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Design of Potato Harvester Combined with a Tuber Collector for Tractor Attachment

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Abstract

In order to address the issues of low production in terms of potatoes as well as the labour-intensive nature of harvesting potatoes, a potato harvester combined with a tuber collector for tractor attachment was designed and fabricated. Field Conditions at which the equipment would be operated, Depth Adjustment Precision and Uniformity, Maintenance and Accessibility, Cost-effectiveness are some of the factors considered. The developed equipment was a basic but extremely effective tractor powered potato harvester combined with a tuber collector suitable for small and medium scale farms. Laboratory tests were conducted to assess the performance of the newly constructed potato harvester in conjunction with a tuber collector for tractor attachment before it was put into use. For improved potato-soil separation, the soil-separation unit's setting was designed to be 15°, and the PTO was linked to the potato harvester's

propeller shaft. The harvester is to run at slope inclination of not more than 16 degrees and with low soil moisture content. One row of potatoes is harvested by the potato harvester on each trip. The categories for the potato harvester are medium-to large-scale farmers, including contract farmers, large-scale farming businesses, agricultural cooperatives, and commercial potato growers. Future research is recommended to focus on optimizing the design and investigating automation technology.

Keywords: *Potato harvester, Tuber Collector, Tractor Attachment, Potato Harvesting, soil separating unit.*

Introduction

Potato (*Solanum tuberosum L.)* is the world's fourth-largest food crop. It is a species that provides good nutrition and is able to adapt to changing climates. Potatoes are cultivated throughout Africa and require less water for nutritional production than any other major food source. More food is produced per unit area from potatoes than from any other major staple crop. Potatoes play a significant role in household income generation, food security, and the sale of excess to the wider market. (Vita and IPF, 2014).

Between 1990 and 2007, the amount of potatoes produced worldwide increased by about 21%. In contrast, emerging countries showed a notable increase in tuber harvesting, with rates reaching about 94% (FAO, 2008). Potatoes can be served at the table or as processed foods. In addition to having carbohydrates, it also has low fat, high protein, fiber, vitamin C, and minerals. The FAO acknowledged 2008 to be the "International Year of Potatoes," with the main goals being to enhance the welfare of both producers and consumers and to encourage the sustainable development of potato-based systems and the potato industry. Global food security, the environment, and agriculture are just a few of the reasons why potatoes are valuable (FAO, 2008). Over 100 countries cultivate potatoes as a main food crop worldwide. FAO (2008), reported that about one billion people consume

potatoes globally. It's an excellent vegetable crop that may be used to prepare over a hundred various kinds of dishes. Potatoes are thought to have better biological value protein than cereals and to be superior to milk in this regard. In order to reduce energy consumption and food expenses, potatoes are a good complement to meat and dairy products. (Ajewole *et al.,* 2021).

Potato farming is a significant agricultural activity worldwide, with millions of tons produced annually. However, potato harvesting remains a labour-intensive and time-consuming process, particularly in Nigeria. Manual harvesting methods lead to high labour costs, increased risk of damage to tubers, reduced harvesting efficiency, and limited timeliness for subsequent cropping (Singh, G., & Singh, H. (2020). The existing potato harvesting methods in Nigeria are inadequate, resulting in low harvesting efficiency, high tuber damage, increased labour costs, and limited mechanization, hindering large-scale potato production. Few potato harvesters combine harvesting and tuber collection capabilities, and most machines are expensive, inefficient, and limited in compatibility (Kumar, V., et al. 2018). In large-scale potato production, the manual harvesting process is inefficient, and one of the main issues with potato production is post-harvest loss, which ranges from 20 to 25 percent. One of this is physical damage brought on by hoeing or using a local plough to dig (lift) the tubers, which lowers potato yield. Furthermore, the majority of potato diggers are imported and not localized, most of the harvesters does not come with tuber collector which scatter the potato tubers on the field during harvesting and it also requires addition time and energy for gathering and packing the tubers for further processing or storage. Therefore, Design and Fabrication of a tractor powered potato harvester combined with a tuber collector is fabricated to bridge the gap. This will assure efficient use of resources, lowers labour costs, expedites processes, lessens drudgery, and improves both the amount and quality of work input in farming potatoes.

MATERIALS AND METHODS

Design Consideration

In designing this equipment the following factors were considered.

Field Conditions: To inform design decisions, a thorough examination of the crop kinds and field conditions that the tractor powered potato harvester combined with a tuber collector will work was considered.

Depth Adjustment: Ensuring adaptability in digging depth is indispensable, given the inevitable variations in tuber size. Thus, the design incorporates a mechanism to facilitate seamless depth adjustments.

Precision and Uniformity: One of the main tenets of the design is to harvest with accuracy and consistency. To optimize tuber protection and minimize waste, this requires careful engineering design considerations.

Maintenance and Accessibility: One of the most important design features, accessibility to essential components for upkeep and repair is intended to reduce downtime and guarantee operational effectiveness.

Cost-effectiveness: Attaining an overall cost-effective design requires carefully balancing budgetary limits with component quality and usefulness.

Design Calculations

Design of digging blade

Depending on the blade's breadth, thickness, and the different forces operating on it, it can be used to dig or to scoop up crops and soil. The width of the share in this digger scenario was determined to be 68cm based on potato ridge. Based on the force needed to dig soil and crops, the blade thickness was calculated.

Calculating the draft on the digging apparatus

The draft of the blade was calculated using the general soil mechanics equation for a blade deforming the soil in two dimensions (Hettiaratchi et al., 1996), which is also utilized by (Narendera et al., 2022). According to Godwin et al. (2007), a blade is a tool used for working soil with a depth/width ratio of less than 0.5, while a narrow tyne is a tool with a ratio bigger than 1. The digger's share was measured to be 680 mm broad based on the crop bed's breadth. Based on the crop profile in the vertical dimension of the field bed, the maximum depth of the potato crop was calculated to be 300 mm. Its blade was turned at these depths, producing a depth/width ratio of 0.441, which is less than 1. As a result, one could assume that the digging share is a blade. Numerous researchers have observed that the digging

share's typical rake angle adapts range from 15 to 25º. A rake angle of 20º produced the least amount of draft and the greatest upward thrust. . For the purpose of determining draft, thus, it was assumed that the share 25º's maximum rake angle would be on the higher side.

The standard soil mechanics equation proposed by (Hettiaratchi et al., 1996) was used in the two-dimensional soil failure approach to compute the soil resistance force in flat blades cutting soil in a passive failure zone. Figure 1 illustrates the pressures of soil resistance exerted on the digger blade. The suggested formula, which is provided below, accounts for various soil characteristics and tool geometry.

$$F_P = \rho_s(p\ (N(s) + Cs + \sigma c + Ca\sigma a) + Qs + N_a)\ d \qquad 1$$

Where,

F_p = Draft force on the potato digging blades, kg/m width

ρ_s = Soil density kg/m^3

d = The Depth of the digging blade, m

N_S = Normal force due to soil weight

C_s = Soil friction Coefficient, (kg/m^2)

C_a = Coefficient of Soil adhesion, (kg/m^2)

σ_c= soil adhesion stress, (N/m²)

C_a= Coefficient of soil adhesion (kg/m²)

σ_a = Soil adhesion stress, (N/m²)

Q_s =Soil surcharge or additional load, Kg/m^2

N_a = Normal force due to soil surcharge, Kg·m/s

N_ρ, N_s, N_q and N_a Are dimensionless N-factors that are dependent on the rake angle blade (α), soil inside friction angle (φ), and soil metal friction angle (δ).

