and 30 DAS of rice. When herbicide application was combined with one hand weeding, the highest net return was obtained with thiobencarb at 2 kg a.i./ha followed by butaclor at 2 kg a.i./ha and thiobencarb at 1.5 kg a.i./ha each combined with one hand weeding at 45 DAS.

Biswas (1984) though the advanced countries have mostly switched over to chemical control. The use of chemicals in for weed control has been quite low in India. However, a large number of herbicides are now available to control different types of weeds in rice crop. The reasons for limited use herbicides in India have been high cost herbicides, lack of knowledge on the available herbicides and their most of actions. Effective chemical control weed required different herbicides and management practices in various systems of rice cultivation. The work done on some of the important herbicides are presented herewith.

Ramamoorthy and Balasubramanian (1991) conducted a field experiment on a clay loam during the monsoon season to develop an economic integrated weed control method for upland direct seeded rice. The treatments comprised pre-emergence Pendimethlin (0.75 and 1.25 kg/ha), pre emergence Thiobencarb (1.0 and 1.5 kg/ha), hand weeding and mechanical weeding using a rotary weeder, alone and in combination. The major weeds were Echinochloa colona (E. colonum), Eclipta prostrata and Cyperus rotundus. Weed dry matter 80 days after sowing (DAS) was the lowest with the pendimethaline + hand weeding 30 DAS treatment (45.6 kg/ha), followed by thiobencarb + hand weeding 30 DAS treatment (58.2 kg/ha) and hand weeding 20, 35 and 50 DAS (75.0 kg). Net returns and grain yields were highest for the pendimethaline + hand weeding 30 DAS treatment (6539 Rs. /ha and 4.6 t/ha respectively), followed by thiobencarb + hand weeding 30 DAS (Rs.61917 and 4.3 tonnes respectively) and thiobencarb + hand weeding 30 and 50 DAS (Rs.57057 and 4.2 t respectively).

2.4.2 Cultural methods of weed control

Hand weeding is very popular in rice and vegetable crops. In this method the weeds are uprooted by the hands.

Datta, et al. (1974) reported that the weeding is traditionally carried out with indigenous hand tools. These involve considerable time and labour.

Patel and Pandey (1983) reported that the hand weeding treatment was superior to chemical method of weed control in direct seeded upland rice.

Venugopal, et al. (1983) observed that weed competition was more under broadcast situation. Hand weeding gave the highest weed control efficiency (89.74%) and higher grain yield (63.55 qt/ha) compared to the herbicidal treatments.

Ghosh and Singh (1985) found that the hand weeding twice, one at 15 days and other at 30 days gave the highest weed control efficiency and the maximum grain yield.

2.4.3 Mechanical weed control

Biswas (1984) reported that the control of weeds is oldest far method of weed control though it received less scientific attention us compared to the other methods of weed control. The mechanical weed control methods are extensively used and shall be used in many developing countries including India because agricultural labour in these countries are cheap and easily available. Mechanical methods of weed control are simple and easily understood by farmers. The tools and implements for mechanical weed control are mostly manual and animal operated. Mechanical control of weeds involves use of weeders operated by human labour, animal drawn or tractor drawn weeders, self-propelled weeders or power weeders.

Hand tools

Datta, et al. (1974) reported that the weeding is traditionally carried out with indigenous hand tools. These involve considerable time and labour.

Weeders

A mechanical device to remove the weeds from an agricultural land is known as weeder. A weeder may be manual or animal drawn and tractor mounted or power operated.
Considering the importance of the problem of weeding, the Regional Network for Agricultural Machinery (RNAM) of ECAP initiated a sub network activity on testing, evaluation and adoption of weeders during 1978. In the first workshop of RNAM in 1979. The available weeder in the participating countries namely India, Indonesia, Peoples Republic of Korea, Philippines, Shrilanka and Thailand were selected for testing and evaluation.

2.4.3.1 Types of weeders

Biswas (1984) according to the power sources of weeder, they classified as follows:

1. Manual weeders

    a) Small tools or aids

    b) Chopping hoes

    c) Pull type hoes

    d) Push type weeder

    e) Push – pull weeder

2. Animal drawn weeders

    a) Hoes with triangular and straight blades

    b) Cultivators with shovels, sweeps and duck foot sweeps

    c) Animal drawn rotary weeders

    d) Hoes with rotary tines

2. Power operated weeders (self-propelled weeders)

2.4.3.1.1 Manual weeder

These are various types of weeders which can be used for mechanical weeding in line sown rice. Manual and bullock mechanical weeder are friendly to environment, reduced time requirements, reduces human effort, manipulate the crop root zone reducing plant mortality, enhance root and shoot growth. The time saved by use of mechanical weeders may be utilized in better care and management of crop gaining higher yield. The mechanical weeders are also reported to be economical than chemicals and other methods Bhardwaj (2004).

Khan, et al. (1987) reported that development of push type cono weeder which uproots and buries weeds in a single pass without requiring a back forth movement, especially suitable for rice. Manual weeding of rice in one hectare requires on an average of 120 man hrs. The cono weeder is about twice as far as to operate as that conventional rotary weeder.

Mishra, et al. (1992) have reported that the human labour output was increased by 8-10 times in weeding with developed Ambika paddy weeder. The weeder cuts the weed into small segments and incorporates those into the mud and facilitates recycle of the plant nutrients in the soil and improve the soil fertility.

Moorthy, et al. (1992) conducted field trials in sandy loam soil and evaluated effectiveness of 2 types of manually operated implement (the rice wheel hoe and the finger weeder), used either once at 15 days after sowing or twice (15 and 30 days after sowing) and compared with hand weeding once at 15 days and twice at 15 and 30 days for weed control in rice. The rice wheel hoe used twice resulted in the 80% weed control and gave rice grain yield 1.65 t/ha and straw yields 3.54 t/ha. The finger weeder used twice resulted in the weed control 86.7% and grain yields 2.18 t/ha and the rice wheel hoe used twice resulted in straw yields 4.68 t/ha. All weed control treatments increased percentage weed control, grain yields and straw yields from un-weeded control values of 0, 0.18-0.64 t/h and 0.47-1.63 t/h, respectively to 26.7-86.7, 0.5-2.18 t/h and 2.03-4.68 t/h, respectively. The rice wheel hoe used twice resulted in the greatest benefit-cost ratio.

Tewari, et al. (1993) concluded that the overall performance of a straight flat blade was the best. The field efficiency was highest, physical damage to crop was the least and weed removal per unit area was the greatest. The average power required by push-pull weeder was 21.3 W.

Mishra, et al. (1993) conducted field experiments at ZARS, Ambikapur and found that the line sowing of Dhuria rice and weeding by Ambika paddy weeder gave higher yield and economic return compared to chemical weed control.

Sharma, et al. (1996) observed that manually operated weeder used twice at 20 and 30 days after emergence controlled the weeds effectively and recorded low weeds.

Ramachandra, et al. (1998) investigated the effect of different hand weeders for weeding. The weeders tested were Varvari (hand hoe), Varvan cruddali, and long handle blade hoe.

Weeding was carried out at 30 DAS and 45 DAS. The Varvari was the best for uprooting weeds, but this was found labour intensive. It was concluded that among the long handled weeders, the wheel hoe was the best because it covered more area and loosened soil between rows.

Shiru (2011) reported that, a push-pull type of mechanical manual weeder was designed and fabricated. The weeder consists of main frame / handle, soil cutter (wedge), spikes, wheel bearing, bicycle chain and sprockets. It was quite simple, effective and the result is immediately observed. Tests result shows a weeding index (e) of 74.53%, efficiency of cutting blades 88% and field capacity of 0.02 ha/h. Small scale farmers can take advantage of the improved weeder to control weeds on their farms.

Muhammad, et al. (2012) developed a hand push mechanical weeder that consists of two set of cone rotor blades, adjustable main frame and a float. The weeder, of effective field capacity of 0.357 ha/h has 64.87 N draft and overall width and depth of cut of 180 mm and 20mm respectively. With a single run of cut in between the rows on the field at a soil moisture content of 40.8%, the optimum weeding efficiency was 84.5% while weeding efficiency at 10.5% soil moisture content was 53.1%. Consequently, the highest plant damage of 8.33% was recorded at the 10.5% soil moisture content. 0.058 hp is the power required by a single person to push the prototype weeder.

Kumar et al. (2013) reported that, two types of manual weeder (cono-weeder and Mandava weeder) for shallow water conditions was selected and evaluated for different age group of workers (25 to 30, 30 to 35, and 35 to 40 years) at different day timings (T1 = 8.00 to 11.00 AM, T2 = 12.00 to 2.00 PM, and T3 = 4.00 to 6.00 PM). The weeding operations by different age group of workers at different working hours showed that the heart rates corresponding to cono-weeder and Mandava weeder was 154.54 beats/min and 140.17 beats/min, respectively. Oxygen consumption rate was 1.76 l/min and 1.47 l/min respectively. Working during 12:00 to 2:00 PM with both weeders developed maximum heart rate and oxygen consumption rate as compared to 8:00 to 11:00 AM and 4:00 to 6:00 PM. The study also reveals that, agricultural workers of 25 to 30 years age group developed maximum working heart rate and oxygen consumption rate during weeding operations, which were higher than the age groups of 30 to 35 years and 35 to 40 years.

Gongotchame, et al. (2014) studied on participatory approaches to examine the suitability of six mechanical weeders (Ring hoe, Fixed-spike weeder, Curved-spike floating weeder, Twisted-spike floating weeder, Straight-spike weeder and 2-Row spike-and-blade weeder) and ranked and compared them in order of 15 preference with weed management practices. The ring hoe had the highest rank with 97 % farmer's preference in the fields of non-ponded water and relatively.

2.4.3.1.2 Animal operated weeder

Yadav (1980) gave details of serrated blade for hoe and harrow, bullock drawn blade cum tine hoe for weeding and intercultural operations in dry land farming. The serrated blade of different size may be fitted in to the traditional blade hoe or blade harrow. The serrated blades easily penetrate into the soil and help in moisture conservation.

Murthy, et al. (1996) evaluated the performance of a bullock drawn blade hoe for 3 different approach angles (120, 130 and 140 degrees) to determine the most effective angle with respect to implement draught, soil moisture conservation, weeding efficiency and crop (finger millet) yield under dry land conditions. The overall performance of the blade hoe was best with an approach angle of 140 degrees with respect to the formation of ridges and furrows, soil moisture conservation and yield but the draught was significantly higher (19.5 kg).

Biswas, et al. (1999) reported that the animal drawn weeder works between crop row spacing, the weeds left over a long rows may be removed manually. The straight blades in traditional hoes tend to remove weeds up to the working width of the blades. However, due to clogging of the straight edges, the output is adversely affected. So there is need to study and use improved blades.

Balachand (2006) designed and developed an animal drawn weeder considering the functional requirements and its required strength to bear soil forces acting on it. The performance of Animal weeder having 3 types of blade viz. Straight blade, curved blade, and sweep blade was compared with the Ambika paddy weeder and Hand weeding. Weeding by Animal drawn weeder with sweep blade results higher field capacity (0.0759 ha/h), field efficiency (73.87%) and performance index (738.75) then the other two blades.

