e-palli

AMERICAN JOURNAL OF FOOD SCIENCE AND TECHNOLOGY (AJFST)

VOLUME 1 ISSUE 1 (2022)

Indexed in

doi | Crossref | Google Scholar | Directory of Research Journals Indexing DRJI

PUBLISHED BY: E-PALLI, DELAWARE, USA

American Journal of
Food Science and Technology (AJFST)

Volume 1 Issue 1, Year 2022
ISSN: 2834-0086 (Online)
DOI: https://doi.org/10.54536/ajfst.v1i1.506
https://journals.e-palli.com/home/index.php/ajfst

Design of Manually Operated Four Rows Rice Seeder

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Article Information

Received: July 21, 2022

Accepted: July 22, 2022

Published: July 24, 2022

Keywords

Design, Rice Seeder, Traditional Seeding, Row seeding, Concept generation, Binary dominance matrix

ABSTRACT

In Ethiopia, rice is one of the targeted agricultural products that has received adequate attention in the promotion of agricultural output. It is regarded as the "Millennium Crop" and is anticipated to help ensure food security in the nation. As a result, over the past few years, its production has increased. Despite the growth, there are still a lot of production system issues that need to be resolved, with planting technique leading the list. The farmers continued to use time- and labor-intensive traditional seed-broadcasting techniques, which led to a sharp reduction in output due to an unfavorable plant population. Consequently, in order to maintain the ideal plant density and get around the issues with the conventional method of disseminating the seed on the farm; there was efforts have made to design suitable planting machine for rice. Then depends on the binary dominance matrix traditional seeding techniques (broadcasting), manual planting technique in rows and the newly designed manually operated four rows rice were evaluated and it was found that newly designed seeder was better than manual method in all parameters. The machinability aspect, which comprises installation, simplicity, durability, choice of material, machine, low pricing, and prolonged life span when operated with high utilization with minimal downtime, was properly taken into account in order to achieve this design target and goals.

INTRODUCTION

Ethiopia's economy is based on agriculture, which accounts for over 46% of GDP, 83.6% of employment, and nearly 80% of foreign export revenues. Tiny-scale farming accounts for 90–95 percent of Ethiopian agriculture's production, with 14.2 small subsistence households having an average of 0.89 hectares of land each (CSA, 2014). In Ethiopia, rice farming is a relatively new development. When wild rice (O. longistaminata) was discovered in the marshy and wet portions of the Fogera and Gambella Plains, Gebey et al., (2012) believed that efforts to introduce rice into Ethiopia had already begun. In Ethiopia, the potential area for rice cultivation is thought to be around 30 million hectares, of which more than 5 million ha are very appropriate, according to the MoARD (2010) assessment. According to CSA, MoARD, and Gebey et al. (2010) and CSA, (2009), the crop's area and output are on the rise. Ethiopia's current rice-producing regions are Amhara, SNNP, Oromia, Somali, Gambella, BeniShangulGumuz, Tigray, and Afar. Compared to its potential, Ethiopia has a small quantity of land planted in rice. The amount of imported rice has increased along with output levels.

The Ethiopian government bought 25,667 tons of rice in 2008 and 30,082 tons in 2009, respectively. If rice output keeps rising, it is anticipated that the nation will soon be able to replace imports and begin exporting (MoARD, 2010). Generally speaking, rice has enormous potential and may significantly impact Ethiopia's socioeconomic development, food and nutritional security, income production, and poverty alleviation.

Farmers in many parts of Ethiopia have expressed a strong interest in rice farming and routinely ask for new technologies. The crop has been designated by the government as "the new millennium crop of Ethiopia" in order to achieve food security because of its significance and potential. However, the lack of pre-harvest, post-harvest, and processing technologies, as well as a lack of knowledge on how to use it, were among the biggest constraints on rice production in Ethiopia, according to Tesfaye et al., (2005). Despite this enormous potential, Ethiopian rice farming is largely traditional, with the majority of participants being small-scale farmers with modestly sized farms. Similar to this, there aren't many rice production processes that are mechanized, including soil cultivation, planting, harvesting, and threshing.

The majority of farm tasks are carried out by hand, with the aid of simple hand tools, or with the aid of equipment pulled by animals. One of the biggest mechanization issues addressed was the planting process, which was caused by the lack of an appropriate rice planter or seeder. For the purpose of disseminating rice seeds by hand, farmers typically utilize this technique. It is evident that the conventional method of planting cannot maintain the ideal plant density in the field while evenly distributing the seed. Low efficiency and excessive costs are the inevitable results. In comparison to conventional hand broadcasting techniques, it was investigated if rice seeding by mechanical means could provide the ideal plant population and attain high field capacity.

Additionally, it is simple to cultivate when the pattern is uniform in rows, and the rows offer the chance to employ an inter-row cultivator. Devnanai, (2002a), Devnanai, (2002b), Tajuddin, and Rajendran, (2002) among many others, have claimed that direct sowing of paddy using a drum seeder has led to lower production costs and

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higher yield when compared to manual transplanting and broadcasting approach. The first issue was that when the grains were repeatedly discharged from the drum through the orifices, the drum's percentage of fill decreased. This resulted in a non-linear change in the grain flow rate, which again affected plant uniformity and, ultimately, crop production. The second issue was that the seeds continued to fall while rotating near the top of the field, potentially wasting better seed. Third, it required frequent refilling and was challenging to gauge the quantity of seeds inside the drum. Even though the machine has these restrictions, Ethiopian farmers find it difficult to obtain and utilize this kind of equipment due to economic issues and the machine's lack of availability in the nation. In light of the aforementioned constraints, it is necessary to construct a suitable rice seeder using materials that are readily available locally.

Therefore, an effort was made in this work to address issues with the traditional methods of planting rice (both broadcasting and row dropping) by creating a four-row rice seeder that is both technologically and economically feasible. The general objective of the project was to design a four rows rice seeder with the following specific objectives.

- To develop functional structure for four rows rice seeder.
- To prepare 3D and 2D drawing of the rice seeder.
- To prepare exploded drawing of the seeder.

MATERIALS AND METHODS

Design procedures

This study was carried out after studying different research reports which are mentioned in the review of literature. Both primary and secondary sources of information have been exploited to conduct the study. The project was conducted using three treatments; Traditional or Local planting (broadcasting), and Traditional/manually (dropping in rows) rice seeder and manually operated four rows rice seeder. Seed rate, seed spacing, planting date, and plant population were the factors used for comparison.

The methods to be used in this design are: The gathering required information which is associated with agricultural operation. Studying the properties of rice seed. Careful consideration and analysis on various parameters led to the selection of the best suitable concept for detailed design formulation will be done through the use of a binary dominance matrix.

- The conceptual design of an appropriate system to meet their needs.
- Modeling (using Solid work 2020 Computer Aided Design software).
- The determination on whether their problem will be solved.
- Specifying material to be used for each component.

Conceptual Design

At this point, the designing of the rice seeding machine begins with the fundamental approach to developing a new system in compliance with technical requirements. Since rice production in our country is still ongoing, seed drilling machines will be developed in accordance with demand, as noted in the literature, as one of the technical transformations of rice product development.

