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DESIGN AND FABRICATION OF A SINGLE ROW SEED SOWING MACHINE (TROLLEY TYPE)

BY

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DECLARATION

With the exception of the amount mentioned in the acknowledgments and references, I, EBSHEL NYASHA MURAHWA, hereby declare that this work is the product of my own inquiries and research. No other university has received a partial or complete submission of this project. Because of this, no portion of this research may be duplicated in any way electronic, photocopy, or otherwise for uses other than academic research without the undersigned's consent. Furthermore, I certify that Bindura University of Science Education approved this study.

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I am incredibly appreciative of my parents' love, support, sacrifices, and prayers as they have educated and equipped me for the future. I owe Kupakwashe Victory Saunyama a great deal for her love, patience, prayers, and unwavering support in helping me finish this study project. I also want to thank my sister Makanaka Nicole for her prayers and support. My special gratitude is extended to my friend Joe Panashe Nyika for his enthusiastic desire to see my thesis through to completion.

DEDICATION

My earnest dedication to this research endeavor is to my parents, who have been supportive and have inspired me to do this study. They have stood by my side the entire time, and when I felt like giving up, they offered me courage and hope. They gave me a lot of motivation and persistence to keep on with this. It would never have been able to conduct this research without their support and affection.

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ABSTRACT

Timely and uniform seed planting is crucial for crop production and reliability. However, manual seed planting methods have limitations, including poor seed placement, inefficient spacing, and physical strain on farmers. These limitations hinder crop yields and make it difficult for farmers to afford imported planters. To address this, we aimed to develop an inexpensive, manually operated single-row seed sowing machine that is accessible to rural farmers, easy to maintain, and reduces labor needs. We successfully achieved our objective, meeting most design specifications, and the machine performed well under acceptable stress and strain conditions. However, it was not suitable for zero-till land due to torque limitations. Future improvements include using a more powerful motor and exploring electric/hybrid power trains to increase coverage and reduce emissions, making the machine even more accessible and affordable for rural and small-scale farmers.

TABLE OF CONTENTS

DECLARATION ii
ACKNOWLEDGEMENTS iii
DEDICATION iv
ABSTRACT v
CHAPTER ONE 1
INTRODUCTION 1
1.1 Introduction and background 1
1.2 Problem statement 3
1.3 Objectives 3
1.3.1 Main objectives 3
1.3 Justification 4
1.4 Limitations 4
1.5 Delimitations 4
CHAPTER TWO 5
LITERATURE REVIEW 5
2.0 Introduction 5
2.1 Maize yield 5
2.2 Importance of maize yield 6
2.3 A review on Seed sowing methods 7
2.3.1.Broadcasting 7
2.3.2.Dibbling 8
2.3.3. Drilling 9
2.3.4. Transplanting 9
2.3.5.Hill dropping 10
2.3.6.Check row planting 10
2.4 The need for improved seed sowers 11
2.5 Overview of Manual Seed Sower main Components 11
2.6 Review of Existing Seed Sower Designs 12
2.7 Power Source for current Seed sowers 20
2.7.1 Human power 21
2.7.2 Animal power 21

2.7.3Engine power 22
2.7.4 Electrical power 22
2.7.5 Renewable energy power 22
2.8Power Transmission for Seed sowers 23
2.8.1 Direct coupling 23
2.8.2. Belt transmission... 24
2.8.3 Gear transmission 24
CHAPTER THREE 25
METHODOLOGY 25
3.0 Introduction 25
3.1 Study area 25
3.2 Engineering design process... 26
3.3 Generation of possible solutions 30
3.3.1 Design overview 30
3.3.2 Possible solution 1 31
3.3.3 Possible solution 2 32
3.3.4 Possible solution 3 35
CHAPTER FOUR... 39
DEVELOPMENT OF CHOSEN SOLUTION 39
4.1 Development of chosen solution 3 39
4.2 Driving wheels... 39
4.3 Seed tube 39
4.4 Furrow closer 39
4.5 Main frame... 39
4.6 Seed box... 39
4.7 Metering mechanisms 40
4.8 Push handles 40
4.9 Belt and pulley transmission... 41
4.11 Cutting... 49
4.13 Verification testing... 50
4.15 Welding 51
4.16 Milling 51

CHAPTER FIVE 54
COSTING 54
5.1 Total manufacturing costs 54
5.1.1 Material costs 54
5.2 Selling price 55
5.3 Payback period 55
CHAPTER SIX 57
RESULTS AND DISCUSSION 57
6.1 Introduction 57
6.5 Impact of forward speed on distribution of seeds 60
6.6 Seed Damage Rate 61
6.8 Comparison between designed seed sower machine and manual sowing 63
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS 65
7.1 Summary 65
7.2 Conclusion 65
7.3 Recommendations 66
REFERENCES 67
APPENDICES 69

Figure 1: National Average Yield: Zimbabwe(2000-2021) (Dirk, 2021) 5
Figure 2Maize yields (UN Food and Agriculture(FAO)) 6
Figure 3:Broadcasting method 7
Figure 4: Dibbling 8
Figure 5: Drilling 9
Figure 6: Transplanting 9
Figure 7: Hill dropping 10
Figure 8: Check row planting 10
Figure 9: Mechanical planters 15
Figure 10: Drill planters 16
Figure 11: Air blast planters 17
Figure 12: Precision planters 18
Figure 13: No till planters 19
Figure 14: Renewable energy distribution in world farms (Makange and Richard, 2014) 23
Figure 15: Gear classification according to axis (Tata, 2012) 24
Figure 16: Area of study 25
Figure 17Engineering Design Processes (Atman et al. , 2007) 26
Figure 18: Design procedures 29
Figure 19: Side view Figure 20: Top view 31
Figure 21: possible solution 2 32
Figure 22: Possible solution 3 35
Figure 23: Seed metering mechanism 40
Figure 24: belt and pulley transmission 41
Figure 25: design structure 42
Figure 26: cutting process 49
Figure 28: verification and testing the dimensions 50
Figure 27: grinding 49
Figure 29: filling 50
Figure 30: welding 51
Figure 31: milling 51
Figure 32: spray painting 52
Figure 33: The finished prototype 53
Figure 34: Results 59
Figure 35: the damaged at speed of 3.41km/hr 61
Figure 36: effects of forward speed on field capacity 62
Figure 37: effects of forward speed on field efficiency 62

CHAPTER ONE

INTRODUCTION

1.1 Introduction and background

The national average yield for maize in Zimbabwe has been gradually falling over the last two decades, from 1.5 t/ha in the 2000-2001 season (Dirk, 2021) to about 0.75 t/ha in 2020-2021 season (Ministry of Lands, 2021). This has been attributed to erratic rainfall patterns (Maroun, 2021) and poor farming practices (Dirk, 2021). In an effort to curb the trend, the Government of Zimbabwe (GOZ) has been working hand in hand with international organizations like Food and Agriculture Organization (FAO) and World Food Program (WFP) to devise mitigation measures (FEWS NET, 2014). Some of these measures include development of seed sowers and planters (Maroun, 2021) , expansion of farming land (Ministry of Lands, 2021), provision of hiring equipment by the government through agricultural contractors (Maroun, 2021) and also advocating for them (Foundations for Farming, 2018) .

One of the most crucial procedures involved in the development of crops is sowing. The early and homogenous establishment of ideal plant populations is a prerequisite for increased crop yield and cropping reliability.

The economy of Zimbabwe is centered on agriculture. The advancement of agriculture raises the nation's economic standing. Farmers in Zimbabwe are having difficulty because of a lack of labor and traditional farming methods that use inefficient equipment, which increases labor costs and consumes a lot of time. The goal of this project is to use a manually controlled single row seed sowing machine to improve farming activities related to seed sowing, cover the seed with soil and place it in every hole at a specific depth and suitable location relative to other planted seeds. The characteristics such as planting rate chances, depth of seed, and distance between two seeds fluctuate. The quantity of cover at maturity, the size of the seed, the rate of germination, and whether or not the plant will produce grain or fodder all affect how many seeds need to be sown per unit area. Most crops are sown on level ground with optimal rainfall conditions. When rainfall is either too little or too much, the seed is sown in furrows or on ridges. In regions where draught animals and human labor are the primary sources of agricultural power, the promptness of field operations particularly seeding operations has been identified as a critical component in increasing the intensity of cropping. Consequently, both the tillage and sowing procedures must be mechanized. By finishing the planting and sowing process as soon as feasible after the previous crop is harvested, you may optimize the advantages of residual moisture.

By helping to disperse seeds in the desired area, a seed sowing machine is a tool that helps farmers save time and money. Many aspects of seed sowing machine features are addressed in the research in order to move the agriculture industry closer to mechanization. Zimbabwe's agriculture industry has historically contributed to the country's economic growth. The population of Zimbabwe is growing, and with it, so is the demand for food. To accommodate this, farmers need to plant various crops more frequently; this necessitates the employment of highly productive machinery. Because of a lack of expertise and access to sophisticated equipment and tools, Zimbabwe's agricultural economy is still in a stage of infancy due to the lack of knowledge the absence of sophisticated equipment and tools

Traditional seed sowing techniques involve broadcasting by hand, using a plough to make furrows, then physically distributing the seeds. Zimbabwe's consistent growth has always been supported by its agriculture sector. The need for product increases along with Zimbabwe's population growth. As a result, farmers are required to plant multiple crops, which call for effective and time-saving machinery. The discussion of several seed-sowing machines in this research project will aid in the agriculture sector's transition to mechanization. Conventional Sowing Techniques: Conventional techniques involve broadcasting by hand, using a country plough to make furrows, and then manually distributing seeds into the furrow using a bamboo or metal funnel that is fastened to the plough. Dibbling, or creating holes or slits with a stick or other object and manually dropping seeds, is a common method of sowing in tiny areas. Hand seed metering and multi-row traditional seeding equipment are favorites among seasoned farmers. When seeds are sown by hand, a uniform dispersion of seeds is not achievable. Even if a farmer plants at the recommended seed rate, there may still be bunching and gaps in the field because of the uneven seed distribution both within and between rows.

Traditional sowing methods have following limitations:

- It is difficult to ensure consistent seed dispersal when sowing by hand.
- Even if a farmer sows at the appropriate seed rate, there may be unequal seed distribution inside and between rows, which could lead to bunching and gaps in the field. Inadequate management of seed planting depth. The labor need is considerable because dumping seed and seed requires two people.
- No plans to prepare the seed bed.
- Inappropriate over-furrow soil compaction.
- The row spacing adjustment is incorrect.

The goal of this research is to create a highly effective seed-sowing machine that will speed up planting, save labor costs, and increase yield. Conventional seed sowing techniques rely on assumptions about seed to seed spacing and placement depth, which are incredibly inefficient and time and labor intensive. Farmers occasionally get back pain as a result. The improvement of agricultural processes, such as seeding on tilled ground, is the focus of this initiative.

1.2 Problem statement

Both tractor- and ox-drawn corn planters have been introduced recently, while ox-drawn planters are not as common as they once were. Due to the high initial cost of equipment and the tiny amount of their field, small-scale farmers may not require a tractor-drawn seed sowing machines, which has presented a hurdle. Traditional seed sowing techniques involve broadcasting by hand, using a plough to make furrows, then physically distributing the seeds there may be unequal seed distribution inside and between rows, which could lead to bunching and gaps in the field and inadequate management of seed planting depth. In order to help these farmers overcome this obstacle, a straightforward and reasonably priced manually operated single row seed sowing machine needs to be created.

1.3 Objectives

1.3.1 Main objectives

- To design a manually operated single row seed sowing machine that is powered by hand(trolley type)

- To fabricate a prototype of a manually operated single row seed sowing machine that is powered by hand(trolley type)
- To evaluate efficiency of the system in comparison with the other type of seed sowers

1.3 Justification

The current era is heading towards a rapid expansion of all areas, including agriculture. Because of the machine’s time efficiency it can finish a plot in a single day small scale communal farmers can organize cooperatives to purchase the machine and divide up the work, lowering the cost of ownership for individual households. The government will be able to expand the initiative's scope thanks to the machine's improved work rate, which will also help the country produce more food. Small-scale farmers who have lost livestock as a result of recent outbreaks of teak-borne disease may also benefit from the invention of equipment that doesn't require draught power. Farmers must use new procedures that won't alter the texture of the soil but will boost crop yield overall in order to fulfill future food demands. Numerous benefits come with the newly suggested gadget that is capable of operation.

- The rate of seed flow is controllable.
- The method of achieving row spacing and seed spacing is possible.
- Seeds can be handled properly and with the least amount of loss.
- The texture of the soil won't be affected.

1.4 Limitations

The seed sowing machine needs more energy when working in hard soil.

1.5 Delimitations

Design is limited to seed sowing. Manure, gypsum and fertilizer application has to be done using conventional methods.

CHAPTER TWO
LITERATURE REVIEW

2.0 Introduction

To date, a great deal of research has been done on seed sowing machines, and numerous instruments have been created to support the investigations. There's always space for improvement, though, and this chapter will help you come up with a design that is inexpensive, portable, and environmentally friendly. Reviewers will examine current designs, paying particular attention to the power transmission, metering device, and framework. Since sowing seeds is the main goal of this design, cover the seed with soil and plant it in each spot at a precise depth and in a location that is appropriate in relation to other seeds that have been planted.

