Training Manual for Two-wheel tractor and ancillary equipment for operators, service providers, extension experts and workshop owners

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Africa- RISING Project

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Background

Mechanization is a term used to describe tools, implements and machinery applied to improve the productivity of farm land and labour force, including crop processing after harvest. Mechanization covers broadly the entire process of on and off farm operations and mechanization may use either human, animal or motorized power, or a combination of these. In practice, therefore, it involves the provision and use of all forms of power sources and mechanical assistance to agriculture, from simple hand tools to draught animal power and to motorized power technologies. In Ethiopia, smallholder farming experiences high drudgery at all stages of crop husbandry and post-harvest processing. Field operations are performed using human and animal power (Mrema et al., 2008). Smallholder farmers without animal power use a lot of human power on crop husbandry and harvesting operations (Daum et al., 2020). Post-harvest threshing and shelling are performed using human power but, in some countries like Ethiopia, farmers use livestock (cattle, donkeys and horses) for wheat, barley and teff threshing (Mohammed and Tadesse, 2018). The use of tractor power is low in Ethiopia and the government aims to increase farm power available to Ethiopian farmers 10 folds (from the current 0.1 Kw ha^{-1} to 1 kW ha^{-1}) by 2025, with at least half of this power is derived from fossil fuel and electric engines.

The government of Ethiopia aims to increase farm power using two-wheel tractors on smallholder farms in addition to four-wheel tractors that are already in use. Two-wheel tractors are sources of power designed to perform most field operations. Due to the size of two-wheel tractors, they have become an economic alternative for smallholder farming. In addition, two-wheel tractors are also more productive than animal traction and they require less time for attendance and preparation, giving the individual farmer more independence and contact with modern technology. Also, due to their simple design, local manufacturing of two-wheel tractors has been implemented in several countries successfully, increasing employment opportunities in the process.

Forward

The benefits of mechanization are well documented, it increases timeliness of operations (field & beyond), precision, efficiency and productivity. Mechanization is one of the three elements (1. seeds, 2. crop protection and nutrition and 3. mean/tool to apply 1. & 2. points, obviously mechanization) contributing equally to crop productivity at field and beyond. However, due to misunderstanding and misinterpretation, mechanization was seen in Africa as job killer in rural areas and mostly associated to tractorization.

Furthermore, agricultural mechanization shall be viewed in addressing capacity, skills and knowledge development in the two following value chains to be successful: i. crop and livestock productions and processing (post-harvest) and ii. manufacturing, supply, delivery and aftersales infrastructure establishment. Attention to agricultural mechanization has increased in the last 10 years. This is seen by a range of new engagement from national government, international donors, development agencies and research organizations including CIMMYT through the implementation of Africa Rising funded project on ‘Scaling out small scale mechanization in the Ethiopian Highlands’. The findings from Africa Rising are disseminated

within sectorial stakeholder landscape through field days, workshops, demonstrations, training and capacity development, exposure and experience visits at various event occasions. However, to ensure sustainability, this manual is documenting the generated knowledge, structured to train and learn based on modules. It is advised for the training to have units of 2WT and if possible one of each implement described in each module for a better knowledge uptake and a practical training under real living conditions. We hope this manual will find its use and the targeted groups can benefit from its contents.

Who should use the manual?

This manual is targeting:

- Individual owners and operators
- Worreda extension agents in place, where mechanization is introduced
- Private service providers
- Private mechanic and maintenance/repairs workshops owners at worreda level

Mechanization Module Overview

This module is designed to be used by two-wheel tractor operators, service providers, worreda extension agentss or private mechanic and maintenance/repairs workshops owners. The topics in each module are divided into three general sections: aim, overview, and technical aspects of two-wheel tractor and ancillary equipment. The module is for operators of two-wheel tractors and their attached equipment. The user is advised to read and understand the instructions for operating each equipment. When not sure about how to operate any equipment, the operator is advised to get support from the agricultural mechanization experts based at the nearest Woreda or zonal office in their area.

Learning Objectives

The main objective of the manual is to support the target groups familiarize with agricultural mechanization machinery and equipment which have been identified as appropriate, profitable and accepted by both small holder farmers and service providers. These equipment/machineries have been the result of Africa Rising intervention in the Ethiopian highlands. Other specific objectives might include i. develop capacity and knowledge for starters and practitioners; ii. Give perspective to rural youth looking for business opportunities and jobs; iii. Promote agricultural mechanization at the last mile in rural areas; iv. Support mechanization service providers; and v. linking service providers to importers/dealers, manufacturers and local micro finance institutions.

At the end of this module, operators, service providers, worreda extension agents or private mechanic and maintenance/repairs workshops owners will be able to:

1. Identify appropriate two-wheel tractor equipment suitable for the rural farmers,
2. Drive a two-wheel tractor and operate the ancillary equipment.
3. Conduct pre-use checks on the two-wheel tractor and attachments,
4. Maintain two-wheel tractor and its ancillary equipment,
5. Safely store two-wheel tractor and its ancillary equipment after use.

Pre-Learning Assessment

1. List the difference between two- and four-wheel tractors?
2. What are the other names given to a two-wheel tractor?
3. List the equipment that can be pulled by a two-wheel tractor during farm operations.
4. What is the first thing you do before operating a two-wheel tractor and its attachments?
5. What are the safety precautions needed when using a two-wheel tractor and its attachments?
6. Describe how you protect yourself when using a two-wheel tractor and its attachments.
7. Explain the importance of cleaning equipment after use.
8. How do you safely store two-wheel tractor and its equipment after use?

Module 1: Two-Wheel Tractor Based Technologies

Aim: At the end of this module, operators, service providers, worreda extension experts or private mechanic and maintenance/repairs workshops owners of two-wheel tractors will be familiar with the tractor and the different equipment/attachments that it uses to support or deliver mechanization services to smallholder farmers.

Overview

Low horsepower (8-20 horsepower) two-wheel tractor mechanization technologies include conventional plough; direct planter which plants maize and wheat into unploughed soil; reaper harvester for wheat and barley; thresher for wheat, barley and teff; sheller for maize; water pumping; and trailer for transportation. This equipment is now locally available in Ethiopia and can be used in the maize and wheat growing parts of the country.

Technical aspects

Two-wheel tractor

Conventional plough

Wheat planter

Maize planter

Reaper harvester

Wheat thresher

Maize sheller

Water pump

Module 2: Two-Wheel Tractor Use and Handling

Aim: At the end of this module, operators, service providers, worreda extension experts or private mechanic and maintenance/repairs workshops owners will know the different parts of a two-wheel tractor and how to operate the tractor correctly and safely.

Overview

Machines need technical knowhow to use and operate them. The most important features involving machines is their handling. Good handling practices are very important for the successful operation, safety of the machine and that of the operator, and the useful life of the machine. Therefore, this module focuses on the main use and handling features that need to be considered before and after operation of a two-wheel tractor.

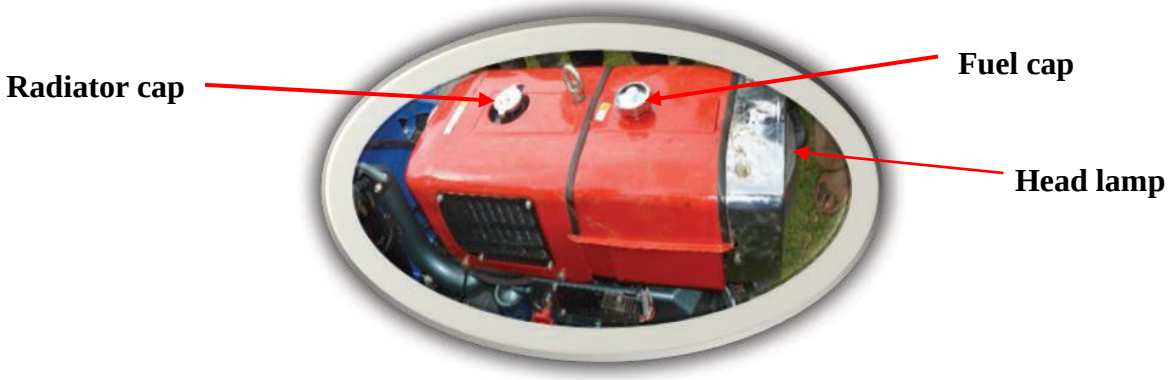
Technical aspects

Important Definition: The two-wheel tractor is given many names, and these are:

- Power tiller
- "walk-behind tractor
- iron-ox
- walking tractor
- mechanical ox
- ox-machine
- pedestrian tractor
- hand tractor
- single-axle tractor

Checking coolant level

Check coolant level by opening radiator cap counter clockwise and top up with a radiator coolant specified by the manufacturer with the specified volume if level is low (most of the standard two-wheel tractor engines require about 5 litres). Depending on the users' manual, it is important to drain the coolant and refill according to the manufacturer's specifications.



