OPERATOR TRAINING

MANUAL

TWO-WHEEL TRACTOR AND ANCILLARY EQUIPMENT

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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

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November 2019 Edition

ISBN: xxxxxxxxxx

ACKNOWTLEDGEMENT

This two-wheel tractor (2WT) and ancillary equipment training modules and technical manuals is a collaborative work by Bisrat Getnet– researcher & FACASI project country coordinator in Ethiopia, Dereje Alemu – a researcher from the Ethiopian Institute of Agricultural Research (EIAR), and Frederic Baudron from International Maize and Wheat Improvement Center (CIMMYT) Zimbabwe. The training modules and technical manuals were jointly developed for training 2WT operators at Technical and Vocational College level. All necessary training materials contained in this manual were made possible due to the support of the FACASI project and the EIAR Agricultural Engineering Research Directorate.

The authors also would like to acknowledge the contributions of fellow researchers, from EIAR, Seyoum W/senbet and Teshome Bullo for their valuable contributions in the preparation of some manuals.

Special thanks to the technical reviewers, Frederic Bourdon of CIMMYT-Zimbabwe and Rabe Yahaya of CIMMYT-Ethiopia.

Finally, the production of this training manual has been made possible by the generous support of the Australian International Food Security Centre (AIFSC), the Australian Centre for International Agricultural Research (ACIAR) via CIMMYT, which is the principal implementer of FACASI project in both phases I & II.

ACRONYMS AND ABBREVIATIONS

2 WT	Two Wheel-Tractor
AIFSC	Australian International Food Security Centre
ACIAR	Australian Centre for International Agricultural Research
CA	Conservation Agriculture
CIMMYT	International Maize and Wheat Improvement Center
CTIC	Conservation Tillage Information Center
DAP	Draught animal power
DP	Diammonium Phosphate
EIAR	Ethiopian Institute of Agricultural Research
FAO	Food and Agriculture Organization
FACASI	Farm Mechanization and Conservation Agriculture for Sustainable Intensification
GMCC	Green manure cover crops
Ha	Hectare
kN	Kilonewton
MT	Minimum tillage
NT	No-tillage
PPE	Personal Protective Equipment
PTO	Power Take-Off
RPM	Revolutions per minute
RT	Reduced tillage
SSA	Sub-Sharan Africa
TVET	Technical and Vocational Education and Training
VMP	Versatile multi-crop planter
ZT	Zero tillage

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2WT OPERATION AND CALIBRATION TRAINING CURRICULUM FOR OPERATORS

Background

The term "mechanization" is used to describe tools, implements and machinery applied to improve the productivity of farm labour and of land including off farm activities (logistic, handling and processing). Mechanization covers broadly the entire process of on and off farm. It 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 mechanical power technologies.

Mechanization is a key input in any farming system. It aims to achieve the following:

- increased productivity per unit area due to improved timeliness of farm operations;
- an expansion of the area under cultivation, where land is available, as it often is in Sub-Saharan Africa (SSA);
- accomplishment of tasks that are difficult to perform without mechanical aids;
- improvement of the quality of work and products;
- a reduction of drudgery in farming activities, thereby making farm work more attractive for youth.

Mechanization systems are categorized into human, animal and mechanical technologies. Based on the source of power, the technological levels of mechanization have been broadly classified as hand-tool technology, draught animal technology and mechanical power technology.

An overview of farm power in Sub-Saharan Africa

A series of studies on farm power conducted by the United Nations' Food and Agriculture Organization (FAO) in SSA in the years 2002–2004, have shown that the principal labour-demand peaks in the farming cycle are for land preparation and subsequent weeding. The constraints to increased farm production are due, to a large extent, to three factors:

- an excessive reliance on human power;
- the low productivity of human labour; and
- a decrease in the labour available.

Human power: With human power, productivity is generally low because of the lack of physical energy available and the limited range of hand tools. The situation has been exacerbated by the HIV/AIDS pandemic and other factors, such as migration, which reduce the numbers of young, healthy people available for farm work.

Draught animal power (DAP): is generally considered to be an affordable and sustainable source of power for small scale-farmers. Oxen and sometimes cows are the animals of choice, but in some African cultures, it is unacceptable for women to use bovines. Donkeys and horses are increasingly being used, as are camels and mules in some areas. Apart from tillage, transport and other field operations, animal power can also be used for logging, pond excavation, and rural road maintenance.

Tractor power: Government-run tractor hire schemes in SSA have often failed essentially due to weak institutions, miss management and consequently to reduction in government expenditure on services that could, theoretically, be provided by the private sector. Private sector tractors have been profitable on large landholdings, but they have seldom proved to be viable for the smallholder sector in SSA, whether in individual or group ownership, or in private hire services.

Mechanization allows smallholders both to intensify and expand agricultural production as well as enabling some family members to seek off-farm jobs and incomes.

Why small holder mechanization?

As rural African youths increasingly migrate to urban centres, the SSA region may face labour shortages along with increasing demand for food' supply to the urban areas. Mechanization can help the often elderly or female farmers who remain in rural areas to keep up with higher output needs, thus contributing to increased food security and climate change mitigation.

This can be achieved when well-managed private sector mechanization service centres are made available and services are within reach. Interventions from the public sector to help this process include providing specific incentives depending on the mechanization power source and user type. It allows for new and

often better jobs in the servicing sector, such as for skilled machinery managers, operators, repair service providers, mechanics, dealers and spare part supply centres.

The promotion of large-scale mechanization in SSA in the 1950s and 1960s raised concerns over possible undesirable consequences (e.g., labour displacement, consolidation of small farms) and led to the emergence of what has been coined 'appropriate' mechanization in the 1970s and 1980s (Mrema et al. 2008). However, none of the small machines that were developed during that period, including a number of 'mini-tractors', were successful in the market (Holtkamp and Lorenz 1990). More than 20 years after the apparent failure of appropriate mechanization in Africa, time has come to re-examine the topic in the context of modern-day developments in the agricultural sector, as new challenges and new opportunities have arisen. Thus, the 2WT is one of the possible options as appropriate mechanization for SSA.

Conservation Agriculture

Current high agricultural commodity prices not only create challenges for African farmers, but also opportunities to intensify agriculture and shift from subsistence dominated systems to more commercially-oriented ones. Agricultural intensification is also an urgent requirement in sub-Saharan Africa for many pressing reasons below:

First, the number of undernourished people is rising with a higher relative incidence in SSA than in other regions. Second, current shortages in agricultural commodities in Africa will be exacerbated by a population projected to at least double between now and 2050, in parallel with an increased urbanization of the population as migration continues from rural areas to towns. To deal with this situation, agricultural production will need to be more than doubled in the next three decades. Third, many African countries are not food-secure.

The recent price surge in food commodities has clearly demonstrated the need for these countries to reduce their dependency on food imports and therefore their exposure to international food price volatility.

FAO uses the name Conservation Agriculture (CA) and defines CA as the simultaneous application of minimum soil disturbance, soil cover and crop rotation (Benites and Ashburner, 2001).

The most fundamental operations in global agricultural system are tillage and are very vital from crop production point of view. During the past centuries, soil cultivation was brought and executed by ploughing, especially with moldboard plough. Its dual functions of cultivation and soil inversion made it very popular among the farming communities, especially in controlling weeds. But, recent economic and environmental concerns have compelled the farming community to reconsider the use of tillage operations and if possible, implement alternative technologies for soil cultivation. Energy consumption and the working efficiency are the basic parameters to assess the performance of the implement, highlighting the moto "produce more with less".

Soil tillage

Lal defined soil tillage, a tool to improve the soil quality and its capacity to perform economic, ecological and aesthetic function (Lal, 1993 & 1990; Deere and Company, 1976). The non-judicious tillage operations by the farmers in South and South-East Asia have resulted in various soil problems (Lal, 1990). Soil tillage may be defined as physical or mechanical manipulation of soil to modify soil conditions for crop production by providing conducive environment for seed germination and root development, suppressing weeds, controlling soil erosion, increasing infiltration and reducing evaporation of soil moisture (Prihar, 1990).

Tillage systems

A diverse range of tillage systems are being practiced throughout the world. This affects the distribution and location of crop residues left behind after harvest. The following tillage systems are the most common practiced by farmers.

1. No-tillage or Zero tillage

In this tillage system, the soil is left undisturbed except for seed or nutrient placement. The use of herbicides has led to the adoption of no-tillage (NT) or zero tillage (ZT). The minimum soil disturbance is achieved with special equipment like coulters, row cleaners and tine openers.

2. Conventional tillage

Conventional tillage or intensive tillage system includes all tillage practices that leave < 15% of residues on soil surface. Moldboard plow and other secondary tillage implements are used, especially in clayey soils with drainage problems. Conventional tillage operations pose some serious concerns; e.g. high fuel and time requirements, soil compaction and deterioration in soil structure. The high fuel cost (in energy conscious world) necessitates the use of alternate tillage systems with less chances of erosion (Mitchell et al., 2009).

3. Minimum or reduced tillage

According to Lal (1999), any tillage system that leaves 15-30% of residue cover after planting is recognized as minimum tillage. The minimum or reduced tillage (MT or RT) system reduces the chances of soil crusting and soil erosion because of less soil disturbance (Lal, 1997).

4. Strip tillage

Strip-till is a conservation system that uses a minimum tillage. It disturbs at minimum only the portion of the soil that is to contain the seed row (seed & fertilizer).

5. Conservation tillage

Any tillage system that leaves >30% of crop residues on the soil surface comes under the category of conservation tillage (as defined by the Conservation Tillage Information Center, CTIC). The conservation tillage system is a generic term used to describe the soil and water loss due to conventional tillage practices (Mannering and Fenster, 1983). The conservation tillage is basically collection of many tillage types with the objective of crop residue management.

6. Ridge tillage

Ridge tillage is a system where the soil is not disturbed from planting to harvest, except for nutrient application, and the crop planting is accomplished on the ridges with disk openers, cleaners, sweeps, coulters and/or row cleaners. The crop residues are retained between ridges on the soil surface.

7. Deep tillage

Deep tillage aims to break the hardpan or plough pan formed under the plough layer due to repeated tillage or traffic to increase the root penetration and water infiltration.

Tillage systems and soil type

The uses of minimum tillage and/or direct drilling depend largely on the selected crop species and soil type under set of climatic conditions. The soil texture has profound effects on soil workability. The coarser the soil, the less its water holding capacity, the greater the rate of water percolation, the lower its ability to retain nutrients for sustainable crop yield. Great resistance is attributed to fine soils as their manipulation is very difficult and have low rate of water infiltration. Medium soils are the most advantageous for better crop growth because of good water holding capacity, aeration and drainage. Soil physical properties affecting seed germination, seedling emergence, establishment of crop stand and crop yield are subjected to change by tillage operations. Therefore, efforts are needed to optimize tillage system capable of coping the drawbacks of all existing practices.

Fig 1. Typical CA farm

Thus, a typical conservation agriculture practice includes the following pillars:

- Little or no soil disturbance (Zero tillage, No-tillage)
- Permanent soil cover (residues or green manure cover crops (GMCCs)
- Crop rotation
- Integrated disease and pest management
- No burning

Fig. 2 also shows the relationship between the three major pillars and the major difference between conservation agriculture and conventional agriculture.

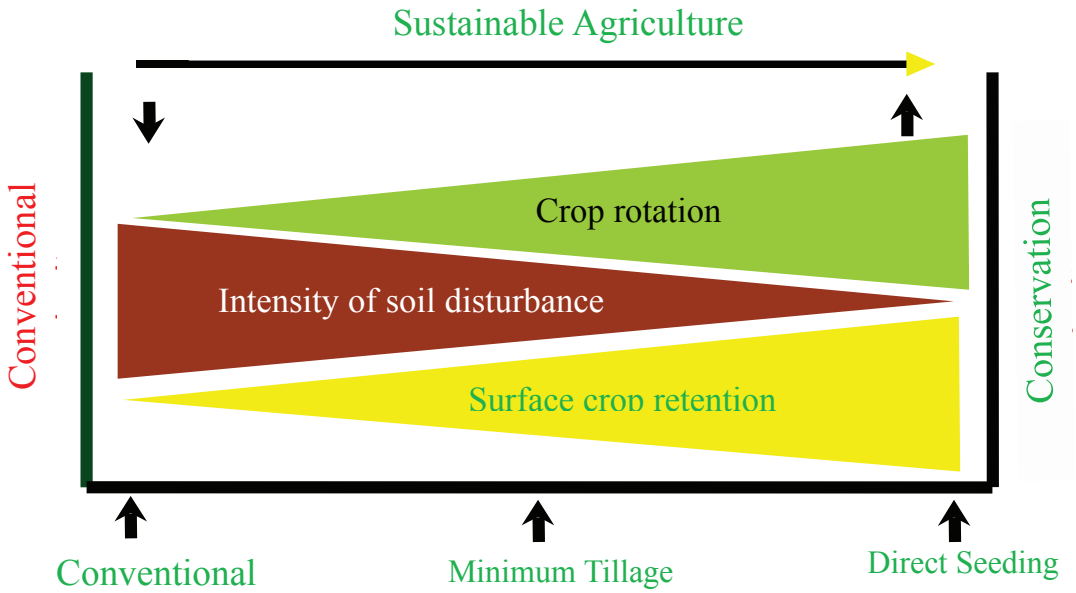

Fig 2. Conservation agriculture vs Conventional agriculture (Adapted from Pereira).

Sustainable Intensification

Sustainable Intensification offers a practical pathway towards the goal of producing more food while causing less negative impact on the environment, intensifying food production while ensuring the natural resource base on which agriculture depends is sustained, and indeed improved, for future generations. In sub-Saharan Africa, a rapidly growing population and increasing food demand, alongside scarcities in resources such as land, water and soil fertility, are compounded by stagnant yields for some crops and alarmingly high rates of hunger and malnutrition. Many of the farming systems in Africa are far from their productive potential while accelerated economic growth in Africa now offers demand-side opportunities for agriculture. Intensification of production can take many forms.

The current model has served us well for a hundred years or more, including its underpinning of the Green Revolution of the 1960s and 1970s that kept the pace food production in line with population growth. But the context has radically changed. Today, we are witnessing recurrent food price spikes, the existence of about a billion chronically hungry people and the need to feed a growing, an increasingly prosperous population, in the face of threats from climate change. And the issue is not a transient affair. Moreover, conventional intensification is not a viable solution if it comes at the expense of the environmental and social resources on which it depends. Therefore, we need radical measures and new paradigms. One such paradigm is Sustainable Intensification.

This pathway strives to utilize the existing land to produce greater yields, better nutrition and higher net incomes, while reducing over reliance on pesticides and fertilizers and lowering emissions of harmful greenhouse gases. This also should be accomplished in a way that is both efficient and resilient and contributes to the stock of natural environmental capital. But, none of the components of this paradigm are new. They comprise techniques of ecological and genetic intensification, within enabling environments created by processes of socio-economic intensification. The need to understand about intensification is that it is the way in which all components are combined as a framework to find appropriate solutions to Africa's food and nutrition crisis.

Why Do We Need Intensification?

Sub-Saharan Africa faces many challenges, not least a high prevalence of chronically hungry people, and the urgent need to feed a rapidly growing population. Demand for food is increasing while supply is insufficient or even declining (Table 1).

Table 1: Demand and supply relationship in SSA.

Demand Changes	Supply changes
• Over 200 million people, nearly 23%, of the African population, are now classed as hungry.	• Based on current production trends, African food production systems will only be able to meet 13% of the continent's food needs by 2050.
• Hunger levels have been rising 2% per year since 2007, compared to declines in previous years.	• More than 95 million ha of arable land, or 75% of the total in SSA, has degraded or highly degraded soil, and farmers lose eight million tons of soil nutrients each year, estimated to be worth $4 billion.
• 40% of children under the age of five in SSA are stunted due to malnutrition.	• Nearly 3.3% of agricultural GDP in SSA is lost annually because of soil and nutrient loss.
• SSA has a population of around 875 million, with an average annual growth rate of 2.5%.	• In the 50-year period between 1961 and 2011, cereal yields have increased by over 200% in Asia and Latin America but only by 90% in Africa.
• The population in SSA will almost double by 2050, to close to two billion people. Between now and 2100 three out of every four people added to the planet will live in SSA.	• In SSA, only 4% of cultivated land is irrigated.
• By 2030, 50% of the SSA population will live in cities.	• In SSA, only about seven million ha of new land have been brought into production between 2005 and 2010.
• Declines in total fertility rates in SSA are occurring later and slower than in Asia and Latin America.	• Between 1991 and 2009 per capita arable land fell by about 76m^2 per year.
• Income levels in SSA are rising in line with GDP per capita, and are expected to reach $5,600 by 2060, resulting in changed diets among the continent's population.	• Under moderate climate change with no adaptation, total agricultural production in SSA is expected to decline by 1.5% in 2050.

Applications of 2WT

Two-wheel tractors (2 WT) are sources of power designed to perform most field operations.

Due to the size of such tractors, they have become an economic alternative for scale farming. In addition, 2 WTs are also much 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.

2 WT may be classified according to the engine power in three categories. Table 2. shows the main physical characteristics for each category.

Table 2. Main characteristics for 2WT[1]

Category	Overall dimensions (LxWxH) mm	Track width (mm)	Clearance (mm)	Mass (kg)	Maximum Traction (kN)	Speed (km/hr)	Power (kW)	Engine
I	1500x40x 1000	315	150	45-60	0.3-0.5	1.55	2.7-4	or 4 cycle gasoline or diesel
I I	830x530x18 00x1230	400-700	200	75-148	0.6-1.2	1-12.6	5-7	4 cycle gasoline or diesel
I I	1900x560x8 00 2680x960x1 250	400-750	200 546	175-465 5.47`[1]	1.37-3.7 3.91[1]	1.16.3	8-10.2	4 cycle gasoline or diesel

[1] Parameters for a high clearance two-wheeled tractor of special design. Lara-L´opez et al. 1982.
[2] Source: catalogues from manufacturers from Europe and Asia and publications on special designs.

Two-wheel tractors of Category I are normally dedicated to garden work, transportation or light inter-row cultivation. Most tractors in the above category can incorporate a rotary tiller on the axle, with a working width of 500–800 mm. Also, due to their low weight and small clearance, these machines are not suitable for ploughing dry and hard soils. However, they may perform a number of field operations, such as lifting water, forage cutting, transport and cultivation.