2.1 Maize yield

The national average maize yield was 0.82 tons/ha. It was also noted that some 34% of the maize was produced by A2 farmers, with 32% coming from the communal farming sector which has declined from 1.5 t/ha in the 2000-2001 season (Ministry of Lands, 2018) as sown in figure 1 and

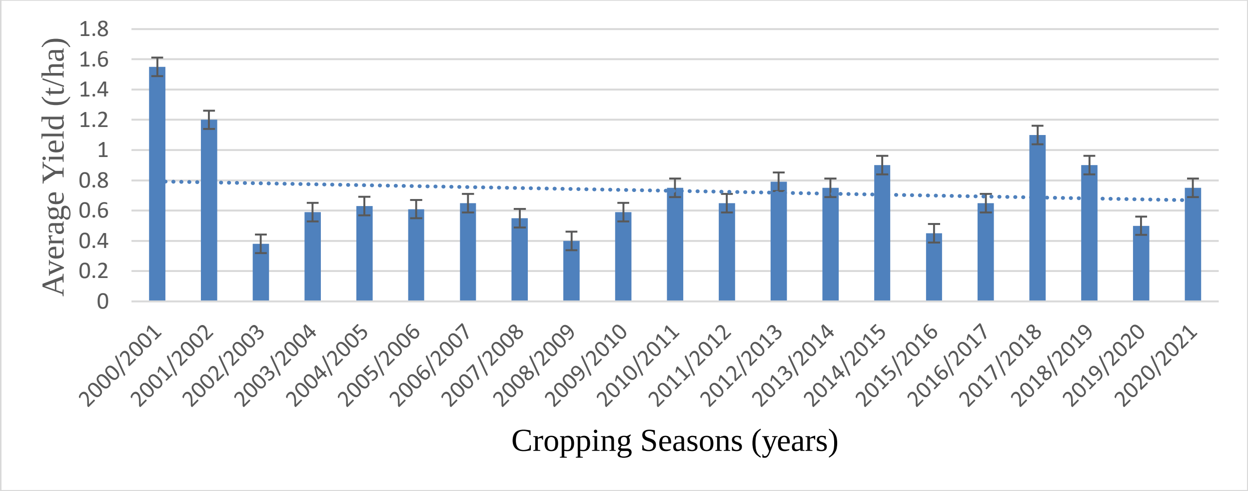


Figure 1: National Average Yield: Zimbabwe(2000-2021) *(Dirk, 2021)*

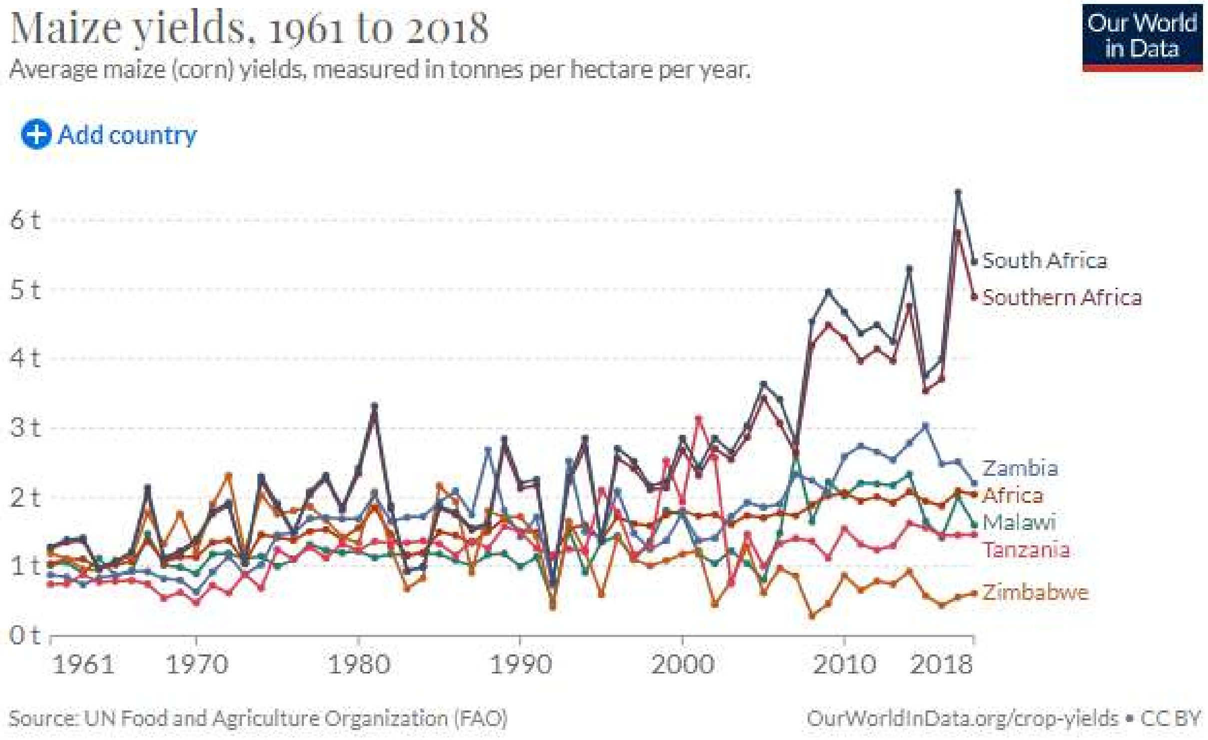


Figure 2Maize yields (UN Food and Agriculture(FAO))

Information reveals that Zimbabwe's yield has has historically fallen behind that of its regional counterparts, a factor that predates its land redistribution program, which began in 2000 and caused a decline in farm output. The country is beginning to recover from this decline thanks to the development of planters and will continue to recover with manually operated single-row seed sowing machines, which will speed up planting, save labor costs, and increase yield because they are more affordable for small-scale farmers than traditional methods, which are incredibly labor- and time-consuming.

2.2 Importance of maize yield

Cereals are rich sources of carbohydrates, proteins, lipids, minerals, and vitamins. Therefore, they play an important role in solving malnutrition problems all over the world (Nawaz et al., 2013). Maize (Zea mays L.) is an important crop that is cultivated (FAO, 2020)widely across the globe. With a greater yielding potential than the other cereals, it ranks first in grain production with an annual yield of 1.1 billion tons globally (FAO, 2020). Maize, which is a C4 plant with different growing times and high yield, is a species with a high photosynthetic capacity. Its adaptability to different climates has allowed its agriculture to spread over large areas (Ozdemir and Sade, 2019). In addition to being used as human food and animal feed, maize is a resource for many unique industrial and commercial products such as breakfast foods, popcorn, alcohol, starch, glucose, spirits, oil, semolina, paint, soap, glue, insecticides, shaving cream, toothpaste, rubber tires, rayon, and molded plastics (Balconi et al., 2007).

60% of the maize produced worldwide is used as animal feed, 20% is used directly for human consumption, 10% is processed into food, and the remaining 10% is used for other uses, including seeds. A significant section of the global population and some nations rely on maize as a staple food.

The purpose of this research project was to develop a manually operated single-row seed sowing machines which will speed up planting, save labor costs, and increase yield because they are more affordable for small-scale farmers than traditional methods, which are incredibly labor- and time-consuming.

2.3 A review on Seed sowing methods

2.3.1.Broadcasting

Figure 3:Broadcasting method

Broadcasting is the process of dispersing seed at random across the surface of a seedbed. Either a mechanical or manual method can be used. The degree of uniformity in the seed is determined by the man's competence when broadcasting manually. Shortly after being distributed, the seeds are covered with planking or other apparatus. This method usually results in higher seed rates.

Mechanical broadcasters are used for large-scale operations. Using this equipment, the seeds are spread at predetermined rates across the surface of the seedbed.

Broadcasting by hand, using a country plough to make furrows and then lowering seeds by hand, and utilizing a bamboo or metal funnel attached to the country plough to drop seeds into the furrow are examples of traditional methods. Dibbling, or creating holes or slits with a stick or other tool and manually dropping seeds, is a common method for sowing in small spaces. multiple rows Experienced farmers tend to favor traditional seeding devices that require manual seed metering. It is impossible to achieve uniform seed distribution when seeding by hand. Even if a farmer sows at the appropriate seed rate, there may still be bunching and gaps in the field due to uneven seed distribution both within and between rows.

2.3.2.Dibbling

Figure 4: Dibbling

Seeds are planted and covered during the process of "dibbling," which involves creating holes in the seedbed. With this technique, seeds are inserted into pre-drilled holes at a set depth and distance apart. The term "dibbler" refers to the apparatus used for dibbling. It is a conical tool used to drill accurate holes in the ground. Several conical projections created in a frame are used to create small hand dibblers. Small seeds are not ideal for this technique because it takes so long. This is how most plants are seeded.

2.3.3. Drilling

Figure 5: Drilling

When drilling, the seeds are dropped into the furrows and then covered with soil. Measuring seeds can be done automatically or manually. There may be one or more rows planted. This technique is highly useful for getting the right depth, right spacing, and right quantity of seed to be spread in the field. Sowing behind the plough and bullock-drawn seed drills & Seed drills pulled by tractors are three methods of drilling.

2.3.4. Transplanting

Figure 6: Transplanting

In order to transplant, seedlings must first be prepared at a nursery and then planted in a field that has already been prepared. For paddy, vegetables, and flowers, it is customary. The process takes a long time. Transplanter is the name of the equipment used to put seeds in the ground.

2.3.5.Hill dropping

Figure 7: Hill dropping

This approach does not drop seeds in a continuous stream, but rather at predetermined intervals. As a result, the distance between each plant in a row is constant. Drills drop the seeds continuously, and the spacing between the plants in a row is not constant.

2.3.6.Check row planting

Figure 8: Check row planting

This method of planting calls for uniform distances between rows and plants. This method ensures that seeds are sown correctly along straight, parallel furrows. Every time, the rows run parallel to one another. For my research project, i have decided to use the dribbling method out of the aforementioned techniques.

2.4 The need for improved seed sowers

It has long been understood that the quality and varietal characteristics of the sowing material influence the crop's quality. It should go without saying that crop concern has a significant impact on harvest. As agricultural sciences and technology advanced, it became evident how crucial the sowing or planting process is. The assumption behind the seeding technologies currently in use is that the grain or seed is carried to the seminal duct, where it will "gravitate" into the soil. In theory, using this technique should result in seeds that are evenly spaced and planted at the same depth.

Several seeds sink deeper between the clumps or stay on the lumps themselves because of the lumpy soil structure. We thus obtain an uneven sowing depth. Deeper-seeded seeds typically produce weaker, later-growing shoots. Insufficiently deep seeds sprout early and frequently experience frost. Consequently, we experience crop losses of roughly 7% hence need for improved methods of seed sowing.

Second, we also have an uneven distribution of seeds across the row's width with most machines that use the row seeding method. In other words, we get a "mound" of seeds stacked on top of one another rather than an even distribution of the seed material over the feeding area (the seeder's width). The result is a decrease in the soil's ability to absorb nutrients, the formation of a narrow row of depleted soil where seeds compete, and a row spacing where the fertility of the soil is essentially unused.

When there are no improvement in seed sowers when planting maize that needs to be sown in a single row with a wide aisle, the problem of how to distribute the seeds so that they don't cross paths and maximize the row's nutrition area emerges.

2.5 Overview of Manual Seed Sower main Components

(Adisa and Braide, 2012)stated that the fundamental specifications for small-scale crop-growing equipment were: should be suitable for small farms, simple in design, improve planting efficiency and reduce drudgery involved in manual planting method. They developed a row planter; its plantation rate was 0.20ha/h with a field efficiency 88%.The basic functions of the planters are opening the seed furrow specific to proper depth, metering the seeds, deposition of the seeds in the furrow and cover the seeds to proper degree for the type of crop involved. The main components of the planter are: hopper; metering system; furrow opener.

The metering mechanism, which comes in a variety of forms for seeding, is the brains of the sowing machine. The function of the metering system is dropping the seeds at the proper rate and helps produce the precise spacing necessary for high yield sand do not allow skipping, doubling and damaging the seeds during the process of planting (Khan, et al., 2015); and (Rabbani, et al., 2016)

Seed tubes, is a channel that seed transfer from seed hopper into the opened furrow **(Bashiri et al., 2013)**

Furrow openers open the soil where seeds metered out and falling through the seed tube will be dropped and covered. Angle of attack and planting depth should be considered in designing furrow openers **(Ani,et al., 2016).**

(Rabbani, et al., 2016)and **(Kyada&Patel , 2014**)designed, developed and tested a low cost manually operated push type maize planter, used for drilling seeds. The vertical shaft delivery system, to which the metering device is attached, transports the seed for placement.

2.6 Review of Existing Seed Sower Designs

(**Shahzad Ahmed et a**l)Focused on solving the problems faced by the majority of African farmers which are poverty, illiteracy, low income, poor health, low productivity and adverse conditions of work. A machine named Seed Sowing Cart was developed, which was economical, affordable, multitasking, and user-friendly (Shahzad Ahmed et al). The machine had width control (displacement along X-axis), depth control (displacement along Y-axis), and control of the linear distance between the seeds (displacement along Z-axis) so that these parameters can be altered according to different seeds by changing the diameter of the gear

Conclusion: This study paper introduces a machine for sowing seeds called a manually operated single row seed sowing machine. The primary goal stated was the need for a sowing machine to advance agriculture and lessen farmers' difficulties. This device is made to plant seeds in rows at the appropriate depth and distance apart, covers the seeds using soil, and ensure that the seeds are properly compacted. They conducted research and discovered that, when compared to a typical sowing width of 15 cm, a row distance of 22.5 centimeters can yield greater yields. Therefore, varying spacing is required based on need, which this machine can accomplish. This machine's unique features guarantee precise control over the seed rate. The belt arrangement rotates when the machine's base wheel is pulled, and a fluted roller seed metering device is used to sow the seeds. Better traction in wet fields is provided by the use of three wheels. This suggests that heavier farms would benefit from lighter ones with more wheels.

(Kalay Khan et al)Found that manual method of seed planting resulted in low seed placement, spacing efficiencies and severe backache for farmers which limit the size of the field that can be planted. So they focused on the design and fabrication of a manually operated planter sowing for different crop seed that is cheap, easily affordable by the rural farmers, easy to maintain, and less challenging to use. Their multi-crop planter has the capability of delivering the seeds precisely with uniform depth in the furrow, and also with consistent spacing between the seeds. Mild steel was used for most of the fabrication except for seed metering mechanism and the seed funnel and tube which was made from suitable quality nylon and rubber material respectively.
Conclusion: In order to provide farmers with the advantages of agricultural mechanization, this research project aimed to introduce a manually operated single row seed sowing machine. I decided to design and build a manually operated single row seed sowing machine that would be inexpensive, easily affordable, simple to maintain, and easier to operate. This planter's adjustable handles made it easy to modify the height of the handles to suit individual heights. This helped to lessen drudgery.

(Tahir Iqbal et al) Focused on decreasing the costs of production of agricultural machinery. The land holdings of farmers were found to be less than 5 hectares. For such small lands owning expensive agricultural machinery is not possible even though they increase the yield gigantically. They introduced a self-propelled multi-crop seed drill for wheat, soybean, and cotton. Seeds can be sowed at required depths and required spacing’s and of different diameters. This self-propelled multi-crop seed drill is economically feasible for the adoption of small landholders. A power source of the 5.5hp engine was used for pulling so that minimal effort was required. The speed was matched with human walking speed so that only the necessary amount of fuel was burnt and the time of operation was minimized

The purpose of this paper was to design and test a suitable manually operated single row seed sowing machine that is self-propelled and pushed by hand. They used a power source to sow the seeds for a medium-sized farm, which decreased fatigue and increased productivity. The hopper was filled with seeds that were arranged at the necessary depths and spacing. The machine required less money to run.