Parameters of the Tool

According to the maximum depth of the crop, the furrow opener's operating depth (d) is 300 mm. Operational width (w) = 680 mm (ridge's bottom width) Ratio of Depth to Width (d/w) = 0.441

Rake angle range: 15° to 25° (25° was used for the draft).

Parameters of Soil

Soil density, ρ = 1470 kg/m^3

According to (Kepner et al. 2003), cohesion and internal friction are considered actual physical characteristics of the soil and are utilized in engineering design to estimate the soil's shear strength. Thus, assuming 0.895 kg/m^2 for cohesion and a 22.54 degree angle of internal friction (φ) (Jain et al., 2015).

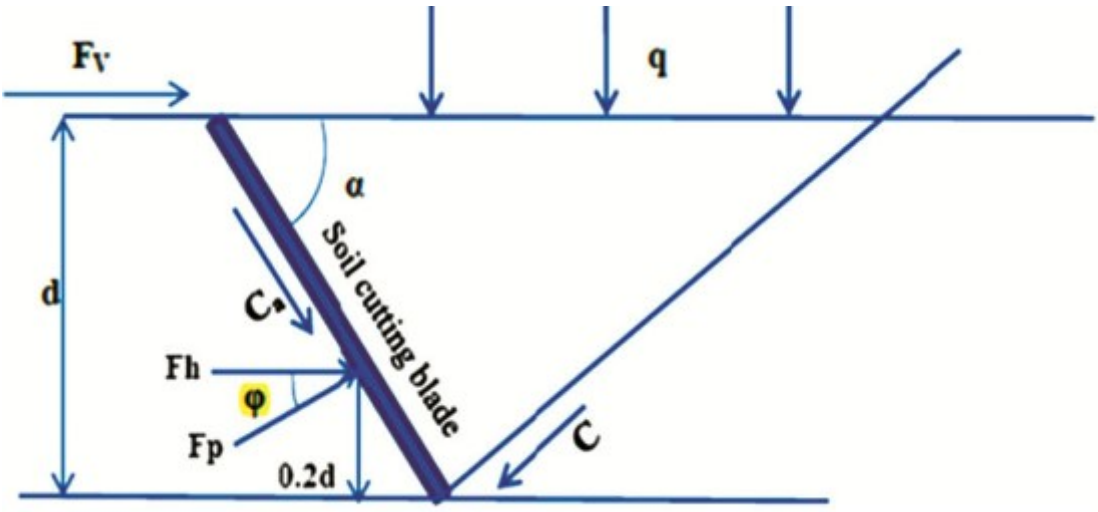


Figure 1. Soil forces acting on a simple digging share

The soil-metal friction angle (β) is equivalent to 2/3× 22.54, or 15.03. It is possible to suppose that the adhesion of the soil is zero, or Ca = 0, as dirt scouring over the blade results in the surcharge q = 0 (Assumed).This was calculated using

$$F_p = (\rho d N_s + C N_q) d \qquad 2$$

For a perfectly smooth (β = φ) and perfectly rough (β = 0) interface, the relationship between the N-factor and the rake angle for different angles of internal friction was interpolated using Eq. 3.

$$N_q = N_{q=0}\left[\frac{N_{q=\Phi}}{N_{q=0}}\right]\frac{\sigma}{\Phi} \qquad 3$$

Where,

N_β =The necessary amount of the suitable N = factor $(N_\rho \ or \ N_q)$

$N_{q=0}$ And N_Φ

The N-factor values at β = 0 and β = Φ, which were derived from the relevant chart

(Hettiaratchi et al., 1996), were utilized to determine the blade's passive resistance.

ρ = 1470 kg/m^3, C= 0.895 kgm^{-2}, Φ = 22.549º, β = 15.03º, α = 25º and d = 0.3 m

The value of N-factors was determined by applying the relationship found in equation 3 to the following formula:

Nρ = 1.3 when β=0, Nρ = 1.4 when β=Φ, Ns= 1.7 when β=0, Ns= 1.6 when β= Φ

Now using Eq. (4)

$$N_\rho \beta = 15.03° = 1.3\left[\frac{1.4}{1.3}\right]^{\frac{15.03}{22.549}} = 1.36$$

$$N_\beta = 15.03° = 1.7\left[\frac{1.6}{1.7}\right]^{\frac{15.03}{22.549}} = 1.63$$

$$N_\rho = 1.36, N_c = 1.63$$

Upon replacing the previously calculated values of Nρ and Ns , the passive resistance (Fp) per unit width of the blade was determined:

$$Fp = 1470 \times 0.3 \times 1.36 + 0.895 \times 0.3 \times 1.63$$

$$F_p = (1470 \times 0.3 \times 1.36) + (0.895 \times 0.3 \times 1.63)$$

$$F_p = (591.6) + (0.871846)$$

$$F_p = 592.471845N$$

Converting the calculated passive resistance (F_p) from newton to kilograms is divided by the acceleration due to gravity (g) which is approximately $9.8m/s^2$

$$F_p(Kg) = \frac{592.471845N}{9.8m/s^2}$$

$$F_p = 60.38kg$$

Determining out the passive resistance in kilograms per meter for each unit width of the blade

$$F_p = \frac{60.38\text{kg}}{0.67\text{m}} = 88.794\text{kg/m}$$

Therefore, Fp for an effective width of cut per 68cm of blade = 60.377kg

The angle of friction (β=15.03) between the passive resistance (F_p) and the interface's normal is being measured. Therefore, the blade face's component parallel (F_R) is as stated:

$$F_R = 60.377\text{Kg} \times \cos 74.97°$$

Converting angle from degree to radians

$$74.97°\left(\frac{\pi}{180}\right) = 1.3075\text{radians}$$

Cosine of 1.3057radians is given as 0.2556

Therefore, $F_R = 60.377 \times 0.2556$ =15.432kg

The component (F_P2) that is parallel to the blade face is as follows:

$$F_H = 60.377 \times \text{Cos}15.02° = 58.308$$

The digger blade's bending moment was calculated using the obtained values of F_R and F_H.

The share would experience direct stress from the F_P horizontal component,F_R while the share would experience a bending moment from the F_P perpendicular component,F_H. The force will act at the share's center of resistance. Shovel acts' average soil resistance was measured 0.2d away from the cutting edge (Narendera et al., 2022). Centre of the resistance = 0.2d =0.2 x 300 mm = 60 mm at the center of resistance of the share, the force will act.

