



A Review on Inter-row Crops Mechanical Weeder

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ABSTRACT

Weeds can be thought of as plants growing in the wrong habitation, place and time thereby, doing further damage than improving the crop. Taking out weed growths is a vital practice but in the same way its time consuming. Increase in the use of machine-like intra-row weeder is of much interest around the world today because of its impact on the environment and a growing request for healthy foods produced. Today the agricultural industries wants non-chemical weed control that can safeguard consumers demand for high quality food crops and pay special attention to food safety. Through the mechanical development of different devices for weeding manually, such as accurate inter-row and intra-row weeders, weeds can be mitigated. Through these mechanical means food production safety can be guaranteed. There is a need to review existing mechanical weeders to know their merits and demerit.

RESEARCH ARTICLE

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INTRODUCTION

Weeds are plants which grows where they are not needed, the history of weeds is as old as when man started practicing agriculture. Since the beginning of crop production system and all through generation, waste plant growth among the planted crops has been the major task facing agriculturalists all generations. There is competition between the non-crop plant and crops for sunlight, soil water, space and soil nutrient, the non-crop plant/waste plant is known as weed (Parish, 1990). Different species of weeds which has been identified is over 3000, weeds compete directly for nutrients, light, soil water, air and space in the soil to decrease yield. In plant propagation and production cycle, weed removal is essential and similarly a tedious operation. It is therefore essential to control weed in order to reduce losses in production cost and improve crop yield. Poor weed control can result in over 50-70 % reduction in crop yield and one third of the cultivation costs is weed cost (Oni, 1990). The damages caused by weeds can be severe in agricultural sector. The damages comprises crop quality loss,

crop yield loss, plant pests sheltering, diseases and in addition decrease values in land. In Africa the common weeding practice is mostly manual, 75% of Nigeria population is involved in agriculture. During a planting season weeding accounts for over 25% of total labor requirements (Nag and Dutta, 1979). As agriculture becomes mechanized, row crops are spaced widely to accommodate farming practices developed to control weeds in inter row work. Weeding in Nigeria is not effective because row crop weeder are not encouraged (Olukunle and Oguntunde, 2006). Mechanical methods of weeding are very easy and simple for adoption and understand by farmers. Weeding done traditionally are done using inter culture tools such as hand hoe and spade (Yadav and Pund, 2007). New technologies are always helping to improve the productivity on the field (Mehta *et al.*, 2019). Weeding mechanically if introduce in subsistence agriculture, it would lead to increase in crop produce and reduce shortages (Olukunle and Oguntunde, 2006). Mechanical weeders can be classified on the basis of power, design and mechanism as manual weeding tools, animal drawn weeders and power or tractor operated weeders (Kumar *et al.*, 2012).

REVIEW of EXISTING MECHANICAL WEEDERS

A review was done to know the merits and demerit of some existing mechanical weeders with their year of production.

Mandava-Single Row Weeder (2000)

Machine description

The parts of the weeder are float, rotor, handle, handle rod and rotor frame (Figure 1 and 2).

Mechanism of operation

The mechanism is to remove weeds from the soil by rotation of the integrated spiked; it is powered by the movement manually.

Merit

1. Low cost of operation and manufacture
2. Less weight (5 kg) with more strength
3. Simple design
4. Suitable to all types of soil
5. Easy to operate
6. Better handle
7. Reduces drudgery
8. Can be manufactured locally

Limitation

1. It ineffectual because it digs deeper into the soil than compulsory.
2. No provision for adjustment
3. It is manually operated



Figure 1. Pictorial view of Mandava single row weeder (Ravi, 2000)

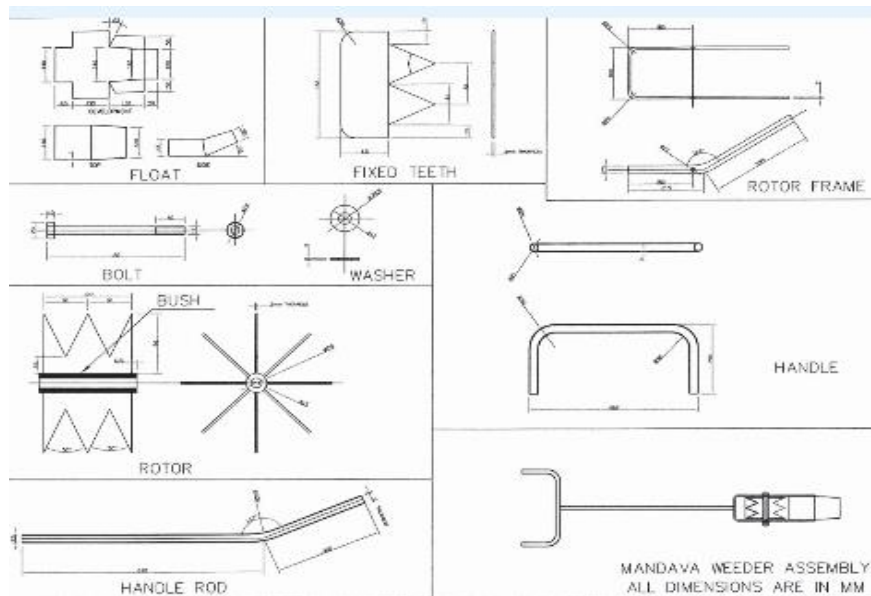


Figure 2. Detailed description of Mandava single row weeder (Ravi, 2000)

Row Crop Weeder (2006)

Machine description

The weeder machine has 5 hp electric motor as the source of power that transmits motion to other part the machine which reduce drudgery and increasing crop production. The machine was developed and found to weed effectively. Parts of the machines are transmission system, spike-brush abrasive auger, motor, wheels and frame. It has an adjustable cutting height and can operate as mower (2 cm to 4 cm above the ground level) and weeder (between 2 cm to 1 cm). For small and medium scale farmers this machine is affordable and has a simple design. The use of this machine reduces drudgery in a positive direction for weeding crops in rows. Operational condition adopted for these machine is for crops on flat beds with conventional tillage, zero tillage and other cultural tillage practices (Figure 3).

Machine mechanism

Width of cut of the machine is 50 cm with field capacity 0.0751 ha h^{-1} . The machine can weed a hectare of farm in a day when operated by two person with 90% average field efficiency and functional efficiency was between 90 and 98.5%.