(Uday Veer Singh et al.) Presented that farm mechanization is an essential element of agriculture. Mechanization helped in improving the utilization efficiency of other inputs, safety, and comfort of the agricultural worker, improvement in the quality and value addition of the produce. The primary objective of sowing operation is to put the seed in rows at desired depth and seed to seed spacing, cover the seed with soil and provide proper compaction over the seed. The recommended row to row spacing, seed rate, seed to seed spacing and depth of seed placement vary from crop to crop and for different agro-climatic conditions to achieve optimum yields. Here in this study efforts are taken to design and develop manually operated single row seed sowing machine which is suitable for marginal land holdings and sow the seed at a specific distance with specific quantity and reduce the requirement of seed per unit area and with suitable furrow covering device

This research project explains the advantages of mechanization and the necessity of time- and labor-saving multi-crop machines. When traditional methods are used, there are gaps in the field and bunching due to the uneven distribution of seeds within and between rows. Various drill types are discussed; including single row manually operated single row seed sower, low-cost maize planters, manual oilseed drills, and manual seed and fertilizer drills.

(Suraj V Upadhyaya et al) Focused on implementing the new techniques which will not affect the soil texture but will increase the overall crop production. The intention was to solve problems such as dependency on ox driven machines, Musko skeletal disorders, high cost of buying and maintenance, and handling of equipment due to excess weight. The growth of weeds was reduced by keeping the land between the row spacing undisturbed. The move from a conventional to a direct seeding system improved access to nutrients, competition with weeds, access o available moisture, and use of sunlight

This paper discusses conventional seed-planting techniques and clarifies the importance of using the appropriate row spacing. It is necessary to use agricultural machinery to maintain row spacing. Appropriate row spacing reduced weed growth and improved resource absorption. It is necessary to have uniformity in depth, soil coverage on the seed, transverse displacement, and seed distribution along rows.

Types of seed sowers

Mechanical planters

Figure 9: Mechanical planters

These planters are attached to a tractor or powered by an engine, allowing for faster and more efficient planting. Mechanical planters are a type of planter that is attached to a tractor or powered by an engine, allowing for faster and more efficient planting. One example of a mechanical planter is the Bare Root Transplanter by Mechanical Transplanter Company, which is designed for planting bare root seedlings. Another example is the Mechanical Transplanter by All the agricultural, which is a versatile planter that can be used for a variety of crops.

The Mechanical Plate Planter by Rovic Leers is another option, which uses a plate to plant seeds at the correct depth and spacing. MONOSEM's Mechanical Planter is also a popular choice, offering high-speed planting and precision seed placement. Finally, A&G Agro Mechanical

Industry's MECHANICAL PLANTER is a robust and reliable option for large-scale farming operations.

These mechanical planters offer several advantages over manual planting, including increased speed and efficiency, improved accuracy, and reduced labor costs. They are also capable of planting seeds in a variety of soil types and conditions, making them a versatile option for farmers. By automating the planting process, mechanical planters can help farmers increase productivity and reduce costs, making them a valuable investment for any farming operation.

Drill planters

Figure 10: Drill planters

These planters have a row of discs or tines that open a narrow trench, drop the seed, and close the trench. Drill planters are a type of planter that use a row of discs or tines to open a narrow trench, drop the seed, and close the trench. This type of planter is ideal for no-till or reduced-till farming, as it minimizes soil disturbance and preserves soil moisture. No-till drills, for example, are able to drill different seed sizes and varieties into all types of planting conditions, making them a versatile option for farmers.

The parallel linkage opener is a key feature of drill planters, as it maintains constant down pressure throughout its operating range. This allows the planter to penetrate firm no-till soil and ensure accurate seed placement. Additionally, the optional hydraulic seed drive reduces the need to change sprockets and has on-the-go rate control, making it easy to adjust seed rates as needed.

The wobble slot is another important feature of drill planters, as it provides the best single seed placement. This slot can be adjusted for different seed sizes, ensuring that seeds are placed at the correct depth and spacing. Finally, there are five press wheel options available for drill planters, allowing farmers to choose the best option for their specific soil type and planting conditions. Overall, drill planters are a valuable tool for farmers looking to improve their planting efficiency and accuracy. With their ability to minimize soil disturbance and preserve soil moisture, they are an ideal choice for no-till and reduced-till farming operations.

Air-blast planters

Figure 11: Air blast planters

These planters use air to separate and distribute the seeds, making them ideal for small, lightweight seeds. Air-blast planters use air to separate and distribute the seeds, making them ideal for small, lightweight seeds. These planters work by using negative (vacuum) pressure to pick up a single seed and positive (air blast) pressure to release that seed into a furrow at a precisely designated time. This precise control over seed placement makes air-blast planters highly accurate and efficient.

The benefits of air-blast planters are numerous. They remain the best and most accurate potato seeding system available, and are ideal for planting potatoes to deliver uniform tubers. By using air to distribute the seeds, air-blast planters can handle small, lightweight seeds with ease, making them a great option for farmers planting crops such as potatoes, sugar beets, and other small seeds.

Consistency is key when it comes to planting, and air-blast planters help to ensure that seeds are planted at the correct depth and spacing. A major step toward consistency at harvest is consistency at planting, and air-blast planters help to achieve this by providing a precise and controlled planting process. By using air-blast planters, farmers can help to ensure a consistent and bountiful harvest.

Precision planters

Figure 12: Precision planters

These planters use technology such as GPS to precisely plant seeds at specific intervals and depths, increasing crop yields and reducing waste. Precision planters are advanced farming tools that use technology to plant seeds with precision, resulting in increased crop yields and reduced waste. These planters use GPS technology to precisely plant seeds at specific intervals and depths, ensuring optimal seed placement and minimizing waste. Additionally, they often come equipped with advanced blockage metrics to detect and prevent seed waste, automated downforce control for optimal seed placement, and real-time data analysis for informed decision-making.

The benefits of precision planters are numerous. They can increase crop yields due to precise seed placement and reduced waste, improve efficiency and productivity with automated features, and enhance decision-making with real-time data analysis. Furthermore, they are often compatible with existing farm equipment, making integration easy and seamless.

For those interested in learning more, there are several resources available. Precision Planting Premier Dealers offer expert support and training, and product manuals and replacement part guides are available for easy maintenance. Free events and training sessions are also hosted by Premier Dealers worldwide.

For those looking for alternative options, Monosem planters offer durable and affordable precision planting solutions. Precision Agri Services provides customized precision planting solutions, and MONOSEM offers expert advice and customer care. Overall, precision planters are a valuable tool for farmers looking to optimize their crop yields and reduce waste

<u>No-till planters</u>

Figure 13: No till planters

These planters can be used to plant seeds directly into undisturbed soil, reducing soil erosion and improving water retention. No-till planters are a valuable tool for farmers, allowing them to plant seeds directly into undisturbed soil, reducing soil erosion and improving water retention. To achieve successful no-till planting, it's essential to maintain sharp openers, including double-disk openers and seed tube protectors, and replace them as needed.

When planting, avoid seeding between old rows and instead plant down the old rows to place seeds in the most biologically active area of the field. Be mindful of planting speed, keeping it around 5 miles per hour to reduce planter unit bounce and ensure uniform seed delivery. Additionally, increase down pressure to cut through residue and hard soil, and place seeds at a uniform depth to achieve uniform emergence.

To ensure optimal planting, consider using residue movers to create a uniform residue layer, and close the seed properly for good seed-to-soil contact. Level the planter to prevent bulldozing and plugging, and consider planting deeper to put seeds in a more buffered soil environment, improving uniformity of emergence and root system establishment. By following these tips, farmers can successfully use no-till planters to reduce soil erosion, improve water retention, and increase crop yields.

2.7 Power Source for current Seed sowers

There are a number of different types of power technologies used to power agricultural conservation tillage tools and implements(Michael and Ojha, 2007). The most common types are human power, animal power, engine or mechanical power, electrical power and renewable energy power sources (Desai and Sivakumar, n.d.) Figure 3 shows the distribution of farm power in different regions.

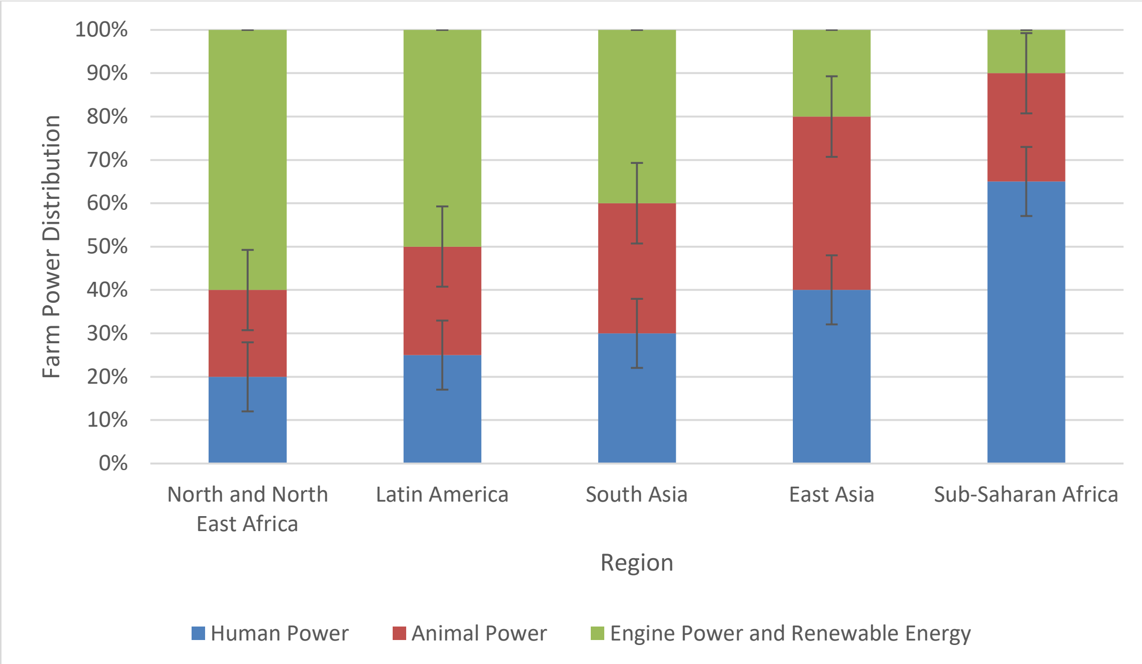


Figure 9 : Farm power distribution in different regions (Simeon et al., 2016)

2.7.1 Human power

Human power is the main source of energy for operating small implements and conventional tools in agriculture(Makange and Richard, 2014).According to Campbell *et al.* (1990), the power of useful work done by human being is given by

$$\mathrm{HP} = 0.35 - 0.092 \log \mathrm{t}$$

where **t** is time in minutes.

The advantages of human power are that it is easily available and can be used for all types of work (Campbell *et al.*, 1990). The disadvantages are that it has very low efficiency; it is affected by weather conditions and seasons and also requires full maintenance when not in use (Makange and Richard, 2014).

2.7.2 Animal power

Animal power is regarded as the most important source of farm power in developing countries and contributes about 80% of the total farm power used in developing countries (Michael & Ojha, 2007).Bullocks and buffaloes are the principal sources of animal power in world farms.

However, camels, horses, donkeys, mules and elephants arealso used as animal power sources(Michael and Ojha, 2007a). Bullocks produce an average of 0.6 Hp with power ranging from 0.5 Hp to 0.75 Hp (Simeon *et al.*, 2016).

The advantages of animal power are that it is easily available, can be used for all types of work, has low initial investment, supplies manure to the field and fuels to farmers and live on farm produce. The disadvantages are it is not very efficient, seasons and weather affect the efficiency, cannot work at a stretch, require full maintenance when there is no farm work, creates unhealthy and dirty atmosphere near the residence and is very slow in doing work(Michael & Ojha, 2007a). In Zimbabwe, animal power is more dominant compared to other sources of farm power (excluding human power).

2.7.3Engine power

The third important source of farm power is mechanical power that is available through tractors and combustion engines. The combustion engine is a highly efficient device for converting fuel into useful work (Michael & Ojha, 2007a). The efficiency of diesel engine varies between 32 % and 38 %, whereas that of the petrol engine is in the range of 25%and 32%.

2.7.4 Electrical power

Electrical power is the most used power source for powering electric motors (Desai & Sivakumar, n.d.). This is a clean and efficient power source compared to human, animal, engine power and also some types of renewable power. The operating cost almost remains constant throughout its life (Simeon *et al.*, 2016). The advantages of electrical power are high efficiency, low maintenance and operating costs, it is not affected by seasons and can work at a stretch continuously for longer periods (Desai & Sivakumar, n.d.). The disadvantages are high initial capital investment, requires technical knowledge and can be dangerous if mishandled (Simeon *et al.*, 2016).

2.7.5 Renewable energy power

It is the energy mainly obtained from biomass; biogas, solar and wind are mainly used in agriculture for power generation and various agricultural processing operations. It can be used for lighting, power generation, water heating, drying, greenhouse heating and other different uses(Makange and Richard, 2014).

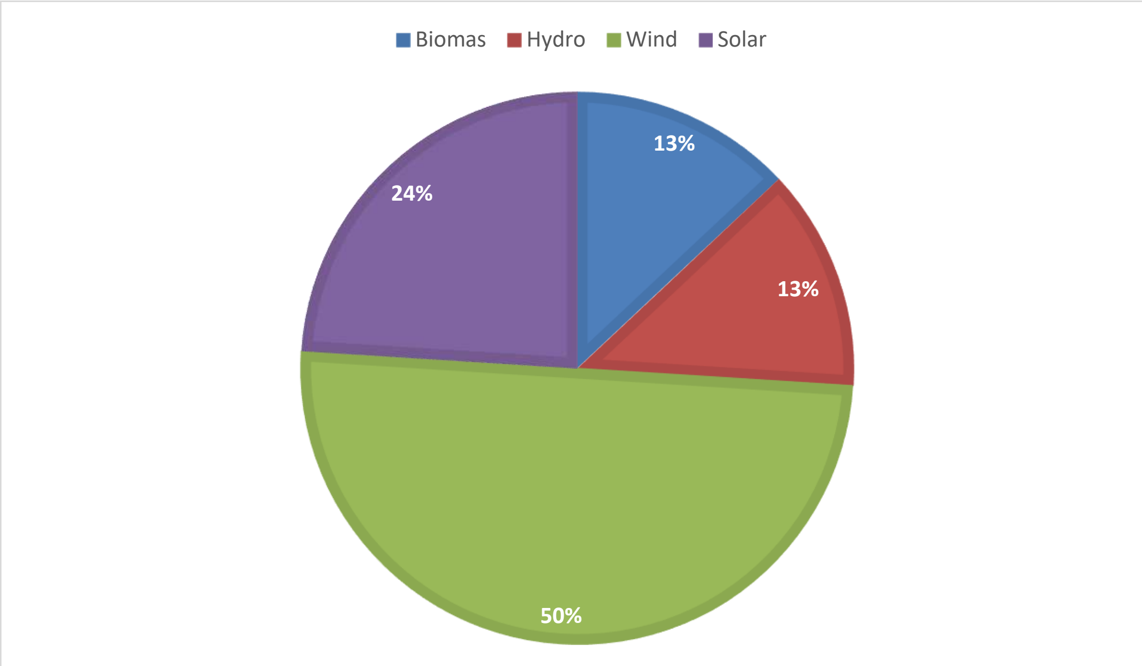


Figure 14: Renewable energy distribution in world farms (Makange and Richard, 2014)

In Zimbabwe, it is difficult to use renewable energy sources to a greater extent because there are relatively low wind speeds on average to use wind power, harsh regulations from water governing bodies like ZINWA make it difficult to use hydropower and policy inconsistence and lack of foreign currency make affect adoption of solar power (Madya, 2022).