Therefore, on the central axis of the blade's width, the center of resistance would be 60 mm from the cutting edge. Positioned 300 mm away from the cutting edge, the share is supported by nuts and bolts. As a result, the following represents the divide between the point of support and the center of resistance:

$$300 - 60 = 240\text{mm} = 24\text{ cm}$$

As a result, the Bending Moment (B.M.) brought on by F_H is;

$$\text{B. M.} = 58.308 \times 24 = 1399.392\text{ Kg} - \text{cm}$$

The value of the bending stress (σ_b) is:

$$\sigma_b = \frac{B.M}{\frac{1}{6}\times bt^2} \quad (4)$$

Where;

B M = Bending Moment, kg-cm;

b = the blade's breadth at the mounting point in cm, and

t = the sheet thickness in cm.

$$\sigma_b = \frac{1399.392}{\frac{1}{6}\times 10t^2} = \frac{839.467}{t^2}\,\text{kg} - \text{cm}$$

And direct stress (σ_d) due to F_{p1} was calculated as,

$$\sigma_d = \frac{F_{P1}}{bt} = \frac{15.308}{10 \times t} = \frac{1.53}{t}$$

$$\text{Total stress } (\sigma) = \sigma_d + \sigma_b \quad (5)$$

$$\sigma = \frac{1.53}{t} + \frac{839.467}{t^2}$$

The thickness (t) of the blade was determined by calculating the overall stress (σ) with the mild steel safe stress of 600 kg/m2, taking into consideration the safety factor of 1.2.

$$600 = \left(\frac{1.53}{t} + \frac{839.467}{t^2}\right)1.2$$

$$t = 0.59\ \text{cm} \approx 6\ \text{mm}$$

Thus, in order to meet the needs of the digging operation, the blade's thickness was maintained at 6 mm and its overall width at 680 mm. The blade's dimensions were 500 x 68 x 6 mm in M. S. flat. The front of the blade was sharpened for easy penetration. The width of the blade was based on the width of the crop that was sown on the bed. The breadth of the crop sowed on the bed served as the foundation for determining the blade's width.

To facilitate the material transfer to the separating unit easier, the blade was also attached to a 500 x 50 x 12 mm M.S. flat bar. Using an M.S. Flat and a nut-bolt, both sides of the sheet were fastened to the mainframe. This equipment has the ability to adjust the digging operation's rake angle.

Design of Soil separation Unit

A separating unit got the soil potato that the digging unit had dug. The soil separation device was positioned directly below the blade for receiving the dugout potato and soil mass. The soil separation unit's orthographical and isometric views. Mild steel round pieces were positioned lengthwise along the digger's path of motion in order to separate the soil from the potato. The oscillation generated by the crank mechanism helped to dislodge the dirt that had adhered to the digger. The different dimensions of the soil separator were calculated using the physical characteristics of potatoes, which include mass, volume, bulk density, density, dimensions, projected area, porosity, surface area, length, breadth, thickness, geometric mean diameter, sphericity, and Young's modulus (Abedi et al. 2019). When considering the best metal for a separating unit in harvesting equipment, the choice was based on factors like durability, friction properties, and cost-effectiveness. While specific information on the best metal for separating units in potato harvesting equipment is not directly provided in the search results, the Mild steel separation unit was fabricated based on recommendations.

Determination of length of soil mass soil separation unit

To determine the volume of material flow on the shaker, the following formula was applied to the separator's volume of material flow (Narendera et al., 2022).
Soil Volume = the share's area covered x the forward speed of motion 6

Assume that the speed of travel is 3 km/h.
Actual width of machine = 0.68 m and
Working depth = 0.30 m

So the volume of soil $= \frac{0.68\times0.30\times3\times1000}{60\times60} = \frac{612}{3600} = 0.17\ \mathrm{m^2/s}$

Weight of soil $= 0.17 \times 1470 = 249.9\ \mathrm{Kg/s}$

Assume that the Potato weighs 3 kg in a bed that is one meter long. Thus, the potato's weight per second = its weight in a meter-long bed x its speed.

$= 3\ \mathrm{X}\ 0.833 = 2.49\ \mathrm{kg/s}$

Total material to be handled (Q_{out}) = weight of soil + weight of crop per sec

$249.9 + 2.49\,\mathrm{Kg/s} = 252.39\,\mathrm{Kg/s}$

Now, assuming that the material will be evenly distributed in a layer 6cm thick on the separator, the amount of material flow and the separator's volume were equaled, yielding the results shown below. As the eccentricity of the digger's crank determines the separator's speed.

$$Q_{out} = \rho \times \text{length} \times \text{thickness of material} \times \text{speed of separator}$$

$$252.39 = 1470 \times L \times 0.06 \times 3$$

$$L = \frac{252.39}{264.60} = 0.95 \approx 1\text{m}$$

As a result, a 1.0 m long separator was constructed using 10 mm diameter mild steel rods, with a rod spacing of 30 mm selected to allow the separating unit area to open as much as possible for soil sieving while also taking into account the approximate minimum size of potato to be retained on the separator. This would make it easier for the soil separating equipment to separate the dirt from the potato as much as possible. The soil separator's distance between successive rods was maintained within a range that prevented the potato from passing between two successive rods. As seen in Fig. 3.6, a lever fastened to the frame allowed for adjustment of the separating unit's tilt. To enable the free and efficient dropping of soil-mass from the separator, the rod spacing was kept at 30 mm. Under actual field conditions, clods of dirt of any kind that were dug up could have been as large as 20 to 30 mm in diameter, and a single potato plant could have had several large tubers. As a result, the actual field design maintained a 30 mm gap to allow for the safe passage of more soil.

Design of Power Transmission Unit

The power is delivered to the separating unit via a crank system. Connecting rod, crank, and propeller shaft make up its essential components. With the aid of the power transmission system, the separating unit was able to move and sieve soil from the potato. The power gets transmitted in two stages: from the P.T.O. to the crank via the propeller shaft, and from the crank to the separating unit via the connecting rod. The propeller shaft, which has 10 splines and measures 42 and 300

mm in diameter and length, respectively, is attached to the tractor PTO at one end, and a bearing connects the other end to the crank. M.S. rod measuring 460 x 40 x 5 mm makes up the connecting rod. The connecting rod has a 45 mm ball bearing attached to the crank, and an M.S. flat measuring 310 x 55 x 10 mm was used to link the opposite end of the rod to the reciprocating frame this mechanism converts the crank's rotational motion into the separating unit's reciprocating action. The diameter and thickness of the crank are 140 mm and 10 mm, respectively. The number of crank revolutions was determined by the tractor's PTO speed. As seen in Figs. 3.7 and 3.8, the soil separation unit's stroke length may be changed by adjusting the slider-crank mechanism, which also allows for power reduction. The crank was positioned away from the center. The separation unit's stroke length is determined by three eccentric points, zero, seventy, and 140 mm, marked from the crank center. The crank radius was calculated using the following formula. Ballaney (1990)

$$X = r\left[1 - cos\theta + n - (n^2 - sin2\theta)^{\frac{1}{2}}\right] \quad 7$$

Where,

X = length of stroke, 14 cm; r = radius of the crank, cm; Θ = Crank's angular displacement; n = 1 / r; and I = connecting rod = 31 cm. For the biggest displacement, θ = 180º. Hence, sin 2θ = 0

X = [2 + (31/r) - √{(31/r)^2 - 1}]

13 = r [2 + (31/r - (31/r) ^2)] ^ (1/2)$13 = r(2)$

$$r = \frac{13}{2} = 6.5 \approx 7\text{cm}$$

By taking a displacement of 14 cm, the crank radius was calculated to be 7 cm. This demonstrates that the offset crank radius was doubled by the stroke length. The reciprocating unit's stroke length can be adjusted by varying the crank radius, which ranges from 0 to 7 cm. The machine was tested in the laboratory at three offset crank sites, which are 0, 3.5, and 7 centimeters from the center.