2WTs of Category II may be used for the same field operations as those of Category I. But, as tractors in this category have a one-metre tiller width, it's possible to cultivate and plow soft soils. Some designs in this category incorporate wing hubs with pawls to assist turning, with many more being are equipped with a rotary tiller driven from a PTO.

2WTs of Category III cover the same applications as those of Categories I and II, but in addition some designs are sufficiently heavy for ploughing dry-land.

For silty clay, the required draft for a 250 mm mould board plow working at 200 mm depth with a speed of 3 km/h is approximately 3.7 Kilonewton (kN). This value is like the maximum draft obtained from some of the heaviest commercial models of 2WTs, although for dry soils with crop residues the draft requirements may be higher.

2 WTs designed for wet land may be lighter than those designed for dry land, where high traction capability is more necessary than flotation. Wetland tractors are equipped with steel wheels with lugs to provide traction. Satisfactory results in dryland agriculture were obtained with a power-to-mass ratio of 0.014 kW/kg. Heavy-duty two-wheel tractors designed for wet land conditions show ratios of 0.022 kW/kg.

Row crops such as corn, sorghum and vegetables are cultivated several times requiring high clearance tractors for multi-row cultivation. Regions such as Latin America, where such crops are staple foods, require such type of equipment. However, the production of high-clearance tractors is rather small.

Module I: Participative learning and facilitation and its implementation

Organization of the module
This training module is designed for use by 2WT operators/trainers. Each lesson/topic is complete, detailing the preparations that need to be made before hand, the materials that need to be kept handy, the core message to be communicated, and the methods that can be used in communicating the message.

The topics and lessons in this module are divided into four sections: an introductory section which includes the lessons to give a trainer on how to conduct the training and what sort of materials are needed for executing a training on 2WT operation and the rest of the sections are on technical aspects of 2WT and ancillary equipment.

Module II
This module focuses on participatory learning and facilitation and its implementation.

Module II-IV
These modules focus on technical topics relevant to 2WT operation, calibration and maintenance of 2WT attached ancillary equipment such as seeders.

Design of the Modules

- Each module consists of various topics. The topics are designed in a similar format and include the subject background, objectives, overview, method of facilitation, time and materials required, and available handout (s) and additional references, if any. It then proceeds to the various learning activities.

The format used in each of the training topics is explained as follows:

- The background outlines the overall message that the topic intends to convey
- The learning objectives clearly state what participants should be able to explain or demonstrate by the end of the training topic.
- The topic overview describes the content of what the trainer intends to communicate to the participants on the given topic. Content may also include a message.
- The method of facilitation describes the methodology used to communicate the content.
- The amount of time required to prepare for each topic and training materials required are detailed by the facilitator.
- The learning activities describe the step-by-step way to conduct the session.

This manual should be used alongside other materials such as:

- 2WT-operation and user's manual provided by the manufacturers.
- Technical manuals for 2WT operation, calibration of 2BFG seeder and other ancillary equipment (trailer, seeders, pumps, threshers and reaper harvesters).

Organisation of the training Course

The training is an important tool and step to effectively convey the knowledge and skill of trainers (operators) and obtaining feedback for refining the curriculum. In addition, it is an important step in the training of operators/youth groups as it ensures that those involved in the operation and maintenance of 2WT and ancillary equipment to acquire the technical details of 2WT and attachments according to specifications and how to use, handle and transport a 2WT with its attachments properly. They also learn technical and maintenance skills that will equip them to deal with the challenges and demands of modern mechanization technology.

The main objectives of the training of facilitator's course include:

- Understanding the basic principles of mechanization, its uses and approaches
- Developing operation, calibration and minor maintenance skills
- Understanding the core activities of operation and calibration

- Developing the skills how to run a 2WT training
- Knowing how to develop action plan for scheduled maintenance training

Duration

This manual has been adapted and designed for operators' course for five training days. Daily sessions are programmed at 8 hours per day, with starting time and ending time dependent on local situation.

Participants

Most trainees should be those, who will serve as operators, who will be in charge of practical 2WT operations, calibration and minor maintenance, with the day-to-day responsibility of facilitating hands on operation training and participatory learning sessions at Technical and Vocational Education and Training (TVET) level. Suitable facilitators (trainers) are those that have a practical understanding of the 2WT technology and are familiar with the ancillary equipment, and have some level of advanced skills in mechanical/agricultural engineering, and have a dynamic and confident personality. In this training course facilitators are trained for the day-to-day running and facilitation of learning sessions with youth groups/trainees. It is also very important to note that operating a machinery requires a skill and it needs intensive training. It would also ideal, for understanding if the operator has some academic background, at least to high school graduation or 10th grade completion level for the case of Ethiopia. It is however not a prerequisite to attain such academic standard to understand this module, as farmers with a competent ability may be able join the college/TVET due to their experience. It is also very important to underline here that agricultural machinery operation requires careful handling, as it can expose operators to fatal accidents, so operators should be selected carefully and be aware.

Venue

The training venue should have suitable facilities, with a flexible layout and enough space for breakout groups and group field exercises, as well as for field calibration works and practical demonstration area such as driving and other operations. The training venue should also be easily accessed by the participants.

Methodology and Content

The 5 days training course is designed to give participants an opportunity to practice some of the most appropriate participatory training methods that would be used to facilitate the proposed training for operators. The facilitator's aim is to ensure that participants will acquire the necessary skills for facilitating practical operation and calibration exercises. The sharing of real examples from previous experiences is a vital contribution to the training. A key strategy will be to stimulate reflections on what would be done in an actual technology operation process and for the subsequent efficient delivery system to the user community as much as possible.

The training will be offered using various forms such as demonstration in small groups and individual practical operation and calibration exercises. Other modes of training will include presentation, group discussion, use and display of visual materials or technologies.

Training content will include among others: basic concepts of mechanization, conservation agriculture, safety precautions, operations, calibration and minor maintenance of 2WT and ancillary equipment, use and handling of 2WT and ancillary equipment. See attached annexes for training support documents (manuals).

During presentations/facilitation, the facilitator must

- State the objectives of the session
- Emphasis backward and forward linkages between different sessions, as well as reference to overall programmes
- Use visualisation techniques when appropriate
- Keep to time, adapt content to fit the time available
- Move focus of training around the room to keep audience's attention, use different parts of the room for different activities

- Observe group norms
- Ensure mini wrap-up at the end of each session to highlight main learning points

Evaluation of the Training

Evaluation of the training will be conducted in many ways. Each day, participants will be given a chance to express their impressions about the day's sessions and activities by employing various tools. The feedback will be presented the following day. They will also be asked to express their views on various aspects of the training at the end of the training to provide feedback to organisers and facilitators. Practical examination will be offered to the trainees at the end of the training. It's considered a good learning process if the practical exam accounts for 70% of the total evaluation, with the theoretical session accounting for the remaining 30%.

Follow up Support

To ensure the quality of the actual training process, there should be follow-up training and mentoring of the trained facilitators by technical experts. This is should be provided throughout the lifecycle of the training, including at start up stage, at mid-way stage and towards the end and/or when the need arises.

Safety precautions

Background

Working with machinery is always a dangerous task; even in more advanced nations, working with agricultural machineries is rated as among the most dangerous jobs. When it comes to 2WTs, the potential danger is even more enhanced as most of the rotating parts of the equipment is not covered with a shield. Thus, it is very important to avoid or to minimize injury as it can potentially be fatal. As such, this part of the training should always be given at the beginning of the training and it is vital to take safety precautions at every step of the demonstration and while working with 2WTs.

Field working and on-road driving can be safe and enjoyable, if one follows some basic safety rules. All the rules are common-sense ideas, but failure to follow these rules will greatly increase the chance of injury when working and driving. The work place is not the place to be in a hurry or have an attitude "it won't happen to me". With sharp and rotating pulleys and shafts unforgiving power equipment, field operation and working can be a dangerous activity. By following basic safety rules, one can considerably reduce the risk of injury. To be effective, safety rules must be implemented every time. Develop the habit of safety mentality whenever using 2WT from the start, and you will never want to work without them.

This session is designed to enable trainees to describe the dangers involved while working with 2WT and attachments. It provides safety precautions in the field and on the road while operating and driving.

Topic objectives

Up on completion of this topic, the trainees will be able to:
- Understand safety rules and their application
- Identify and properly use the 2WT and any attached ancillary equipment
- Show proper use and care of 2WT and ancillary equipment

Topic overview

1. The need for safety precaution in the work environment & general rules for safe practice
2. Use of personal protective equipment (PPE) & proper use and care of hand tools and 2WT with accessories.

Method of facilitation

- Description/explanation
- Participatory/interactive discussion (through question and answer to determine comprehension)
- Demonstrate how to use and hand tools and materials etc.
- Show a film on 2WT and agricultural machinery safety in general.

Time:

2 hrs and 30 minutes for theoretical sessions and 2 hrs for practical session

Materials:

PPE, safety posters, PC/TV or LCD for video show, common maintenance tools and equipment

Activity learning

Activity 1:

The need for safety precaution

- Explain that the session's objective is to improve awareness of safe work practices while using 2WT and its ancillary equipment on farm and on road.

- Ask the participants to state/identify and make oral presentation on the most dangerous jobs in Ethiopia.
- What will happen to your family and your lifestyle if you get injured and can't work? What will you lose if you get injured?
- Sources of hazards in 2WT (starting, handling and using hand tools, portable power tools and machines).
- Safe work practices pertaining to tools and equipment.
- Basic safety rules in working with 2WT.
- Summarize the session by emphasizing on the need to follow basic safety rules and develop the habit of using safety equipment from the start, and never want to work without them.

Activity 2:

Use of PPE & proper use and care of sheet metal hand tools and shop equipment

- Ask participants to list the safety precautions needed which are essential while operating 2WT.
- Ask participants to demonstrate how to protect themselves while operating equipment safely.
- Ask participants to observe safety posters
- Ask participants to list the safety measures they need to adopt to avoid injury while operating
- Use questions and answers to determine comprehension.
- Summarize the session by emphasizing on the need to develop the habit of safety from the start, and never want to work without them. Also, to properly use and care.

MODULE II: MANAGEMENT OF 2WT

2WT use and handling

Background

Machines in general need technical knowhow to use and operate. 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, the useful life of the machine as well. Therefore, the following topic focuses on the main use and handling features that need to be considered before and after operation of any 2WT.

Topic objective

Upon successful completion, the trainees will be able to:

- Explain the general features of 2WT, how to handle and use it appropriately
- Explain the need to use a 2WT properly and the proper handling of the 2WT along with its ancillary equipment
- Identify the key maintenance issues in 2WT.

Topic overview

1. Description of technology
2. Use and handling of 2WT technology

Method of facilitation

- PowerPoint presentation
- Brief Explanation
- Technology display
- Demonstration
- Question and answer

Time:

4 hours for theoretical session and 2 days for practical session

Materials:

PC/TV or LCD, flipchart, marker, 10 litres of diesel fuel, one 8-15 hp 2WT, manual starting handle, 2 litres of distilled water or coolant, hard copy of the operation manual

Practical learning activities

Activity 1: Description of technology

- Ask participants to observe the 2WT
- Ask participants to discuss in group on the general layout of the 2WT:
- What are the main components of 2WT technology?
- Identify the starting system, the fuel system, brake system, clutch system and power train (gear) systems used
- Explain how to start the 2WT and drive it
- Wrap-up discussion

Activity 2: Use and handling of the 2WT

- Ask participants on the need of grain drying and cleaning for storage
- Demonstrate correct pre-starting procedures of 2WT (checking engine oil, coolant and fuel level)
- Demonstrate how to start, drive and turn the 2WT
- Ask participants to state the care and maintenance activities of 2WT and ancillary equipment (seeders, reaper harvesters, pumps, threshers and trailers)
- Demonstrate how to transport 2WT
- Wrap up discussion and summarize

MODULE III: 2WT ATTACHED SEEDER CALIBRATION AND HANDLING

Background

Seeders are agricultural machineries that are used for planting relatively large kernel sizes like maize crops, whereas drilling is a term used for seeding small kernel sizes like wheat crops. Thus, before using any seeder/planter, operators need to calibrate the seeders for the recommended amount of seed and fertilizer to be seeded at the recommended seeding/planting depth and row spacing between plants and within rows. Let us see the definition of calibration.

The procedure of testing the seed drill for correct seed rate is called calibration of seed drill. It is necessary to calibrate the seed drill before putting it in actual use to find the desired seed rate. It is done to get the pre-determined seed rate of the machine. The seed drill could be ground wheel driven and power take-off (PTO) driven. The following steps are followed for calibration of ground wheel driven seed drill.

Calibration procedure

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. 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 reference

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 m^2

Recommended seed of wheat = 100 kg/ha.

10000 m^2 - 100 Kg

0.15072 m^2 - $\frac{100}{10000}$ 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

= $\frac{0.005072}{6}$ = 2.512x 10-4 kg

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 needs to know how to calibrate a seeder before conducting planting/seeding operation.

Topic objective

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.

Topic overview

- Description of technology
- Use and handling of 2WT-attached seeder technology

Method of facilitation

- PowerPoint presentation
- Brief Explanation
- Technology display
- Demonstration
- Question and answer

Time:

4 hours for theoretical session and 1 day for practical session

Materials:

PC/TV or LCD, flipchart, 15-20 kg of diammonium phosphate (DAP)-(18% N2 and 46% P2O5) /, 15-20 kg of wheat seed, 1 pocket meter (3-5 meters),1 surveying/ measuring/ meter (30-50 meters length), one 8-15 hp 2WT, transparent plastic bags (3-5 kg capacity), digital balance (0.01 gm accuracy), tool box (with all spanners, open and closed end wrenches), note book, pen, hard copy of the operation manual (preferably EIAR-prepared VMP manual for the training).

Learning activities

Activity 1: Description of technology

- Arrange participants in groups (2-4 people/group)
- Ask participants to observe the 2WT seeder
- Ask participants to discuss in group on the general layout of the 2WT:
- What are the main components of the 2WT-attached seeder technology?
- Identify the metering units, metering system for seed and fertilizer used
- Explain what to calibrate and steps of calibration?
- Demonstrate the steps of calibration, adjust the seeder according to the desired rate, and measure the collected seeds and fertilizer with a digital balance.
- Compare each row with the desired/required rate.
- Repeat experimental/trial exercise at least three times
- Wrap-up discussion

Activity 2: Use and handling of the 2WT

- Ask participants to explain the proper handling of 2WT
- Demonstrate correct pre-starting procedures of 2WT (checking engine oil, coolant and fuel levels)
- Demonstrate how to start, drive and manoeuvre the 2WT
- Ask participants to state care and maintenance activities of 2WT and ancillary equipment (seeders, reaper harvesters, pumps, threshers and trailers)
- Demonstrate how to transport 2WT
- Wrap up discussion and summary presentation

Two-wheel tractor (2WT)

Two-wheel tractor (2WT) or walking tractor are generic terms understood in the USA and in parts of Europe to represent a single-axle tractor, which is a tractor with one axle, self-powered and self-propelled, which can pull and power various farm implements such as a trailer, cultivator or harrow, a plough, or various seeders and harvesters.

A 2WT specializes in pulling any of numerous types of implements, whereas rotary tillers specialize in soil tillage with their dedicated digging tools.

Different names of 2WT:

Research has identified several terms used to identify two-wheel tractors, including

- Power tiller
- “walk-behind tractor
- iron-ox
- walking tractor
- mechanical ox
- ox-machine
- pedestrian tractor
- hand tractor
- single-axle tractor
- in Asia, tuk-tuk

Two-wheel tractor with different attachments (implements) can accomplish many kinds of farm work like tillage, planting, harvesting and transportation. When a tillage implement is attached to a two-wheel tractor, it is called power-tiller. There are many types of two-wheel tractors such as: mini tiller type (1.5-2.2 kW), traction-type (2.9-4.4 kW), dual type (3.7-5.2 kW), drive type (5.2-10.3 kW) and Thai type (5.9-8.8 kW). The demand, production and concentration of two-wheel tractors have been of significance in certain countries of Asia, especially those in which low-land rice is a major crop (Kathirvel et al., 2000).

Applications of 2WT

For soil-working: rototillers, moldboard plows, disc-plows, rotary plows, root/tuber harvesting plows, small sub-soiler plows, powered and non-powered harrows, seeders, trans-planters, and planters. Even zero till/ no-till planters and seeders have become available.

Fig 3. 2WT application for ploughing (at Wolmera District, Oromia Region, Ethiopia)
In planting/seeding different crops.

Fig 4. 2WT application for planting/seeding (Machakel district, Amhara Region, Ethiopia).

In plant protection and weed control: two-wheel tractor implements consist of various inter-cultivators and sprayers.

Fig 5. 2WT application for chemical spraying (Bangladesh).

Fig 6. 2WT application for water pumping for irrigation (a) Machakel District, Amhara Region and (b) Adwa district, Tigray Region, Ethiopia.

- For harvesting forage: Sickle bar mowers, disk mowers, hay rakes, hay tedders, hay balers and bale wrappers [for silage production].
- For grain harvest: reaper/grain harvesters, reaper-binders, and even combine harvesters are available [although typically only for Asian two-wheel tractors].

Fig 7. 2WT application for harvesting (Wheat harvesting in Machakel district, Amhara Region, Ethiopia).

- For grain threshing and shelling

Fig 8. 2WT application for shelling and threshing (a) at Melkassa and b) at Machakel district, Amhara Region.

- For transport, trailers with capacities from 0.5 to 5 plus ton cargoes are available

Fig 9. 2WT application for transportation(c) 1ton trailer at Gudeya Bila, Oromia Region, Ethiopia (d) 5 t trailer in Bangladesh.

- General mowing implements consist of lawn mowers, brush mowers, and flail mowers.
- For snow removal, implements consist of snow blowers, power sweepers, and snow/dozer blades.
- Other implements include: chipper/shredders, log splitters, electrical generator, pressure washer, crimper-roller, fertilizer/salt/lime spreader, and stump grinder.

How to operate a 2WT

2WT operation requires skill 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 2WT before attempting to do so. Before starting a 2WT, there are certain things to be checked. The following are the mandatory checks before starting the engine of the 2WT.