Abstraction

This part is used to identify the general criteria of the Rice seeding machine specially,

- To develop best drilling system (accurate line spacing as possible)
- To decrease energy consumption
- To reduce weight or space required
- To significantly lower initial cost as possible
- To improve production methods

Problem Formulation

- Add the Rice seed in its bucket
- Start the operation
- Counting amount of rice seeds
- Avoiding stick property of drilling material
- Metering space between row
- Starting drilling the Seed

Detail design development

Design Consideration

The four rows rice seeder for direct seeding rice was designed as a functional and experimental unit. The design of machine components was based on the principles of operations and lab tests. It was compared with the compared conventional method, to give a correct shape in form of design. The mechanical design details were also given with due attention so, that it gave adequate functional rigidity for the design of machine.

Agronomical Considerations

Rice agronomist recommendations;

- Seed rate; it should be in the range of 50 – 80kg/ha,
- Row to row distance given 20cm,
- Plant to plant distance should be 2 – 3cm, and
- Measured values (i.e. bulk density of paddy/Rice 689kg/m3, angle of repose 360) were considered.

Design concept

A set of customer needs and target specifications serve as the basis for the concept generation process, which yields a series of product concepts from which we can create the final specification (Ulrich, 2020). In order to address issues with the current manual, traditional method, low cost automation was introduced. There are several unsure planting devices in this mechanism, like rice row seeding. The concept of the work is,

- Observe the manual methods to identify the important process variables.
- Quantify the important method.
- Investigate all areas of automated forming.
- Refine design of the machine, as this plays a major

role in rural area.

With the aforementioned factors in mind, a semi-automated machine that replaces manual labor can be designed.

List

The system is more probably chosen what it's seeking by fulfilling the following general requirement.

- Small in size to transport from place to place
- Less Number of components
- More accurate system as possible
- Safe and Easy to operation
- Manual power source
- Less initial cost
- Easy to assemble and Maintainability

Concept Generation

Functional structure

Based on the problem related with rice seeding and assessing the literature of existing planting techniques we should have to design the new system. So let's construct the functional structure as follow:

Figure 1: Overall functional structure Sub-function

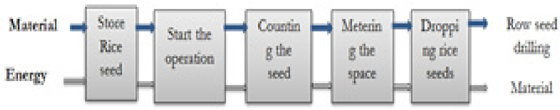

Figure 2: Sub functional structure

Concept Selection

The process of selecting a concept involves assessing it in light of the needs of the client and other factors, comparing its relative merits, and choosing one over another for further research, testing, or development. The following potential other options will be considered while evaluating the variant. Due to the focus of this project being on rather damp soil conditions, we have neglected using another power source for machinery. The system may then go to the darkened region as follows after creating the decision tree. The decision is made using a straightforward system and a source of availability.

Table 1: Selective system option

Seeding mechanism or method	Broadcasting(traditional)	Dropping in rows manually	Four rows seeder
Power source	Man	Man	Man
Seeding material	Rice seed only	Rice seed only	Rice seed only
Operating type	Carrying and walking	Carrying and walking	Pulling and rotating
Seed dropping method	Throwing by hand and gravity	Dropping and gravity	Gravity
Seed metering system	Difficult to meter the seed	Random counting	Metering shaft
Seed holding device	Bucket	Cylindrical container or Bucket	Hopper
Weight	Heavy	Medium	Low
No of wheel	0	0	2

Decision Tree

Standing from the above possible alternative option system, we do have construct the following decision tree

Selection of working Principal Variants

From the aforementioned decision tree, which contains those 10 potential seeding system combinations, we must choose the best system. Then, only using the following criteria, they have narrowed the options down to a few.

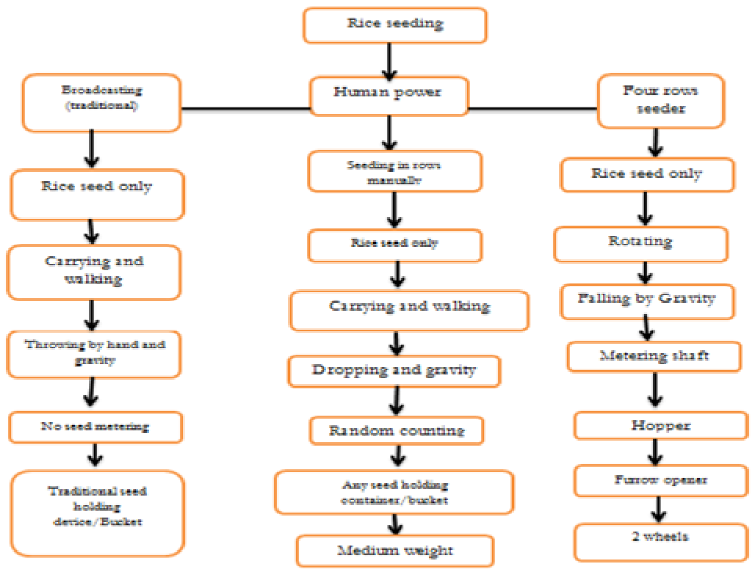

Figure 3: Decision tree.

- o System complexity
- o Easy during operation,
- o Probability of seed drawn
- o Required number of power
- o Simplest mechanism
- o Probability of manufacturing in Ethiopia