Consequently, the half- and full-revolution travel distances of the soil separation unit were calculated.

Hitch System

The main frame was welded to the three-point hitch system. The hitch system was set up in accordance with ASABE (2014) (Part 1): specifications. The hitch system's mast height was maintained at 610 mm. With the aid of a fasting system, two wheels are linked to the digger to control depth and provide stability. (Narendera et al., 2022).

Main Frame

The primary frame measured 1000 x 820 mm and was constructed using M.S. rectangle section (100 × 50 × 5 mm). MS iron square section was welded to this frame at a distance of 330 mm from the front side, or what is known as the hitching point. Two MS flats (500 x 50 x 12 mm) were also welded on both sides of the frame to connect the blade, while another portion was bolted with the assistance of a pedestal at a distance of 760 mm from the front side of the machine.

The blade support was mounted to the main frame through two flats of size 500×50×12 mm welded to the mainframe on both sides. The power transmission and soil separating unit were mounted with a square hollow section of 50×50 mm by welding and bearing at a distance of 330 and 760 mm, respectively, from the front of the frame.

Tuber Collector Design

Designing with a potato tuber collector for a harvester involves creating a mechanism that efficiently dig potatoes from the soil, separates them from debris, and deposits them into the tuber collector for further processing. The tuber collector needs to be robust, effective, and adaptable to different soil conditions and potato varieties. Tubers are known to exhibit round, oblong, and long-oblong morphological traits. The tuber collector volume was computed using the tuber's average bulk density. Every form of tuber, including long oblong, oblong, and round tubers Because of this, the machine's tuber collector was made to make gathering potatoes throughout the harvesting process straightforward.

Volume and Capacity of Tuber Collector

The tuber collector was design in rectangular shape. According to Yogesh and Shambhu (2022), to work out the volume of entire tuber collector as shown in equation 8 was taken into consideration.

$V = a \times b \times h$ 8

Where,

V = Volume of upper rectangular box

a = length;

b = width;

h = height of the rectangle

$70 \times 61 \times 61 = 260470cm3$

Therefore the volume of the tuber collector is $260470\text{cm} = 0.26047\text{m}^3$

The volume of full-scale equipment as indicated by equation 9 was chosen, according to Gachanja (2019).

Volume of full-scale equipment = $V_t \times 10$ 9

Where

$V\text{t} =$ Entire volume of tuber collector

$V_t = 0.26047m^3 \times 10 = 2.60m^3$

Machine Description

The potato harvester combined with a tuber collector for tractor attachment consists of : Main frame, Digging blade, Three point hitch, Shaker/soil separating unit, Crank, Connecting rod, Propeller shaft, Tuber collector , Hub, Ground wheel, Tuber collector sides covers and motion converter. Development of potato harvester combined with collector for tractor attachment has a general specifications with overall dimension of (2000×870×1225 mm), the power transmission mechanism enables the separating unit to transfer and extract soil from the crop. The power is transferred in two stages: from the P.T.O. to the crank via the shaft of the propeller, and from the crank to the separating unit via the connecting rod.

The harvested tuber are further drop in the tuber collector, which is directly behind the shaker/soil separation unit. The potato tubers keep accumulating in the tuber

collector till the weight exceed the force of the spring loaded cover and it discharges the potato tubers on ground at a particular point and the cover automatically return back to its normal position. The process take place throughout the harvesting operation.

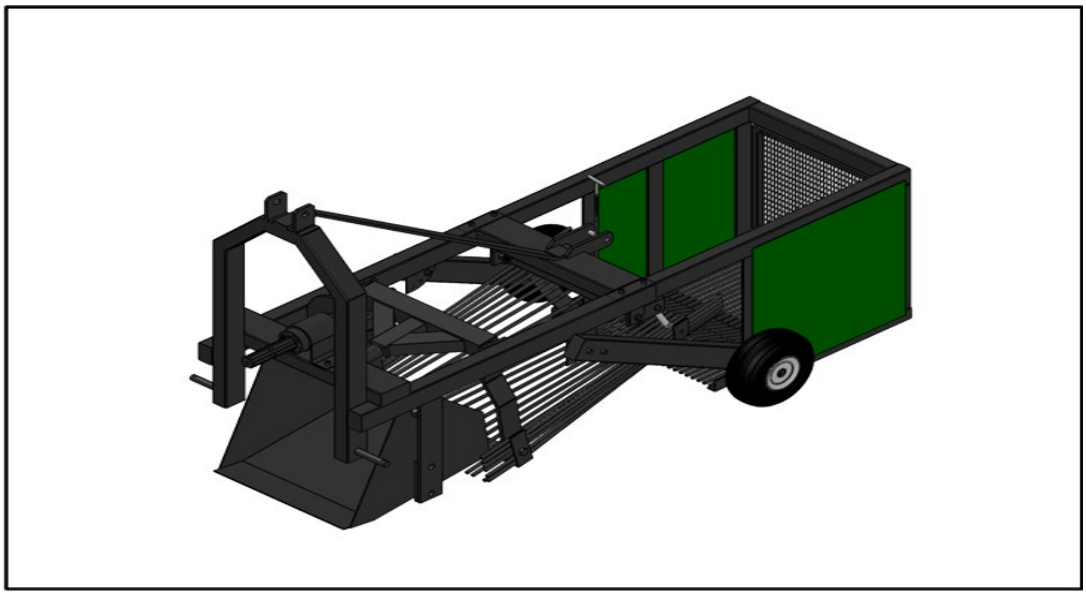


Figure 2. Isometric view of the tractor powered potato harvester combined with tuber collector

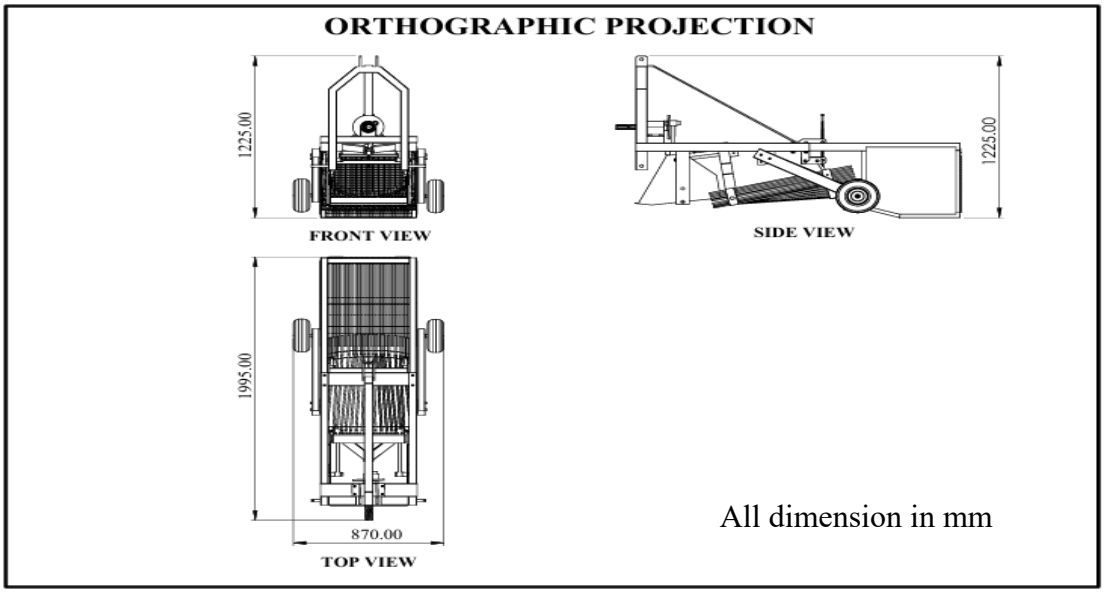


Figure 3. Orthographic view of the designed tractor powered potato harvester combined with tuber collector.