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 level while filling.

Fig10. 2WT engine oil level check.

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. See the engine manual for oil specifications and oil filter service instructions.

Before checking the oil level:

1. Move the 2WT to a 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 oil according to the manual depending on the type of engine. For diesel engines use 15W40 oil and for gasoline engines use 15W30 oil. Do not overfill.
8. Clean up any spillage that may have occurred.

Checking coolant level

Check coolant level by opening radiator cap counterclockwise and top up with a radiator coolant specified by the manufacturer with the specified volume if level is low (most of the standard 2WT engines require about 5 liters). Depending on the users' manual, it is important to drain the coolant and refill according to the manufacturer's specifications.

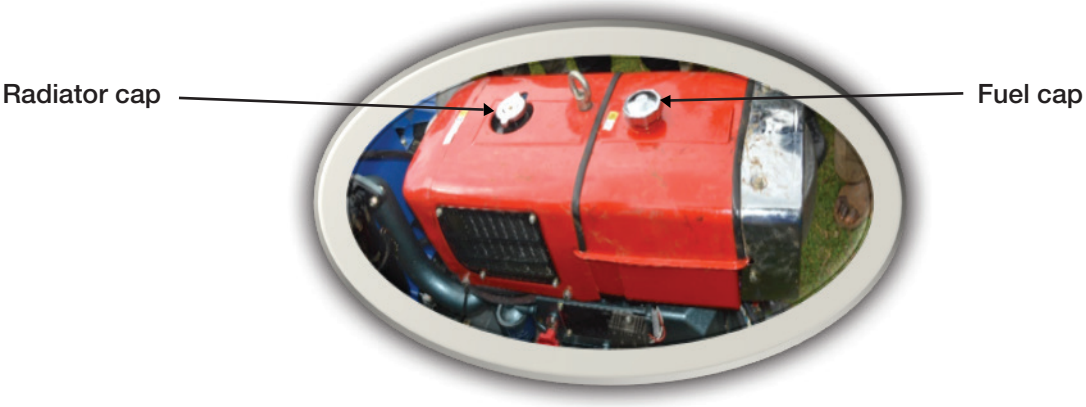

Fig 11. 2WT coolant and fuel check points (caps and taps).

Checking fuel level

Check fuel level by opening the cap and top up (Fig. 11). Never try to start the engine if the fuel level is too low, as air will enter in to 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. **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 into the fuel system.

Use caution with fuel. 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.

Fig 12. Fuel cup with a strainer filter in a 2WTs.

Other important checkups before starting the engine

- Check the belt tension. Push the belts firmly with your right thumb at the center. 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 it may have dirt in it. Please check the condition of the oil by simple visualization and by using your right hand. It can be changed if it is too dark in its color and if it has dirt in it. Refer the user's manual or check and read the label on the air cleaner housing (on some models) the oil type to be changed with recommended hours of use will be written.

Fig 13. Checking air cleaner oil.

Starting steps

To start a 2WT, 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)

Fig 14. 2WT manual starting (a) and electrical starting (b).

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.

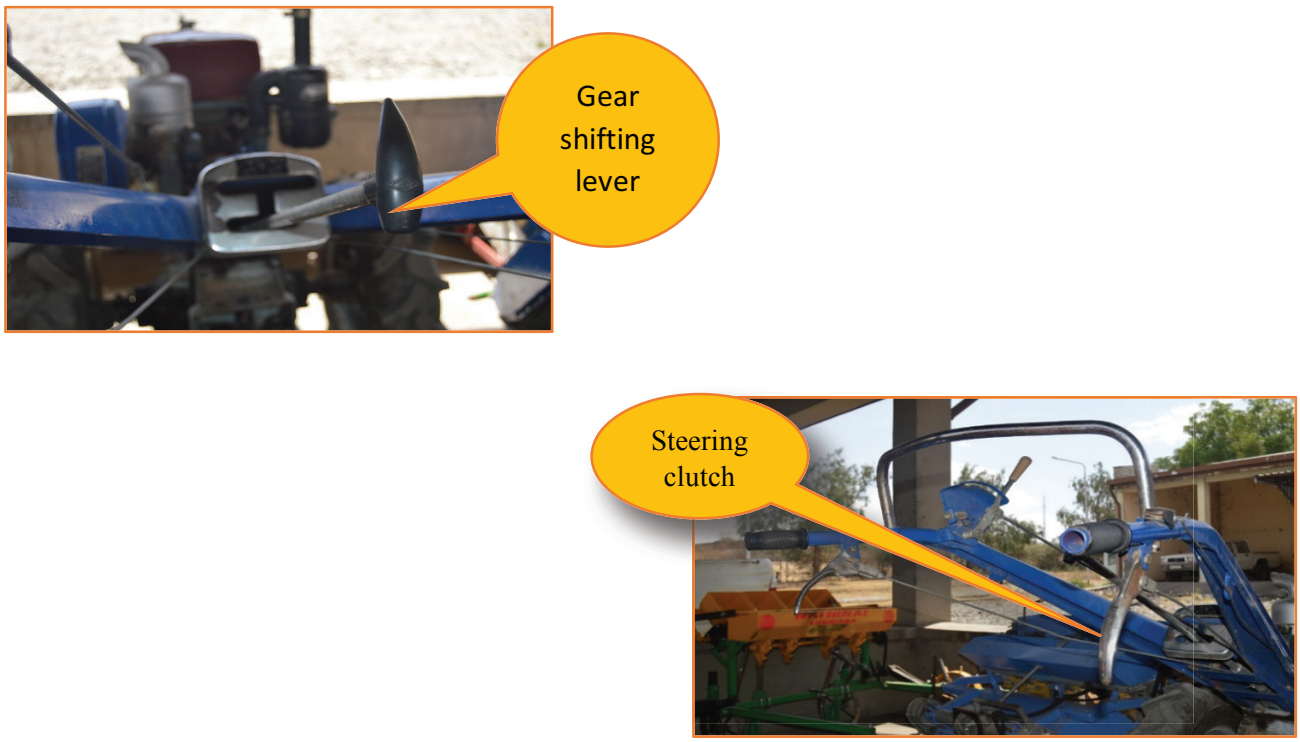

Fig 15. 2WT gear shifting lever and steering.

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

Step in starting:

- Move the throttle knob to half/turn it to 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. In other terms, the operator will start the engine without extra effort needed.

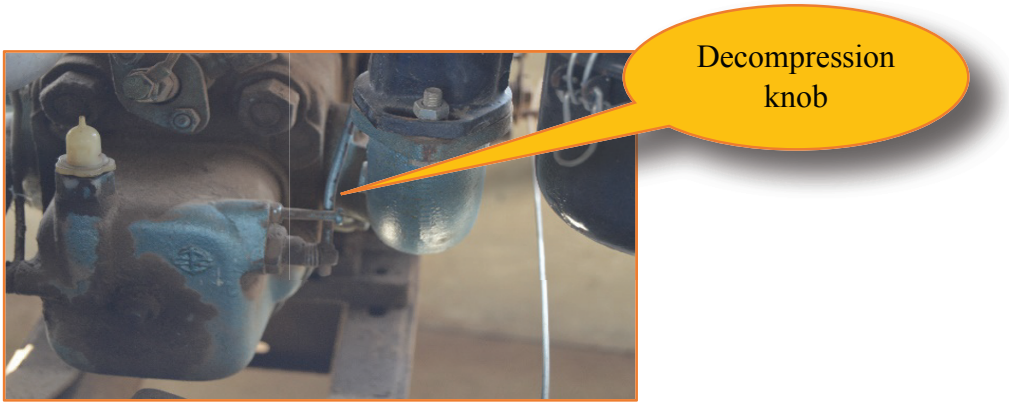

Fig 16. 2WT decompression knob.

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

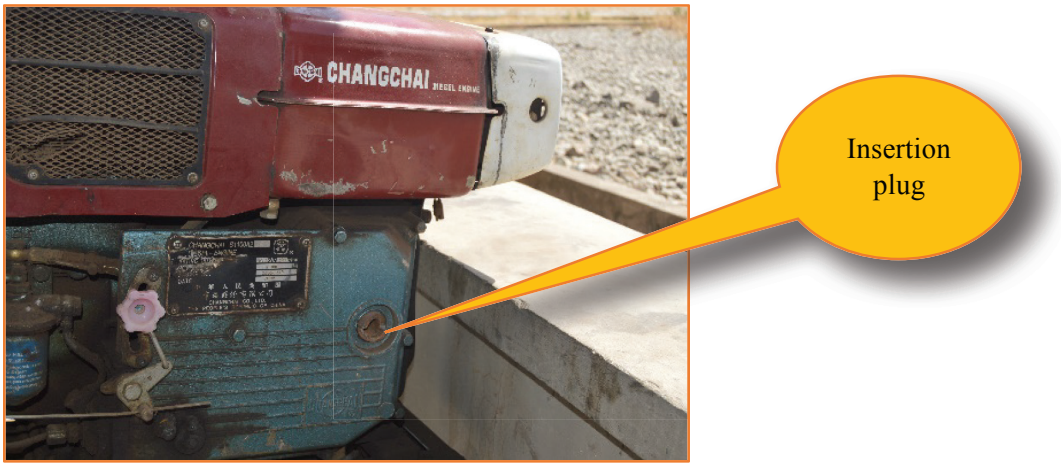

Fig 17. 2WT manual starting handle insertion plug.

- 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

Step in forward driving:

- The gear was in the neutral position when the 2WT is started, now you should select first or second gear depending on your desire.
- There are two options/low and high gear.
- To select high gear, pull the lever upwards, for low gear push the lever down.
- Engage the gear-shifting lever to 1st gear.
- Increase the throttle gradually.
- Engage the clutch/brake lever to its forward position.
- Now the walking tractor should start moving forward.
- 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 2WT, like in a vehicle (car). Instead, the levers/clutches/in the right and left handles act as a steering wheel.

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

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.

Fig 17a. 2WT steering clutch (left & right sides).

Note that: the steering might be different in driving steep slope while attaching a trailer with a full load. Please take a great care while driving downhill.

Attaching ancillary equipment to 2WT

The 2WT is a multi-purpose tractor, which can handle many 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

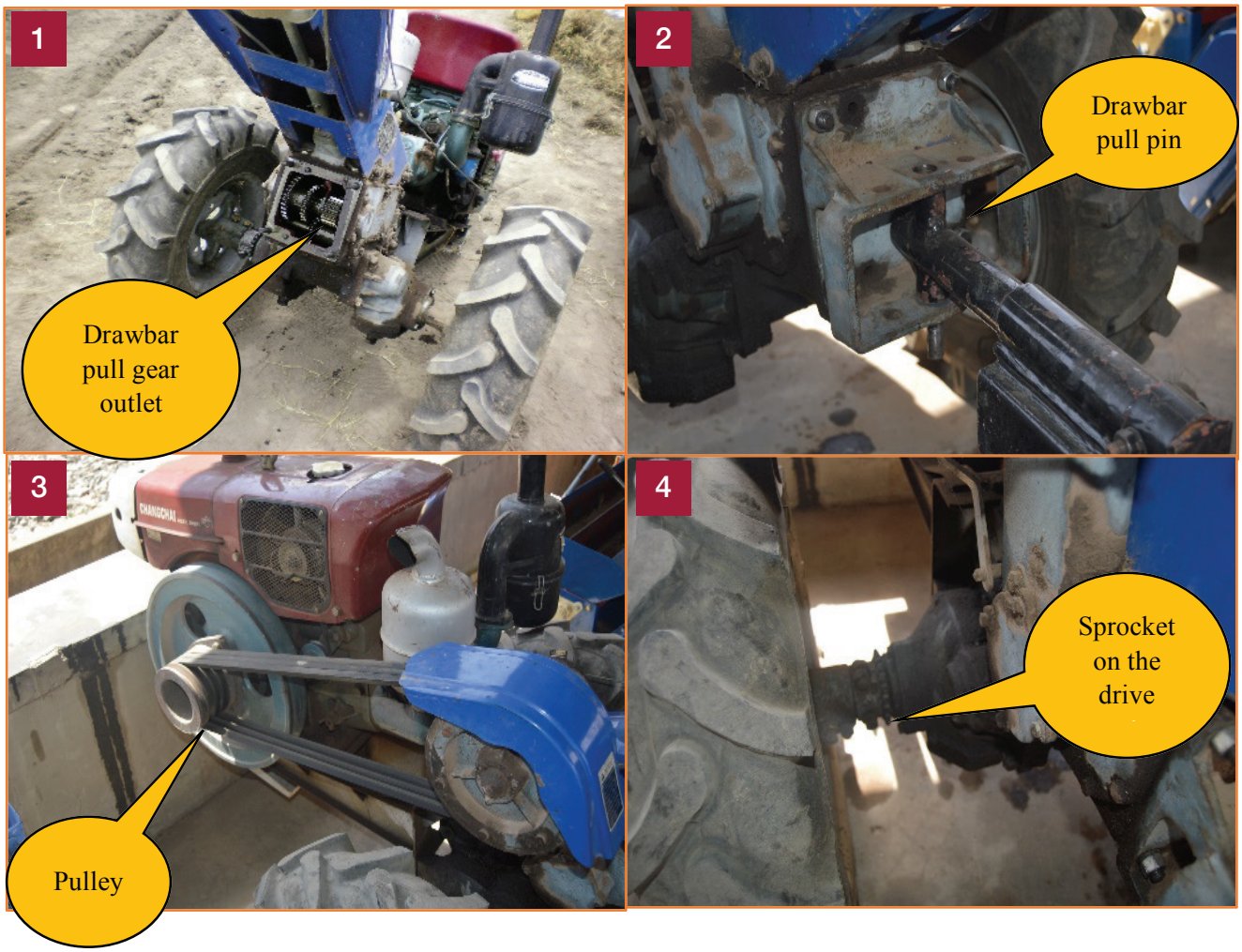

Fig 18. Attaching ancillary implement to 2WT.

Please note: none of the attachments should be done at once. Depending on the operation, it is essential to make the decision to attach. For example, a 2WT with a reaper harvester cannot be attached to a pump simultaneously. It is important to put the activity priority before making an attachment so that the downtime will be reduced.

1. 2BFG-100 Seeder

The seed drill is designed to drill seeds, apply fertilizer, and cover the seeds firmly into the soil. It can be used for either strip and no-till depending on the number of blades fitted and the type of tillage required. The seed is dropped down along rows through plastic. In a single operation, it prepares and pulverizes the soil, along the row at which the seed is dropped at certain depth according to agronomic recommendation.

2. Major components and description of 2BFG-100 seeder

2.1. Hopper

The planter consists of trapezoidal shaped seed and fertilizer hopper, made of mild steel sheet metal which are mounted side by side (fertilizer box in front and seed box in the rear) on the frame. The hopper is part of the seed drill in which the seeds to be planted are kept before their gradual release into the furrowed tunnel through a hose. The amount of seed and fertilizer contained depends upon the size of the seed hopper.

2.2. Seed metering unit and delivery system

Metering mechanism is the heart of a planting machine and its function is to distribute seeds uniformly at the desired application rates. The major seed metering unit and delivery system consists of rotary seed and fertilizer fluted rollers, shaft, sprocket, chain, seed and fertilizer engaging and dis-engaging lever. The seed and fertilizer rate are adjusted by the two-adjusting knob fitted at both seed and fertilizer metering section. The performance of a planter depends much upon right calibration of metering device.

2.3. Rotary tiller

The seed drill consists of rotary tiller driven by a power transmitted from the gear box of the 2WT. It is used for pulverizing and preparing seed bed for planting. There are a number of blades on the rotavators which can be used for tilling parts of the soil at which the seed will be dropped.

2.4. Furrow opener

Furrow openers are parts of a seed drill that are used to open furrow so that seed is placed at a specific depth below the surface. Since the rotating tiller pulverizes the soil during operation, the furrow opener can easily open furrow at recommended depth. The depth can be adjustable by using different holes placed vertically at furrow opener.

2.5. Press wheel/roller

Press wheel is used to firm and/or to level the entire field surface, i.e. exert their influence over both the row area and the inter-row space during planting. It can be used for controlling depth of operation with the help of depth controlling lever at the both sides of the seed. It can also level the field surface to facilitate uniformity in the depth of cover over the seed and control small weeds at time of planting. It is also incorporated with scraper for removing mud from roller during operation.

Fig 19. Assembled 2BFG-100 seeder.

3. Principles of operation

In general, this 2WT attached seed drill works with power obtained from the rotation of sprocket assembled on the left side 2WT axle wheel. As the tractor starts to move, the sprocket on the axle will starts to rotate. The sprocket of the 2WT and the sprocket at the seed drill seed metering shaft is connected through chain (The seed and fertilizer metering parts are connected by a chain -sprocket arrangement to the 2WT wheel axle). As the tractor starts to move, the shaft of seed metering unit will rotate, which can intern rotate the fluted roller and hence the seed and fertilizer metered through fluted roller will be delivered to the seed outlet (the seed and fertilizer metering mechanism gets the power directly from axle through the chain and sprocket).

4. Assembling 2BFG-100 seed drill

Before assembling the seed drill with 2WT, make sure that you have selected a good working environment, wear recommended clothes and safety shoes. Check if all accessories and appropriate necessary assembling tools are readily available.

4.1. Assembling the Sprocket to 2WT axle

Once the above pre-assembling procedures are fulfilled, start assembling the sprocket which drive the shafts of the metering mechanisms for both seed and fertilizer to the left wheel side of the axle as shown in *figure 19*. A drive sprocket should be assembled in the left axle of the 2WT. Loosen the two bolts connecting the two sprockets facing, align the sprocket key way, insert the sprocket facing, insert the bolts and tighten the bolt.

Fig 20. Inserting the drive sprocket to the drive axle.

4.2. Assembling Furrow Opener

Assembling of furrow openers depending on the row spacing needed for the crop to be planted. For example, if the seed is wheat that should be seeded with row spacing of 20 cm, it is necessary to install six furrow openers with a 20 cm spacing as shown in *figure 21*. If the seed to be planted is maize, you need to install only two furrow openers at 75cm row spacing and the rest furrow openers will not be installed.

Fig 21. Assembling of furrow openers.