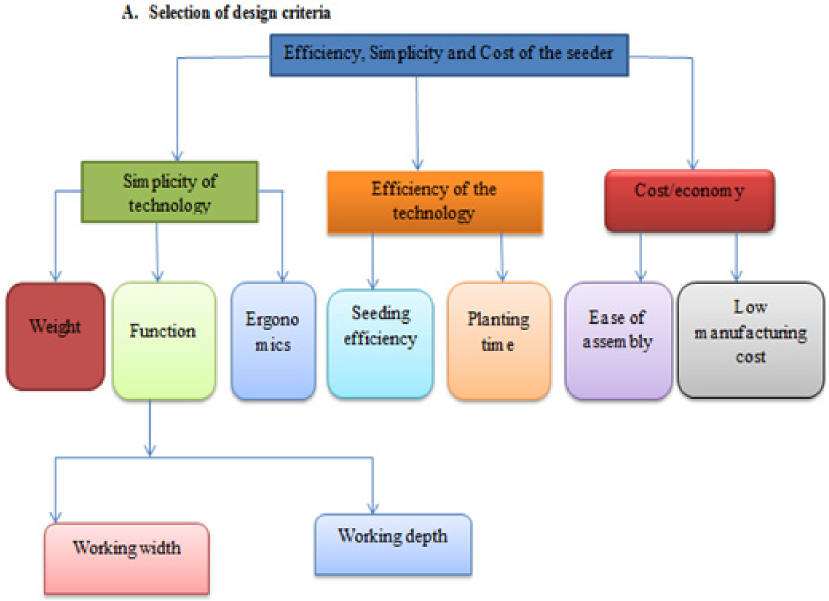

Figure 4: Structure of objective Tree

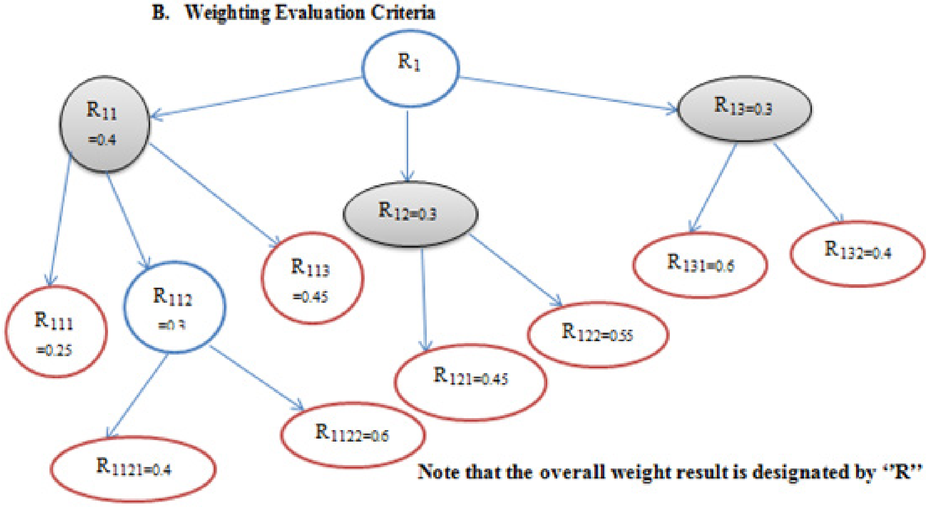

Figure 5: Assigning of weighting factor for each criterion

Determination of weighting factors of the ending Branches in tabular form

Table 2: Sub weighting and overall weighting factor the end branches

No	End branches	Dropping in rows manually	Four rows seeder
1	R111	0.25x0.4	0.10
2	R1121	0.4x0.3x0.4	0.048
3	R1122	0.6x0.3x0.4	0.072
4	R113	0.45x0.3x0.4	0.054
5	R121	0.45x0.3	0.135
6	R122	0.55x0.3	0.165
7	R131	0.6x0.3	0.18
8	R132	0.4x0.3	0.12

Assessment of Values and Determination of Overall Values

The values are expressed in points of use value analysis approaches by giving 1 for more important criterion and 0 for less important criterion in a given pair of criteria to be evaluated.

Table 3: Weighted and Un-weighted Overall Values Determination

Criteria	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Un weighted overall**	**Weighted overall**
1	-	1	1	0	1	0	1	0	4	0.143
2	0	-	0	0	0	1	0	0	2	0.071
3	0	1	-	0	0	1	0	0	2	0.071
4	1	1	1	-	1	1	1	1	7	0.25
5	0	1	1	0	-	0	1	1	4	0.143
6	1	0	0	0	1	-	1	0	3	0.107
7	0	0	1	0	0	0	-	0	1	0.036
8	1	1	1	0	0	1	1	-	5	0.179

Un-weighted Overall Value was calculated by:

$$Ovi = \sum_{j=1}^{n} V_{ij} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1)$$

Weighted Overall Value was calculated by

$$Owvi = \sum_{i=1}^{n} WV_{ij} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (2)$$

Comparing Concept Variants

Table 4: Satisfaction for achieving the criteria in Percentage

Satisfaction (%)	**Description**
100	Excellent, Complete satisfaction, objective satisfied in every aspect
85	Very Good, Extensive satisfaction, objective satisfied in all of important aspect
70	Good, Considerable satisfaction, objective satisfied in the majority of aspects
50	Fair, Moderate satisfaction, a middle point bin complete and no satisfaction
25	Bad, Minor satisfaction, objective satisfied in some but less than half of the aspect
10	Failure, Minimal satisfaction ,objective satisfied to very small extent
0	No satisfaction, objective is not satisfied in any aspect

Concept variants result of power source in decision matrix

Three power sources are considered to sow rice with different range of rate within the specified time according to their capacity. These concept variants are; A=Single Man, B= Single man and single animal and C=Single man with pair of animal.

Here as shown in the table, the maximum rating is 78.03 and hence concept variant A is selected as the best concept or alternative. So, Single Man can be used for the operation of the seeding machine

Table 5: Decision making matrix for the power source for the rice seeding purpose

Criteria		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Overall satisfaction**
Owvi		0.143	0.071	0.071	0.25	0.143	0.107	0.036	0.179	
A	%	85	90	75	80	75	70	70	75	
	%* Owvi	12.155	6.39	5.325	20	10.725	7.49	2.52	13.425	78.03
B	%	75	60	70	55	60	65	70	65	
	%* Owvi	10.725	4.26	4.97	13.75	8.58	6.955	2.52	11.635	63.395
C	%	80	80	60	75	80	80	50	80	
	%*Owvi	11.44	5.68	4.26	18.75	11.44	8.56	1.8	14.32	76.25

Concept variants result of Seeding techniques in decision matrix

Three planting technique are considered to sow rice with different range of rate within the specified time according to their capacity. These concept variants are Traditional (Broadcasting), Manual row seeding, and Four rows rice seeder. A= Traditional planting (broadcasting), B= Four rows rice seeder and C= Manual seeding techniques (dropping seeds manually in rows)

From the decision making matrix the maximum value of

Table 6: Decision making matrix for rice seeding technique

Criteria		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Overall satisfaction**
Owvi		0.143	0.071	0.071	0.25	0.143	0.107	0.036	0.179	
A	%	25	70	25	10	80	70	70	20	
	%* Owvi	3.575	4.97	1.775	2.5	11.44	7.49	2.52	3.58	32.5
B	%	85	80	90	95	65	80	75	90	
	%* Owvi	12.15	5.68	6.39	23.75	9.3	8.56	2.7	16.11	84.68
C	%	80	85	60	75	85	85	50	80	
	%*Owvi	11.44	6.035	4.26	18.75	12.15	9.10	1.8	14.32	77.8

concept variant is 84.68 at B; therefore manually operated four rows rice seeder is the final selection

Concept variants result of Hopper type in decision matrix

The hopper is a device in which the seeds to be planted are kept before their gradual release into the furrowed tunnel. The amount of seed depends upon the size of the seed hopper. Four concept variants are considered to design the four rows rice seeder. These concept variant are Cylindrical, Conical, Trapezoidal, and Rectangular hopper types. Let denoting A= Cylindrical, B= Conical, C= Trapezoidal and D= Rectangular

Here as shown in the table, the maximum rating is 85.53 and hence concept variant C is selected as the best concept or alternative. Therefore Trapezoidal shape is the most appropriate hopper needed to hold rice seed.

Table 7: Decision making matrix for Hopper shape type

Criteria		1	2	3	4	5	6	7	8	Overall satisfaction
Owvi		0.143	0.071	0.071	0.25	0.143	0.107	0.036	0.179	
A	%	25	70	25	10	80	70	70	20	
	%* Owvi	3.575	4.97	1.775	2.5	11.44	7.49	2.52	3.58	32.5
B	%	10	80	50	20	80	40	20	60	
	%* Owvi	1.43	5.68	3.55	5	11.44	4.28	0.72	10.74	42.84
C	%	80	95	80	90	85	85	100	80	
	%*Owvi	11.44	6.745	5.68	22.5	12.155	9.095	3.6	14.32	85.535
D	%	60	80	75	80	75	60	75	70	
	%*Owvi	8.58	5.68	5.325	20	10.725	6.42	2.7	12.53	71.96

Concept variants result of Furrow opener type in decision matrix

Furrow openers are parts of a planter that are used to open furrow so that seed is placed at a specific depth below the surface. The design of furrow openers of seed planters varies to suit the soil conditions. Here the variants to be used are, A=Stub runner, B= Hoe type, C= single disk type and D= Double disk.