Checking fuel level

Check fuel level by opening the cap and top up. Never try to start the engine if the fuel level is too low, as air will enter into the fuel system and the engine will not start. Therefore, please

always check the fuel level every morning before starting the engine. Add fuel to the fuel tank as needed. If you are not sure about the type and grade of fuel to use, seek help from the mechanization expert at the nearest woreda office. Put the two-wheel tractor in an open area. Stop the engine and lock the brake. Clean the fuel cap and the area around the fuel cap to prevent dirt from entering the fuel tank. Remove the cap from the fuel tank. Fill the fuel tank. Be careful not to spill the fuel. Install the cap on the fuel tank and tighten. Clean up any spilled fuel before starting the engine.

Attention!! Do not remove the fuel strainer while filling. The main purpose of the strainer is to pre-filter unwanted materials such as dirt, fine crop residues such as straws, sand or any foreign material not to enter the fuel system.

Attention!! Fuel is very flammable especially if the engine is gasoline. Keep fuel in a clean and tight container. Keep fuel away from fire or heat. Never put fuel in the fuel tank while the engine is running or hot. Clean up any spilled fuel before starting engine. Remember also to identify the fuel and water caps so that fuel will not be filled in the radiator and vice-versa.

Checking the engine oil

Check the engine oil daily prior to use. IMPORTANT: Never operate the engine with the oil below the low mark on the dipstick. Seek help from the mechanization expert at the nearest woreda office if you are not sure of anything during this process.

Before checking the oil level:

- Move the two-wheel tractor to a level ground.
- Clean around the dipstick and filler tube to prevent dirt from entering the engine.
- Remove the dipstick and wipe off the oil on the depth stick.
- Put the dipstick back into the engine and remove again.
- When the dipstick is removed, note the oil level. Oil should be between the full and low mark.
- Put the dipstick in its place again.
- If required, for diesel engines use 15W40 oil and for gasoline engines use 15W30 oil. Do not overfill.
- Clean up any spillage that may have occurred.

Removing the dipstick to check engine oil

Checking engine oil level

How to Operate a Two-Wheel Tractor?

Two-wheel tractor operation requires skill on how to operate. Without proper training, operation of two-wheel tractor might be dangerous and will expose the user to an unnecessary injury. Thus, it is very important to know how to operate a two-wheel tractor before attempting to do so. Before starting a two-wheel tractor, there are certain things to be checked. The following are the mandatory checks before starting the engine of the two-wheel tractor:

1. Check oil level by using dipstick as shown in the pictures below.
2. See the level of the dipstick. It should be between the upper and the lower marks.
3. Never exceed the recommended level while filling oil.

Other important check-ups before starting the engine

1. Check the belt tension. Push the belts firmly with your right thumb at the centre. If the distance is too much it needs tightening but if it is not, it does not need any adjustment.
2. Check tire pressure visually.

Tractor Starting Steps

To start a two-wheel tractor, there are two options:
1. Using starter battery/key.
2. Using mechanical crank handle/manually (*the crank handle is supplied with the two-wheel tractor maintenance kit*).

Before starting the engine:

- Make sure that you engage the gear to neutral. If the gear is not neutral, the crankshaft of the engine cannot rotate so that it will be tough for an operator to start.

IMPORTANT: Never operate the engine with the oil below the low mark on the dipstick.
See the engine manual for oil specifications and oil filter service instructions.
To check oil level:

1. Move the 2WT to level ground.
2. Clean around the dipstick and filler tube to prevent dirt from entering the engine.
3. Remove the dipstick and wipe off the oil on the depth stick.
4. Put the dipstick back into the engine and remove again.
5. When the dipstick is removed, note the oil level. Oil should be between the full and add mark.
6. Put the dipstick in its place again.
7. If required, add 5W40 below 40° according to the manual depending on the type of engine. For diesel engines use 15W40 and for gasoline engines use 15W30. Do not overfill.
8. Clean up any spillage that may have occurred

✓ Check water level by opening radiator cap top up if level is low

Radiator cap

Fuel cap

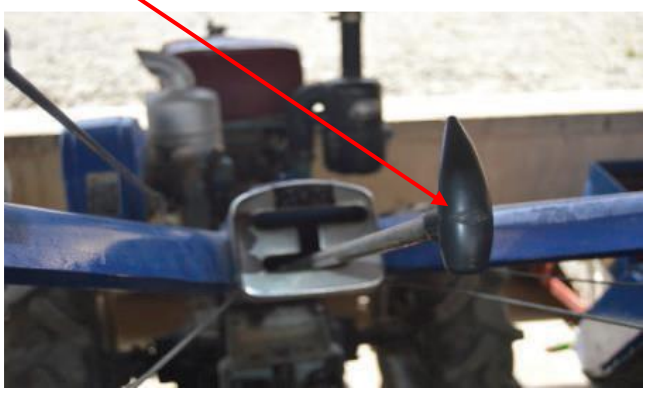
Check fuel level by opening the cap and top up. Never try to start the engine if the fuel level is too low, air will enter into the fuel system and the engine will not start. Therefore, please always check the fuel level every morning before starting the engine. Add fuel to the fuel tank as needed. See your engine manual for the correct type and grade of fuel. Put the 2WT in an open area. Stop the engine and lock the brake. Clean the fuel cap and the area around the fuel cap to prevent dirt from entering the fuel tank. Remove the cap from the fuel tank. Fill the fuel tank. Be careful not to spill the fuel. Install the cap on the fuel tank and tighten. Clean up any spilled fuel before starting the engine.

Use caution with fuel. Fuel is very flammable. Keep fuel in a clean and tight container. Keep fuel away from fire or heat. Never put fuel in the fuel tank while the engine is running or hot. Clean up any spilled fuel before starting engine. Remember also to identify the fuel and water caps so that fuel will not be filled in the radiator and vice versa.

- ✓ Check the belt tension. Push the belts firmly with your right thumb at the centre. If the distance is too much it needs tightening but if it is not, it does not need any adjustment.
- ✓ Check tire pressure visually
- ✓ Check oil in the air cleaner reservoir. The oil level in the reservoir might be low and if also may have dirt in it. Please check the condition of the oil by simple visualization and by your right hand. It can be changes if it is too dark in its colour and if it has dirt in it. Refer the user's manual or check and read the label on the air cleaner housing.

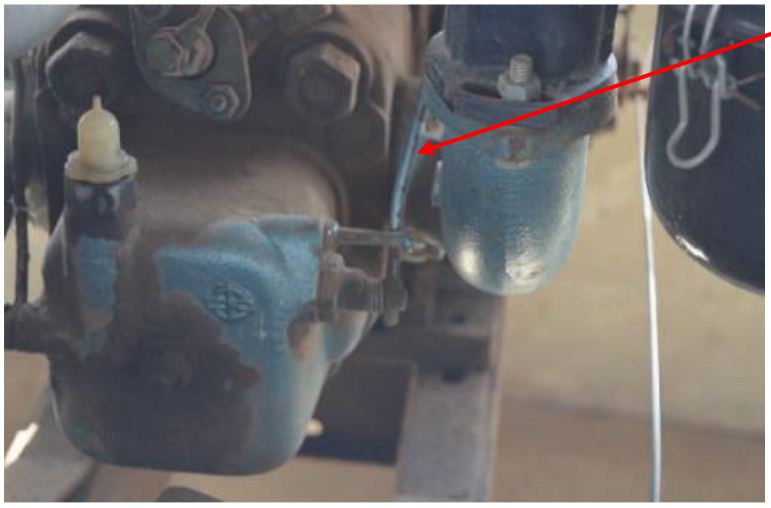
Gear shifting lever

Steering clutch



- Disengage the Clutch/Brake lever to brake position by using your left hand.