Merits

1. It's cost effective and consumed less fuel
2. Increase in the brush speed increases the weeding efficiency

Limitations

1. It can be used on dried land
2. Its can only be used for small scale farm
3. It's not self-propelled



Figure 3. Pictorial view of a row crop weeder (Olukunle and Oguntunde, 2006)

Manual Weeder with V-Frame (2007)

Machine description

The machine consist of the following parts the handle, blade (spokes), v-frame and wheel. The wheel of the machine was made from mild steel flat with a hub made from mild steel. At the wheel centre the spokes were attached to the hub. Mild steel flats was selected for the weeding blade because it is ductility to withstand forces acting as load of the machine. The soil is penetrated through the sharp blades at suitable angle and anticipated depth during weed removal. Mild Steel Square bar was the material used for the prongs having dimensions 175 x 10 x 10 mm. The headpiece houses the blade and prong fixed at both ends. Galvanized iron pipe material was selected for the headpiece 30 mm x 350 mm in diameter and length with adjustable grooves for spacing between blades. Nut and bolts were supported by U–shape flat bar and shaft. The ground wheel with the main frame supports the handle connected by a V-shape steel flat. Mild steel pipes was used to fabricate the handle with a height of 955 mm at an angle of 37°. The ergonomics of the machine was done to fit the operator. Mild steel material was used for depth control with 120 mm diameter of ground Wheel (Figure 4 and 5).

Mechanism of operation

The mechanism was cut at the first impart with the weed. The materials selected was able to withstand the resultant resistant of the weed to cut, with steel flat weeding blades. The machine is rigidly supported by mild steel V-shape support directly fused

to the handle to link the ground wheel with the main frame. Working depth of the machine developed 30 mm, field capacity of 0.048 ha h⁻¹ with to 92.5 % weeding efficiency.

Merits

1. It's easy to operate
2. The cost of production is low
3. The ergonomics of the operator was design for in the machine

Limitation

1. It is manually operated
2. It can only be used at early stages



Figure 4. Pictorial view (Yadav and Pund, 2007)

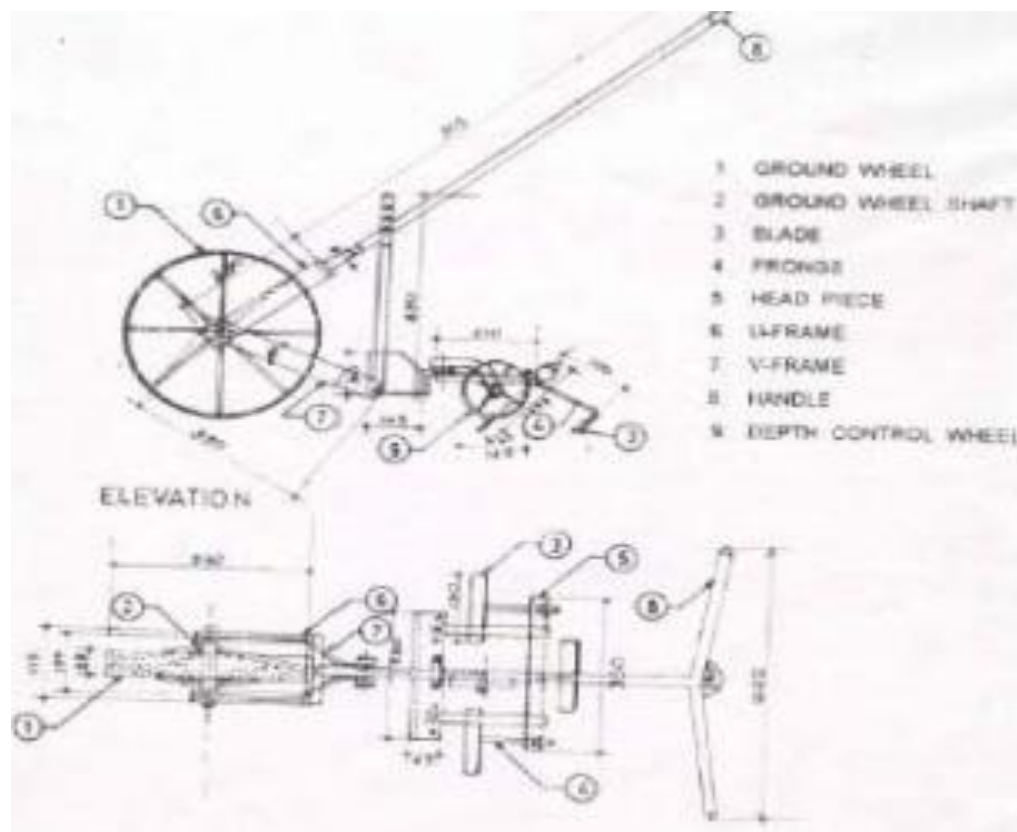


Figure 5. Isometric view (plan and side view) (Yadav and Pund, 2007)

Hymatic Cono Weeders (2008)

For shallow water weeding conditions Hymatic Cono Weeders can be utilized.

Mechanism of operation

Its mechanism involves uprooting (teeth) and burying weeds in the mud by push and pull operations of the machine. It saves labour by 50% while covering 0.18 ha day⁻¹ (Figure 6 and 7).

Machine description

The parts that make up the machines are floater, cones, handle, cono and frame.

Merits

1. It can easily be operated by both gender.
2. The cost of weed control is low.
3. It is not heavy to work with.
4. Easy for farmers to operate.

Limitations

1. It cannot be used on dry or stony land
2. It can only be used at early stages of the crop

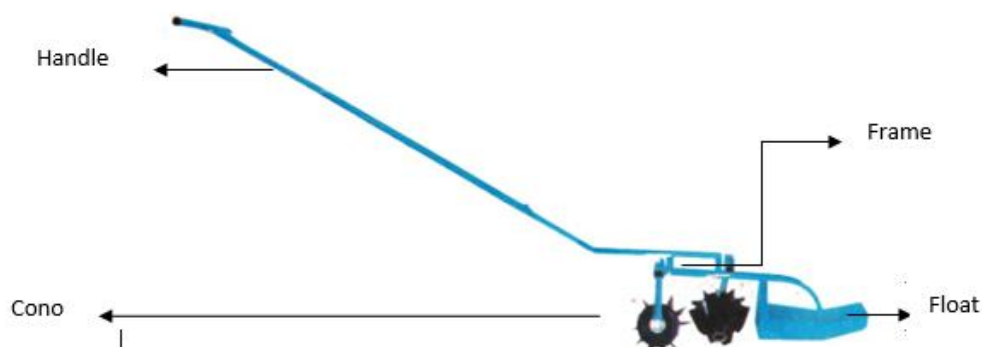


Figure 6. Pictorial view of hymatic cono weeder ([www.hymatic.in/hymatic cono weeder](http://www.hymatic.in/hymatic-cono-weeder))