2.8Power Transmission for Seed sowers

2.8.1 Direct coupling

A coupling is a device that connects two shaft ends together so that power may be transmitted through the juncture(Michael and Ojha, 2007b).There is a rigid coupling, a flexible coupling, and a fluid coupling(Iyas, 2021). The simplest type is a flanged coupling which is classified as a rigid type (TATA, 2012). Since it is rigid, it is used on shafts that are in good alignment(Tata, 2012).
A chuck can also be used for quick coupling of motor and shaft (Rupesh *et al.*, 2016). Chucks can be keyless or can use a geared key.

2.8.2. Belt transmission

Belts and pulleys are used when the distance between shafts is too great to make it practical to use gears (Tata, 2012). There are mainly two kinds of belts namely flat belts and V belts (Bolton, 2021). Flat belts are wider and thinner than V belts which have a V shaped section. Both kinds are made of rubber-based materials. Belts are a quiet and efficient means of transmitting power and are also able to absorb vibration (Tata, 2012).

2.8.3 Gear transmission

A gear system can be used to transfer motion and torque from motor to output shaft when the motor shaft axis is parallel, intersecting or non-parallel and non-intersecting the output shaft axis (Juvinall and Marshek, 2012).

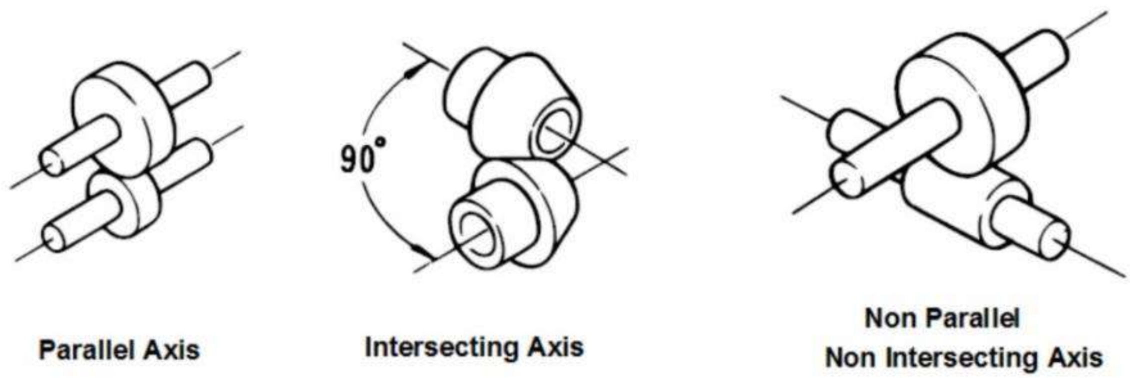


Figure 15: Gear classification according to axis (Tata, 2012)

A nominal classification can also be used with gears being classified as spur, bevel helical or worm(Khurmi and Gupta, 2005). Gears can be used when the output shaft is to have rotational motion opposing that of the motor shaft or when the angular velocity or toque is to be increased or decreased. Compound gears or gearboxes can be uses to provide different speed and torque combinations depending on operator’s preferences(Juvinall and Marshek, 2012).

The advantages of gear transmissions are that it transmits exact velocity ratio, it may be used to transmit large power, it may be used for small center distances of shafts, it has high efficiency, it has reliable service, it has compact layout(Khurmi and Gupta, 2005). The disadvantages are that they are costly as the manufacturing process require special tools and equipment (Khurmi & Gupta, 2005).

For my research project, i have decided to use belt transmission

CHAPTER THREE
METHODOLOGY

3.0 Introduction

This chapter is going to highlight the methodology and design analysis of the design project. The sections covered include, the design process that was followed, possible solutions and selection of the best solution using the solution matrix. Development of the chosen solution was also done in this section; this included merging of ideas in possible solutions, decision matrix and working drawings that were done.

3.1 Study area

Figure 16: Area of study

3.2 Engineering design process

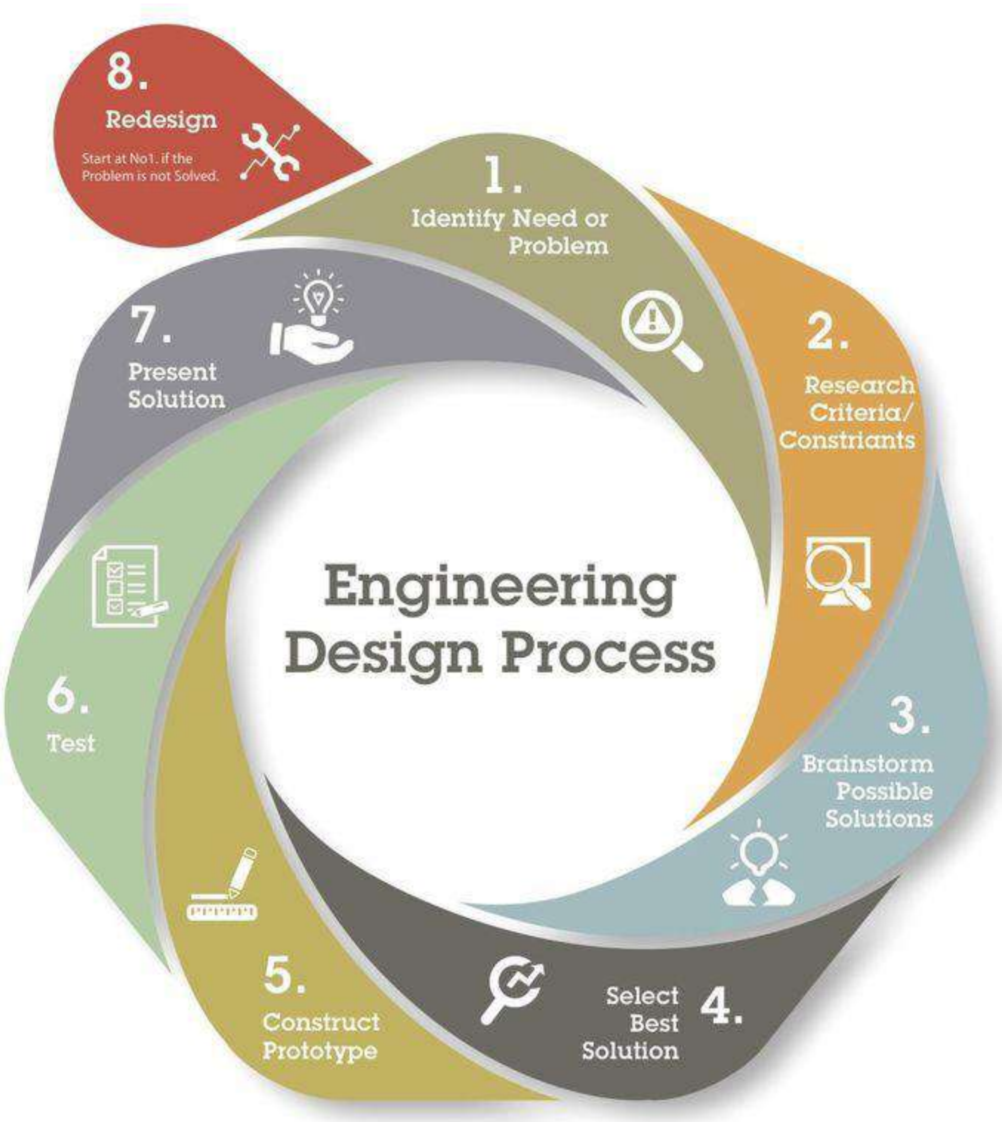


Figure 17Engineering Design Processes (Atman et al. , 2007)

Design Process In this section, the problem-solving methodology in engineering design process to be explained below which was used. The processes described below was used by the designer to come up with a manually operated single row seed sowing machine prototype through which the problem was solved as shown on Figure below.

Stage 1: Problem identification Identify the need or problem.

The problem was identified while keeping in mind the person who experienced it and the significance of finding a solution. Problem was identified through research and interviewing the farmers practicing on small scale. The annual reports by the ministry of agriculture also helped in problem identification

Stage 2: Problem Research

Examining the problem's existing condition and available remedies was part of this. using the internet, libraries, interviews, and other research techniques to investigate other choices. I researched competitors and studied similar projects, taking note of opportunities for improvement and positive outcomes. I conducted a competitive analysis of consumer behaviour and market trends to better understand the scope of the overall market.

Stage 3: Developing of concepts

involved generating ideas for potential fixes, using science and math. Farmers were interviewed practicing small scale to get ideas of what they expect a seed sower to look like. I came up with the desired specifications and important aspects of the design. I designed three possible solutions trying to incorporate all or most of the design specifications and considerations. I weighed the designs and used a decision matrix to come up with the best solution which I chose for development.

Stage 4: Selecting the best concept

Solid Works 2024 and AutoCAD 2023 and 2024 were used for the drawing. This phase of the project also involved the selection of materials. Involved figuring out the best solution to meet the project's goals and objectives.

Stage 5: Construction of the prototype

During this phase, a number of engineering procedures, such as material selection, component construction, and component assembly, were used to build prototypes.

Stage 6: Test the prototype for performance

This is carried out in order to confirm the prototype's performance or functionality and ascertain whether it fulfilled the initial design goals.

Stage 7: present solution

Presenting the solution

Stage 8: Redesign

When the prototype falls short of the goals and objectives of problem-solving, redesigning is necessary.

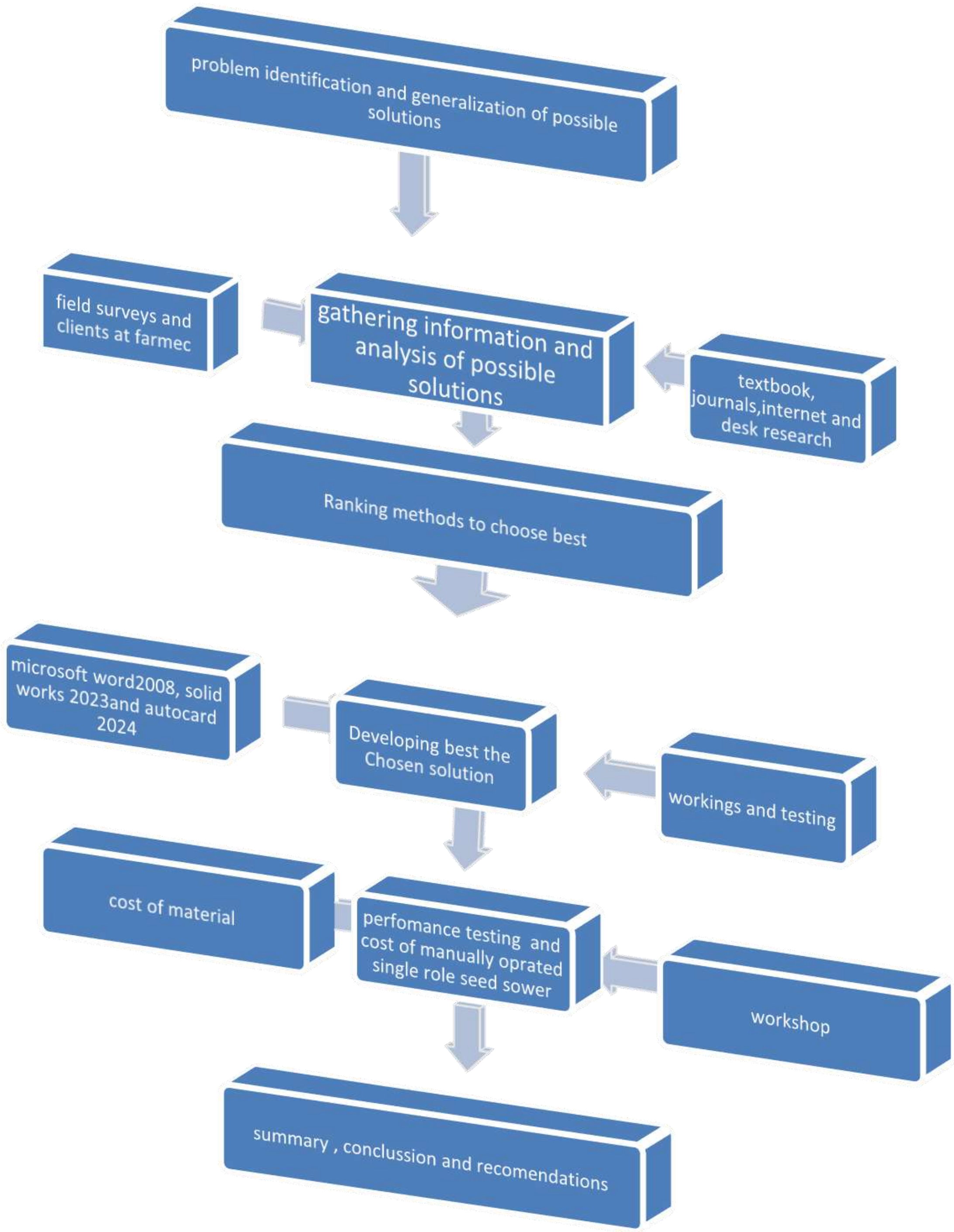


Figure 18: Design procedures

3.3 Generation of possible solutions

3.3.1 Design overview

This manually operated seed sower was designed for

- Compatibility
- Mobility
- Reparability
- Functionality
- Durability
- Affordability
- Simplicity and manufacturability (the design suitable for local manufacturing capabilities).