From this decision matrix, the best concept variant is concept A which is 78.55.So Stub runner type is chosen to open the furrow for seeding machine

Table 8: Decision making matrix for Furrow opener type

Criteria		1	2	3	4	5	6	7	8	Overall satisfaction
Owvi		0.143	0.071	0.071	0.25	0.143	0.107	0.036	0.179	
A	%	95	90	75	65	85	75	70	80	
	%* Owvi	13.58	6.39	5.32	16.25	12.15	8	2.52	14.32	78.55
B	%	70	60	60	70	60	65	70	90	
	%* Owvi	10.01	4.26	4.26	17.5	8.58	6.95	2.52	16.11	70.19
C	%	50	70	80	85	70	65	55	40	
	%*Owvi	7.15	4.97	5.68	21.25	10.01	6.95	1.98	7.16	65.15
D	%	0	80	60	75	85	80	50	70	
	%*Owvi	7.15	5.68	4.26	18.75	12.15	8.56	1.8	12.53	71.23

Concept variants result of Ground Wheel type in decision matrix

The ground wheel is the power transmission device to provide motion to the ground wheel shaft and rotating metering shaft. For our design let us consider the matrix of three variants, A= Wood wheel, B= Iron wheel, and C= Pneumatic wheel.

As we can see from the above decision matrix concept B which is 83.745 is the best variant concept. So, ground wheel of Iron cover type will be chosen for the design.

Description and Design requirements of the manually operated four rows rice seeder

Description of row seeding machine

As the name suggests, a manually driven four-row seeder was created. It has four rows, each of which has its

Table 9: Decision making matrix for Ground Wheel type

Criteria		1	2	3	4	5	6	7	8	Overall satisfaction
Owvi		0.143	0.071	0.071	0.25	0.143	0.107	0.036	0.179	
A	%	35	75	35	15	75	70	70	20	
	%* Owvi	5.005	5.325	2.485	3.75	10.725	7.49	2.52	3.58	40.88
B	%	85	80	90	95	65	80	75	85	
	%* Owvi	12.15	5.68	6.39	23.75	9.3	8.56	2.7	15.215	83.745
C	%	80	80	60	75	80	80	50	80	
	%*Owvi	11.44	5.68	4.26	18.75	11.44	8.56	1.8	14.32	76.25

own hopper, and it uses a rotating shaft as a metering mechanism. Because there are holes all the way around the shaft, when the shaft's holes are in the lowest position, the seeds fall out due to gravity. The ground wheel and four hoppers were fixed on the shaft; but, they have not rotated while the ground wheels are rotating. Paddy stored in the hopper and the seed flow to the metering shaft is controlled by the cut-off mechanism. One operator could pull the implement using a long beam handle that was provided.

The paddy seed was covered during planting by the chain attached made of angle iron at the bottom of the machine's back end. The operator could regulate the unneeded seed flow and seed waste during the turning trip by standing up, spinning one of the ground wheels, and setting the other ground wheel to the idle position. This machine was ideal for row planting of a variety of crops, including wheat, barley, soybeans, sorghum, etc. since it had holes on the spinning shafts that were provided based on the conventional seed-seed and row-row spacing. For this particular design, it was simply taken into account as paddy or rice seed. Typically, a seeder consists of drive wheels, a frame, seed hoppers, metering systems, furrow openers, and furrow covering tools.

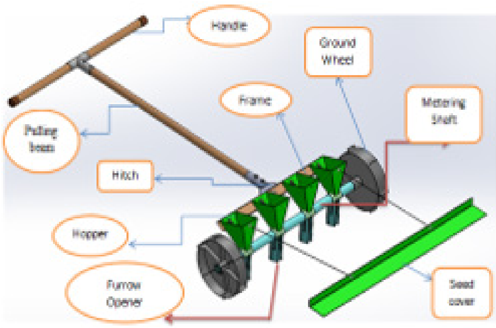

Figure 6: Isometric view of Manually Operated Four Rows Rice Seeder and its Components

Design requirements of the Seeding Machine

In order to start the design, depending on many literatures the following assumed values were taken in to consideration.

> Speed of operation 1 – 3km/hr,

> Machine weight 12kg, wheel diameter 28cm),

$F_f=(C_R+i)$……………………………………..6

Where C_R = Rolling resistance

m_wt = machine weight = 12kg = 58.86N

i= maximum gradient of the ground, let 1%

The rolling resistance can be found by using the following formula:

$$F_f = \left(\sqrt[2]{\frac{3}{28}} + 0.01\right) 58.86N = 21.23N = 2.123kgf$$

At first, wheel revolution and machine weight on wheel would be calculated as follows:

> Peripheral distance $=\pi D = \pi*28cm=0.88m$,

> As wheel covers 1.89m/rev, at 1m/s it covers (1m/s) $\frac{1m/s}{0.88m/rev}$, therefore, wheel revolution Nw become 1.136 rev/s or 68.2 rev/min,

Since the machine has two ground wheel, Machine weight, M_{wt} on wheel equals the machine weight divided by two, m_{wt} = 58.86N

Power developed by the operator

According to Campell et al. (1990) the power of useful work done by human being is given by:

HP=0.35-0.092logt……………………………3

Where, HP = horse power developed during time t

t = time in minutes

Now, for 6 – 8 hours continues work the power developed by the operator would be

HP=0.35-0.092log(360 minor 480)=0.115-0.103 hp

Let's take the average of the ranges; it becomes = 0.109hp.

Therefore, based on the calculation above, the power of productive labor created by a typical human worker is equal to 0.109 horsepower.

We can use the following formula to convert this power into force:

$$HP = \frac{pull(kgf) * speed(\frac{m}{s})}{75} \dots\dots\dots\dots 4$$

Let the operating speed of the machine be 1m/s, therefore by rearranging equation 2 we can get

$$Pull(kgf) = \frac{HP * 75}{speed\left(\frac{m}{s}\right)} \dots\dots\dots\dots\dots\dots 5$$

Hence, force developed by an average human worker = 8.175kgf

The Torque produced by the driving wheel

Torque produced by the driving wheel, Tw is one of the required data to calculate the torque produced by the driving wheel for both shaft analysis and wheel analysis. Consequently, it was determined utilizing the following formula:

$T\_W=F_F*D_W/2$……………………………………9

Where, T_W = torque produced by the driving wheel

F_F= Force required maneuvering the machine, kgf

D_W = diameter of the wheel, 0.28m

Therefore, substituting the values in equation 9 we can get; Tw = 21.23N X 0.14m = 2.972N.m

Power required driving the planter

Equation 2.9 determined the machine's one-person operability; this property may also be represented in terms of power, thus the following equation was used to compute it:

$P_m=T_W N_W$……………………………10

Where, N_W = wheel revolution in rad/sec,

P_m = 2.972N.m x (1.136 x 2π) = 21.21 watt.

Since 1kw equals 741hp, it became

0.02121/0.741=0.0286hp

Therefore, Po of operator much greater than Pm demand of the machine, so again this shows us it is safe to operate by one person(i.e. 0.109hp of the operator produced greater than 0.0286hp of the power required by the machine, so we can conclude that it is easy to operate).

Design Analysis and Material Selection of Major Components of the manually operated four rows Rice Seeder

Mainframe

The planter's frame, which serves as the platform for other components to be affixed, is its skeletal framework. The main frame's material was chosen to achieve the desired strength and reasonable weight. The frame's design was also influenced by the components that would be put on it.

To provide the necessary strength and rigidity while taking into account the orientation and attachment of various components, such as hoppers and handle beams, a mild steel sheet metal with a thickness of 2mm, width of 80mm, and length of 710mm was chosen. The pulling beam channel and seed collecting hoppers were directly mounted in the middle of the frame using the proper nuts and bolts that had holes for assembly adjustments. Provisions were created during the frame's design process to fix the adjustable hopper and pulling beam placement at a 20 cm distance, or the distance between two rows. As illustrated in Figure 7(a) and (b) below, the pulling handle was attached to the frame's center section at the necessary spacing and in accordance with the ergonomic criteria.