CAD specifications

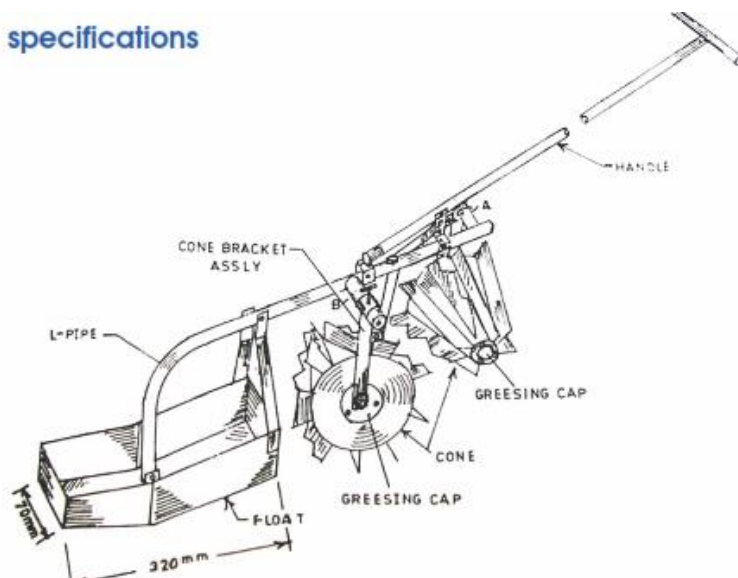


Figure 7. Isometric view of hymatic cono weeder ([www.hymatic.in/hymatic cono weeder](http://www.hymatic.in/hymatic-cono-weeder))

Row Crop Mechanical Weeder (2009)

The machine comprises of three set of blades, petrol engine as main source of power was, frame, transmission system and ground wheel. The dimension of the machine was 0.32 m wide, 0.85 m long and 0.24 m in height. The weeding efficiency of the machine was observed during field test to be 95% having a depth of cut of 0.24m, cutting speed of 800 rpm and 0.7L h⁻¹ fuel was consumed on the average. The weeding capacity of the machine was 0.053ha h⁻¹. As at 2007, production cost of the weeder was estimated to be US\$285.

Machine description

The weeder was designed and constructed to research in crop rows. The main features of the weeder are as follows:

Mainframe: it was built of a rectangular hollow pipe (with a length of 500 mm a steel channel was welded to the frame, with brackets to hold the engine in place.

Handle: the main frame was the point of attachment for the handle. This feature helps in push or pull mechanism of the machine with the aim of controlling the direction by the operator during operation within crop rows.

Cutting blade: there are three sets of the cutting blades mounted on the shaft with the frame given main support. For every gang there are four L-shaped blades arranged into orthogonal planes.

Blade shields: a shield was necessary to cover cutting area. The operator is protected by a shield from soil splash and cut weeds so that he/she can concentrate on the job

Transmission unit: the arrangement of belt and pulley from the prime mover transmits power to the cutting blades.

Wheels: two types of wheels were used, a single wheel in front of the machine behind the blades whose function were to control.

Internal combustion engine: a commercial 5hp petrol engine (Honda), engine speed (4200 rpm) was used as the power source (Figure 8 and 9).

Mechanism of operation

The engine gives the source of power and transmits it all other parts.

Merits

1. It's environmental friendly because it does not pollute the environment
2. The machine protects crop
3. Its fuel economic
4. It's cost effective
5. The machine was rugged and designed for easy maintainability

Limitation

1. Used in early stage of the crop
2. It can work for small hectares of land and dependent on the operator



Figure 8. Pictorial view of row crop mechanical weeder (Manuwa et al., 2009)



Figure 9. Cutting blade of the row crop mechanical weeder (Manuwa et al., 2009)

Manually Operated Single Row Weeder (2010)

Machine description

Frame support: Metallic square pipe material of 82 cm by 10 cm was selected with pipe supports of different measurements.

Secondary cutting edge: A sharpened metallic flat bar of 30 cm in length was used for the design of the cutting edge

Handle: The material selected for the handle is a square pipe of different sizes

Frame cover: The metallic sheet of 82 cm by 10 cm was used as the cover of the frame on both sides of the weeder.

Primary cutting edge: The primary cutting edge was made up of flat bar. On a horizontal bar of 30 cm long were placed vertically eight blades sharpened at both ends

Machine mechanism

The machine is operated manually by human using cutting edge mechanism (primary and secondary) for weed cutting. The loosening of the soil and the lifting of the weeds is done by the primary cutting edge in the front while the cutting is done by the blade behind. A rope pulled through a loaded spring balance was used to determine the force needed to uproot a weed. The principle of operation of the machine was impact and abrasion mechanism which cause weed stem failure and soil or root failure. Fabrication which include metal cutting, bending, shaping and welding was carried out at the

workshop. The machine was tested at average human being speed on different types of soil (clay, loamy and sandy) and different position on the soil (Figure 10).

Merits

1. It easy to operate
2. It can operate on different soil
3. Its cost effective

Limitations

1. Its uses only the human speed so its operation is dependent on the operator
2. It can be used at early stage of the crop
3. The primary and secondary cutting blade can only uproot with low depth of penetration into the soil

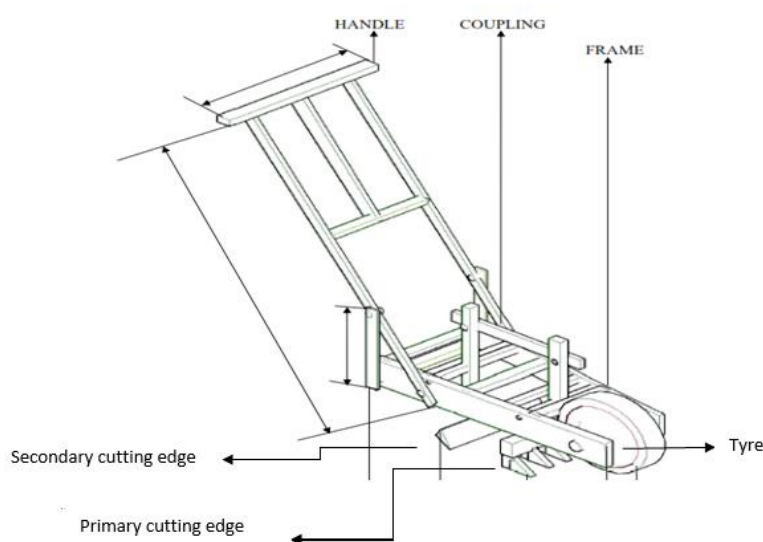


Figure 10. Manually operated single row weeder (Quadri, 2010)