This was ascertained by

- Low cost material
- Hand push to power the sower

3.3.2 Possible solution 1

Principle of operation

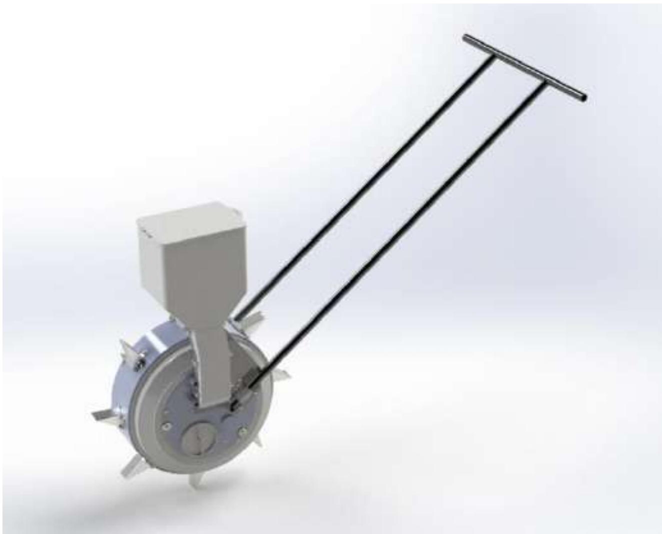


Figure 19: Side view

Figure 20: Top view

Principle of operation

This seed sower releases seeds from the inside of the wheel as it rotates. The breakdown of its working principle:

<u>The principle of operation</u>

The single wheel of the planter revolves as the operator pushes or pulls it. When the wheel rotates, the mechanism for releasing seeds opens, letting seeds drop from the seed reservoir into the hole or furrow. The seeds are sown in the hole or furrow, usually at the same depth and distance apart. As it advances, the revolving wheel aids in the soil's application to the seeds. The user fills the seed reservoir with seeds. The seed metering system is adjusted to control the amount of seeds released. As the user pushes or pulls the planter, the wheel rotates, releasing seeds from the inside through the seed release mechanism. The seeds fall into the furrow or hole, and the rotating wheel covers them with soil.

<u>Merits</u>

- Simple and lightweight, making it easy to maneuver and operate.
- Affordable and economical, especially for small-scale farming or gardening.
- Compact design, ideal for small plots or areas with limited space.

- Seeds are placed at a consistent depth and spacing, promoting healthy growth.

Demerits

- Small seed reservoir requires frequent refilling.
- Simple seed metering system may not provide precise control over seed release.
- May not be suitable for planting seeds at varying depths.
- May not perform well in heavy clay or rocky soils.
- Requires regular cleaning and maintenance to ensure optimal performance.
- Designed for specific seed types and planting conditions.
- User may experience fatigue from pushing or pulling the planter, especially in large areas.

3.3.3 Possible solution 2

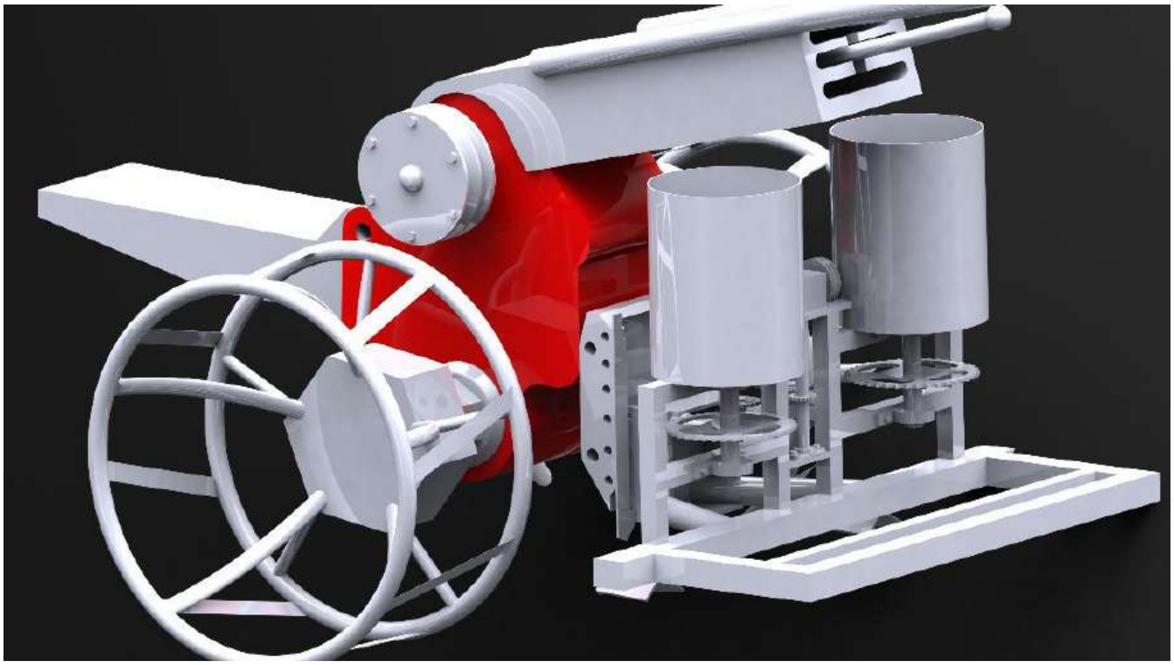


Figure 21: possible solution 2

The working principle

A seed sower using a petrol engine to power belts! That's a more heavy-duty and mechanized approach to seed sowing. Here's a breakdown of its working principle:

Key Components:

Key component	Function
• **petrol Engine**	• Provides the power source for the seed sower.
• **Transmission System**	• Transfers the engine's power to the belt system
• **Belt System**	• Consists of multiple belts and pulleys that transmit power to the seed metering and planting mechanisms
• **Seed Metering System**	• Regulates the amount of seeds released, often using a combination of gears, levers, and sensors
• **Seed Planting Mechanism**:	• Places the seeds in the soil at the desired depth and spacing. •
• **Furrow Openers**	• Create the furrows or holes for seed placement.
• **Seed Covers**	• Covers the seeds with soil after planting.

Table 1: solution 2 key components

Working Principle:

The two stoke engine generates power, which is transmitted to the transmission system. The transmission system converts the engine's power into rotational energy, driving the belt system. The belt system transmits the power to the seed metering and planting mechanisms. The seed metering system regulates the amount of seeds released, based on factors like seed size, spacing, and soil conditions. The seed planting mechanism places the seeds in the furrows or holes at the desired depth and spacing. The furrow openers create the furrows or holes for seed placement. The seed covers cover the seeds with soil, ensuring good contact and protection. The seed sower moves forward, planting seeds in a continuous process.

Benefits:

- Increased efficiency and productivity
- Ability to handle large areas and high seeding rates
- Improved accuracy and consistency in seed placement
- Reduced labor requirements

Demerits

- The complex mechanical system requires regular maintenance, repairs, and replacement of parts.
- The petrol engine consumes significant amounts of fuel, increasing operating costs and environmental impact.
- The engine and machinery generate substantial noise, potentially disturbing wildlife and nearby residents.
- The seed sower is large and heavy, requiring significant storage space and potentially damaging soil or crops during operation.
- The cost of purchasing and setting up the seed sower is substantial, making it less accessible to small-scale farmers or gardeners.
- The seed sower is designed for specific seed types, soil conditions, and planting configurations, limiting its adaptability to diverse farming needs.
- The complex machinery requires specialized training and expertise to operate safely and efficiently.
- Mechanical failures or breakdowns can occur, causing delays and losses in planting and harvesting schedules.
- The fuel consumption, noise pollution, and potential soil compaction contribute to environmental concerns.
- The seed sower relies on fossil fuels, making it vulnerable to fuel price fluctuations and availability.

3.3.4 Possible solution 3

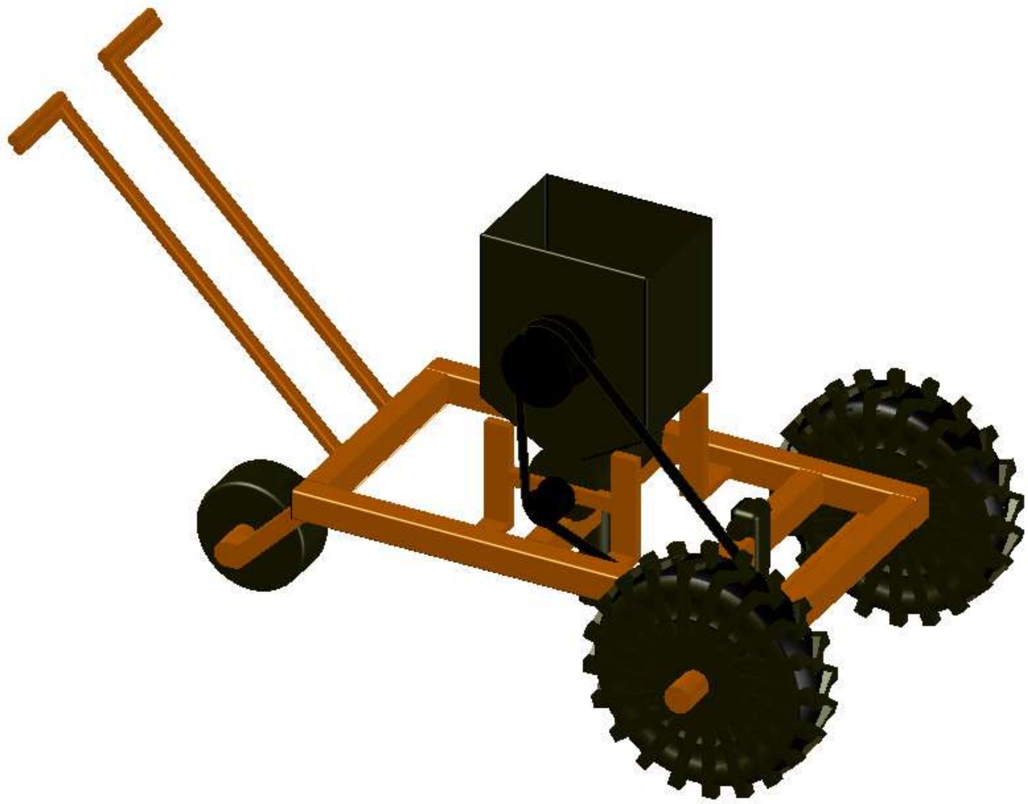


Figure 22: Possible solution 3

<u>Working principle</u>

This machine uses a wheel and pulley system to transmit motion to a seed metering mechanism, which measures out seeds from a seed box. The seeds are then dropped into a pipe and planted in the ground, where they are pressed down by a press wheel to ensure good contact with the soil and promote germination.

<u>Principle</u>

The wheel rotates the pulley on its axle, transmitting motion to the seed metering mechanism. The nylon wheel in the metering box rotates, collecting seeds from the seed box through a hole in the metering device. The seeds are rotated in the metering box until they drop into the pipe below. The seeds are then dropped to the ground. The press wheel presses the seeds down into the soil for better germination.

Merits

- The machine can plant seeds quickly and efficiently, saving time and labor.
- The seed metering mechanism ensures that the correct amount of seeds is planted at the right depth and spacing.
- The machine can plant seeds consistently, reducing the risk of human error.
- The machine can plant a large number of seeds in a short amount of time, increasing productivity.
- The machine can reduce the need for manual labor, saving costs

Demerits

- The machine may be prone to mechanical failure, which can result in downtime and lost productivity.
- User may experience fatigue from pushing or pulling the planter, especially in large areas.
- Requires regular cleaning and maintenance to ensure optimal performance.

Decision matrix

Criteria.	Weight.	Possible Solutions.		
		1	**2**	**3**
Durability	0.20	50	60	80
Affordability	0.15	30	40	90
Functionality	0.30	90	100	100
Mobility	0.15	50	90	80
Compatibility	0.05	55	80	85
Reparability	0.05	80	50	80
Simplicity	0.10	80	50	90
Weighted Total	**100%**	**62.14%**	**67.14%**	**86.43%**

Table 2: design matrix for best solution selection

Development of chosen solution 3

The several components of the selected solution all work together to ensure the smooth operation of the design. The primary parts are the driving wheels, seed tube, furrow closer, main frame, seed box, metering mechanisms, push handles, belt and pulley transmission, and furrow opener.

Material selection of the chosen solution

Analysis of material performance in fabricating manually operated seed sower was done considering:

(1) Functional requirements of the seed sowing machine-the characteristics of the seed sowing machine which correspond with measurable material properties being selected for wear resistance, shear strength and reliability.

(2) Ease of manufacture- it is the measure of the ability of the selected materials to be worked and shaped into a finished product. Most important was to focus on welding and cutting material used to fabricate the seed sowing machine.

(3) Cost-it is an important factor considered when evaluating materials to be used so as not to exceed the cost limit

(4) Reliability- it is the probability that the selected materials for the digger will perform the intended function for the expected life without failure.

(5) Resistance to service conditions – the environment in which the seed sowing machine is going to operate plays an important role in determining the material performance requirements. Examples include a corrosive environment and soil quality.

(6) Ergonomics-The human factor in engineering was also important to consider. The primary consideration for the user is to sow seed without much labour and with limited resources much targeting small scale farmers

CHAPTER FOUR

DEVELOPMENT OF CHOSEN SOLUTION

4.1 Development of chosen solution 3

The several components of the selected solution all work together to ensure the smooth operation of the design. The primary parts are the driving wheels, seed tube, furrow closer, main frame, seed box, metering mechanisms, push handles, belt and pulley transmission, and furrow opener. The components' functions are listed below.

4.2 Driving wheels

These were positioned with treads to lessen slippage at the front of the main frame (Garden Tire 400-8 R1 Pattern pneumatic Rubber Wheel). Tires measure 9 by 3 by 4 inches.

4.3 Seed tube

Seeds are transferred from the metering system to the furrow using this conduit. It is composed of a 1.5-inch-diameter, 18-cm-long steel tube.

4.4 Furrow closer

For correct soil coating and compaction over the seeds, use the back wheels Its tiny heavy duty nylon construction has a diameter of 21 cm and a thickness of 6 cm. It is attached to the machine frame and has two 40x40mm-cent hollow square tube that are used to install the route during planting

4.5 Main frame

This is the planter machine's skeleton, upon which all other parts are fixed. It is composed of 90 x 30 cm mild steel square (40x40mm) beams.

4.6 Seed box

A theoretical hopper capacity of 9000 cm3 is provided by a cuboidal box made of steel sheet that is 2 mm thick and attached with a three-dimensional trapezoidal. It has a small base with a circular opening that measures 2.5 cm in diameter, and its side slope is higher than the average angle of repose of the seeds to ensure free flow of seeds.