2.4.3.1.3 Power weeders

Power weeders are self-propelled walking type machines used for weeding specially in lowland rice.

Yatsuk, et al. (1982) has reported about use of miniature rototillers for soil working. Rototillers with small cutting width can also be used for light cultivation and weeding the space between the rows of some crops. Manual weeder with a flexible drive shaft and a portable engine earned on the shoulders is one of the types of miniature rototillers. The depth of soil working is regulated by the forward speed of the tiller: the lower the speed, the greater the depth of soil working. Miniature tillers are widely used in England, Japan and Italy. Pandey (1983) defined the mini power tiller as the smallest types of power tiller fitted with 2 to 4 hp petrol/ kerosene or diesel air cooled engine. It weighs from 60 to 100kg.

Tewari (1987) developed a weeder cum herbicide application machine at the Agricultural Engineering department of IIT Kharagpur. It had a ground wheel made of MS tats with 40 cm diameter having MS rod spokes, and a wheel guide extended rearwardly and fixed to a main platform made of angle iron having slots to attach different weeding blades. The unit could be used both as a mechanical weeder and an herbicide applicator. To enable the machine work as a weeder it could be conveniently attached with various weeding range blades- flat inclined, flat inclined with serrated edges, four time double and the improved double blade. The applicator mechanism consisted of feed tank, dripping mechanism and application mechanism. The herbicides consumption was 100 to 200 L/ha. The mechanical weeder required 8 to 12 man- days /ha.

Singh (1988) used a portable frame and engine of knap sack power sprayer to transmit rotary motion to a serrated disc rotary blade. A flexible shaft was used as means of power transmission. Also an electric motor of 0.5 hp was used as prime mover for operating the same machine set. On testing the man-hour requirement of knapsack sprayer engine and electric motor operated slasher came 57 and 50 respectively. But after some time of operation flexible shaft had broken due to more jerks coming on it. He also developed a front mounted power tiller attached cutter blade to accomplish cutting in small time period. Bearings inside a hollow shaft were used to support a cutting blade rotating in horizontal plane and power transmission was done using a bevel gear set and V-belt. On testing it was found that only 16 man-hour are required to accomplish the cutting of one ha but power of the engine was underutilized thus making wastage of energy.

Rangasammy, et al. (1993) developed a power weeder and performance was evaluated and compared with the performance of conventional method of manual weeding with hand hoe and using manually operated dry land weeder. The field capacity of weeder was 0.04 ha/h with weeding of 93 per cent for removing shallow rooted weeds. The performance index of weeder was 453.

Panwar (1999) designed and developed a lightweight, low horsepower engine operated weeder cum seeder for weeding of row crops and single row seeding of different crops. The machine was powered with 1.5 hp petrol start kerosene run engine. The common chassis was designed for reduced rolling resistance and adequate traction ability. The engine power was transmitted to 280 rpm ground wheel through a specially designed reduction gear box and chain and sprocket system. For weeding operation, three types of tools such as hoe blade, sweep and L-blade were attached at the rear of the machine. The weeding tool can be selected based on density of the weed and requirement of the operator. It is a walk behind type of machine with an average ground speed of 2.5 km. The field capacity of the machine ranged between 0.5 - 0.6 ha/day for 8 working hours per day. The average fuel consumption was observed in the range of300-350ml/h.

Tajuddin (2006) designed, developed and tested an engine operated weeder with 2.2 kW (3hp) petrol started kerosene run engine. The rated speed of 3300 rpm at load was reduced to 60 rev/min of ground wheel by belt – pulley and sprocket – chain mechanism. A sweep type weeding blade was designed for structural strength. The effective field capacity 0.10 ha/h, fuel consumption rate 0.60 to 0.75 l/h, depth of operation 37mm,35mm, 39mm, field efficiency

85.71, weeding efficiency 85.85% , initial cost of weeder 20,000 cost of operation 580/ ha were found.

Cloutier, et al. (2007) stated that mechanical weed control is generally widespread and used by farmers who do not use herbicides and recommendations always come to control weed during the early crop stages because limited tractor and cultivator ground clearance and machine-plant contact may potentially damage the crop foliage at later growth stages.

Padole (2007) evaluated the comparison in field performance between rotary power weeder and bullock drawn blade hoe. Rotary power weeder comprises engine, gearbox, clutch, main frame, depth control wheel, V shaped sweep, cutter wheels, handle, controls and transportation wheels. It worked better than bullock drawn blade hoe in respect of working depth 5.67 cm (16.67% more), effective field capacity 0.14 ha/h (40% more), and field efficiency 90%, which is 34.11 % more than that of bullock drawn blade hoe. The cost of operation was found to be 798.46 compare to 894.87 per ha by bullock drawn blade hoe. Hence, it is more economical and effective than bullock drawn blade hoe as it saves 10.77% weeding cost; reduce plant damage up to 54.23%, and achieved weeding efficiency up to 92.76%.

Manuwa, et al. (2009) designed, fabricated and tested a petrol engine powered mechanical weeder for row crop at Federal University of Technology, Nigeria. The main component of weeder is 5 hp internal combustion petrol engine, transmission unit, three sets of weeding blades main frame and ground wheel. The length, width and height of weeder are 0.85, 0.32, 0.65m, respectively. The cutting blade width is 0.24 m which rotates at 800 rpm. The field test was conducted in moist soil condition, determined weeding efficiency as 95% with effective weeding capacity of 0.053 ha/h and fuel consumption of 0.7l/h. The production cost of weeder is US$ 285 in 2007.

Niyamapa, et al. (2010) designed three prototype rotary blades to reduce the tilling torque, impact force and specific tilling energy, and tested in a laboratory soil bin with flat tilling surface. Experiments with the prototype rotary blades and Japanese C-shaped blade were carried out at forward speeds of 0.069 and 0.142 m.s-1 and at rotational speeds of 150, 218, 278 and 348 rpm (or 3.30, 4.79, 6.11 and 7.65 m.s-1) by down-cut process in clay soil.

Nkakini, et al. (2010) designed and fabricated a rotor-weeder powered with 1.4 hp petrol engine and compared the field performance with the traditional manual hand hoe. The weeder consists of main frame, handle, rotary blades, shaft, sprocket and chain, chassis, cutting depth hint rear cutting depth adjuster, wooden engine seating, engine and ground wheel. Theoretical field capacity of the rotor-weeder was 0.47 ha/h with an effective field capacity 0.34 ha/h which was approximately twenty times that of manual weeding. The performance index was 1,700 and fuel consumption was 3.2 l/day. Weeding efficiency of rotor weeder was 71% for removing shallow-rooted weeds.

Ratnaweera, et al. (2010) designed and fabricated a power weeder. The weeding ability was optimized by weeding three rows simultaneously. The double-action weeding drum was driven by a small 1.3 kW gasoline engine, which can enable removal of weeds, while facilitating the forward motion of the machine. In addition, the conical shaped weeding drums designed to loose-up soil without harming the rice. A novel row changing mechanism was helpful for operating the machine by single person without destroying rice. A helical shaped tooth was designed in the weeding drums to enhance the shearing effect for weeding while losing up the soil.

Zareiforoush, et al. (2010) presented a new theoretical approach to design main tillage components of rotary tillers. In designing the rotary tiller shaft, it was revealed that in addition to the torsional moment, the flexural moment was also effective on the system safety. It was also recognized that in designing a rotary tiller, blades are most subjected to fracture by incoming stresses. The optimal value of rotor diameter considering the values of maximum tangent force was about 39.4 mm.

Alizadeb (2011) studied field performance evaluation of four types of mechanical weeders, single row conical weeder (W1), two rows conical weeder (W2), rotary weeder (W3) and power weeder (W4) and was compared with hand weeding (W5) in rice. The results revealed that among the mechanical weeders, the highest weeding efficiency (84.33%) was obtained with W4 and the lowest value (72.80%) was measured with W3. The average of damaged plants in mechanical weeders was obtained as 3.83% compared to 0.13% in hand weeding. The weeding cost was reduced by 15.70, 38.51, 22.32 and 48.70% for W1, W2, W3 and W4, respectively as compared to W5.

Olaoye, et al. (2011) studied on the motion of weeding disc at any point on the surface of a rotary tiller. The weeder consists of 5 hp petrol engine, three pneumatic ground wheel, tool assembly, frame and handle. The performance of the weeder was investigated by considering the effects of four (4) weeding tools (Iron rod tine, Cable tine, Line yard tine and Plastic strand tine) and three (3) levels of weeding speeds (1804 rpm, 2435 rpm, 3506 rpm) on the weeding index, weeding efficiency and field capacity. The study resulted that for the forward speeds of 0.4 m/s to 0.5 m/s and engine speeds of 1804 rpm to 2261 rpm the weeding efficiency was 54.98% to 59.05% respectively.

Bin Ahmad (2012) suggested that to design an effective intra-row power operated weeder; the weeder should be targeted for different scale crops production and to achieve intra-row weed control efficiency of 80% or more. Also, the weeder should be able to control weeds with minimal crop plant damage with low bulky overall dimensions of the weeder.

Ojomo, et al. (2012) conducted a study on machine performance parameters by developing and evaluating a motorized weeding machine for the effect of moisture content (10%, 13% and 16%) and the type of cutting blades (Flat blade, spike tooth blade and curved blade) on the machine efficiency, quality performance efficiency, percentage of uprooted weeds and percentage of partially uprooted weeds. At 16% soil moisture content, the spike tooth blades gave the best machine efficiency by 94%, quality performance efficiency by 84%, percentage of uprooted weeds by 2.8% and least percentage of partially uprooted weeds by 1.8%.

Olaoye, et al. (2012) developed and evaluated a rotary power weeder to reduce the drudgery and ensure a comfortable posture of the operator during weeding and increases production with weeder components parts as frame, rotary hoe (disc), tines, power unit and transmission units. The results of field performance evaluation showed that, field capacity and weeding efficiency of the rotary power weeder were 0.0712 ha/h and 73% respectively. The cost of operation with this weeder was estimated as N 2,700 as against N 12,000 as manual weeding.

Thorat, et al. (2013) was designed and developed for weeding of ridge planted crops. The main working components of the weeder were cutting blades and rotor shaft. Three types of blades (L-type, C-type and Flat-type) were selected having length, width and thickness of 100 mm, 25 mm and 6 mm, respectively, operating with a rotor shaft of 18 mm in diameter. C-type blades were most suitable at gang speed of 200 rpm and 15.26±0.96% (d.b) soil moisture content with weeding efficiency, plant damage, field capacity of 91.37%, 2.66%, and 0.086 ha.h-1, respectively. Time saving with ridge profile power weeder as compared to manual weeding was 92.97 per cent.

Kankal (2013) designed a self- propelled weeder on the basis of agronomic and machine parameters. The main features of prototype self- propelled weeder were, a 4 hp petrol start kerosene run engine, power transmission system, weeding blade (Sweep) and cage wheel. The rated engine speed 3600 rpm was reduced to 23 rpm of the cage wheel by using chain and sprocket mechanism in three steps.