Model Cl262 Power Weeder (2011)

Machine description

A 1.4hp Mitsubishi (japan) engine which operates on the weeder machine, which transmission of power from the engine is through the gear box (the worm type, grease filled gear box) the weight of the power weeder was 0.014 kg, height was 1.02 m, engine type is a petrol engine with mixing oil of 2T 30 ml for 1 litre of petrol while the fuel tank capacity was 600 ml, principle of operation was that the blades are the ones doing the cutting in the direction of motion. The starting model of the machine was a recoil type with sizes of wheels/blades 4 numbers; width of wheels/blades 0.25 m and also 4 wheels/0.25 m, 3 wheels/blades 0.2 m, 2 wheels/blades 0.17 m. The power weeder can be run on 4, 3 or 2 blades with the handles and controls provide controls for the forward motion of the power weeder.

Mechanism of operation

The main source of motion/power is the engine connected to the gear box to which the other moving parts like the wheels and blades are all connected through rotary motion.it is self-propelled with a 1.4hp fuel/petrol engine with capacity of 1-8ha day⁻¹ (Figure 11).

Merits of the machine

1. This machine increases the yield up to 15%.
2. Enhances even crops with better land utilization.
3. Helps in saving water.
4. Labour and time saving.
5. Enhances proper weed control.

Limitations

1. The machine produces fume which is not environmental friendly
2. The cost of machine and maintenance is much to be used commercially
3. Power weeder can be used at early stage of the crop

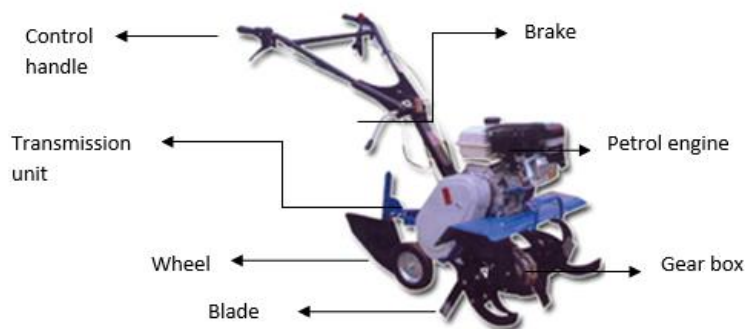


Figure 11. Model CL262 Power Weeder ([www.RekhaAgriplasltd.com/power weeder CL262](http://www.RekhaAgriplasltd.com/power_weeder_CL262))

Rotary Power Weeder (2011)

Machine description

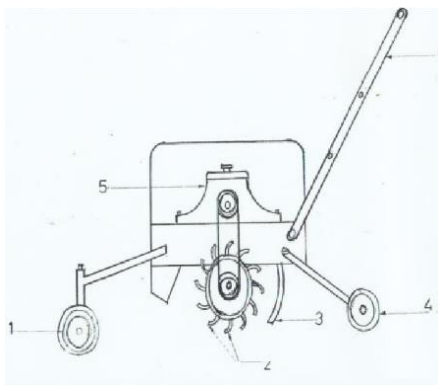


Figure 12. Schematic illustration of power rotary tiller: 1: Front wheel, 2: Tine, 3: Guard, 4: Rear wheel, 5: Prime mover, 6: Handle (Olaoye and Adekanye, 2011)

Mechanism of operation of a Rotary Power Weeder

A vivid arrangement of a rotary power tiller is shown above. The major component of the machine are ground wheel, two assembly, petrol engine motor, frame and handle. The machine is manually operated and powered source from the petrol engine motor that supplies power to rotary hole through the transmission system (belt and pulley). A theoretical motion analysis was carried out by Hendricks and Gill (1978) rotary tiller blade. The weeding disc motion at every point on rotary tiller surface travels through a trochoidal or cycloidal path subject to point of distance from the rotor axis (radius).

During operation, the motion of the rotor is generated by combining forward and rotational motion of disc-type tines and rotor Radius (Figure 12, 13 and 14). The parametric equation which describes the path of a point on the rotor is as shown in Figure 15.



Figure 13. Isometric view of a power rotary tiller (pictorial view) (Olaoye and Adekanye, 2011).