Decompression knob



Step in starting:
Move the throttle knob to half/turn it to the left. Press the decompression knob. The purpose of the decompression knob is to let out/allow the compressed air from the combustion chamber in the cylinder so that the operator will feel easy on his hand while starting. This allows the operator to start the engine without extra effort being needed.

- Engage the manual cranking tool into the right side of the insertion plug on the injection pump.

Insertion plug

Manual starting

Electrical starting

- Rotate clockwise gradually and to a higher rotation while pressing the decompression knob until you feel the engine has reached its starting revolutions per minute *(rpm*).
- Now quickly remove your left hand from the decompression knob and un-plug the cranking tool from its position by using your right hand.
- If the engine starts, reduce the throttle knob to idle position. There is no indication in the knob but you can feel the sound of the engine, not too loud not too quiet.

Forward Driving

1. The gear was in the neutral position when the two-wheel tractor is started, now you should select first or second gear depending on your desire.
2. There are two options/low and high gear.
3. To select high gear, pull the lever upwards, for low gear push the lever down.
4. Engage the gear-shifting lever to 1st gear.
5. Increase the throttle gradually.
6. Engage the clutch/brake lever to its forward position.
7. Now the two-wheel tractor should start moving forward.
8. If you want to shift the gear to 2nd, disengage the clutch/brake lever to its backward position and shift the gear to 2nd gear.

Steering

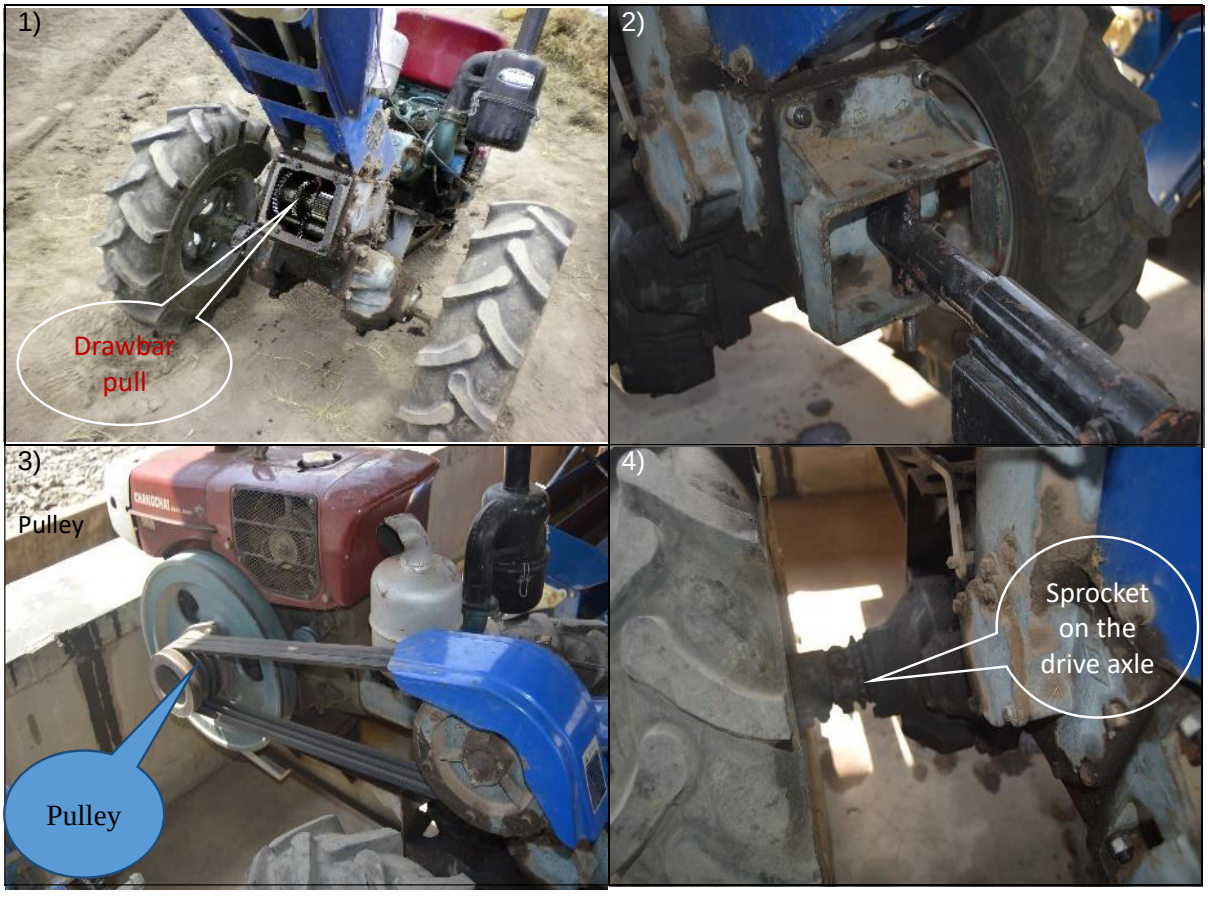
There is no circular steering wheel in a two-wheel tractor, like in a vehicle (car). Instead, the levers/clutches/in the right and left handles act as a steering wheel.

1. To turn to the left, the left lever should be pulled.
2. To turn to the right, the right lever should be pulled.

Attaching ancillary equipment to 2WT

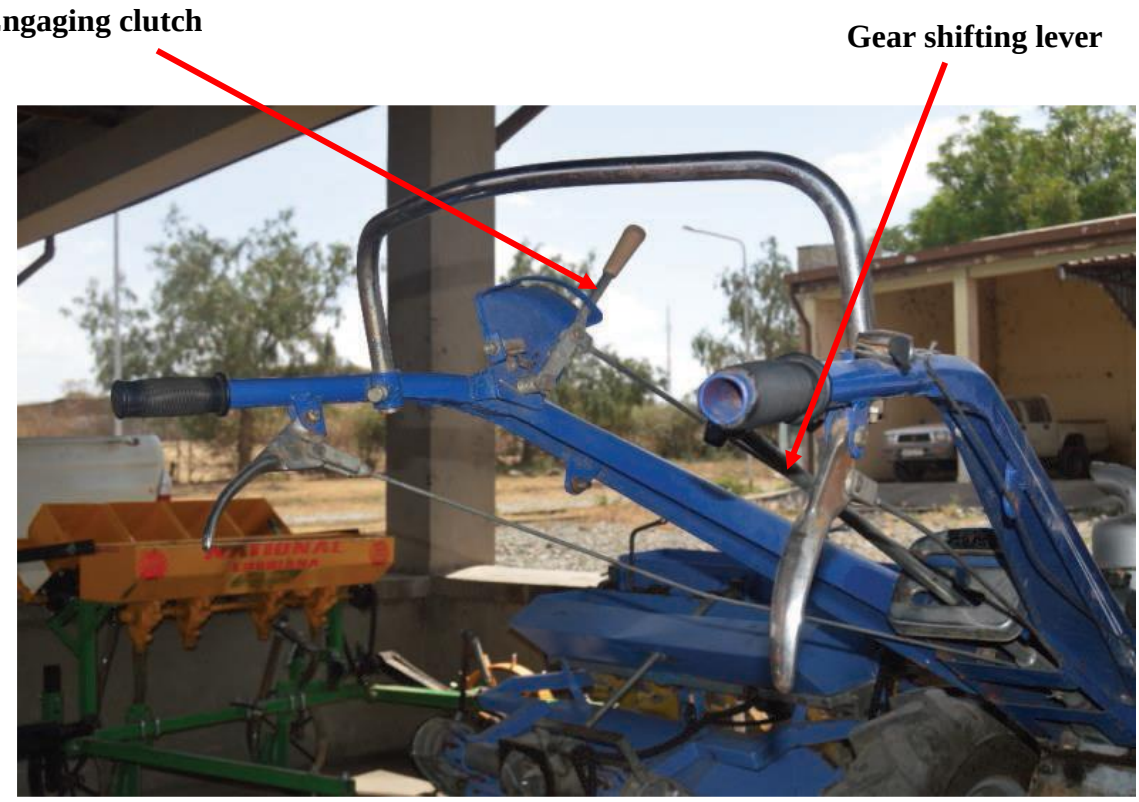
The 2WT is a multi-purpose tractor which can handle a lot of tasks if appropriate ancillary equipment is attached properly. There are four ways to get a desired power/pull from the 2WT.