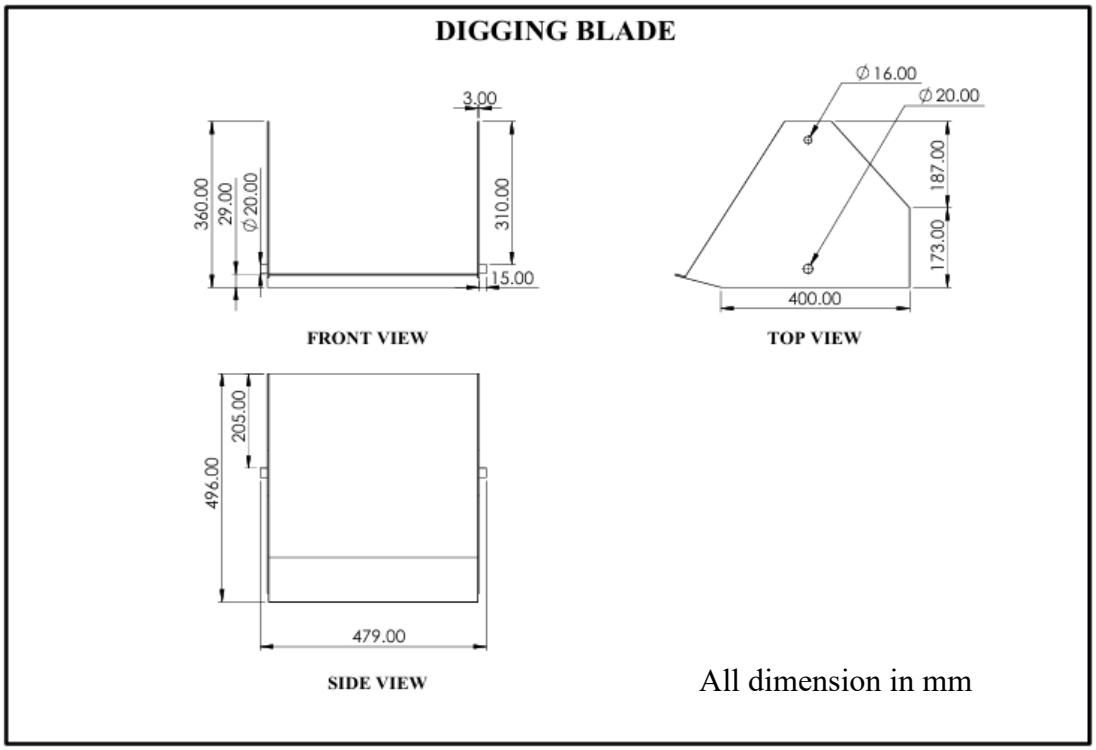


Figure 4. Orthographical view of digging blade

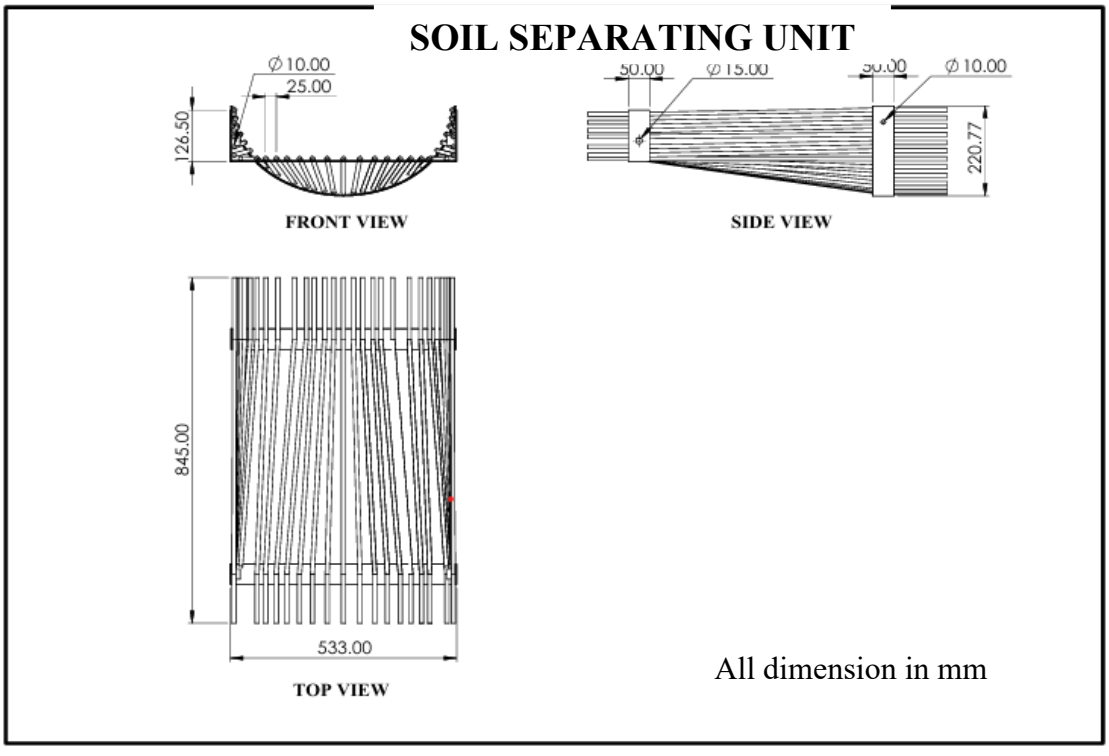


Figure 5. Orthographical view of soil separating unit.