Mahilang, et al. (2013) designed, developed and fabricated a power operated rotary weeder. The developed power weeder had a 1.4 hp petrol start/kerosene run engine as prime mover. The power was transmitted by means of belt, pulley from engine to traction wheel and to cutting units. For cutting, standard six L shaped blades were provided on the hub which in turn was fitted on rotary shaft. The weeding efficiency (91%), quality of work (14%), field efficiency (60%) and operational cost was found to be 808.42.

Hegazy, et al. (2014) developed a power weeder for maize crop with modified vertical blades which were mounted on a circular rotating element on its horizontal side; the motion was transferred to blades units by amended transmission system. The effect of weeder forward speeds, depth of operation, number of blades and soil moisture content on fuel consumption, plant damage, weeding index, effective field capacity, field efficiency, energy required per unit area and total cost were studied. Three levels of soil moisture content (7.73, 12.28 and 16.18%), two blades arrangements (two and four vertical blades for each unit), three weeder forward speeds (1.8, 2.1 and 2.4 km/h) and two depths of operation (from 0 to 20 and from 20 to 40 mm) was chosen. The results showed that, the minimum value of fuel consumption was 0.546 l/h and recorded by using two blades with 1.8 km/h weeder forward speed at depth of operation ranged from 0-20 mm and soil moisture content 16.18 %. The highest field efficiency was 89.88% by using two blades with 1.8 km /h weeder forward speed at depth of operation ranged from 0 to 20 mm and soil moisture content 16.18%. The minimum value of effective field capacity was 0.198 fed/h by using four blades, weeder forward speed 1.8 km/h, soil moisture content 7.73% and under depth of operation ranged from 0 to 20 mm and soil moisture content 16.18%. The minimum value of effective field capacity was 0.198 fed/h by using four blades, weeder forward speed 1.8 km/h, soil moisture content 7.73% and under depth of operation ranged from 20-40 mm. The lower value of total cost was 55.09 L.E /fed and was obtained by using two blades with 2.4 km/h weeder forward speed at depth of operation ranged from 0-20 mm and soil moisture content 16.18 %.

2.5 Common Types of Weeding Methods in Nigeria

Manual weeding is common in Africa particularly in Nigeria where about 75 % of the population is engaged in farming. This method is labour intensive and is one of the major problems of farming in Nigeria. The resultant effect is that youths detest farming and engage in rural- urban migration in search of greener pastures. Mechanical weeding is not yet introduced in Nigeria, as there are no effective row crop weeders. In developed countries chemical weeding is more prominent than mechanical weeding. However in the recent times the problem of environmental degradation and pollution is making the world to have a rethink on the adoption of mechanical weeders. Busari (1996) opined that the use of herbicides has possible effect on desert encroachment and other adverse environmental impact.

Development of row crop weeders is the viable option in order to ensure sustainable crop production and optimum environmental conditions. It is very easy to use ploughs, harrows and mowers to control weeds in the open field where crop had not been planted. However special care must be taken when using weeders in row crop plantations.

For maximum work efficiency, it is suggested that the elbow flexon angle should be 850 to 1100, (Grandjean, 1988). For push-pull operation of a machine, the elbow flexon angle would be 900 (Tiwari, 1985) and the optimum holding height for male is 630-677 mm and that of female is 534-630 mm (Tiwari et al, 2007). As the time period available for weeding is limited, improved mechanical weeders are to be used to complete the weeding operation in due time at less cost. At present, more than 10 different designs of hoes and weeders are available in Nigeria. All these designs are region specific to meet the requirements of soil type, crop grown, cropping pattern and availability of local resources. Therefore, effort has been made to develop a weeder for dry land crops, to evaluate its field performance along with the Ergonomical aspects. Its performance was compared with other available weeders like wheel finger weeder, wheel hoe and traditional method of weeding by trench hoe for groundnut crop at different soil moisture content.

2.6 FORCES ACTING ON TILLAGE IMPLEMENTS

A tillage tool is subjected to three independent force systems, these systems are the weight acting at the center of gravity of the tool, the soil forces acting on the tool, and the forces acting between the tool and the prime mover. These force systems are in equilibrium if no acceleration is involved. Since the soil forces are determined by the soil-tool system and tool weight can be considered constant, the forces acting between the tool and the prime mover "adjust" so that equilibrium is maintained. If the prime mover is replaced by a dynamometer, and the weight of the tool is appropriately considered, soil forces on a tillage tool can be measured.

Although the principle of measuring soil forces is direct, actually obtaining meaningful measurements is not. Soil conditions, tool shape, and manner of tool movement directly affect soil forces. Except for wear, tool shape remains essentially unchanged for a tool; but the manner in which the tool is moved through the soil is controlled by the dynamometer. Therefore, a dynamometer must not only be able to measure the forces between itself and a tool, it must also be able to hold the tool in position so that the tool's depth, width, and orientation do not change during operation. Because the condition of soil at any particular location cannot be quantitatively expressed with accuracy, and because of the wide variability in soil, soil conditions must also be controlled by soil preparation techniques. Variations between two areas within one field may cause greater differences in measured forces than the difference caused by two different tools.

Experience has shown that control of soil conditions is essential; hence, elaborate facilities have been devised and constructed. In these facilities bins of uniform soil material are maintained to provide more uniform plots of soil than can be found naturally in the field.

2.6.1 HOW IMPLEMENT PERFORMANCE IS AFFECTED BY SOIL FACTORS

Draught is influenced by four main groups of factors. Which are:

- Soil/Soil parameters.
- Soil/Metal parameters.
- Implement shape.
- Forward speed.

2.6.1.1 Soil/Soil parameters

Little can be done to change the apparent cohesion and angle of shearing resistance of a given soil, although any compaction on the failure surface will increase. However, it is apparent that minimizing the normal load in frictional soils and the area in cohesive soils will minimize the soil shear strength and hence the draught force. Vibrations, to a very limited extent, can reduce the apparent normal load in frictional soils, but the important factor is to ensure no unnecessary surcharging load is applied to the soil. Kolbuszewski, et al. (1964).

2.6.1.2 Soil/Metal parameters

The polish on an implement surface is usually more important than the material in influencing the value of the angle of soil/metal friction. A large reduction in diameter can be achieved by removing the rust from a tine, but the worthwhile returns obtained from very high degree of polish are very small in most soils. Minimizing the normal load on the interface and the interface area will minimize the frictional and adhesive components respectively when they are present. Nichols, (1931).

The normal load can be reduced by eliminating all unnecessary surcharge and by attempting to lift the soil away from the interface, e.g. by providing an air cushion using compressed air, or by vibrating. By choosing a suitable path of oscillation, it is possible to throw, or attempt to throw the soil away from the interface, and if interface motion can then occur whilst the normal load is reduced, a reduction in the sliding force will be achieved. Eggenmuller, (1959).

The soil moisture content at the interface plays a very large part in determining the sliding resistance. Since the area of the soil/implement failure surface is usually fairly small (at least when compared with soil/soil failure surface) there is the possibility of changing the soil moisture content around the tine to advantage. The interface moisture content can be varied by a number of methods. Heat may be applied e.g. from exhaust gases, to reduce the moisture content. Electro-endosmosis may be either to increase or decrease the moisture content. This effect arises when an electrical potential is applied between the implement and the soil. Water will migrate to the negative electrode and can therefore be induced to move towards or away from the implements depending upon the polarity. One of the major weakness of these techniques is that moisture changes are slow and so they are generally only applicable in the slower operations. The moisture content can also be increased by adding water directly at the interface. Crowther, et al. (1924).

One further way of reducing the interface resistance is to eliminate sliding completely by using such things as moving belts and rollers.

2.6.1.3 Implements shape

The tine rake angle has a very large effect on the draught force. The draught increases slowly from rake angles of 10^0 to 50^0, above50^0, however, the rate of increase is very rapid indeed. Therefore, for minimum draught, rake angles of less than 50^0 should be used, providing that tines set at this inclination will do the job satisfactorily. Payne, et al. (1959).

Badly placed tines and depth wheels can interfere with the soil failure patterns and may increase the surcharging load and hence soil shear strength and the draught force. A similar surcharging effect could be produced by the tractor rear wheels with closely mounted acute angled tines.

In a narrow tine soil failure, a wedge of soil moves up the face of the tine and if this impinges on the undersurface of the beam, a surcharging load will be produced. Dransfield et al (1964).

2.6.1.4 Forward speed

Increased forward speed increases draught with most implements, mainly because of the more rapid acceleration of the soil. Greater forces are required to provide this acceleration and since they also increase the reaction at the interface, a higher sliding resistance results. The increased sliding resistance contributes most to the increased draught force. O'callaghan et al (1965). To reduce the effect of speed on draught these acceleration forces should be kept to a minimum, particularly, those acting at right angles to the interface. Olson, et al. (1965).

CHAPTER THREE
MATERIALS AND METHODS

This chapter's deals with the design and testing of the developed mechanical weeder for rice. The various factors involved in design were operation safety, light weight of machine, overcomes man power scarcity, saves time and cost, easiness in fabrication are taken into account for its design procedure.

The design component of the machine is from Engineering principles and standard equations. Detailed drawings would be required after the design, using AutoCAD to represent the different views of the machine.

The materials and methods about the development of the mechanical weeder are discussed in this chapter.

3.1 DESIGN CONSIDERATIONS

A mechanical weeder was designed for weeding of rice. From the design point of view-cutting blades, crank shaft, reciprocating mechanism and sprocket and chain were the important components to be designed of mechanical weeder for rice. From the various cases of weeding methods studied in the review of literature, the following deductions can be made for the effective design of this mechanical weeder.

1. The Prime mover

   The weeder is to be moved via the prime mover.

2. The draft requirement of the machine

   This factor is influenced by four main groups of factors according to Gordon spoor (1969).

   a. Soil/Soil parameters

Where $\text{H} = \text{Shear force}, \text{C} = \text{Cohesion}, \text{A} = \text{Area}, \text{W} = \text{Normal load}, \phi =$ Angle of shearing resistance.

   b. Soil/Metal parameters
   c. Implement shape
   d. Forward speed.

(a) From $H = CA + W\tan\phi$. it is apparent that minimizing the normal load in frictional soils and the area in cohesive soils will minimize the soil shear strength and hence, the draft force. Vibrations, can reduce the apparent normal load in frictional soils. (Spoor 1969). Hence a reciprocating mechanism is used in this project to generate vibration.

(b) Soil/Metal parameters. Removing the rust from a tine by grinding can reduce angle of soil/interface friction.

(c) The blade's shape. The tine rake angle has a very large effect on the draft as shown below.

The draft increases slowly from rake angles of 10^0 to 50^0, above 50^0 however, the rate of increase is very rapid. Therefore for minimum draft, a rake angle of 30^0 is selected.

(d) Increased forward speed increases draft with most implements, hence in this design, the forward speed is 1m/s maximum and it is assumed to be constant.