1. Through direct assembly to the drawbar
2. Through a pin to the drawbar
3. Through a v-belt on the pulley
4. Through a sprocket on the driving axle



Please note: that all of the attachments should not be done at once. Depending on the operation, it is essential to make the decision to attach. For example, a 2WT with a harvester cannot attach a pump simultaneously. It is important to put the activity priority before making an attachment so that the downtime will be reduced

Directional Reference: All reference to left, right, front, or rear are given from the operator's position, where the operator is positioned and facing the direction of forward travel.



Storage of Two-Wheel Tractor after Use

- Keep the tractor in a shed when not in use,

- Keep the tractor dry and protected from rain and direct sun,
- If a shed is not available, a tent can be used to cover the tractor and its equipment,
- Do not use a plastic cover a tractor and its equipment, it is not recommended,
- Do not store the 2-wheel tractor: in damp rooms; in rooms in which artificial fertilizer is stored, or in stables or adjacent rooms as this will lead to severe corrosion,
- If the tractor is not to be used for a longer period, clean it thoroughly, repair any paint damage and spray bare parts with anti-corrosion oil,
- **Conserve the engine** (change the oil); when doing this, remove the spark plug and pour 1 to 2 teaspoons of motor oil into the spark plug aperture. Turn the engine over slowly several times. Screw in the spark plug. Turn the engine over until there is compression (valves are closed). Turn the engine over slowly every 4 - 6 weeks (pull off the spark plug cap beforehand),
- Jack up the **driving wheels** so that the tyres are not resting on the ground. Pneumatic tyres become unusable in a very short space of time if they are left under load without air in them,
- Close the petrol tap if the machine is left to stand for longer periods of time.

Module 3: Direct Seeding Planters

Aim: At the end of this module, operators, service providers, worreda extension experts or private mechanic and maintenance/repairs workshops owners will know the components of maize and wheat planters, and how to drive a two-wheel tractor mounted with maize and wheat planters.

Overview

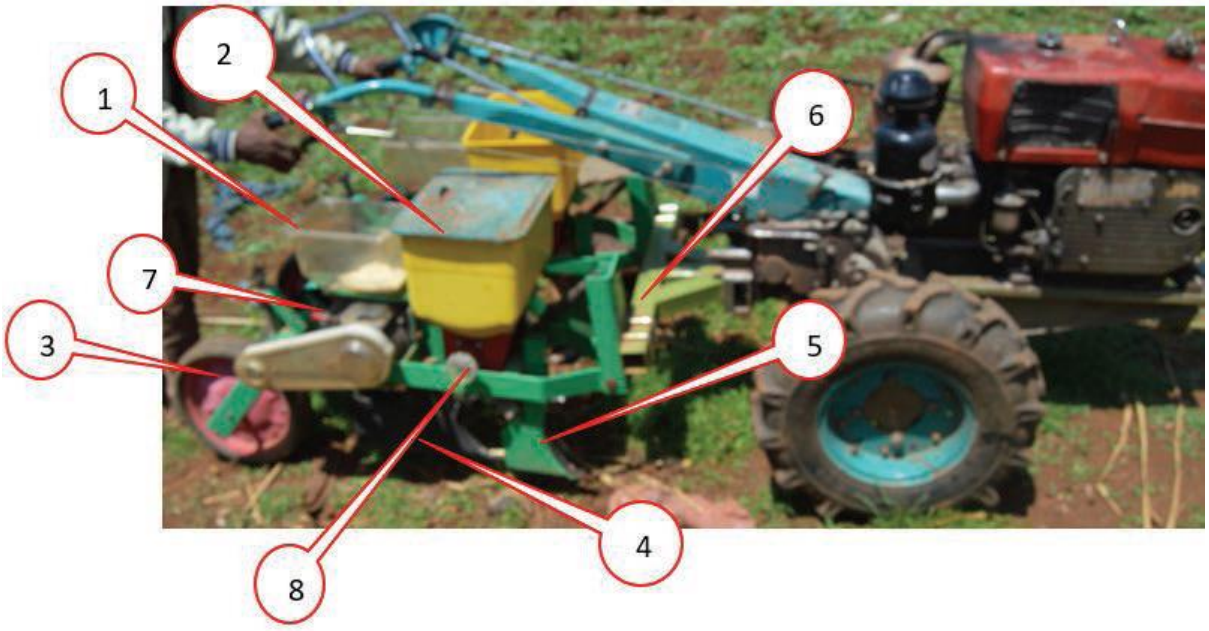
The direct seeding planters reduce human labour required to till the soil, plant seed, and place fertilizer during planting in the field. Planting is fast and reduces time required to complete the field operation. In addition, the planters increase precision of seed and fertilizer placement in the soil, and this promotes high yields of crops at the end of season.

Technical aspects

Definition*:* Direct seeding is the process of planting crops and applying basal fertilizer without first tilling the soil.

Components of a Minimum Tillage Maize Planter

For proper maize planting, it is important to understand each part of the planter and how it functions properly. This minimum tillage maize planter consists of seed hopper, fertilizer hopper, seed metering units, furrow opener, toolbar and drive wheel.



Major parts of maize planter - **1:** Seed hopper, **2:** fertilizer hopper, **3:** drive wheel, **4:** furrow opener for seed, **5:** furrow opener for fertilizer, **6:** toolbar, **7:** metering unit speed adjusting gearbox.

Operation Principles

This two-wheel tractor attached maize planting machine operates with the power obtained from the rotation of a sprocket mounted on the drive wheel. As the tractor starts to move forward, the sprocket on the drive wheel starts to rotate. The sprocket on the drive wheel is connected to three different sprockets on seed metering shaft, fertilizer metering shaft and gearbox attached on the seed metering unit through a chain. Then, the shaft on the seed metering unit, fertilizer metering unit and gearbox will rotate, which in turn rotates the inclined seed metering plate, fertilizer fluted roller and seed metering unit gears in the gearbox, leading to the seed and fertilizer metered to be delivered into the seed and fertilizer outlet. The operator of the tractor walks behind the planter during the planting process.

Seed and Fertilizer Hoppers

The seed and fertilizer hoppers are made of plastic material. The hopper is part of the planting machine in which the seed to be planted and fertilizer to be applied are kept before their gradual release into the furrowed tunnel through hose during operation by metering unit. The amount of seed and fertilizer contained depends upon the rate recommended by agronomist and the number of refilling per hectare which determine the size of the hopper.

Seed and fertilizer hoppers.

Drive Wheel

Drive wheel of the planter.

The drive wheel is attached at the back of the metering unit's front bar frame. The function of drive wheel is to transmit power to the seed. The depth of operation can be adjusted by tightening or loosening of the spring-loaded vertical stud/bolt. Sprockets are attached to the drive wheel and to the driving shaft which are connected through the chain.