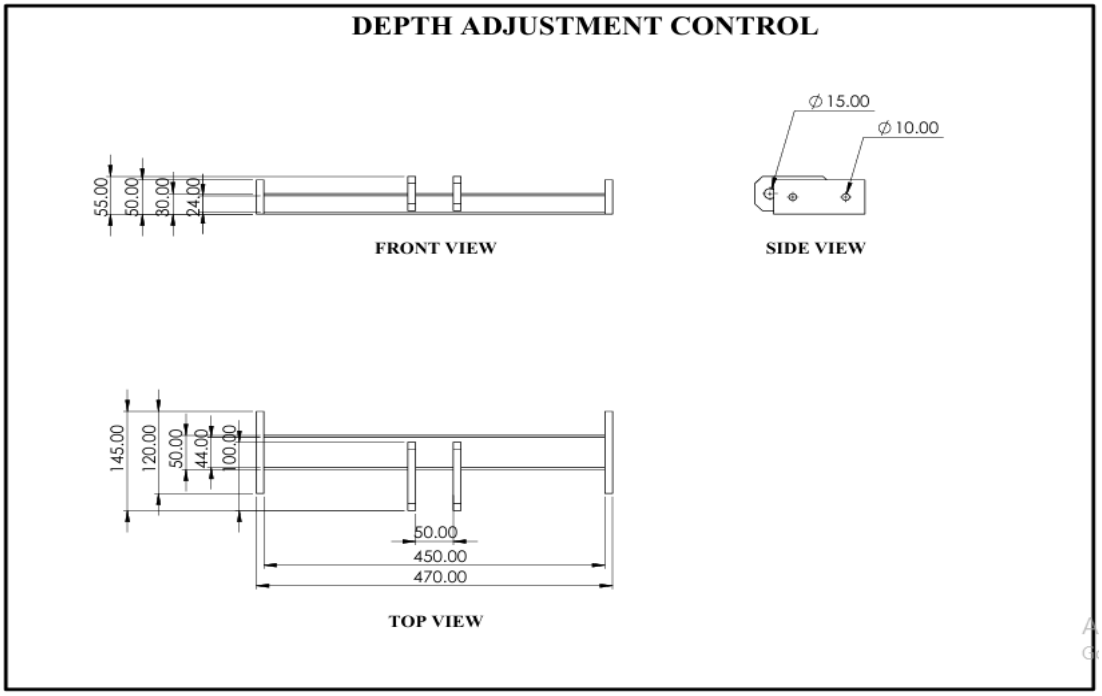


Figure 6 Shaker adjustment control

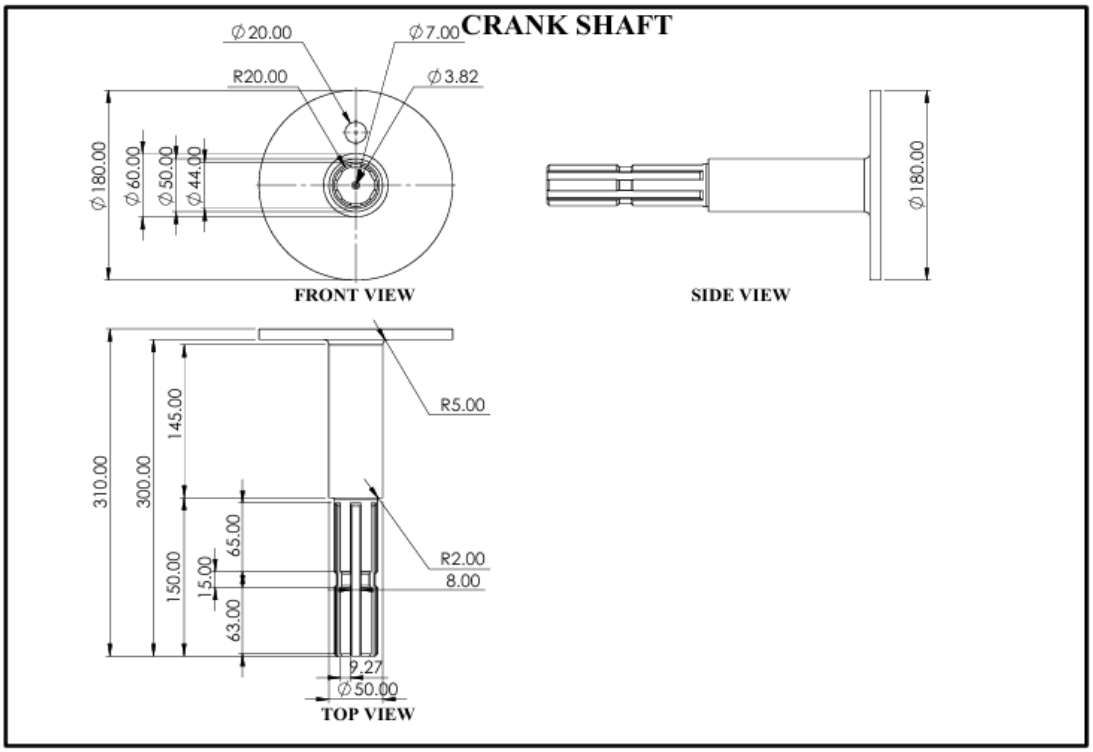


Figure 7. Orthographical view of the crank and propeller shaft

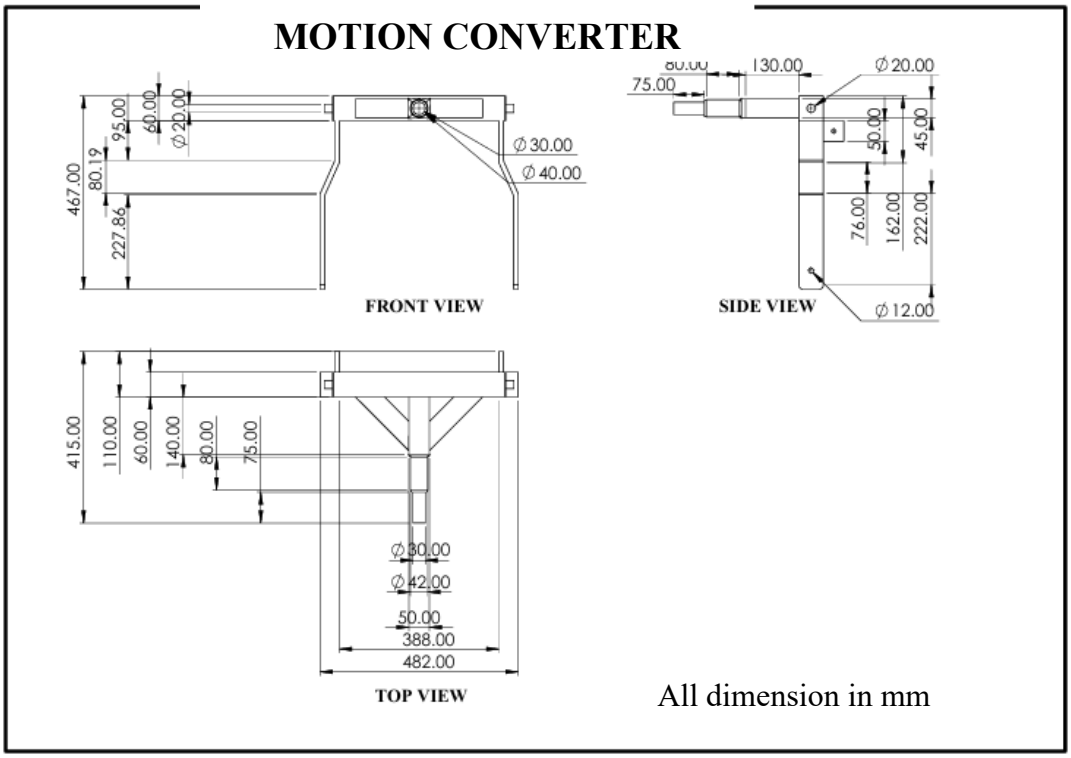


Figure 8 The orthographic of the motion converter

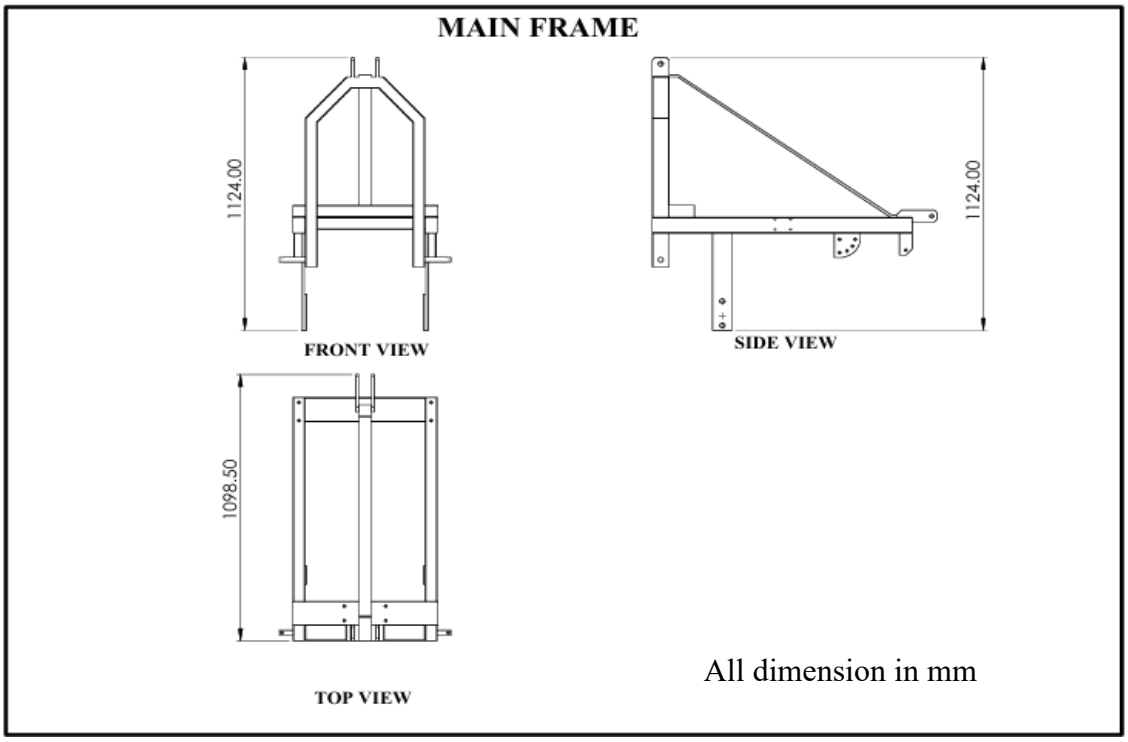


Figure 9a Detailed dimensions of the main frame

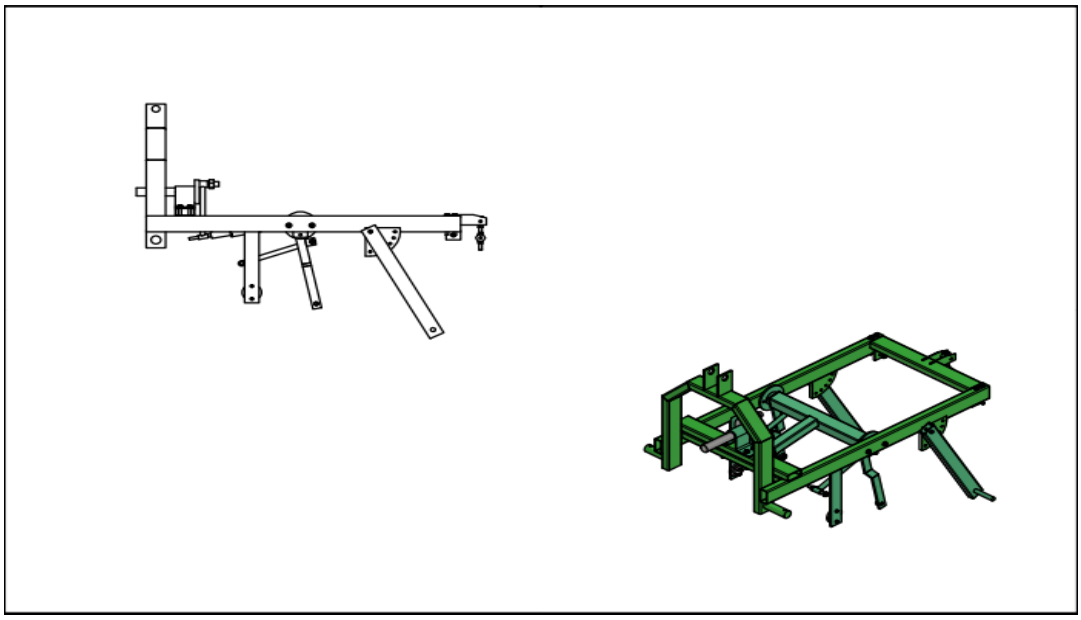


Figure 9b. The frame with other attachment

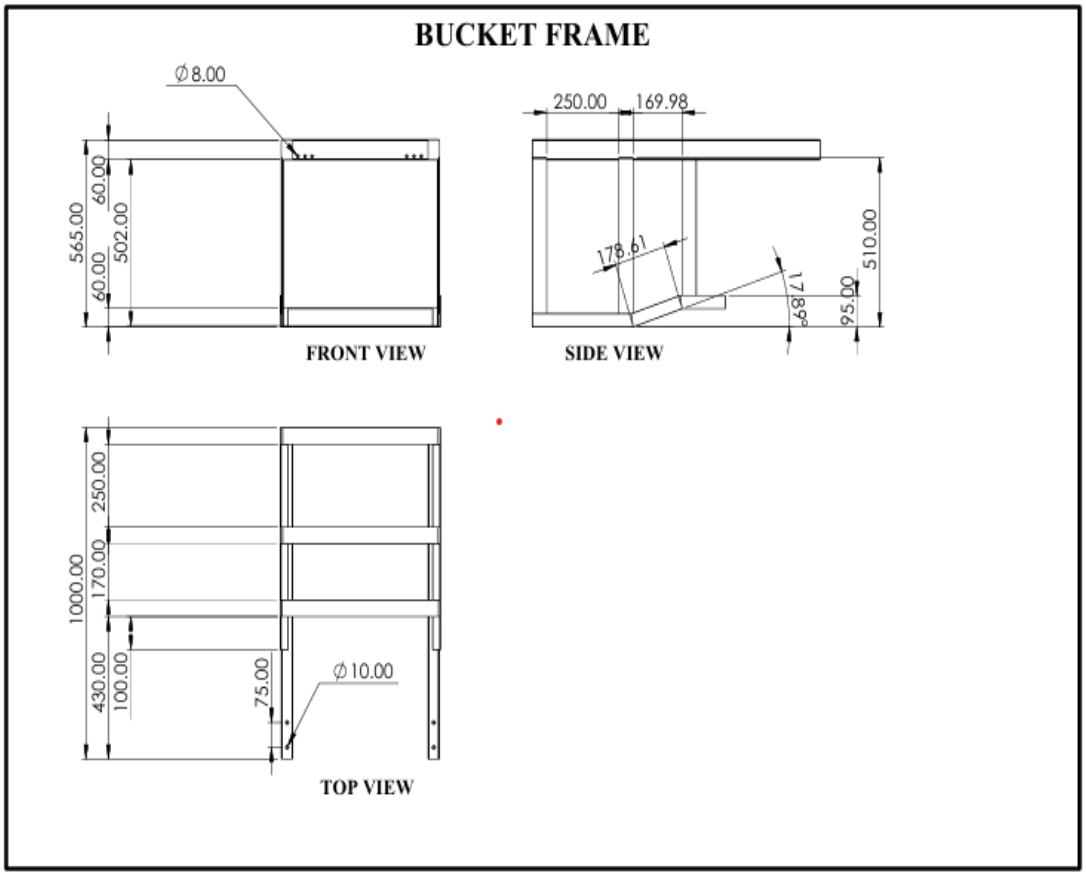
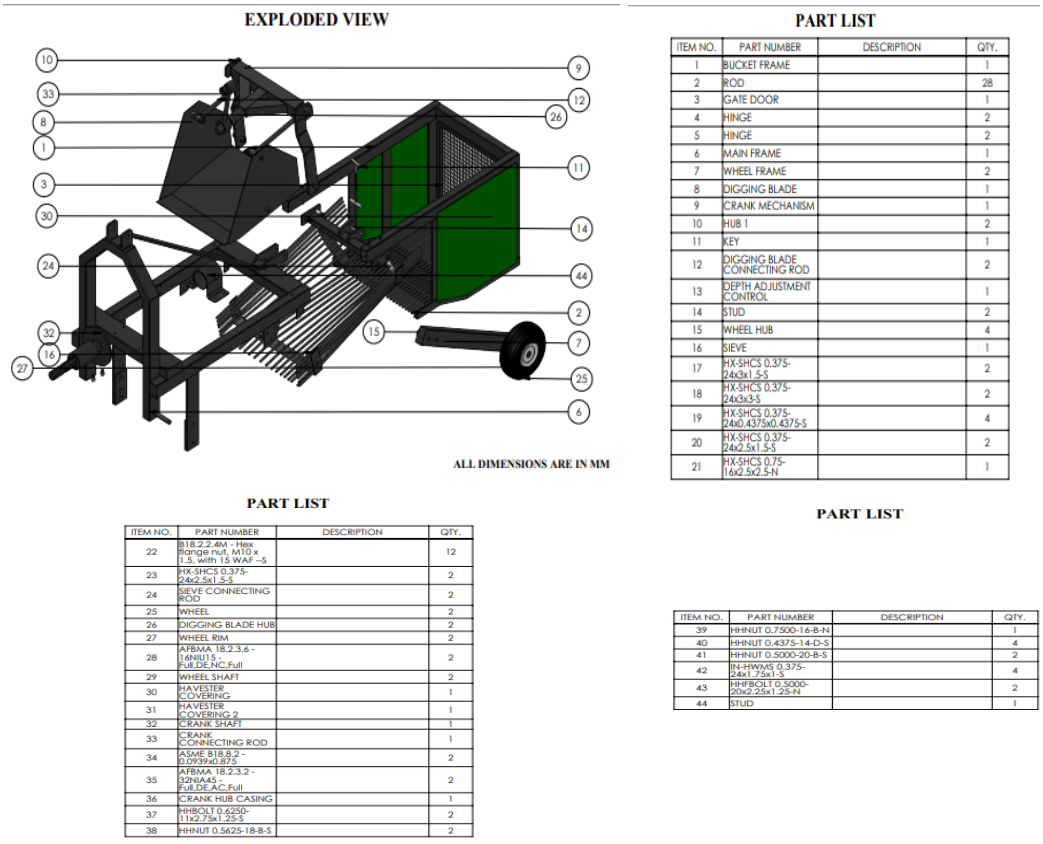


Figure 10. Orthographic of the tuber collector

Figure 11 illustrates the exploded assembly view of the designed potato harvester combined with a tuber collector unit, suitable for tractor attachment



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	BUCKET FRAME		1
2	ROD		28
3	GATE DOOR		1
4	HINGE		2
5	HINGE		2
6	MAIN FRAME		1
7	WHEEL FRAME		2
8	DIGGING BLADE		1
9	CRANK MECHANISM		1
10	HUB 1		2
11	KEY		1
12	DIGGING BLADE CONNECTING ROD		2