3. The control of shallow weeds can be best achieved by cutting below them and lifting them onto the surface, and for this, a wide tine type of tool would seem to be the most appropriate. (Spoor 1961).
4. The shapes and dimensions of the tools are such as to maximize strength, minimum weight and minimum cost of production.
5. The soil conditions under which the machine will be adapted are: cultivated medium soil to light soils with the following characteristics

   ϕ = angle of shearing resistance of soil $= 30^o$

   δ = angle of soil/interface friction $= 10^o$

   c = cohesion $= 10 - 15\ KN/m^2$

   C_α = adhesion $= 3.5\ KN/m^2$

   σ = soil unit weight $= 17.3\ kg/m^3$

   Surcharge pressure $= 0$

maximum working depth of machine = 2.54cm

The soil is assumed stump free without stones and tough roots.

6. The frame of Machine

   The frame forms the mounting support of all other units of the weeder. Hence, stability and strength were the two major points of considerations.

7. The crank mechanisms

   The lengths of the links comply with the conditions AB = DC and BC = AD, that is four bar parallel crank mechanism.

   One stroke of the crank

8. It is assumed crops are grown in rows and the width of machine is made in reference to the minimum spacing possible between rice crops of 25cm × 25cm.

3.2 DESIGN ANALYSIS

3.2.1 Design of cutting blades

According to Spoor and Godwin (1978), the rake angle of the cutting blade, ∝, should be greater than zero so as to achieve weed cutting below the soil surface and good disturbance of both sparsely and densely distributed weeds, but it should be as low as possible in order to minimize draught. The obtained values will be used to determine the draught, bending moment, and moment of inertia of the blade. The blade would cut the weed just immediately below the soil surface. The weeder would be weeding two rows of the rice field at once, the designed total width of the blade is selected by 42cm. This would give allowance of about 2.5cm from the rice rows. There would be four blades for the rows because the width of the material used for the blades would not permit for any under width. So the width would be 10.5cm per blade.

The blade thickness was designed on the basis of drag/forces acting unit.

Required data

Rake Angle, $\propto = 30^0$ [for minimum draught, weed cutting below soil surface, good disturbance of weed, both for sparsely and intensely distributed weeds].

Working depth of blade b = 2.54cm

Depth of blade Z = 2cm

ϕ = angle of shearing resistance of soil = 30^o

δ = angle of soil/interface friction = 10^o

c = cohesion = $10\ KNm^{-2}$

C_α = adhesion = $3.5\ KNm^{-2}$

σ = soil unit weight = $17.3\ kN/m^3$

Surcharge pressure = 0.

It is assumed that the soil type is plastic loam.

Therefore, from the expression for the actual soil factor, N, is given by

$$N = N_\delta = 0 \quad \frac{[N_\delta = \phi\ ]^{\frac{\delta}{\phi}}}{[N_\delta = 0]} \qquad \ldots (1)$$

The actual soil weight, cohesion and adhesion factors are calculated to be 1.41, 1.86 and 0 respectively. Therefore, soil force per unit width of blade is given as:

$$F_U = \sigma b^2 N_\sigma + C_0 b N_C \qquad \ldots (2)$$

Where, $F_U =$ soil force per unit width of blade

$\sigma =$ soil unit weight $= 17.3\ kg/m^3$

$b =$ Working depth of blade $= 2.54cm$

$N_\sigma =$ Soil weight factor $= 1.41$

$N_C =$ Cohesion factor $= 1.86$

$C_0 =$ cohesion $= 10kN/m^2$

$$F_U = 17.3 \times 0.0254^2 \times 1.41 + 10 \times 0.0254 \times 1.86$$

$$F_U = 0.488KNm^{-1}$$

Therefore, draught per unit width of blade is given as:

$$D_U = F_U \sin(\alpha + \delta) + b\, C_\alpha \cot\alpha \ldots\ldots (3)$$

$$D_U = 0.488 \sin(30 + 10) + 0.0254 \times 3.5 \times \cot 30$$

$$D_U = 0.4678KNm^{-1}$$

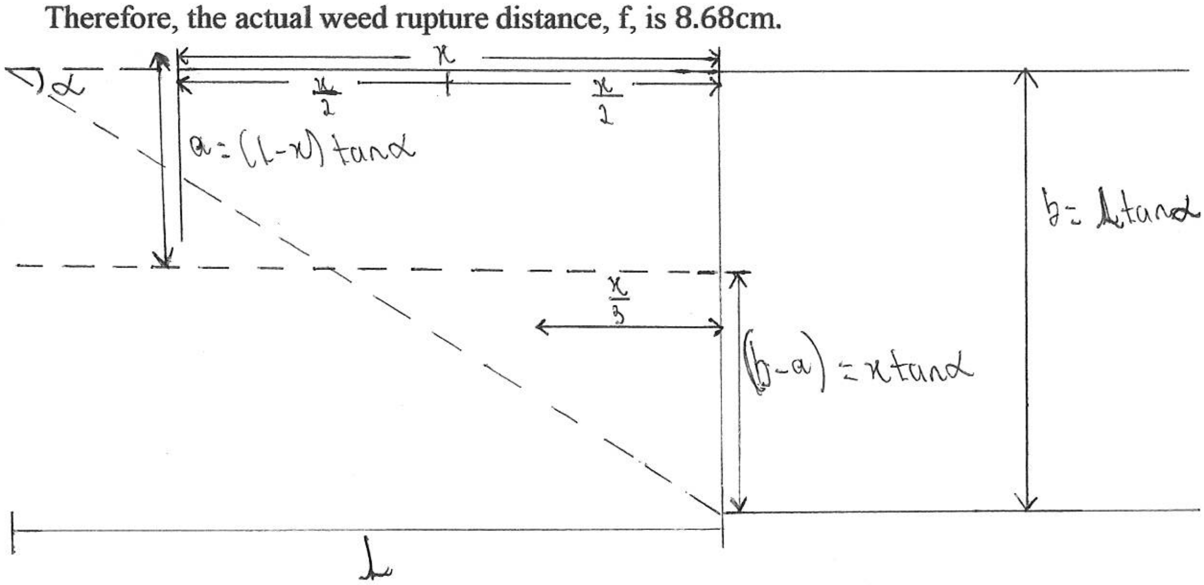
Therefore, power requirement per unit width, P_U, of the blade is given as $0.7536KWm^{-1}$. The width of the blade, w, is 0.105m.

When $\delta = 0$, $m = 3.40$

When $\delta = \phi = 30^0$, $m = 3.45$

Where m is the soil rupture distance ratio. Hence, applying similar analysis as applied for soil factor, the actual soil rupture distance ratio is 3.4165.

Therefore, the actual weed rupture distance, f, is 8.68cm.



3.1 Specification of Blade and Soil on it.

Considering the soil directly on top of the cutting blade, from point 0, the centroid of the section OBCD, $\bar{X}$ is given by:

$$\frac{x}{2}(a+b) \quad \bar{X} = ax.\frac{x}{2} + {}^{1}/_{2}\,(b-a)\,x \times \frac{x}{3}$$

$$i.e. \quad \bar{X} = \frac{(2a+b)x}{3(a+b)}$$

$$\bar{X} = \frac{(2(l-x)\tan\propto + l\tan\propto)x}{3(l-x)\tan\propto + l\tan\propto)}$$

$$\bar{X} = \frac{(3l-2x)x}{3(2l-x)} \qquad \ldots (4)$$

If the load intensities at points 0 and A are respectively w_0 *and* w_a, the average load intensity over the length $l = \frac{W_0}{2}$

Therefore, the total vertical force on the blade, v_t, is given by

$$V_t = \frac{W_0 L}{2}, \qquad \therefore\ W_0 = \frac{2V_t}{L}$$

Also, the average load intensity over the length x:

$$= \frac{W_0 + W_a}{2}$$

Since $\frac{W_a}{L-X} = \frac{W_0}{L}$

$$i.e. \quad W_a = \frac{W_0(L-X)}{L}$$

Therefore, the average load intensity over the length x

$$= \frac{2W_0L - W_0X}{2L}$$

Total load acting over the length x

$$= \frac{(2W_0L - W_0X)X}{2L}$$

i.e. The shearing force at point A

$$= \frac{-W_0X(2L-X)}{2L}$$

$\therefore$ The bending moment at point A

$$= \frac{-W_0X(2L-X)(X-(3L-2X)X)}{6L(2L-X)}$$

i.e. The bending moment at point A

$$= \frac{-fx^2(3L - X)}{6L}$$

At $X = 1$, the bending moment at point A

$$= \frac{-FL^2}{3} = \frac{2}{3} V_t L$$

i.e. The bending moment for the blade of length l is given as

$$M_b = \frac{2}{3} V_t cos\alpha L \quad \ldots\ldots\ldots (5)$$

The total vertical force on the blade is given as

$$V_t = W(F_u cos(\propto + \delta) + bc_{\propto} \quad \ldots\ldots\ldots (6)$$

$$V_t = 0.105\ (0.488\ cos(30\ + 10) + 0.0254 \times 3.5)$$

$$V_t = 4.858 \times 10^{-2} KN.$$

Hence, the bending moment for the blade, M_b, is

$$M_b = \frac{2}{3} V_t cos\alpha L$$

$$M_b = \frac{2}{3} \times 4.858 \times 10^{-2} \times cos30^0 \times 0.0508$$

$$M_b = \ 1.43 \times 10^{-3} KNM^{-1}.$$

From moment of inertia, $I = \frac{M_b h}{2\sigma} = \frac{Wh^3}{12}$

$$h = \left(\frac{12M_b}{2\sigma w}\right)^{0.5} \quad \ldots\ldots\ldots (7)$$

Where,

w is the width of the blade.

h is the thickness of the blade.

σ is the normal stress i.e.0 constant for steel.

Therefore, the actual thickness of the blade is given as

$$h = \left(\frac{12M_b}{2\sigma w}\right)^{0.5}$$

Where c is the factor of safety.

$$h = c \times \left(\frac{12 \times 1.43 \times 10^{-3}}{2 \times 0.14 \times 0.105}\right)^{0.5}$$

$$h = 2.29mm.$$

3.2.2 Design of the Reciprocating mechanism

The design of the reciprocating mechanism, involves the determination of the optimum length of crank that will allow for weeding with minimum overlapping of the weeding surface and also the travel speed correlating with reciprocating motion of the cutting blade.

Diameter of the wheel = $40cm$

Speed of travel = $1m/s$.

Let the length of crank be xcm.

The distance covered by the wheel at 1 revolution = $\pi \times 40cm = 126cm$.

But engine speed = $3000rpm$.

The speed of the reducing gear $15 : 1$. Therefore, the rpm of the crank, which is attached to the shaft of the reducing gear = $200rpm$.

If the speed of rotation of crank $i.e\ nc$ is 5 times that of the wheel $i.e\ nc = 5nw$. hence, when $\pi w = 1revolution = 126cm$.

$$nc = 5\,revolution\ of\ blades = 10strokes$$

$$i.e\ in\ 1\ revolution\ of\ crank = 2strokes\ of\ the\ blade$$

Therefore, the wheel covers = $\frac{126cm}{5} = 25.2cm$.