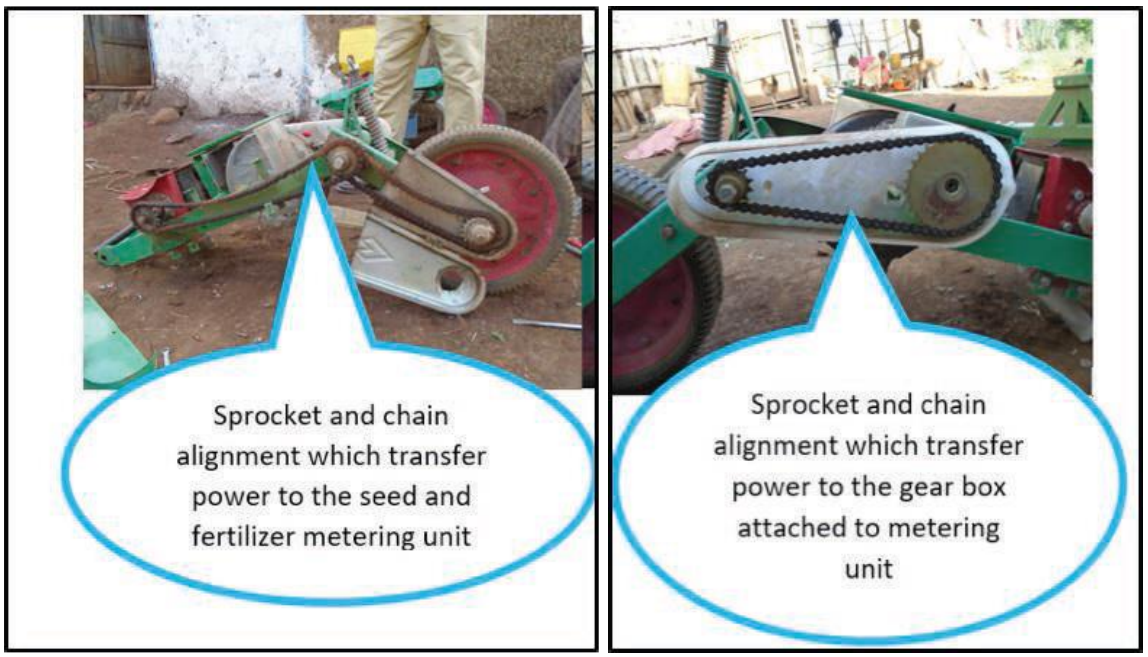
Furrow Opener

Furrow openers are attached to the lower portion of the frame which are used to make furrow at which the seed to be planted. There are two furrow openers (one for seed and one for fertilizer) that are separated by around 5 cm horizontally to prevent them from coming into contact with each other. As the furrow openers make furrows, the seeds and fertilizers come into the furrow opener separately through seed and fertilizer delivery pipes and drops the seed and fertilizer in the soil at 5 cm parallel distance. When the cutting portion of furrow openers (point of share) is worn-out, we can replace it by removing the worn-out part by using screwdriver. It is attached to the frame with nuts and bolts. The quality of material used to make the furrow openers will ultimately decide the operational quality and durability of the furrow opener. Single boot is provided behind each furrow opener to receive a tube (steel ribbon tube) each to host seed and fertilizer delivery hose.

Furrow opener, the green one is furrow opener for fertilizer while the black one is for seed.

Metering Unit

The major seed and fertilizer metering unit and its delivery system consists of a rotary, a seed metering plate and fertilizer fluted rollers, three hexagonal shafts, four sprockets of different sizes, three chains with different lengths, seed rate adjusting/control lever, fertilizer rate adjusting knob and driving wheel. The performance of a planter highly dependent on the proper functioning and calibration of metering unit and delivery system.



Seed metering mechanism and its components.

Mounting the Planter to Two-Wheel Tractor

Before mounting the planter, select a levelled surface. At least three persons are required to carry and mount the planter on two-wheel tractor.

1. Two persons (*one on the left and one on the right*) carry and mount the planter.
2. Align the tractor drawbar pull cover and the planter tool bar hole.
3. Slightly lower and raise the two-wheel tractor until the hole is aligned.
4. If the hole on the draw bar pull cover is aligned with the three holes on the tool bar, insert the middle pin first and then insert the rest two pin respectively.
5. Insert the cotter pin in each pin.

Calibration for Seed and Fertilizer

1. Attach transparent polythene bags to each of the four seed delivery tubes.
2. Operate the planter on a pre-measured 50-meter travel distance
3. After every 50-meter linear distance run, collected seeds should be counted and fertilizers in transparent polythene bags should be weighed separately, using calibrated digital balance and the total fertilizer weight should be also noted.
4. Repeat this method by varying the gears on the seed metering unit, fertilizer adjusting knob and seed rate adjusting/control lever until the desired rate is obtained.

5. Check that all chains are well greased and are free for smooth operation.
6. Check that the clutch is free and working well.
7. Check that all seed and fertilizer tubes are free and not blocked.
8. Check that fertilizer fluted rollers are clean and free of all old, caked fertilizer and dust.

Using the Maize Seeder

Once the planting machine is mounted, the next step will be to check whether the planter works properly or not. Caution! Please go through all the necessary check-ups before starting the tractor. Consult a mechanization expert at the woreda office if you have any doubts. The next step will be to apply grease on the gears inside the seed metering gearbox.

1. Check that all chains are well greased and are free for smooth operation.
2. Check that the clutch is free and working well.
3. Check that all seed and fertilizer tubes are free and not blocked.
4. Check that fertilizer fluted rollers are clean and free of all old, caked fertilizer and dust.

Components and Description of Minimum Tillage Wheat Planter

Versatile multi-crop planter (VMP) is a planter which can do the planting operation with a drilling and precision planting options. The main source of power for this planter is two-wheel tractor greater than 12 horsepower.

1: Seed box, 2: Fertilizer box, 3: Seed delivery tube, 4: Toolbar frame
5: Fertilizer delivery tube, 6: Depth contoroller, 7: Press roller, 8: Furrow opener

Operating the VMP

1. Start the engine of the two-wheel tractor and engage the rotavator lever, drive forward and observe the rotation of the blades. If the blades are not rotating, check the engaging lever of the VMP.

2. Engage it and check.
3. Now if the blades are working properly, the next step is to check whether the metering units of both seed and fertilizer work properly or not.
4. Engage the seed metering lever which is located in front of you (see the figure).

Drive the two-wheel tractor forward and observe the metering discs and metering shafts. If they are rotating the metering mechanisms are working properly. If not, check the chain and sprockets.

Calibration

Seed rate

To calculate the seed rate per meter for a certain crop, we need to know the seed rate per hectare and the number of rows per hectare. The following step will be to calculate the rate per row per meter as per the procedure below:

i. Determine the nominal width (W) of seed drill
   W = M x S,
   Where M = Number of furrow openers, and S = Spacing between the openers, m
ii. ii. Find the length of the strip (L) having nominal width (W).
   Suppose we have 1 ha of area
   We know 1 ha = 100 m x100 m=10000 m2
   L*W= 10000 L = 10000/W, meter
iii. Determine the number of revolutions (N) of the ground wheel of the seed drill required to cover the length of the strip (L)
   L = P x D x N = 10000/W
   N = 10000/P x D x W revolutions per minute
iv. Jack the seed drill so that the ground wheels turn freely. Make a mark on the drive wheel and a corresponding mark at a convenient place on the body of the drill to help in counting the revolutions of the ground wheel
v. Fill the selected seed in the seed hopper or plastic bags. Place a container under each boot for collecting the seeds dropped from the hopper
vi. Set the seed rate control adjustment for maximum position and mark this position on the control for refence
vii. Engage the clutch and rotate the ground wheel for N = 10000/P x D x W, revolutions per minute
viii. Weigh the quantity of seed collected in the container and record the observation.
ix. Calculate the seed rate in kg/ha
x. If the calculated seed rate is higher or lower than the desired rate of selected crop, repeat the process by adjusting the seed rate control adjustment till the desired seed rate is obtained.
   (a) Measure the ground wheel diameter ‘cm’
   (b) Measure the number of furrow openers
   (c) Measure distance between two openers ‘cm’
   (d) Perimeter of ground wheel P = π D
   (e) Width of implement W = 1.2 m Let us use Diameter D = 40 cm

Give one revolution to the ground wheel
Area covered/revolution of ground wheel
= πDW
= 3.14 x 1.2 x 0.40
= 0.15072 m2
Recommended seed of wheat = 100 kg/ha.
10000 m2 - 100 Kg
0.15072 m2 - 100 /10000 X (0.15072)
= 0.005072 kg for a single revolution
If number of furrows to be sown simultaneously, say 6.
Seed to be dropped by each furrow opener per revolution of ground wheel
= 0.005072/6
= 2.512x 10-4 kg 6 As this is not measurable quantity Calculate seed dropped in 200 revolutions 2.512x 10-4 kg X 200 = 50.24 gm

Therefore, an operator, service provider, extension agent needs to know how to calibrate a seeder before conducting planting/seeding operation.

The next steps should be followed for seed drilling.

1. After getting the rate per row per meter of certain crop seed rate, use a plastic tape and measure 30 meters and make a mark as shown in the figure below.

2. Tie plastic bags on the seed delivery tubes so that the seeds will be collected for counting or weighing depending on the type of crop to be sawn.