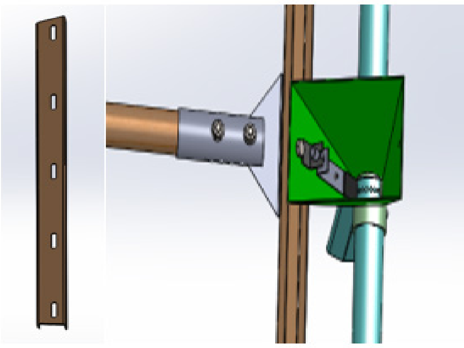

Figure 7: Seeder frame and seeder parts attached to the frame

Design of Seed Hopper

The hopper is a tool used to store planting seeds prior to their slow release into the tunnel's ridges. The size of the seed hopper determines how much seed it can hold. The trapezoidal hopper's four distinct compartments for holding and releasing seed are installed on the spinning shaft and supported by the frame to lower maintenance expenses. They share the same material and are the same size. Mild steel sheet metal with a thickness of 1.5 mm was utilized for construction since it is widely accessible and reasonably priced. To make opening easier, the hopper also incorporates a cut-off controller. Figure 8 depicts the design and measurements of each hopper chamber.

When designing a hopper, the necessary volumetric efficiency, bulk density (689 kg/m3), and angle of repose are taken into account. The hopper was designed to ensure proper flow of seeds by the action of gravity only. The slope of the hopper wall is maintained as per the requirement of metering mechanism, which should be more than the angle of repose of rice seed (360).

In the design of hopper capacity, seeding rate of 40 kg/ha for rice was considered; and the bulk density of rice at a seed storage moisture content of 15%, was considered as 689kg/m3 (Waziri and Mittal, 1983). Equation given by Olaoye and Bolufawi, (2001) was used to estimate the volume of the hopper as follows;

$V=S_R/(n\times\gamma_s)$..11

Where: -

V= is the volume of the hopper

S_R = seeding rate (kg/ha)

n = number of refilling per hectare (let, 40 times)

γ_s = bulk density of the seeds (kg/ m^3)

$V=S_R/(n\times\gamma_s)=(50kg/ha)/(40/ha\times 689kg/m^3)=1.45\times 10^{-3}m^3$

The maximum volume of the designed trapezoidal hopper is:

$V=h/2\ (A_1+A_2+\sqrt{A_1\times A_2})$..................12

Where; V = volume, m3

h = height, m

A_1 = Area of trapezoid, top of hopper, m^2

A_2 = Area of trapezoid, bottom of hopper, m^2

So, the volume the designed hopper will was;

$V=150/2(16{,}000mm^2+800mm^2+\sqrt{(16{,}000mm^2\times 800mm^2)})$

$V=1528328.157mm^3=1.5\times 10^{-3}\ m^3$

Since the designed volume of seed hopper is 1.5×10^{-3} m^3 is higher than the theoretical volume (1.45×10^{-3}) m^3) found by equation 12. Therefore, the designed dimensions of the hoppers are correct.

Weight of the Hopper

Since the seed attached to the metering hoppers have equal dimensions and made from the same material, the area of the single hopper used for the rest three hoppers was estimated from the following equations (Math.com, 2012);

$A_{hm}=A_1+A_2$......................................13

$=(100\times 160)+(20\times 40)=16800mm^2$

Where;

A_1 = Area of trapezoid, top of hopper, m^2

A_2 = Area of trapezoid, bottom of hopper, m^2

The volume of hopper can be computed using the following equations (ITSI-SU, 2011);

$V_{hm}=A_{hm}\times t_{hm}$...................................14

$=16800mm^2\times 1.5mm=25200mm^3=2.52\times 10^{-5}m^3$

The mass of hopper can be computed using the following equations (ITSI-SU, 2011);

$M_{hm}=V_{hm}\times \varrho_{hm}$......................................15

$=2.52\times 10^{-5}m^3\times 7850kg/m^3=0.1978Kg$

For the four hoppers we have:

$M_{hm}=no.of\ hoppers\times V_{hm}\times \varrho_{hm}=4\times 0.1978Kg=0.792Kg$

The weight of hopper can be computed using the following equations (Gat, Uri, 1988);

$W_{hm}=M_{hm}\times g$..................................16

$=0.792Kg\times 9.81m/s^2=7.76N$

Where: -

A_{hm} = Surface area of the hopper material
V_{hm} = Volume of the hopper material
t_{hm} = Thickness of the hopper material
M_{hm} = Mass of the hopper material
ϱ_{hm} = Density of the hopper material
W_{hm} = Weight of the hopper material

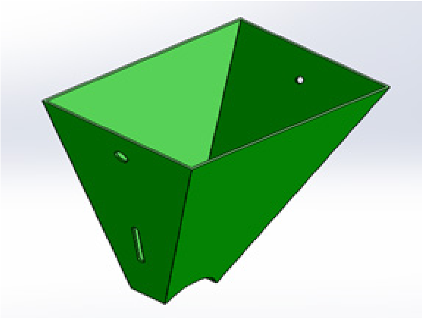

Figure 8: Seed hopper

Design of the seed metering mechanism

The seed sowing machine's metering system, which distributes seeds consistently at the desired application rates, is its brain. The drum served as measuring mechanisms in this instance (figure 9). However, the hopper's purpose as a feeder was employed, and the shaft then metered the seeds.

As previously indicated, the shaft of this machine served as a measuring mechanism and was used to plant paddy rice seed or rice grain in rows. Therefore, it was decided to compute the number of holes on shafts in each hopper using the following formula:

$n=\pi D/(I\times X)$……………………………….…17

Where,

n = number of holes on the drum
D = diameter of the shaft, it takes 4.1cm
X = required seed to seed spacing, it takes 2cm
I= ratio of wheel to metering shaft rotation, 1:1

Therefore, substituting the values in eq. 34 we found that;
$n=(\pi*4.1cm)/2cm=6.44$=takes 7 holes

The length(l), width(w), and thickness(t) of 50 seeds were taken, and the size of the hole was calculated based on the average geometrical mean of the rice grain. According to Yonas L., (2017) their geometrical mean average was calculated using the following equation and came out at 2.95mm. We used 6mm for the design.

$D_g=\sqrt[3]{(L*W*T)}$……………………………..…18

Where: -

L = mean length (mm)
W = mean width (mm)
T = mean thickness (mm)
D_g = mean geometric diameter (mm)

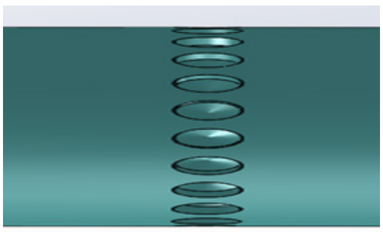

Figure 9: Seed metering shaft

Design of Furrow Opener

The components of a planter known as furrow openers are used to open a furrow so that seeds can be planted at a particular depth below the surface. Furrow openers for seed planters come in a variety of designs to accommodate different soil types. Furrow openers of the adjustable curved stub runner type were created to prevent seed rebounding, roll over impediments, and increase seed placement accuracy at various planting depths. Furrow openers of the stub runner type are appropriate for usage when it is necessary to penetrate agricultural residues or hard terrain. They can be kept quite clean, which makes them more effective than permanent openers in wet, sticky soils. Because the depth can be regulated by using the slot supplied on the furrow opener for the purpose of altering the depth of the seeder, curved runner furrow openers are particularly well fitted to medium or shallow seeding of row crops that are crucial in regard to planting depth. The furrow openers were made of mild steel sheet metal that was 2 mm thick, bent, and had dimensions of 164.5 mm in height by 152 mm in width. They were then connected with a shaft and a furrow opener connecter using slotted nuts and bolts.