4.3. Assembling Rotary Blade

After installing the furrow openers at recommended spacing, the next step is to install the rotary blades for ripping. We already set up the 2BFG-100 furrow openers at 20 cm spacing. Therefore, twenty-four blades will be installed in the rotavator shaft radially and exactly in front of the furrow openers aligned in straight line, as shown in *figure 22*. This is because the furrow openers will follow the ripped/pulverized soil/lines and the seed and fertilizer metered will fall in the opened furrow through plastic hose.

Fig 22. Installed blades on the rotavator shaft.

4.4. Assembling press wheel/Roller

Loosen the bolts on the left and right side of the press wheel and align the press wheel with working depth adjustment lever. Insert bolt and tighten properly *(Fig 23).*

Fig 23. Assembling press wheel/roller.

4.5. Mounting the 2BFG-100 Seed Drill

Before mounting the 2BFG-100, tilt the 2WT so that its front side will touch the ground, to avoid leakage of gearbox oil when the cover is opened. There are four nuts in the drawbar pull plate of the 2WT located on the gearbox *(figure 24)*. Loosen the nuts and remove the cover.
Caution: the 2WT gearbox is filled with oil, so care should be taken to avoid oil leakage.

Fig 24. Removing drawbar pull cover.

Once the draw bar cover is removed, the next step is to mount the 2BFG-100 seed drill. At least four persons are required to carry and mount 2BFG-100 on 2WT as shown in *Fig 25*.

- Two persons each on the left- and right-hand sides to carry and mount the planter.
- Carry the planter and align the gear on the front side of the 2BFG-100 gearbox to the opened gearbox of the 2WT. One additional person is needed to tighten the nuts uniformly, while the four persons are aligning the 2BFG-100 front gearbox to the 2WT gearbox, .i.e. the right side and left side nuts need to be tightened almost simultaneously. Caution: Carry the seed drill properly until the bolt is tightened and the support lever on seed drill and with the tractor handle tighten to avoid fatal injury.

Fig 25. Mounting the 2BFG-100 to the drawbar pull/gearbox of the 2WT.

As soon as you finish tightening the nuts, place the 2WT on a normal horizontal position. Next tighten the mounting levers to the right and left sides of the 2WT *(figure 26)* to fix the seed drill rigidly so that when someone is trying to lift the planter while turning, it will facilitate safe turning and operation.

Fig 26. Mounting levers to attach the VMP to the 2WT steering column.

4.6. Alignment of Sprockets and Chain

Misalignment of the seed metering drive sprocket with the axle sprocket of the 2WT will result in the chain to frequently come off the sprockets and drive to the seed box will cease. Moving the securing pin and sliding the sprocket on either the axle or the seed box shaft until the drive chain is completely aligned. Once we are sure that the sprocket and chain is perfectly aligned, we can easily make a groove on the axle and tighten the sprocket and axle with a bolt. Ensure that the drive chain sits evenly on the chain tensioner idler. After aligning the chain, replace the securing pins in the correct position *(figure 27)*.
Note: Please ensure that the chain drive from the axle to the seed box is equally aligned and tight.

Fig 27. Alignment of sprockets and chain.

Once the sprockets are fitted, the furrow openers are adjusted, blades are set, press wheel/roller is assembled and the 2BFG-100 is mounted, the next step will be to check/see whether the planter works properly or not.

1. Fill the 2BFG-100 gearbox with oil in the oil filling inlet *(figure 28)*. **Caution:** The 2BFG-100 gearbox is not supplied with oil. Operating the gearbox without oil will cause gearbox failure and damage.

Fig 28. 2BFG-100 gearbox oil filling inlet.

2. Check that all chains are well greased and are free for smooth operation, as shown in *Fig 29*.

Fig 29. Lubricating the chain and sprocket.

3. Check that the clutch is free and working well.
4. Check that all seed and fertilizer tubes are free and not blocked.
5. Check seed metering roller and ensure that small internal brush is lightly touching against the metering mechanism *(figure 30)*.

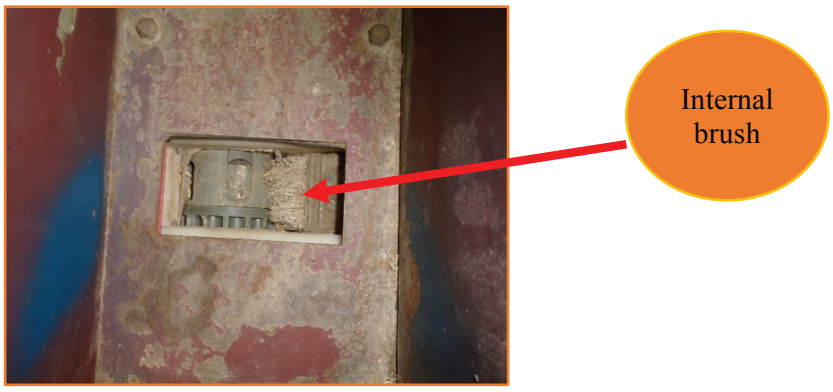

Fig 30. Fluted seed metering roller and internal brush.

6. Check that fertilizer fluted rollers are clean and free of all old caked fertilizer *(figure 31)*.

Fig 31. Fluted fertilizer metering roller.

- 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.
- Drive forward and observe the rotation of the blades. If the blades are not rotating, check the engaging lever of the 2BFG-100 seed drill.
- 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.
- Engage the seed metering lever which is located in front of you *(see figure 32)*.

Fig 32. Seed and fertilizer metering engage and disengage lever.

7. Alignment of drive sprockets and chain

Please ensure that the chain drive from the 2WT wheel axle to the seed box is equally aligned and tight. Caution: Misalignment of the seed metering driven sprocket and the axle of the 2WT drive sprocket will result in the chain frequently coming off the sprockets, and drive to the seed box will cease.

8. Adjusting row spacing

Before commencing planting, determine the row spacing to be used (consult an agronomist). Move the seeding tines by loosening the bolts on the furrow opener across the tool bar and measure the distance between them with a measuring tape, as shown in *Fig 33*. After setting row spacing, tighten the bolts to firmly locate the tines on the tool bar.

Fig 33. Adjusting furrow opener spacing.

9. Adjust Depth of planting

Depth of planting is adjusted by increasing or decreasing the height of the furrow opener, according to a recommendation by an agronomic. Loosen the bolts for each furrow opener, increase or decrease the vertical spacing depending on the agronomic recommendation on the type of crop to be sown *(figure 34)*.

10. Calibration

10.1. Seed and Fertilizer Rate Calibration

First, change the seed meter setting to suit the type of seed to be sown/drilled. For large seeds and spaced crops (maize, etc.) the large flute setting should be used. Attach transparent polythene bags to each of the six seed delivery tubes, as shown in *Fig 34.*

Fig 34. Attaching transparent polythene bags to each of the six seed delivery tubes.

The seed drill should be operated on a pre-measured 50 meter (m) travel distance with a sowing width of 1 m, thus providing a 50 m2 area. After every 50 m linear distance run, collected seeds and fertilizers in transparent polythene bags should be weighed separately using calibrated digital scale and the total seed weight should be also noted as shown in *(figure 35).*

Fig 35. Weighting collected seeds separately.

This method should be repeated by turning the knobs to either increase or decrease the opening of the fluted roller until the desired seed rate is obtained. As shown in *(figure 35)*, there are two adjusting knobs, in which the left one is used to adjust the opening of the seed fluted roller metering unit, while the right adjusting knob is used to adjusting fluted roller fertilizer opening. Since the seed metering device is connected by a chain-sprocket arrangement to the 2WT wheel axle, the speed of the tractor should not be a factor in calibration, unless there is wheel slippage. Repeat this method by turning the knobs to either increase or decrease the opening of the fluted roller until the desired seed rate obtained. Once the desired rate is obtained; fix the knobs at right position and replicate the test run three times.

Fig 36. Seed and fertilizer rate adjusting knob.

10.2. Planting procedure

Before commencing to plant each field, determine the best layout for planting. As shown in (figure 37) planting the rows (lines) of seeds parallel to the longest side of the field is the most efficient.

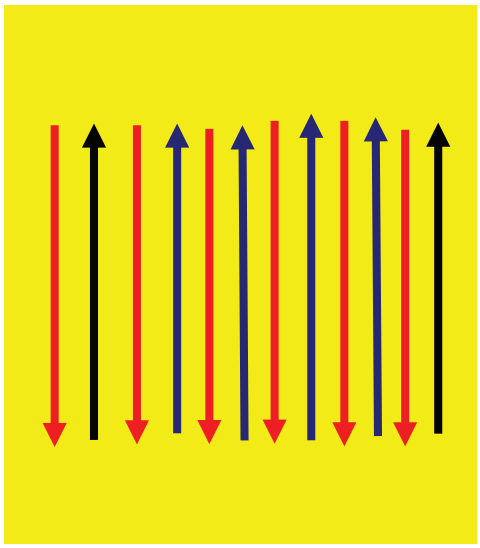

Fig 37. Diagram showing main seeding plot operation.

- When the end of the field is reached, disengage the seed and fertilizer metering unit, lift the seed drill clear of the ground and turn around.
- When the 2WT is aligned for the next pass, engage the seed and fertilizer metering unit, drop the seed drill into the soil and plant back to the original end, keeping the row (line) spacing the correct distance from the starting rows.
- Continue back and forth planting the field until the other side is reached. Caution: make sure that you have engaged the seed and fertilizer disengage lever during turning in each turning.
- When planting, check regularly that the seeds are falling down and out through the bottom of the tubes and into the soil by raising the seeder at the end of the field. Seeds will continue to fall out of the seed tubes, and can be easily seen.

When the main seeding plot is completed, seed the turning areas at each end of the field, make sure that these areas are planted (figure 38).

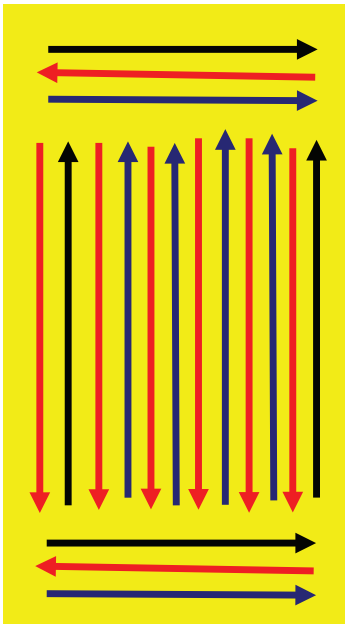

Fig 38. Diagram showing how turning area planting operation.

11. Seed drill storage

Before storing the seed drill for any length of time:

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

Versatile multi-crop Planter (VMP)

Versatile multi crop planter (VMP) is a planter, which can do the planting operation with drilling and precision planting options. The main source of power for this planter is a 2WT, which must have power greater than 12 horsepower.

Assembling the VMP

Since the planter has different parts, make sure that all the accessories and necessary assembling tools are readily available. Start with right side chain and sprocket assembling. There are three different sprockets each should be installed on individual shafts (two shafts are used for seed metering and one shaft is used for fertilizer application).

Fig 39: Chain assembly in the fertilizer and seed metering drive shafts.

After assembling the shaft, the next step will be to install the seed metering discs or opening the seed metering covers depending on the type of seed you need to drill or make precision planting. If the seed is to be drilled, you do not need to install the metering discs instead you need to open the cover of seed metering device.

Fig 40. Seed metering disc for precision planting like maize.

Fig 41. if there is a need to drill a seed like wheat.

Now the seed metering discs are installed.

- The next step will be to install the furrow openers depending on the row spacing needed for the crop to be planted. For example, if the seed is a maize variety to be seeded with row spacing of 60 cm, you need to install only two furrow openers with a 60 cm spacing. The rest of the furrow openers will not be installed.

Fig 42. Furrow opener and assembling hinge with u-bolts.

- After installing the furrow opener, the next step will be to install the delivery pipes depending on the number of rows required to plant the seed.
- Next comes the installation of the rotary blades for ripping. We already have set up the VMP furrow openers at 60 cm spacing. Therefore, four blades will be installed in the rotavator shaft radially and exactly in front of the furrow openers aligned in straight line. This is because the furrow openers will follow the ripped lines and seed metering will also be in the furrow.

Fig 43. Ripping blades on the rotavator shaft.

After the blades are assembled, align the front gearbox of the VMP sliding gears as shown in *Fig 44*. This step is needed to engage the gear on the shaft of the VMP front side gearbox using the gear-shifting lever of the rotary tiller.

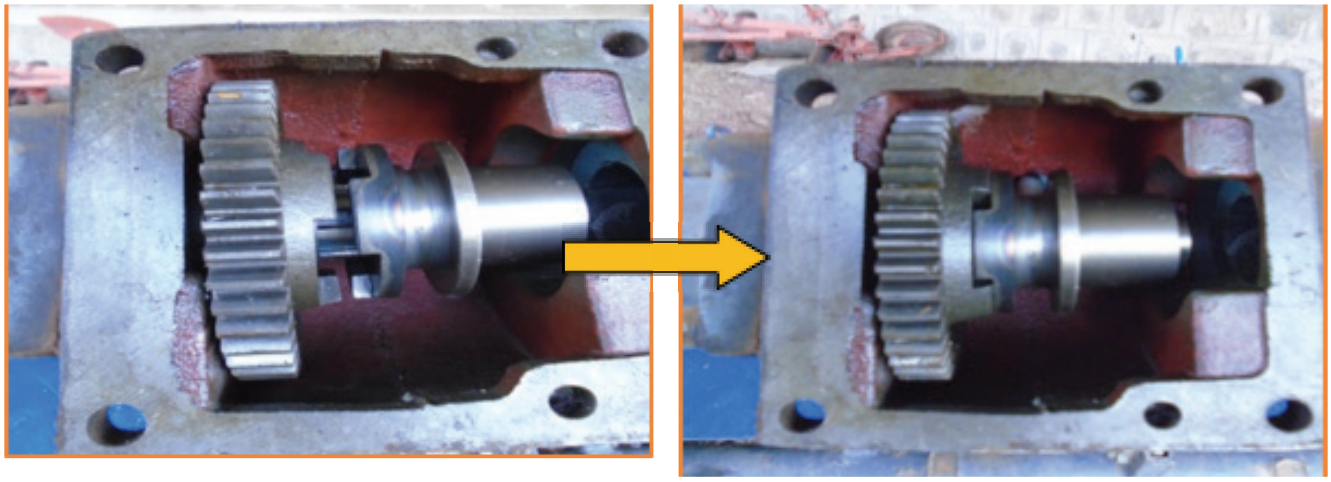

Fig 44. Gear engagement on the rotavator shaft inside the gearbox.

Now the planter is ready to be mounted on the 2WT.

Mounting the VMP

Before mounting the VMP, tilt the tractor so that its front side will touch the ground to avoid leakage of gearbox oil when the cover opened. There are four nuts in the drawbar pull plate of the 2WT located on the gearbox (see figure 45). Loosen the nuts and remove the cover. *Caution: the tractor gearbox is filled with oil, care should be taken to avoid oil leakage.*

Fig. 45. Drawbar pull cover removed.

- At least four persons are needed to carry and assemble the VMP on 2WT.
- Two persons each on the left- and right-hand to carry and mount the planter.
- Carry the planter and align the gear on the front side of the VMP gearbox to the opened gearbox of the 2WT. One additional person need to tighten the nuts uniformly while the four persons are aligning the VMP front gearbox to the 2WT gearbox, i.e. right side and left side nuts need to be tightened almost equally. **Caution:** VMP is quite heavy, so watch out! There could be danger if the planter is not lifted properly, potentially leading to a fatal injury.

Fig 46. Mounting the VMP to the drawbar pull of the 2WT.

As soon as you finished tightening the nuts, place the 2WT on normal horizontal position. Now tighten the L-shaped mounting levers to the right and left side of the 2WT (see figure 47) to fix the planter rigidly so that when someone is trying to lift the planter while turning, it will facilitate safe turning during operation.

Fig 47. Mounting levers to attach the VMP to the 2WT steering column.

Assembling the sprocket

A sprocket is needed to drive the shafts of the metering mechanisms for both seed and fertilizer. A drive sprocket should be assembled in the left front axle of the 2WT. The following steps should be followed:

1. Tighten the nuts of the left wheel using a 19.mm spanner.
2. Lift up the wheel using hydraulic jack. *Caution: be sure to insert a stand under the axle to avoid injury!*
3. Remove the wheel.
4. Tighten the nuts and bolts in order to remove the flange from the axle. *Caution: Use rubber mallet or steel hammer and a piece of wood to remove the flange.*
5. After removing the flange, align the sprocket key way and insert the sprocket facing the gearbox housing as shown in the (figures 48 to 50).
6. Tighten the two bolts and assemble the flange until it is in its correct position.
7. Now you can place the wheel to its original position and tighten the nuts.
8. Remove the stand and jack.
9. Tighten the wheel again.
10. Now you can install the chain and insert the pin to secure to the desired position. *Caution: Use rubber mallet to kick the sprocket and the flange to avoid damage since those parts are made of cast iron.*

Fig 48. Lifting the wheel with a hydraulic jack

Fig 49. Removing the flange of the axle and inserting the drive spropcket to the drive axle.

Fig 50. Assembled sprocket and chain drive.

Now the blades are set, the furrow openers are adjusted, the VMP is mounted. What is left is to see whether the planter works properly or not. In the section below, the important steps to be followed for operating the planter are described as follows.

Operating the VMP

Start the engine of the 2WT 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. Engage it and check. Now if the blades are working properly, the next step is to check whether the metering units of both seed and fertilizer are also working. Engage the seed-metering lever, which is located in front of you (see Fig 51).

Fig 51. Metering system engagement lever.

Drive the 2WT 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

After ensuring normal operation of the VMP, the next step will be calibrating it to the desired recommended seed rate, fertilizer rate, row spacing and depth of planting.

Seed rate

In order 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 used to calculate the rate per row per meter. 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 52).

Fig 52. Measuring 30 meters for calibration.

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.

Fig 53. Tying up a plastic bag for seed collection.

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 on the (Fig 53).

Fig 54. Metering mechanism adjusting lever for seed drilling.

We can also use VMP for precision drilling using metering discs which will be installed inside the seeding hopper vertically by using a screw with a hexagonal socket (Allen screw) (see Fig 55).

Fig 55. Seed metering disc.

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

Row spacing need to be adjusted according to agronomic recommendations and depending on the type of crop to be sawn.