3. Start the engine, engage the forward gear drive until the 30-meter mark.

4. Collect all plastic bags and weigh or count. If there is a need to increase the seed rate, loosen the bolt and nut of the seed metering adjustment as shown in the figure.

Fertilizer rate

Use the same steps above for calibrating fertilizer rate. The metering mechanism adjusting lever is located in between the fertilizer hopper and the seed hopper.

Row spacing

1. Row spacing need to be adjusted according to agronomic recommendations and depending on the type of crop to be sawn.
2. Add or remove number of furrow openers with seed delivery pipes. In the case of drilling, shut off the metering inlets with a rectangular transparent plastic provide with the machine.
3. Simply rotate the screw clockwise so that it will firmly close. Removing the fertilizer delivery pipes may not necessarily close the system. A plastic masking tape may be needed to firmly close the inlets of both fertilizer and seed metering system. **Caution**: Check whether the openings are firmly closed to avoid wastage of seed and fertilizer.
4. Width of planting is adjusted by increasing or decreasing the width between furrow openers.

- Determine the number of rows (from agronomic recommendations for the seed to be sown), for example if we are going to sow a wheat (let us say the row spacing is 20 cm) install the four furrow openers supplied with the VMP. If the seed is maize and row spacing is 75cm, remove the two central furrow openers and measure the distance between the remaining furrow openers and adjust if necessary.
- Loosen the four U- bolts for each furrow opener, increase or decrease the horizontal spacing depending on the agronomic recommendation of the crop to be sown.

Depth of Planting

Depth of planting is adjusted by increasing or decreasing the height of the furrow opener.

1. Determine the number of rows (from agronomic recommendations for the seed to be sown), for example if we are going to sow a wheat (let us say the depth of planting is 3 cm) install all the four furrow openers supplied with the VMP. If the seed is maize and depth of planting is 5 cm, remove the two central furrow openers and measure the distance between the remaining furrow openers and adjust if necessary.

2. Loosen the four U- bolts for each furrow opener, increase or decrease the vertical spacing depending on the agronomic recommendation of the crop to be sown.

3. Finally run the VMP and fine tune the results according to the recommended values.

Safe Storage of Planters

Before storing the planters for any length of time:

1. Clean each part of the machine.
2. Ensure seed and fertilizer boxes are completely empty.
3. Reapply grease to the sprocket and chain.
4. Store the planters in a dry, well-ventilated room.
5. Keep the appropriate tools with the machine during storage to ensure that they will be available when needed again.

Upon successful completion, the trainees will be able to:

• Explain and know 2WT attached seeder general feature, learn how to handle and use the 2WT attached seeder (2BFG-100) appropriately

• Explain and know the need to use a 2WT attached seeder and calibration properly and the proper handling of the 2WT attached seeder

• Identify the key pre-and post-operation handing issues in 2WT seeder

Module 4: Reaper Harvester, Thresher and Sheller

Aim: At the end of this module, operators, service providers, worreda extension experts or private mechanic and maintenance/repairs workshops owners should be able to use a two-wheel tractor powered wheat harvester and thresher, and maize sheller.

Overview

Harvesting wheat is done manually and takes a long time to complete. Threshing and shelling of crops are the most important farm operations which are time consuming and labour

intensive. It is estimated that harvesting and threshing of crops consume about one third of the total time requirement of the crop production system. The total labour requirements for harvesting/threshing of cereals/ pulses ranges between 120 and 200 man-hours/ha.

Technical aspects

Definitions

Threshing is breaking grain free from other plant material by applying mechanical force that creates a combination of impact, shear, and/or compression. The operation refers to separating threshed grains from bulk plant material such as straw.

Shelling is a postharvest operation that removes maize grain from the cob.

Parts of a Wheat Reaper Harvester

A front mounted vertical conveyor reaper is a common reaper to harvest wheat and barley crops. It can also be used for harvesting of soybean and other similar crops. Engine operated reaper can be operated with a two-wheel tractor engine. Width of cut is about 1.6 m in two-wheel tractor reaper. Two-wheel tractor front mounted vertical conveyer reaper can cover about 0.2 ha/hr.

Parts of a Wheat Thresher

Parts of a Maize Sheller

Starting and Running a Thresher/Sheller

Step 1: Ensure that all the security bolts on the concave are tightened down and the concave is snug.
Step 2: Rotate the threshing drum by hand to make sure that there are no restrictions to rotation.
Step 3: Insert the belt to the pulley in the drum and on the engine.
Step 4: Make sure that the belt is aligned to avoid belt slipping.

Step 5: Start the engine with a cranking button/key (depending on the method of starting for different engines)

Step 6: Slide the engine with handle pulley up on the slide to tension the belt (remember to only tension the slack side of the belt) and make sure that the belt is seated properly in all pulleys and is not rubbing on anything. All set screws on the pulley should be tightened and the nuts on the idler should be wrench tightened. (**Caution:** un-tightened pulley may fly and can cause serious fatal injuries).

Step 7: After the engine is started, lower the speed to idle speed for 3-5 minutes for warming up.

Step 8: Now the engine is warmed up, gradually increase the speed (RPM) and insert the un-threshed/unshelled material through the inlet of the thresher/sheller.

Step 9: Check the outlet and take a sample to see whether the thresher/sheller is working properly i.e. there is no breakage and no un-threshed grain. If there is un-threshed /unshelled grain slowly increase the speed (*rpm*) and repeat until you get threshed grain. If there is breakage, reduce the speed so that the breakage will be avoided. **Note:** *Breakage is not only due to higher speed but it may be due to over dried un-threshed harvest.*

Feeding Tray

For a proper operation the feeding of crop materials to be threshed/shelled has to be done by three persons, two persons who place material on the left-hand side of the plat form and 1 person who feeds this martial in an even flow into the conveyor.

Note: *the number of people feeding the machines may vary depending on the available persons but generally the feed rate is directly related with the output of the machines.*

Warning: Do not try to push the material too far towards the drum, because the drum does not make any difference between grains and hands.

Safety While Working with Threshers and Shellers

Warning: Thresher or sheller is driven by an Internal Combustion Gasoline/Diesel engine or a two-wheel tractor. This engine contains hazardous chemicals, toxic fumes and hot surfaces that could cause harm or even death. The engine also contains flammable chemical that could result in a fire or even an explosion.

Warning: Thresher or sheller contains moving parts that could cause serious harm or even death if anything is caught in the moving drum or in the belt system.

1. While in operation: All guards should be in place and all adjustment bolts should be tightened properly.
2. While loading, the loader's hand should never come close to the opening at the end of the input. If the crop gets stuck on the input or output, turn off the thresher and only proceed when it is completely stopped.
3. It is recommended that anyone with long hair working on or with the thresher put up their hair or where a hat to reduce that risk of their hair being caught in the belt or on the drum. This could result in very serious injuries.

Lubricating Moving Parts

Lubricate all rotating shaft bearings, sieve drive axle, front and rear wheel hubs using the grease nipples by a grease gun.

Oil: Some designs may have bearing on steering axle, pivot points of belt tensioner, belt tensioning nuts, and pivot points of oscillating racks to be oiled daily after use. You can also use grease whenever needed.