4.7 Metering mechanisms

Figure 23: Seed metering mechanism

The seed sowing machine features high-quality nylon wheels and a seed metering system that dispenses seeds evenly and at the appropriate rates. The system consists of a 14.5 cm diameter seed metering wheel with elliptical-shaped cells, 2 cm x 1.5 cm x 1.4 cm deep, that select and drop two maize seeds and one bean seeds per row. The seeds are guided from the hopper to the open furrow through a seed tube. The rotating axis is secured with screw bolts and nuts, allowing for easy removal and replacement of the seed metering housing cover and feeder wheel. Two 40 cm long, 2 cm wide, and 0.4 cm thick steel strips provide added stability. This design ensures precise seed placement and spacing, making it ideal for rural farmers and small-scale agriculture..

4.8 Push handles

The planter's handle was designed to be adjustable and flexible to accommodate different user heights, reducing laborious work. The handle consists of a 90 cm long, 2-inch steel pipe and a 15 cm long mild steel pipe, welded perpendicularly to the handle pipes, allowing for ergonomic adjustment and comfortable grip.

4.9 Belt and pulley transmission

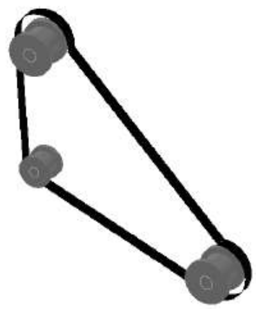


Figure 24: belt and pulley transmission

The belt and pulley driving system consists of three pulleys: a 15 cm diameter drive pulley connected to the front drive shaft, a 9.5 cm diameter driven pulley connected to the metering shaft, and a 2.5 cm diameter intermediate pulley for easy belt installation and removal. The V-belt measures 140 cm in length, and its circumference was calculated by wrapping a tape around the three pulleys

4.10 Design structure

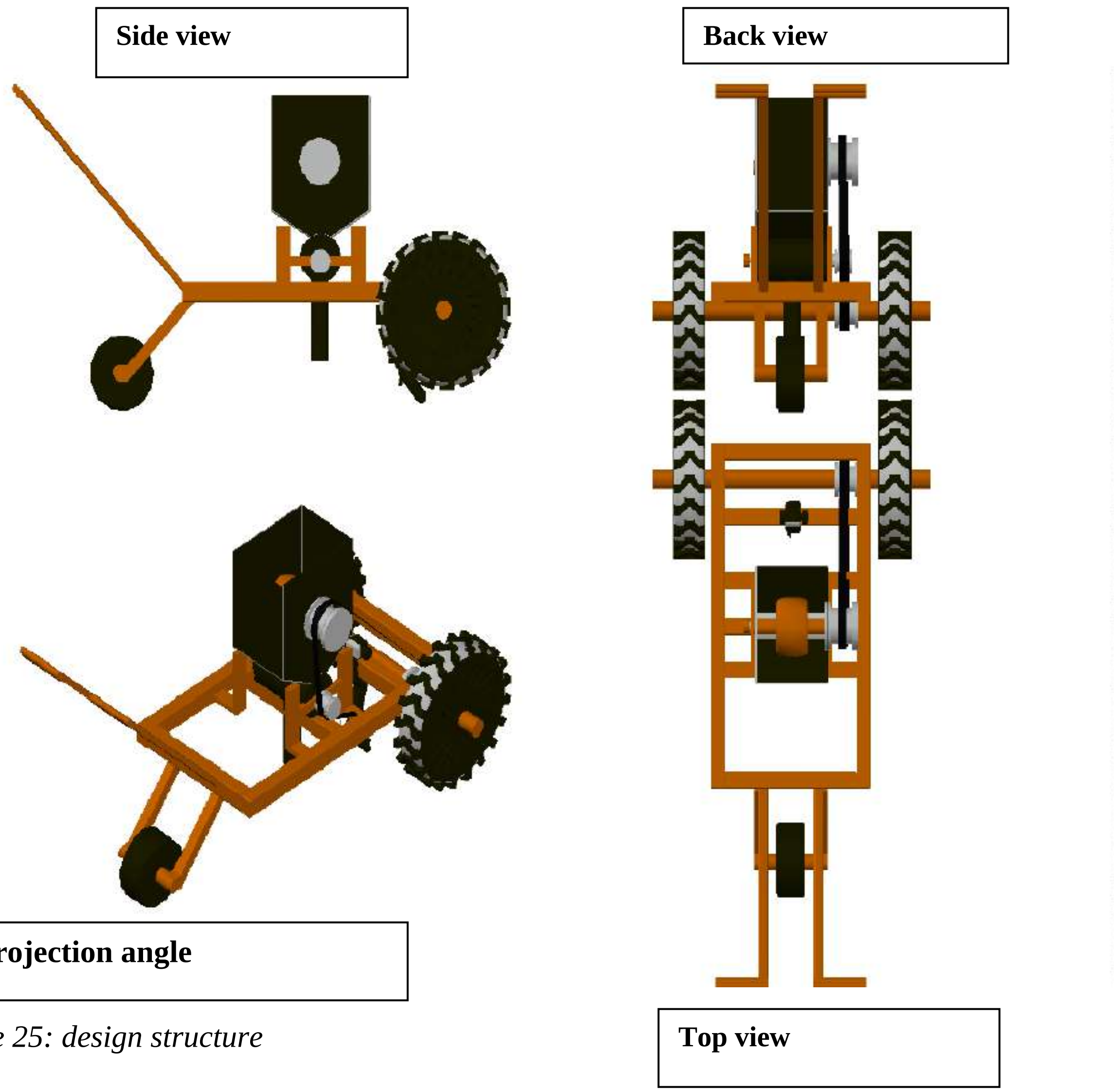


Figure 25: design structure

	Date	Name	Signature	ƆURA UNIVERSITY OF SCIENCE EDUCATION
Drawn	16/03/2024	E.MURAHWA		
Checked by				
Scale	***a manually operated single row seed sowing machine***			Number: B201958B Replace to: Replaced by:

Measurements

Analysis of design:

The design analysis was conducted to choose the different components of the machine.

1. **Seed dimensions** including length, width, thickness, and bulk density were measured using a caliper for 100 randomly chosen maize seeds displayed on the table, these measurements were used to determine the dimensions of the feeding metering mechanism cells, as the bulk density is utilized for determining the total weight of seeds in the hopper.

2. **The friction angle** was determined by placing seeds in a rectangle galvanized steel container and tilting it until the seeds began to slide. The angle was then read from a scale. Five trials were conducted. Hopper sides should be angled greater than the friction angle. Seed characteristics of the seeds utilized in assessing the manually operated single row planter. 2mm steel sheet for the seed box measuring 300mmx 20mm on top.

3. **Total weight of the seed(theoretical)**

Total weight of the seed(theoretical)

= (hopper capacity, cm3(theoretical) × (seeds bulk density, kg/cm3.(kg)

The actual mass of seeds

=Total Weight of seeds(theoretical) × **0.75** = …… kg

-When 0.75 is used to fill the seed hopper

-Weight of seeds will be calculated according to maize seeds because that the main seed planted by the seed sower

The actual Weight of seeds

$= 15000 \times 10^{-6} \times 875.17 \times 0.75 \times 9.81$

= 96.6 N

4. **Weight of the Main Frame:**

The weight of the longitudinal meter of hollow square beam measuring 850 x 40 x 40 mm = 13.6 kg/m (MAIAK-M company. 2019)

The weight of the main frame

$= 13.6 \times 0.9 \times 9.81$

= 106.7 N

5. **Weight of seed box :**

The weight of the square meter of steel sheet 2 mm thickness is 15.56 kg. (E-Village Forum. 2019)

Weight of seed box

= Total surface area of the seed box, (m2) × weight of the square meter of the used material (kg/m2)

$= 0.326 \times 15.56 \times 9.81$

= 49.0 N

Total weight of seed box and seeds

$= 96.6 + 49$

= 145.6 N

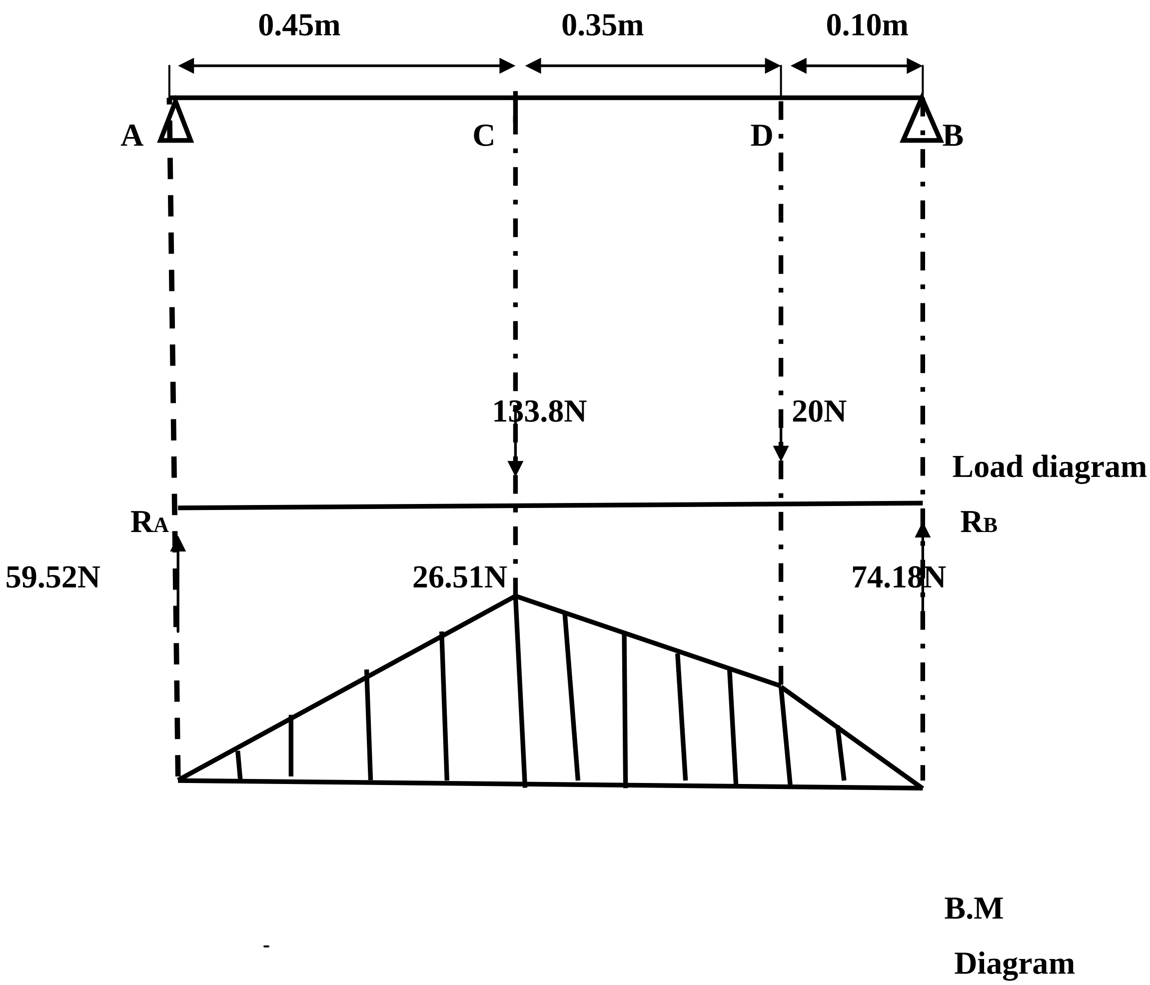
6. **Check the suitability of the main frame thickness:**

The vertical load diagram is shown in fig below. Let RA and RB represent the reactions at A and B respectively for vertical loading. By taking the moments about A

∴ RA = 59.52N∴RB = 74.18N

Fig. (5) shows the bending moment diagram for vertical loading.

It is obvious that C is the point of maximum bending moment (MC) = 26.51 N.m.



7. **Determination of the shaft diameter**:

The shaft diameter was determined to ensure satisfactory strength and rigidity when the shaft transmite power under various operating and loading conditions. For a shaft having little or no axial loading, the diameter may be obtained using the ASME code equation (Khurmi and Gupta, 2005)

$$d^3 = \frac{16}{\pi s_s}\sqrt{[k_b m_b]^2 + (k_t m_t)^2}$$

given as

where

d : Diameter of shaft(m)

$\mathbf{m_b}$: resultant bending moment(Mn)

$\mathbf{m_t}$: Torsional moment(Nm)

$\mathbf{k_b}$: Combined shock and fatigue factor applied to bending moment.

$\mathbf{K_t}$: Combined shock and fatigue factor applied to torsional moment.

$\mathbf{S_s}$: Allowable shear stress of the shaft material, MN.m-2.

Allowable shear stress (Ss) For rotating shafts when load is suddenly applied, and for shaft without key way, allowable stress is 55 MN / m2 (Khurmi and Gupta, 2005)

8. <u>Length of furrow opener</u>

The minimal length of the furrow opener L is given by:

$$\boldsymbol{L = \frac{d + c + S + b + h}{\sin \beta}}$$

where:

d = The appropriate depth for seeds planting= 5 cm

c = Addition to attaching or wearing = 3 cm

s = The distance between the bottom of the main frame and ground surface = 19 cm;

b= The height side of the main frame = 5 cm;

h= The distance up to the first fixed point over the main frame = 7 cm;

β = Angle of furrow opener is 60º.