To attain an overlap of $3cm$ of cut by the blade, the total length travel of the blade should exceed the distance covered by the wheel.

$$25.2cm + 3cm = 28.2cm.$$

Therefore, the length of crank to achieve this equals

$$3 + (2x) = 28.2cm$$

$$2x = 28.2cm - 3cm$$

$$2x = 25.2cm$$

$$x = \frac{25.2cm}{2} = 12.6cm.$$

3.2.3 Design of the Sprocket and Chain

i. **Chain pitch** $= \frac{Sprockets\ centre\ to\ centre\ distance}{Distance\ between\ centre\ of\ sprockets\ in\ Pitch}$ ………………………………(8)

$a = [30\ to\ 50]p$

Where,

$a = Optimum\ centre\ distance, mm.$

$p = Pitch\ of\ chain, mm.$

Selecting a centre distance of $210mm$,

Therefore chain pitch p $= \frac{210}{30} = 7mm.$

From the design data table, 8.00 pitch is close to the calculated value. From the table, a chain having a pitch of 8.00 has a projected Bearing area of $0.22cm^2$ and a minimum breaking load of $800kgf$ and weight per meter value of $0.33kgf$.

ii. $\frac{Z_2}{Z_1} = \frac{N_1}{N_2} = i$ ……………………………………………………………(9)

From the table selected, transmission ratio $i = 5$

$rpm\ of\ Engine = 3000rpm$

$reducing\ gear\ box = 15 : 1$

Where,

$Z_2 = Number\ of\ teeth\ of\ large\ sprocket = 115$

$Z_1 = Number\ of\ teeth\ of\ small\ sprocket = 23$

$N_1 = Speed\ of\ rotation\ of\ small\ sprocket = 200rpm$

$N_2 = Speed\ of\ rotation\ of\ small\ sprocket = 40rpm$

iii. **Calculate the diameter of the sprockets**

Available sizes of sprockets with transmission ratio $1 : 5 = 60mm : 300mm.$

Where, $d_1 = 60mm,\ d_2 = 300mm.$

iv. **Determine the design power transmitted on the basis of allowable bearing stress**

$N = \frac{\delta\ .\ A.\ V}{102k} Kw$ ……………………………………………………………(10)

Where,

$\delta\ = allowable\ bearing\ stress\ [kgf/cm^2]$

$A\ = Projected\ bearing\ area\ cm^2$

$V\ = chain\ veleocity\ m/s$

$k_s\ = Service\ factor\ = 1.25$

δ From the table, speed of rotation of small sprocket $i.e\ n_1\ = 200rpm$

$\delta\ = 3.15, \quad A\ = 0.22, \quad V\ = ?$

To get V $\quad i.e\ v\ = \frac{\pi d_2 n_2}{60}$

Where, $d_2\ = 300mm\ = 0.3m,\ n_2\ = 200rpm$

$$V\ = \frac{22\ \times 0.3\ \times 200}{7\ \times 60}$$

$$V\ = \frac{1320}{420}\ = 3.14m/s.$$

v. Design power transmitted on the basis of allowable bearing stress

$$N\ = \frac{\delta\ .\ A.\ V}{102k} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (11)$$

$$N\ = \frac{3.15\ \times 0.22\ \times 3.14}{102\ \times 1.25}$$

$$N\ = \frac{2.18}{127.5}\ = 0.0171kw$$

Therefore, design per strand $= \frac{Design\ power}{multiple\ strand\ factor}$

$$Design\ power\ = Design\ per\ strand\ \times multiple\ strand\ factor$$

$$= 1\ \times 0.0171kw\ = 0.0171kw.$$

vi. The load on shaft is given by

$$Q_a\ = K_1\ \times\ P_1\ \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (12)$$

Where,

$Q_a\ = Load\ of\ shaft\ due\ to\ chain$

$K_1\ = Load\ factor$

$P_1\ = Tangential\ force\ due\ to\ power\ transmission\ kgf$

$$P_1 = \frac{102N}{V} \; if \; N \; is \; kw$$

$$P_1 = \frac{102 \times 0.0171}{3.14} = \frac{1.7442}{3.14}$$

$P_1 = 0.5555kgf$

Load factor $K_1 = 1.5$

$Q_a = 1.5 \times 0.5555$

$Q_a = 0.8333kgf$

$Q_a = 0.8333 \times 9.81$

$Q_a = 8.175N.$

vii. Length of chain

$$= 2a_p + \frac{Z_1 + Z_2}{2} + \frac{(\frac{Z_2 - Z_1}{2\pi})^2}{a_p} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (13)$$

Where, $a_p = \frac{a_o}{p}$

a_p = *Approximate centre distance in multiple of pitches*

a_o = *Initially assumed centre distance, mm*

p = *Pitch, mm.*

$a_p = \frac{210}{7} = 30mm$

Therefore, Length of chain:

$$= 2 \times 30 + \frac{23 + 115}{2} + \frac{(\frac{115 - 23}{2 \times 3.142})^2}{30}$$

$$= 60 + 69 + \frac{214.33}{30} = 136.14cm.$$

3.2.4 Design of the Crank shaft

Required Data

1. **Load of sprocket on shaft Q_0** $= 8.18N$
2. **The weight of small sprocket on shaft weight** $= Volume \times density \times 9.81$

The material selected for the sprocket is mild steel. Density of mild steel as previously calculated= $7821.95kg/m^3$

$$Volume = \frac{\pi d^2 h}{4} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots. (14)$$

Where, $d = 60mm,\ \ h = 0.01m$

$d = 0.06m$

$Volume = \frac{3.142 \times 0.06^2 \times 0.01}{4} = 2.83 \times 10^{-5} m^3.$

Therefore, weight of small sprocket on shaft

$= 2.83 \times 10^{-5} m^3 \times 9.81 m/s \times 7821.95 kg/m^3$

$= 2.171N.$

3. **weight of crank**

Material for the crank is Mild steel, Hence density= $7821.95kg/m^3$

a. Volume of crank= $L \times B \times H \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots. (15)$

$= 0.15m \times 0.2m \times 0.01m = 3 \times 10^{-4} m^3.$

Hence, weight of crank= $3 \times 10^{-4} \times 7821.95 \times 9.81 = 23.02N.$

4. **Load on shaft**

Total load on shaft $= load\ of\ crank + force\ on\ the\ 3tines.$

To calculate maximum load on crank, $F = mw^2 r \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (16)$

Where,

$M = mass\ of\ the\ reciprocating\ part\ (the\ frame, blade\ and\ support)$

i. **Mass of blades** $= density \times volume \times number\ of\ blades$

Volume of blade $= l \times b \times h$

Volume of blade $= 0.081m \times 0.105m \times 0.00229cm$

Volume of blade = $1.95 \times 10^{-5} m^3$.

The blades are of mild steel, Hence, density = $7821.95 kg/m^3$.

Mass of blades = $1.95 \times 10^{-5} m^3 \times 7821.95 kg/m^3 \times 4 blades$

Mass of blades = $0.610 kg$.

ii. Mild steel blade's handle

Diameter = $0.02m$, Height = $0.4m$

Total volume = $\frac{\pi d^2 h}{4}$

Volume = $\frac{3.142 \times 0.02^2 \times 0.4}{4} = 1.26 \times 10^{-4} m^3$.

Therefore, Mass of frame = $1.26 \times 10^{-4} m^3 \times 7821.95 \times 4$

Mass = $3.93 kg$.

iii. Mild steel frame made up of flat bars and channels.

To calculate the volume for portion (a) of flat bar

$$Volume = (l \times b \times h) - (volume\ of\ bore) \quad \ldots (17)$$

$$= (0.3 \times 0.05 \times 0.005) - \frac{3.142 \times .0.064^2 \times 0.005}{4}$$

$$= 7.5 \times 10^{-5} - 1.61 \times 10^{-5}$$

$$= 5.89 \times 10^{-5} m^3$$

To calculate the volume for portion (c) of flat bar

$$Volume = (l \times b \times h) - (volume\ of\ bore)$$

$$= (0.3 \times 0.05 \times 0.005) - \frac{3.142 \times .0.064^2 \times 0.005}{4}$$

$$= 7.5 \times 10^{-5} - 1.61 \times 10^{-5}$$

$$= 5.89 \times 10^{-5} m^3$$

To calculate the volume for portion (b) and (d) of flat bar = $2b$

$$Volume = (0.3 \times 0.02 \times 0.005)\ m^3 \times 2$$

$$Volume = 3 \times 10^{-5} m^2 \times 2 = 6 \times 10^{-5} m^3$$

∴ Total volume of frame = $volume\ of\ (a) + volume\ of (c) + 2 \times volume\ of (b)$

$$Total\ volume = 5.89 \times 10^{-5} m^3 \times 5.89 \times 10^{-5} m^3 \times 6 \times 10^{-5} m^3$$

$$Total\ volume = 17.8 \times 10^{-5} m^3 = 1.78 \times 10^{-4} m^3.$$

Hence, Mass = $Volume \times density$

$Mass = 1.78 \times 10^{-4}m^3 \times 7821.95kg/m^3$

$Mass = 1.392kg.$

iv. Mass of Anchor of blade to blade holder.

$Volume\ of\ anchor\ = (0.02 \times 0.3 \times 0.005) \times 4$

$Volume = 1.2 \times 10^{-4}m^3.$

$Mass = volume \times density$

$Mass = 1.2 \times 10^{-4} \times 7821.95kg/m^3$

$Mass = 0.94kg.$

v. Mass of the connecting Rod.

$Volume = (l \times b \times h)m^3$

$Volume = (0.30 \times 0.02 \times 0.005)m^3$

$Volume = 3 \times 10^{-5}m^3.$

$Mass = 3 \times 10^{-5}m^3 \times 7821.95kg/m^3$

$Mass\ of\ the\ connecting\ rod = 0.235kg.$

Therefore, mass of the reciprocating part =

$Mass\ of\ blades + Massof\ blade\ handle + Mass\ of\ frame + Mass\ of\ connecting\ rod.$

$Mass\ of\ the\ reciprocating\ part = 0.610kg + 3.93kg + 1.392kg + 0.94kg + 0.235kg$

$Mass\ of\ the\ reciprocating\ part = 8.34kg.$

Calculation of the frame hind support

$$Volume = \frac{\pi d^2 h}{4}$$

Where, $d = 0.2m, \quad h = 0.05m.$

$$Volume = \frac{3.142 \times 0.2^2 \times 0.05}{4}$$

$Volume = 1.57 \times 10^{-4}m.$

$Height = 1.57 \times 10^{-4}m \times 7821.95kg/m^3$

$Height = 1.23kg.$

Therefore, $to\ calculate\ F = mw^2r,$

Where, $w = angular\ speed = 2\pi n \qquad (n = 200rpm.$

$$w = 2 \times \frac{22}{7} \times \frac{200}{60} = 20.9rad/s.$$

$$r = \frac{25}{2} = 12.5cm = 0.125m.$$

$$F = 8.34 \times 20.9^2 \times 0.125 = 445.37N.$$

Force on the tine as calculated previously $= 4.86 \times 10^{-2} KN\ Per\ blade$

$Number\ of\ blades = 4$, Therefore, total force on blade = 194.4N

Total load of crank on shaft $= 445.37N + 0.1944N = 539.7N.$

Since Number of crank on shaft = 2.