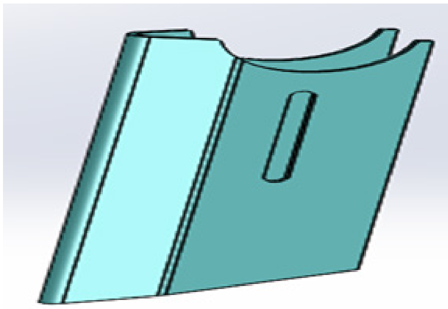

Figure 10: Curved runner type furrow opener

Adjustable Seed Covering

Planters should be made to compact the earth, push the seeds into the compacted dirt, then cover the seeds with loose soil in order to achieve the best outcomes for germination and emergence. The capillary continuity between the lower moist soil layers and the upper layers in which the seed is placed, as well as between the seed and soil immediately surrounding it, is improved by increasing the seed/soil contact below and around the seed. The soil just above the seed row should be left loose to reduce crusting and encourage simple emergence. In order to prevent birds from dropping soil, it is also crucial that the grain is covered in seed. The specially created furrow

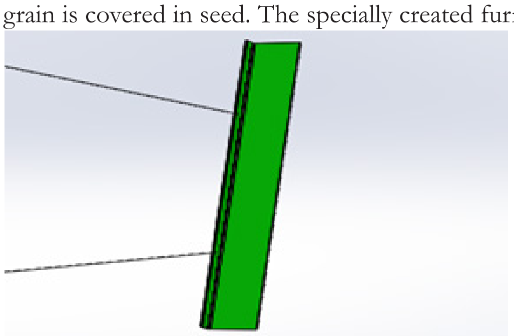

Figure 11: Seed covering mechanism

covering tools enable optimum soil coverage over the seeds in the furrows. The material used for the design was mild steel flat iron of 980*140*3mm positioned and fitted immediately at the back of the seeder hopper two ends

Pulling Beam and Handle

Pulling beam is principal parts used to join the main seeder parts and the handle used for pulling forward the seeder during planting. For the design Single circular beam having 36mm and 1240mm diameter and Length respectively made up of wood for the purpose of decreasing the weight of the machine was selected. The beam was hinged to the hitch. The pulling beam was attached to the frame by using of the frame and beam connecter used as a hitch at one end and attached to the handle holder on the other end as shown on Figure12 below.

In order to transfer the planter from one location to another during planting operations, a handle is used to supply the pulling force from a human operator. The planned handle was made of a circle of wood that measured 865 mm in length and 36 mm in outer diameter. Through the use of connecting bushing and nuts and bolts, the handle was fastened to the pulling beam. The handle on the seeder was primarily designed to regulate planter pull when sowing and turning in the field. The length of the handle and pulling beam were designed with ergonomics and surface smoothness in mind.

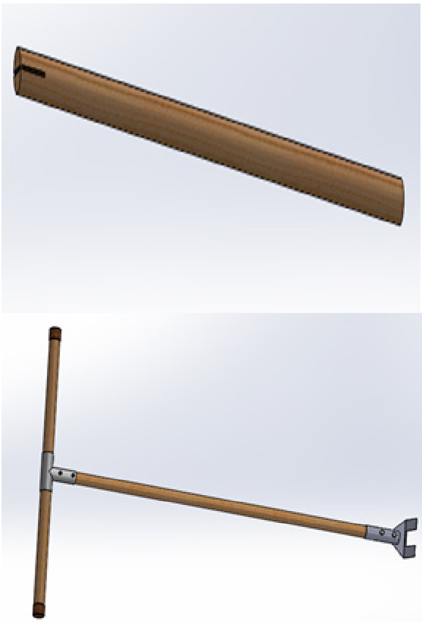

Figure 12: Pulling beam and Handle

Shaft design and analysis

A shaft is a rotating machine element which is used to transmit power from one place to another. The power is delivered to the shaft by some tangential force and the resultant torque (or twisting moment) set up within the shaft permits the power to be transferred to various machines linked up to the shaft. In other words, we may say that a shaft is used for the transmission of torque and bending moment. The various members are mounted on the shaft by means of keys or splines. For this project hollow shaft having the internal diameter of 8.5mm and outer diameter of 41mm was designed. These types of shafts are stronger per mass of material, for particular power transmission, it requires minimum weight, and they may be forged on mandrel, thus making the material more homogenous than would be possible for the solid Shaft.

The stresses, torques, and bending moments generated in the shaft during operation must be seen in relation to the shaft that the seed hopper assembly is mounted on. When power is transferred from the ground wheel to the seed hopper, the shaft is intrinsically subjected to a torsional moment, or torque, at a specific rotational speed. As a result, the shaft develops torsional shear stress. Additionally, a shaft typically carries the load from a hopper or seed box, which applies pressure to the shaft in a transverse orientation (perpendicular to its axis). The shaft develops bending moments as a result of these transverse forces, necessitating a consideration of the stress from bending. Because shear stresses and regular stresses from bending occur at the same time in these shafts, integrated stress analysis is actually necessary.

Where, (R1and R2) or (F_m)= the Ground reaction due to the sum of machine weight, and weight of seeds carried by the ground wheel.

F_m = 12kg + 10kg = 22kg or 215.82N

F_f= force driving the wheel, equals13.75N, we found it

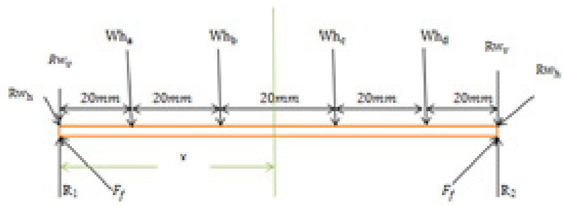

Figure 13: Load distributions on the driving shaft

by eq.8

Rw_h = wheel reaction at one end in the horizontal direction.

Rw_v= wheel reaction at other end in the vertical direction.

$Rh_{(a,b,c)}$= weight of seed hoppers including the seed at full load at point

Here, we established the ideal shaft diameter and used the following procedures to determine the forces acting on the shaft and how much of each force they depend on:

Finding the load exerted on the shaft

The seed hoppers are what put pressure on the shaft. The following formula can be used to determine the weight coming from the seed hoppers; (since the seed box stands on the shaft with four foot, the load should be divided in to four). As stated above, it was made to hold 6 kilogram of rice seed.

Wh_a=Wh_b=Wh_c= Wh_d=0.25[seed weight at full load + hopper weight]…………………………………..19

= 1/4(6kg + 5kg) x 9.81 = 26.98N

Forces exerted on the shaft in the vertical direction (YZ)

Finding the forces acting vertically on the shaft was the second stage, as demonstrated above. Considering the sum of the forces, that is ∑F = 0, we can get the following:

$-Rw_v - Wh_a - Wh_b - Wh_c - Wh_d = 0$ …….......………20

From the equation 20 the only unknown is Rw_v, it can be rearranged in to eq.2.21 below

$-Rw_v = Wh_a + Wh_b + Wh_c + Wh_d - F_m$……… 21

= 44.15 + 53.96 + 53.96 + 44.15 - 215.82 = 19.6N

Rw_v = -19.6N, (this result shows that the assumed direction is correct), so reducing this value, i.e. ***F*** = F_m + Rw_v = 196.22N (net upward force).