9. <u>**Determination of the Force Required to Push the Planter**</u>:

The force required to push the planter may be obtained from the following formulas:

$\sum$ FX =FP cos θ - RS cos φ - FR = 0.0 ……… (1)

$\sum$ FY =RS sin φ - FPsinθ - WP = 0.0..……… (2)

Where,

FP= Planter push force, N

FR= Horizontal soil resistance force, N

RS= soil friction resistance =10 - 20 N/m2 for Clay Loam soil (Dragan L. 2018)

φ = Soil friction angle = 18 - 32° for Clay Loam (according to Dragan L. 2018)

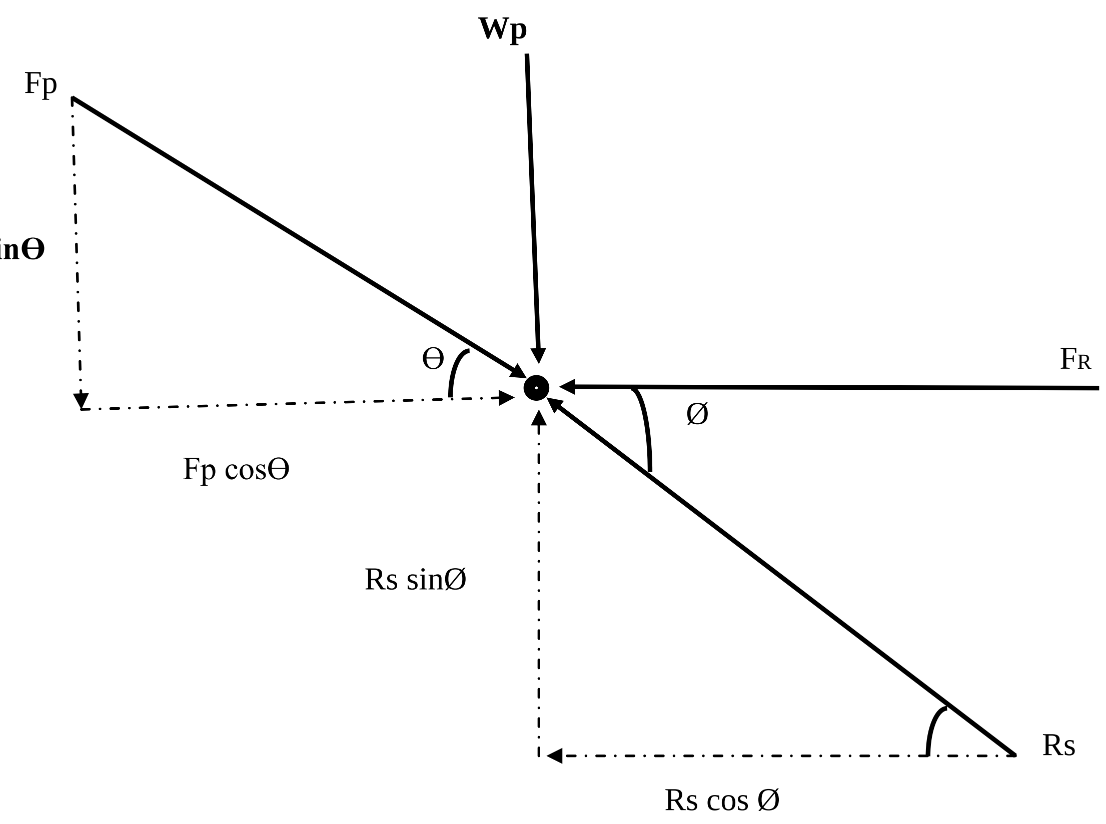
θ = Angle between planter handle and the horizontal plane= 55º)by measuring)

Suitable for the average height of men labours during age of 15 25 years in Zimbabwe Which ranged from 169 – 177cm the majority were 166.7 cm(Amer D. 2016)

WP = Weight of planter

= 3333.54+ 96.6

= 430.14 N



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Free body Diagram showing all forces acting on seed sower

Horizontal soil resistance force (FR):

FR =Soil Resistivity ×d ×t0

= 10×0.5×5

= 25N

The frictional resistance of the contact surface must satisfy the Coulomb's equation:

RS =Ca A + P tanφ...........(1)

RS = (24000 × .05 ×0.005) + (19.62 × tan 32)

= 6 + 12.26

= 18.26 N

where,

RS = frictional resistance (N)

Ca = soil-material adhesion = 12000 - 24000 Pa for cohesive soil with medium consistency (GEO5, 2019)

φ= angle of soil/material friction = 32º

P = normal force on surface = 19.62 N

A = the surface area of the furrow opener in contact with soil,

m2 was estimated Using:

AS = dt×

to where :

dt =The recommended depth for seeds planting = 0.05 m t0

= The thickness of the furrow opener

= 0.005 m

The Required force to push the designed Planter (FP)was calculated using the Following equation (referred to fig 8):

FP cos θ - RS cos φ

FR = 0.0 (FP×cos 55)

= (18.26 × cos 32)+25

FP

= 40.48 N

On an average, a farm labour develops nearly 0.1 horse power (Jain, S. C. 2003) at the maximum manually sowing speed (3.41km/h.) the labour cane produce force equal to79.18 N, which greater than the required force for operated the designed machine

Following a thorough analysis of the optimal solution, the prototype was fabricated at the Engineering Workshop at Bindura University of Science Education. This was preceded by a comprehensive functional determination and material selection process. The processes involved in fabricating the prototype include cutting, grinding, filing, sheet metal development and bending, welding, painting and milling

4.11 Cutting

Cutting was done with high precision to avoid material wastage. The cutting angle iron, iron round rods, metal sheets and pipes was done by using cutting disks and the hacksaw. below shows the cutting of material using a cutting disc

Figure 26: cutting process

4.12 Grinding

Grinding was done with high precision to smoothen and levelling the surface of material. The grinding of angle iron, iron round rods and metal sheets was done by using grinding disks, and a stone grinder.

Figure 27: grinding

4.13 Verification testing

Verification testing was done using a tape measure to check the correct length of materials, such as the seed channels and metering devices, to ensure that they were fabricated to the precise dimensions specified in the design.

Figure 28: verification and testing the dimensions

4.14 Filing

Filing was done to smoothen and leveling the surface of material. The filing of angle iron, iron round rods and metal sheets was done using square, round and flat files.

Figure 29: filling

4.15 Welding

Joining of steel tubes was done through welding using Arc welding with Vietamax 10 Gauge welding rods.

Figure 30: welding

4.16 Milling

The was done using a leath machine to achieve the desired level of precision and surface finish

Figure 31: milling

4.17Painting

Black spray paint was used to paint the prototype for aesthetics and protection of the mild steel from rust.

Figure 32: spray painting

The final prototype

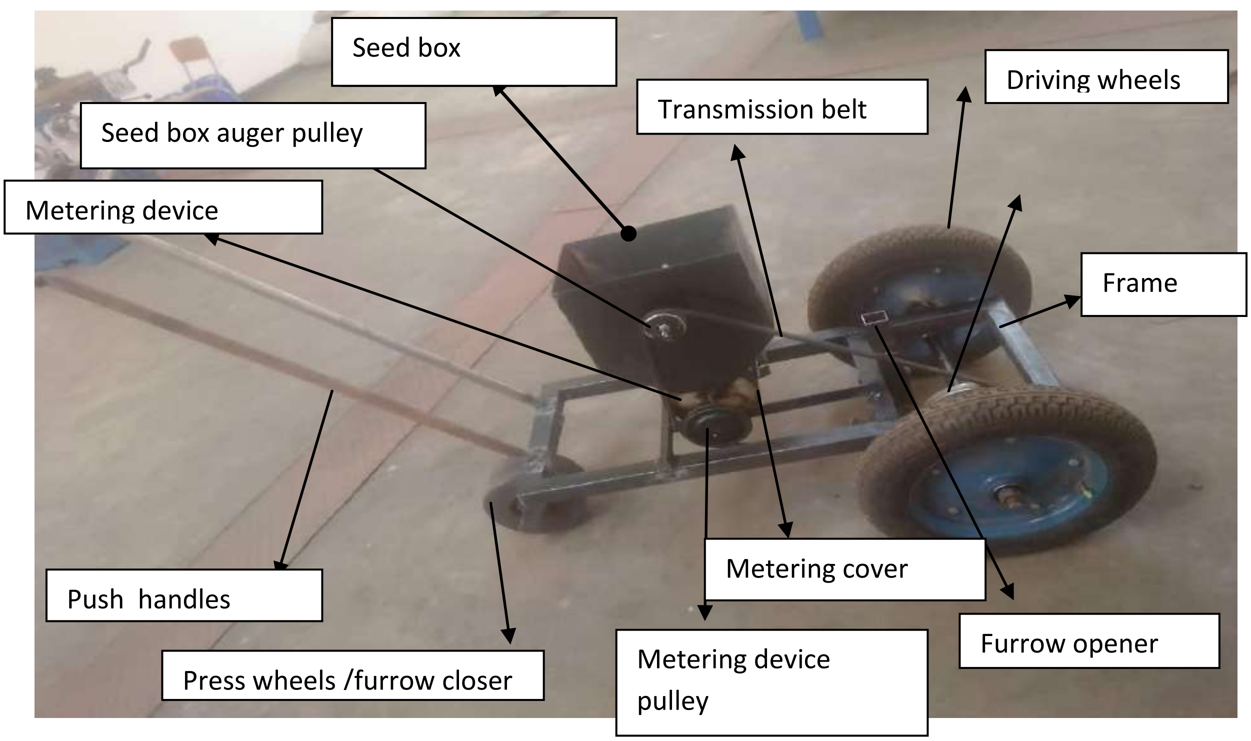

Figure 33: The finished prototype

Figure 34: final prototype 2

CHAPTER FIVE

COSTING

5.1 Total manufacturing costs

The total manufacturing costs are made up of the material costs, operating costs and costs consumables. The cost only incorporates manufacturing costs and excludes testing and evaluation costs.

5.1.1 Material costs

Item	specification	Quantity	Price$	Total$
Wheels		**2**	**30**	**60**
Hollow steel tube	**40x40**	**6m**	**16**	**16**
Hollow round bars		**1**	**3**	**3**
Nylon wheels		**1**	**10**	**10**
Steel sheet		**1**	**10**	**10**
Heavy duty nylon wheels		**2**	**5**	**10**
Transmission belt		**1**	**5**	**5**
Pulleys		**3**	**4**	**12**
Welding rods		**1kg**	**7**	**$7**
TOTAL				**133**

Table 3: material costs

<u>Other costs</u>

Cost	Amount$
Manufacturing cost	20
Cost of utilities	10
Total	**30**

Table 4: other costs

5.2 Selling price

The Selling Price (SP) is a sum of **Total Manufacturing Costs** (TMC), **Value Added Tax** (VAT) and **profit margin** (PM) .On top of the Total manufacturing Costs, VAT was charged at 15% and a profit margin of 15% added.

$$\boldsymbol{Sellingprice(SP)} = TMC + VAT + PM$$

= 163+25+25

=213

5.3 Payback period

Payback period is the time in which the initial cash outflow of an investment is expected to be recovered from the cash inflows generated by the investment. It is one of the simplest investment appraisal techniques.

$$Paybackperiod = \frac{initialinvestment}{cashinflowperperiod}$$

$$\underline{Initialinvestment = \ Assembledcomponentcost + operationnalcosts}$$

Assembled component cost is the sum of the selling cost of potholing and depth metering component and the main frame and distance metering component.

Assembled component cost = US$ 213 + US$ 150

= **US$ 413**

Assuming an operating cost of US$ 80 per cropping season

Initial investment = US$ 460 + US$ 80

= **US$ 363**

$$Cashinflowperperiod = Areacultivated * Yieldperhectare * sellingpricepertonne$$

Assuming an area of 2 hectares, a selling price of US$ 350 per ton(Commodity Marketing Bulletin, 2022)and an average yield of 0.8 t/ha(Ministry of Lands, 2021)

Cash inflow per period = 2 * 213 * 0.8

= **US$ 340** per cropping season

Payback period = $\frac{US\$ 363}{US\$ 340}$

= **1.06** cropping seasons

Therefore, the initial investment will be paid back in 2 cropping seasons.

CHAPTER SIX

RESULTS AND DISCUSSION

6.1 Introduction

This section presents the outcome of our design and testing of a single row manually operated seed sower, an innovative tool aimed at enhancing the efficiency and accuracy of seed planting. I discussed the performance of our service in terms of seed placement accuracy, planting depth control and user experience. Results show that the manually operated seed sower successfully addresses the limitation of traditional seed planting methods, offering a reliable and user friendly solution for small scale farmers and gardeners. We also explore the implications of our findings and potential avenues for future improvements.

6.2 PRODUCT PERFORMANCE TESTING

The manual seed sowing machine was fabricated and tested against key performance parameters at Bindura University of Science Education. Testing was done after design and fabrication. The manual seed sowing machine was tested on its capacity to operate as per design requirements and characterizing its ability to sow seeds efficiently and effectively. The importance of performance testing is to:

- Determine the performance of the manual seed sowing machine.
- Expose defects.
- Identify areas of improvement.

This testing process aimed to evaluate the machine's ability to meet its design specifications, identify any defects or issues, and pinpoint areas for enhancement to ensure optimal performance in real-world applications.

6.3 TESTING PROCEDURE

The seed sowing machine was thoroughly inspected for any damage or wear on components like the seed hopper, seed tubes, and furrow openers before testing. The correct seed type and size were verified, and the seed hopper was filled to the appropriate level.

A dry run was conducted without seed to ensure all components were moving smoothly and functioning correctly. Seed spacing was checked and found to be uniform, with seeds planted at the correct depth and placed in the center of the furrow. However, some damage was observed on the bean seed discs, which were replaced before proceeding.

The furrow openers were observed to create a consistent furrow and close properly. The seed sowing machine was then tested at different speeds, and seed flow was monitored to detect any blockages or issues. During testing, one of the seed outlets outputted a broken bean seed, but this only happened once and did not recur for the remainder of the testing process. Additionally, one of the seed outlets outputted only one seed instead of the expected two, but this anomaly was also isolated to a single incident and did not recur.

After testing, a final inspection was conducted, and no further damage or wear was observed. In a subsequent test, the machine successfully sowed another batch of seeds, demonstrating its reliability and consistency. The testing procedure confirmed that the seed sowing machine is functioning correctly, with only minor, isolated issues that did not affect overall performance

The testing procedure aimed to evaluate the machine's ability to meet its design specifications and ensure successful integration of its components, resulting in optimal performance and desired outcomes.

The designed Seed sower was tested based on the following criteria.

6.3.1 The results

Figure 35: Results

6.4 **The spacing uniformity**

Crop	Plant spacing	Row spacing	Planting pattern
Maize	26cm	40cm	Uniform
Beans	10cm	40cm	Uniform

Table 5: spacing uniformity

The maize crop demonstrates good uniformity, with plants spaced 26 cm apart along the row. This consistent spacing allows for even growth and development, optimal resource allocation, and reduced competition among plants. The row spacing of 50 cm provides sufficient room for growth and air circulation, further promoting healthy development.

The beans exhibit excellent uniformity, with plants spaced closely together at 10 cm apart along the row. This tight spacing encourages mutual support and optimal growth, making the most of available resources. The row spacing of 40 cm strikes a good balance between plant density and air circulation, setting the stage for a successful harvest.

Overall, the uniform spacing of both crops creates an ideal environment for growth, development, and maximum yields. By maintaining consistent spacing, you've set the stage for a successful and productive harvest.