Therefore, force on each crank$= \frac{539.7}{2} = 269.85N.$

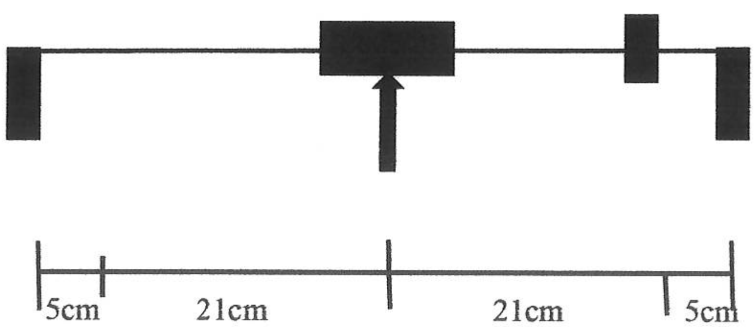


Fig. 3.2 Vertical loading

1. ***Vertical loading***

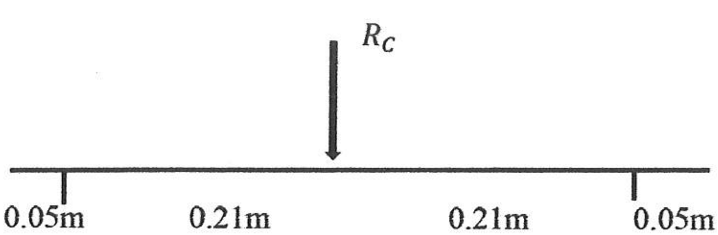


Fig. 3.3 Vertical loading

$$R_B + R_D = R_A + R_C + R_E$$

$$R_B = R_D = \frac{R_A + R_C + R_E}{2}$$

Where, $R_A = 23.02N,\quad R_C = 2.171N,\quad R_E = 23.02N$

$$R_B = R_D = \frac{23.02N + 2.171N + 23.02N}{2} = 24.1N$$

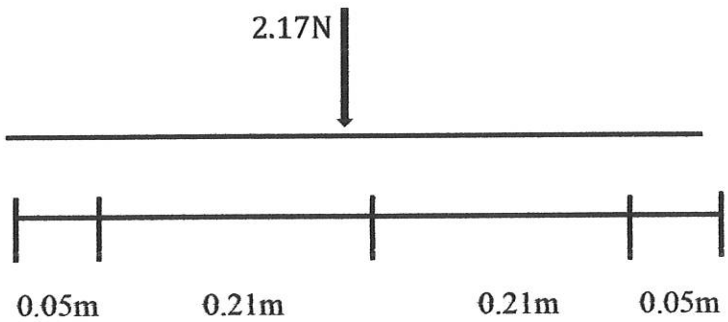


Fig 3.4 Vertical loading.

Vertical Moment Diagram

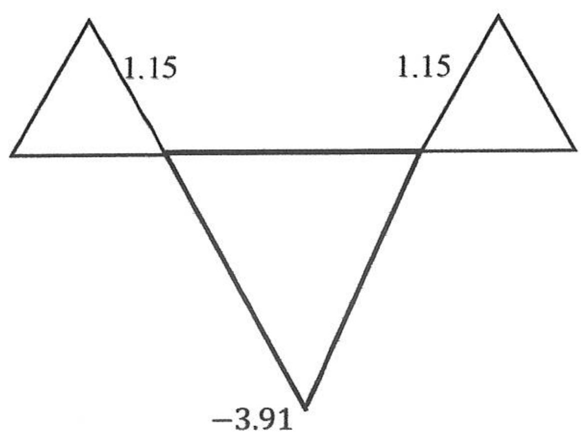


Fig 3.5 Vertical Moment Diagram.

Hence, vertical bending moment $M_V = -3.91Nm$.

2. *Horizontal Loading*

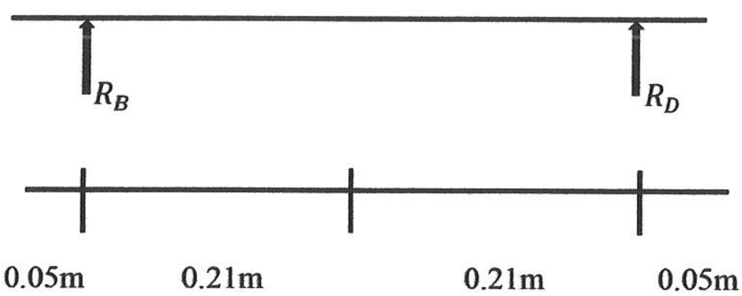


Fig 3.6 Horizontal loading.

$$R_B + R_D = R_A + R_C + R_E$$

$$R_B = R_D = \frac{R_A + R_C + R_E}{2}$$

Where, $R_A = 269.85N$, $R_C = 8.181N$, $R_E = 269.85N$

$$R_B = R_D = \frac{269.85N+8.18N+217.25N}{2} = 273.94N.$$

Horizontal Moment Diagram

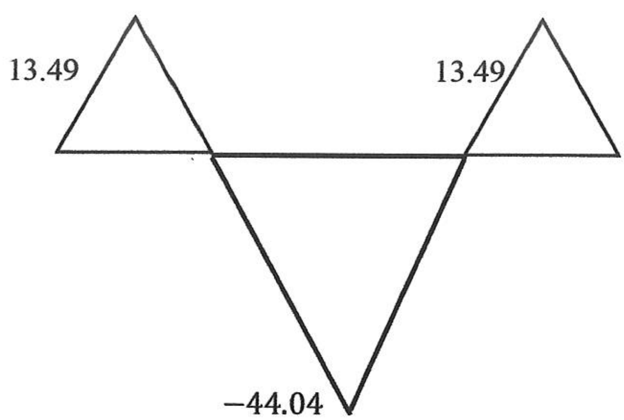


Fig 3.7 Horizontal Moment Diagram.

Hence, maximum bending moment $M_h = -44.04Nm$.

3. **Resultant bending moment M_b**

$M_b = \sqrt{3.91^2 + 44.04^2}$

$M_b = \sqrt{15.29 + 1939.5216}$

$M_b = \sqrt{1954.8097}$

$M_b = 44.2$

4. **Torsional moment M_t**

Where, $M_t = \frac{p}{2\pi n}$

$p = 6.75\text{hp to KW} = 6.75 \times 0.7457 = 5.03\text{KW}.$

$n = \frac{200}{60}$

$M_t = \frac{5.03}{2 \times 3.142 \times \frac{200}{60}}$

$M_t = 0.2401$

Diameter of shaft, d

$d^3 = \frac{16}{\pi \delta s}\sqrt{(K_b M_b)^2} + \sqrt{(K_t M_t)^2}$

Where,

$d = \text{diameter}$

$M_t = \text{Torsional moment Nm}$

$M_b = \text{Bending moment Nm}$

$K_b = $ Combine shock and fatigue factor applied to bending moment

$K_t = $ Combine shock and fatigue factor applied to Torsional moment

$\delta s = $ Allowable stress 40×10^{-6} for steel.

$d^3 = \frac{16}{3.142 \times 40 \times 10^{-6}}\sqrt{(1.5 \times 44.2)^2} + \sqrt{(1.5 \times 0.2401)^2}$

$d = 34\text{mm shaft.}$

3.2.5 Power Requirement

i. $\mathbf{P = f \times v}$, **where**

P = power requirement of the machine,

f = force on crank,

v = speed of the machine= $1m/s$.

$\mathbf{F = mw^2r}$, **where**

Where, $w = angular\ speed = 2\pi n$ $(n = 200rpm.$

$$w = 2 \times \frac{22}{7} \times \frac{200}{60} = 20.9rad/s.$$

$$r = \frac{25}{2} = 12.5cm = 0.125m.$$

$$F = 8.34 \times 20.9^2 \times 0.125 = 445.37N.$$

Therefore, $\mathbf{P = f \times v}$,

$P = 445.37N \times 1m/s$

$P = 1.48$hp.

3.3 MATERIAL SELECTION

Table 3.1 Material Selection for the Machine.

S/N	Machine component	Criteria for selection	Most suitable material	Material actually selected	Reasons for selecting the material	Limitation of the material selected
1.	Sprockets	They should have high strength and toughness.	Steel C 30.	Steel C 30	Most appropriate and available.	
2.	Crankshaft and Axle shaft	High strength, ductility, and fatigue resistance	Steel C 40.	Steel Rod	Most appropriate and available.	Can get distorted with shock and large load.
3.	Connecting rod	The properties should allow for improvement by heat treatment.	Steel C 40.	Steel Angle iron	Not easily deflected and not heavy.	
4.	Bolts	High strength properties	Steel C 40.	Steel C 40	Most available and appropriate.	Not strong enough.
5.	Bushes		Steel C 30.	Iron pipes	Inexpensive and available.	
6.	Keys	They should have moderate wear resistance.	Steel C 50.	Iron rods	Most appropriate and available.	
7.	Blade	Ability to withstand impact load and shock without	Hard carbon spring steel plate.	Hard carbon spring steel plate.	Most appropriate.	

		failure because of high tensile and compressive properties.				
8.	Blade holder	They should have moderate wear resistance.	Steel C 50.	Angle iron	Quite suitable, readily available and in expensive.	Can get distorted with shock and large load.
9.	Blade gang	Strength in tension, shear and compression.	Mild steel angle iron.	Angle iron	Most Appropriate.	Does not allow for proper sealing of the component hence there is need for tacking.
10.	Reciprocating body			Angle iron		
11.	Body frame	Machinability and weldability.	Steel C 40.	Angle iron	Readily available, inexpensive and not easily deflected.	
12.	Handle and support	Hardness and toughness.	Steel C 40.	Galvanized Hollow Metal.	Readily available, inexpensive and not easily deflected.	
13.	Crank			Angle iron		

14.	Chain	Moderate in strength tension, compression and shear. Also good properties of ductility and toughness.	Steel C 14.	Steel C 14	Readily available, appropriate.	Can slip and sink during operation of the field.
15.	Wheel	Minimum rolling resistance and impact effects reduction of soil displacement.	Pneumatic off road tyre.	Pneumatic tyre.	Most appropriate.	