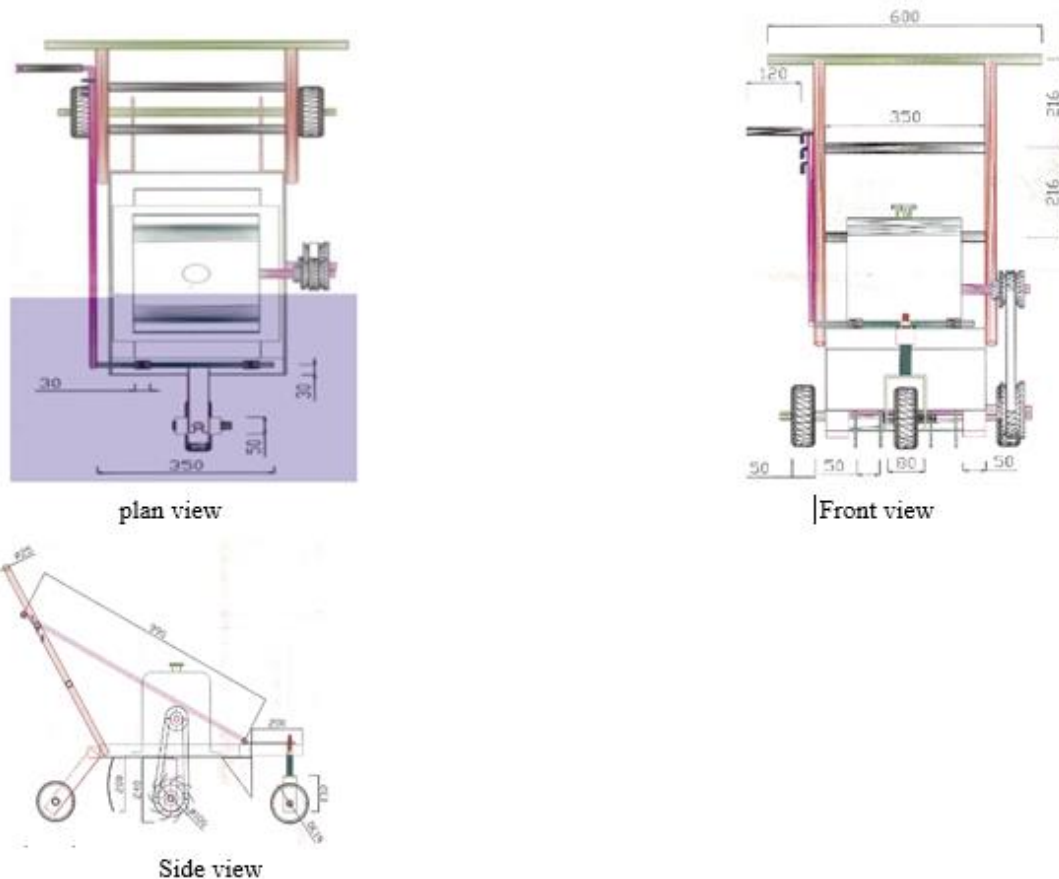


Figure 14. Orthography view of a power weeder (Olaoye and Adekanye, 2011)

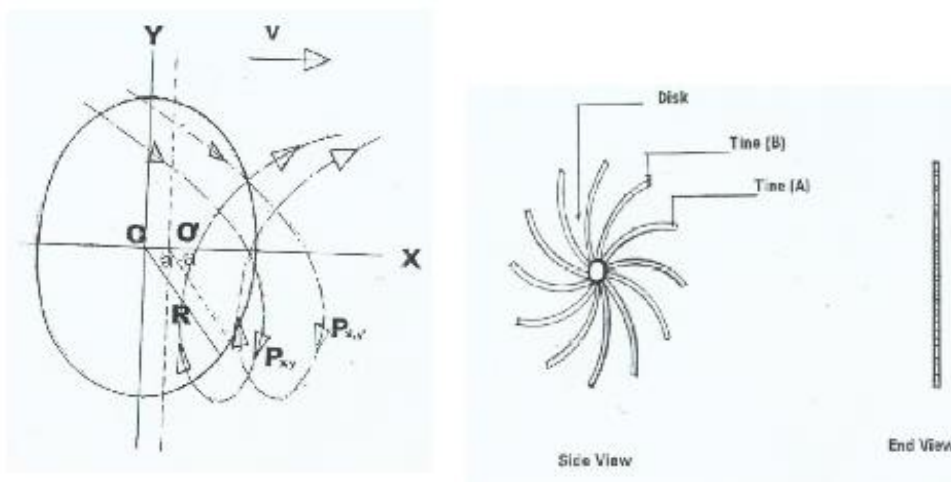


Figure 15. Sketch of disc with tines motion (Olaoye and Adekanye, 2011)

Merits

1. Ease of operation
2. Cost effective
3. Good ergonomics on the part of the operator

Limitations

1. It can only be used at the early stages of the crop.
2. It is not automated
3. It can work for a longer period it works is dependent on the availability of fuel and energy of the operator.

Cono-weeder technical drawings (2012)

Machine mechanism

The machine was used on swampy land, the teeth of the machine uproot the weeds and bury them in the mud as the machine is move to and fro manually (Figure 16, 17 and 18).

Merits

1. The machine buries the weed cut thereby adding manure to the soil.
2. During operation of the machine it gives aeration to the root.
3. Longer life to the tool.

Limitations

1. It's used on swampy soil
2. It can only be used at early stages of the crop



Figure 16. Pictures of the cono weeder (Godfrey and Jonne, 2012)



Figure 17. CAD design of a cono weeder (Godfrey and Jonne, 2012)