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. 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 systems. Caution: Check whether the openings are firmly closed to avoid wastage of seed and fertilizer.

Width of planting is adjusted by increasing or decreasing the width between furrow openers.

1. Determine the number of rows (based on agronomic recommendations for the seed to be sown), for example, if we are going to sow a wheat (let us assume the row spacing is 20 cm), install the four furrow openers supplied with the VMP. If the seed is maize and row spacing is 75 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 horizontal spacing, depending on the agronomic recommendation of the crop to be sown.

Fig 56. Furrow opening U- bolt clamps.

Depth of planting

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

1. Determine the number of rows (based on agronomic recommendations for the seed to be sown), for example if we are going to sow 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.

Fig 57. Furrow opening U-bolt clamps.

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

Components and description of zero till maize planter

For proper maize planting, it is important to understand each parts of the planter and their function properly. This zero till maize planter consists of seed hopper, fertilizer hopper, seed metering units, furrow opener, toolbar and drive wheel (figure 58).

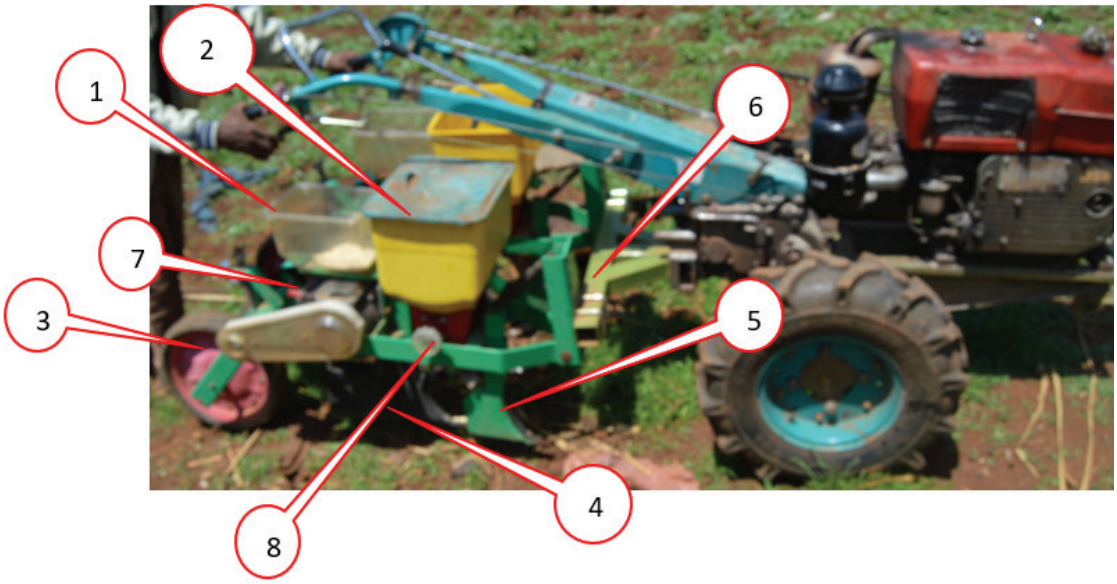

Fig 58. Major parts of maize planter1: Seed hopper, 2: fertilizer hopper, 3: drive wheel, 4: furrow opener for seed, 5: furrow opener for fertilizer, 6: toolbar, 7: metering unit speed adjusting gearbox.

Seed and Fertilizer Hopper

There are a total of four separate seed and fertilizer hoppers made of plastic material (figure 59). 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.

Fig 59. Seed and fertilizer hopper.

Drive Wheel

As shown in (figure 60), 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.

Fig 60. Drive wheel.

Furrow Opener

Furrow openers are (figure 61) 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 in order 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.

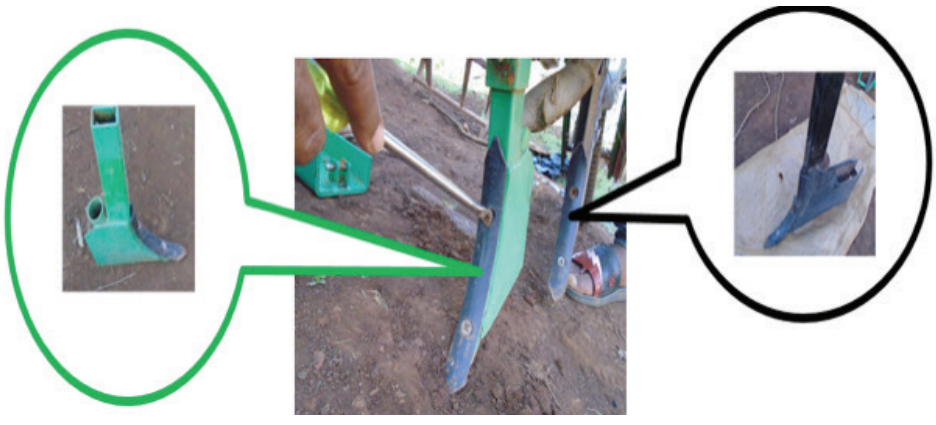

Fig 61. Furrow opener, the green one is furrow opener for fertilizer while the black one is for seed.

Metering Unit

As shown in (figure 62), 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, 4 sprockets of different sizes, 3 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.

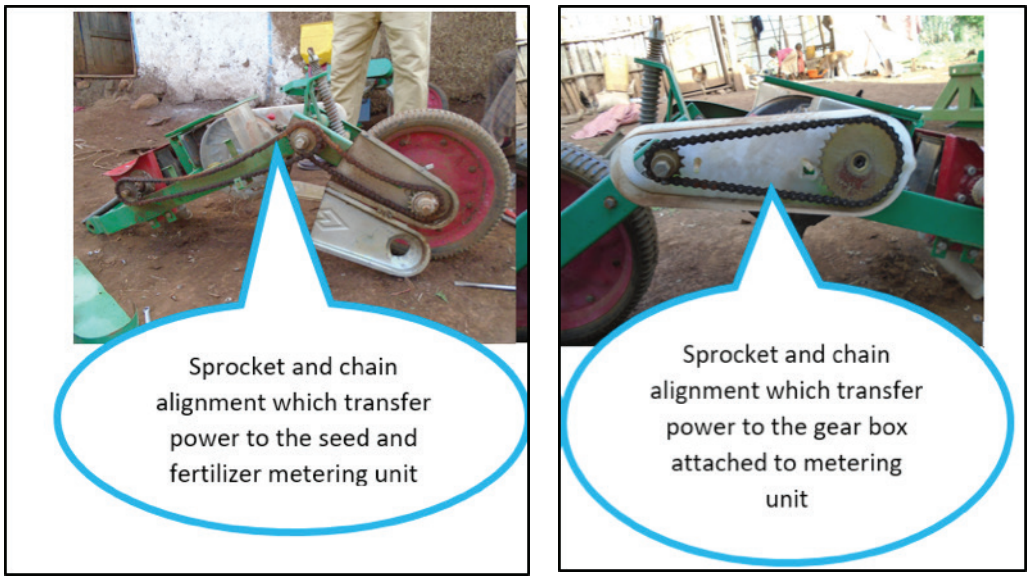

Fig 62. Seed metering mechanism and its components.

Tool Bar

The tool bar is parts of the planting machine used to connect the seed drill and 2WT (figure 63).

Fig 63. Tool bar.

Operation principles

This particular 2WT attached maize planting machine operates with the power obtained from the rotation of sprocket mounted on the wheel drive. As the tractor starts to move forward, the sprocket on the wheel

drive starts to rotate. As shown in figure 64, the sprocket on the wheel drive 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 intern 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.

Assembling the zero till maize planter

Assembling Hopper

The first step is to assemble the seed hopper using a cross-shaped (Philips)-screw driver for tightening and tighten the four Philips-head screws to fix the seed hopper with the frame (see figure 64).

Fig 64. Mounting the seed hopper.

The second step is to assemble the fertilizer hopper using a 14 mm wrench/spanner, tighten the bolts to fix the fertilizer hopper with the frame (figure 65). Make sure that during the tightening, the bolts will not rotate with the nut so that it will not be difficult to tighten.

Fig 65. Fertilizer hopper assembling.

Assembling Furrow Opener

As described in section 4, this planter has two different furrow openers in the same line of planting. Assembling of furrow openers depends on the depth and recommended row spacing needed for the crop to be planted. For example, to plant maize with 75 cm row spacing, you need to loosen the bolt on the tool bar using a 19 mm wrench/spanner, and use pocket meter to measure the distance between the row (figure 66).

Make sure that you have loosen the inner nut first before tightening or loosening the bolts on the fertilizer furrow opener using a 19 mm wrench/spanner.

Fig 66. Furrow opener assembling.

Metering Unit and Delivery System Assembling

As described in section 5, there are four different sprockets. Each sprocket should be installed on individual shafts (2 shafts for seed metering, 1 shaft for fertilizer metering and 1 shaft for gearbox attached to the metering unit) (see figure 67).

- Insert each sprocket on individual hexagonal shaft.
- Make sure that each sprockets are aligned properly.
- Connect the sprocket with power transmission chain.
- Cover the connected sprocket and chain with guards
- Use a 10 mm wrench/spanner and a Philips-screw driver to tighten and loosen the chain and sprocket safety guard.

Fig 67. Assembling of metering unit.

Drive wheel Assembling

Driving wheel is the most important parts of the machine. If it is not assembled properly, power cannot be transferred to the metering unit (figure 68). It's therefore imperative to assemble it with proper care.

- Put the wheel at the right position and insert the wheel shaft through the wheel.
- Make sure that the holes on the shaft and the hub of the wheel are aligned.
- Insert the bolt and tighten it with a 14 mm wrench/spanner.

Fig 68. Drive wheel assembly a): Inserting drive wheel, b): Tightening the securing bolt and c): Assembled drive wheel.

Mounting the Planter to 2WT

Before mounting the planter, select a leveled surface. At least three persons are required to carry and mount the planter on 2WT, as shown in (figure 69).

- Two persons (one on the left and one on the right) to carry and mount the planter.
- Align the tractor drawbar pull cover and the planter tool bar hole.
- Slightly lower and raise the 2WT tractor until the hole is aligned.
- 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.
- Insert the cotter pin in each pin.

Fig 69. Mounting the planter to 2WT drawbar using pins.

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 checkups before starting the tractor as described in the 2WT operation manual.* The next step will be to apply grease on the gears inside the seed metering gearbox (figure 70).

Fig 70. Metering unit gearbox.

- Check that all chains are well greased and are free for smooth operation.
- Check that the clutch is free and working well.
- Check that all seed and fertilizer tubes are free and not blocked.
- Check that fertilizer fluted rollers are clean and free of all old caked fertilizer and dust (figure 71).

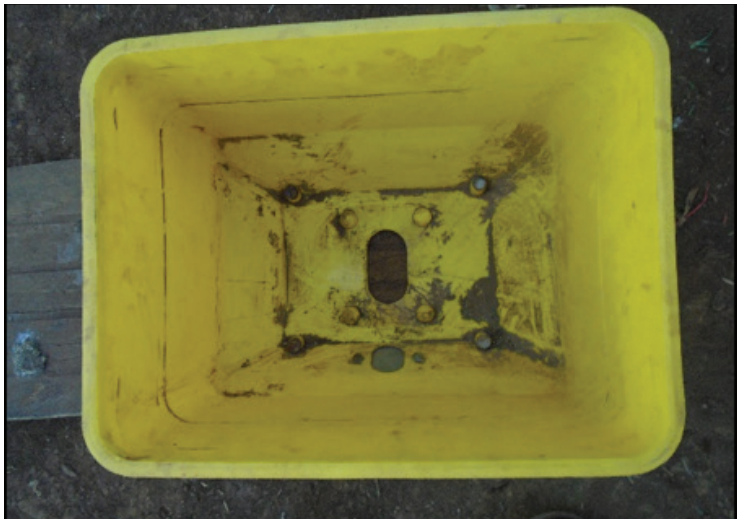

Fig 71. Fluted fertilizer metering roller blocked with dust/mud.

Calibration

Seed and fertilizer rate calibration

- Attach transparent polythene bags to each of the four seed delivery tubes.
- Operate the planter on a pre-measured 50-meter travel distance
- 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.
- 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.

Seed drill storage

Before storing the seed drill for any length of time:

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

EIAR

Ethiopian Institute of Agricultural Research
Agricultural Engineering Research Process
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Pump

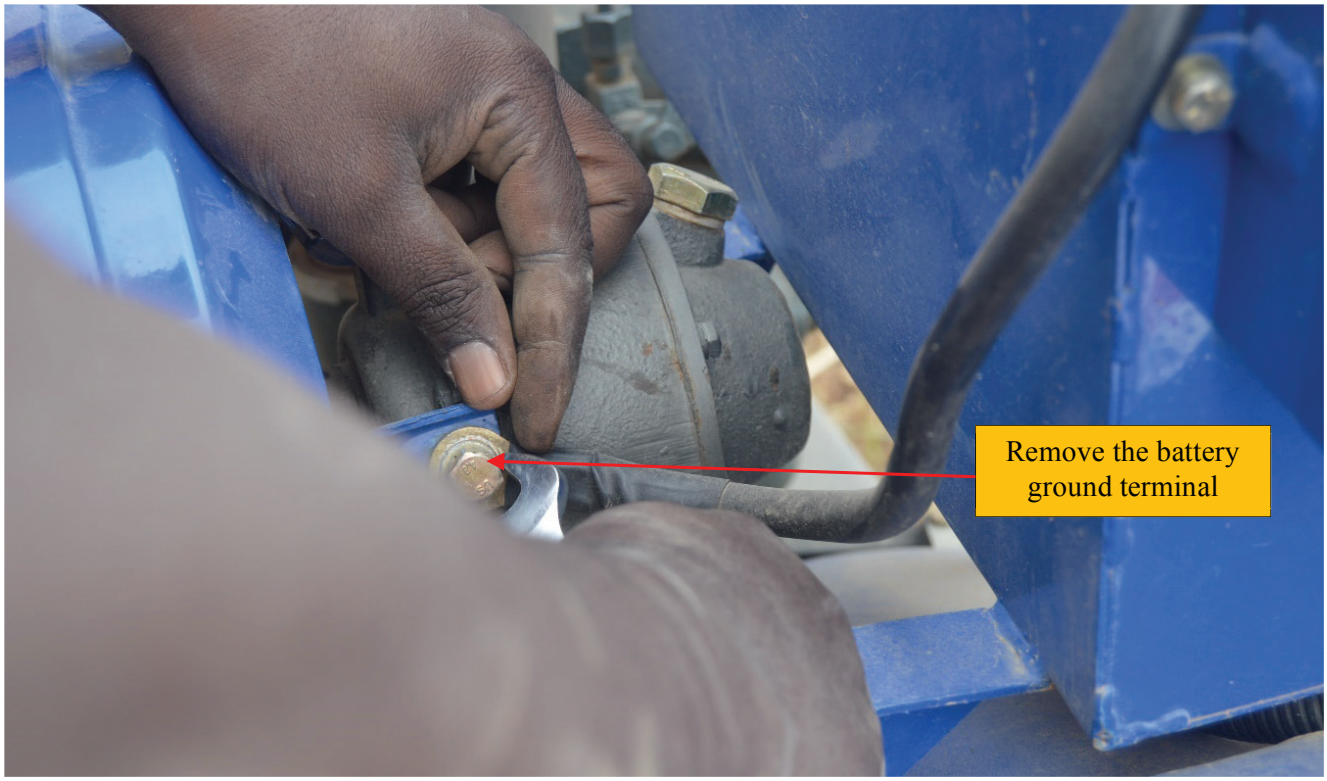
DAWANG brand is a portable 2WT driven pump. It is small in size, light weight, good in performance, and easy to operate and maintain. It is also reliable and widely used for irrigation, drainage, mines, construction sites and daily water supply systems.

Preparations before assembling

Separate the trailer from the 2WT by removing the drawbar pin (as shown in the figure 72). After that, place the trailer in a safe flat position so that there will not be slipping and to avoid injury.

Fig 72. Separating the trailer form the 2WT.

- Remove the battery's ground terminal (-ve) and v-belt guard as shown in the (figure 73).
- Remove the starter battery set by loosening the fixing bolts (as shown in figure 71 &72). Use designated spanner and carefully remove the securing bolts from each side (two on the right and two on the left side). **Attention!** Care should be taken not to damage the bolts during removal.