3.4 DESCRIPTION OF THE WEEDER

In order to fully understand the mechanism of operation of the machine. It is necessary to be familiar with the function of the various components of the machine. The reciprocating weeder comprise of the following: The Blade unit, The Bearing arrangement, The Crank system, The Drive, The Main frame, The Weeding system.

a. The Blade Unit

The blade unit of the mechanical weeder comprises of the following:

i. The blades are four in number and are arranged in such manner as to allow for a width of cut 42cm, spreading little beyond the width of the machine frame which is 40cm wide. The approach angle of the blade is30^0. This is brought about by the use of an anchor joined permanently to the blade upright frame at an angle of 25^0. The blades are joined to the anchor with the use of bolts and nut. This is to make way for changing of the blade when it wears out. The blades are made of hard spring steel which are grinded at the upper surface to an angle of about 5^0 making a total approach angle of about 30^0.

b. The Bearing Arrangement

The main gang of the blade frame is equipped with four bearings. This is to give way for the reciprocating motion caused by a connected cranking system. The bearing arrangement allows the blade unit to move without friction on the main frame of the machine rolling on it.

c. The Crank system

This is brought about lease from shock and occasional stoppings the blades might encounter. The crank system drives the blade system. It is by its revolution that a reciprocating motion is achieved by the blade unit. The crank system which is fixed to the crankshaft is made of angle iron material. The motion is connected to the blade unit through a connecting rod which is 30cm long.

d. The Drive

The crank system is driven by a crankshaft which transmits motion from the axle shaft through a chain wheel which on the other hand affects the motion of the machine is relative to the movement of the operator.

e. The Handle

The Handle of the machine is such that the operator would be able to control the movement of the machine and also have a firm grip of the machine. Hence it would be made very rigid and braced across with flat bar for rigidity. The inclination angle of the handle can be adjusted to suit the convenience of the operator through the hinge to which is attached.

f. The Main frame

This is the supporting member for the whole machine. It is made of angle iron for lightness. The depth is adjusted by changing the height on the height adjustment slots on a clamp provided. Also various are made possible through the use of washers and spacers at various components of the machine.

g. Weeding System

There are many system by which a field may be weeded with a weeding machine. In selecting any type of weeder, the size and shape of the filed, any special needs of the seed bed, any undulations of the land, any drainage problems and after cultivations, must be all considered. However, it is important to adopt a definite plan of procedure. If cultivated in ridges and furrow, the most appropriate pattern is the headland pattern, since the machine is rectangular.

3.4.1 Maintenance

3.4.1.1 Daily Attention

1. Before starting a day's work, the blades should be checked for tightness and condition. The approach angle being30^0.
2. The bearings should be checked and if lubrication is necessary. It should be administered to.
3. Check for any form of distortion on the blades and holder and the frame and handle positions.
4. Check and adjust tension of chain and the chain and sprockets must be kept in line.
5. At the end of each day's work, all the soil engaging surfaces of the weeder should be cleaned and coated with oil or rust preventive. This is particularly important on farms having heavy, sticky soil.

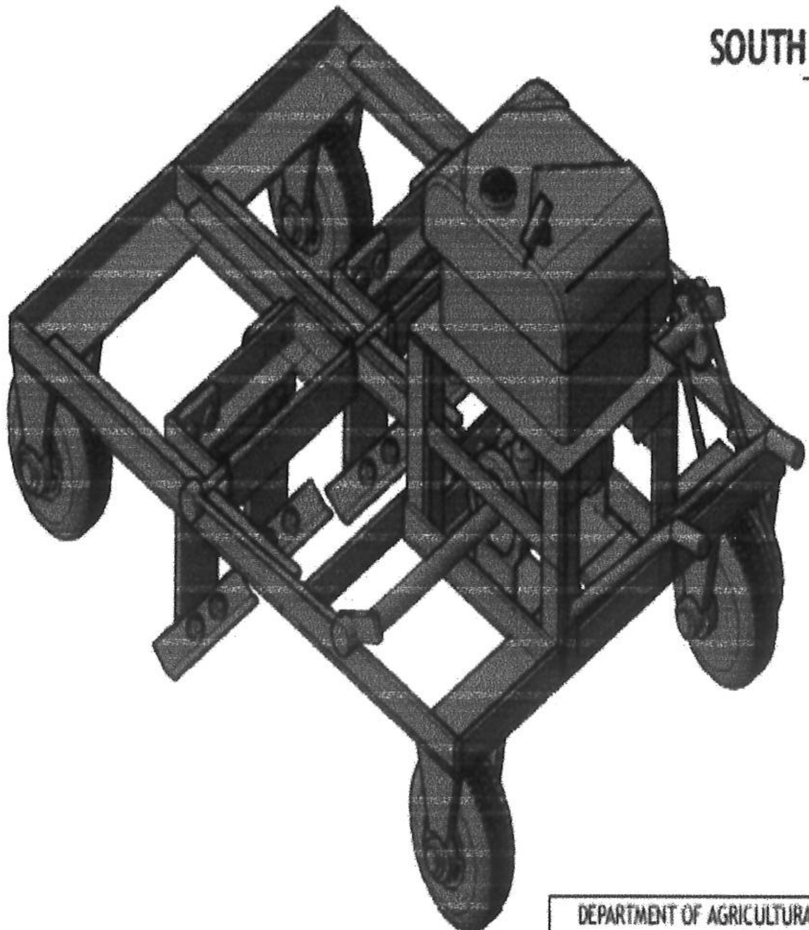
3.4.1.2 End of Season Attention

At the end of a season's weeding, it is necessary as well to check the weeder over, so that replacements and adjustments can be obtained in good time. For the next period of service, hence the following should be done:

1. **The Frames:** These may become distorted due to impact and to check them, a string should be stretched both along the length and across the width and then hammered properly. If on the other hand, there are cuts and wear, these should be properly mended with arc welding.
2. **The Drives:** The maintenance of chain is made easy with regular inspection to check the link or section of links to repair a stretched chain should be avoided. Putting new chain on a worn sprocket should be avoided. Grease the chain with the appropriate grease e.g. The Graphite grease. When fitting the chain, the open side of each tongue should face away from the wheel on which it runs and the tongue end of each link should face the direction of travel.
3. **The Tyres:** Pneumatic tyres are very costly items and can easily be ruined through lack of care and attention. Hence, the following should be carefully carried out:
   a. Keep tyres on the correct pressures.
   b. Keep tyres free from all oils and grease.
   c. Avoid driving too quickly over large stones or other objects.

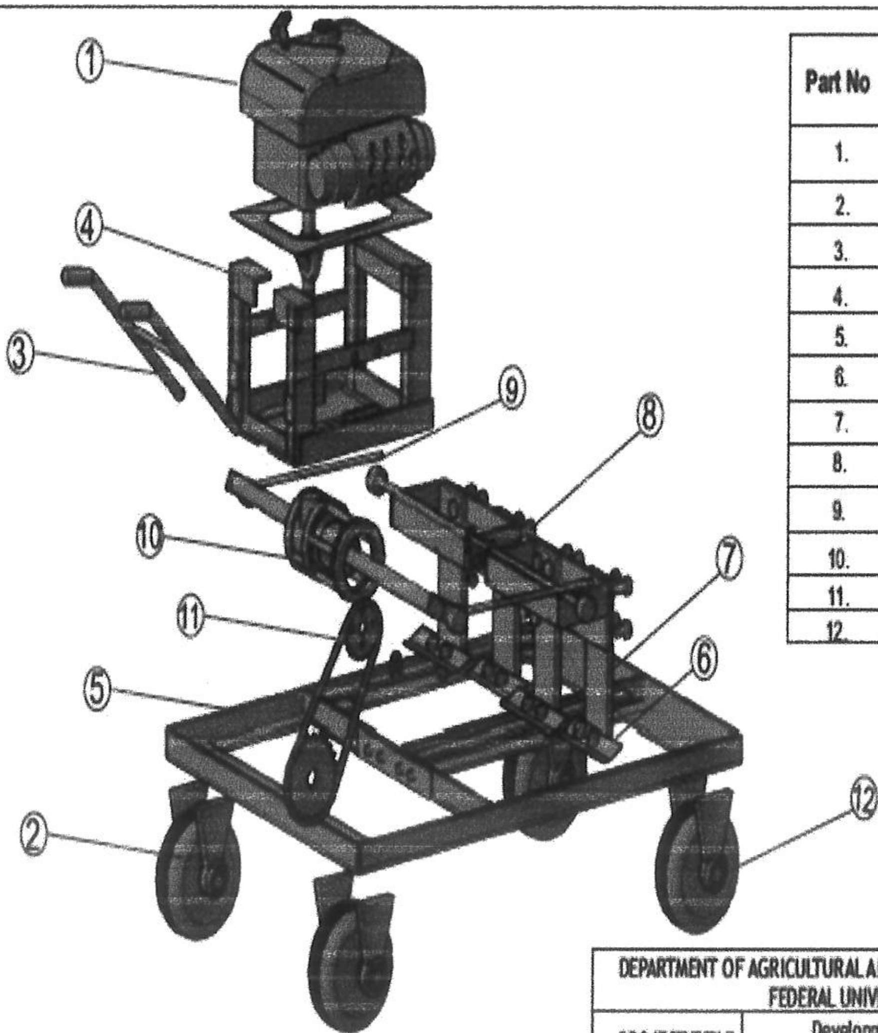
3.5 AutoCAD Detailed Design Drawings

SOUTH EAST ISOMETRIC VIEW



DEPARTMENT OF AGRICULTURAL AND BIORESOURCES ENGINEERING, FEDERAL UNIVERSITY, OYE-EKITI.			
PROJECT TITLE	Development of a weeding machine for an upland rice farm		
DRAWN BY	Sanni Olamide Kazeem		
SUPERVISOR	Dr. Mrs F.T. Fayose and Mr A.A Adesanya		
CHECKED BY	Dr. Mrs F.T Fayose		
SCALE	1:1	DATE	November, 2017
ALL DIMENSIONS IN CENTIMETERS			

3.2 South East Isometric Drawing.



Part No	Part Name	Quantity
1.	Engine(6.57Hp)	1
2.	Tyre (Rear Wheel)	2
3.	Handle	1
4.	Engine Seat	1
5.	Frame	1
6.	Blade(Spring Steel)	4
7.	Blade Holder	4
8.	Bolt and Nut	24
9.	Reciprocating Arm	2
10.	Gear Box	1
11.	Chain And Sprocket	1
12.	Tyre(Front Wheel)	1