Forces exerted on the shaft in the horizontal direction (XZ plane)

Considering Summation of forces, ∑F = 0, we found equation 2.22 below;

$F_f - Rw_h = 0$ ………………………….....…....…22

From equation 3.8 we found that $F_f = Rw_h$ = 13.75N, (F_f was found by eq.2.8 above)

Thus, all forces acting in the horizontal direction become zero, and we draw the conclusion that neither a shear stress nor a bending moment exist.

Determining the maximum bending moment

Finding the product of the above-found vertical and horizontal seconds was the next stage. Consequently, we can apply the following formula to this:

$M_{max} = \sqrt{(M_H^2 + M^2)}$………....................................23

$M_a = \sqrt{(0^2 + 4.42^2)}$ =4.42N.m

$M_b = \sqrt{(0^2 + 9.81^2)}$ =9.81N.m

$M_c = \sqrt{(0^2 + 26.25^2)}$ =26.25N.m

$M_d = \sqrt{(0^2 + 12.02^2)}$ =12.02N.m

$M_w = \sqrt{(0^2 + 6.62^2)}$ =6.62N.m

Therefore, from the results of equation 23 at each point a, b, c, d, and w we found that the maximum bending moment occur at point c.

The torque on the shaft

The power transmitted from the driving wheel to the shaft with 1:1 ratio, i.e. directly, hence torque produced at the wheel and the shaft are equal, 1.925N.m or we can also calculate using the following formula:

$P = T_1 N_1 = T_2 N_N$…………………………….24

Where,

p = power transmitted

T1 = torque produced at the wheel, equals 1.925N.m (which was found by eq. 24 above)

T2 = torque produced at the shaft, which is equal, 1.925N.m

N1 = angular rotation of the driving wheel, =1.136 rev/s or 68.2 rev/min (taken from the initial mentioned parameters above)

N2 = angular rotation of the shaft, 1.136 rev/s or 68.2 rev/min (because of 1:1)

Design of Ground wheel

The ground wheel is the power transmission device to provide motion to the ground wheel shaft and rotating metering shaft. The seed hoppers were made fixed on the shaft by using bushing and keys. Lug type wheel was used for designing of the ground wheel because of its suitability to use under wet or sticky soils; whereas pneumatic wheels fail to work.

Ground wheel of 280 mm diameter was selected for the designing of the wheel. The wheel is made of M.S. Rod (1.5 mm diameter) and width is kept 60 mm. The spokes were made up of mild steel flat Iron of 1.5 mm thickness 6 spokes were provided on each wheel extended 130 mm towards Centre and maximum width at the both ends was kept 45mm and welded with the bush having diameter of 42 mm and the length of bush is 100 mm. Disk plates having 47mm and 4mm diameter and thickness respectively and also Lugs are provided on the ground wheel for better traction of machine on the field the lugs are made of G.I. Sheet of 6 gauge thick.

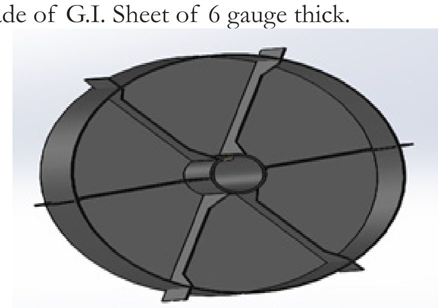

Figure 14: Ground wheel

Determination of Seeder performance and capacity

Field capacity and efficiency were determined in accordance to the recommendation made by Kepner (1978) and using relevant parameters that included effective operation time, turning time and time losses due to obstructions on the field. From the data gathered working speed (km/h), effective field capacity (ha/h) and field efficiency (%) were estimated using the expressions below (Kepner1978);

$V = D/t_a$ ……………..................................……25

Where: -

V = Working speed,

D = distance of run (m)

t_a = average time of each pass (second)

$e = 100 * T_e / T_t$ …………...............................…26

Where: -

e = field efficiency (%).

T_e = effective operating time (sec.)

T_t = total time (effective operating time +time lost for turning)

$C_e = (W_e * S_{mf} * e)/10$……………....................…27

Where: -

C_e = effective field capacity (ha/hr)

W_e = implement effective width/inter row spacing (m)

S_{mf} = mean forward speed (km/h)

e = field efficiency (decimal value)