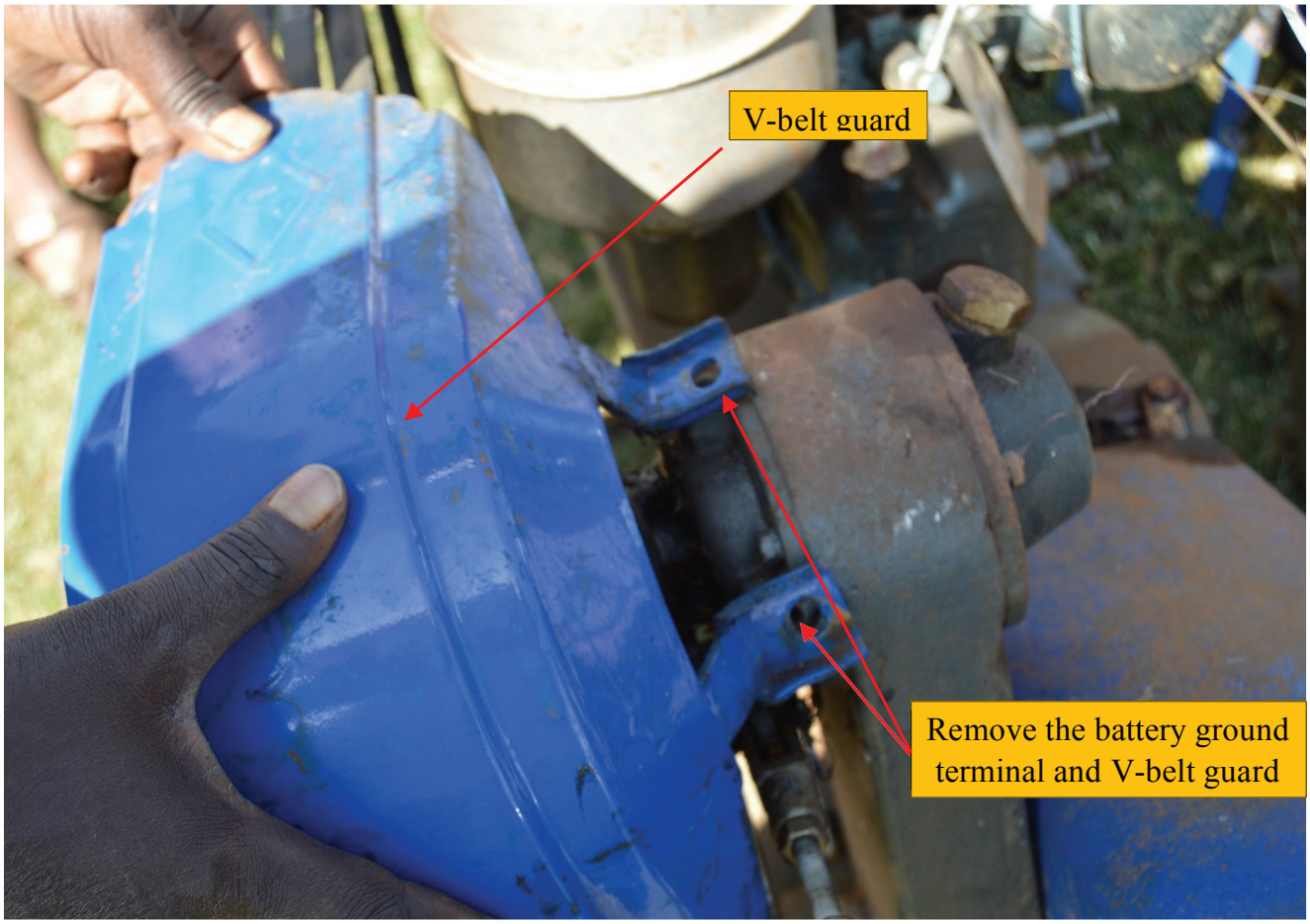


Fig 73. Removing the battery ground terminal and v-belt guard.

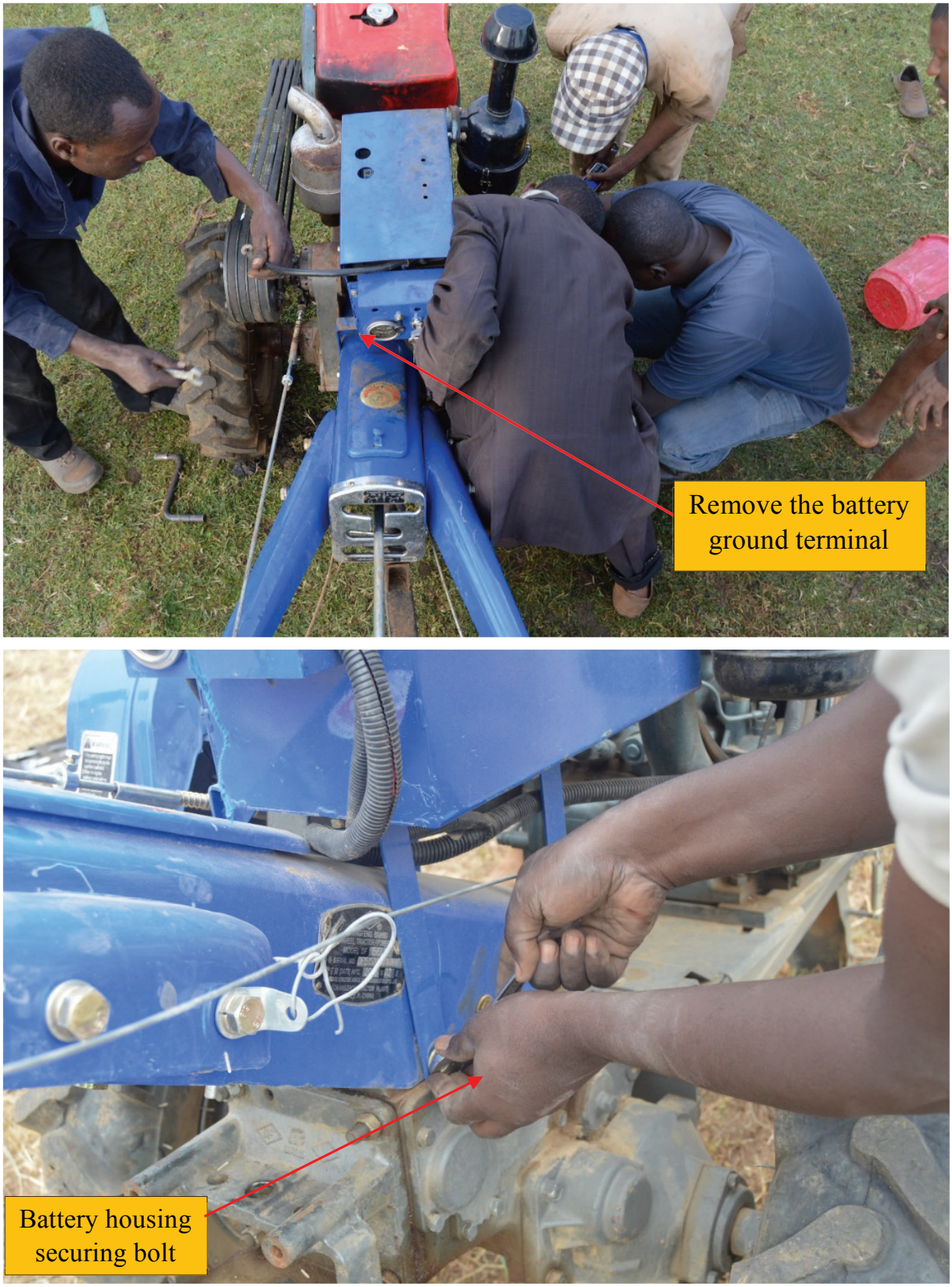


Fig 74. Removing battery ground terminal and housing security bolt.

Now, carefully remove the battery and place it in a secure place to avoid damage and injury. *Caution: Please do not try to carry the battery by a single individual since it is filled with sulfuric acid, which is very hazardous to human beings, and to avoid spilling, and damage to skin, eyes and other parts of the human body.* Please carry it by using at least two people carefully. In case of accidental spill, please wash immediately with water and visit a physician).

Assembling procedures

First step is to make sure that each pump accessory parts are in the right place as shown in (figure 75). Please learn the name of each part for future use.

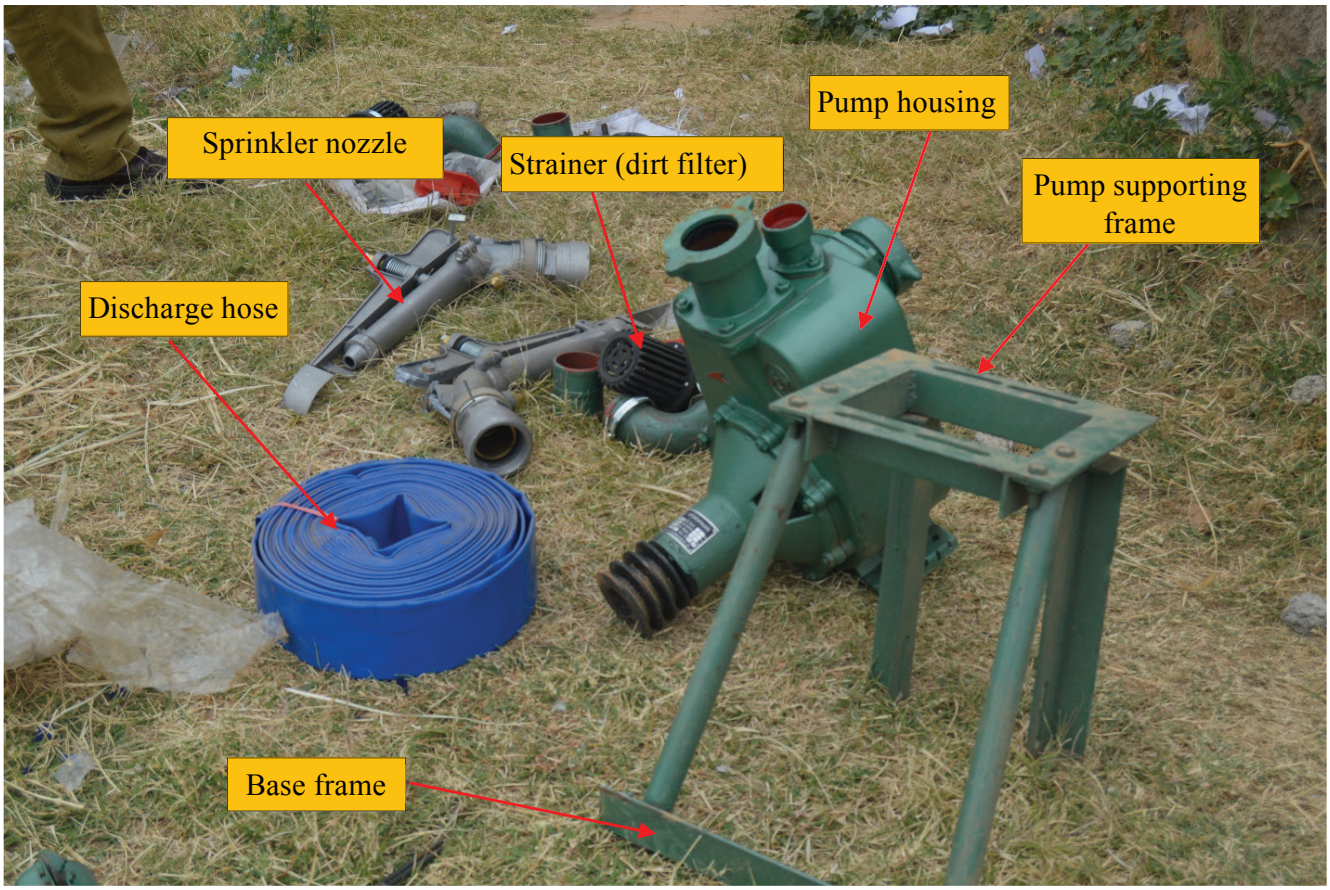


Fig 75. Complete set of 2WT attached water pump.

Pump parts & Definitions

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: Pump supporting frame is the frame structure specially made to support the pump on top of the 2WT.

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.

Pump Installation steps

Step 1:
Remove the securing bolts and nuts from the base of the pump supporting frame as shown in (figure 76).

Fig 76. Removal of the securing bolts.

Step 2:
Secure the pump support base with three bolts that you removed from the 2WT as shown in (figure 77) below when viewed from the front top of the 2WT.

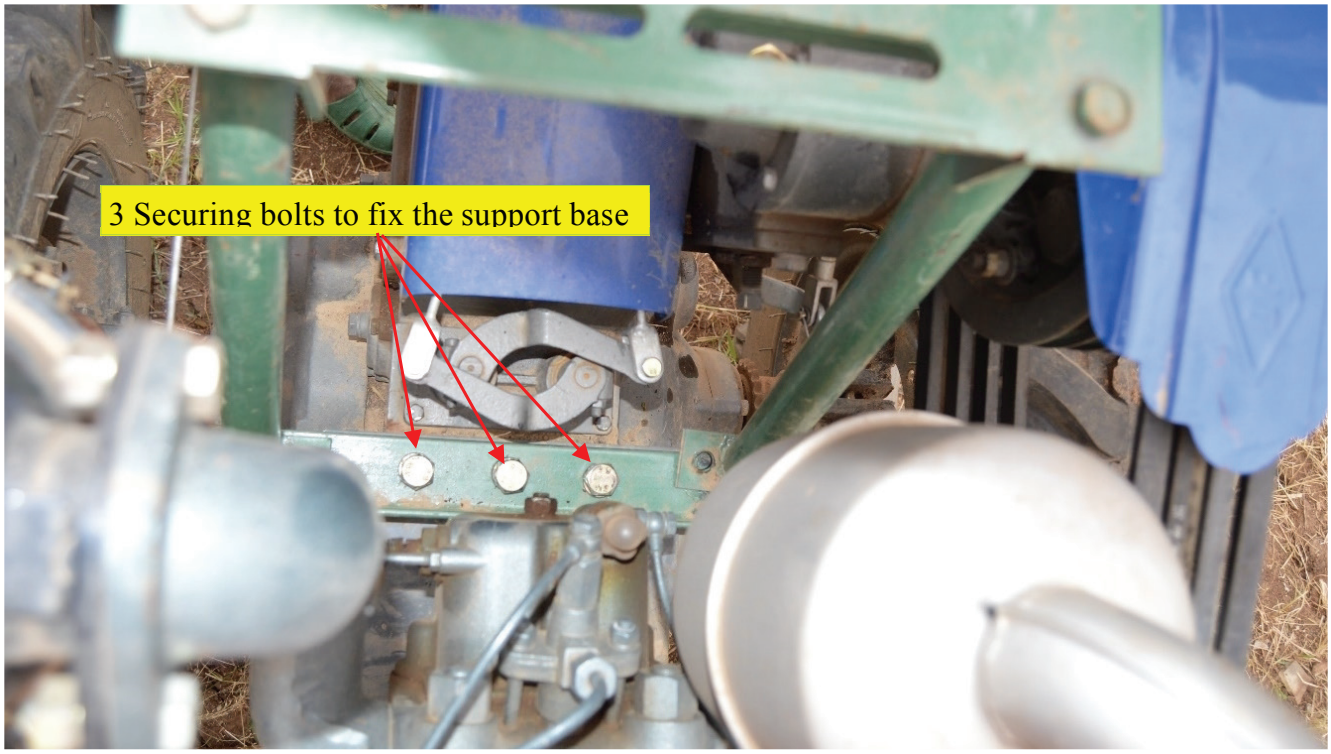


Fig 77. Installing the pump support in the 2WTviewed from the top.

Step 3:
Install the pump on the pumping support by four bolts and nuts as shown in (figure 78). Note that the pump pulley should be aligned with the engine pulley. Alignment of the two pulleys can easily be done by visual inspection and taking the pump support securing left and right slots. After ensuring that the two pulleys are aligned, tighten the nuts at a proper torque. ***Caution: Note that bolts are placed up-side down as in the picture below.***

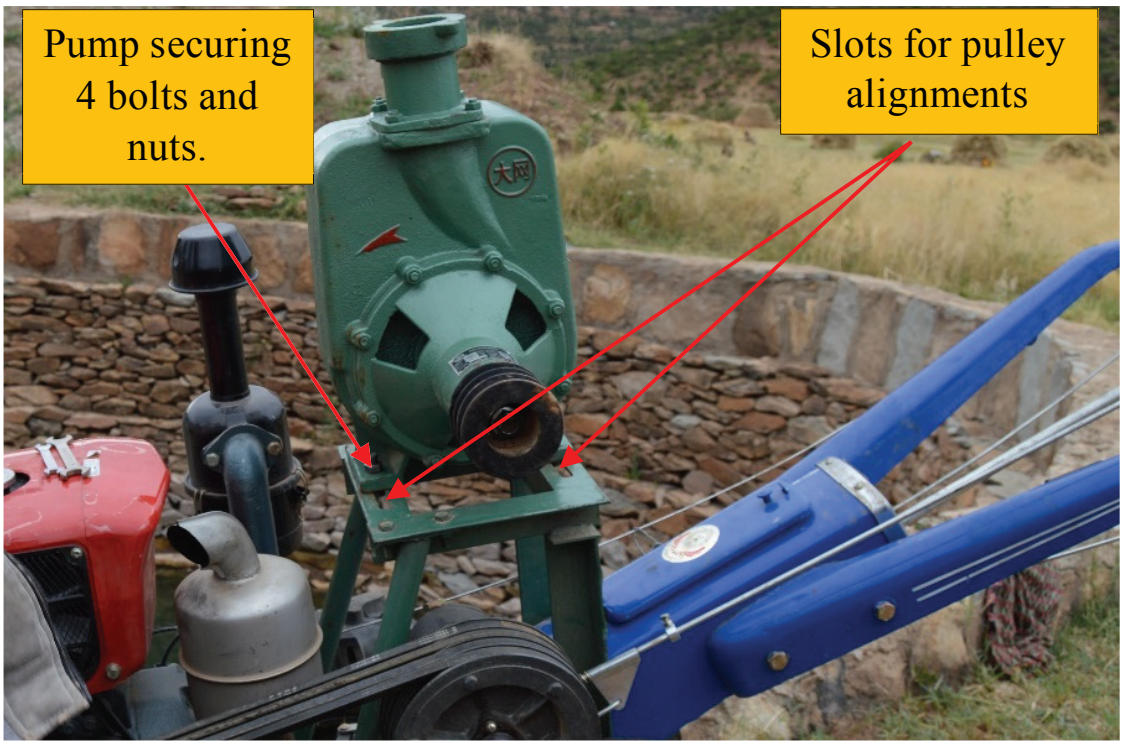


Fig 78. Installed pump on the support.

Step 4:

After the pump is installed properly, the next step is to remove the belts from the clutch to the 2WT engine pulleys. This step involves tightening the engine belt tensioner and the engine base securing bolts as follows:

- First start by loosening the four engine base securing nuts. Caution: do not remove them yet, just loosen them until they are free from the base.
- Next, loosen the first and second nuts on the tensioner stud and then loosen the inner nut and tighten the second nut clockwise so that the engine will be pushed away from you. As a result, the three-engine v-belts will be loosened enough to be removed from the crankshaft pulley and clutch pulleys respectively.