Storage of Threshers and Shellers

1. Do not expose the V-belt to acid or alkali substances. Remove the belt to clean debris.

2. Open all parts of the machine to clean the internal debris.

3. To maintain the balance of the wheel, clean the mud and straw of each driving belt.

4. Store planters in dry places, away from rain or direct sun.

Module 5: Two-Wheel Tractor Powered Water Pump

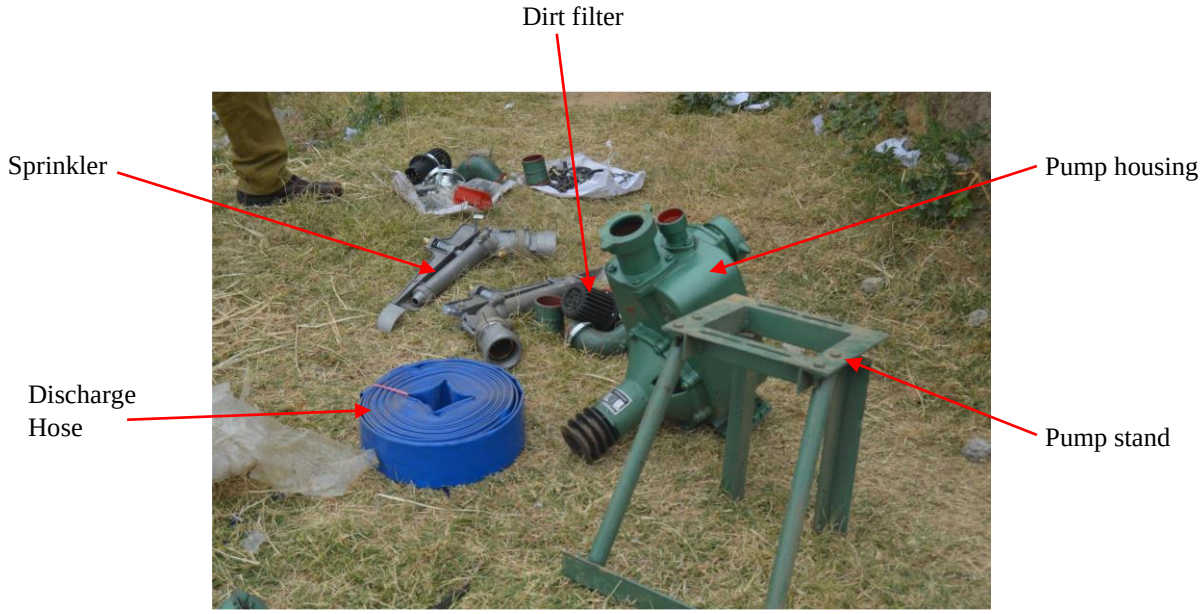
Aim: At the end of this module, operators, service providers, worreda extension experts or private mechanic and maintenance/repairs workshops owners should be able to use a two-wheel tractor driven water pump.

Overview

A portable two-wheel tractor driven pump is small in volume, light in weight, good in performance, easy in operation and maintenance. It is also reliable and widely used in agricultural irrigation, drainage, mines, construction sites and daily water supply systems.

Technical aspects

Parts of a Water Pump



Pump housing: Pump housing is the main body of the water pump, which creates pressure to suck from the water point and discharge at the desired place.

Pump supporting frame/stand: Pump supporting frame is the frame structure specially made to support the pump on top of the two-wheel tractor.

Strainer (dirt filter): It is a plastic strainer used to filter dirt during the suction process from the water point.

Discharge hose: Discharge hose is a hose made of hard plastic material used to transport the sucked water to the desired place.

Sprinkler nozzle: Sprinkler nozzle is a nozzle made from cast iron which can add more pressure to the sucked water by reducing the size of the water droplets and producing a splashing effect while the water is getting out of the discharge hose *via* the sprinkler.

How to Operate a Two-Wheel Tractor Driven Water Pump?

Step 1: Insert the suction pipe into the well (water point)

Step 2: Fill water at the right top of the pump until it is full (priming).

Step 3: Check and fill the fuel tank with fuel.

Step 4: Check engine oil, fill if necessary.

Step 5: Start the engine (manually or with key).

Step 6: Start irrigating, adjusting water outflow/pressure when necessary.

Precautions While Working with a Water Pump

1. Switch off a pump if it becomes overheated: If a pump does start to overheat while you are using it, turn it off and allow it to return to a safe temperature before you resume pumping with it. This simple precaution can drastically reduce the risk of a pump becoming a fire hazard.
2. Make sure safety guards are in place while operating the water pump.
3. Do not run the water pump in a flammable environment because heat can cause a fire to start.
4. Replace Worn-out Components. For instance, when the bearing is worn out, the pump shaft begins to wobble, and the pump becomes noisy and eventually will overheat.
5. Internal parts need to be maintained. Worn components can cause wobble, excessive noise, and overheating. Worn suction line fittings and pipe plugs can allow foreign material into the pump, which could cause wear to seal faces or other damage.
6. Check for Air Leaks. Make sure the suction line is airtight by regularly checking for air leaks. A vacuum gauge can be used to check air leaks.
7. Experienced Personnel Only. Only experienced personnel should be allowed to operate a centrifugal pump and do not remove warning tags or labels from the machinery. Also, authorized personnel should not wear loose clothing around the machinery and must be provided with appropriate safety gear.

Storage of a Water Pump
1. Drain any remaining water from the pump components.

2. Store water pump away from rain, high humidity and high temperatures to avoid development of rust on parts of the pump.
3. Inspect periodically to check if the protection of the pump is adequate.
4. Keep water pump dry and do not add oil/grease.

Module 6: Trailer

Aim: At the end of this module, operators, service providers, worreda extension experts or private mechanic and maintenance/repairs workshop owners will be able to use a trailer hitched to a two-wheel tractor.

Overview

A trailer is a carriage that will be hitched to any tractor or a vehicle so that it can carry any type of load required. It is very critical to know the road conditions and the trailer load carrying limit. The trailer can transport a load of up to 1000 kg maximum.

Technical aspects


Getting the safety message/safety thinking to farmers/buyers?

- Good practices and brief discussions by the demo team
- Through the beneficiary trainings at the regional level
- Through posters in districts centers, DAIL
- Through FM radio programming

Necessary Checks Before Hitching a Trailer to Two-Wheel Tractor

1. Check the tyre pressure before hitching.
2. Check all the wheel bolts, tighten and replace if there are missing bolts.
3. Make a visual observation so that if any missing bolts and other body parts are in their place.
4. After hitching the trailer, drive slowly with first gear and check whether the brakes are working properly. If they are working properly then load what you wanted to transport but do not exceed the limits. For example: Most two-wheel tractors having 12-15 HP can carry

a trailer with 1000 kg but the only limiting factor for the trailer capacity is its brake drum diameter and size of the shoes. Therefore, strictly follow the carrying capacity of the trailer.

5. Most of the time you can find the labelling at the back side of the trailer. Depending on the capacity load what you want but please secure it properly so that you will avoid dropping of staff from the trailer.

Never operate a two-wheeled tractor unless:

- You have been fully trained in their operation and maintenance, or:
- You have had years of experience operating and maintaining the particular model in question

Driving a Two-Wheel Tractor with a Trailer

1. Never exceed the maximum carrying capacity of the trailer. Trailer brakes are designed to halt the trailer with its maximum designated carrying capacity only.
2. Always abide and observe all public traffic regulations while driving on the roads.
3. Always observe speed limits on the roads.
4. Use appropriate speed for difficult/crowded/high traffic conditions.
5. Be sure that the brake of the trailer and the two-wheel tractor is appropriately always adjusted before starting to drive.
6. Remember both brakes can be applied at the same time in emergency conditions.
7. Never make a sudden turn at higher speeds.
8. Never run the tractor in 5^{th} and 6^{th} gear unless the road is in very good condition
9. Never drive across a steep slope.
10. Go down steep slopes in reverse to avoid tipping forward.
11. Be sure that the brake is appropriately always adjusted in good working order.
12. Never let children approach or ride on the tractor.
13. Observe the road rules pertinent to two-wheeled tractor use.

Module 7: Safety

Aim: At the end of this module, operators, service providers, worreda extension experts or private mechanic and maintenance/repairs workshop owners will be able to operate safely 2WT and attached implement

Overview

The safety of 2WT and with attached implement relies on the operator being aware of the proper use and inherent dangers associated with the task being performed. Always read and follow the manufacturer provided operator's manual before using the equipment and any attachments. Although many units appear similar, there may be safety and operation feature unique to each type of implement, brand or manufacturer. If the operator's manual cannot be found, obtain a replacement by contacting the equipment manufacturer or a local dealer.

Technical aspects

Follow these general precautions before fueling and starting the equipment:

- Become familiar with proper equipment operation including starting, stopping, and engaging any attachments.
- Inspect the unit and the attachments for signs of wear and damage.
- Make sure belts, shafts and connections are properly tensioned or tightened.
- Verify that the shields and guards are in place, and that the safety features are not overridden.
- Refuel the engine only when it is cool.
- Do not ever smoke when working around fuel sources.
- Place the equipment in neutral and disengage the implements before starting.
- Do not operate equipment in a closed building, as poisonous gases (carbon monoxide) can build up quickly.