Machine description in detail

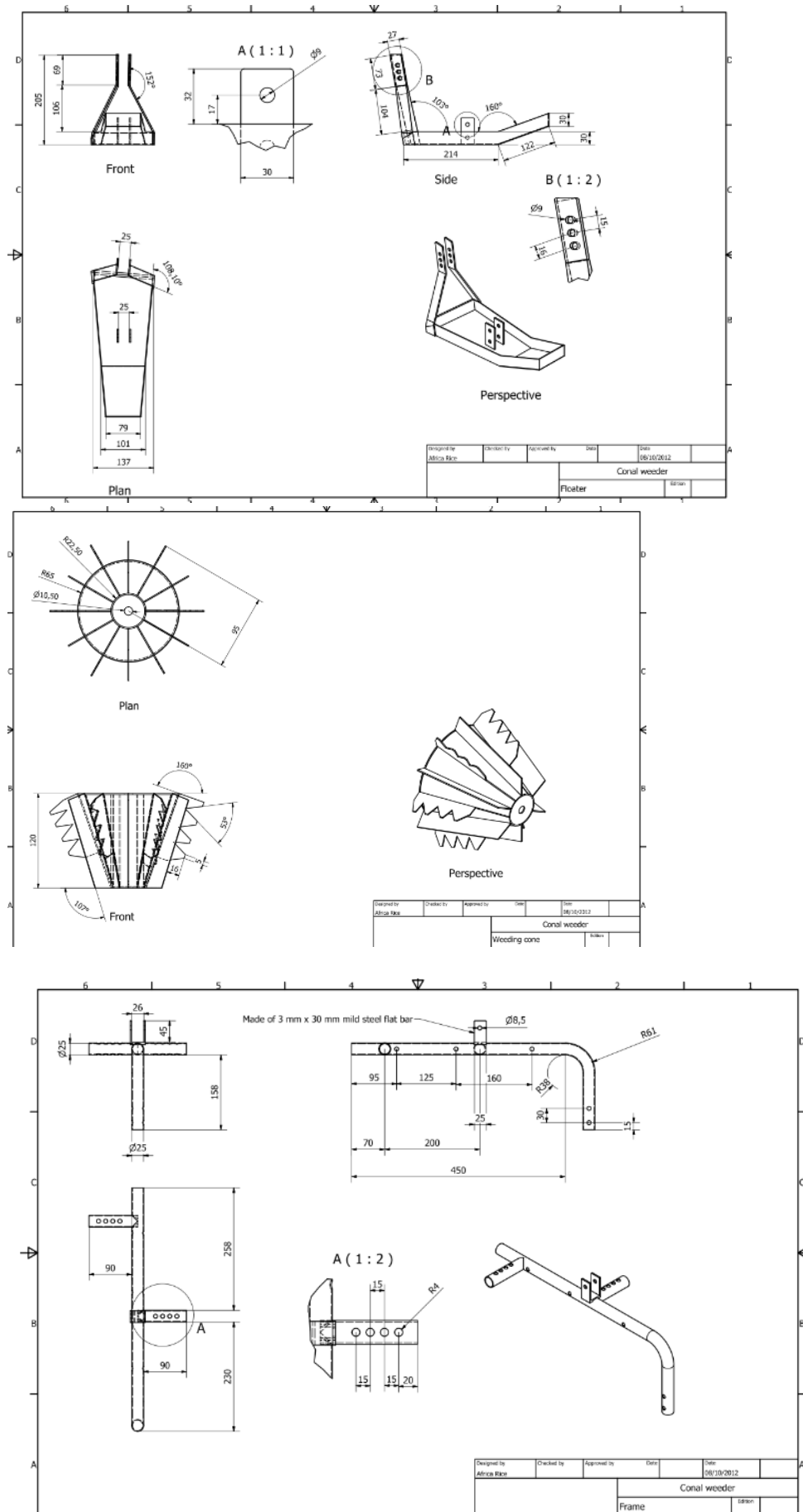


Figure 18. CAD design of Cono weeder (Godfrey and Jonne, 2012)

Rotary Power Weeder (2012)

The use of non-chemical control for weeding has been effective for crop production. Performance evaluation was carried out on the machine it was observed that weeding efficiency was 73% while the field capacity was 0.07 ha hr⁻¹. Estimating cost of manual weeder to be N 12,000.00 as against N 2,700.00 for rotary power weeder.

Machine description

The following are the components part of the machine:

Frame: mild steel angle iron of 30 mm x 30 mm x 5mm thickness. Marking out was done to cut the material into 600 mm and 350 mm sizes as required. The instrument used for cutting and chamfering edges was a hacksaw blade for effective joining through welding of the cut part to form the frame of the machine.

Rotary Hoe (Disk): A circular disk plate of mild steel material was cut out 12 mm thickness in five sets having 128 mm diameter each. In each disk a drill hole of 50 mm was made at the centre for shaft passage with 60 mm length circular pipes was drilled and welded to make it stable.

Tines: A 13 mm diameter metallic rod made from mild steel was curled and welded centrifugally on the disk with twelve tines per disks. The tine was 138 mm in length and effective to cut weeds.

Transmission units: A 5 hp internal combustion engine was used to power the machine and transmitted through belt and pulley to other moving parts (Figure 19).

Mechanism of Operation

The machine is manually moved from one place to the other. The cutting blades (tines) was given motion/power from the electric motor and the transmission unit is through the belts, pulley, shaft and bearing. The machine was tested on the field and it was observed that 2261 rpm speed gives a better weed cut than 2400 rpm speed which means the machine efficiency is influenced by the speed of the engine. The forward movement of the machine give the draught and cutting in the direction of motion.

Merits

1. It's easy to operate and maintain i.e. its cost effective
2. The movement of the machine is controlled by the operator
3. Helps in saving time on field operation

Limitation

1. The machine can't work for a longer period of time
2. It's not self-propelled
3. The work rate is dependent on the operator

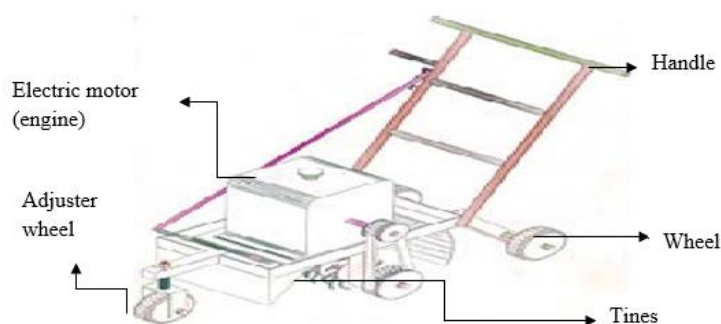


Figure 19. Pictorial view (Olaoye et al., 2012)

Manually Operated Ridge Profiler (2013)

A ridge profile rotary weeder was designed, fabricated and tested. The operation of the machine was manual. The machine has two rotary hoes with one half of the each hoe in line ridge during weeding. The rotary hoe is adjustable to the ridge profile at an angle to the ridge with row spacing of 750 – 900 mm not considering crop height. It was observed during the pilot tests carried out on the machine that the energy requirement is high and young weeds were effectively controlled.

Mechanism of operation

The machine was designed for inter-row operations. The component parts are two rotary hoes, frame and handle. It is not limited by crop height, which is a major advantage over other manual weeder. For every rotary hoe the ridge was inclined at about 30° and sloped in the direction of travel at an angle of 60° . Draught power ranging from 0.71-1.26 kW was found to be the optimum setting for weed removal. The soil type and ridging technique determines angle of repose of the ridge. It was also observed that a decrease in angle of repose increases draught power and decreases weeding efficiency of the machine

The arrangement of the rotary hoe is to ensure gradual weed removal and a slight disturbance of soil around the base of the crops.

Machine description

The machine was designed to have the following component parts: frame, tool bar, rotary-hoe gang, handle and ground wheel as shown in Figure 11. The major part used for cutting is the rotary hoes which consist of tines sharpened both at the cutting edges and at the tip (Figure 20 and 21).

Merit

1. It is used for inter row weeding
2. Limitation
3. It is manually operated
4. It can operate better using a combustion engine to make it automatic

Limitation

1. The machine can be used only for rows
2. The handle cannot be adjusted it's stationary

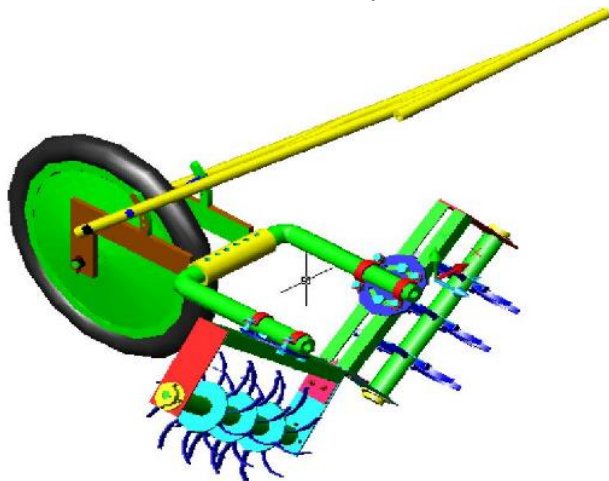


Figure 20. Pictorial view of ridge profile weeder (Kamal and Oladipo, 2013)