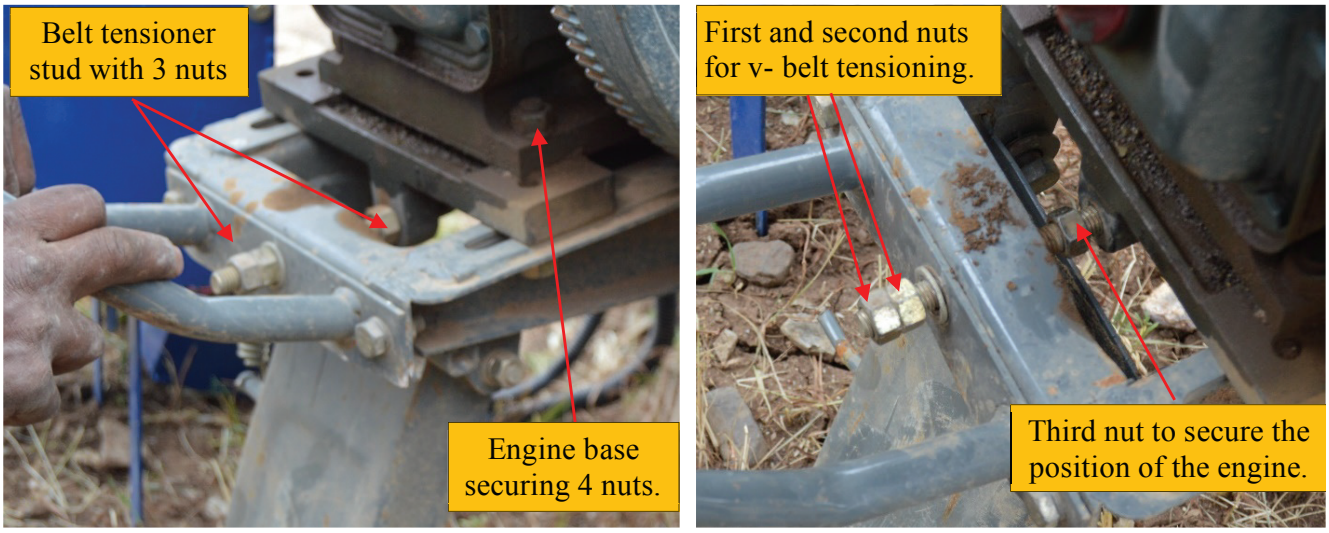


Fig 79 & 80. Tightened (Left side) and Loosened engine belt tensioner (Right side).

Step 5:

Now after loosening the belts, the next step is to remove all three v-belts starting from the outer most to the middle and the inner v-belt. While rotating the engine with the manual starting lever, using a long flat screw driver put in the inner side of the v-belt as shown in (figure 81). Slowly remove the v-belts one by one starting from the engine pulley and finishing with the clutch pulley as in (figure 82). After inserting the new v-belt into the pulleys, secure the engine v-belt tensioner as shown in (figure 83). Caution: Please exercise caution while removing the v-belts, as you may hurt your hands in the process.

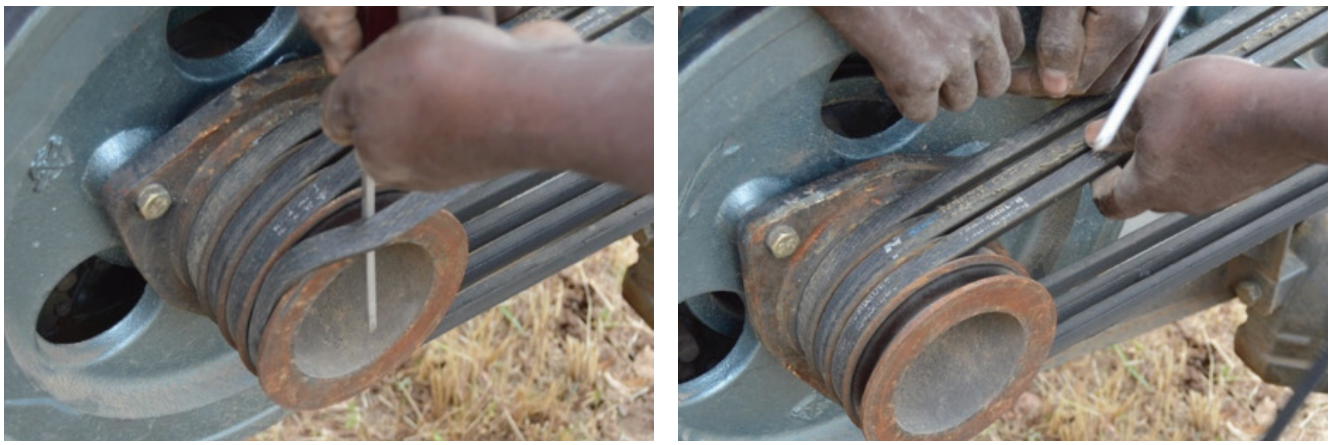


Fig 81 & 82. Removing the v-belts from the engine crankshft pulley.

Fig 83. Inserting a v-belt from the engine pulley side and then from the cluch pulley.

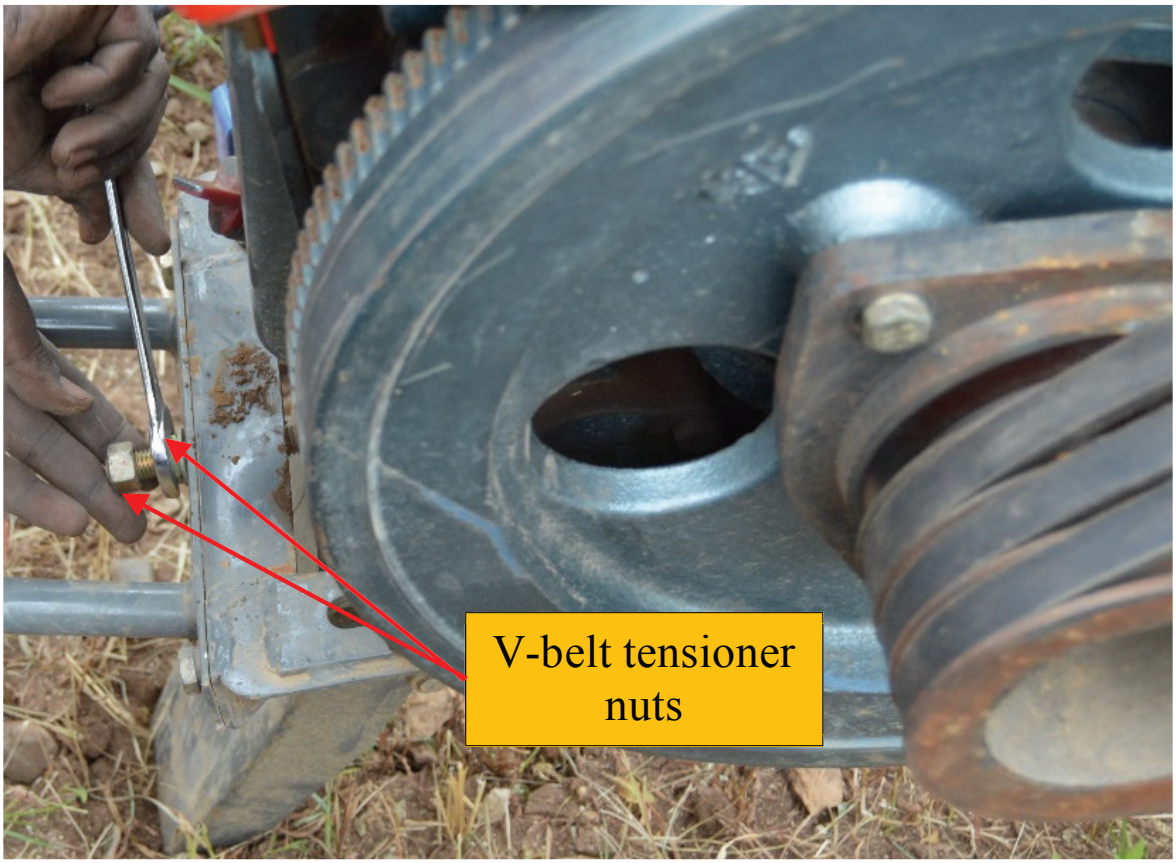


Fig 84. Securing the v-belt tensioner after inserting the new v-belts in to the pulleys to drive the pump.

Step 6:

- Now all the necessary spteps have been taken, what is left installing the discharge and suction pipes.
- Start with installing the suction pipe with tightening the reducer holder nut with your hand in (figure 85).
- Then insert the suction pipe into the reducer, as shown in (figure 86). *Caution: Tightning the reducer holder correctly is very crucial. If there is a leak, the pump will not work and will also lead to an unnessary and increased fuel consumption.*
- Insert strainer at the end of the suction pipe and tighten the clamp properly with a flat screw driver, as shown in (figure 87).

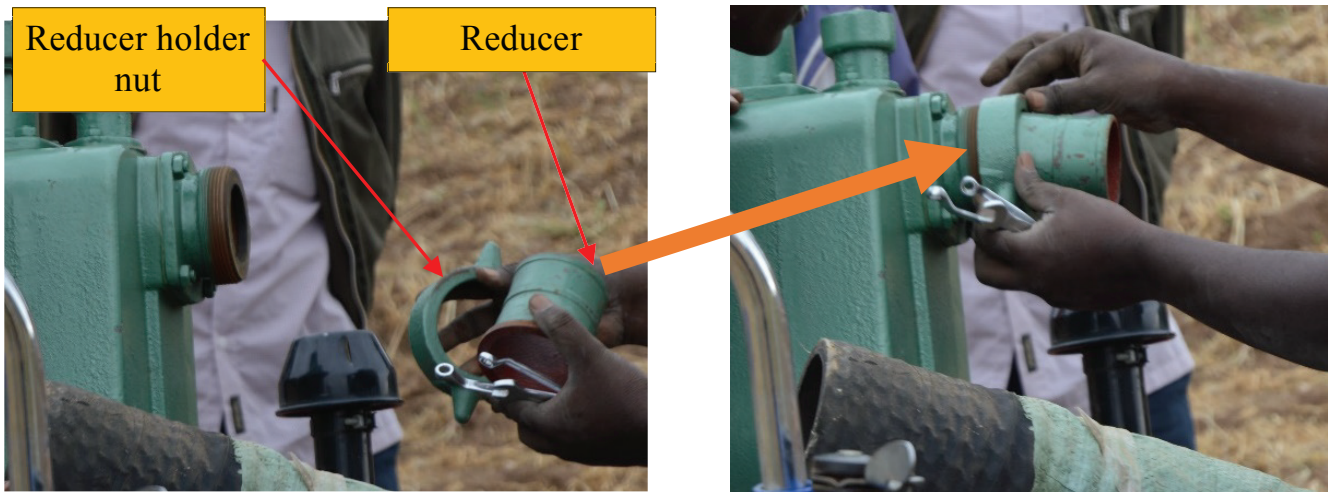


Fig 85 & 86. Tightening the reducer holder while inserting the reducer in the suction pipe.

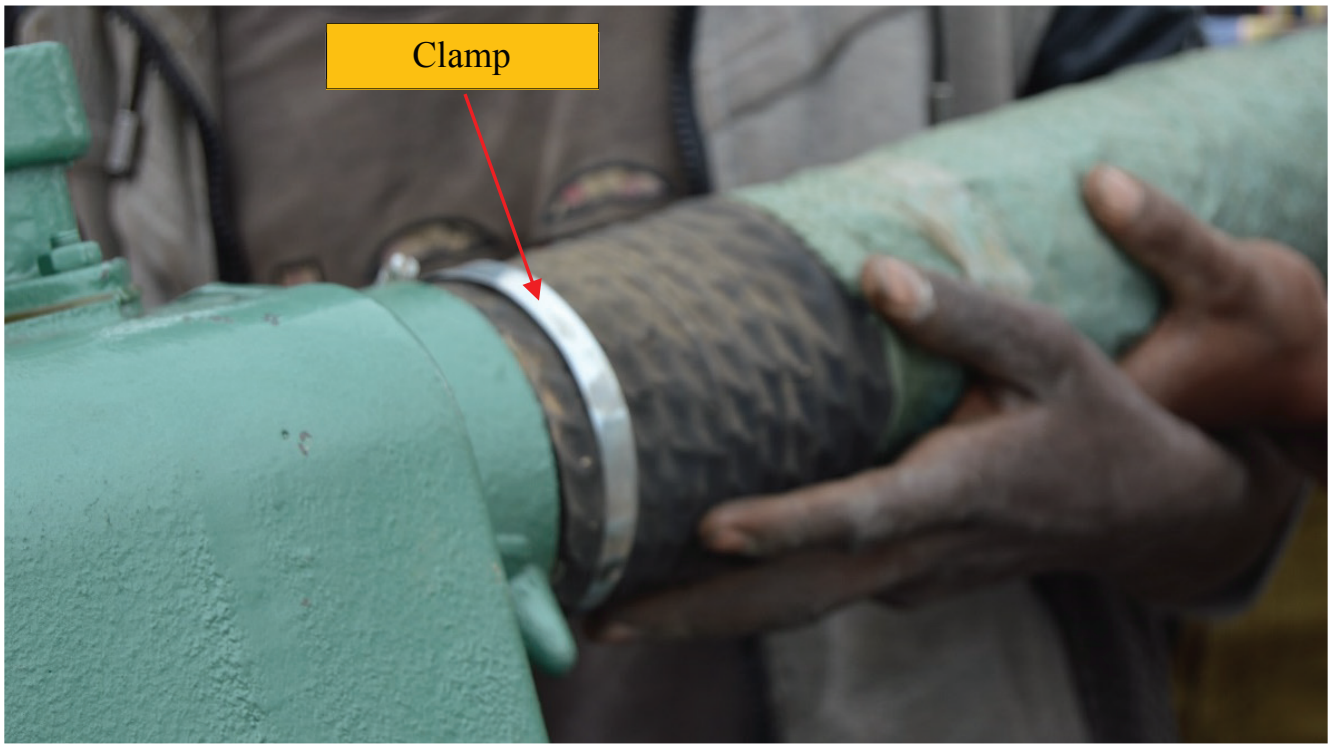


Fig 87. After inserting the suction pipe in the reducer, tightening the clamp with a screw driver.

Fig 88. Inserting a strainer at the end of the suction pipe and tightening it with a clamp.

- Similarly, install the elbow with its holder in the discharge side of the pump, as shown in (figures 89 & 90).
- Now secure the blue discharge pipe on the elbow and tighten the clamp with a screwdriver. *Caution: Unless you tighten the clamp properly, there will be water leakage as soon as the pump starts working.*
- Finally, stretch the discharge pipe without any bending along the line to avoid pipe damage and unnecessary pressure on the pump. This will also have an impact on the life of the pump.

Fig 89 & 90. Inserting the elbow in the discharge side (top of the pump).

Step 7:

- The final step will be to fix a tripod for the sprinkler. Fix the tripod, as shown in (figure 91).
- Insert the discharge pipe at the center of the tripod and tighten the clamp properly with a screwdriver, as shown in (figure 92).
- Remove the red plastic cover from the nozzle tip and install it at the top of the tripod carefully.
- Insert the suction pipe end with the strainer into the well (water point), as shown in (figure 95).
- Fill water into the pump until it is full before starting to remove the air inside the suction side of the pipe. This process is called priming.
- Check and fill the fuel tanker with fuel, depending on the length of time the pump will be used.

- Finally, start the engine and water your land area.

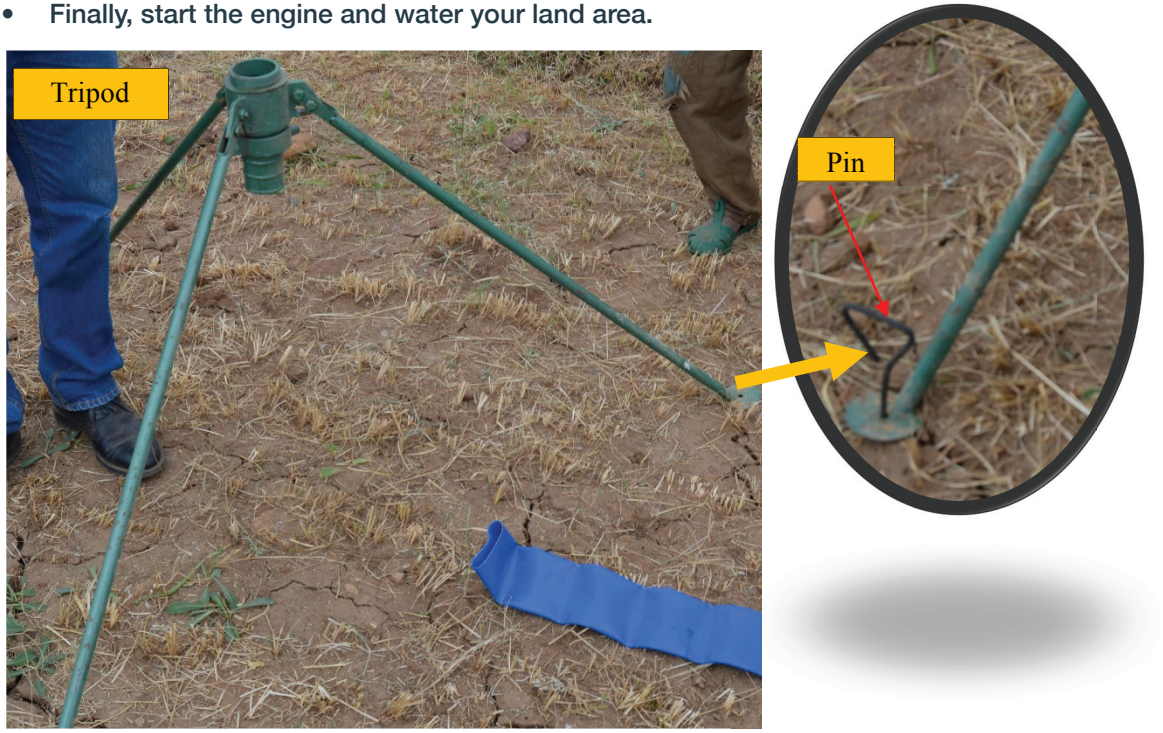


Fig 91. Fix the tripod on the ground using the black pins using your foot or any other hammering tool.

Fig 92. Inserting the discharge pipe at the center of the tripod and tighten the clamp properly with a screwdriver.

Fig 93 & 94. Removing the red plastic cover from the nozzle tip and installing it at the top of the tripod carefully.

Fig 95 & 96. Inserting the suction pipe into the well (water point).

Fig 97. Fill water at the right top of the pump until it is full (priming).

Fig 98. Check and fill the fuel tank with fuel.

Fig 99. Check the pump and begin watering.