- ***Follow these general precautions when operating the equipment:***
- Operate the unit only on stable ground or footing to avoid potential slips and falls.
- Do not disable safety features such as auto-clutches and shut-off switches, and do not secure levers and switches in the "on" position to simulate operator presence.
- Do not leave the unit running unattended.
- Inspect the area where the equipment will be used, and remove all stones, sticks, wires, or other debris.
- Keep the hands and feet away from moving parts.
- Work slowly when tilling and avoid forcing the unit through the soil.
- Use the attachments only as they were designed to be operated.
- Be aware of bystanders in the event of thrown objects and keep a safe distance.
- Do not operate the equipment when fatigued or under the influence of drugs or alcohol.
- Operate the equipment only with adequate visibility and light.
- Do not approach/operate a two-wheel tractor with loose clothing/scarf.
- Take special care near the running engine / turning belts
- Take special care that feet do not slip from footrests/steering peddles into the rotavator's blades.
- Never engage the clutch from a starting position with one of the steering clutches disengaged.
- Never drive the 2-wheel tractor up or down a steep slope at high speed.
- Never "coast" down a hill with clutch / gears disengaged (freewheeling).
- Never disengage both steering clutches at the same time
- Never drive the 2-wheel tractor at high speed on a rough road (gears 4-6).
- Never attempt to start the tractor from dead stop in gears higher than # 3.
- Never drive across a steep slope
- Go down steep slopes in reverse to avoid tipping forward
- Be sure that the brake is appropriately always adjusted in good working order.

Working on slopes with a gradient higher than 40% or in uneven terrain

- On slopes with a gradient of over 40% or in uneven terrain, the device can slip or tip over; the danger zone is extended by the possible slipping or tipping area of the machine.
- Select the correct tyres: Twin tyres, additional iron slope wheels, spiked roller.
- Use the maximum possible track and axle width.
- Check the tyre pressures.

- It is compulsory to wear sturdy, closed shoes with gripping soles. Work with crampons if necessary.
- Keep persons clear of the danger area.
- Adapt your working speed to the surroundings.
- Keep a constant watch on the lie of the terrain.
- Pay attention to the weather- increased risk of accident in wet weather
- Only authorized persons may work with the 2-wheel tractor. The minimum age for operators is 16 years.
- Operating permit and driving license are required (in some countries) for single-axle traction and working machines guided by pedestrians via steering shafts.
- The operator is responsible for the safety of third parties in the working area.

Personal Protective Equipment

Always use personal protective equipment (PPE) when operating a two-wheeled tractor or tiller. Consider the following PPE recommendations:

- Wear safety glasses with side shields or goggles to protect the face and eyes from flying debris when using cutting attachments.
- Wear ear protection to preserve hearing and protect the ears from the high level of noise produced by the engine and attachments.
- Wear leather gloves to protect the hands from cuts, splinters, abrasions and contact with sharp cutting edges.
- Wear safety boots or hard-soled shoes to protect the ankles and feet from the rotating tiller tines. Steel-toed boots help provide additional protection.

Module 8: Maintenance/Repair

Aim: At the end of this module, operators, service providers, worreda extension experts or private mechanic and maintenance/repairs workshop owners will be able to understand maintenance care philosophy, discipline to follow schedule recommended by manufacturer to maintain 2WT and attached implement available at any time it is needed to perform operational task and reduce high repair costs but also understanding where and when to go for a specialised workshop for repair issue.

Overview

To make good use of 2WT and attached implement, it is essential to keep and maintain in functional order/conditions to perform tasks it supposed to do. Hence, it is recommended to use the maintenance schedule provided in the operator's manual, which is the best source of information regarding equipment maintenance. Proper maintenance will increase the life of the equipment, better reselling value, and decrease the likelihood of safety risks due to equipment malfunction. Well-maintained equipment will result in less strain on the equipment and operator, and will allow tasks to be performed more efficiently and at any time you need to do so. Always shut off the engine and disconnect the spark plug wire before performing maintenance or unclogging tines or jammed implements.

Technical aspects

Follow these common maintenance and inspection guidelines (including in **tables** below):

- Review the operator's manual for recommended service.
- Maintain proper oil levels and lubrication of moving parts.
- Maintain the cutting edges on blades (not required on tiller tines).
- Replace the tiller tines when they are excessively worn or damaged.
- Properly tension or tighten all belts, drive shafts and connections.
- Inspect, adjust or replace all guards and safety features.
- Drain the fuel tank in a safe area and run the engine on idle until it stops, before storing the equipment for extended periods.
- Do not wear loose or ragged clothing. Dangling or frayed edges can get caught in moving parts.

Table 1: Two-wheel tractor (2WT) maintenance schedule.

1st maintenance (each 100 working hrs.)	2nd Maintenance (each 500 working hrs.)	3rd Maintenance (each 1000 & each 1500 working hrs.)
Add to the daily or shift maintenance the following:	Add to the 1st maintenance the following:	Dismount the gears, chains, bearings, oil seals of the transmission box, main gearbox, final transmission, rototiller and etc. and wash them clean with diesel
Check and adjust V-belt tension	Wash the gearbox, clean and renew the lub oil	Check the wear –and-tear of gear, sprockets, chains, and braking ring, shifting forks, bearings and oil seals and renew them if necessary.
Check and adjust the controls of clutch and brake	Special instructions: rototiller has to undergo the 2nd class maintenance after 200 working hrs.	Check the working reliability of the springs of gear shifting forks and the steering system and renew if necessary
Check and adjust the chain tension of transmission case and the rototiller chain case		Check and adjust the accuracy of all the control mechanism, repair or renew if necessary
Check and adjust the steering mechanism and controls		Check the wear–and-tear of the V-belts, friction discs of clutch, tyres and other parts. Replace if excessive wear found
Check tyre pressure and keep the same pressure on both two drive wheel (upper pressure limit while rototilling and lower for transport)		Special instructions: rototiller has to undergo major overhauling after 500 working hrs.

Checking and maintenance overview

	P	S	8 [h]	25 [h]	100 [h]	at least once per year	C
Safety stop lever Function check		O					
Lubricate the rapid-change flange	1	O				O	O
Check and lubricate shift rods	2	O	O			O	O
Check, adjust and lubricate Bowden cables	3	O	O			O	O
Change the oil Gearbox For the first time Then every	4			W	 W	W	
Check the oil level Gearbox		O	O			O	
Check screws and operating parts		O	O			O	
Tyre pressures		O	O				
Wheel nuts		O	O			O	

Engine maintenance: refer to the respective engine manufacturer's operating manual

P = Position
S = before each start-up
O = checking and care work that can be carried out by operator
W = have the maintenance work carried out by a specialist workshop
C = after each cleaning mainly with a high-pressure cleaner

Post-Learning Assessment

1. List the differences between two-wheel and four-wheel tractors.

2. List the advantages of using a two-wheel tractor in rural farming areas.

3. Explain how the coolant (water in engine) and oil are checked before starting a tractor.

4. Why should a fuel strainer/filter not be removed during refuelling?

5. Before starting a two-wheel tractor engine, what adjustments should be done to the gear shifting lever and the clutch/brake lever?

6. Explain how direction of forward movement is selected when driving a two-wheel tractor.

7. Describe how a two-wheel tractor and its equipment are safely stored when not in use.

8. After using planters, shellers and threshers, why should they be cleaned before storage?

9. What safety measures should be taken by an operator when using a sheller and a thresher?

10. What is the importance of lubricating moving parts on a two-wheel tractor and its equipment?

11. Why should a two-wheel tractor and its equipment be stored in a dry place, away from rain and direct sunlight?

12. What precautions are necessary while using a trailer with the two-wheel tractor?

13. In the old days before agricultural machinery what were the main hazards in farming?

14. Where do the main hazards/injuries in agriculture around your village come from today?

15. What are the most dangerous jobs in Ethiopia?

Further Reading Materials

Garnet B., Alemu D., Woldesenbet S., Bullo T., Baudron F. 2019. Operator Training Manual Two-Wheel Tractor and Ancillary Equipment. Prepared in Collaboration with EIAR and CIMMYT by Farm Mechanization and Conservation Agriculture for Sustainable Intensification (FACASI-II) Project Addis Ababa, Ethiopia. ACIAR. 88pp.

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