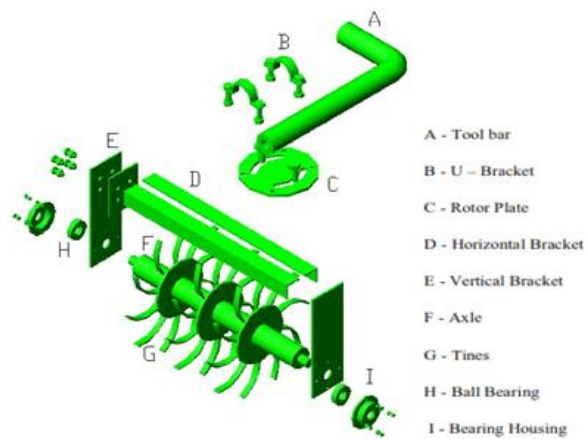


Figure 21. Exploded view of the rotary hoe (Kamal and Oladipo, 2013)

Single Wheel Weeder (2013)

Mechanism of operation

The machine is made up of primary cutting edge and secondary cutting edge. The loosening of the soil is done by the primary cutting edge while cutting and lifting of weeds by secondary cutting edge. The machine can also add fertilizer and seeds to the soil through the funnel. The machine was able to perform tilling, mulching and weeding.

Machine description

The machine can be describe to have cutting edges (primary and secondary), frame, handle and funnel (Figure 22).

Merits

1. The weeder is more efficient compared to hand weeding.
2. It require less skills to operate
3. The cost of maintenance is low

Limitations

1. It has no ability to roll over obstacle.
2. Since the handle can't be adjusted, ergonomics is poor

Scope for future work

1. Lightweight materials can be selected to reduce the weight of the machine.
2. It can be semi-automated.

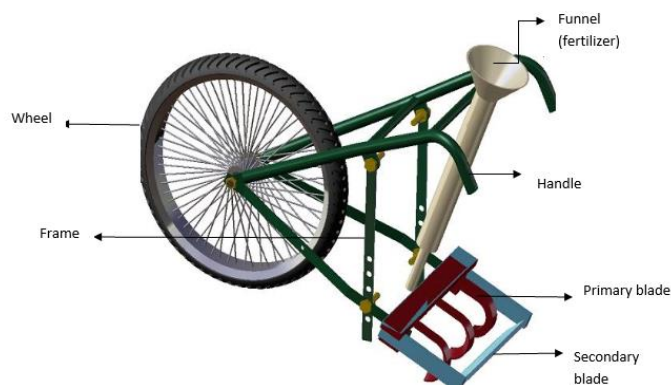


Figure 22. Conceptual ideal (Sridhar, 2013)

Multipurpose weeding machine (2015)

Machine description

Different components of multiple purposes weeding machine are:

i) body ii) prime mover iii) shaft iv) v belt v) pulley vi) director wheel vii) chain sprocket viii) blades ix) safety cover of blade shaft (Figure 23).

Machine mechanism of operation

During the operation of the weeder there is interaction between soil and machine caused by the blades. The geometry design of the blades helps to reduce power required and size of the machine. The electric motor provides the power needed for all the moving parts of the machine. On the flange there are blades attached to a rotating shaft through bolts and nuts. A blade with L-shaped design is economical and efficient as its help to reduce plant damage and weeding cost by 10.88%, with weeding efficiency up to 91%. Hence belt can safely transmit 550.54 kW power.

Merits

1. It will save the total labour cost involved in whole weed removal operation.
2. The weeds can be removed in much shorter span of time.
3. Its environmental friendly
4. The design is compact so that it is capable of removal of weeds from complex places.
5. It will reduce the need for frequent inspection of weeds by farmers.

Limitations

1. Its can only be used on the early stages of the plant
2. Its cannot be used in all type of soil
3. The weeder machine is also self-propelled.

Application

1. Large agricultural fields.
2. Fields with huge quantity of weeds.
3. Labour deficient regions
4. Private lawns



Figure 23. Pictorial view of a multipurpose weeding machine (Pathade et al., 2015).

Double Wheeled Multipurpose Weed Remover (2015)

Machine description

The major components of the machines are chassis, engine, chain, sprocket, handle, blades, seeding box, shaft and wheels (Figure 24).

Machine mechanisms

The weeder is driven by petrol engine to move in forward direction and the blades are attached at rear end of the machine. The engine transmit power to the blade given it strength to cut weeds. The machine works on chain and sprocket mechanism. Motion is transmitted to the wheel through a rotating shaft. The forward direction of the blades attached at the rear end of the weeder turns the soil and removes the un-wanted plant.

Merits

1. There is reduction in labour cost
2. It reduces drudgery

Limitation

1. Weight of the machine is much
2. The time required to assemble the machine

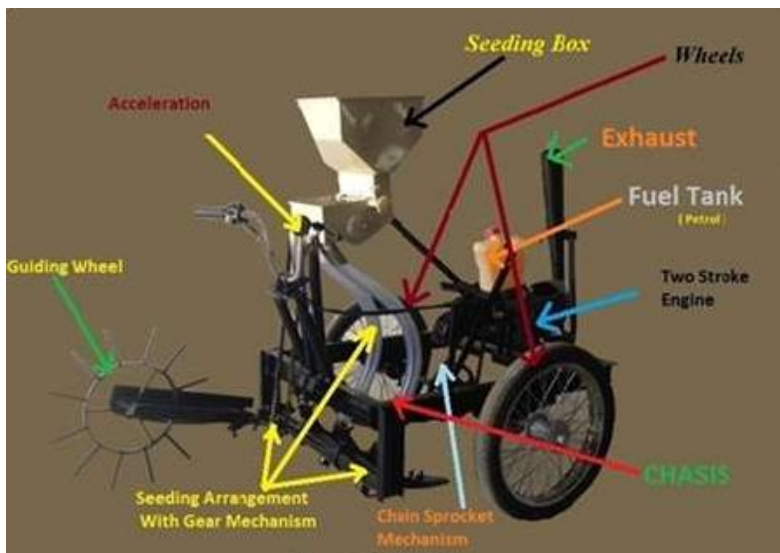


Figure 24. Pictorial view double wheeled multipurpose weed remover (Madhusudhana et al., 2015)

Prototype: A Ridge Profile Mechanical Power Weeder (2017)

Machine Components

The major components of the machine are main frame, rotor shaft, power transmission system, cutting blades, handle and power source.