6.3.2

MAIZE = Plants per meter (along row): 1/0.26 = 3.85 plants/m

Plants per hectare= 3.85 plants/m x 20,000 m²/ha

= 77,000 seeds/h

BEANS= Plants per meter (along row):=1/0.1 = 10 plants/m

Plants per hectare= 10 plants/m x 25,000 m²/ha

= 250,000 seeds/ha

Field capacity

Crop	Machine field capacity
Maize	**77000 seeds/ha**
Beans	**250000 seeds/ha**

Table 6: Field capacity

6.5 Impact of forward speed on distribution of seeds

The designed seed sower was tested on light foil sheet at speeds range from 1.80 to 3.41 km/h. with maize and bean seeds. There was no significant difference for any pushing speeds in seeds distribution and seeds quantities per area; this might be due to the calibration of the seed metering device

6.6 Seed Damage Rate

Figure 36: the damaged at speed of 3.41km/hr

The level of seed damage was extremely low at the slowest speeds of 1.80.The speed was 2.50 km/h with no change, while the maximum rate was 0.03% at 3.41 km/h. Recording the speed of maize seed while also recording the highest rate of damage to beans. The control speed of 3.41 km/h resulted in a 0.01% recording of damage to bean seeds. The reason for the lower percentage of bean seeds compared to maize seeds may be attributable to the firmness of bean seeds and also the consistent form of seeds of beans

6.7Effects of forward speed on field capacity and field efficiency

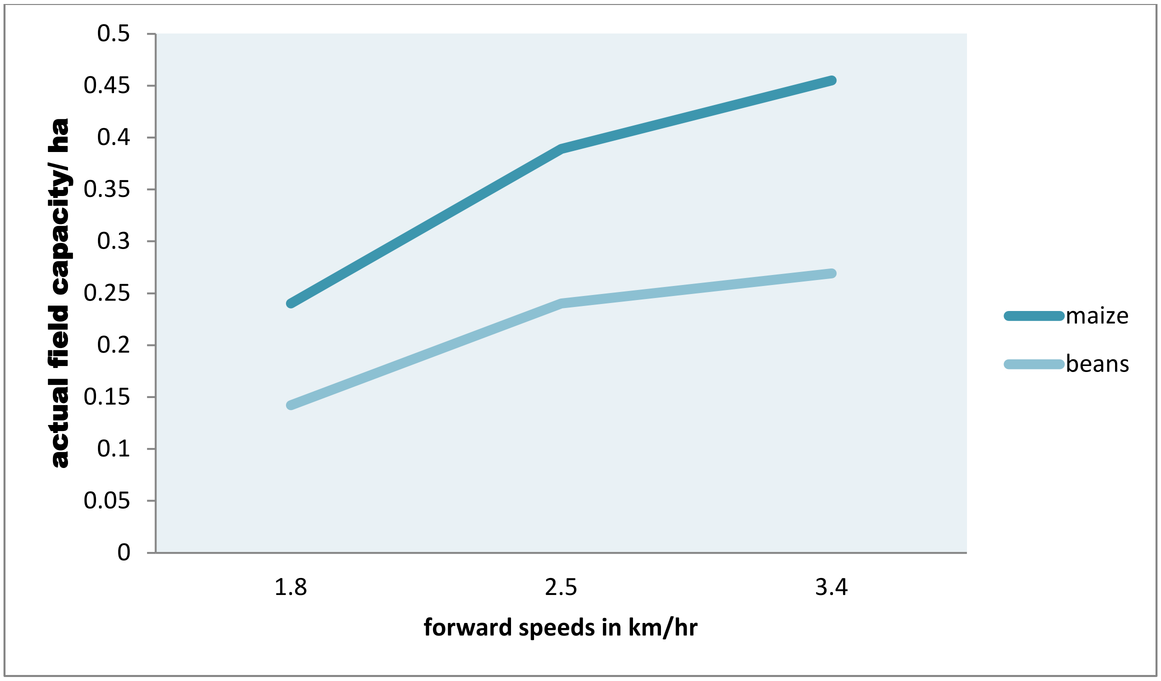

Figure 37: effects of forward speed on field capacity

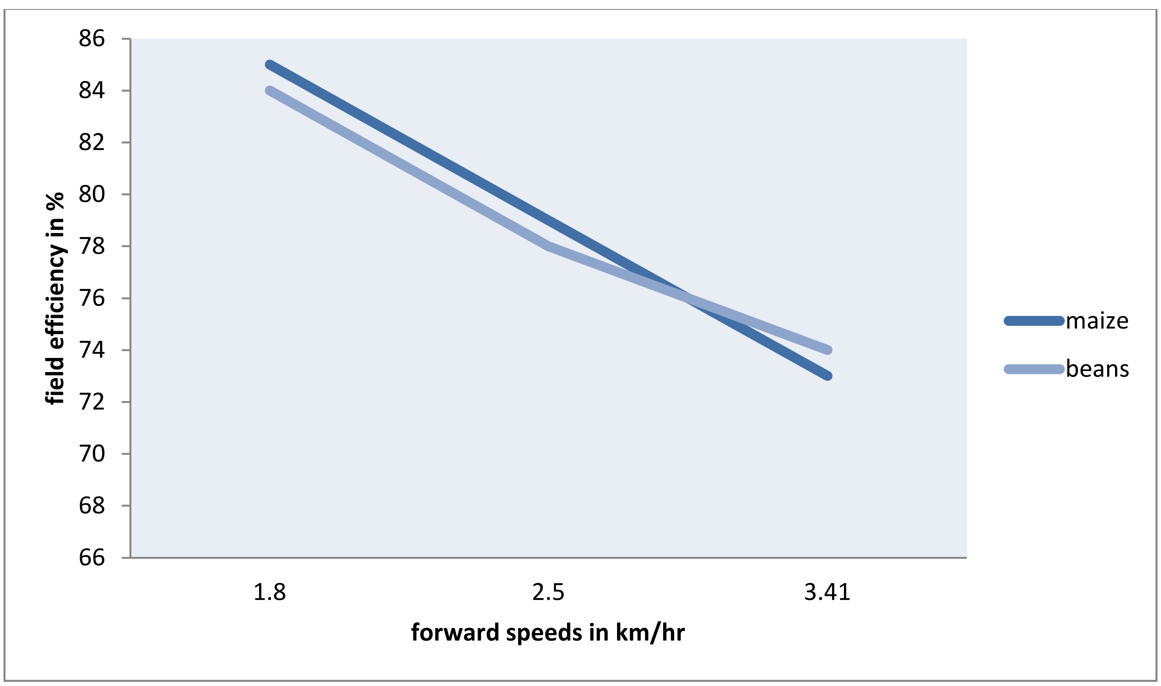

Figure 38: effects of forward speed on field efficiency

The rise in pushing speed led to a higher actual field capacity and a lower field efficiency across all pushing speeds in the field according to the following figs

The actual field capacity of maize planting increase from 0.24 to 0.455 m2/h. when the forward speed increased from 1.89 to 3.41 km/hr. while the field efficiency decreased from 85 to 73%, in bean sowing the actual field capacity increased from 0.142 to 0.269/h. when forward speed increased from 1.80 to 3.41 km/h., while the field efficiency decreased from 84 to 74 %, while increasing the forward speed from 1.80 to 3.41 km/h.

6.8 Comparison between designed seed sower machine and manual sowing

Manual planting required 14 kg /ha. of maize and 55 kg/ha. Bean with planting speed of 0.21 km/h, and field capacity were 0.38and 0.20h ./day (working day=6h) for maize and bean respectively. Results of the manual sowing were compared to those obtained by the use of the designed machine under the two pushing speeds without seeds breaking which were 1.80 and 2.50km/h. in maize plantation and were 1.80 and 2.5 km/h. in bean plantation. This comparison showed high significant different which was clear in the following

The field capacity was significantly increased by the use of the designed machine, compared to manual planting. For maize, the increase was substantial, with a 7.6 and 10.2 times boost at the two used speeds. Similarly, for beans, the field capacity was enhanced by 8.9 and 11.9 times at the two used speeds. This remarkable improvement in field capacity with the use of the designed machine highlights its potential to greatly enhance planting efficiency, making it a valuable tool for farmers and agricultural workers.

The use of the designed machine also resulted in a significant reduction in seed quantity, with a 40% decrease for maize and an 11.5% decrease for beans. Additionally, the machine ensured regular seeding and appropriate coverage, further optimizing the planting process. This reduction in seed quantity, combined with improved seeding patterns, can lead to cost savings and more efficient use of resources for farmers and agricultural workers

According to Table BELOW, the total cost of sowing one hectare using the designed planter was significantly lower than manual sowing, with a reduction of 85.92% and 86.63% for maize, and

89.35% and 89.84% for beans, under the two possible speeds respectively. This indicates a substantial cost savings when using the designed planter, making it a more economical option for farmers and agricultural workers.

COMPONENTS OF SOWING COST	**Costs of using the designed machine under two selection speeds**				**Costs of manual planting USD**	
	MAIZE		BEANS		MAIZE	BEANS
Operating speed (km/h.)	1.80	2.5	1.80	2.4	0.20	0.19
Actual field capacity (M2 /h)	0.242	0.332	0.140	1.89	0.020	0.011
Planting time (h./ HACTARE)	8.13	6.1	12.85	10.05	94.66	120.78
Planting costs (USD/ HACTARE)	6.66	5.02	11.05	8.14	194.55	314.15
Price of used seeds (USD/HACTARE)	5.63	5.63	50.43	50.43	8.54	51.04
Planting total costs (USD/HACTARE)	12.32	10.63	61.45	58.65	297.45	485.64

Table 7: comparison between manual planting and designed machine costs

Total cost of operating the manual seed sower = 1.63 usd

Daily wage of sowing labour = 6.22 usd

Maize seed price per kg= 3,60 usd/kg

Beans seed price 4,30usd/kg

CHAPTER SEVEN

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

7.1 Summary

The main objective of the project was to design and fabricate a manually operated single row seed sowing machine. A decision matrix was used to determine the best solution of three possible solutions. The design of the final solution was done using arithmetic calculations to suite the final operating conditions of the implement. The designs were drawn and modeled using Solid Works and AutoCAD. Simulation of the design was done using Solid Works for mechanical components. The simulation deduced that mechanical components were designed to withstand all the forces the implement is expected to face during operation as long as the safety factor was not exceeded. The following conclusion was made.

7.2 Conclusion

In conclusion the main objective was achieved. The design also managed to fully attain most of the design specifications mechanically. We concluded that the design was suitable to use in any acceptable stress and strain conditions. However, the design is not recommended for use in zero tilled land as it failed to reach the torque requirements to reach a depth of cm in clay. The design passed the minimum requirements for mass production but can be improved in future.

This study focused on the design and evaluation of a manually operated single-row seed sower that is easy to use, maintain, and lightweight, requiring less labor and costs. The design prioritizes simplicity, maintainability, and reduced material usage, resulting in a cost-effective and efficient solution.

The manual operated single-row seed sower demonstrates improved productivity, with an increased field capacity and optimized seeding density, leading to reduced seed consumption and enhanced resource allocation. This is achieved through a significant increase in field capacity compared to manual planting, allowing for more efficient use of time and resources.

The machine incorporates ergonomic design principles, reducing operator fatigue and improving overall usability. Its modular design also enables adaptability for various crop types, enhancing its versatility and applicability. This makes it a more comfortable and sustainable option for farmers, and it can be used for planting other crops such as maize and beans by simply switching the seed metering device.

The manual operated single-row seed sower boasts a user-friendly interface and minimal operational complexity, ensuring ease of use for operators with varying levels of expertise. Optimal operating speeds of 2.5 km/h for maize and 2.4 km/h for beans are recommended to maximize productivity and minimize operating costs.

The designed manual operated single-row seed sower is an effective and efficient tool for farmers. To further enhance its utility, development of compatible feeding devices for various crops is suggested, enabling year-round usage and minimizing downtime. This would maximize its utilization throughout the year and reduce operating costs.

7.3 Recommendations

I recommend future designers to consider using a motor with more power to increase the toque and gears for power transmission so as to further reduce the total weight of the implement. I also recommend the use of a motor to increase the area that can be covered by a single person.

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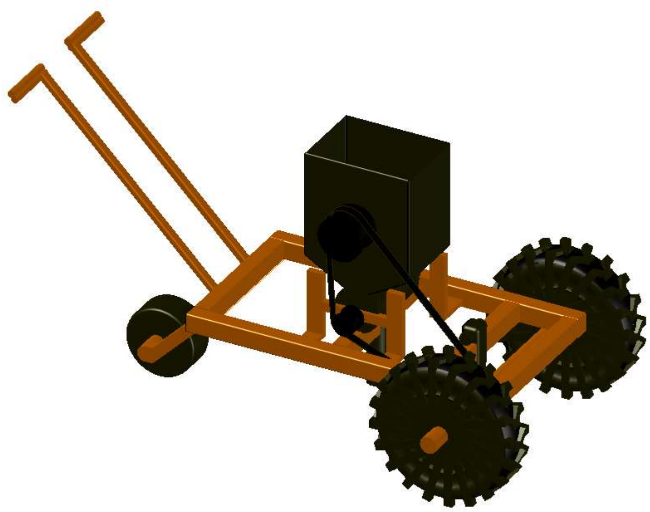
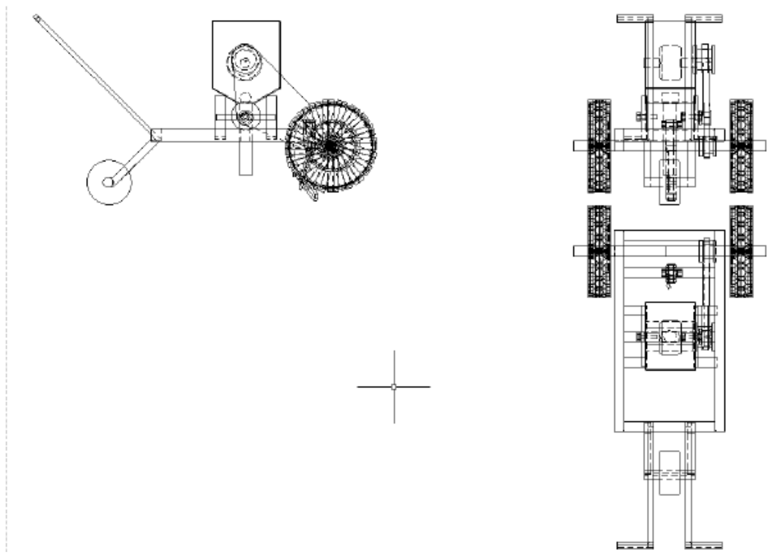
APPENDICES

ULTIMATE STRENGTH OF MATERIALS AND THEIR YOUNG'S MODULUS				
Material	Compression (in MPa)	Tension (in MPa)	Shear (in MPa)	Modulus of Elasticity(GPa)
Structural.Steel	--	400	--	200
Alum.Alloy	--	110	70	70
Ponderosa Pine	36	55	7.6	9
High Strength Concrete	40	low	--	30
Nylon	95	75	--	2.8
Marble	125	15	28	7.2
Cast Iron	655	170	240	12.1

Appendix 1: Ultimate strength of materials (Hibbeler, 2005)



Appendix 2: Assembled Model



Appendix 3: 2d assembled drawing