THRESHER/SHELLERS USERS TECHNICAL MANUAL
BISRAT GETNET, SEYOUM WOLDESENBET & TESHOME BULLO

Introduction

Threshing and shelling of crops are among the most important agricultural operations, but are also time consuming and labor-intensive. It is estimated that harvesting and threshing of crops consume about one third of the total requirement of the production process. The total labor requirements for harvesting/threshing of cereals/pulses varies from 120-200 man-hours per hectare.

Threshing is the process of separating the grain from the crop/chaff/pod/nut by applying mechanical force that creates a combination of impact, shear, and/or compression. The operation of separation refers to separating threshed grains from bulk plant material such as straw.

Shelling is threshing action by cutting coupled with rubbing action in such as case we call the process of separating the grain from a cob. Maize is one of the most important staple crops in Ethiopia. Lack of appropriate maize shellers is one of the major constraints affecting maize production, both in terms of quantity and quality. Farmers shell the bulk of the maize using the traditional method of beating on the bare ground or loosely packed in sacks. The method:

- Has low productivity - hand shelling takes a lot of time, even with some hand-operated simple tools;
- Causes high physical damage and
- Has contamination with foreign substances, resulting in low market value and reduced shelf-life of the crop.

Threshing cylinders are:

1. the rasp-bar cylinder and concave, as shown in (figure 100).
2. the spike-tooth peg cylinder and concave, as shown in (figure 101).
3. the angle-bar cylinder and concave, as shown in (igure 102).

Fig 100. Rasp bar type cylinder.

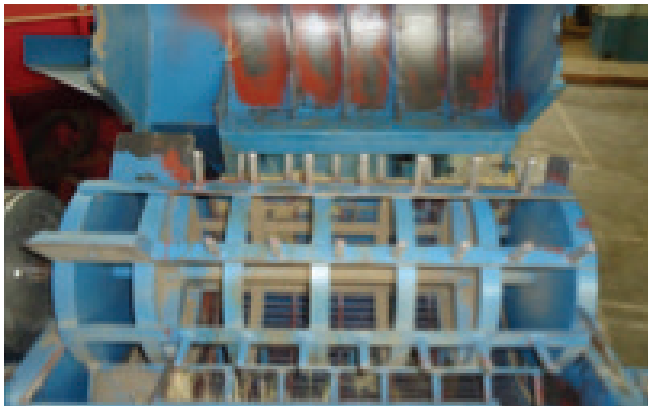


Fig 101. Spike tooth peg cylinder.

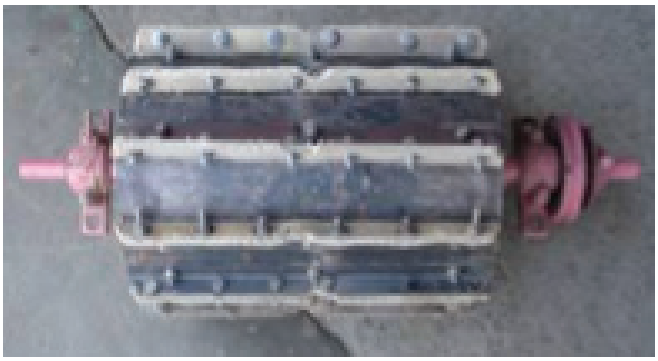


Fig 102. Angle bar cylinder.

To make an effective threshing/shelling, we need to consider the following parameters:

I. Quality of threshing depend on:

1. Cylinder speed
2. Cylinder concave clearance
3. Feed quantity

II. Operating parameters:

1. Cylinder speed
2. Cylinder-concave gap
3. Material feed rate

III. Crop condition:

1. Crop moisture content
2. Crop maturity
3. Crop type

Safety while working with threshers and shellers

Warning: Thresher has an internal combustion gasoline/diesel engine. This engine contains hazardous chemicals, toxic fumes and hot surfaces that could cause harm or even death. The engine also contains a flammable chemical that could result in a fire or even an explosion. For the complete overview of all warnings and risks please read the engine manual before use.

Warning: Thresher contains moving parts that could cause serious harm or even death if anything is caught in the moving drum or in the belt system. While in operation, all guards should be in place and all adjustment bolts should be tightened properly.

Warning: 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. It is recommended that anyone with long hair working on or with the thresher put up their hair or wear a hat in order to reduce that risk of their hair being caught in the belt or on the drum which could result in very serious injuries.

Warning: while threshing or shelling, there will be dirt and dust which will be blown by the threshing or shelling action. Therefore, it is strongly recommended that a person doing the threshing and shelling job should wear a dust mask or any other clean cloth to cover the mouth and nose to protect the breathing organs.
In adjustment or maintenance mode:

- Ensure that the motor throttle is set in its off position, and it is recommended that the spark plug wire be disconnected and kept away from the spark plug if it is a gasoline engine. If it is diesel engine, move the throttle in to the acceleration position or move it away from acceleration to stop position.
- Be careful around the motor as it may be hot. Never touch the engine parts especially the exhaust muffler and exhaust manifold area.
- It is recommended that anyone with long hair working on or with the thresher should put up their hair or wear a hat in order to reduce that risk of their hair being caught in the belt or on the drum.
- It is recommended that the user does not wear gloves when adjusting the thresher as they could get caught and that could result in an injury.

Warning: Never start the machine if anything is inside of the threshing area. This could result in injury or damage to the thresher.

Caution: Various parts of the thresher may get hot during operation. Caution is recommended after prolonged usage.

Caution: Do not overlift the concave. This could result in the drum hitting the concave, potentially resulting in broken parts. There is also a chance of flying parts that could result serious injury. One should always spin the drum by hand before operation to ensure that the drum will not hit the concave and all concave adjustment points should be tight.

Caution: When the output is in the upright position, it could easily fall and cause injury to anyone below it. It should be tied down to make sure this does not occur.

Caution: When working on or with a thresher, beware of any pinch points or sharp edges as one could get hurt.

Operation

Starting and Running the Thresher/Sheller

- Ensure that all the security bolts on the concave are tightened down up and the concave is snug.
- Rotate the threshing drum by hand to make sure it moves freely and that there are no restrictions to rotation.
- Insert the belt to the pulley in the drum and on the engine.
- Make sure that the belt is aligned to avoid belt slipping.
- Start the engine with a rope or a cranking button (depending on the method of starting for different engines).
- 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 setscrews on the pulley should be tightened and the nuts on the idler should be tightened by wrench. Caution: un-tightened pulley may fly and can cause serious fatal injuries.
- After the engine is started, lower the speed to idle speed for 3-5 minutes for warming up.
- Now the engine has warmed up, gradually increase the speed (rpm) and insert the un-threshed material through the inlet of the thresher/sheller.
- 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 due to over dried un-threshed harvest.

Installation

Once arrived on location the threshing/shelling machine has to be placed horizontally on its four support legs. This might be done by raising the thresher by jack, first at the front then at the back, before lowering the support legs depending on the design. These support legs provide the machine stability and prevent vibration, which otherwise would influence the threshing in a rather negative way. The machine always has to be placed with the drum shaft horizontal.

The machine should always be placed in a horizontal position, both lengthwise as widthwise. For this purpose, some thresher/sheller designs may have a liquid level indicator, which is mounted on the main frame.

The threshing/shelling machine can be operated either by a 2WT engine, small horsepower gasoline or diesel engines, 220/110V electric motor, three-phase electric power , or by the 4-wheel tractor power take off (PTO). The position of the tractor must be at right angle to the thresher. Most designs do not allow to have any angle in the PTO shaft larger than thirty degrees. Be sure that the tractor is safely parked by means of the hand brake or wheel blocks. In case no handbrake or wheel blocks are available, all the tractor wheels can be blocked by means of big stones or by digging 4 holes of about 15 cm deep to fit the tractor wheels.

During operation, the main drive pulley should always operate at 460 rpm. This corresponds with full speed of a diesel engine or normal speed of an electric motor. But, when using the PTO, it has to run at 460 rpm, meaning a good working tractor meter (standard on nearly all tractors) is required.

A tractor supplier often gives just the rotation speed of the engine, by which 540 rpm or 1000rpm on the PTO are available. The required 460 rpm can therefore be obtained by multiplying the engine speed by 540 rpm by 460/540.

For example:

A tractor of make x has 540 rpm at 1900 rpm of the engine. In this case the engine speed of the tractor has to be set at 460/540 x1900=1620. So, it should be set at between 1600 and 1650 rpm.

Drum (cylinder) speed

The threshing speed of the drum is adjusted depending on the type of crop that needs to be threshed. Due to the difference in humidity, maturity and even in variety within a single crop, it is not possible to give one exact rotation speed for every crop. However, it is possible to give a range within which the optimal speed is obtained. See Table 3 below.

Fig 103. Cylinder (drum) and concave clearance measurement.

Table 3. Drum speed for different types of crops

Crop type	R.P.M.	Rotation speed in m/sec
Barley	630-1315	18.5-38.5
Wheat	536-1050	15.7- 30.8
Rice (Paddy)	630-1315	18.5-38.5
Maize (Corn)	368-728	10.8-21.3
Sorghum	368-728	10.8-21.3
Peas	368-788	10.8-23.1
Grains	368-788	10.8-23.1
Sunflower	630-1248	18.5-36.6

Speed can be varied by using different combinations of pulleys for the drum drive. Refer manufacturer's chart for a specific threshing or shelling machine. It is recommended that in general a first trial is made about in the middle of the range.

For example:

Paddy: 630-1315 rpm. The middle is about 870 rpm. Depending on the result of this trial one can change to a higher or a lower speed.

Changing Pulleys:

For adjusting the drum speed, pulleys have to be interchanged. There are different diameter sizes of pulleys. Any combination which can give the desired threshing drum speed can be selected, depending on the design of the thresher/sheller and the crop type. For replacement, the tension of the belt has to be taken away completely. After taking off the belt, the pulleys can be removed by loosening the bolts with which the pulleys are held to their flanges. Then, once the correct size of pulleys are mounted, the belt can be replaced and tensioned again. Make sure the tensioning nuts are properly tightened.

Position of the concave

The concave can be adjustable or fixed, depending on the design. This means, when multi-crop threshing/ shelling machines have adjustable concave, the distance between the drum and concave (as shown in figure 103) can vary, while single crop threshers/shellers have a fixed concave that is not adjustable.

The concave and its hinge point are placed in such a way that the opening between the concave and the drum has a wedge shape. The opening at the beginning is always twice the size of the opening at the rear. The position of the concave can be set by a special key which fits on an eccentric. Placing the concave high means a narrow opening and maximum threshing effect. Placing the concave low on the other hand means a big opening and minimum threshing effect. Generally speaking, the concave should be set narrower when the humidity of the grain is higher. But when threshing dry and very mature grain, the opening can be set wider.

Note: Some designs may recommend the removal of every second wire from the concave for crops with seeds over 8 mm diameter.

The drum and concave system have two functions:

Through the friction in the wedge-shaped opening, the grains are separated from the straw, grains can fall through the openings in the concave and the straw should go over the concave to the straw rack. Of course, this separation in not 100%, after having passed the concave there still is straw in the grains, just as there are grains in the straw. The grain is being cleaned from straw by air and the straw is being cleaned from grains by shaking depending on the design. The straw rack has an oscillating movement forwards and backwards. Through this movement and the cams on the straw shaker the straw is being shaken backwards and the underlying top sieve.

Exchanging drums and concave

For rice, a peg-tooth type drum and concave are recommended. For replacement, take away the cover plate over the drum, remove the drive belt and the belt for the drive of the conveyor chain. After removing the securing bolts and nuts with which the bearing blocks are mounted on the frame, the complete drum can be taken out by lifting it up. Place the bearing blocks in vertical position.
The concave is taken out by removing the hinge bolts in the side plate.

Note: Some bolts are locked with counter nuts inside the thresher/sheller in some designs, these bolts with which the concave is resting on the eccentric have to be removed.
To reassemble: reverse the above-mentioned procedure.

Note: First check if drum can rotate freely before tightening the bolts and nuts for the bearing block.

Grain Cleaning

The grain is cleaned from straw and chaff and other impurities by air and a double action sieve system, depending on the design. Since every crop has different size and aerodynamic properties, the air as well as the sieves have adjustment possibilities. The air direction can be governed by tow adjustable wings in some designs and adjustable doors in other designs. The more vertical the air blows the more aggressive is the cleaning. *Note: Adjusting the volume of the air is necessary otherwise the grain might be blown together with the chaff in the outlet.*

There may be sieves that are adjustable and non-adjustable depending on the design. The top sieve may be an adjustable sieve. The size of the openings can be adapted to the size of the grains by means of the adjusting nuts. Generally, it can be said that the opening should be as long as the length of the average grain in the particular crop. In case of round seeds, the opening should be 1.5 to 2 times the diameter of the average seed.

Under the top sieve, an exchangeable bottom sieve may be situated. This sieve is the last step in the cleaning and separation section. The size of this sieve has to be such that the grains should fall through easily.

All the material which falls through this sieve is first quality seed and comes out of the 1st quality outlet. In most cases approx. 90% of the grain without impurities should come through this outlet.
All material, which falls through the top sieve and not through the bottom sieve, comes through the second quality outlet. This second quality grain (about 10%) can later be threshed separately again in order to get it cleaned a second time. Light impurities like straw and chaff have to be blown over the sieves.
In order to prevent the risk of dry and light grains blowing over the sieves a chaff plate can be placed behind the sieve box. This chaff plate can be adjusted in height and is generally set in high position with dry (light) grains and in low position with wet grains.

In order to reduce the speed of the straw on the straw shaker and in order to stop grains which have been thrown away backwards by the fast-moving drum, rubber flap is hanging above the straw walker. It can be necessary, however, in very wet crops to remove this flap.

Field Adjustment

1. Set machine horizontally.
2. Select correct drum speed (see chart depending on the design of thresher/sheller).
3. Set concave in correct position (normally in the middle) if dry, and very mature in maximum opening and if wet and not mature in minimum position.
4. Set air direction properly (light material levers up, heavy material levers down.).
5. Adjust top sieve (opening equal to length of seed or 1.5 times diameter round seed). (Optional: depending on the type of thresher/sheller).
6. Select proper bottom sieve.
7. Adjust chaff plate shield:
   For dry grain: set in high position.
   For wet grain: set in low position.

After these adjustments, the machine has to be tested on proper threshing and cleaning.

Following points have to be examined.

I. A. Are there still un-threshed grains in the straw? If yes: the distance between concave and drum has to be decreased, that means concave up and even a higher speed on the drum may be necessary.
First try to adjust the concave and if this does not give enough result, increase the drum speed by means of changing the pulleys.

B. Are there broken grains? If yes: this indicates a too narrow distance between drum and concave. If

increasing this distance does not help enough, decrease the drum speed.
II. Are there coming grains over the straw shaker on the outlet?
If yes: (a) try to narrow the opening between drum and concave. If this does not help tilt the machine, a little bit down at the front depending on the design.

III. Are grains leaving the machine over the sieve box and chaff plates?
If yes: (a) put the air speed less aggressive (levers up).
(b) Make the openings of the top sieve a little larger
(c) Put the chaff plate in higher position.

IV. Is there too much impurity in the first quality grain?
If yes: (a) Down ease the wind effect (levers).
(b) Top sieve is too wide open.
(c) Size of bottom sieve is too large.
(d) Concave distance is too narrow.

Feeding Platform

For a proper operation, the feeding has to be done by 3 persons, 2 persons place material on the left-hand side of the platform and 1 person feeds this martial in an even flow in to 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.

Tensioning of drive belt

Make sure tension of drive belt is never too low or is never too high. This will cause mis-alignment of drum shaft, resulting into poor quality of threshing and damage to driveshaft and bearings.
Tension is okay when you can push the drive belt in over a distance of at least the width of two of your fingers. If you have to push too hard, or you cannot push far enough, loosen check nut. Check tension again. Repeat doing this, until belt has right tension. Now tighten tensioning nut.
Note: If belt tension is too low, belt slippage will occur, or at extreme low tension, belt will simply come off. In these cases, tension regulation should be in line with adjustment procedure.

Lubricating Scheme

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.**

2WT trailer

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 for optimum loading and safety during travel. Trailers are required to transport farm products to and from the farm to the warehouse or to the market. In Sub Sharan Africa, most of the post-harvest losses comes from major causes such as storage, threshing or shelling or farm transportation. Thus, trailers are very important farm machineries to reduce the post-harvest losses.

It is also very important to note a trailer without appropriate accessories will likely cause an accident, if used on public roads. Some trailers have those accessories such as break lights, horns, rearview mirrors and accessories such as roofs to protect the operator against the sun/rains. In general, the following simple instructions are worth noting before operating 2WT-attached trailers.

Fig 104. Modified 1000 kg capacity trailer to be use on roads made by EIAR through FACASI phase-II project (demonstrated during field day at Tiyo District, Oromia region, Ethiopia).

Necessary checks before hitching a trailer to 2WT

- Check the tire pressure before hitching.
- Check all the wheel bolts, tighten and replace if there are missing bolts.
- Make a visual observation so that if any missing bolts and other body parts are in their place.
- 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 2WTs 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.
- Most of the time you can find the guideline 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 stuff from the trailer.

Driving 2WT

The following are general considerations to be taken when operating a 2WT.

- Do not approach/operate a 2WT with loose clothing/scarf/tie.
- Take special care near the running engine/turning belts.
- Take special care that feet do not slip from foot rests/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 2WT up or down a steep slope at high speed.
- Never “coast” down a hill with clutch/gears disengaged (free-wheeling).
- Never disengage both of the steering clutches at the same time.
- Never drive the 2WT at high speed on a rough road (gears 4-6).
- Never attempt to start the tractor from dead stop in gears higher than 3rd gear.

Driving 2WT with Trailer

- Never exceed the maximum carrying capacity of the trailer. Trailer brakes are designed to halt the trailer with its maximum designated carrying capacity only.
- Always abide and observe all public traffic regulations while driving on the roads.
- Always observe speed limits on the roads.
- Use appropriate speed for difficult/crowded/high traffic conditions.
- Be sure that the brake of the trailer and the 2WT is appropriately adjusted always before starting to drive.
- Remember both brakes can be applied at the same time in emergency conditions.
- Never make a sudden turn at higher speed.
- Never run the tractor in 5th and 6th gear unless the road is in very good condition.
- Never drive across a steep slope.
- Go down steep slopes in reverse to avoid tipping forward.
- Be sure that the brake is appropriately adjusted in good working order always.
- Never make sudden turns at high speed.