13	DEPTH ADJUSTMENT CONTROL		1
14	STUD		2
15	WHEEL HUB		4
16	SIEVE		1
17	HX-SHCS 0.375-24x3x1.5-S		2
18	HX-SHCS 0.375-24x3x3-S		2
19	HX-SHCS 0.375-24x0.4375x0.4375-S		4
20	HX-SHCS 0.375-24x2.5x1.5-S		2
21	HX-SHCS 0.75-16x2.5x2.5-N		1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
22	B18.2.2.4M - Hex flange nut, M10 x 1.5, with 15 WAF --S		12
23	HX-SHCS 0.375-24x2.5x1.5-S		2
24	SIEVE CONNECTING ROD		2
25	WHEEL		2
26	DIGGING BLADE HUB		2
27	WHEEL RIM		2
28	AFBMA 18.2.3.6 - 16NIU15 - Full,DE,NC,Full		2
29	WHEEL SHAFT		2
30	HAVESTER COVERING		1
31	HAVESTER COVERING 2		1
32	CRANK SHAFT		1
33	CRANK CONNECTING ROD		1
34	ASME B18.8.2 - 0.0939x0.875		2
35	AFBMA 18.2.3.2 - 32NIA45 - Full,DE,AC,Full		2
36	CRANK HUB CASING		1
37	HHBOLT 0.6250-11x2.75x1.25-S		2
38	HHNUT 0.5625-18-B-S		2

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
39	HHNUT 0.7500-16-B-N		1
40	HHNUT 0.4375-14-D-S		4
41	HHNUT 0.5000-20-B-S		2
42	IN-HWMS 0.375-24x1.75x1-S		4
43	HHFBOLT 0.5000-20x2.25x1.25-N		2
44	STUD		1

Figure 1. Exploded view with part list of the designed tractor powered potato harvester combined with tuber collector.

Conclusion.

The ultimate goal of this research was to design a basic but extremely effective tractor powered potato harvester combined with a tuber collector suitable for small and medium scale farms in order to address the issues of low productivity as well as the labor-intensive nature of harvesting. This goal was accomplished. The harvester is to run at slope inclinations of not more than 16 degrees and with low soil moisture content. One row of potatoes is harvested by the potato harvester on each trip. The potato harvester's construction and testing revealed that it works well in a range of soil types. In order to improve on this equipment, future research

focusing on optimizing the design and investigating automation technology is recommended.

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