Figure 15: Pulling beam

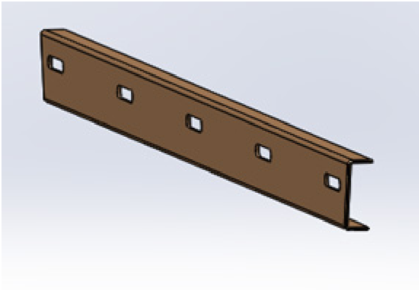

Figure 16: Seeder supporting frame

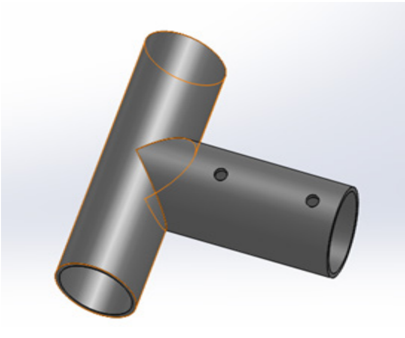

Figure 17: Handle holding Bushing

Figure 18: Handle

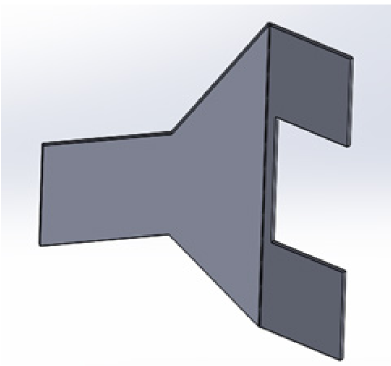

Figure 19: Hitch

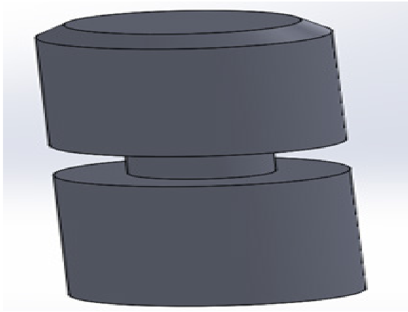

Figure 20: Hopper and cut-off support

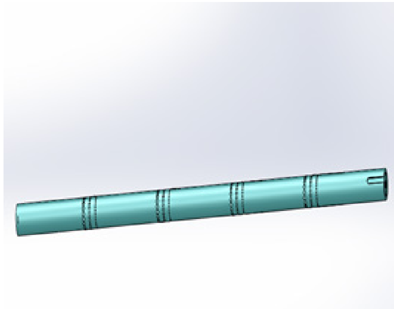

Figure 21: Rear wheel shaft

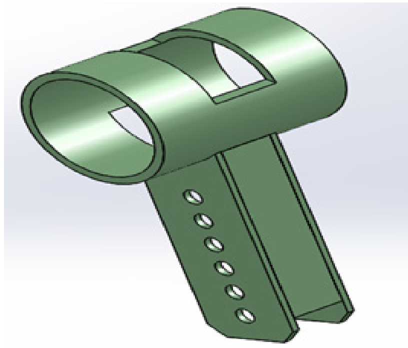

Figure 22: Shaft and furrow opener holder

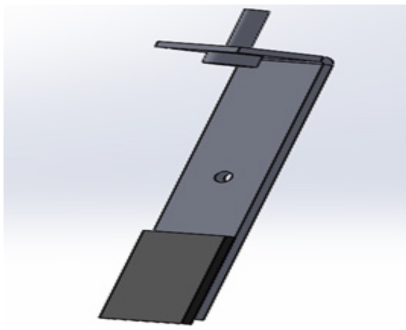

Figure 23: Seed cut-off controller

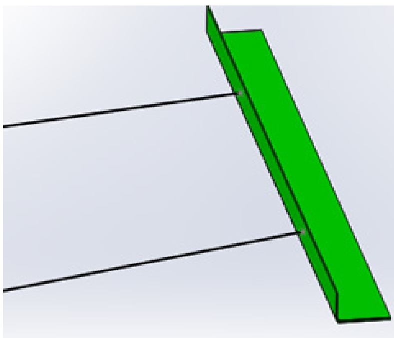

Figure 24: Seed covering mechanism

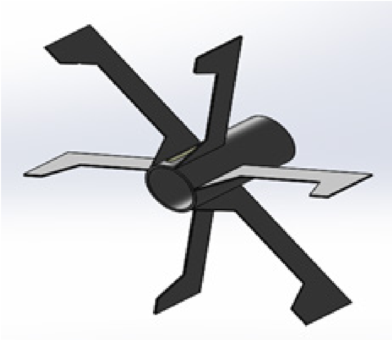

Figure 25: Spokes and Hub

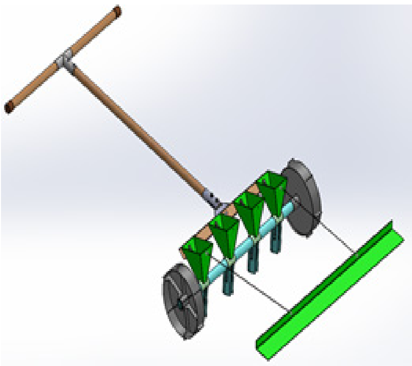

Figure 26: Overall Assembly of Manually Operated Four Rows Rice seeder

Manufacturing Process

This chapter covered a detailed explanation of how each machine component of the seeding machine was made. This stage of the manufacturing process aids in producing the machine locally using materials that are readily available. The appropriate machinery and tools are utilized as needed.

Manufacturing process of Component

Table 10: Selected manufacturing process of the main seeder components

S.No	Seeder Components	Required material	Required tools and activity/ process
1	Handle	Eucalyptus tree	measuring, Cutting, milling, smoothening, and drilling
2	Pulling beam	Eucalyptus tree	cutting, milling, measuring, smoothening, and drilling
3	Hitch	Mild steel sheet metal	cutting, measuring tool, drilling, and bending
4	Frame	Mild steel sheet metal	cutting, milling, measuring , drilling, and bending
5	Metering Shaft	Mild Steel	turning, facing, boring, cutting, and milling
6	Hopper	Mild steel sheet metal	cutting, measuring tool, drilling, welding, grinding, and bending
7	Furrow opener	Mild Steel Flat Iron	cutting, measuring tool, boring/ slotting, and bending tools
8	Ground wheel	Mild steel Rod	cutting, measuring tool, drilling, welding, grinding, and rolling
9	Seed cover	Mild Steel angle Iron	Cutting, and drilling

Main Technical Specifications for Manually operated four rows rice seeder

Table 11: Specifications of main parts of four rows rice seeder

No	Products	Specification
1	Number of Hoppers	04
2	Number of furrow openers	04
3	Number of shafts	01
4	Width of Ground wheel	02
5	Height of the seeder	95.0 cm
6	Approx. Weight	12 kg

Materials used for seeder construction

Table 11: List of materials used for construction of the seeder machine

No	Components	Material
1	Main Shaft	Mild Steel
2	Seed hopper	Mild steel sheet metal
3	Bushing	Bronze
4	Seed covering	Mild Steel angle Iron
5	Furrow opener	Mild Steel Flat Iron
6	Beam and Handle	Eucalyptus tree

Cost Estimation and Cost of Operation

By figuring out the cost of various components, the unit cost of a manually operated four-row rice seeder was established. Cost analysis is a crucial component of technology design and production that helps ensure the dependability and affordability of the technology. Individual components or functional groups can be used to determine the cost of a subsystem for a given system (carrying out a single function). The overall system expenses are calculated by adding these expenses collectively. The cost estimation method begins with a set of technical drawings for the assembly's component parts and figures out the price of each activity related to component manufacture, assembly, and finishing. Eliminating pointless processes has a significant impact on reducing manufacturing process costs. This can be accomplished through careful planning, operating in succession, and grouping individual activities or groups of operations. the following benefits of grouping operations;

o Reduced fixed cost
o Reduced labour cost
o Less handling
o Reduced setup time
o Smaller in process inventory

Depending on the types of manufacturing process, total cost of the designed machine was determined by considering the following. The main elements of cost analysis includes

o Direct material total cost
o Standard items cost
o Direct Labour cost
o Operation cost

Direct material total cost

To determine the total cost of direct materials used in the manufacture of the manually operated four rows rice seeder a material balance and flow sheet should be developed. Once the materials balances established, raw material prices must be assessed and identified. Therefore the materials and their current cost needed
to manufacture the seeder were studied from the current markets.

Cost summary of the Manually Operated Four rows Rice seeder

Table 13: Total Cost summary of the construction of the seeder

Raw material cost (Birr)	Material wastage 2.5 % of 1 (Birr)	Machine cost (Birr)	Labor cost(Birr)	Over-head cost 5 % of 3 & 4	Production cost (1+2+3+4) Birr
3400.6	85.015	11.754	20.249	1.600	3,519.218

RECOMMENDATIONS

> There is need to create awareness among the farming communities on adoption of newly designed technologies to increase and improve their agricultural production.

> There is need for development of low cost Animal Operated or tractor mounted high efficiency Rice seeder for farmers for more mechanization of their agriculture.

> The row planter prototype is needed to be fabricated, tested and demonstrated in the farmer's field.

> Promotion and dissemination of the technologies has to be done to end users.

> Adjustable seed metering mechanism should be used to use the planter for different Rice varieties and crops.

CONCLUSION

In Ethiopia, rice is one of the targeted agricultural products that has received adequate attention in the promotion of agricultural output. It is regarded as the "Millennium Crop" and is anticipated to help ensure food security in the nation. As a result, over the past few years, its production has increased. Despite the growth, there are still a lot of production system issues that need to be resolved, with planting technique leading the list. The farmers continued to use time- and labor-intensive traditional seed-broadcasting techniques, which led to a sharp reduction in output due to an unfavorable plant population. Therefore, attempts were undertaken to design a suitable planting machine for rice in order to address the issues with the conventional method of spreading the seed on the farm and maintain the ideal plant density. the binary dominance matrix determines It was determined that the novel constructed seeder outperformed the manual approach in all aspects.

Traditional seeding techniques (Broadcasting), Manual row planting technique, and the newly created Manually Operated Four Rows Rice were all assessed. The machinability aspect, which comprises installation, simplicity, durability, choice of material, machine, low pricing, and prolonged life span when operated with high utilization with minimal downtime, was properly taken into account in order to achieve this design target and goals. The designed machine "Manually Operated Four rows Rice seeder machine" can help to substantially reduce the human labor involved in planting and also reduces the time used for seeding operation on small farms. The designed seeder was easy to operate and repair, applicable for different sizes of grains according to their physical properties, do not break the Rice grains during seeding process. Design permits fabrication from locally available materials.

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