EXPLODED VIEW

DEPARTMENT OF AGRICULTURAL AND BIORESOURCES ENGINEERING, FEDERAL UNIVERSITY, OYE-EKITI.			
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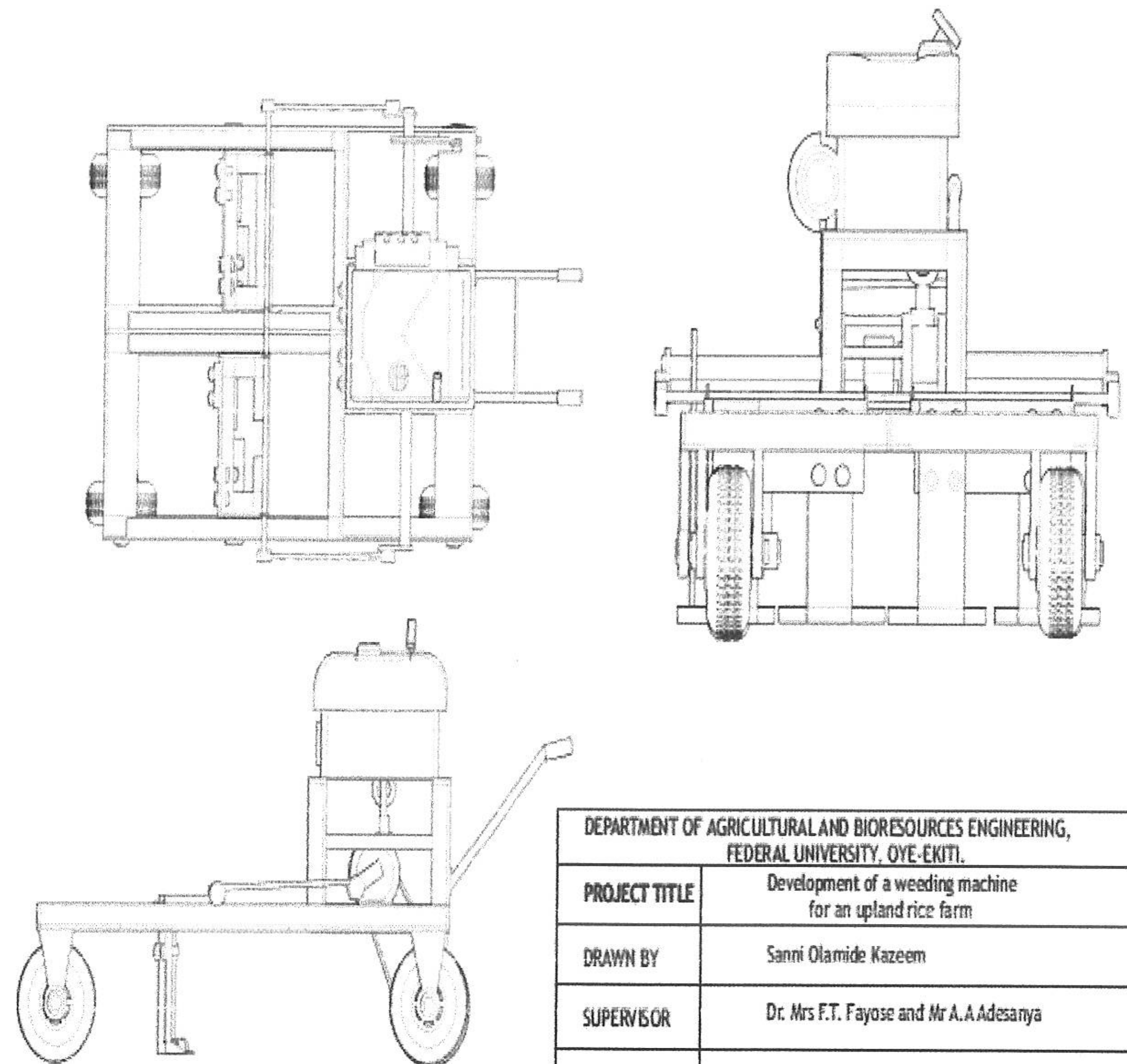
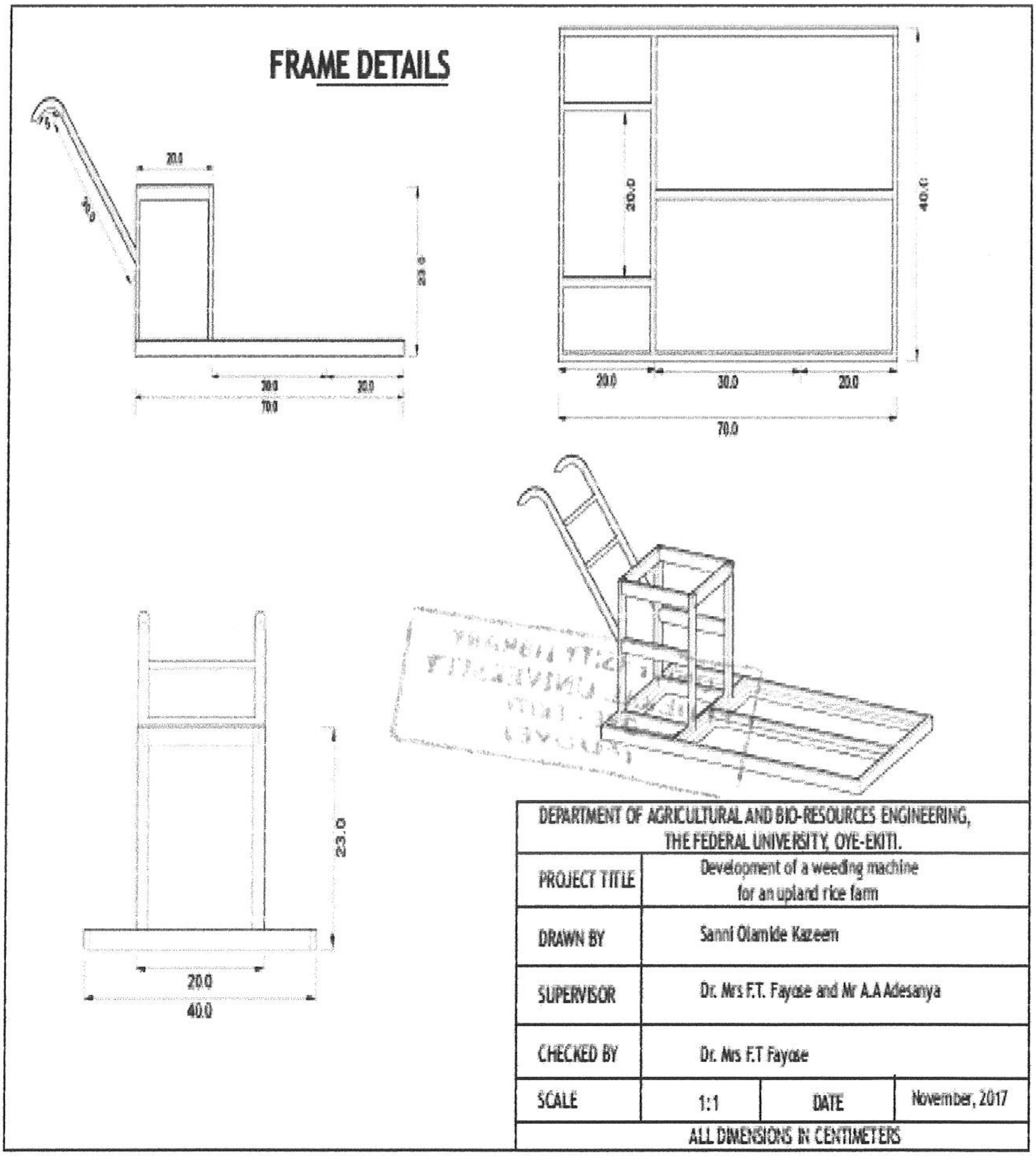
CHECKED BY	Dr. Mrs F.T Fayose		
SCALE	1:1	DATE	November, 2017
ALL DIMENSIONS IN CENTIMETERS			

3.3 Exploded View of the machine.



DEPARTMENT OF AGRICULTURAL AND BIORESOURCES ENGINEERING, FEDERAL UNIVERSITY, OYE-EKITI.			
PROJECT TITLE	Development of a weeding machine for an upland rice farm		
DRAWN BY	Sanni Olamide Kazeem		
SUPERVISOR	Dr. Mrs F.T. Fayose and Mr A.A Adesanya		
CHECKED BY	Dr. Mrs F.T Fayose		
SCALE	1:1	DATE	November, 2017
ALL DIMENSIONS IN CENTIMETERS			

3.4 Orthographic Drawings.



3.5 Frame Details

3.6 PRODUCTION COST

Table 3.2 Bill of Quantity.

S/N	Materials	Specifications	Quantity	Unit Cost(#)	Total Cost (#)
1.	Angle Iron		2	3,500.00	7,000.00
2.	Engine		1	30,000.00	30,000.00
3.	Sprocket	5 : 1	1	7,500.00	7,500.00
4.	Chain		1	5,000.00	5,000.00
5.	Pneumatic Tyre	ϕ20mm × 20mm	4	3,000.00	12,000.00
6.	Bolts and Nuts	14mm × 19mm	24	180.00	4,320.00
7.	Reducing Gear		1	13,500.00	13,500.00
8.	Bearings	ϕ25mm × ϕ52mm	4	500.00	2,000.00
9.	Electrodes	Oil Kon	2	2,800.00	5,600.00
10.	Paint	Gauge 12	2	2,800.00	5,600.00
11.	Shaft	30mm × 30mm	2	1,500.00	3,000.00
12.	Connecting Rod	16mm	1	3.200.00	3,200.00
13.	Cutting Disc		1	500.00	500.00
14.	Grinding Disc		2	550.00	1,100.00
15.	Galvanized Hollow Metal.		1	5,000.00	5,000.00
	Amount				105,320.00

CHAPTER FOUR

RESULT AND DISCUSSION

4.0 RESULT AND DISCUSSION

The machine have not yet been tested but these are the procedure to be followed for the result and Discussion.

The following efficiences must be determined when testing the machine on the Rice farm.

1. The Weed efficiency (functional efficieny).

$$\text{functional efficiency} = \frac{\text{Weight of weeds removed on the farm}}{\text{Actual weight of weeds}} \times 100$$

2. The Field capacity.

$$\text{Actual field capacity} = \text{Effective width of cut} \times \text{speed of cut}$$

3. The Theoretical field capacity.

$$\text{Theoretical field capacity} = \text{Design width of cut} \times \text{speed of cut}$$

4. The Machine Efficiency.

$$\text{Machine efficiency} = \frac{\text{Actual field capacity}}{\text{Theoretical field capacity}} \times 100$$

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

A reciprocating weeder which has a power requirement of 4Hp has been designed. By the time the machine is completed, it would serve the purpose of minimum damages done to rice plants, it would be cost effectiveness, it would be easy to handle, low weight and fabrication by using locally available components and easy maintenance would be the main features of this design. The relevance of mechanized weeding, includes, Reduction in time consumption and significantly improves weeding efficiency, reduce drudgery on rice farms as well as the quality of weeding.

The Design calculations, which were calculated in the previous chapters includes:

1. **Design of Cutting Blades**

   Thickness of the Blade $h = 2.29mm.$

2. **Design of Reciprocating Mechanism**

   Length of Crank $l = 12.6\text{cm}.$

3. **Design of Sprocket and Chain**

   Length of chain $l = 136.14cm.$

4. **Design of Crank Shaft**

   Diameter of Shaft $\text{d} = 34\text{mm shaft}.$

5.2 Recommendation

- The application of electrical sensors would identify and guide the mechanical weeder to avoid stumps while weeding on the rice farm.

- The mechanical weeder can be designed to perform more than one operation using the same prime mover i.e. both for Upland and Lowland Rice farms.

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