Description and working of weeder

The power is generated for weeding purpose from ground by using a drum. The drum is mounted on a shaft, which moves when drum moves. A bicycle chain wheel is also mounted on that shaft which is connected to the free wheel, which is mounted on pinion shaft through a chain. So when drum moves the pinion shaft as well as tine mounted on pinion shaft also move with more peripheral velocity due to difference in number of teeth of chain wheel and gear wheel. The rotary blade enables cutting of weeds and

integrating it into soil. The width of coverage of weeder is 30 cm and depth of operation can be adjusted.

Weeding efficiency percentage ranged from 74.47 to 93.89% for different soil-machine parameter combinations (Figure 25).

Merits

1. It's easy to operate and maintain i.e. its cost effective
2. The movement of the machine is controlled by the operator
3. Helps in saving energy

Limitation

1. The machine can't work for a longer period of time because of manpower
2. It's not self-propelled
3. The work rate is dependent on the operator

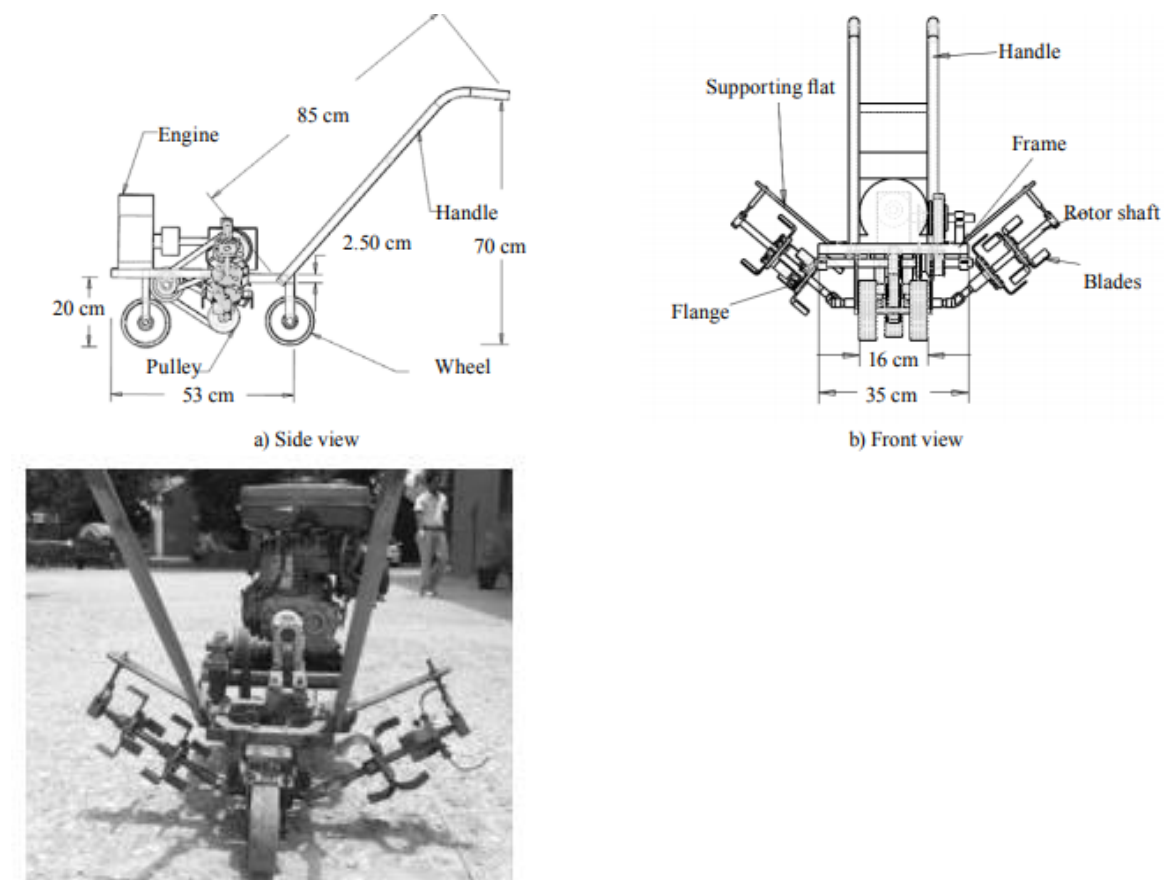


Figure 25. Developed prototype of ridge profile power weeder (Thorat et al., 2017)

Intra Row Weeder in Soil Bin (2019)

The developed machine was evaluated in the laboratory for the plant damage at different operating conditions. The evaluation was done in soil bin unit at Farm Machinery and Power Engineering department of College of Agricultural Engineering and Technology, Junagadh, India. The evaluation was conducted after creating an appropriate field condition. The soil bin unit was prepared in such a way that it could assist in computing the performance of developed automated intra row weeder.

Soil bin utilized for testing was rectangular in cross section having the area of 24 m² with soil fill. The soil bin module consists of a tool carrier, trail, variable speed motor,

rope drum unit and speed controller. The soil fill was perfectly levelled and seed bed condition was created by removing soil clods and stones. Tool carrier was held over a trail and was driven by rope drum unit through variable speed motor. The already existed tool carrier was attached with a frame to carry unit of developed automated intra row weeder as shown in the Figure 18. A 20 hp variable speed motor with speed control system was used to drive the tool carrier through rope drum unit over the trail. Speed of the tool carrier was varied by varying the speed of the motor using speed control knob on the control panel (Figure 26).

Merits

1. It's easy to operate (automation) in a controlled environment
2. The movement of the machine is controlled by the precision
3. Helps in new inventions on field operation

Limitation

1. The machine can't work for a longer period of time
2. It is self-propelled
3. The work rate is dependent on the operator



Figure 26. Laboratory setup and replant in the test track of soil bin (Jakasania et al., 2019)

CONCLUSION

In crop production weed management is a key operation involving high techniques as removal of weeds is costly and hard to accomplish. In this research, mechanical weeder has shown to be evolving in design, principle and mechanism over the years reviewing merits, demerit and limitations. Such findings reveal that much work is still needed to be done by researcher especially in Africa.

DECLARATION OF COMPETING INTEREST

The authors declare that there are no conflict of interest.

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

Adewale Moses Sedara contributed to the manuscript in conceptualization, investigation writing original draft and review.

Oluwadunsin Seun Sedara contributed in the aspect of editing.

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